DESIGN AND DEVELOPMENT OF PADDY SEEDLING TRANSPLANTING MACHANISM

By

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ABSTRACT

Agriculture is the most important sector of the Sri Lankan economy. It is the most important source of employment for the majority of the work force in the country. Approximately 38 percent of the total labor forcewas engaged in agriculture in 1999. Among that highest percentage was in paddy sector. Rice is the major stable food of the country. Releasing of work force to sectorsother than Agriculture is important to develop the country. To release the work force in paddy sector mechanization plays a big role. To feed growing population is a huge challenge. Importation of rice will lead to drain out the economy of the country. Mechanization of paddy sector will lead to higher productivity with releasing of work force to other sectors. The objective of this project was to design a paddy transplanting mechanism to transplant paddy seedlings by small scale farmers in the country.

ACKNOWLEDGMENTS

I wish to express my most sincere gratitude to my supervisor Dr. D.N. Jayatissa, Senior Lecturer, Department of Agricultural Engineering, Faculty of Agriculture, University of Peradeniya, for this excellent supervision, valuable advice and guidance extended to me to complete this research successfully.

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1. INTRODUCTION

1.1 BACKGROUND INFORMATION

The major sector in Sri Lanka is Agriculture sector. Paddy is the main crop in Agriculture sector. The net extent harvested in 2010 Yala season was 376,024 hectares and the total production was 1,671,054 MT and the net extent harvested in 2010/2011 Maha season was 525,017 hectares and the total production was 1,993,014 MT. The agriculture contribution to the national GDP was 11.9 in 2010. About 1.8 million farm families are engaged in paddy cultivation islandwide. The per capita consumption of rice fluctuate around 100kg per year. Rice demand will increase at 1.1% per year and to meet that requirement rice production must grow at the rate of 2.9% per year (www.statistics.gov.lk).

According to the Department of Agriculture,Government of Sri Lanka(2010) the distribution of the methods of establishment of rice in 2000 Yala season had been Broadcasting (85.5%), Row seeding (0.1%), Transplanting in rows (1.4%), andRandom Transplanting (12.6%). The method of establishment of ricedepends on

- Age of the variety
- Availability of moisture
- Climatic conditions
- Availability of inputs and labor

Among these reasons, availability of inputs and labor play a huge role on deciding the method of establishment of rice.

1.2 METHODS OF ESTABLISHMENT

There are two methods practices in establishment of paddy in Sri Lanka. Those are Direct sowing / seeding and Transplanting.

1.2.1 Direct sowing / seeding

There are two types

I. Wet seeding
II. Dry seeding

I. Wet seeding

Pre germinated seeds are broadcasted into puddled and leveled fields which are free from standing water. At the time of puddling basal fertilizer should be mixed. Irrigation should be done when seedlings are of about 5cm tall. The stand establishment by this method varies with the quality of land preparation, weed competition, water management and rainfall during the initial period after sowing

II. Dry seeding

Ungerminated dry seeds are sown to dry soil either in rows or in random. Seed rate generally vary with the severity of the environment and the type of physical damages of the seeds. The seed rate varies from 150Kg/ha to 300Kg/ha depending on the level of weed infestation in dry seeded rice.

Direct sowing / seeding can be done in two ways by manually or mechanically and also be subdivided in to two categories:

a) Row seeding

   This method follows a uniform spacing between plants. This will require planting guides to have uniform spacing. If use mechanical seeders ungerminated seeds have to be used.

b) Random seeding

   In this method seeding is done without a definite distance. It is also known as broadcasting. This is the highly practiced method in Sri Lanka.

Advantages of Direct seeding

- It requires less labor
- Direct seeded plants mature seven to ten days earlier than transplanted rice
- Well establishment of plant
- No transplanting shock to the plant
- Suitable method for short duration varieties

Disadvantages

- More seeds are required
- The seeds may be exposed to birds, rats and snails
- There is greater crop weed competition as rice and weeds are of similar age
- Mechanical weed control is difficult
- Flood and drought can damage the seeds

1.2.2 Transplanting

In this method seed is sown in one place and the seedlings after they have grown a little are transplanted to another. This is done in order to get higher yields and less weeding. In Sri Lanka, the extent of transplanted rice is decreasing due to the scarcity of labor, resources and reduction in cultivation of 4-4 ½ month rice varieties. Manual transplanting is labor intensive and requires 250 -350 manhours per hectare that is 25% of the total labor requirement of the crop.

