DEVELOPMENT AND PERFORMANCE EVALUATION OF FOUR ROW SELF PROPELLED PADDY TRANSPLANTER

A Thesis submitted to

DR. BALASAHEB SAWANT KONKAN KRISHI VIDYAPEETH
DAPOLI - 415 712
Maharashtra State (India)

In the partial fulfillment of the requirements for the degree
of

MASTER OF TECHNOLOGY

(AGRICULTURAL ENGINEERING)
in

Farm Machinery and Power

by

Mr. Gaikwad Pravin Balasaheb

B.Tech. (Agril. Engg.)

DEPARTMENT OF FARM MACHINERY AND POWER
COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY
DR. BALASAHEB SAWANT KONKAN KRISHI VIDYAPEETH
DAPOLI- 415 712, DIST. RATNAGIRI, M. S. (INDIA)

2013

DEVELOPMENT AND PERFORMANCE TESTING OF FOUR ROW SELF PROPELLED PADDY TRANSPLANTER

Thesis submitted by

Gaikwad Pravin Balasaheb
B. Tech. (Agril. Engg.)

DEPARTMENT OF FARM MACHINERY AND POWER
COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY
Dr. BALASAHEB SAWANT KONKAN NRISHI VIDYAPEETH
DAPOLI, DIST. RATNAGIRI
2013

DEVELOPMENT AND PERFORMANCE EVALUATION OF FOUR ROW SELF PROPELLED PADDY TRANSPLANTER

DEVELOPMENT AND PERFORMANCE EVALUATION OF FOUR ROW SELF PROPELLED PADDY TRANSPLANTER

A Thesis submitted to the

DR.BALASAHEB SAWANT KONKAN KRISHI VIDYAPEETH
DAPOLI – 415 712.
Maharashtra State (India)

In the partial fulfillment of the requirements for the degree
of
MASTER OF TECHNOLOGY
(AGRICULTURAL ENGINEERING)
in
FARM MACHINERY AND POWER

Submitted by
Mr. Gaikwad Pravin Balasaheb

Approved by

(P.U. Shahare)
Professor and Head, Dept. of FMP
(Chairman and Research Guide)

(V.V. Aware)
Associate Professor, Dept. of FMP
(Committee Member)

(S.V. Pathak)
Associate Professor, Dept. of FMP
(Committee Member)

(S.H.Sengar)
Assistant Professor , Dept. of EOES
(Committee Member)

DEPARTMENT OF FARM MACHINERY AND POWER
COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY
DR. BALASAHEB SAWANT KONKAN KRISHI VIDYAPEETH
DAPOLI – 415 712. DIST. – RATNAGIRI. M.S. (INDIA)
FEBRUARY 2014

DEDICATION

THIS RESEARCH PROJECT REPORT

AFFECTIONALY DEDICATED

TO MY

PARENTS

WHO HAVE GUIDED ME THROUGH THE CORRECT PATH AND THEY CULTIVATE GOOD VIRTUE IN MY HEART. THEIR GOOD VIRTUE IS MY ENDLESS WEALTH. THEIR TEACHING IS A COMPASS THAT DIRECTS MY LIFE AND DESTINY

LIST OF ABBREVIATIONS

Abbreviation	Description
cm	centimeter
Dr. B.S.K.K.V.	Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth
eg.	Example
et al	and others
etc.	et cetera, and other things
Fig.	Figure
g	gram
GR	Gear ratio
ha	Hectare
hp	horse power
hr	hour
i.e.	that is
kg	kilogram
l/h	liters per hour
m	metre
min.	minute
mm	milimetre
No.	number

ABSTRACT

DEVELOPMENT AND PERFORMANCE EVALUATION OF FOUR ROW SELF PROPELLED PADDY TRANSPLANTER

By

Pravin Balasaheb Gaikwad

College of Agricultural Engineering and Technology,
Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli-415 712,
Dist. Ratnagiri, (Maharashtra)

2013.

Research Guide: Dr. P.U. Shahare
Department: Farm Machinery and Power

India has largest area under rice (42.6 million hectares) and with the production of about 103.4 million tonnes it ranks second only to China. In Maharashtra 15.14 lakh ha land is under rice cultivation with rice production of about 27.12 lakh tones. Rice is staple food of Konkan region of Maharashtra. It is grown on 4.136 lakh hectare with annual production of 10.42 lakh tones and the average productivity is 2.56 tones/ha. Rice is generally grown by transplanting seedlings in flooded field conditions or direct sowing depending upon the availability of water. The cost of puddling and transplanting shares 50 % of total production cost. Rice transplanting is a tedious and very time-consuming job requiring about 250 to 300 man-hour/ha. Hence there is a great need to mechanize the transplanting operation. In many parts of country as well as in Konkan region of Maharashtra eight row self propelled paddy transplanter has been used and it is found useful. The limitations are observed due to smaller plot size and hilly terrain. The efforts have been made to develop two row transplanter at Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli. It could work on smaller plots but the field capacity is very less and also plant to plant spacing is not maintained. In order to enhance the field capacity the work on high capacity transplanter of a four row is necessary and it is decided to develop four row self propelled paddy transplanter.

The developed four row self propelled transplanter consists of main frame, engine, gear box, transplanting mechanism, tray movement mechanism and drive system. The total power required for removal of seedlings and their placement and forward motion of machine was found to be 3.2 hp. Based on the power requirement the commercially available Honda-GK-200 petrol engine (3.5 hp) was selected as a

prime mover. The engine was fitted over main frame with nut and bolts.Engine speed was reduced to 288 rpm through gear box of 12.5:1 ratio which was required to operate transplanting arm. The commercially available actuating type transplanting arms (2 Nos) were used for this transplanter. In order to achieve forward speed of machine 1.5 km/hr the drive wheel having lugs was designed. The drive wheel speed was reduced to 24 rpm using another small worm type gear box with gear ratio 12:1.

Laboratory test results showed that transplanting mechanism and feeding mechanism functions properly.The newly developed four row self propelled transplanter was operated in field for filler trial. The result reveals that the hill spacing for newly developed transplanter was 13.16cm. The planting depth of the transplanting was observed to be 3 cm. The seedlings per hill and missing of hills/m^2 were observed to be 3.66 and 4.33 respectively. The total number of hills/m^2 area was obtained as 30. Fuel consumption for the newly developed transplanter was 1.9 l/h. The operating speed of the transplanter was observed to be 1.48 km/h. The field efficiency of the transplanter was 80.47%. Total time of operation for one hectare field was obtained to be 7.19 hr. The field capacity of the transplanter was 0.14 ha/h. The operating cost of newly developed transplanter was ₹359/h and ₹2580 /ha. In general, the newly developed transplanter worked satisfactorily in the field.

CANDIDATE'S DECLARATION

I hereby declare that the experimental work and its interpretation of the thesis entitled **"Development and Performance Evaluation of Four Row Self Propelled Paddy Transplanter"** or part of thereof has not been submitted for any other degree or diploma of any University nor the data have been derived from any thesis/publication of any University or scientific organization. The sources of material used and all assistance received during the course of investigation have been duly acknowledged.

Place: CAET, Dapoli **(Pravin Balasaheb Gaikwad)**

Date: / /2013 (Reg. No. ENDPM-053/2011)

Dr. P. U. Shahare

B. Tech (Agril. Engg.), M. Tech (FMP), Ph. D (FMP)

Professor and Head,
Department of Farm Machinery and Power,
College of Agricultural Engineering and Technology,
Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth,
Dapoli- 415 712, Dist. Ratnagiri,
Maharashtra, India.

CERTIFICATE

This is to certify that the research project report entitled **"Development and Performance Evaluation of Four Row Self Propelled Paddy Transplanter"** submitted to the Faculty of Agricultural Engineering and Technology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri (Maharashtra State) in the partial fulfillment of the requirements for the award of the degree of **MASTER OF TECHNOLOGY (AGRICULTURAL ENGINEERING)** in **FARM MACHINERY AND POWER** embodies the record of a piece of **bonafide** research work carried out by **Mr. Pravin Balasaheb Gaikwad** under my guidance and supervision. No part of the research project report has been submitted for any other degree, diploma or publication in any other form.

The assistance and help received during the course of this project work and sources of the literature have been duly acknowledged.

Place: CAET, Dapoli

Date: / / 2013

(Dr. P. U. Shahare)

Chairman,
Advisory Committee and Research Guide

Dr. P.U. Shahare

B. Tech (Agril. Engg.), M. Tech (FMP), Ph. D (FMP)

Professor and Head,
Department of Farm Machinery and Power,
College of Agricultural Engineering and Technology,
Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth,
Dapoli- 415 712, Dist. Ratnagiri,
Maharashtra, India.

CERTIFICATE

This is to certify that the project report entitled **"Development and Performance Evaluation of Four Row Self Propelled Paddy Transplanter"** submitted to the Faculty of Agricultural Engineering, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri (Maharashtra State) in the partial fulfillment of the requirements for the award of the degree of **MASTER OF TECHNOLOGY (AGRICULTURAL ENGINEERING)** in **FARM MACHINERY AND POWER,** embodies the record of a piece of bonafied research work carried out by **Mr. Pravin Balasaheb Gaikwad** under the guidance and supervision of **Dr. P.U. Shahare,** Professor and Head, Department of Farm Machinery and Power, College of Agricultural Engineering and Technology, Dapoli. No part of the project report has been submitted for any other degree, diploma or publication in any other form.

The assistance and help received during the course of this project work and sources of the literature have been duly acknowledged.

Place: CAET, Dapoli **(Dr. P.U. Shahare)**

Date: / / 2013 Professor and Head
Department of farm Machinery and Power

Prof. dilip MAHALE

B. Tech (Agril. Engg.), M.Tech. (SWCE),

Associate Dean,
College of Agricultural Engineering and Technology,
Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth,
Dapoli- 415 712, Dist. Ratnagiri,
Maharashtra, India.

CERTIFICATE

This is to certify that the project report entitled **"Development and Performance Evaluation of Four Row Self Propelled Paddy Transplanter"** submitted to the Faculty of Agricultural Engineering, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri (Maharashtra State) in the partial fulfillment of the requirements for the award of the degree of **MASTER OF TECHNOLOGY (AGRICULTURAL ENGINEERING)** in **FARM MACHINERY AND POWER,** embodies the record of a piece of bonafied research work carried out by **Mr. Pravin Balasaheb Gaikwad** under the guidance and supervision of **Dr. P.U. Shahare,** Professor and Head, Department of Farm Machinery and Power, College of Agricultural Engineering and Technology, Dapoli. No part of the project report has been submitted for any other degree, diploma or publication in any other form.

The assistance and help received during the course of this project work and sources of the literature have been duly acknowledged.

Place: Dapoli **(dilip MAHALE)**

Date: / / 2013 Associate Dean
College of Agricultural Engineering and Technology

CHAPTER - I

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the leading food crops in the world within the worldwide-cultivated cereals, and is second only to wheat in terms of annual for food consumption (Alizadeh, 2011). The cultivation of rice is immense importance to food security of Asia, where more than 90 per cent of the global rice is produced and consumed. Being the staple food for more than 62 per cent of people, our national food security hinges on the growth and stability of its production. India has largest area under rice (42.6 million hectares) and with the production of about 103.4 million tonnes it ranks second only to China with the average productivity of about 2240 kg/ha during the year 2011-2012 (Anonymous, 2012). Maharashtra has 226.1 lakh ha land under cultivation out of which 15.14 lakh ha land is under rice cultivation with rice production of about 27.12 lakh tones and productivity is 1.8 tones/ha during the year 2011-12 (Anonymous 2012). Rice is staple food of Konkan region of Maharashtra. It is grown on 4.136 lakh hectare with the annual production of 10.42 lakh tones and the average productivity is 2.56 tones/ha (Anonymous, 2008).

The traditional rice farming system in India broadly includes wetland (lowland) and upland system. Dry cultivation system is confined mainly to rain fed ecosystem with no supplementary irrigation facilities. In semi dry cultivation system, the seeds are sown just after receiving the first shower of season as in dry system. Wet cultivation system is prevalent in areas, where adequate water supply is assured either through rainfall or irrigation or both. Rice is generally grown by transplanting seedling in flooded field conditions or direct sowing depending upon the availability of water.

Transplanting has number of advantages over direct sowing as given below.

1. Transplanting helps the plant to have better start over the weeds hence results in less growth of weeds.
2. More chance for selection of more healthy seedlings for vigorous growth.
3. Allow better water management practices.
4. Less seed requirement.
5. Better weeding and intercultural operations.

Transplanting refers to the planting of 20-22 days old seedlings of 12-15 cm height under wet land condition. The seedlings are raised in nursery and uprooted for transplanting. Nursery system uses 15-20 per cent of the total farming area. In preparing the nursery seedbed, the surface needs to be level, free from weeds and well drained. There are five ways for development of nursery for transplanting.

1. Wet nursery
2. Dry-bed nursery
3. Dapog or mat nursery
4. Bubble tray nursery
5. Seedling boxes for mechanical transplanting

Wet-bed nursery

The wet-bed nursery is mainly used in areas where there is enough water. Pre-germinated seeds are broadcasted on a soil that is thoroughly puddled and leveled. Drainage canals for proper removal of water must be constructed. Addition of organic manure (decomposed) and small amounts of inorganic fertilizer as basal dressing will increase easiness of uprooting of seedlings and seedling vigor**.** Total seed bed area is about 1/10 of the area to be transplanted and requires about 100 kg of seed paddy per ha.

Dry-bed nursery

The nursery is prepared in dry soil conditions. Seed bed is prepared with convenient dimensions with raised soil to a height of about 5-10 cm. Nursery area should be about 1/10 of area to be transplanted. Seed rate is higher than the wet-bed method (about 150 kg/ha) as the germination could be lower. Uprooting of seedlings should be done between 15 - 21 days after germination.

Dapog or mat nursery

This nursery can be established on a flat surface. If low land paddy field is used, water supply and control should be very reliable. Area required is about 10 m^2/ha of the transplantable land. Dapog method required area is much smaller than conventional nurseries. Leveled seed bed should be made and center of the bed should be slightly higher than the edge to permit water to drain off the surface.

Bubble tray nursery

The bubble tray nursery is a good system to develop 12-15 day old seedlings with "root balls". These trays have 434 plugs (micro-pots of 1.3cm dia. and 1.3 cm depth) with a tiny hole in the bottom to facilitate movement of water and nutrients from the soil below into soil plugs through capillary action. Soil is filled into the pots and 2-3 seeds are placed in each pot. When the seedlings are 14-21 days old, they are thrown into the field to be planted at random spacing. It requires 400 -750 trays per hectare of paddy.

Seedling boxes for mechanical transplanting

Mechanical transplanting requires techniques that are different from hand transplanting. Usually seedling boxes are used that are adapted to the type of transplanter. In a seedling box, seedlings are grown on a thin layer of soil in 33 cm x 5 cm plastic trays. In some instances, seedlings are grown on larger areas and then cut into rectangular strips (mats of seedlings) that fit into the planting trays of the transplanter.

Transplanting is done either manually or using transplanters. Different types of transplanters like manually operated, power tiller operated, riding type, tractor operated and self propelled types are available. During manual transplanting the uprooted seedlings are to be put in puddled soil. A person puts 2-3 seedlings per hill in the puddled soil at a depth of 3-5 cm. On an average, a worker dips fingers 1, 40, 000 times to transplant one acre of land and can transplant only 0.016 ha/day. Konkan region is basically a narrow strip of 40 km wide and running 750 km of length from north to south and is a hilly terrain lying between Sahyadri ranges in the east and Arabian Sea in west. It receives an annual rainfall between 3000 to 4500 mm during June to October. In this region terrace farming is followed for paddy crop and the field is fragmented. In this region, wet land cultivation system is followed. The land is ploughed thoroughly and puddled in 3-5 cm standing water. The puddling is mostly done by bullock drawn country plough and wooden planks in the region. In some of the pockets, the power tiller is used for puddling, but the extent is very low. In Konkan, and particularly in Ratnagiri district, the status of mechanization is very low. Hence the transplanting operation is done manually.

Increase in world population and limitation in agricultural land demand to efficiency and productivity in whole stages of rice production in Konkan region. The

small land holders having land availability less than 2 ha are 72 per cent, that of medium and large are 25 and 3 per cent respectively with land availability of 2-10 and more than 10 ha respectively. The availability of agricultural labours is about 10.4 lakh out of which 37.5 per cent are women workers. Rice transplanting is a tedious and very time-consuming job requiring about 250 to 300 man-hour/ha which is roughly 25 per cent of the total labour requirement of the crop. At transplanting time, there is acute shortage of labour. This results in increased labour wages and a delayed transplanting operation. In some cases, a proper crop stand is not maintained by the hired labour. Hence there is an urgent need to have mechanization in rice production which will result in reducing the labour work and time consumed. Mechanical transplanting of paddy seedlings is a solution to the prevailing situation in the Konkan region of Maharashtra to release the work force and to reduce the cost of paddy production. Farmers are aware of the advantages associated with transplanting of paddy over the broadcasting. But they are unable to practice it for high scarcity of labor. The transplanting machines available in the country are imported. They are costly and unable to meet the plant geometry.

To reduce the cost and labour in transplanting operation, manually operated imported Japanese transplanters were introduced in the country during 1970's. These transplanters could not become popular among the farmers as the person has to walk behind in puddled soil during transplanting and has to pull the transplanter. To overcome this difficulty the efforts have been made by Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli to popularize eight row Yanji-Shakti transplanter. Number of demonstrations of this machine was taken in the Konkan region. The limitations are observed due to smaller plot size and hilly terrain. The two row transplanter has been developed at Dr. B.S. Konkan Krishi Vidyapeeth (Bhat and Shahare, 2011; Desai, 2012) Dapoli. The developed machine can work on smaller plots but the field capacity is very less and also plant to plant spacing is not maintained. In some pockets drum seeder for dry cultivation is tried. For this before the onset of monsoon, seeds need to be drilled using seeder on fine seedbed. Proper seed rate is not maintained and non uniform seed delivery observed many times. This leads to uneven plant stand. The high rainfall with high intensity scatters the seeds and restricts drum seeder for sprouted seeds. Considering the limitations of eight row transplanter, two row

transplanter and drum seeder, in order to enhance the field capacity, the work on high capacity transplanter of a four row is necessary to undertake.

Hence the study entitled “Development and Performance Evaluation of Four Row Self Propelled Paddy Transplanter” is planned with the following objectives:

1. To develop four row self propelled paddy transplanter.
2. To evaluate the field performance of developed four row self propelled paddy transplanter.

CHAPTER - II

REVIEW OF LITERATURE

Rice one of the three most important food crops in world, forms the staple diet of 2.7 billion people. In Konkan region, rice is an important crop. Transplanting is most labour consuming operation during paddy cultivation. Precision agriculture and automation is the current trend in agricultural mechanization. Paddy is grown by transplanting under wetland conditions or direct sowing depending upon the availability of water. The main difference between the two methods are direct seedling method, the seeds are sown directly in wet or dry field, whereas in transplanting method, seedling are first raised in seedbed in the nursery and uprooted for transplanting manually or mechanically. Paddy transplanting remains the most common method in India. The transplanting has number of advantage over direct sowing, as listed below:

1) The time that a crop occupies the land is reduced by 3-4 weeks.
2) Helps the plant a better start over the weeds.
3) Permits optimum plant spacing, which is critical for higher yield.
4) Ensures uniform maturity of the crop.
5) Less seed requirement.
6) Facilitate better weeding and intercultural operations.

This chapter reveals the review related to transplanting technology which is divided into various sections on the topic under study. The chapter has cited the review under following heading.

2.1 Planting methods.

2.2 Raising of mat type seedlings.

2.3 Paddy Transplanter.

2.1 Planting Methods

Singh *et al*. (2002) have carried out field experiment in Uttar Pradesh during the 2000 kharif season to compare the effect of different methods of transplanting, viz., manual transplanting, mechanical transplanting, direct dry sowing and direct sprouted sowing. The effective field capacity of the transplanter was 0.125 ha/h. The cost of transplanting was Rs. 1152/ha and energy requirement was 230 MJ/ha. The maximum grain yield was observed in mechanical transplanting followed by manual transplanting, direct dry sowing and direct sprouted sowing. Mechanical transplanting

significantly increased grain yield by 23%, 37% and 63%; straw yield by 17%, 14% and 22%; and biological yield by 20%, 24% and 39% over manual transplanting, direct dry sowing and direct sowing of sprouted rice in puddled conditions, respectively.

