DEVELOPMENT OF PADDY WEEDING ATTACHMENT TO MINI TILLER

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PROJECT REPORT

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DECLARATION

We hereby declare that this project report entitled **"DEVELOPMENT OF PADDY WEEDING ATTACHMENT TO MINI TILLER"** is a bonafide record of project work done by us during the course and that this report has not previously formed the basis for the award to us of any degree, diploma, associate ship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

Certified that this project report entitled **"DEVELOPMENT OF PADDY WEEDING ATTACHMENT TO MINI TILLER"** is a record of project work done by Ms. Athira P, Ms. Gayatri Gopan and Mr. Nipin Balu K under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to them.

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DEDICATED TO OUR BELOVED PARENTS

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LIST OF ABBREVIATIONS USED

AICRP	-	All India Coordinated Research Project
Al	-	Aluminium
Anon	-	Anonymous
DAS	-	Days after sowing
FC	-	Field capacity
FIB	-	Farm Information Bureau
Fig	-	Figure
GI	-	Galvanised Iron
gm	-	Gram
h	-	Hour
ha	-	Hectare
ICAR	-	Indian Council of Agricultural Research
IWM	-	Integrated Weed Management
KAU	-	Kerala Agricultural University
KCAET	-	Kelappaji College
kg	-	Kilogram
kmph	-	Kilometre per hour
kW	-	Kilowatt

l - Litre

m - Metre

ml- Millilitre

mm- Millimetre

MT - Million Tones

rpm - Revolutions per minute

Rs - Rupees

TFC - Theoretical field capacity

TNAU - Tamil Nadu Agricultural University

% - Percentage

INTRODUCTION

CHAPTER I

INTRODUCTION

Rice is the staple food of over half the world's population providing 20% of the world's dietary energy supply. India is one of the world's largest producers of white rice and brown rice, accounting for 20 percent of world's production. Estimates for 2015-16, suggests that the total rice production in India is estimated at 104.32 million tonnes which is lower by 1.17 million tonnes than the production of 105.48 million tonnes during the preceding year (Government of India, 2016-17).Rice is one of the most important crop grown in Kerala. It occupies 7.46% of the total cropped area of the state. Palakkad, Alappuzha, Thrissur and Kottayam accounts for about 81.2% of total rice production (Anon, 2016). However, the area under rice has been falling at an alarming rate ever since 1980s. From 8.82 lakh ha in 1974-75, the paddy area has come down to 1.96 lakh ha in 2015-16(Anon, 2016). Even though there was a marginal increase in the productivity of rice in the past four decades, the total production of rice was observed to be declining (FIB, 2017).The production has concomitantly declined from 13.76 lakh MT in 1972-73 (peak of production) to 5.49 lakh MT in 2015-16 (Economic review, 2016). This is because area under paddy cultivation has increasingly been converted for cultivation of other crops as well as for non-agricultural purposes. This is mainly due to the low relative profitability in paddy cultivation, which in turn is due to rising wages and relative price changes in favour of competing crops. Another major challenge is seasonal shortage in agricultural labour.

A reversal of this long-term trend in paddy cultivation in Kerala is necessary because paddy fields are a vital part of Kerala's environment and ecological systems. They provide natural drainage paths for flood waters, conserve ground water, and are crucial for the preservation of a rich variety of flora and fauna. In several regions of Kerala paddy cultivation is carried out in a manner that enriches the geographical features of the region.

Highly labour intensive practises are not economically sustainable in a state like Kerala, where wages are very high. Farmers also face the problem of acute labour shortage during the periods of intense crop production activity. The widely accepted solution to these problems is the adoption of mechanised farming. James and Regina (1994) suggested that increased rice production can be achieved by mechanisation of rice group farms in Kerala. James and Pillai (1998) have discussed the emerging technical strategy for rice farm mechanisation and highlighted the advantage in mechanising the highly labour intensive operation. There has been a major thrust on farm mechanisation in Kerala by the State government as well as the local self-governments.

In the present scenario, machinery use in the intercultural operations in paddy cultivation are also of due importance. One such operation is paddy weeding. Ever since man started growing crops, he had come with the problems of weed. Weeds compete with crop plants for nutrients and other growth factors and in the absence of an effective control measure, remove 30 to 40 per cent of applied nutrients resulting in significant yield reduction (Dryden and Krishnamurthy, 1977). Delay and negligence in weeding operation, affect the crop yield and the loss in yields due to weeds in upland rice crops varied from 40 to 60 percent and in many cases, caused complete crop failure (Singh, 1988).