Paddy transplanting machine has problems of poor traction, sinkage and steerability. Efficient working of self-propelled rice transplanter requires a suitable puddled soil condition, optimum depth of puddling, degree of puddling and soil strength of puddled field. Transplanting will reduce the ability to withstand moisture stress.Transplanting is recommended for 4-4 ½ month varieties and when 3month varieties are transplanted it should be planted with young seedlings. It is recommended to transplant when land preparation is not up to standard and water management is poor.The reason why transplanting of long age varieties show higher yield compared to broadcasting is that transplanting reduces the excessive build up of vegetative biomass due to

transplanting shock.The spacing of transplanted paddy varies with the age of the variety. For long age varieties(4 -4 ½ months) and short age varieties (3 -3 ½ months) best spacing are 20 x 20 cm^2 and 20 x 15cm^2, respectively. A hill should be planted with 2 -4 healthy seedlings. If random transplanting is practiced, hill density of about 25cm^2 for 4 -4 ½ month varieties and 30 -35 cm^2 for 3 -3 ½ month varieties is optimum. For transplanted rice seedling age is a major factor in determining yield. The set back of growth due to uprooting and replanting of seedlings, transplanting shock is occurred. This increases with the increase of age of seedling of the variety. In general, the effect of transplanting on yield increases,but it decrease with age.Seedling age (in calendar days) also vary with the environmental condition and the type of nursery. The physical and bio-chemical factors would set a minimum and maximum age for a particular nursery. Minimum age of a seedling for transplanting would be about 12 -14 days. For a three month age crop seedling age should not be increased beyond 15 days while for a 4 month crop it is about 21 days. Seedling age of a dapog nursery should not exceed 14 days (www.agridept.gov.lk/).

1.2.2.1 Nursery systems

Seedling nurseries use 15 -20% of the total farming area.In preparing the nursery seedbed, the surface needs to be level, free form weeds, and well drained. Low rates of nitrogen and phosphate fertilizer can be applied to the nursery. Seeding rates vary from 400 to 800 kg per hectare of nursery depending on locality, soil type, and seed quality. The choice of a particular nursery system depends on the availability of water, labor, land and agricultural implements.

There are 5 nursery systems for transplanting:

- the wet-bed nursery
- the dry-bed nursery
- the dapog or mat nursery
- A bubble tray nursery
- seedling boxes for mechanical transplanting

A) Wet-bed method

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. Seed rate should be adjusted for small grain varieties. Nursery site should be without shade and with adequate irrigation and drainage facilities. Quality rice seeds should be soaked in cleans water for a minimum period of 24 hrs, and incubate in a warm dry place for about 48 hrs. Sprouted seed should then be broadcasted uniformly on the nursery bed. Before seeding the nursery should be drained completely. Thereafter, nursery should be maintained in moist condition for about 5 days. Once the seedlings are established, the nursery is impounded with water and raises the level gradually. The best stage of transplanting seedling is about 15-21 days. Nursery should be free from weeds, any pest or disease incidence and nutrient deficiencies.If such conditions occur it must be treated at the nursery level.

B) Dry-bed method

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. Distribution of thin layer of half burned paddy husk could be distributed on the nursery bed mainly to facilitate easy uprooting. Dry or just sprouted seeds are sown in rows, which are about 10cm apart to dry nursery bed.Random sowing also possible but should be discouraged as the weed control is difficult. Adequate irrigation facilities and free of shade are required for the site. 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. Moisture stress should be eliminated in the nursery. If soil nutrient content is low, mixing of basal fertilizer is recommended. The advantage of this method is that seedlings are short and strong, has longer root system than wet bed and can be raised even during heavy rain which is not possible with wet bed.A major

drawback is those roots may get damaged during pulling. Seedlings of upland nurseries may also get infected with blast and are more prone to pests such as rodents etc.

C) Dapog method.

This method 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 m2/ha of the transplantable land. Dapog method required area is much smaller than conventional nurseries. Seed rate is about 125Kg/ha. 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.Banana leaves without mid rib, poly ethylene sheets or any flexible material are recommended to cover the surface to prevent seedling roots penetrating to the bottom soil layer. Cemented floors can also be used for the same purpose. Burned paddy husk or compost is used to cover the seed bed with about 1/4" thick layer.Sow pre-germinated seeds uniformly on the seed bed to a thickness of 2-3 seedsto a density of 700-1000 g/m2. Splash the germinating seeds with water and press down by hand or with a wooden flat board in the morning and afternoon up to 3-4 days to prevent uneven growth. Frequent irrigation is required if seed were sown without the bedding, and to reduce temperature. Transplanting of nursery should be done in 12-14 days after germination of seeds. The advantage of the "dapog" over wet/dry bed nursery is that less area is needed and the cost of uprooting of seedling is minimal. However since the seedlings are small transplanting is difficult. Very young seedlings from dapog nurseries are subjected to less transplanting shock than of other nurseries, thus these seedlings are more suitable for short aged varieties. Other disadvantage of dapog seedling was the field should be very well leveled and free of water since the seedlings are very short (www.knowledgebank.irri.org/).

D) 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.

E) Seedling boxes for mechanical transplanting

Mechanized 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.

When considering the details, transplanting of paddy is better over other methods as they have got some advantages.When practicing manual transplanting,labor scarcity is a major problem. Mechanical transplanting of paddy seedlings requires high capital and skilled labor and land area also become a problem as prevailing machines required comparatively large land area. Mechanical transplanting machine is a better solution for the Sri Lankan condition. Still problem associate the situation should be solved. Those are high capital, spacing of rows, and weight of the machine and size of the machine.

1.2.2.2 System of rice intensification (SRI method)

SRI method is developed to obtain the full potential of paddy plant and give high yield.The method expects 5 objectives to be achieved.