Suseela and Susan (2003) have carried out study on the transplanting methods in Kerala. According to them, the acute shortage and increased cost of labourers (Rs. 180/day) forced the farmers of Kerala to adopt machines for transplanting. Farmers of Kerala have started using different types of transplanters like manual IRRI five row, six rows and power tiller operated eight row transplanters since 1982 but these transplanters were not successful for various reasons. The imported eight row self propelled Chinese transplanter (Yanji-Shakti) was successfully demonstrated first time in Kerala during 1996. Thereafter, hundreds of hectares of land were put under mechanized transplanting. The washed root type conventional nursery was not successful for machine transplanting. It was suitable for transplanting mat type rice seedlings in puddled soil. It was observed that seeding mat of size 500 mm×210 mm×25 mm with 18-22 day old seedlings was found to be appropriate.

Singh *et al*. (2005) studied the response of rice to different planting methods. They reported that in India, rice cultivation is becoming increasingly expensive as seedling are raised in nurseries and transplanted manually. Rice transplanters are yet to be popularized. Manual transplanting alone accounts for nearly 20% of the total cultivation cost. In most cases, the required plant population is not maintained because laborers are not properly supervised as transplanting is done on a contractual basis. Manual transplanting takes longer period to complete transplanting operation. Therefore, major constraints are the high cost of manual transplanting and uneven plant population.

Badr *et al*. (2007) studied the effect of some planting and harvesting methods on rice-crop yield. They used planting machines as tractor mounted broadcasting machine using rice grain rate of 80 kg/fed, sulky type mounted seed drill with row spacing 15 cm and forward speed 4 km/h, walking type transplanter to transplant 21 days old seedlings at 30 x 30 cm spacing with a speed of 1.5 km/h and manual transplanting at spacing 20 x 20 cm of 30 days old seedlings with a team of 10 laborers. Five planting methods were tested viz., manual broadcasting, drilling, pods planting (about 20 – 30 pregrminated grains with 15 – 25 cm spacing), and manual and mechanical transplanting. Five harvesting methods were tested, viz., Manual

harvesting by sickle with threshing by hand, manual harvesting with threshing by Barmeel rice thresher, harvesting by mower with threshing by Barmeel rice thresher, small combine (CA-385 EG Japan made) and big combine (Class combine German made). Using manual rice transplanting and big combine gave the highest yield and highest net profit as comparing with other methods of planting and harvesting.

Ehsanullah *et al.* (2007) conducted an experiment to determine the effects of different sowing methods on plant population and yield of fine rice cv. Super Basmati. The sowing methods included direct seeding by broadcast at field capacity (DSBFC), direct seeding by broadcast in standing water (DSBSW), direct seeding with drill at field capacity (DSDC), transplanting at 20 cm apart rows (TR-20), farmer's practice (FP), transplanting by parachute method (TPM). They recorded the data of plant population, number of panicle bearing tillers, plant height, number of grains per panicle, spikelets per panicle, 1000-grain weight and grain yield. It was also observed that maximum paddy yield (3.06 t/ha) was produce by TR-20 while minimum paddy yield (2.52 t/ha) was observed in case of DSBSW. TR-20 means transplanting at 20 cm apart proved to be the most productive planting method for rice cultivation.

2.2 Raising of mat type seedlings:

Transplanting of rice reported the better yield than other method. The raising of paddy nursery on mat has many advantages over other methods. This method is also suitable for mechanical transplanting of rice.

Alam *et al.* (2002) carried out experiment to investigate the effect of three seedling ages viz., normal wet, modified wet, floating and modified dapog on the yield and yield components of transplant aman rice. Except the number of non-effective tillers /hill, weight of 1000 grains, harvest index and other characters were significantly influenced by both seedling ages and seedling raising techniques. Besides these, straw and biological yield showed non-significant results in respect of seedling ages. The interaction between seedling ages and seedling raising techniques had significant effect on number of total tillers/hill, number of effective tillers/hill, grain, straw and biological yield. The 35 days seedlings gave better performance than 28 or 21 days old seedling in transplant aman season in the climatic conditions of the study area. The modified wet seedbed technique was the best followed by floating and normal wet seedbed respectively.

Sahay *et al.* (2002) reported that for raising mat type nursery, the frames of M. S. flats of the size 12 × 28 cm were fabricated in such a way that frame consists of 18 such rectangles. Black soil, cow dung and sand were mixed thoroughly in the ratio of 3.3:1 and filled up to the height of 2 cm in the frame. The frame was kept on cemented floor thus there was no chance of roots going deeper. Healthy seed varieties (RCPL1-82) were taken and seed rate for nursery was kept 1.6 kg/m^2. The seeds were uniformly spread over the bed. The seedbed was mulched heavily for protection from the birds. It was given irrigation daily for good germination. After twenty one days of sowing, the seedlings came to 4-5 leaf stage and were ready for transplantation.

Rajendran *et al.* (2004) developed a modified rice mat nursery at the Soil and Water Management Research Institute, Thanjavur, India. It produced robust seedling in 15 days after sowing that were similar in size as that of 25 to 30 days old seedling produced in traditional nursery. Seedling mats could be easily transported and easily separated. The modified rice mat nursery could save the cost on seed, water and labour and thereby an overall saving of cost by about 50% was achieved. Soil+ pressmud mixture (1:1 w/w) produced the most vigorous seedling in 15 days, recording the maximum seedling height of 20.8 cm, root length of 9.9 cm, leaves/seedling (4.2) and seedling- vigour index (8.2). Soil alone or 90% soil + 10% rice husk mixture also produced healthy seedlings. Other organic manures can be used for mat nursery provided it is fully decomposed and well mixed with soil. Seedling of 15 days age when planted gave 16-20% higher yield than the rice crop planted with 25 days old seedlings of traditional wet nursery.

Shiratsuchi *et al.* (2008) reported that conventional seedling mats in Japan are heavy to carry, and much labour is required to carry, wash and store the nursery boxes. In addition seedling time overlaps with hardened rice seeds moulded on to rice-hull mat with a cover of soil glued on. Seed hardening was done by soaking the seeds in water at 15^0c for 5 days followed by drying and heating of seeds at 50^0c for 5 -7 days, this reduces the time of germination by 50 %. In dormant seeds, the heating before hardening enhanced the effect of hardening. Now a layer of soil was sprayed on to the mat. The seed mats can be prepared in winter and can be stored up to seedling raising season in spring.

Haytham *et al.* (2010) studied the preparation of mat – type seedlings for mechanical paddy transplanter. A plastic box (58 cm × 28 cm × 3 cm) called a nursery box, was used for raising rice seedlings. This conventional soil seedbed system had

been a major problem viz., a nursery box filled with soil weighs about 6 kg, high cost of the nursery boxes and heavy and hard work. The seedling mat (120 cm × 28 cm × 3 cm) was established in a layer of treated rice straw arranged on a firm surface and has been developed in the Rice Research and Training Center, Egypt, to save the operation cost. This study showed the potential of SM technology to stimulate agriculture in the region and consequently led to increased productivity.

2.3 Paddy Transplanter

Machine transplanting using rice transplanters requires considerably less time and labor than manual transplanting. It increases the approximate area that a person can plant from 0.7 to 1ha/day. Transplanting of paddy seedlings can be categorized into three groups as follows:

1. By hand (manual)
2. Manually operated machines (work by man power)
3. Mechanically operated machines (work by engine power)

A rice transplanter is a specialized machine used to transplant rice seedlings in the field. A common rice transplanter comprises:

1) A seedling tray like a shed roof on which mat type rice nursery is set.
2) A seedling tray shifter that shifts the seedling tray like the carriage of typewriters.
3) Plural pickup forks that pick seedlings up from mat type nursery on the seedling tray and put the seedlings into the earth, as if the seedling were taken between human fingers.

2.3.1 Design and Development of Paddy Transplanter

2.3.1.1 Manual Paddy Transplanter

Gowda and Rudraradhya (1998) have modified a six row manually operated rice transplanter, developed by IRRI (Philippines), for Indian conditions at the TNAU Campus, Bangalore, India. Field trials were conducted at the University of Bangalore and in farm fields. The modifications include the use of different materials to strengthen the pickers and main body of the seeding compartments, and the replacement of joint pins with hardened nuts and bolts. The machine, consisting of a wooden float, metallic main body, tray moving mechanism, mat pusher and handle, when fully loaded, weighs about 25 kg. In well prepared land, with good quality seedlings, 5-6 labourers can transplant 1 ha of land, in comparison to manual

transplanting which would require another 30 workers.

Islam *et al.* (2000) have conducted the experiment for improvement of the IRRI designed, six row manually operated rice transplanter to adapt in rice producing countries. After modification, a five row prototype was developed and both IRRI and BRRI transplanters were evaluated and compared with hand transplanting. The wooden skid of the I RRI transplanter was replaced by a skid made of G.I. sheet in BRRI transplanter which made it durable, light weight and incurred less sliding resistance. As a result, the dragging force for modified transplanter was reduced by 30% compared to the previous prototype. The circular configuration of the picker finger of IRRI transplanter was modified to a semi-circular one which improved its cutting action.

Budiman *et al.* (2006) has developed 4 prototypes of four rows manual rice seedling transplanter consisting of a unit rice transplanter 4 rows duplicated from IRRI type, a unit rice transplanter 4 rows with thrusters free (independent) and two units of manual rice seedling transplanters with un-free drivers, consisting of one unit of bar type of planting finger and 1 one unit plate type of planting finger. The results of laboratory and field tests in (ICAERD) Indonesian Center of Agricultural Engineering Research and Development showed that the manual rice seeds transplanters could not have optimal function. The missing holes are still high, 20 - 30% and then work capacity is low, 300 to 400 m^2/person/day. Two units of manual rice seed transplanters have been sent to the Department of Agriculture, Kab Kebumen Central Java, consisting of a prototype manual rice seed transplanter developed by ICAERD and a unit of IRRI type as a comparison.

2.3.1.2 Self Propelled Paddy Transplanter

A self propelled paddy transplanter was developed in 1970 by Acharya N.G. Ranga Agricultural University. The machine used 25-30 days seedlings for transplanting. The settlement period required for soil is 48 hr. The field capacity was 0.08 ha/hr with 20 cm row spacing and plant to plant spacing varied from 8 to 14 cm with a forward speed of 1-1.2 km/hr. The cost of operation was Rs. 1500 /ha. Missing in hill percentage was 8, and number of hills/m^2 were 26 (Singh, 1979).

Early in 1978, Japanese manufacturers started to market bigger riding type machines having a minimum of 8 rows but these did not become popular. Transplanter development in People's republic of China shifted from manual to 12-14

row riding type self propelled machines have three wheels and small gasoline engine that drives the front traction wheel through a chain and sprocket transmission system. These machines have small seedling tray and side rakes for storage of seedlings making it necessary to employ two men, in addition to the driver, to manually feed the seedlings. Power for feeding and planting is transmitted through a propeller shaft from the transmission power take-off. A wooden platform is provided as a float. These machines made use of 20-30 cm root washed and pruned seedlings. Row spacing could be adjusted to 10, 13.3, 16.7 and 20 cm and planting depth from 3.5 to 7.0 cm.

Garg and Sharma (1984) designed PAU riding type engine operated paddy transplanter using mat type seedlings. A six – row riding type paddy transplanter operated by a diesel engine of 4.8 hp has been developed at PAU. It is designed to utilize mat type seedlings. It has uniform row spacing of 22.5 cm. Plant to plant spacing could be varied. Machine transplanted 0.116 ha/h at a working speed of 1.01 km/h and 0.15 ha/h at a working speed of 1.26 km/h. Average hill population was $25/m^2$ when planted at plant spacing of 14 cm and $20/m^2$ when planted at plant spacing of 19 cm. Missing were 16.67 per cent in low gear and 13 per cent in high gear when average plant per hill were 4. Net labour and financial saving over the traditional system are 144.92 man-h and Rs.154.32 /ha respectively.

Khan and Gunkel (1988) had taken efforts to mechanize the rice transplanting operation in Pakistan. Korean rice transplanter was found appropriate for the country's condition as it uses root washed seedlings grown by the traditional method. This machine needs improvements in both feeding and transplanting mechanism. Design improvements such as a positive unloading mechanism, seedling box with pressure plate and planting fork in the transplanter decreased the maximum number of rice seedlings in a hill from 8 to 4 and improved its seedling distribution pattern. Feeding and transplanting mechanism of the transplanter were mounted on stationary frame. The transplanter PTO shaft was powered with a variable speed electric motor. Metal containers of 20×20×275 cm (Width, Height and Length) mounted on two pairs of rubber wheels were placed on a rail made from aluminum C-channel. A variable speed, right angle gear drive motor was mounted on a frame with two rubber wheels provided for the soil box travel. A sprocket attached to motor shaft ran on a chain placed in the groove of the aluminum C-channel coupled to the rail. The soil box was connected to the motor frame and could move back and forth by the motion of motor.

A control box with a time delay relay switch was constructed to simultaneously run both the transplanter and the soil box motors. A positive unloading mechanism was developed and installed on the fork mounting shaft to release the seedlings at the lowest position of the planting fork into the puddled soil which work satisfactorily and improved the seedling distribution pattern of the machine.

Konoshi *et al.* (1999) have developed two types of zigzag (i.e. planting in a zigzag pattern) rice transplanter. The first had four planting mechanisms of spacing 45 cm. A test field transplanted by the prototype yielded the same as that for a conventional transplanter with more planting mechanisms. The second prototype had a mechanism spacing of 36 cm, so was suitable for high density transplanting, (30 hills/m^2). Results from field tests showed that high density zigzag transplanting was possible. Studies on manually planted field indicated that the yield of high density zigzag planted rice was 10% higher than usual.

In order to develop a new type of high efficiency rice transplanter, the three important characteristics of planetary eccentric gear mechanisms were analysed by Ying Yi Bin (2000). A kinematics model of the transplanting mechanism of a rice transplanter with planetary eccentric gears was developed by analytic methods, and the effects of parameters on the relative motion velocity and absolute motion locus of the seeding claw were analysed. The results provide a theoretical basis for designing a highly efficient rice transplanter.

Tatugade and Valvi (2006) developed 2- row paddy transplanter considering the limitations in operation of 8 –row paddy transplanter in Konkan region. Two –row rice transplanter was developed to operate with the available power source. The power requirement of the machine was found to be 1.7 hp. The transplanter consists of transplanting arm with separating needle and knock out mechanism, nursery-feeding tray operated with chain and sprocket. These mechanisms are mounted on floats made up of M.S. sheets and assembled to main frame made up of M.S. angles and flats. Transplanter worked satisfactory in laboratory. But due to rigid linkage sinkage of transplanter was high due to which desired plant to plant spacing was not observed in field trial. Forward speed of transplanter was observed as 1.8 km/h.

In order to improve the working efficiency and quality of the rice transplanter, the kinematics analysis of transplanting mechanism with the new non-circular planetary gears has been performed by He Li *et al.* (2007). The kinematics model of the transplanting mechanism was established by using the mathematical analysis

method. The displacement and velocity of the mechanism were analyzed. The effects of the structural parameters on the path and relative velocity of the seedling claw were obtained. The analysis results were of theoretical significance to the design of the high speed transplanter.

Nagasaka *et al.* (2008) developed an automated rice transplanter by modifying a commercial six row transplanter. Steering, transmission, and the transplanting implement were controlled through a Controller Area Network (CAN). A network Real-Time Kinematics (RTK), Geographical Positioning System (GPS) receiver was used for locating position and an inertial measurement unit was used for measuring the vehicle posture. The transplanter made nine back and forth traverses planting long mat type hydroponic seedlings. The deviation from the desired straight path had a root mean square of 0.052 m during operation.

Shahare and Bhat (2011) modified Korean semiautomatic manually pulled engine operated two row paddy transplanter and its performance was studied. The drive wheel of 48 cm was fabricated. The lugs were provided on outer periphery of drive wheel. The power required for forward motion of the transplanter was provided and transmitted from output shaft of gearbox to the chain and sprocket on drive wheel.

Pateriya and Datta (2012) evaluated the self propelled riding type rice transplanter using mat type seedlings. Based on the performance some modifications were made. Based on the performance in the existing rice transplanter certain design deficiencies like main clutch lever spring, front tyre, side wheel beam and beam support were observed which affected the performance of the machine. The components after modifications were fitted and the modified rice transplanter using mat type seedlings was again evaluated for their performance, the observations indicated that all the modified components worked satisfactorily.

2.3.2 Performance of paddy transplanter

2.3.2.1 Manual Paddy Transplanter:-

Singh and Sharma (1985) conducted field studies at IRRI farm on manual rice transplanter, developed at IRRI. three levels of land preparation i.e. low, medium and high; three water depths i.e. 0-30, 30-60, 60-100 mm and three seedling ages of 14-17, 18-21 and 22-25 days were selected. The studies were extended to two other types of soil in farmers' field to assess the results for the combination of land preparation, water depth and seedling age found to give minimum defective hills among treatment

groups at the IRRI farm. At this farm the transplanter performed well, with less than 5% defective hills when using seedlings 14-17 days old in up to 100 mm water depth at the medium level of land preparation, up to 60 mm water depth at the low level of land preparation and up to 30 mm water in over prepared (high level) land. The transplanter also worked satisfactorily using 18-21 day old seedlings at up to 60 mm water depth in medium level prepared fields, and up to 30 mm water in low level tilled fields. In sticky soils, at Zaragoza, the planting depth was greater and there were more defective hills of all kinds than at the IRRI farm. In the loam soils of Florida-Blanca the planting depth was less, and only floating hills were significantly more than at the IRRI farm. The machine had an average work rate of 0.034 ha/h.

Singh and Vatsa (2006) evaluated PAU 6-rows manual transplanter to mechanize the operation of paddy sowing in hills. Field capacity of transplanter was 0.03-0.035 ha/h and labor requirement was 57-66 man-h/ha that was 2-3 times less over the traditional methods. The cost of operation was observed 73% and 54% less on use of the transplanter. Yield increase was in the range of 30-35 %. It was also observed that a transplanter with lesser width of coverage would be more useful.

Dixit *et al*. (2007) concluded the comparative performance of different paddy transplanter. The transplanters were classified on the basis of nursery used i.e. machine using wash root seedling and machine using mat type seedlings. Mat type seedlings were raised on a polythene sheet with the help of frames. 20-30 days seedlings were found most suitable for transplanting. The mat thickness of 2 cm had resulted into best performance.

2.3.2.2 Self Propelled Paddy Transplanter

Eam-O-Pas *et al.* (1990) studied that the performance of the 4-row riding type and 2-row walking type Japanese transplanter in actual paddy fields prepared by traditional method were satisfactory. When operated at half throttle setting speed, the 4-row riding type transplanter had a field capacity of 0.1485 ha/hr compared to 0.01ha/hr that of hand transplanting, assuming 800 m^2/day can be completed by hand transplanter. The 2-row walking type self propelled transplanter and manually operated IRRI transplanter had a field capacity of 0.1139 ha/hr and 0.0508 ha/hr respectively. It can be seen that transplanter worked five times faster than hand transplanting.

Khan and Gunkel (1988) evaluated the performance of 6-row developed paddy transplanter. The machine transplant seedlings up to a vertical planting speed of 3.8 km/h while travelling speed of 2.16 km/h. A better seedling distribution was found with a planting speed of 1.44 km/h and rice seedlings of 2 cm root length. The planting fork of a 6-row Korean transplanter can transplant seedlings up to a vertical planting speed of 108 cm/s while travelling at a forward speed of 60 cm/s. A better seedling distribution was found with a planting speed of 40 cm/s and rice seedlings of 2 cm root lengths. The maximum number of seedlings in a hill decreased from 8 to 5.

Baruah *et al.* (2001) carried out performance of eight-row self propelled paddy transplanter with respect to the technological feasibility, economic merits and energetic was compared with manual transplanting. Total area of 5 ha was covered in two districts of Assam during field trials. Cost of machine transplanting was found to be only Rs. 1310/ha in comparison to Rs. 2463/ha for manual transplanting. The cost of growing mat type nursery for mechanical transplanting was about 40 per cent whereas the cost for raising conventional nursery was only 25 percent of the cost of transplanting. The energy requirements for mechanical and manual methods of transplanting were found to be 1074 and 757 MJ/ha respectively. Forty per cent of the total energy requirement in mechanical transplanting was required in mat nursery preparation while energy share for traditional nursery under manual transplanting was only 11 per cent. The average number of hills planted per m^2 by the transplanter was 31 with four numbers of plants per hill. The yield of mechanically transplanted paddy was found to vary from 3.75 t/ha to 5.70 t/ha with an average yield of 4.71 t/ha. Average yield in manually transplanted paddy was 4.50 t/ha.