Traditionally, the most common method of weed control is manual hand weeding by labourers. In manual weeding, weeds are uprooted by hands and it requires more time, labour and the weeding costs are high. Moreover, the method proves to be a discomfort to the labourers. Recently, mechanical and chemical weed control methods are replacing manual weeding and are becoming popular. In the chemical method, farmer uses weedicides which may be pre-emergent or post-emergent type. The large-scale use of weedicides may lead to residual effects, can alter physico–chemical property of soil and may be hazardous to environment (Ragesh, 2015).

Mechanical weeding is performed by de-rooting the whole weed plant either by simple hand tools or by mechanical weeders. It not only uproots the weeds between the crop rows but also keeps the soil surface loose, ensuring better soil aeration, stimulating the activity of soil micro flora, reducing the evaporation of soil moisture, facilitating the infiltration of rainwater and water intake capacity (Nag and Dutt, 1979., Gite and Yadav, 1990., Gite and Yadav, 1985). Manual hand weeding can give a clean weeding but it is a slow, time consuming and a labour intensive process.

The other types of non-chemical weed control methods are flame weeding, pneumatic weeding, and laser weeding. These methods require other sources of energy to control weeds. The flame weeder, for example, requires propane gas to produce heat which elevates the temperature of the weed plants and either burns the weed biomass or causes weed plant cells to rupture and damage the plant structure. Pneumatic weeders require an air compressor, which injects compressed air into the soil to loosen and uproot small weeds (Weide et al., 2008). Both of these methods have substantial energy requirements and are not used in India.

Poor weed control leads to loss of several tones of major food grains every year. Therefore, timely weeding is very much essential for a good yield and this can be achieved by using mechanical weeders which perform simultaneous job of weeding and tilling that reduce labour, cost of weeding and drudgery involved in manual hand weeding. Among the mechanical weeders, power weeders offer higher operating comfort and efficiency. But the high initial cost and maintenance cost of power weeders limits their use, especially among marginal farmers. Hence it is imperative to find an alternative to overcome the problems enumerated above.

Mini tiller is a farm implement for stirring and pulverizing the soil, either before planting or to remove weeds and to aerate and loosen the soil after the crop has begun to grow. They are generally powered by a small petrol engine. Mini tillers have a robust design. They are mostly used by vegetable farmers, in small homestead farms, nurseries etc. and are easy to operate and handle. But, mini tillers are found to have only limited hours of usage in a year. They have the potential to become a multi-purpose implement for different agricultural operations at the level of small and marginal farmers.

Mini tillers were first introduced in agriculture for preparing seed beds and for weeding horticultural crops. If they are used judiciously they can perform many operations except deep tillage. The compact structure of mini tiller offers an advantage for its utility in various operations even in paddy cultivation. Mechanised transplanting has become very common in the major rice producing areas of the state. Even though transplanting system is adopted with a view to reduce the weed menace, the problem is still persistent in rice cultivation. The paddy weeders presently available in the market cannot be used for any other purpose and they are costly for small and medium farmers. The annual hours of use do not justify the cost of the machines. Hence refinement and modification of the mini tiller by providing a paddy weeding attachment can be very useful to the farmer. This is because the cost involved can very well be justified due to the increased annual hours of use.

In general, mini tillers presently having limited hours of usage can be made cost effective and can be a boon to the farmer if suitable attachments are developed to enable multipurpose use in horticulture as well as for paddy cultivation. Considering these factors, a study was undertaken with the following objectives:

- Assessment of powered weeders for paddy weeding
- Development of a wetland paddy weeding attachment to mini tiller.
- Evaluation of the developed mini tiller for paddy weeding.

REVIEWS OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

As old as agriculture, weed control is also an old practice in agriculture. It is the method of removal of weeds from the surroundings of main crop for the better growth of the main crop. Several studies and research works were being carried out for effective weed control using various cultural, chemical and mechanical methods.

This chapter deals with the review of the research work carried out by various investigators from India and abroad on various aspects of controlling weeds in paddy, development and testing of mechanical weeders, on various brush cutters and their attachments as well as on powered mini tillers and rotary tillers.

2.1 Rice cultivation and weed removal techniques

In Kerala there are three seasons of paddy cultivation (KAU, 2016);

a) Virippu (first crop) - April-May to September-October
b) Mundakan (second crop) – September-October to December-January
c) Puncha (third crop) – December-January to March-April

The major rice cultivation practices followed in Kerala are direct seeding (dry seeding and wet seeding) and transplanting. In direct seeded rice under upland rain-fed condition, weeds often emerge simultaneously with the crop and competition for soil moisture may begin early, especially in low rainfall areas. Weed seedlings, due to their greater competitive ability, grow rapidly than rice seedlings. But in transplanted rice, flooding and puddling destroy the existing weed growth before seedlings are planted (Rao, 2000).

Weeds, the unwanted and undesirable plants which interfere and compete with the main crop for utilization of land, nutrients, sunlight and water are more severe in direct seeded crop than the transplanted crop. The weed competition in direct seeded rice is maximum during the first three weeks. The weed growth is generally vigorous and cause loss of yields. It is depicted that, in direct seeded upland rice, yield reduction due to weeds ranges from 42- 65% (Rao, 2000).