- A plant should have more number of tillers
- The number of effective tillers should be higher
- Panicle length and number of grains per panicle should be higher
- The grain weight should be more
- The roots should have extensive and healthy growth

And the method has 6 attributes

- Wide planting
- Less seeds
- Transplanting young seedling
- Less water
- Turning back the weeds into the soil
- Use of organic manures

Inter-row and intra-row spacing used in SRI method differ with the variety as 25 x 25cm, 30 x 30 cm, 40 x 40 cm, 50 x 50 cm. Spacing is higher than normal transplanting methods. Any rice variety can be cultivated by this method. Theseed rate is about 10kg/ha.

Advantages of SRI

- Saving on seed cost as the seed requirement is less
- Saving on water as Irrigated – Dry method is followed
- Cost of external inputs gets reduced as chemical fertilizers and pesticides are not used
- Incidence of pests and diseases is low as the soil is allowed to dry intermittently
- More healthy and tasty rice as a result of organic farming practices.
- Higher yields due to profuse tillering, increased panicle length and grain weight
- Seed multiplication with less quantity of parent seeds
- Farmers can produce their own quality seeds

Disadvantages

- Higher labor requirement
- Cost of production is high
- Time consuming method

1.3 RESEARCH PROBLEM

Mechanical transplanting of paddy seedlings is a solution to the prevailing situation in the Sri Lanka 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.Still the transplanting machines available for the country are imported.Engine driven transplanters are high in cost and the inter-raw, intra-raw spacing are fixed which are not suitable for the Sri Lankan condition. Existing manually operated transplaners are inefficient. The main reason for the poor acceptance was the law capacity of the machine. A simple engine operated transplanter or manually operated transplanter having an average capacity of one hectare per day would be a better solution.

1.4 OBJECTIVES

Main objectives in this study were to:

- Design a mechanism for transplanting paddy seedlings
- Test the performance of the transplanting mechanism

2. LITERATURE REVIEW

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

- A seedling tray like a shed roof on which mat type rice nursery is set.
- A seedling tray shifter that shifts the seedling tray like the carriage of typewriters.
- 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.

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 700 to 10,000 m^2/day (en.wikipedia.org/). Transplanting of paddy seedlings can be categorized into three groups as fallows:

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

2.1 TRANSPLANTING BY HAND

This method is good for small fields and to fill patches.Manual transplanting does not require costly machines and is most suited for labor-surplus areas and for small rice fields. Manual transplantingcan be done in fields with less than optimal leveling and with varying water levels. Seedlings are raised in a wet, dry or modified mat nursery. Proper nursery management will produce healthy, vigorous seedlings.

Limitations:

- Transplanting is tedious and time-consuming (up to 30 man days /ha)
- Planting laborers can suffer from back problems(health risk)
- Difficult to get enough labor at peak periods to planton time
- Difficult to maintain optimum spacing and uniform plant density, especially with random transplanting and contract labor
- Low plant density with contract transplanting on area basis lowers yields

- Risk, in rainfed areas, that seedlings (especially of modern varieties) may get too old before rain falls and the field is ready to be planted

(www.knowledgebank.irri.org)

2.2 MANUALLY OPERATED TRANSPLANTERS

Manually operated translators are powered by man power. Operator has to move with the transplanter and power the machine by hand. These machines are small enough to operate manually. Various types of machines existin the world.In Sri Lanka, mainly those machines are designed by FMRC (Farm Mechanization Research Center at Mahailluppallama) and FMTC (Farm Mechanization Training Center at Anuradhapura) targeting small scale farmers in the country. The details of the 6-row paddy seedling transplanter,introduced by FMRC,shown in the Figure 1 (www.rajkumaragromachines.com/) are given below.

1.	Function	:	For transplanting mat type paddy seedlings. Suitable for all transplanted type paddy varieties.
2.	Specification	:	
	i. Type	:	Manually operated
	ii. Power requirement	:	One operator and one labor to transport mat seedlings
	iii. Overall dimensions	:	1230 x 1250 x 835 mm
	iv. Weight	:	17 kg
	v. Capacity	:	0.25 ha / day
3.	General Information	:	The machine consists of a seedling tray, forks, handle and skids. By pressing the handle, the forks pick-up the seedlings and plant them in 6 rows. For every stroke of the handle the seedling tray moves side wards for uniform picking of seedlings by the forks. The operator has to pull the machine while punching the handle at the desired spacing. The Row to row spacing is 200 mm.

The manually operated rice transplanter manufactured in China is shown in the Figure 2.

Figure 1: Hand powered mechanical transplanter

Figure 2: Hand cranked rice transplanter

This is walking backward type. It can plant 2 rows simultaneously. The row spacing is 250mm, planting distance can be adjustable.Specifications of this transplanter are given below:

- Weight: 20 kg
- Turning radius: 210 mm

- Max. planting depth: 65 mm
- Max planting frequency: 120/minute
- Resistance of crank: 1.5-2 kg
- Resistance of moving: 1-2 kg
- Planting speed: about 530 square meters/hour

This transplanting machine is designed to transplant bare plant without mud. The plant from the nursery should be taken after wash off the soil or mud.Machine is operated by one hand while it is pulled by the other hand. It has very light and compact structure for easy operation and maintenance. This machine is used in china for small scale farmers (www.rajkumaragromachines.com/).