Chaudhary *et al.* (2005) concluded that rice transplanting by self-propelled transplanter ensured timely operation, saving in cost and minimum human drudgery. A detailed economics of both manual and machine transplanting was worked out based on the study done at the G. B. Pant University of Agriculture and Technology, Pantnagar during 2000. The self-propelled rice transplanter gave net profit of Rs 1146 and Rs 1319 per hectare when annual use of machine was 300h (one season) and 500 h (two seasons), respectively, over the manual transplanting. The field capacity, field efficiency and fuel consumption of the transplanter was 0.16 ha/h, 60.02% and 2.87 l/ha, respectively. Payback period for investment on the transplanter was 10.23 years and 1 year when annual area covered was 20 and 80 ha, respectively. The break even area of coverage by transplanter should be more than 13.14 hectare per year to make

the machine transplanting profitable in comparison to the manual method of transplanting.

Manjunatha *et al.* (2009) studied the performance of an eight row self propelled paddy transplanter in Karnataka state on the feasibility of mechanizing transplanting operations in paddy crop to reduce the cost of cultivation. The field capacity, field efficiency and fuel consumption of the transplanter were 0.19 ha/h, 78 per cent and 6.25 l/ha respectively. Cost of mechanical transplanting was Rs. 789/ha as compared to Rs. 1625/ha in case of manual transplanting. The mechanical transplanting would be economical provided an area of 28 ha and above per year. Grain yield in both manual and mechanical transplanting remained on par with mean grain yield of 53.77 and 54.01 q/ha respectively. The performance of the mechanical transplanter was quite satisfactory.

Mohanty *et al.* (2010) reported that the inadequate number of hills per hectare transplanted by manual labour and the delay in transplanting due to labour shortage during peak transplanting season pushed the demand for a mechanical transplanting. Manually operated 4 row transplanter was not successful due to low work output dependence on human labour and drudgery. To overcome these problems, studies were conducted at farmers' field by Krishi Vigyan Kendra, Deogarh, Orissa state during 2009 on feasibility of mechanizing transplanting operation of paddy crop with a view to reduce the cost of cultivation. A plant population of 34-36 hills/m^2 was achieved by this transplanter. Number of plants per hill was observed to be within 3 to 5. An eight row self propelled transplanter was used for the purpose. The performance of mechanical transplanter was quite satisfactory. The field capacity, field efficiency and fuel consumption of transplanter were 0.123 ha/h, 78 percent and 6.5 l/ha respectively cost of mechanical transplanting was Rs. 1554/ha as compared to Rs.2675 /ha in case of manual transplanting.

Alizadeh *et al.* (2011) conducted the study to evaluate the techno-economic performance of a self-propelled four rows walking-type rice transplanter and comparison with hand transplanting method in the paddy field. Mat type seedlings of a high-yielding rice variety namely Hybrid was used for transplanting. In order to evaluate the performance of the rice transplaner, observations on planting depth, number of seedlings per hill, hill spacing, number of missing, floating hills and costs of operation were recorded. The experiment was carried out in randomized complete block design with four treatments, viz. hand transplanting (T_1) and rice transplanter

(machine transplanting) at three seeding rates of 60 g per tray (T_2) , 80 g per tray (T_3) and 100 g per tray (T_4). The results indicated that the hill spacing in hand transplanting was measured to be 13.20 cm compared to the average of 12.67 cm in rice transplanter. The number of seedlings per hill in rice transplanter increased from 1.7 to 2.8 as the seeding rate increased from 60 to 100 g per tray. The missing hills decreased from 13.32 to 7.65 % with increasing seeding rate from 60 to 100 g per tray. The average labor input in rice transplanter was 30 man h/ha compared to 126 man h/ha in hand transplanting. The total cost of transplanting in the treatments of T_2, T_3 and T_4 was decreased by 19.20, 22.44 and 25.70%, respectively as compared to hand transplanting.

Shahare and Bhat (2011) tested two row self propelled paddy transplanter at the Agronomy field of Dr. B.S.K.K.V., Dapoli. Various parameters like plant to plant spacing, planting depth, field capacity, field efficiency, total time of operation, speed of operation were recorded during field evaluation. The field efficiency and field capacity of the transplanter was observed to be 84.5 per cent and 0.051 ha/hr respectively. The total numbers of hill/m^2 area were obtained as 23.3 and plants to plant distance, plant depth were obtained as 12.46 cm and 4.49 cm respectively.

Pateriya and Datta (2012) evaluated the performance of self propelled riding type paddy transplanter. From the results, they found that the percentage of missing hill varied 8.06 to 9.75, plants per hill ranged 2 to 4; planting depth was 50 to 65 mm. The hill to hill spacing was 95 to 102.5 mm at low gear and 147.7 mm at high gear, the row to row spacing varied 230 to 235 mm.

The review revealed that the transplanting with self propelled rice transplanter (6-8 row) can reduces the labour requirement to a large extent. These transplanters are suitable at present on bigger farm, plane land and not suitable for hilly terrain. They require mat type seedling of 15-22 days developed on raised bed covered with plastic. Manually operated and bullock drawn transplanter could not perform well. By manual and bullock drawn transplanters plant to plant spacing varies to a large extent. Self propelled transplanter give better field capacity as compared to manual transplanting. Looking into the limitations of Konkan region of Maharashtra it is needed to develop a self propelled transplanter of smaller size (four row) which will be suitable for small farm with mat type nursery seedling and also affordable by small and marginal size farm holders.

CHAPTER - III

THEORETICAL CONSIDERATIONS

Timeliness of transplanting is essential for optimizing the yield and this can only be achieved through mechanical transplanting. A delay in transplanting reduces the yield. Manual transplanting of paddy requires about 300-350 man hours/ha. In spite of the huge labour requirement, plant to plant and row to row spacing are not achieved. So mechanical weeding is not possible. Hence mechanical transplanter suitable for Konkan region is needed to develop. This chapter deals with the

theoretical considerations involved in the development and testing of four row self propelled paddy transplanter.

The transplanter needed to develop by considering following factors.

1. The developed machine should be light in weight for easy transportation from one field to another.
2. The developed machine should be able to move forward with least slippage in puddled field and at the same time it should pick up 3-5 seedlings at a time from mat pieces and plant them in field.
3. The power requirement of the machine should be as low as possible.
4. The machine should be able to give the required plant geometry (23.8 X 15 cm) and plant population.
5. The developed machine should be smaller in size so as to suit the smaller plot size in Konkan region.
6. The developed machine should have higher field capacity in order to complete transplanting operation within time.
7. It should be simple in construction and can be operated easily by farmer.
8. It should be of low cost.

Considering these factors it is planned to develop a self propelled walking type rice transplanter. The developed machine is consisting of engine, power transmission, picking and delivery of seedling mechanism and drive system.

The transplanter is fitted with 2.8 kW engine. Engine power is supplied through gear box of suitable ratio to reduce speed. From gear box, part of power is transmitted to transplanting mechanism while other is transmitted for the forward motion of machine to drive the wheels. The power transmission path is shown in Fig. 3.1. At the time of transplanting operation, the cut mat nursery is placed on the tray. After every stroke of transplanting arm, the tray slides and 3-5 seedlings from mat nursery are properly picked up by needles and planted in the puddled soil at 4-5 cm depth. The tray has the horizontal sliding movement which controls the supply of seedling to the needle at every stroke.

The transplanting arm starts rotating in elliptical path. During downward movement of transplanting arm, the separating needle removes 3-5 seedlings from mat nursery placed in the tray and at the end; knock out mechanism pushes it in the soil to a specified depth of 4-5 cm. As the tray is moving at every stroke, the transplanting arm removes new area of mat nursery and the planting of rice seedlings

thus occurs. The power from gear box is transmitted to drive wheels through chain and sprocket arrangement. As the engine is started, power is transmitted from gear box to drive wheels which causes the forward motion of the transplanter.

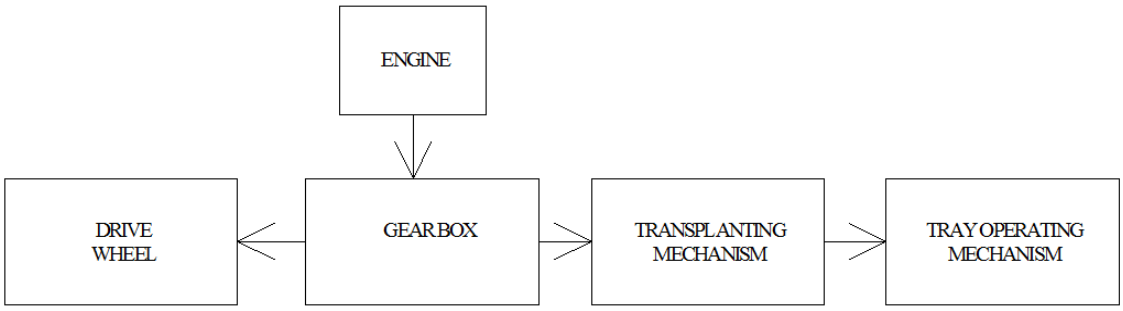


Fig. 3.1 Power transmission in transplanter

3.1 Design parameters of four row self propelled transplanter

The developed machine should meet the requirement in the region and have low power requirement. The terms, parameters, formulae associated with the design of machine are described in following sections.

3.1.1 Size of machine

Transplanting of paddy is a highly labour intensive operation and is still done manually. It has been observed that plant population achieved by labour is not optimum and it causes decrease in the yield. Higher labour requirement of about 250-300 man- h/ha (Singh, 1985) is required for transplanting. Scarcity of labour during peak season of transplanting creates a problem to complete the transplanting operation in time.

The 8 row self propelled rice transplanter using mat type seedlings has advantages over the manual hand transplanting. The performance of the machine was found satisfactory and could be recommended for adoption by farmers (Mohanty *et al.*, 2010). The average field capacity of the machine was found 0.12 to 0.15 ha/h. The width of the machine was 184 cm and able to maintain row to row spacing 23.8 cm and plant to plant spacing 14 and 16 cm. The machine worked well in some of the regions of Konkan where plot size is big. This machine has limitations with smaller plot size. The higher weight of machine makes transferring difficult from one field to another with big bunds and that too on terraces.

Mostly in the Konkan region, paddy fields are available on terraces and plot size is very small. In small hilly plots, turning spaces and transportation of the

machine is very difficult. Considering these limiting factors; light weight, small, walking behind self propelled machine of two row or four row is needed to be developed for small fields. Hence, it is planned to develop four row self propelled, light weight, small size transplanter.

3.1.2 Plant population

The ultimate productivity of a crop is determined by plant population per unit area. Low plant population may result in increased tillering which creates more variation in panicle maturity, increased weed population and reduced yield potential of the variety. High plant population may reduce yield and quality. The paddy seedlings are planted at 20 to 25 cm row to row spacing and 15 cm plant to plant spacing. In one hill, 3-5 seedlings are planted. Hence the machine developed should give the required row spacing of 23.8 cm and plant spacing of 15 cm. The yield of the crop fully depends upon the plant population. The commercially available transplanting arms give 23.8 cm row spacing. Hence the same arms are selected for the machine.

3.1.3 Prime movers for transplanting mechanism

Eight row riding type Chinese transplanter (make Yanji-Shakti) work satisfactorily in Konkan region. It has 2.9 kW air cooled diesel engine. The cost of the machine is 1.7 lakh. The small plot size on hilly terrain is the limitation for this machine. Hence, the small size self propelled four row machine with engine lighter in weight with low machine cost, easily transportable is planned to develop.

Self propelled four row walking type, light weight with 2.8 kW petrol run engine could fulfill the need of the hilly region of Konkan. It will require one to two labours for operating in the field. Also, walking type of machine gives idea of planting rows in straight manner. Hence, small machine with self propelling arrangement for forward movement with petrol run 2.8 kW engine is undertaken for development.

3.1.4 Forward speed of machine

Power tiller operated seven row paddy transplanter using conventional seedling was comfortably operated at 0.9 to 1.2 km/h speed. Six row riding type paddy transplanter (PAU design) with operating speed of 0.8 to 1.13 km/h resulted in field capacity of 0.084 to 0.137 ha/h, (Garg I.K., 1992). Chaudhary *et al.* (2005) operated the walk behind type two row and four row transplanter at forward speed of 2.27 km/h and 1.76 km/h respectively with field capacity of 0.125 ha/h and 0.163 ha/h

respectively. The higher speed also results into low plant population (23 hills/m^2) against recommended value of 33 hills/m^2. Also they operated the eight row self propelled paddy transplanter at 1.4 km/h and 1.8 km/h speed comfortably. For development of four row walking type transplanter, forward speed is selected as 1.5 km/h.

3.1.5 Power requirement of transplanter

The total power required for the transplanting mechanism is the sum for power required for removal of plant from nursery and power required for forward motion of transplanter.

1. Power required for removal of plants from mat (P_r)

The power available for the removal of plant from nursery can be calculated as given below.

$$\text{Power required } (P_r) = \frac{2\pi N_g T_g}{4500}$$

Where,

P_r = Power available for removal of plant from nursery, hp

N_g = Output speed at gearbox, rpm

T_g= Torque at gearbox, Kg-m

2. Power required for forward motion of transplanter (P_m)

The rolling coefficient, weight of machine, width of drive wheel, diameter of wheel is the influencing parameters for power requirement of the developed transplanter. The drive wheel works in puddled soil offers rolling resistance, as well as tractive efforts. The tractive effort of the drive is the summation of drawbar pull and rolling resistance of the machine.

1. Tractive effort = Drawbar pull + Rolling resistance

2. Torque at drive wheel shaft = [Tractive effort] × [Rolling radius of drive wheel]

3. Power required for forward motion of transplanter (P_m)

$$P_m = \frac{2\pi N_g T_d}{4500}$$

Total power required = $P_r + P_m$

3.1.6 Drive wheel of four row self propelled transplanter

The developed wheels should be able to balance part weight of transplanter. It should be able to plant the seedlings at required plant spacing. The wheel developed should be able to run at required forward motion. Also, it should be able to produce required traction at the time of transplanting in puddled field.

Diameter of wheel was determined using formulae. Considering the forward speed of transplanter as 1.5 km/hr, diameter of wheel was determined.

1. Rotational speed of drive wheel = $\frac{\text{Engine speed}}{\text{Gear ratio}}$

2. Let us take D as diameter of drive wheel in meter.

3. Forward motion of transplanter (S) = $\pi \times D \times N_g$.

Where,

N_g= Rotational speed of drive wheel, rpm

4. Assuming 30% slippage in field during actual forward motion of transplanter

$$= 0.70 \times \pi \times D \times N_g.$$

5. Considering normal walking speed of the human being as 1.5 km/h (Choudhary *et al.*, 2005)

$$1.5 = \frac{\pi \times D \times N_g \times 0.70 \times 60}{1000}$$

$$D = \frac{1.5 \times 1000}{\pi \times N_g \times 0.70 \times 60}$$

3.1.7 Tray movement mechanism

The mat is fed to transplanting mechanism from seedling feed tray. The mat is cut to a width of 238 mm. After every stroke of transplanting arm, the seedling tray must be moved by equal to the width of removed piece of mat. To achieve this movement tray movement mechanism is designed. The lead screw is used to achieve tray movement. The lead screw is consisting of a rod 36 cm long and having 2.54 cm diameter. The groove of 5mm depth is marked along periphery across the length of rod. The lead is fixed in groove so that it can slide in that groove along the length of rod. The rod has drive from the transplanting mechanism in 2:1 ratio. The lead is fixed to the tray so tray slides with lead. While working of machine the rod rotates through transplanting mechanism. Due to the rotation of rod the lead slides in the groove so that it covers distance sideways. One revolution of rod slides 1.5 cm distance of lead. As the lead is fixed to tray it automatically slides tray. After covering

distance of 23.8 cm the direction of the lead is reversed along the periphery without disturbing the direction of rotation of rod.

3.1.8 Seedling picking and transplanting mechanism

The seedlings are picked by the needles provided on the transplanting arm. The transplanting arms are purchased from market having elliptical path. During their forward stroke needles enter into the mat type nursery pieces placed on the sliding tray. During downward stroke transplanting needles pick 3-5 seedlings from mat and transplant them into the puddled soil. Machine has forward movement of 1.5 km/h and drive wheel of 50 cm diameter. Transplanting needles are set for 300 rpm using gear box of 12:1 ratio as the engine having 3600 rpm at gear box input.

3.1.9 Nursery Raising

For transplanting operation using machine, a special kind of nursery is prerequisite. Field plot should be selected for the preparation of mat nursery over which plastic sheet is spread. The raised bed is prepared on levelled ground. The bed surface needs to be compact and smoothen. Normally three raised beds of 10×1 m are required for 0.4 ha land (1 acre). Normally 5 kg seeds are required for one bed. The bed is covered with the polythene sheet (150-200 gauge) with perforations and is spread to serve as base. The frame size of 1 m × 1 m × 0.25 m is made with M.S. angle iron of 25 mm and 2 mm thick is filled with prepared mixture of soil FYM and leveled properly. The soil is moistened with water and sprouted seeds are spread evenly in frame with hand.

After 21 days of sowing, the seedlings come to 3-4 leaf stage and are ready for transplantation. If the seedlings becomes old the number of tillers increases along with height. It creates difficulties for picking and placement. Hence, seeding age should be optimum for picking 3 to 5 seedlings from the tray by the fingers. At proper age the roots are entangled with each nicely and it facilitate easy carrying of pieces of nursery, picking and placement.

Hence, it is decided to grow mat type nursery on raised bed covered with plastic.

3.1.10 Soil condition

It is generally known that soil conditions can significantly affect the performance of transplanters. The transplanter can be successfully adopted under favourable field conditions. The water level in the field at time of transplanting should be about 5 cm. It also reported that when water level is less, the soil sticks with the

wheels and planting becomes difficult. When water in the field is more at the time of transplanting, the seedlings are not placed properly in the soil and start floating. The depth of puddling should be shallow for proper working of machine. The soil should be well puddled and well settled for better performance (Garg and Sharma, 1984).

Shallow tillage of 15-20 cm depth is recommended when the transplanter is used in field. Depth of puddling maximum up to10 cm is recommended for Japanese paddy transplanter (Singh and Garg, 1984). The soil flow can be avoided in the levelled field after 48 to 72 hours of puddling.

Most critical factor is soil settlement period. Soil settlement period after puddling varied from 1 to 4 days for proper functioning of different types of transplanter. The 24 hours soil settlement time results into maximum number of tillers (31/ hill) after 45 days of transplanting at silt loam calcareous soil of Pusa, Samastipur (Chandra and Ram, 2003). Soil settlement period ranges from 24 to 72 hours in silt clay loam. The hill damage was found more in case of lower settlement period of 24 hours for silt clay loam and 2 hours for sandy loam in Punjab.

Hence, it is decided to go for shallow ploughing of 15-20 cm, with settlement period of 48- 72 hours after puddling.

3.1.11 Operating conditions

In order to obtain satisfactory operation, good quality work and efficiency of the developed machine besides ensuring good technical condition and correct operation of the machine, suitable soil conditions in the field should be available. The machine has to be operated for transplanting mat type seedlings in the puddled field. The quality of nursery and puddling must be favorable and uniform for easy machine operation. The suitable conditions of the field and the seedlings are presented in Table 3.1.

Table 3.1 Suitable conditions of the field and the seedlings

S.N.	Items	Sub-items	Good suitable conditions
1.	Paddy field	Depth of tillage	10-15 cm
		Depth of water in field during puddling	Average depth of standing water 2-4 cm
		Soil quality in field	Sandy soil with a certain percentage of

			sand
		Foreign matter	No stones and no foreign matter in the field.
2.	Tray nursery seedlings	Seedbed soil	1. Uniform soil layer, seedling slice in good order and completely formed mat. 2. No foreign matter in soil, proper water, seedbed soil thickness 20-25 mm.
		Height of seedling	Seedling height 10-20 cm
		Quality of seedling	1. Dark green sturdy seedlings, no futile growth, no disease. 2. Uniform growth, nor too thick or too thin.
		Quantity of seedling	1. Small seedling: 1.2 kg/m^2 (dry seed) 2. Middle seedlings: 0.6 kg/m^2 (dry seed) or 0.74 kg/m^2 (urge sprouted seeds)

3.2 Measurement of parameters

The theory involved in the measurement of soil and machine parameter is presented in this section. The parameters are determined using mathematical relationship and also direct measurement.

3.2.1. Field efficiency

The field efficiency is the ratio of the effective field capacity to the theoretical field capacity, usually measured in terms of percentage.

$$Field\ Efficiency = \frac{Effective\ field\ capacity}{Theoretical\ \ field\ capacity} \times 100$$

3.2.2. Sinkage

The sinkage can be measured with the help of sinkage measuring apparatus. The sinkage measuring apparatus consist of hollow circular cylinder. Scale is marked on the outer side of the cylinder, which gives direct reading of sinkage.

3.2.3. Puddling index

The puddling index can be measured by collecting the soil samples from various area of the field. The sample should be kept for settlement for 24-36 hours.

Then the puddling index can be measured by using following formula. (Behera *et al.* 1991)

$$\text{Puddling index (PI)} = \frac{Vs}{V} \text{ x } 100$$

Where,

Vs = Volume of soil, ml

V = Total volume of the sample, ml

CHAPTER IV

MATERIAL AND METHODS

The chapter material and methods consists of an approach for design of paddy transplanter, material and methodology used to conduct the study, facility developed for laboratory evaluation and performance testing of the four row self propelled paddy transplanter.

Paddy transplanter is used to increase the speed of the transplanting operation and also proper placement of paddy seedlings in rows. The four row paddy transplanter was developed and tested in the laboratory and its functional trials were conducted in field. It was developed for rice (*Oryza sativa*) with consideration that, the development of the four row paddy transplanter was undertaken with the view to find the possible solution to the problems in paddy transplanting in the hilly terrain of Konkan region. The machine was developed considering various factors affecting the

performance of the transplanter. The factors affecting the design and performance of transplanter are discussed below.

4.1 Paddy transplanter

Transplanter is a machine used to transplant matured (15-21days) paddy seedlings at proper place, at right time into the puddled field. A common paddy transplanter comprises; a seedling tray on which mat type rice nursery is kept; a seedling tray shifter that shifts the seedling tray and pickup forks with needles that pick up a seedling from mat type nursery on the seedling tray and put the seedling into the puddled soil. The float of the transplanter served as a base and also helps in movement of the machine over excess water in the field. It creates 2-3 cm raised bed for placement of seedlings at 4-5 cm depth. It also serves as a platform for placement of nursery during transplanting operation. Eight row as well as four row commercially available self propelled transplanter, riding type transplanter and its components is shown in fig. 4.1 and 4.2.

4.2 Development of four row self propelled paddy transplanter

Considering constraints of mechanization in Konkan region and limitations of commercially available riding type paddy transplanter it was decided to develop small light weight, walking type paddy transplanter able to transplant paddy seedlings automatically in four rows at row spacing of 23.8 cm and hill spacing 12 cm.

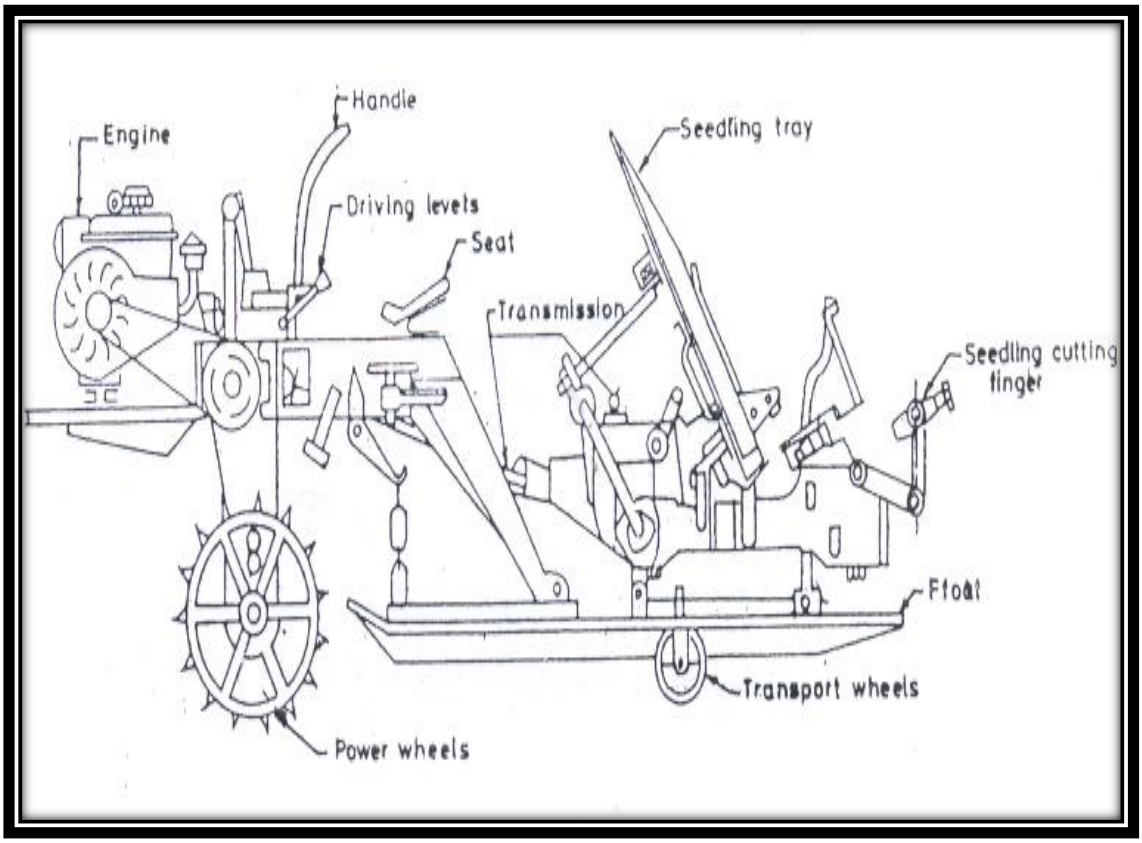


Fig.4.1. Eight row riding type rice transplanter

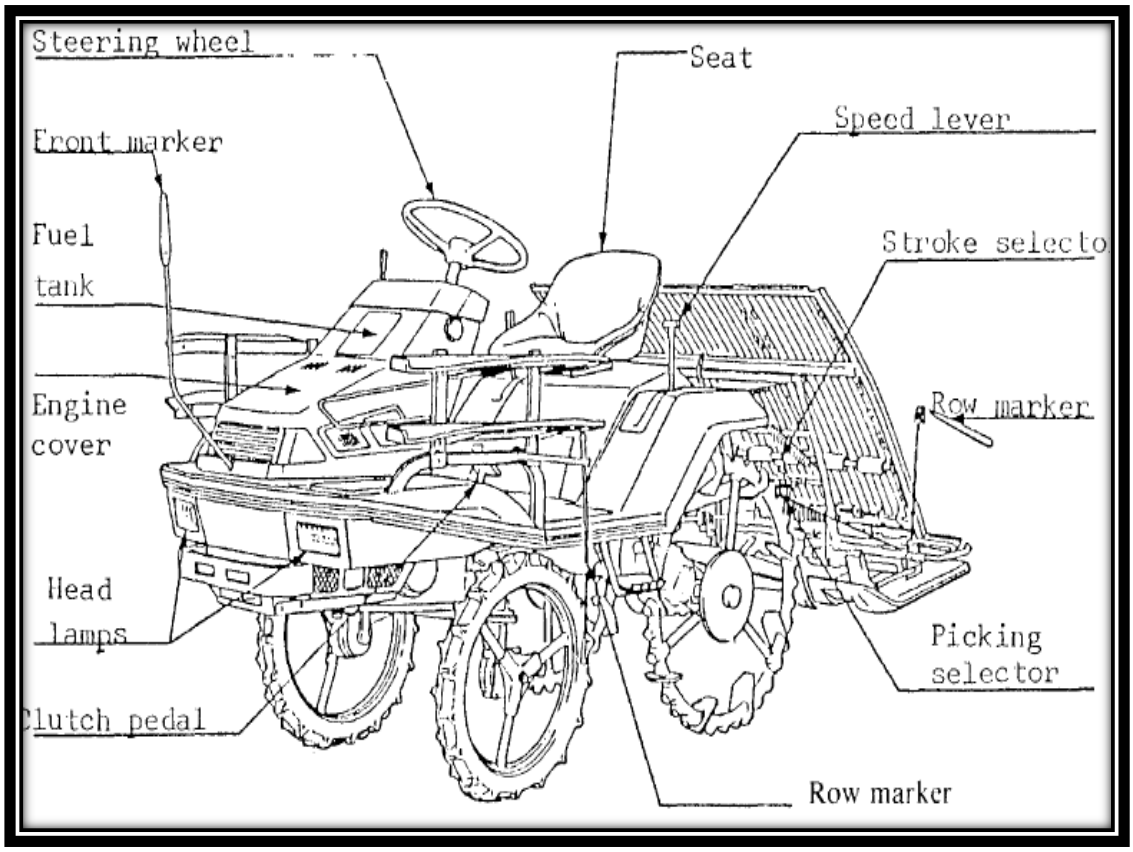


Fig. 4.2 Four row riding type rice transplanter

The paddy transplanter in general consists of much complex mechanism in design to work satisfactorily on field. Four row self propelled paddy transplanter was designed in farm Machinery and Power (FMP) department, CAET, Dapoli. Based on design it was fabricated in FMP workshop.

The developed paddy transplanter consists of mainly power source (Engine), transplanting, tray movement and forward movement mechanism. The various functional components are as follows:

1. Main frame
2. Engine
3. Gear box
4. Transplanting mechanism (Transplanting arm, Rocker arm)
5. Tray movement mechanism (lead screw)
6. Nursery holding tray
7. Power transmission unit

8. Float
9. Drive wheels
10. Handle

The engine is main power source and the power is utilized for forward movement of transplanter as well as for transplanting mechanism. It was decided to select light weight petrol engine as these are lighter in weight with less vibration.

4.2.1 Power requirement for paddy transplanter

The total power of engine is utilized for the placement of seedlings onto soil (mud) from seedling tray and to give forward motion to the machine. Seedling removal is more power consuming operation. Initially total power requirement for seedling removal and placement was determined practically. The power required for forward motion of transplanter is calculated theoretically.

4.2.1.1 Power requirement for removal of seedlings as well as tray movement

1) Required speed of transplanting arm shaft = 288 rpm

2) Required average torque for transplanting arm = 1.27 kg-m (Appendix A)

Transplanting arms removes the seedlings (3-5 No.) and place them in soil.

Considering maximum power required for removal of seedling than placement of seedlings.

Therefore power required for seedling removal for single unit:

$$Power\ required\ \ for\ seedling\ removal = \frac{2 \times \pi \times N_g \times T_g}{4500} \qquad \ldots\ldots\ldots\ldots(1)$$

Where,

P_r = Power required to remove seedlings from mat, hp;

N_g = Speed from gear box, rpm;

T_g = Torque at transplanting mechanism, kg-m.

$$Power\ required\ \ for\ seedling\ removal = \frac{2 \times \pi \times 288 \times 1.27}{4500} \qquad \ldots\ldots\ldots\ldots(2)$$

$$\approx 0.51 \text{ hp}$$

Therefore the power required for transplanting mechanism is 0.51 hp.

Considering 20% additional power of seedlings removal is required for tray movement.

Hence power required for tray movement = 0.51 × 0.2

$$= 0.102 \text{ hp}$$

$$\approx 0.10 \text{ hp}$$

Total Power required for seedlings removal as well as tray movement =

Power required for seedlings removal + Power required for tray movement

= 0.51 + 0.10

= 0.61 hp

Therefore, the total power required for seedlings removal from mat type nursery as well as for tray movement was 0.61 hp.

4.2.1.2 Power required for forward motion of transplanter

The forward motion of transplanter is achieved through the drive wheel. The drive wheel works in puddled soil offers rolling resistance, as well as tractive efforts. The engine is mounted at front side of transplanter. Hence most of the weight is available on the drive wheel of the machine. The tractive effort of the drive is the summation of drawbar pull and rolling resistance of the machine.

Tractive effort = Drawbar pull + Rolling resistance ……....(3)

= 55 + 85

= 140 Kg

Torque at drive wheel shaft = Tractive effort × rolling radius of drive wheel

= 140 × 0.27 m

= 37.8 Kg-m

$$Power\ required\ \ for\ \ forward\ motion = \frac{2 \times \pi \times N_d \times T_d}{4500} \quad \text{……(4)}$$

Where,

N_d = Drive wheel speed, rpm

T_d = Torque at drive wheel shaft, Kg-m

$$= \frac{2 \times 3.14 \times 24 \times 37.8}{4500}$$

= 1.266

≈ 1.27 hp

Total power required for the operation of transplanter = Power required for removal of seedlings as well as tray movement + Power required for forward motion

= 0.61 + 1.27

= 1.88 hp

Considering transmission loss to 40 % and factor of safety to 30% the total power requirement of the developed paddy transplanter will be = 1.88 × 1.7

= 3.19

≈ 3.2 hp

Petrol engine of 3.2 hp size is not available in the market. Hence next higher size engine i.e. 3.5 hp is selected for the transplanter.

4.2.1.3 Gear box:

Commercially available petrol engine of 3.5 hp has rated rpm 3600 rpm. The required transplanting arm shaft speed is 288 rpm. Gear box is speed reduction mechanism. Considering the maximum engine speed of 3600 rpm, the reduction ratio of gear box will be 12.5:1. Hence a commercial light weight gear box with reduction ratio 12.5:1 is selected for the study.

4.2.2 Design of drive wheel

It was decided to provide one drive wheel. Drive mechanism for transplanter has been designed so that one person can operate it comfortably.

Considering the forward speed of transplanter, as 1.5 km/h, diameter of wheel was determined. The calculations for determining the diameter of drive wheel is as follows:

1.Rotational speed of output shaft of gear box- 288 rpm.

2. Gear ratio of output shaft of gear box to drive wheel- 12:1.

Hence, rotational speed of drive wheel, rpm $= \frac{\text{Speed from gear box}}{\text{Gear ratio}}$ ..... (5)

$$= \frac{288}{12} = 24$$

3. Let us take D as diameter of drive wheel in meter.

4. Forward motion of transplanter, = $\pi \times D \times$ Rotational speed of drive wheel

…….. (6)

$$= \pi \times D \times 24 \text{ m/min}$$

$$= \frac{3.14 \times D \times 24 \times 60}{1000} km/h$$

6. Considering normal walking speed of the human being as 1.5 km/h (Choudhary *et al.*, 2005).

From equation (6),

$$1.5 = \frac{3.14 \times D \times 24 \times 60}{1000}$$

Considering 30% slippage,

$$1.5 = 4.52 \text{ x } 0.7 \text{ x } D$$

Hence, D = 0.46 m

Effective diameter of the lugged wheel = 0.46 m.

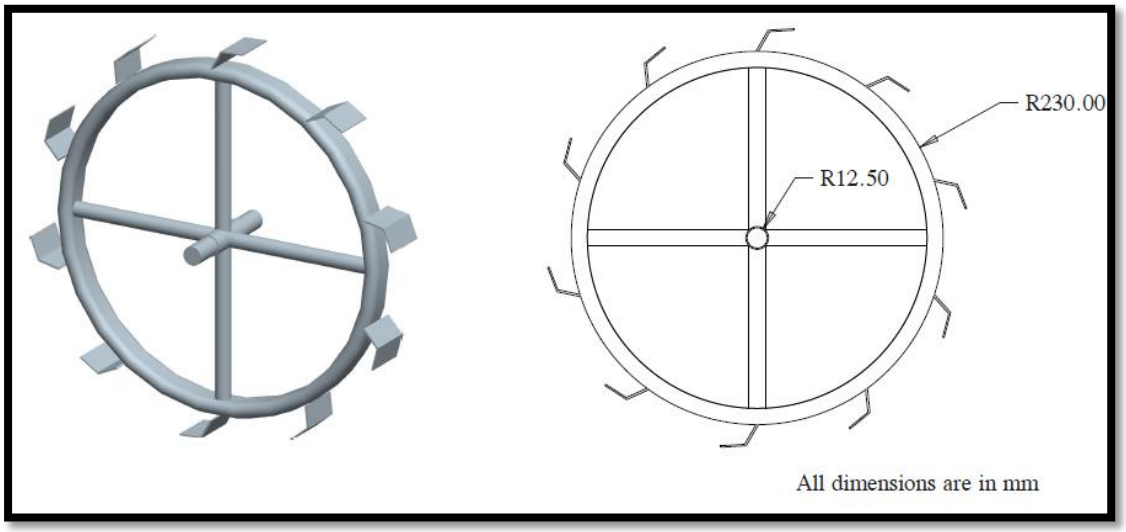
The design dimensions of the drive wheel are shown in the Fig. 4.3.

4.3. Fabrication and assembling of components

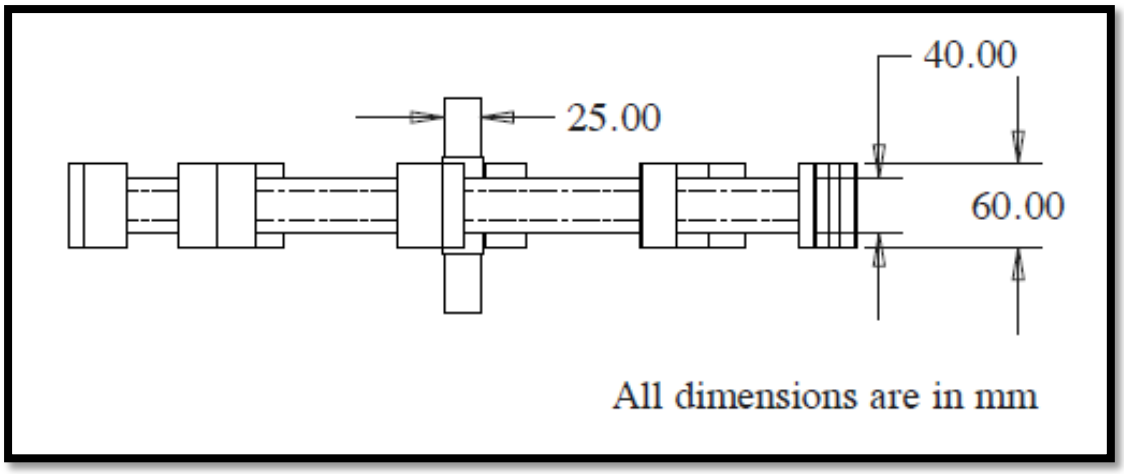
After determining the power requirement of the transplanter, designing and the drive wheel, the different components were fabricated and assembled to main frame. Some of the components viz. tray, float, tray movement mechanism, drive wheel were fabricated in FMP workshop of CAET Dapoli. The procedure of their fabrication and mounting in is described as under.

4.3.1 Main frame

The main frame is important component of transplanter where all other components viz. engine, gearbox, transplanting mechanism, tray movement mechanism and drive wheel are fitted. The main frame consists of engine support, gear box support, transplanting mechanism supports, inverted U-frame for tray support and drive wheel support. The Honda engine (GK-200) is fitted with nut bolts on the main frame at front side of machine. The frame is made up of 16 gauge M.S. sheet and 18 gauge M.S. 19 mm square hollow pipe. One gear box (reduction ratio 12.5:1) is fitted 10 cm



a) Isometric and Side view of drive wheel



b) Top view of drive wheel

Fig. 4.3 (a,b) Design dimensions of drive wheel of transplanter

behind the engine at the middle of frame and the other (reduction ratio 12:1) is fitted 200 mm below the first gear box.

These two gear box are joined with sprocket arrangement. The drive wheel of the transplanter is fitted on the vertical supports made with box pipe (2 inch × 1 inch) extended downward 80 mm from main frame. At the end of these two supports pedestal bearings are fitted.

4.3.2 Engine

Based on the power requirement and the procedure described in Section 4.3.2.1 the commercially available Honda-GK-200, four stroke, petrol engine was selected. The engine was fitted over main frame with nut and bolts. It has rated speed of 3600 rpm. The weight of engine was 19 kg. The prime mover of the transplanter is as shown in plate 4.1.

4.3.3 Gear box

Two gear boxes of reduction ratio 12.5:1 and 12:1 are used to reduce the speed. The first gear box with circular casing is used to reduce the speed up to 288 rpm. Its power is transmitted to picking and transplanting mechanism. Another small gearbox of rectangular casing is used to reduce the speed further to 24 rpm. The power from this gear box is transmitted to drive wheel. Spur type gears are available in first gearbox however worm type gears are available on second gear box. The width of first gear box casing is 100 mm and 160 mm in diameter. The engine power is transmitted to input shaft of gear box with the coupler directly. The power from gear box is given to picking - cum - transplanting mechanism from where it is given to tray movement mechanism (lead screw). The second gear box is placed below the

first gear box. The drive to second gear box is given from the output of first gear box through chain and sprocket mechanism with 1:1 ratio. The gear boxes for developed paddy transplanter are shown in plate 4.2.