2.3 ENGINE OPERATED TRANSPLANTERS

Engine operated translators are powered by engine. Operator has to move with the transplanter or in some, the operator can sit on it. The walking behind type engine operated transplnters are light enough to operate by one operator and other type transplanters carry one or more labors to operate and to add mats to trays.Engine operated transplanters manufactured by China, Japan, South Korea, India and other industrialized countries are not suitable for the Sri Lankan condition as the field conditionsand spacing used by our farmers are different and the cost of the machines are higher.

There are two type of engine operated transplanters exist

I. Walking behind ricetransplanter
II. Self-propell rice transplanters (Riding type)

I. Walking behind rice transplanter

This type of transplanter(Figure 3) required operator to walk behind and operate. (KUBOTA paddy transplanters)

The rice transplanter consists of prime mover, transmission, engine, float, lugged wheels, seedling tray, seedling tray shifter, pickup fork and pickup fork cleaner. It uses mat type nursery and transplants the seedling uniformly without damaging them. The planting depth and hill-to-hill spacing can be adjusted. Automatic depth

control helps in maintaining uniform planting depth. The machine has safety clutch mechanism, which prevents break down of planting device from the impact against stones in the field. For operation, the machine is transported to the field and mat type nursery is loaded in the tray of the transplanter. The machine is put in transplanting mode and operated in the puddled field. The performance of the transplanter is checked within 2-3 m of travel for transplanted seedlings for hill-to-hill distance, depth of placement and number of seedling per hill.If the transplanting is in order the machine is operated in normal transplanting operation.

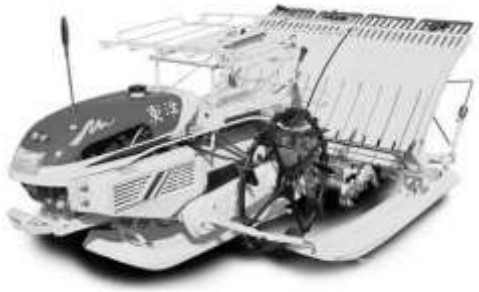

Figure 3: Walking behind type mechanical rice transplanter

Specifications of the transplanter are given below:

Length (mm)	: 2450
Width (mm)	:1480
Height (mm)	:840-950
Weight (kg)	:170
Row interval (mm)	:300
Hill-to-hill spacing (mm)	:117/131/147
Power Requirement (hp)	:3.7, petrol engine

II. Self-propell rice transplanters (Riding type)

This type of transplantersare capable to carry operatorson the machine.A single wheel driven transplanter is shown in the Figure 4.

It is fitted with diesel engine. The machine transplants seedlings from mat type nursery in eight rows in a single pass. The drive wheel receives power from the

engine through V -belt, cone clutch and gearbox. A propeller shaft from the gear box provides power to the transplanting mechanism mounted over the float. The float facilitates the transplanter to slide over the puddled surface.

Figure 4: Self-propell type rice transplanter

The tray containing mat type nursery for 8 rows is moved sideways by a scroll shaftmechanism, which converts rotary motion receivedfrom the engine through belt-pulley, gear anduniversal joint shaft into linear motion of a rodconnected to the seedling tray having provision toreverse the direction of movement of tray after itreaches the extreme positions at ends. Fixed forkwith knock out lever type planting fingers(cranking type) are moved by a four bar linkage togive the designed locus to the tip of the planting finger.Specifications of this machine are given below:

Type	: single wheel driven
Length (mm)	: 2410
Width (mm)	:2130
Height (mm)	:1300
Engine (hp)	:4.0, air cooled diesel
Numbers of rows	: 8
Row spacing (mm)	:238
Hill-to-hill spacing (mm)	: 100 - 200
Working speed (km/h)	:1.5-2.0
Speed of travel on road (km/h): 8.24	
Field capacity (ha/h)	:0.13 – 0.20
Weight (kg)	: 320

A four wheel, riding type transplanteris shown in the Figure 5.

Figure 5: Self-propell type rice transplanter

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

Overall length (mm)	: 3020
Overall width (mm)	:2140
Overall height (mm)	:1530
Weight (kg)	: 570
Engine type	: 4-cycle, air-cooled OHV gasoline
Maximum output (rpm)	: 12.0 – 1800
Starting method	: Electric
Steering	: Power steering
Number of rows	: 6
Planting width (cm)	: 30
Transplanting speed (m/sec)	:0.24 – 1.3

3. MATERIALS AND METHOD

3.1 MATERIALS

Following materials were used to manufacture the rice transplanting mechanism:

- Iron strips
- Iron rods
- Bearings
- Sprocket wheels and chains
- Nuts and Bolts, Rivets
- Aluminum plates and rods
- Wood
- Springs

Equipments:

- Toolkit and Measuring Equipments
- Welding plant (Arc and Gas welding)
- Lathe machine
- Iron cutters, Benders, Drill, Grinders
- Saws (wood saw, Hacksaw)

3.2 METHOD OF DESIGN

This included designing of

- Planting unit
- Paddy seedling tray
- Power transmission system and attachments

3.2.1 Designing of planting unit

When designing the planting mechanism following aspects were considered:

I. Moving pathway, speed of traveling

II. Plant catching mechanism

III. Depth of planting

I. Moving pathway

Prototype design (Figure 6) was build using wood, nuts and bolts and evaluated to get the required measurements. The design was simple and with less number of moving parts. Free play became a problem when shafting gets long.