4.3.4 Float

Float is the component of transplanter which is in touch with the mud. The float gives support to main frame, tray movement mechanism and transplanting mechanism. The float of the transplanter serves as a base which helps in easy movement of the machine over puddled field. The float also prevents the transplanter from sinking in puddled soil. Float provides right direction to machine under all swampy conditions and provides constant planting depth of seedlings. The arrangement of five wings to its backside is made to facilitate some compaction on puddled field for vertical seedling placement without lodging. These five wings made up of G.I. sheet (22 gauge) of size 750 mm × 140 mm spaced at 100 mm are joint to a G.I. plate of size 1100 mm × 20 mm. These are covered with PVC sheet of 1100 mm × 450 mm × 8 mm. PVC is lighter in weight and having better floating properties. Thus the PVC sheet covered five wings up to 450 mm out of 750 mm length.The G.I. sheet is curved at forward end to avoid entry of mud on the float. The developed float of paddy transplanter is shown in plate 4.3.

4.3.5 Seedling tray

The seedling tray was fabricated with 22 gauge G.I. sheet. It was made into four compartments to keep four cut piece of the nursery mat. The size of tray was kept 900 × 25 mm. After every stroke of transplanting arm, tray slides horizontally along with rectangular plat form at the bottom. The tray was fitted at 45^0 angle and supported from rear side by inverted U frame. The height of tray from the main frame was kept 300 mm. The developed seedling tray is shown in the Plate 4.4.

4.3.6 Picking - cum - transplanting mechanism

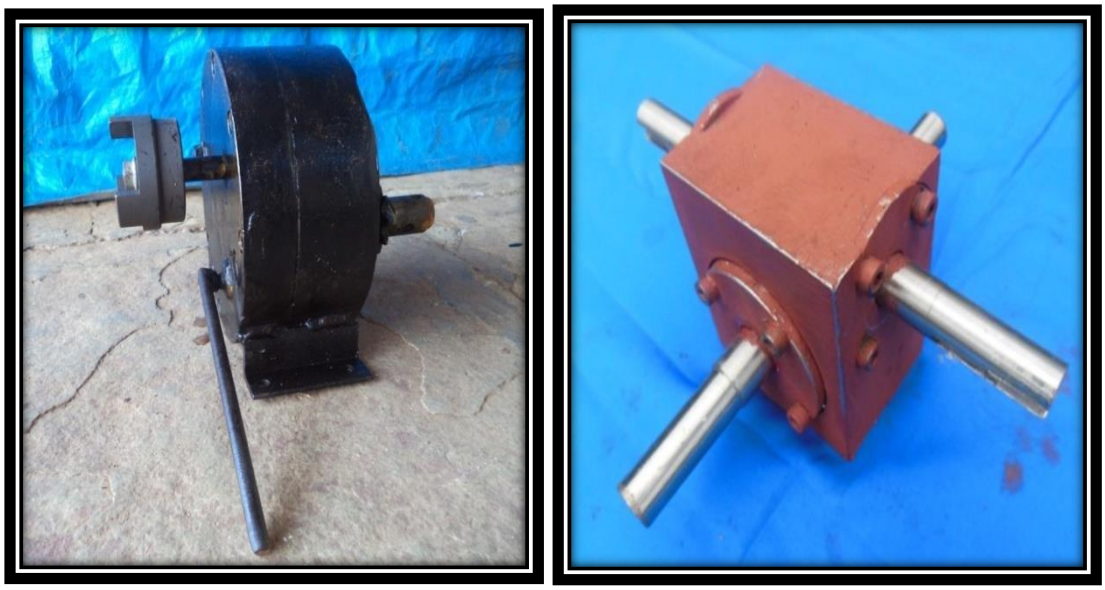
The function of this mechanism is to pick 3-5 numbers of seedlings from tray. Also it carries these seedlings to puddled soil surface in standing position. This mechanism is used to transplant the seedlings into puddled soil. Actuating type of commercially available transplanting mechanism is used on the machine. It consists of one transplanting arm, two fingers, two rocker arm and two needles. The rocker arm and needle are attached to both sides of transplanting arm. The fingers actuate with the help of cams, pinions and push rods.

Pair of separating needles and knock out mechanism is fitted in aluminium casing. The separating needles are made up in U- shape 4 mm thick, and the distance between two tongs of needle is 4 mm. (plate 4.5) The knockout mechanism have cam, rocker arm. Actions of all these components press the seedlings into puddled soil. The rocker arm helps the needle to achieve proper elliptical profile by restricting the rotational movement of rear end of transplanting arm led soil at lowest point of profile of separating needle. Rocker arm is made up of aluminium casting connected at rear end of transplanting arm and hinged to the adjustable link of chain case. One end of rocker arm is fixed while other moves in arc. The transplanting forks are shown in plate 4.5

4.3.7 Tray movement mechanism

The cut pieces of nursery mat are kept on the tray. It reciprocates horizontally. At bottom of tray one horizontal frame of M.S. sheet of size 1100 mm × 800 mm is fitted. On the frame four windows of 15 × 15 mm are cut. The needles of transplanting arm picks up 3-5 seedlings from the bunch of seedlings in mat. The width of mat is kept as 238 mm while cutting nursery mat. After every stroke of transplanting arm, the seedling tray move equal to the width of removed piece of mat.

Plate 4.1 Honda engine (GK 200) used for power transmission



(a) **(b)**

Plate 4.2 Gear boxes used for speed reduction

(a) Reduction ratio 12.5:1 **(b) Reduction ratio 12:1**

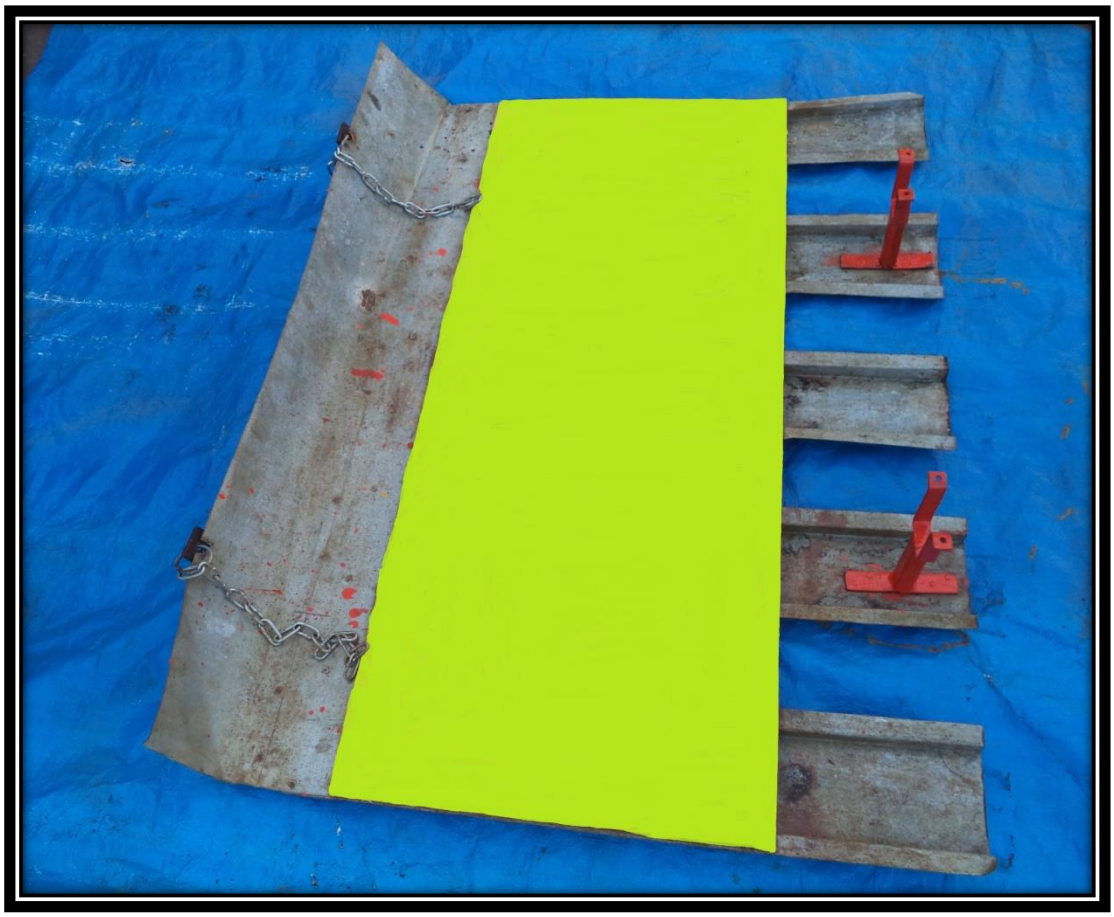


Plate 4.3 Float of developed paddy transplanter

Plate 4.4 Tray for developed paddy transplanter

The lead screw is used to achieve tray movement. The lead screw is consisting of a rod 360 mm long and having 25.4 mm diameter. The groove of 5 mm depth is marked along periphery across the length of rod. The lead is fixed in groove so that it can slide in that groove along the length of rod. The rod has drive from the transplanting mechanism in 2:1 ratio. (Plate 4.6) The lead is fixed to the tray so tray slides with lead. While working of machine the rod rotates through transplanting mechanism. Due to the rotation of rod the lead slides in the groove so that it covers distance sideways. The one revolution of rod slides 15 mm distance of lead. As the lead is fixed to tray it automatically slides tray. After covering distance of 238 mm the direction of the lead is reversed along the periphery without disturbing the direction of rotation of rod. The schematic representation of tray movement mechanism is shown in Fig. 4.4. The tray movement mechanism of developed transplanter is shown in plate 4.6.

4.3.8 Drive wheel

Based on the calculations one drive wheel was fabricated with G.I. hollow rod of 25.4 mm diameter. The lugs were provided on outer periphery of drive wheel. Considering the lug height of 20 mm, the effective diameter of wheel was taken as 460 mm. Thus diameter of lugged wheel was taken as 0.5 m. The wheel rim was fabricated using MS sheet of 40×4 mm. The hub diameter was selected as 40 mm. The hub was made hollow for inserting axle shaft. Total four G.I. rods of 25.4 mm diameter were used as spokes for drive wheel. On the periphery of the wheel, 12 lugs were welded at uniform spacing of 30 mm. Two wheels were fixed on axle shaft of diameter 30 mm. The distance between wheel and float was 100 mm. The power from output shaft of worm gear box was transmitted through bevel gear and then chain mechanism to the drive wheel. The drive wheel for paddy transplanter is shown in plate 4.7.

4.3.9 Handle

One handle at front side of transplanter is provided for the movement of transplanter and to give some amount of pull in case of slippage during operation in the puddled soil. For operating, clutch levers were provided on handle, also engine acceleration was controlled from the lever fitted on the handle.

4.3.10 Final prototype

The different component of transplanter are fabricated and assembled. The overall dimensions of developed transplanter are shown in Fig 4.5. The final prototype of four row paddy transplanter is shown in Plate 4.8.

4.4 Power transmission unit

The power transmission unit transmitted power from engine to transplanting mechanism and drive wheel. Petrol run 3.5 hp engine is fitted on main frame which gives power to the transplanter. The engine power is transmitted to main shaft of gear box with the help of coupler directly. The clutch is also provided to connect and disconnect power from engine. The gear box of speed ratio 12.5:1 is provided on machine. Through chain and sprocket arrangement, the power is transmitted to shaft of transplanting arm. The engine speed is 3600 rpm. The engine speed reduced to 288 rpm with help of gear box. The speed in the gear box is further reduced to 24 rpm to operate drive wheel. The different components of the developed machine are shown in plate 4.9.