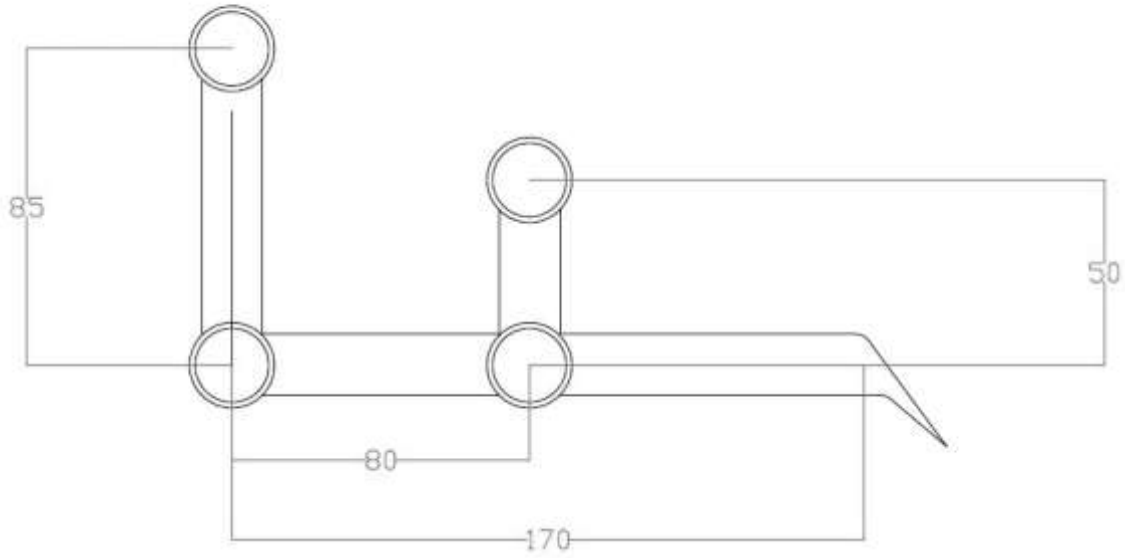

Figure 6: Dimension of the planting arm

II. Plant Catching Mechanism

There are several parameters were considered in designing the plant catching mechanism:

- Place of catching
- Number of plant per catching
- Distance of travel
- Releasing Point
- Tension on plants
- Angle of Planting

Plant should not be damaged while catching and releasing by the planting arm. Suitable speed, position and angle of catching and angle of planting, height of tray, width and length of figures are the factors governing the proper planting mechanism.

Distance of travel was calculated according to walking speed of a normal man.

Man walking speed = 1.5 km/ hour

=(1.5 km/ hour)*(1000m/km)*(1hour/60min)

=25m/min

Diameter of the ground wheel =30cm

Perimeter of the ground wheel $=2\pi r$

$=2*\pi*30/2$

=94.277cm

Distance of plants =25cm

Number of plants per one ground

Wheel rotation $=3.77 \approx 4$

Planting arm and fingers (Figure 7) are made of flat iron. Fingers are welded to the arm. Tension of the plant should be enough to catch the plants and to prevent release until end point and not to damage the plant during the process.Angle of planting was decided by tray feeding point angle and moving direction.

Figure 7: Planting arm

III. Depth of planting

Planting depth is important for growth of roots and to stand with the submerge condition. Planting depth was controlled using height adjustable floater.Figure 8 shows the floater and planting arm at lowest position.

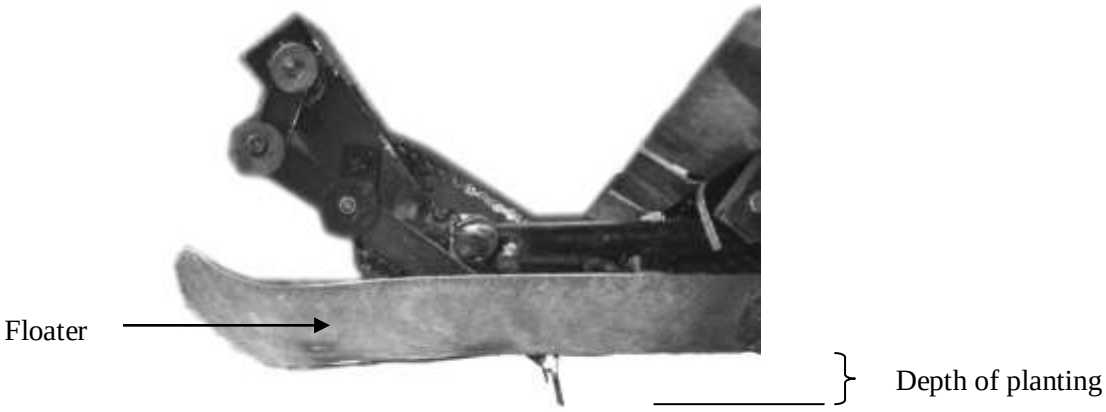

Figure 8: Planting arm at lowest position

3.2.2 Designing of Tray

Tray is to carry the dapog mat and to direct the plants to planting arm. Basic factors (width, length, angle, speed of movement) were considered in designing the tray mechanism. As two plant rows were planted at once, the tray width was twice as plant space. Movement of the tray per one planting of arm was decided by the volume taken away from the planting finger at a time. The volume taken by finger depends on the space of the finger jaw. Tray movement decides by the speed of ground wheel rotation.

To make constant feeding of dapog mat to the planting arm it should come down to the end of the tray by gravity.Higher angle reduce energy requirement to feed the dapog mat to transplanting arm while too much angle affect on falling down and compaction of nursery at end of the tray making difficult to take out the plants from the nursery by transplanting arm.

Length decided by the power given to the machine. Higher the length of the mat makes higher the power requirement to carry the weight of the mat. So to reduce weight of the machine tray length was reduced to have optimum weight. The mechanism used to move the tray is shown in the Figures 9 and 10.