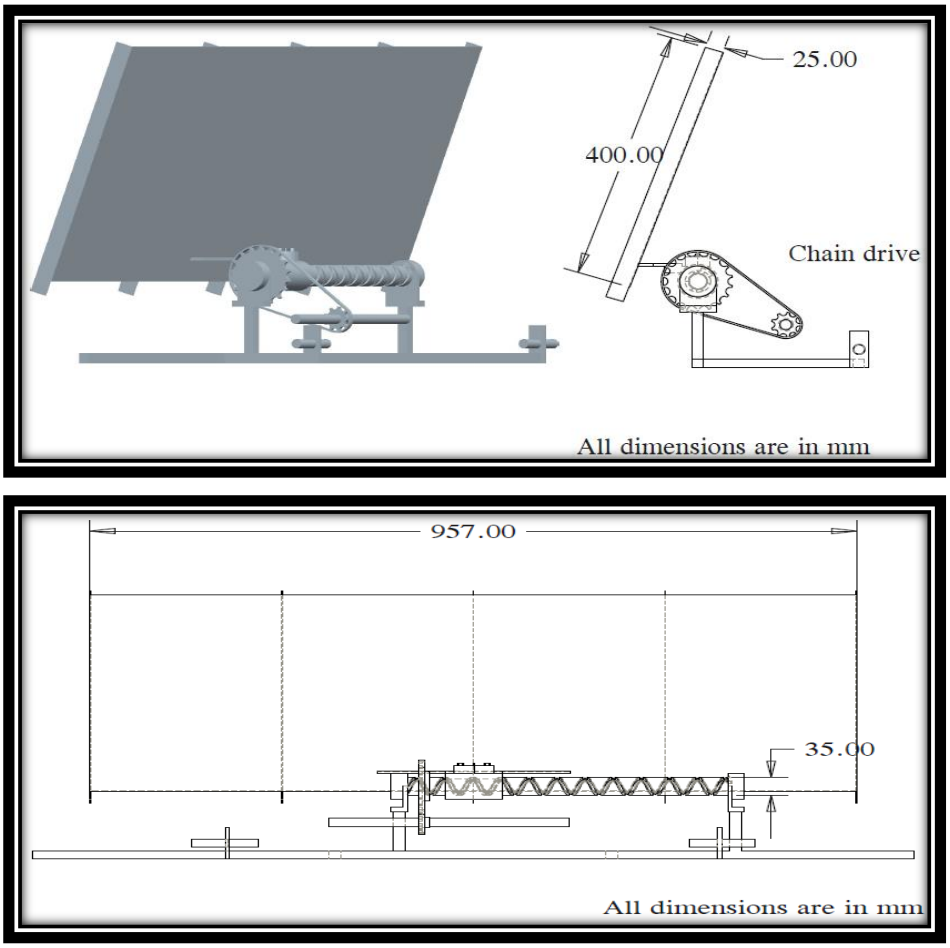


Fig. 4.4 The schematic representation of tray movement mechanism

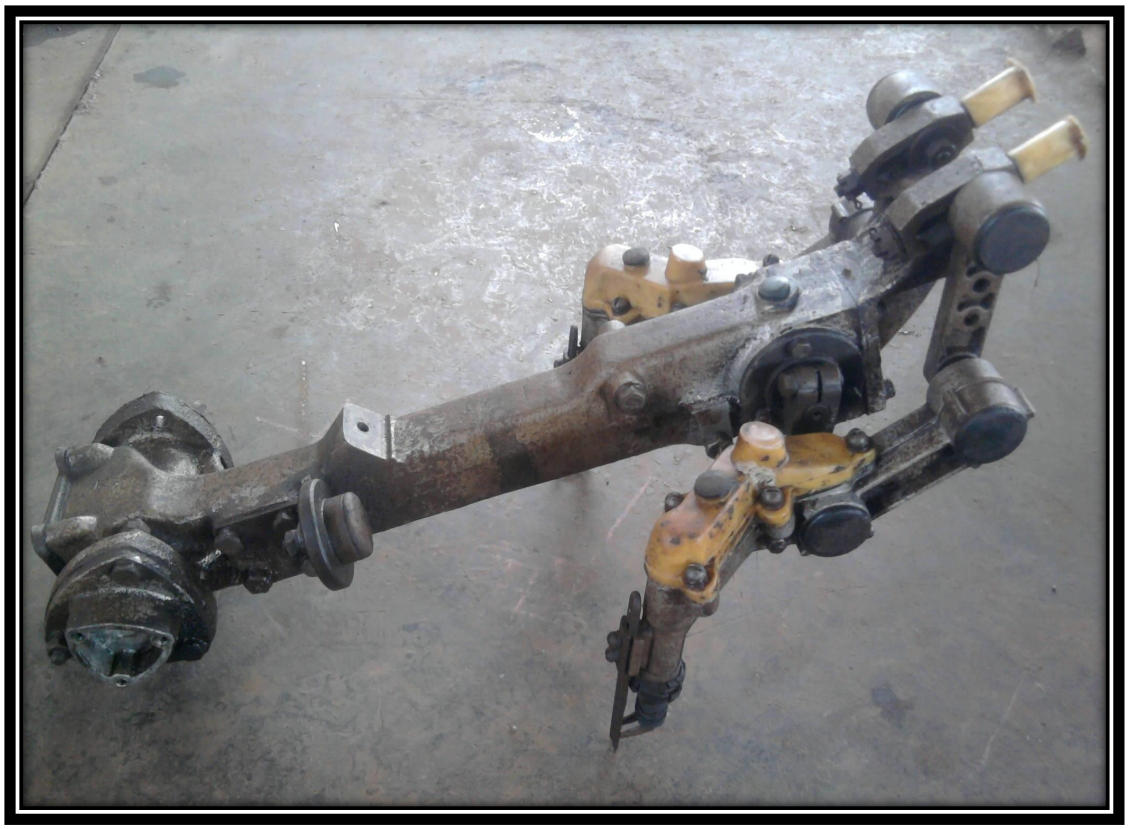


Plate 4.5 Transplanting fork with needles

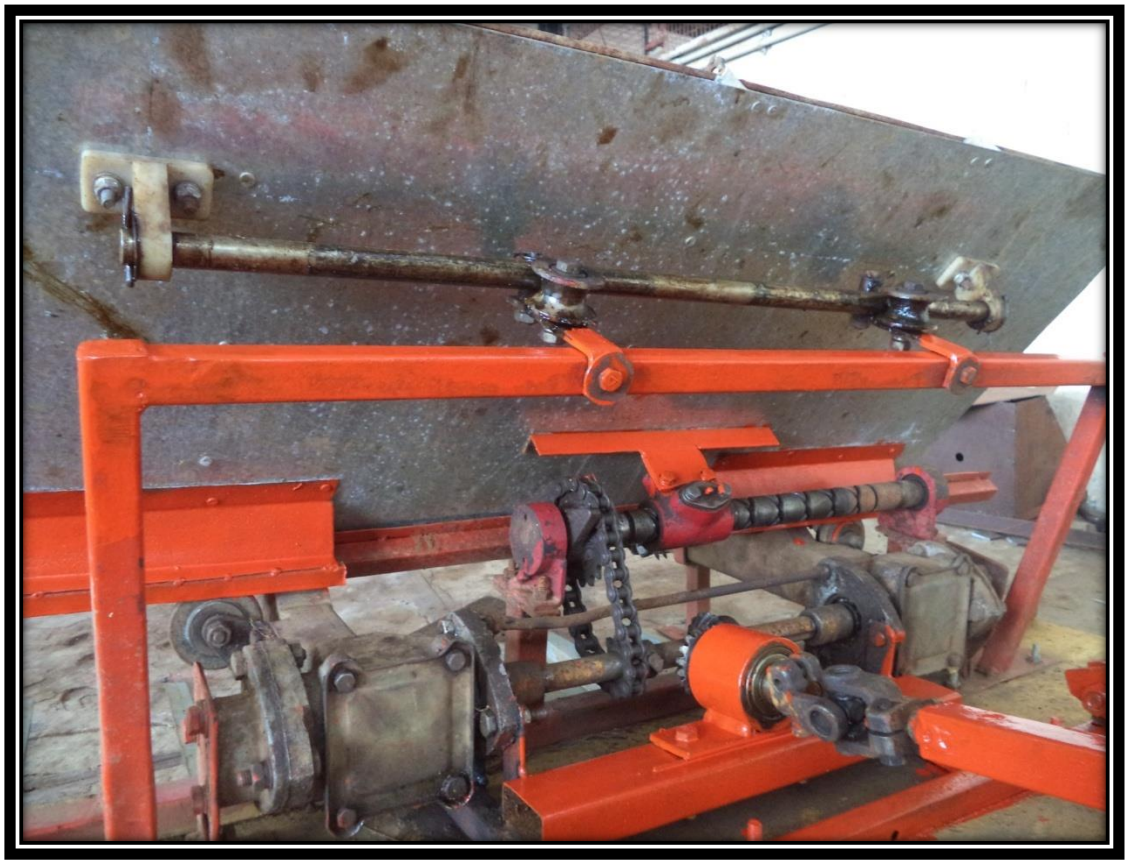
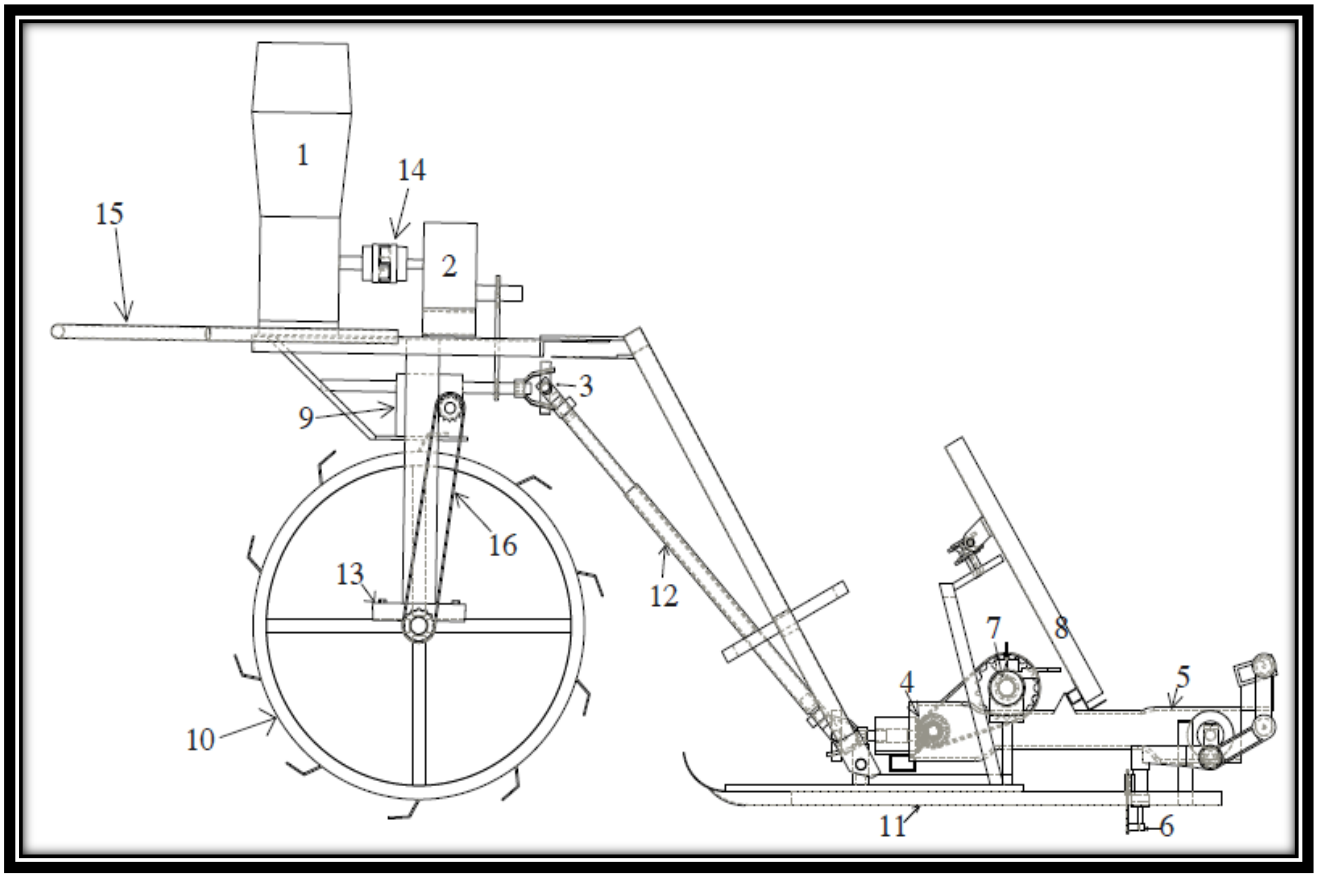


Plate 4.6 Tray movement mechanism

Plate 4.7 Drive wheel for forward motion of paddy transplanter

Plate 4.8 Developed self propelled paddy transplanter

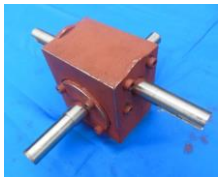


1) Engine; 2) Gear box (GR 12.5:1); 3) Universal joint; 4) Bevel gear; 5) Transplanting arm; 6) Needle operating mechanism; 7) Tray operating mechanism; 8) Tray; 9) Gear box (GR 12:1); 10) Drive wheel with lugs; 11) Float; 12) Propeller shaft; 13) Pedestal bearing; 14) Coupler; 15) Handle; 16) Chain and sprocket mechanism

Fig. 4.5 Schematic representation of developed paddy transplanter

Engine

Gear box GR 12.5:1



Gear box GR 12:1

Transplanting mechanism

Drive mechanism

Tray movement mechanism

Needle operating shaft

Plate 4.8 Power transmission unit of developed paddy transplanter

4.5 Working of four row paddy transplanter

The four row paddy transplanter can plant four rows of paddy at a time. It gets power from the engine by belt and pulley arrangement. An engine is used as a power source for the transplanter. The floats ensure the floating of transplanting assembly on the puddled soil and also avoid the sinking of machine. At the time of transplanting operation, the cut mat nursery is placed on the tray. After every stroke of transplanting arm, tray slides, each needle picks 3-5 seedlings from mat nursery and places it properly in the puddled soil at 4-5 cm depth. The tray has the horizontal sliding movement through indexing mechanism at the back of the tray which moves tray sideways.

When engine get started, the transplanting arm starts rotating in elliptical path. While planting arm moves in downward position, the separating needles remove 3-5 seedlings from mat nursery placed in the tray and at the end of downward movement knock out mechanism pushes it in the soil to a specified depth of 4-5 cm. As tray slides, the transplanting arm at every stroke removes new area of mat nursery and hence proper planting of rice seedlings occurs.

4.6 Method of raising nursery

A special type of mat nursery was prepared for growing the rice seedling for mechanical transplanting of paddy. Efficiency of machine mainly depends on quality of mat type nursery and puddling of field. So, care should be taken while preparing the mat type nursery. For raising mat type nursery, the raised bed was prepared on leveled ground. The bed surface was leveled, compacted and smoothened. The bed of 10×1 m was prepared.

4.6.1 Preparation of raised bed

Well drained site was selected for preparation of raised bed. Levelled the land and prepared raised bed of 10 × 1 m size. Maintained height of bed as 15-20 cm. Dug the trench of 15-20 cm in between two raised beds to drain the excess water or to irrigate the beds as per requirements. The thick plastic paper of 11 × 2 m size was spread over the raised bed. It is shown in plate 4.10.

4.6.2 Seed treatment

The selected seeds were dipped in 15-16% salt solution. Floating seeds from the water were removed. Then the seeds were dipped in good quality water of 40^0 C for 24 hours. Then seeds were from water and kept in gunny bag.

4.6.3 Spreading of sprouted seeds

The frame size of 1 m×1 m×0.025 m was made with angle iron of 25 mm and 2 mm thick placed on the raised bed covered with plastic. The prepared soil mixture was spread uniformly in the frame and compacted it well. The sprouted seeds were spread uniformly over the soil mixture (Plate 4.11). Soil mixture (soil + dry cow dung) of 5 mm thick was spread over sprouted seeds. The sprouted seeds were covered with rice straw for protecting seeds from birds. The straw removed on 4^{th} day. The water splashed over the seedlings for next 7-8 days as per the requirements. Water applied to the seedlings through the trench dug around the raised bed so as to get continuous water to the roots. After 21-22 days, the seedlings were ready for mechanical transplanting. Spreading of sprouted seeds on raised bed is shown in plate 4.11. The Germinated seeds after 5 days are shown in Plate 4.12 and nursery after 21 days ready for transplanting is shown in Plate 4.13.

4.7 Methodology for measurement of Performance parameters

The performance testing of four row rice transplanter was carried out as per test code and procedure provided by RNAM (1995) at Agronomy farm of Dr. B.S.K.K.V, Dapoli. The test sheet is prepared to record the items to be studied as required. The performance test is required to obtain reliable data on operating accuracy, work rate, field efficiency and other parameters in field. The methodology adopted for measurement of crop and field parameters under study are as given below.

4.7.1 Crop parameters

4.7.1.1 Nursery height

Nursery height was measured by 30 cm scale. For measurement purpose, the seedlings were uprooted randomly from different nursery locations and ten observations were noted. The height was measured from bottom of the seedlings to tip of leaves (Garg I.K. *et al.*, 1999).

4.8.1.2 Leaf stage

Numbers of leaves of uprooted seedlings were counted. Ten observations from different locations were recorded to find average.

4.7.1.3 Stem diameter

Stem diameter of the seedling was measured with the help of vernier calliper. The diameter was measured at the height of 25 mm from the root to maintain uniformity in readings. Ten such readings were noted to find average.

Plate 4.10 Preparation of mat type nursery

Plate 4.11 Spreading of sprouted seeds on raised bed

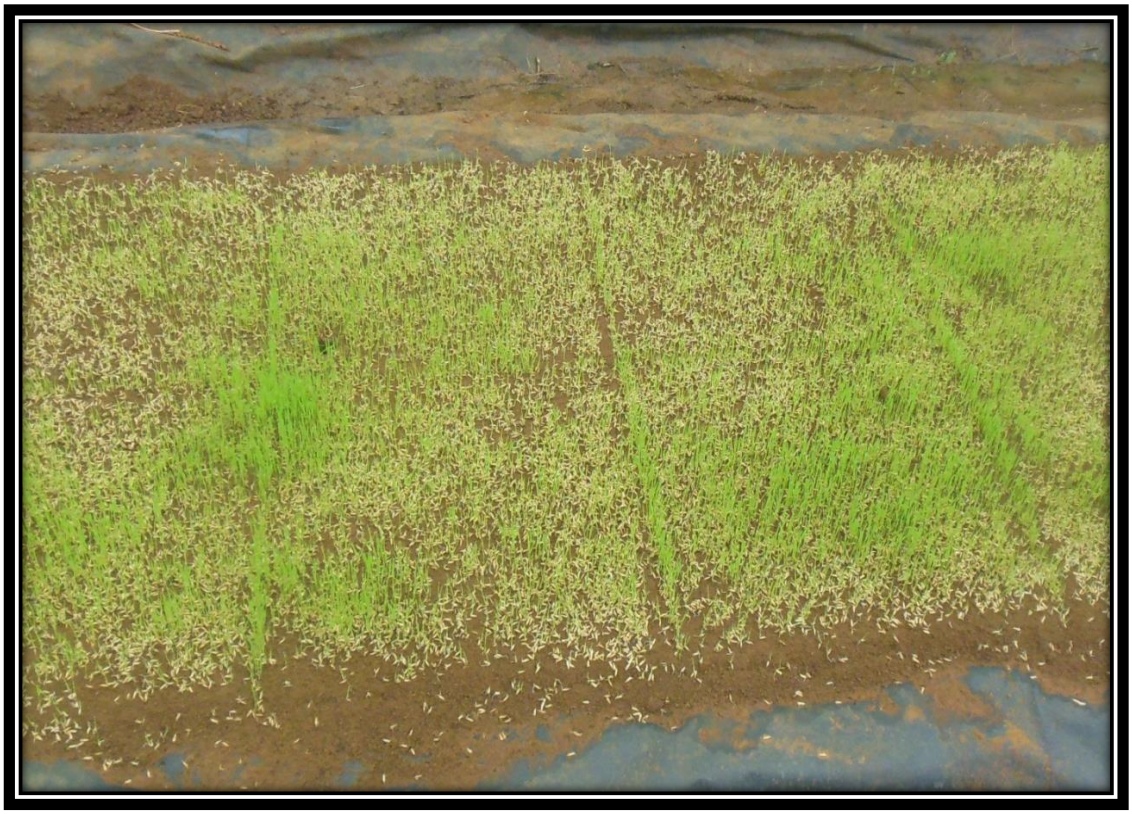


Plate 4.12 Germinated seeds after 5 days

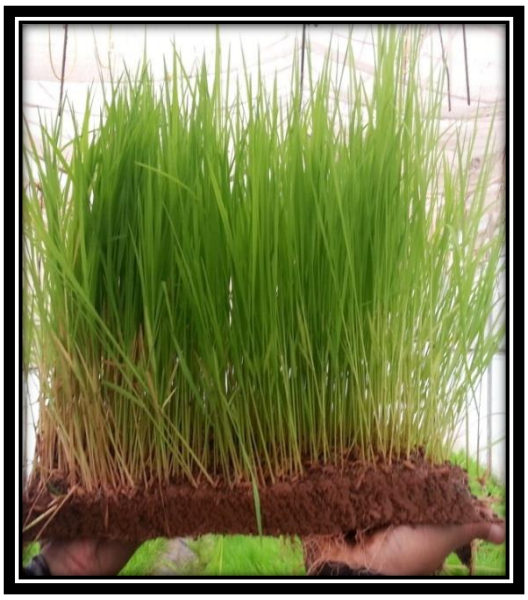


Plate 4.13 Nursery ready for transplanting after 21 days

4.7.2 Field performance parameters

The field performance parameters viz. row to row spacing, number of plants per hill, missing of hills, speed of operation, sinkage etc. were measured during field testing. The methodology adopted for measurement of these parameters is as given below.

4.7.2.1 Row spacing

Row spacing of the plant was measured with the help of 30 cm scale. Ten readings were noted from different locations of field and average row spacing was taken into consideration.

4.7.2.2 Number of plants per hill

Numbers of plants on each hill were noted from different location of the field. Average number of plants on hill was calculated.

4.7.2.3 Number of hills per row

Number of hills on each row was noted. Then the average hills per row were calculated.

4.7.2.4 Missing of hills

The observed missing hills were taken into consideration.

4.7.2.5 Total time required for operation

Total time required for operation of transplanter is the total time required for transplanting, time required for turning, time required for feeding nursery, time required for repair and adjustment. The time required for the operation was measured with the stop watch (Make: Angat).

4.7.2.6 Speed of operation

The time required to cover 10 m distance was measured with the help of stopwatch. Total five replications were taken for each set of observation.

4.7.2.7 Time required for turning

Time required for turning of transplanter for each row is measured with the help of watch. Total time spent for turning is the sum of time spent for turning in each row.

4.7.2.8 Field efficiency

It is the ratio of the effective field capacity and theoretical field capacity expressed in percentage. The field efficiency can be calculated using following formula.

$$\text{Field efficiency } (\eta) = \frac{To \times 100}{Te + Th + Ta}$$

Where,

To = Theoretical time to cover one ha (h);

Te= Effective time to cover one ha (h);

Th = turning loss per ha (h);

Ta = Time loss in repair and adjustment (h).

4.7.2.9 Puddling index

Soil water suspension sample were collected during last lap of puddling from different spots with the help of 1.25 cm diameter steel pipe. Samples were taken by closing the upper end of the pipe with thumb and collecting in a measuring cylinder till the volume reached 500 ml. The soil suspension was allowed to settle for 24-36 hours and the volume the soil water suspended was allowed to settle for 48 hours and the volume of soil settle was recorded. Then the puddling index was determined by using following formula.

$$\text{Puddling index (PI)} = \frac{Vs}{V} \text{ x } 100$$

Where,

Vs = Volume of soil, ml;

V = Total volume of the sample, ml.

4.8 Performance testing of newly developed prototype

The newly developed four row paddy transplanter was tested for its performance. Before testing the machine in the field, the laboratory test of the transplanter was carried out. The machine was operated in laboratory for observing its forward movement and working of transplanting mechanism using newly developed driving mechanism.

4.8.1 Laboratory tests

Laboratory testing of newly developed four row paddy transplanter was done and different parameters were measured. The transplanter was jacked first; arrangement was made properly to test the transplanter in laboratory. Observations of engine speed, drive wheel

speed, speed of transplanting mechanism was taken. The hill to hill spacing and number of seedling per hills was measured.

4.8.2 Field testing

After satisfactory working of the machine under laboratory condition, the performance of developed machine in the field was studied. The field of 10 m ×10 m size was prepared using power tiller. The depth of tilling was kept as 10 cm. Puddling of the field was carried out with the help of power tiller. The soil was allowed to settle for 48 hours. After settlement, depth of water was maintained in the field to 2-4 cm. Before field testing, sufficient practice was given to operator for operating the machine in the puddled soil without load (running in idle without operating transplanting mechanism). The crop of 21 days old of 12-15 cm height with 3-4 leaves grown in mat type nursery was cut into small pieces and placed on the tray and field test of the developed transplanter was carried out. The trial was replicated three times. The developed machine operating in the field is shown in Plate 4.14.

The various parameters recorded during field testing are as given bellow.

1. Plant to plant spacing
2. Planting depth
3. Number of plants per hill
4. Number of hills per m^2 area
5. Missing hills.
6. Total time required for operation
7. Time loss for turning
8. Speed of operation
9. Field efficiency
10. Puddling index
11. Field capacity
12. Fuel consumption.

As discussed in this chapter, the four row paddy transplanter was developed. Its performance was tested in field. Its performance in detail is described in next chapter.

Plate 4.14 The developed machine operating in the field

CHAPTER V

RESULTS AND DISCUSSION

This chapter includes the results obtained from the experiments conducted on developed four row self propelled paddy transplanter in laboratory as well as in the field. The results are described and discussed as follows:

1. Crop nursery
2. Laboratory test
3. Field performance testing of developed paddy transplanter

5.1 Crop nursery

Mat type nursery of rice is the pre requisite for the developed transplanter. The data on crop nursery was collected. It required for proper functioning of the developed self propelled paddy transplanter. The rice seeds were used for crop nursery.

The rice belongs to family Gramineae and genus of *Oryza* and botanical name is *Oryza sativa.* The variety selected was Ratnagiri-724. The plant parameters recorded during nursery raising is presented in the Table 5.1

Table 5.1 Details of plant parameters during nursery raising

Sr. No.	Parameter	Observations
1.	Variety of seed	Ratnagiri -724
2.	Type of nursery	Mat
3.	Age of seedling (days)	21-25
4.	Leaf stage	3-5 leaf
5.	Height of seedling (cm)	15-18

5.2 Testing of developed transplanter

The developed self propelled four row transplanter was tested in laboratory as well as in field for its performance.

5.2.1 Laboratory tests

The developed four row self propelled paddy transplanter was tested in the laboratory. Laboratory setup was arranged as discussed in the subsection 4.8.1 of chapter IV. The

machine was checked for specifications and functioning in laboratory. The specification of the developed four row paddy transplanter and observations are given in Table 5.2 and 5.3.

5.2.2 Specifications of four row self propelled paddy transplanter

The four row self propelled paddy transplanter was developed and fabricated in workshop of Department of Farm Machinery and Power, Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli. The specifications of machine are as given below.

Table 5.2 Detailed specification of transplanter

Sr. No.	Particulars	Details/ Specifications
1.	Overall dimensions (mm)	Length : 1350 mm; Width :1150 mm; Height : 1100 mm
2.	Weight (Kg)	110 Kilograms
3.	Planting rows	Number : four Spacing : 238 mm
4.	Engine	Model: GK-200 (Honda Make); Power (kW): 2.8 kW/3.5hp; Speed (rpm): 3600 rpm; Fuel : Petrol
5.	Wheels	Type : Lugged, 60×60 mm, No. of lugs=10 Diameter: 500 mm; Speed = 24 rpm
6.	Float	Shape: Rectangular Size : 1100 mm× 750 mm, made up with G.I. sheet (22 gauge), covered with PVC sheet of size 1100 × 450 × 8 mm
7.	Planting mechanism	Mechanism of planting fork: knock out mechanism. No. of fork = 4, spacing = 238 mm, Shaft speed 288 rpm Locus of planting : Elliptical

8.	Number of workers required for operating the machine	2 No.; One for operating and other for feeding nursery

5.2.3 Performance of developed machine in laboratory

The developed four row self propelled paddy transplanter was tested at three different engine speeds i.e. 288 rpm, 250 rpm, 230 rpm. The transplanter was raised on platform of 6 inch height so as to run drive wheel idle and operate planting mechanism. The engine was started. Laboratory tests results of the machine are mentioned below in Table 5.3.