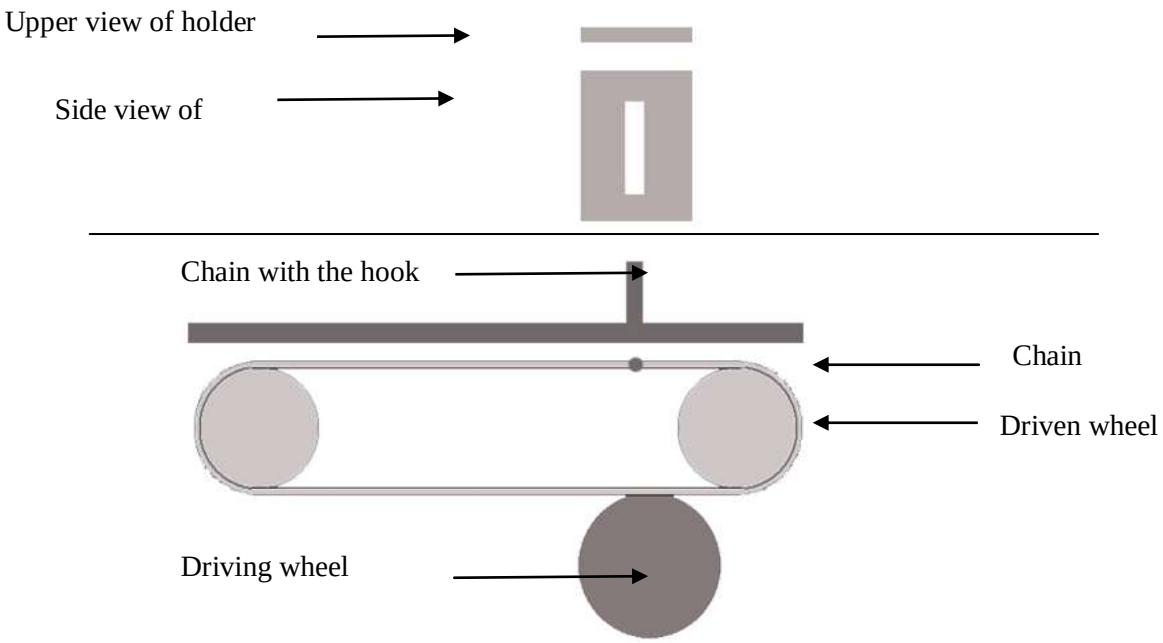

Figure 9. Tray moving mechanism

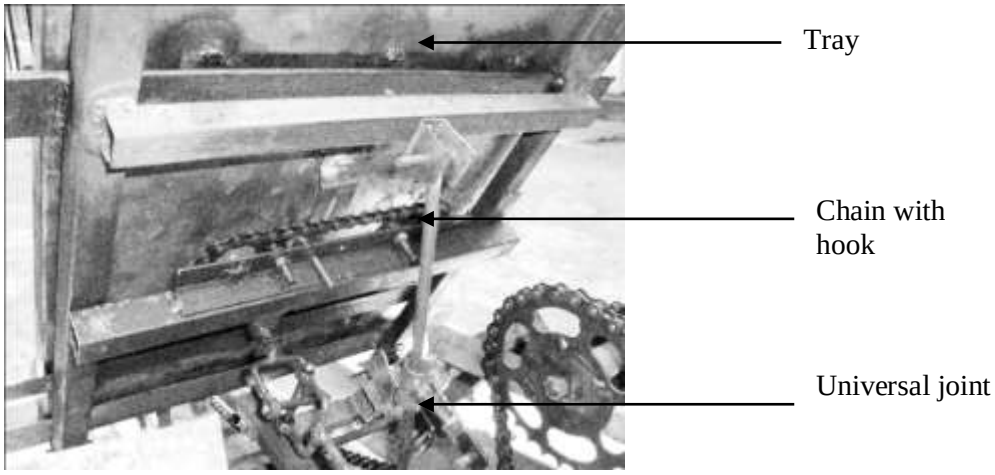

Figure 10. Tray moving mechanism

3.2.3 Power transmission system and attachments

It was decided to havewithin row spacing of 25cm and plant four hills of seedlings per revolution of the ground wheel. Therefore, speed ratio of 1:4 from ground wheel axial of planting unit was needed. Therefore 47 teeth sprocket wheel was mounted on the ground wheel axle and 17 teeth sprocket wheel was mounted on the planting arms. Then, 17 teeth planting arm sprocket was connected to a 21 teeth sprocket wheel by chains. 47 teeth sprocket was joined to 18 teeth sprocket wheel by chains. 18 teeth

sprocket and 21teeth sprocket was mounted on same axel as shown in the Figures 11 and 12.

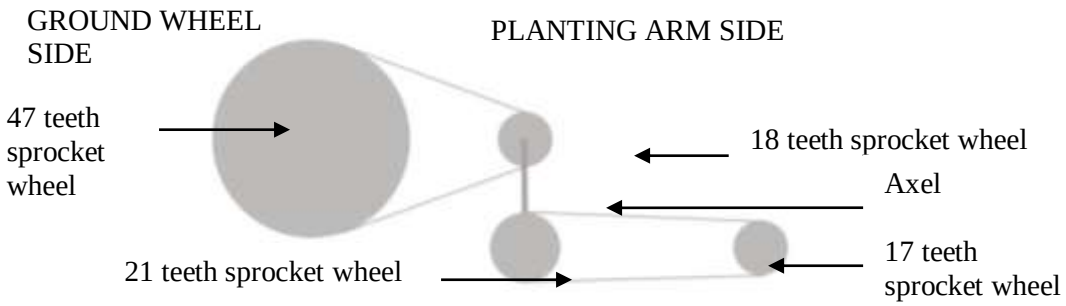

Figure 11: Power transmission to planting arm

Gear reduction between 47 teeth sprocket and 18 teeth sprocket wheel = 47/18

= 2.6111

Gear reduction between 21 teeth sprocket and 17 teeth sprocket wheel =21/17

=1.2352

Total gear reduction between ground wheel to planting arm =2.6111+1.2352

=3.8463

Power transmission to ground wheel to planting arm was done by several steps using sprocket and chains. Planting arm takes ≈1cm wide section from bottom(mud part)of the dapog at a time. Therefore tray should move 1cm at each cycle of planting arm. Tray move 20cm from one side to its position. Driving arm rotates once to move 20cm of the tray. There for the gear reduction of the planting arm and tray was 20:1.

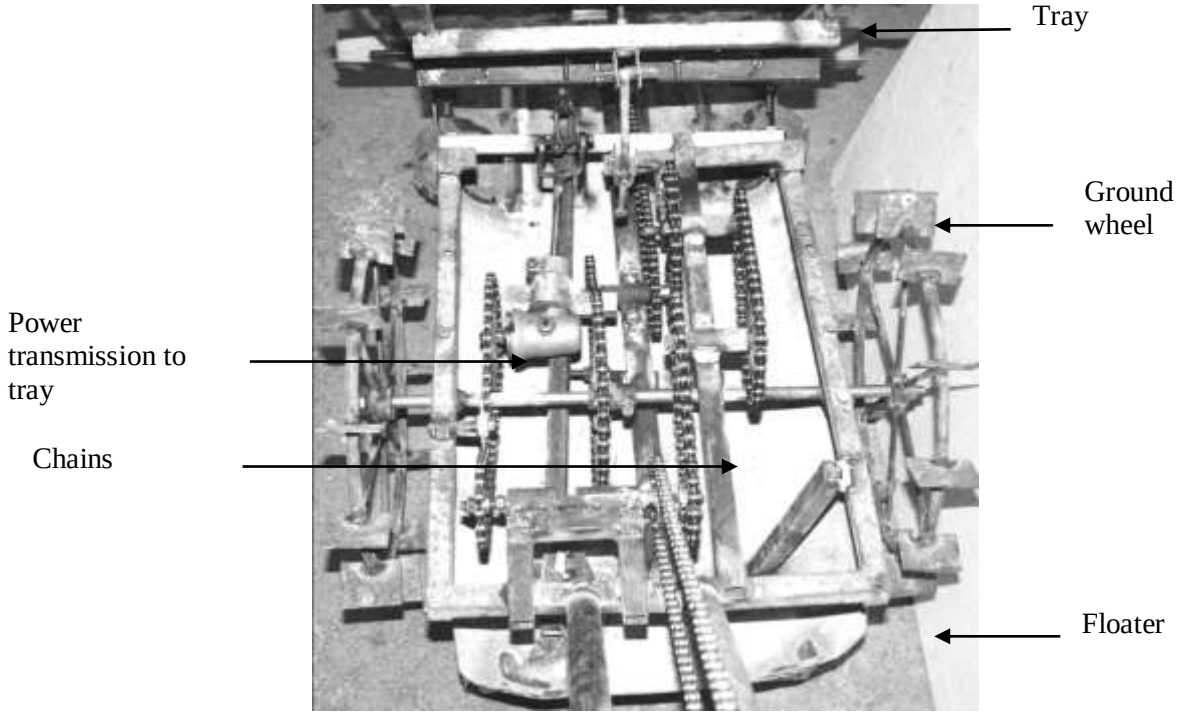

Figure 12: Power transmission to tray

The complete design is shown in the Figure 13.