Table 5.3 Laboratory test results of transplanter

Sr. No.	Observations	Test 1	Test 2	Test 3
1.	Engine speed, rpm	3600	3125	2875
2.	Speed at gearbox (output), rpm	288	250	230
3.	Speed of drive wheel, rpm	24	21	20
4.	Speed of transplanting arm, strokes /min	285	247	225
5.	Row to row spacing, cm	23.8	23.8	23.8
6.	Number of seedlings per stroke	4-5	3-5	4-6
7.	Hill spacing (calculated)	12	12	12

5.2.3.1 Speed of transplanter

The machine was tested by operating at different engine speeds so the relation between the engine speeds, speed of transplanting arm and speed of drive wheel were observed. Best results were obtained at engine speed of 3125 rpm and transplanting arm speed of 247strokes/min.

5.2.3.2 Plants removed per stroke

The separating needles of transplanting fork were set to remove the required number seedlings. The plants removed per stroke were observed to be 3 to 5.

5.2.3.3 Hill population

Number of hills spaced per unit area was found to be about 30 hills/m^2 and that slightly varied as per the forward speed of the machine. The obtained hill/population is satisfactory level.

5.2.3.4 General

The machine operation was found to be satisfactory during laboratory testing. Results have shown that transplanting and feeding mechanism was functioning properly. No break down was found during laboratory testing. While designing, the engine speed was considered to be 3600 rpm. Using coupler and gearbox with reduction ratio 12.5:1, the output speed at gearbox was achieved to 288 rpm. The speed achieved at the fork of transplanting arm was 285 rpm at gearbox speed of 288 rpm indicated the hill to hill spacing to a satisfactory level during field operation considering slippage in puddled field.

5.2.4 Field testing of developed four row self propelled paddy transplanter

The functional field trial of the developed four row paddy transplanter was carried out in the Agronomy farm of Dr. B.S.K.K.V., Dapoli. Various observations were taken during field trial and results are discussed below.

5.2.4.1 Condition of seedlings

The details about nursery seedlings are given in Table 5.4.

5.2.4.2 Conditions of field under test

The observations of the field condition during transplanting operation were taken. These are given as in Table 5.5.

Table 5.4 Condition of seedlings during field trial

Sr. No.	Items	Details / Specifications
1.	Variety of Paddy	Ratnagiri-24
2.	Type of Nursery	Mat nursery
3.	Soil type of seed bed	Laterite
4.	Date of sowing in the nursery	24 /09 /2013
5.	Date of transplanting in the field	19 /10 /2013
6.	Age of seedlings (days)	25
7.	Leaf stage	4 leaves per seedling

8.	Size of seedlings (thickness at the base of shoot, mm)	1 mm
9.	Length of seedling (mm)	170-180 mm
10.	External treatment, if any	Urea aplication (10 gram in 1 litre)
11.	Growing density of seedling	16 to 18 seedlings per cm^2

Table 5.5 Conditions of field under test

Sr. No.	Items	Details/ Specifications
1.	Location	Agronomy farm, DBSKKV, Dapoli
2.	Length of field (m)	10
3.	Width of field (m)	10
4.	Area of field (m^2)	100
5.	Puddling index	62 %
6.	Interval between puddling and transplanting	48 hours
7.	Depth of water at the time of transplanting	3.2 cm

5.2.5 Field performance

Field testing of developed four row self propelled paddy transplanter was carried out at Agronomy farm of Dr. B.S.K.K.V, Dapoli. The plot size of field was 10×10 m^2. Shallow puddling up to 15 cm of the field was done using power tiller. After 48 hours of pudding, mat type seedlings of 29 days old were used for the transplanting and the field testing of transplanter was carried out. Three field trials were taken. The observations during trial are given in Table 5.6 – 5.8

Table 5.6 Observations during functional field trial

Sr. No.	Items	Details / Observations
1.	Date of transplanting	19 / 10 / 2013

2.	Time of start	11:25
3.	Time of finish	11:55
4.	Ease of operation of machine	Easy to carry
5.	Ease and precision of machine	Acceptable
6.	Skill of operator	Moderate

The result reveals that, average plant to plant spacing and planting depth during testing was 13.16 cm and 3 cm respectively. The average seedlings per hill were 3.66. The average numbers of hills in one square meter area were found as 30 hills/ m^2. The newly developed self propelled machine maintained the required row spacing and hill spacing. The plant population obtained from the machine is obtained as 105.47/m^2 which is quite satisfactory with the required plant population of 100 seedlings/ m^2 considering missing hills. Missing hills/m^2 was observed to be 4.33. The performance parameters in details are given in Table 5.8

Table 5.7 Operating parameters of newly developed four row transplanter under different tests

Sr. No.	Items	Transplanting			
		T_1	T_2	T_3	Average
1	Planting distance,(cm)	12.5	13	14	13.16
2	Row spacing, (cm)	23.8	23.8	23.8	23.8
3	Planting depth, (cm)	2.5	3.5	3	3
4	No. of seedlings/ hill	3	4	4	3.66
5	No. of hills/m^2	30	32	29	30
6	Travel speed (km/hr)	1.56	1.42	1.46	1.48
7	Missing hills/ m^2	6	4	3	4.33
8	Sinkage (cm)	3.5	3.1	2.7	3.1
9	Fuel consumption (l/h)	1.9	1.93	1.89	1.90
10	Field efficiency, (%)	83.33	79.04	79.06	80.47
11	No. of persons required for operating machine	1	1	1	1
12	No. of persons required for mat feeding	1	1	1	1

Table 5.8 Time required for different operations

and field capacity under different tests

Sr. No.	Operation	Time required (hr/ha)			
		T_1	T_2	T_3	Average
1	Planting	4.86	4.95	4.47	4.76
2	Turning	0.65	0.72	0.78	0.71
3	Feeding	1.16	1.9	2.1	1.72
4	Total time of operation	6.67	7.57	7.35	7.19
5	Field capacity (ha/h)	0.15	0.132	0.136	0.14

Table 5.7 also shows the average speed of operation of transplanter was 1.48 km/hr. Fuel consumption of the machine was recorded 1.9 l/h. Only one operator is required to operate the transplanter. Details of time requirement of transplanter for transplanting, nursery feeding, repair and adjustments, are presented in Table 5.8

The time required for planting was observed to be 4.76 h/ha. The time loss in turning and feeding was 0.71 h/ha and 1.72 h/ha respectively. Total time of operation of the transplanter was observed to be 7.19 h/ha. The field capacity of the machine was found to be 0.14 ha/h. For operating the transplanter, operator has to guide the machine, which was easy than pulling machine in the puddled field. The field efficiency of newly developed machine was found to be 80.47 % (Table 5.7). As compared to manual transplanting method, transplanting with newly developed machine has saving of ₹ 2420/ha which is 48.40 % over manual transplanting (5000/ha) method.

5.3 General observations

The weight of newly developed paddy transplanter is 110 Kg. The handling of machine into the puddled field was easy. It requires one person to operate and another for feeding nursery mat. Hinge points were well adjusted at the time of fabrication which was resulted into proper balancing of machine during field operation. Good traction was provided to machine in puddle soil by the lugged drive wheel. No breakdown of the machine observed during the functional field trial. The field capacity of the developed transplanter is 0.14 ha/hr which is quite encouraging. It is more than double as compared to commercially available two row transplanter. Considering its lighter weight, easy handling, maneuverability and its

operating cost (₹358/h), the newly developed transplanter can be a solution for the present problems of mechanization in Konkan region.

CHAPTER VI

SUMMARY AND CONCLUSION

In India, rice is generally grown by transplanting seedlings in flooded field conditions. Transplanting of young rice seedlings in puddled soil is one of the most widely accepted cultivation practices for rice crop. Manual transplanting is very common in most of the rice growing countries. Rice transplanting is a tedious and very time-consuming job requiring about 250 to 300 man-hour/ha which is roughly 25 per cent of the total labour requirement of the crop. Mechanization in agriculture has released millions of agricultural workers in the industrial sectors, which reduces level of manpower. All current methods of producing rice depend largely on availability of manual labour.

In Konkan region terrace farming is followed for paddy crop and the field is fragmented. In this region, wet land cultivation system is followed. The land is ploughed thoroughly and puddled in 3-5 cm standing water. The puddling is mostly done by bullock drawn country plough and wooden planks in the region. In some of the pockets, the power tiller is used for puddling, but the extent is very low. In Konkan, and particularly in Ratnagiri district, the status of mechanization is very low. Hence the transplanting operation is done manually. To reduce the cost and labour in transplanting operation, manually operated imported Japanese transplanters were introduced in the country during 1970's. These transplanters could not become popular among the farmers as the person has to walk behind the transplanters in puddled soil during transplanting and has to move the transplanter. To overcome this difficulty the efforts have been made by Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli to popularize eight row Yanji-Shakti transplanter. Number of demonstrations of this machine was taken in the Konkan region. The limitations are observed due to smaller plot size and hilly terrain. The two row transplanter has been developed at Dr. B.S. Konkan Krishi Vidyapeeth (Bhat and Shahare, 2011; Desai, 2012) Dapoli. The developed machine can work on smaller plots but the field capacity is very less and also plant to plant spacing is not maintained. In some pockets drum seeder for dry cultivation is tried. Proper seed rate is not maintained and non uniform seed delivery observed many times. Considering the limitations of eight row transplanter, two row transplanter and drum seeder, in order to enhance the field capacity the work on high capacity transplanter of a four row is necessary to undertake. Hence

the study entitled “Development and performance evaluation of four row self propelled paddy transplanter” is planned with the following objectives:

3. To develop four row self propelled paddy transplanter.
4. To evaluate the field performance of developed four row self propelled paddy transplanter.

The self propelled transplanter in general consists of main frame, engine, gear box, transplanting mechanism, tray movement mechanism and drive system. The total power required for removal of seedlings and their placement and forward motion of machine was found to be 3.1 hp. Based on the power requirement the commercially available Honda-GK-200 petrol engine was selected as a prime mover. The engine was fitted over main frame with nut and bolts. Engine speed is reduced to 288 rpm through gear box of 12.5:1 ratio which is required to operate transplanting arm. The commercially available actuating type transplanting arms (2 Nos) were used for this transplanter. It consists of one transplanting arm, two fingers, two rocker arm and two needles. The rocker arm and needle are attached to both side of transplanting arm. The fingers actuate with the help of cams, pinions and push rods. Pair of separating needles and knock out mechanism is fitted in aluminium casing. In order to achieve forward speed of machine 1.5 km/hr the drive wheel having lugs was designed. The drive wheel speed was reduced to 24 rpm using another small gear box. This gear box was also coupled to main gear box. Tray operating mechanism was developed such that after every stroke of transplanting arm, the tray slides to 1.5 cm and 3-5 seedlings from mat nursery are properly picked up by needles and planted in the puddled soil at 4-5 cm depth. The movement of tray mechanism was given through chain and sprocket from transplanting mechanism. Mat type nursery was developed for testing of the developed prototype. Its performance was tested in laboratory as well as in field. During laboratory test the prototype was supported and raised so as to operate drive wheel and transplanting arm freely. The power tiller was used to puddle the test field. After 48 hours of settlement period, the machine was operated in field for filler trial. The performance testing of transplanter was carried out as per RNAM test code. The parameters like plant to plant spacing, missing hill/m^2, number of hill/m^2, sinkage, total time of operation, time loss in feeding nursery, speed of operation etc. were recorded.

Laboratory test results showed that transplanting mechanism and feeding mechanism functions properly. Constant row spacing of 23.8 cm was maintained. No break downs were observed during laboratory test. The newly developed four row self propelled transplanter was operated in field for filler trial. The result reveals that the hill spacing for newly developed transplanter was 13.16 cm. The planting depth of the transplanting was observed to be 3 cm. The seedlings per hill and missing of hill were observed to be 3.66 and 4.33 respectively. The total numbers of hill/m^2 area were obtained as 30. Fuel consumption for the newly developed transplanter was 1.9 l/h. The operating speed of the transplanter was observed to be 1.48 km/h. The field efficiency of the transplanter was 80.47%. Total time of operation for one hectare field was obtained to be 7.19 hr. Time required for transplanting, turning, feeding the nursery were found to be 4.76, 0.71, 1.72 h/ha respectively. The field capacity of the transplanter was 0.14 ha/h. The operating cost of newly developed transplanter was ₹358/h and ₹2580/ha. In general, the newly developed transplanter worked satisfactorily in the field.

Conclusions

1. The performance of developed four row self propelled paddy transplanter was satisfactory.
2. Considering engine speed 3600 rpm and reducing it to 288 rpm at gearbox output, designing tray movement mechanism, driving mechanism, the achieved hill to hill spacing of 13.16 cm at forward speed of machine 1.48 km/hr and row spacing 23.8 cm, picking 3-5 seedlings by the arm in a stroke indicated the developed transplanter works satisfactory to achieve desired plant population of 105.47/m^2 against 100 m^2 of the theoretical plant population.
3. The field capacity and field efficiency of newly developed transplanter was found to be 0.14 ha/h and 80.47 % respectively.
4. The labour requirement for transplanting operation was reduced to two.
5. The newly developed transplanter remarked saving in cost of transplanting operation by 2420/ha (48.40 %) which is quite substantial amount.

Looking into the light weight, higher field capacity as compared to two row transplanter, hill and row spacing and optimum plant population with newly developed

transplanter, it can be concluded that this machine can be a solution for mechanized transplanting in the fragmented hilly region of Konkan.

CHAPTER VII

REFERENCES

Alam M. Z., M. Ahmed, M.S. Alam, M.E. Haque and M.S. Hossin. 2002. Performance of seedling ages and seedling raising techniques on yield and yield components of transplant aman rice. Pakistan *J. of Biological Sciences*, 5(11): 1214-1216.

Alizadeh M.R., A.R. Yadollahinia and F. R. Ajdadi. 2011. Techno-Economic performance of a self-propelled rice transplanter and comparison with hand transplanting for hybrid rice variety. *Int. J. of Natural and Engg. Sci.,* 5 (3): 27-30.

Anonymous. 1977. Farm machinery for rice production in Japan, part- I, Rice transplanter, lecture text no. 5, Uchihara International Agricultural Training Centre, JICA, Japan.

Anonymous. 2008. Area and production of rice in India at http:// www.irriindia.com.

Anonymous. 2009. District social and economical report of Ratnagiri district. Directorate of financial and statistics, planning department M.S. pp-35.

Anonymous. 2010. Agricultural Diary. D.B.S.K.K.V, Dapoli. pp: 13.

Anonymous. 2010. Directorate of Economics and Statistics. Dept. of Agriculture and Cooperation, New Delhi.

Anonymous. 2012. Directorate of Economics and Statistics. Planning Dept. Govt. of Maharashtra, Mumbai.

Badr S. E., H. A. El Gindy, B. Hemida and A. M. El Lithy. 2007. Planting and harvesting method effects on rice productivity. *Misr J. Ag. Eng*., 24(2): 318-326.

Baruah D.C., Goswami N.G and R. Saikia. 2001. Manual transplanting vs. mechanical transplanting of paddy. A techno- economical analysis in Assam. *J. of Agril. Engg.,* 38(3): 66-72.

Behera B.K., Varshney B.P. and A. K. Goel. 1991. Studies on optimization of puddle soil characteristics for self propelled rice transplanter. *J. Agril. Mech. in Asia, Africa and Latin America,* 34(3): 12-16.

Bhangoo B.S., Sharma V.K., Pannu C.S. and A. K. Madan. 1990. Studies on raising of mat type nursery for paddy transplanter. Paper presentation at National Seminar on rice transplanter held at CIAE, Bhopal. Oct 11.

Budiman D. Atma, Pitoyo, Joko, Rosmeika, Sulistiadji, Koes, and Sulistiadji. 2006. Design and development of manual rice transplanters. *J. Agril. Engg. Res.*, 43: 350-357.

Chandra S. and R. B. Ram. 2003. Field evaluation of self propelled transplanter under local conditions. *J. Agril. Engg.*, 3(1): 45-49.

Chaudhary V.P., B.P. Varshney and M.S. Karla. 2005. Self propelled rice transplanter-better alternative than manual transplanting. *J. Agril. Engg. Today*, 29 (5-6): 32-45.

Chivilkar A.D. and Bhere H.S. 2008. Development and performance evaluation of two row paddy transplanter. Unpublished thesis. B.Tech. Dr.B.S.K.K.V., Dapoli.

Datt P. 1995. Development and evaluation of a manually operated rice transplanter. *J. Agril. Engg. Toda*y, 19:(3-4).

Desai K.S. 2012. Development and performance testing of two row paddy transplanter. Unpublished thesis. M.Tech. Dr.B.S.K.K.V., Dapoli.

Dixit A., R. Khurana, J. Singh and G. Singh. 2007. Comparative performance of different paddy transplanters developed in India- a review. *Agric. Rev.*, 28 (4): 262-269.

Eam-o-pas K., Goto Y. 1990 Comparative performance of the rice transplanters in thailand's field conditions. *Kasetsart J. (National Science Suplementary)* 24:64-68.

Ehsanullah, A. Nadeem, J. Khawar and H. Tahir. 2007. Comparison of different planting methods for optimization of plant population of fine rice (*oryza sativa* l.) in Punjab. *Pak. J. Agri. Sci.*, 44(4): 597-599.

Garg I.K. and V. K. Sharma. 1984. Design, development and evaluation of PAU riding type engine operated paddy transplanter using mat type seedlings. *Proc. ISAE. SJC*, 1(2): 7-63.

Garg I.K. 1986. Development of six row manually operated paddy transplanter. *J. Agril.*

Engg. Today, 2(3) : 12-16.

Garg I.K. and V.K. Sharma. 1986. Design and development six row riding type transplanter. *J. Agril. Engg.*, 21(1-2): 17-24.

Garg I.K. and V.K. Sharma. 1989. Comparative evaluation of different methods of raising mat type paddy seedlings. *J. Agril. Mech. in Asia, Africa and Latin America*, 20(4): 27-30

Garg I.K. 1992. Investigation on design and operational aspect of manually pulled engine operated paddy transplanter using mat type seedlings. Unpublished thesis M. Tech. (FMP). PAU, Ludhiana.

Garg I.K., V.K. Mittal and V.K. Sharma. 1999. Ergonomic studies on manually pulled engine operated paddy transplanter. *J. Agril. Engg*., 36(2): 15-25.

Gowda M. C. and Rudraradhya M. 1998. Current Research University of Agricultural Sciences Bangalore, 27(5): 95-97.

Hatyam. , Hassancin. , Zahoor., Kotanny. 2010. Rice straw – seedbed for producing rice seedling mat. Int. J. of Sustainable Agriculture, 2(2): 26-33.

He Li, Xu Ji Qian, Zhou Na, Zhao Liang, Yan Hua Nongye and Jixie Xuebao. 2007. Transactions of the Chinese Society for Agricultural Machinery. 38(12):74-77.

Islam M.S. 1998. Modification, performance and adaptation of manually operated transplanting and seeding machines for lowland paddy. Published thesis. Ph. D. University Putra, Malaysia.

Khan A.S. and W.W. Gunkel. 1988. Design and development of a 6-row korean transplanter. *J. Agril. Mech. in Asia, Africa and Latin America*,19 (1):27-34.

Konoshi, T. K. Tsuga, M. Tomita, T. Ichikawa and S. Yoshida. 1999. Development of zigzag ransplanting mechanism for rice transplanter (part 2). *J. Agril. Engg. Today*, 60(5): 91-93.

Manjunatha M.V., B.G. Masthana Reddy, S.D. Shashidhar and V.R. Joshi. 2009. Studies on the performance of self propelled rice transplanter and its effect on crop yield. *Karnataka J. Agric. Sci.,* 22(2) : (385-387).

Mohanty, D. K., Barik K. C. and M.K. Mohanty. 2010. Comparative performance of eight row self propelled rice transplanter and manual transplanting at farmer's field. *J. Agril. Engg. Today*, 34(4) : 15-17.

Nagasaka, Y. Saito H, Kitagawa H, Kobayashi K, Seki M, Tamaki K,Taniwaki K, Miyazaki M and Tateishi K,. 2008. Development of six row rice trransplanter *J. Japanese Soc. of Agril. Machinery,* 70 (1): 79-84.

Pateriya R. N. and R.K. Datta. 2012. Design modifications of mat type rice transplanter *Int. J. Adv. Tech. & Engg. Res*., 2(6): 87-91.

Rajendran R., Ravi V., Valliappan K., Nandanasabapathy T., Jayaraj T., Ramanathan S. and V. Balasubramanian. 2004. Early production of robust seedlings through modified mat nursery for enhancing rice (*Oryza Sativa*) productivity and profit. *Indian Journal of Agronomy* , 50(2) : 132-136.