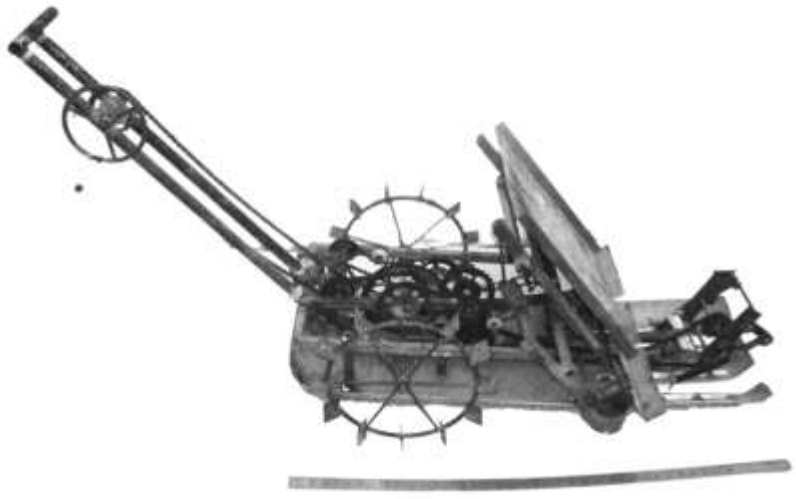

Figure 13: Complete design of the paddy transplanter

4. RESULTS AND DISCUSSION

Prototype mechanism was evaluated in the field, and it worked. There were some points to be redesigned. Tray mechanism worked but the design should be altered or improved. The tray move to both left and right directions while the tray on a grove. That resulted high friction. Therefore it is better to have nylon bushes and iron or aluminum rodsto reduce the friction. Tray moving mechanism made using nylon sprocket wheel. As the tension is high in that chain the nylon sprocket get damaged easily. It's better to use iron sprocket with same diameter and number of teeth to reduce the damage when tension is high. The sprocket and chain used for the machine was foot cycle chains and sprockets. When machine is operated the sprockets get damaged by bending the teeth. So it is better to have motorcycle chains and sprockets to power transmission. But that will result an increase in weight. Therefore, instead of chain and sprocket speed reducing mechanism, a gear system should be used.

In this machine ground wheel supplies the power to operate transplanting arm and tray mechanism. Pulling the machine will rotate the ground wheel. Increasing the size and number of lugs (fins) around ground wheels will increase contact area of the ground wheel with the field and make it easy to operate.

The machine has to pull to operate. Ergonomically it is better to push weight rather than to pull. So it is better to turn the handle and the power supplying mechanism to push the machine instead of pulling it.

Use of aluminum and alloy for constructionwill help to reduce the weight of the machine. The machine used to plant 2 rows simultaneously. Number of plants per one hill can be increased while altering the tray moving distance and adding engine to power the operation.

The dapog mat was compacted due to high tray angle.Tray angle should be reduced to avoid the problem. Suitable dapog for the machine must have amud layer 1cm or less thick. Increased thickness of the mud layer increases the power requirement to the planting arm.

Diameter of the ground wheel axel should be increased to have better power supply and stability of the machine. Axel of the sprocket wheel must be constructed using

shafting iron to reduce the friction and play. Instead of iron bushes for sprocket wheel axel nylon bushes must be used.

5. CONCLUSIONS AND RECOMMENDATIONS

The paddy seedling transplanting machine worked satisfactorily. But, there were some improvements to be done before introducing to the farmers. The machine is driven by man power but engine can be coupled to enhance the performances. Machine can be developed to transplant several rows simultaneously. Weight of the machine should be reduced by removing sprocket, chains and adding small gears. The dapog must have thin mud layer for easy removal of seedlings.

6. REFERENCES

Department of Agriculture, Government of Sri Lanka, 2010., www.agridept.gov.lk/index.php/en/crop-recommendations/904.htm Accessed on 6/6/2011

en.wikipedia.org/wiki/Rice_transplanter Accessed on 20/6/2011

www.knowledgebank.irri.org. Accessed on 15/6/2011

www.knowledgebank.irri.org/ericeproduction/II.5_Nursery_systems.htm Accessed on 15/6/2011

www.rajkumaragromachines.com/rice-machines.html#hand-cranked-rice-transplanter Accessed on 21/6/2011

www.statistics.gov.lk/agriculture/Paddy%20Statistics/PaddyStatsPages/2010Yala.pdf 2010. Accessed on 6/6/2011

www.tnau.ac.in/aecricbe/aetc/fm2-11.htm Accessed on 20/6/2011