Sahay C. S., K. K. Satapathy, K. N. Agrawal and K. A. Mishra. 2002. Evaluation of self propelled rice transplanter in vally and terraced land of northeastern hilly region, *J. Agril. Engg. Today*, 26(5-6): 1-10.

Shahare P. U. and Mugdha R. Bhat. 2011. Development and performance evaluation of two row paddy transplanter *Int. J. of Agril. Engg.,* 4 (1): 103 -105.

Shiratsuchi H., Kitagawa H., Okada K., Nakanishi K., Suzaki M., Ogura A., Mastsuzaki M. And Yasumoso S. 2008. , Development of rice "seed mats" consisting of hardened seed with a cover of soil for the rice transplanter, Plant Production Science, 11(1): 108 -115.

Singh, C.P., I.K. Garg, V.K. Sharma, and B.S. Panesar. 1982. Design, development and performance evaluation of ten row tractor mounted paddy transplanter. *J. Agril. Engg. Today.,* 19 (3): 81-89.

Sing K.K., Sat A.A, and S.K. Sharma. 2002. Improving productivity and profitability of rice through tillage and planting management. Japanese Society of Agricultural Science., 75 (7): 396-399.

Singh R., A. Kumar and S.S. Singh. 2005. Response of rice cv Pusa Basmati 1 to different planting methods, *IRRN*, 30

Singh S. 1979. Rice Research and extension in Punjab, Haryana and Himachal Pradesh, *Indian Farming*, 21(7): 69-74.

Singh S. and D.K. Vatsa. 2006. Performance evaluation of PAU manual paddy transplanter in hills of Himachal Pradesh. *J. Agril. Engg. Today*, 30(3) : 19-25.

Singh, C.P. and I.K. Garg. 1984. Field evaluation of a Japanese Paddy Transplanter. *J. Agril. Engg.*, 13(1): 1-4.

Singh G., T. R. Sharma, C. W. Bockhop. 1985. Field performance evaluation of a manual rice transplanter. *J. Agril. Engg. Res.*, 32 : 259-268.

Suseela P. and P.E Dipti Susan. 2003. Transplanting methods in Kerla. *J. Agril. Mech. in Asia, Africa and Latin America*, 52(4) : 56-60.

Syedul M., Baqui M.A. and Dera Bim Ahmad. 2000. Modifications test and evaluation of manually operated transplanter for low land paddy. *J. Agril. Mech. in Asia, Africa and Latin America*, 31(2): 33-38.

Tatugade D.P. and Sonal D. Valvi. 2006. Development and performance evaluation of two row paddy transplanter. Unpublished thesis. B.Tech. Dr.B.S.K.K.V., Dapoli.

Ying Yi Bin; Zhao Yun. 2000. Research in dynamic simulation of separating the planting mechanism in rice transplanter. Agricultural Mechanization in Asia, Africa and Latin America, 28(3): 15-19.

VIII. APPENDICES

Appendix A

1) Measurement of torque required for removal of seedlings

The procedure adapted for measurement of torque for removal of seedlings is as follows

Requirement: Nursery, tray, transplanting arm etc.

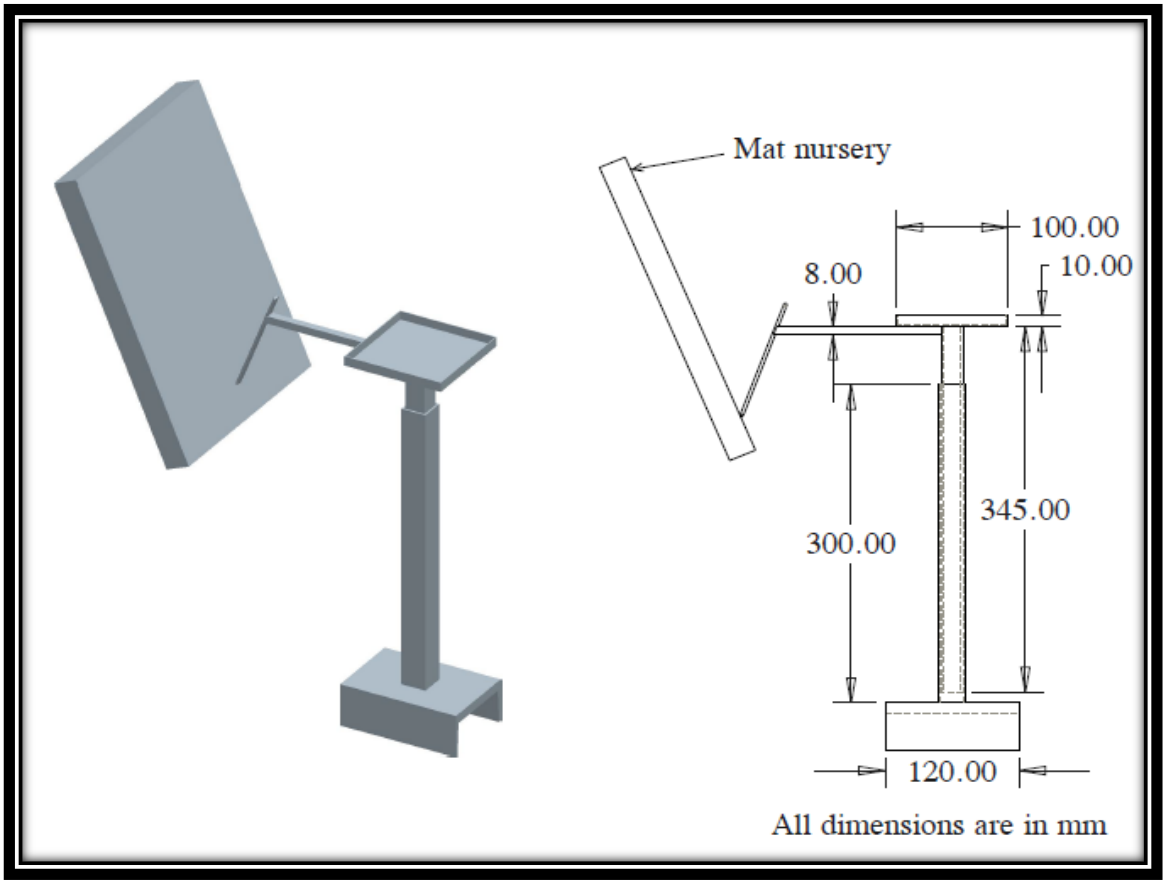


Fig. 8.1 Design dimensions of the tool used for force measurement

The weight on needle to remove seedlings was varied and observations were as follows

Table 8.1 Weight for torque measurement

Sr. No.	Weight Added (gm)	Weight of instrument (gm)	Total Weight (gm)
1.	1800	470	2270

2.	1600	470	2070
3.	1650	470	2120
4.	1750	470	2220
5.	1550	470	2020
6.	1650	470	2120
7.	1600	470	2070
8.	1550	470	2020
9.	1700	470	2170
10.	1600	470	2070
Average			2115

Torque required for one arm (kg-m) = Total weight (kg) × Distance of Point of force application (m)

= 2.1 × 0.15

= 0.317

Torque required for 4 arm = 0.315 × 4 = 1.27 kg-m

Appendix B

Methodology adapted for determination of drawbar pull and rolling resistance

A) Drawbar pull

Drawbar pull for two row transplanter (weight 60kg, ground contact area 0.49 m^2) was obtained by Bhat 2010, to 25 kg. Considering the weight (110 kg) and float ground contact area (0.825 m^2) the drawbar pull for four row transplanter is considered as 55 kg. The measurement of drawbar pull of two row paddy transplanter is shown in Plate 8.1

B) Rolling Resistance

The sametwo row machine was used to determine rolling resistance. The same methodology (Bhat 2010) was also adapted to determine rolling resistance. The machine was pulled for the front side with the help of spring balance; pull required to overcome the resistance of machine (just to get initial motion) was measured.

Rolling resistance for two row transplanter= 35 kg

Considering the weight of four row transplanter and ground contact area, the rolling resistance for new four row transplanter is considered as 85 kg.

Plate 8.1 Measurement of drawbar rolling resistance for two row transplanter

Appendix C

A) Cost estimation of newly developed four row self propelled paddy transplanter

Table 8.2 Cost of material used for developed self propelled paddy transplanter

Sr. No.	Component	Specification	Quantity		Weight (Kg)	Rate (₹)	Amount (₹)
			'm'	No.			
1.	**Main frame**						
	U frame	M.S. box pipe – 50mm×25mm×3mm	1.2	1	1	50/Kg	50
	Base frame	M.S sheet – 300 mm× 3 mm M.S.Flat – 100mm×50mm×3mm	0.5	2 3	1.9 0.7	40 / Kg 40 / Kg	76 28
2.	Float	G.I. sheet 20 Gauge 110 cm×90 cm PVC sheet 110cm×450cm×8mm	-	1 1	4.5 2	60 /Kg 280/Kg	270 560
3.	Seedling feed tray	G.I sheet 22 Gauge 45 cm × 100 cm	-	1	4.8	60/ Kg	288
4.	Connectingpipe	M.S. sq. pipe – 25mm×25mm×3mm	1	2	2	45 / Kg	90
5.	**Fixed angular support**						
	Nut bolts	Ø 1/4" × 50mm Ø 5/16" × 50 mm	-	12 20	-	4/bolt 6/bolt	48 120
	Al. Rivets	Ø 4mm × 12m m Ø 3mm × 5mm	-	20 60	-	1 1	20 60
6.	**Tray movement Mechanism**						
	Roller	Fibre rollers Ø 40 mm × 25mm	-	2	-	10	20
	Chain	Pitch 13 mm	0.44	1	-	50	50
	Nut bolts	Ø 1/4" × 40mm	-	4	-	5	20
	Sprocket	9 teeth Ø 40 mm 18 teeth Ø 80 mm	- -	1 1	- -	70 130	70 130
	Drive axle	M.S rod Ø 16mm× 650mm	0.65	1	1	60	120

7.	Power source	Honda engine (GK 200)	-	1	-	18500	18500
8.	**Power transmission**						
	Bearings	P 205	-	2	-	200	400
	Gear box	GR12.5:1(spur type) GR 12:1(worm type)	-	1 1	-	10300 7000	10300 7000
	Bevel Gear	18 teeth		2	-	375	750
	Sprocket	9teeth Ø mm 14 teeth Ø mm	- -	2 2	- -	70 110	140 220
9.	Transplanting mechanism	YanjiShakthi (2ZT-238-8)	-	2	-	9500	19000
10.	Cage wheel	M.S pipe Ø 25mm M.S. sheet 7mm×3mm	1.57 0.6	1 1	5.2 0.4	60/ Kg 60/Kg	312 24
Total							58666

Hence, total material cost = ₹58666

Initial cost = ₹58666

B) Operating cost of newly developed transplanter

i) Fixed cost

1. $Depreciation = \frac{C - S}{L \times H}$

$$= \frac{58666 - 5866.6}{4 \times 200}$$

$$= ₹65.99$$

$$\approx ₹\ 66$$

2. $Interest/h@10\% = \frac{C + S}{2} \times \frac{i}{100 \times H}$

$$= \frac{58666 + 5866.6}{2} \times \frac{10}{100 \times 200}$$

$$= ₹16.13$$

Housing cost, insurance cost, taxes@ 3% of initial cost

3. Housing cost /h = $\frac{58666 \times 3}{100 \times 200}$

$$= ₹8.80$$

Total fixed cost = 66.00 + 16.13+ 8.80

= ₹90.93

ii) Variable cost

1. Fuel cost /h = 1.9× 78.18

   = ₹148.54

2. Cost of lubrication /h @ 20 % of fuel cost = 148.54 × 0.20

   = ₹29.70

3. Repair and maintenance cost @ 5 % = (58666 × 5) / (100 × 200)

   =₹14.67

4. Wages of operator /h @ ₹300 / day = (2 × 300) /8

   = ₹75

Total variablecost /h = 148.54 + 29.70 + 14.67 + 75

= ₹267.91/ h

Total operating cost = Fixed cost + variable cost

= ₹90.93 + ₹267.91

= ₹358.84/h

Total operating cost, ₹/ha = ₹358.84 × 7.19

Total operating cost/ha = 2580.06₹/ ha

C) Cost of operation of transplanter

The cost of transplanting is the sum of operating cost of machine and cost of nursery preparation and management and labour cost.

i) Operating cost of machine = 358.84₹/hr

≈ 359 ₹/hr

= 2580.06₹/ha

≈ 2580₹/ha

ii) Nursery preparation and management –

No. of labours = 2/ha

Labour cost = ₹120 /day

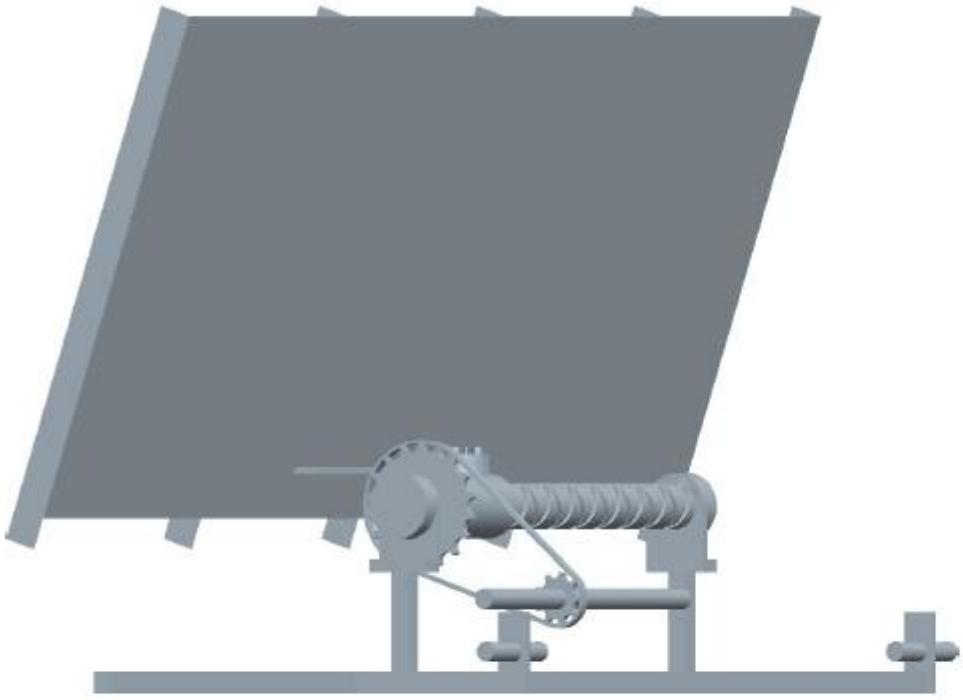
=₹240/ha

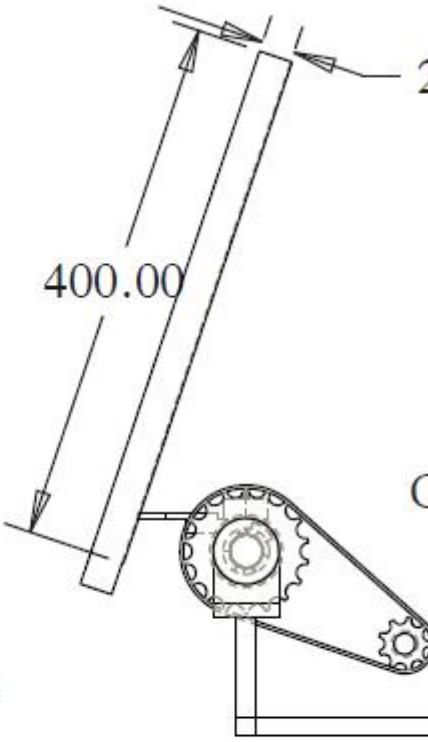
Hence, total cost of transplanting operation = Operating cost of machine + cost of nursery preparation and management

= 2580.06 + 240

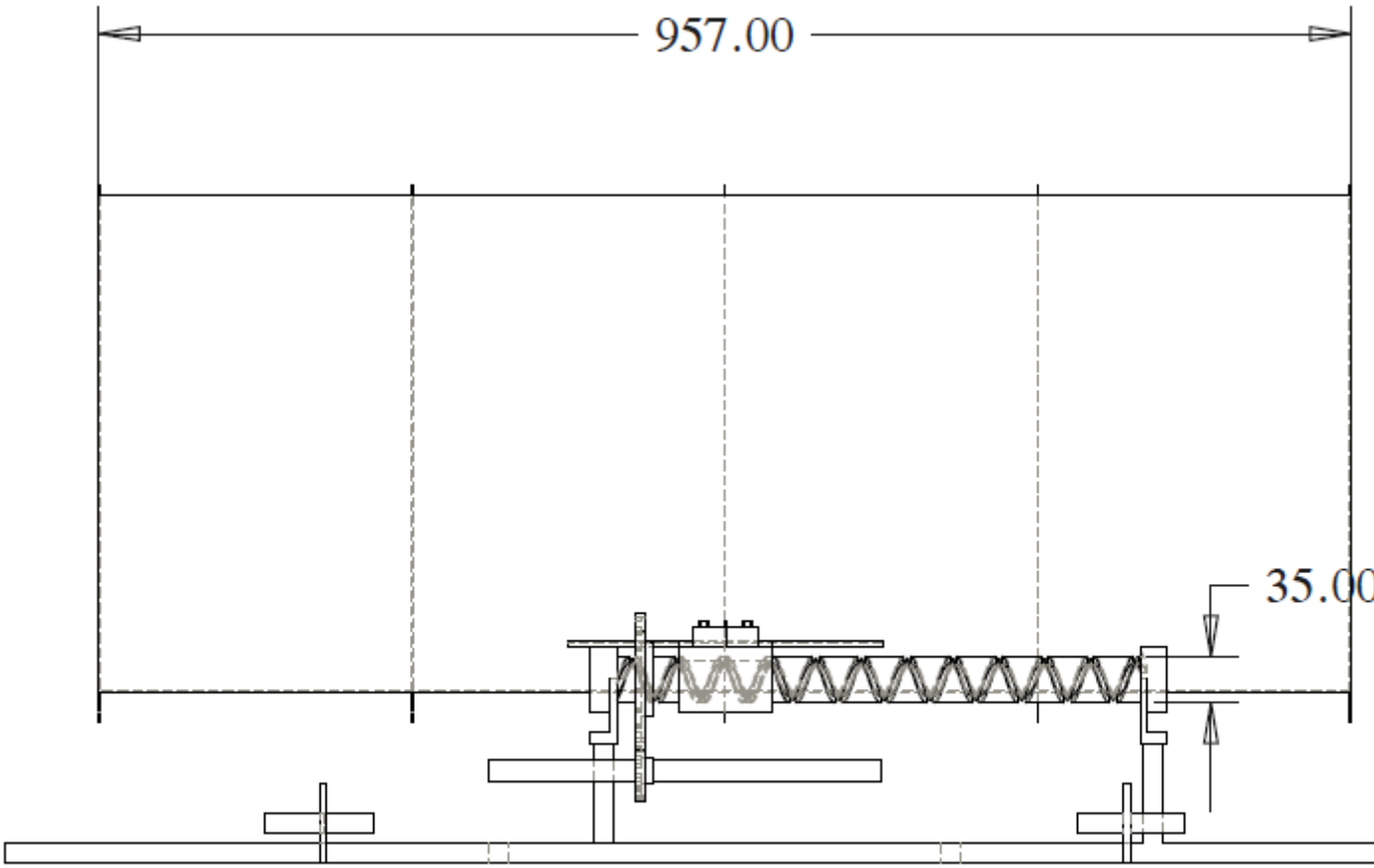
= 2820.06₹/ha

≈ 2820 ₹/ha

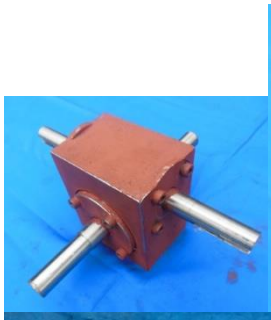
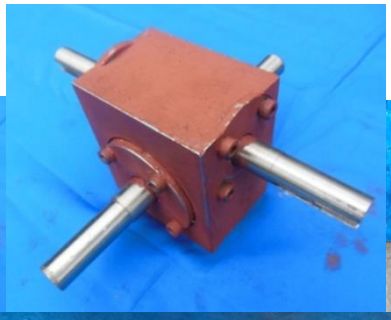




All dimensions are



All dimensions are in


OFF
ON