Moorthy (2004) reported about the problem of weeds in rice and given the weeds and their groups as (i) Grasses (*Echinochlora sp., Eleucine sp.etc.),* (ii) Sedges (*Cyperus sp*.) and (iii) Broad leaved weeds *(Amaranthus sp.)*

2.2 Methods of weed control

Weed management is a strategy that makes a desired plant population successful in a particular agro ecosystem using knowledge of the ecology of the undesired plants that is the weeds (Ghersa et al., 2000). It is a multi-dimensional regime and cannot be achieved by focusing on a single approach (Bajwa, 2014). The most effective method of weed management is by making physical contact with the weeds themselves, which is weed control. Currently, there are several ways of controlling weeds, either by using manual, chemical, mechanical or biological means.

2.2.1 Hand weeding

Datta *et al.* (1974) reported that weeding is traditionally carried out with indigenous hand tools. This involves considerable time and labour. In single hand weeding the labour requirement is as high as 300 - 1200 man hours per hectare. Availability of labourers required during peak seasons of the year is a problem.

Singh *et al*. (1981) concluded that two weeding of upland rice required 1,964 man h ha^{-1}. Hand hoes could be used as an aid for weed control in upland rice. They reduced the time required for weeding and the corresponding cost involved is less than half of that required for hand weeding.

Raut *et al.* (2013) described the major aspects of hand weeding, which was very popular in paddy. In this method, weeds are uprooted by hands and require more labour, consume more time and leads to high weeding cost. The 33 per cent cost of cultivation was spent on weeding alone when carried out with the manual labour. He reported that, the complicated operation of manual weeding was performed with the use of traditional hand tools in an upright bending posture, inducing back pain for majority of labourers. An estimate of 400-600 man hours per hectare was normally required for hand weeding which amounted to Rs. 2200 per hectare. He observed that availability of labour was also a main challenge in weeding operation.

2.2.2 Chemical weed control

Chemical weed control is a method involving the use of chemicals (herbicides). It is now extensively and intensively used. Some advantages of chemical weed control are the low labour requirement, easiness in application, possibility for use even in broadcasted crop and their high effectiveness in killing weeds. But environmental consideration must be taken because of its poisonous nature results in pollution and hazardous to the life of human being as well as animals.

Fagade (1980) reported that the cost of herbicide application for weed control was half than that of hand weeding. Singh *et al.* (1982) found that the highest net return was obtained with two weedings at 15 and 30 days after sowing of rice. When herbicide application was combined with one hand weeding, the highest net return was obtained with thiobencarb at 2kg ha^{-1}followed by butachlor at 2 kg ha^{-1} and thiobencarb at 1.5 kg ha^{-1} each combined with one hand weeding at 45 days after sowing (DAS).

2.2.3 Mechanical weed control

A mechanical device to remove the weeds from an agricultural land is known as weeder. There are various types of weeders which can be used for mechanical weeding in line sown rice. They are effective in controlling weeds as well as they benefit the crop by breaking up the surface crust, aeration of soil, stimulating the activity of soil micro flora, reducing the evaporation of soil moisture and facilitating the infiltration of rainwater, manipulate the crop root zone, enhance root and shoot growth, reduces time requirements and human effort. This method of weed control is simple, easily operatable and mostly done by labourers. There are also weeders powered by animals or tractors as used as self-propelled weeders or power weeders. It is one among the important methods used in controlling weeds and also the most recommended method on pollution point of view. The mechanical weeders are also reported to be economical than chemical and other methods (Singh, 2001 and Bhardwaj, 2004).

Kepner *et al.* (1978) claimed that mechanical method of weed control is the best with little or no limitation because of its effectiveness. According to Kepner *et al.* (1978) and Buckingham (1976), the primary objective of row crop cultivation is to enhance the use of farm machinery for eliminating weeds from the crop land. The effect of this method is to promote plant growth and better quality crops.

2.2.3.1 Classification of mechanical weeders

Biswas (1984) reported that, according to the power sources, weeders are classified as follows:

1. Animal drawn weeder

a) Hoes with triangular and straight blades
b) Cultivators with shovels, sweeps and duck foot sweeps
c) Animal drawn rotary weeder
d) Hoes with rotary tines

2. Manual weeder

a) Small tools or aids
b) Chopping hoes
c) Pull type hoes
d) Push type weeder
e) Push – pull weeder

3. Power operated weeder (self-propelled weeder)

2.2.3.1.1 Animal drawn weeders

Yadav (1980) gave details of a serrated blade for hoe and harrow as used as a bullock drawn blade cum tine hoe for weeding and intercultural operations in dry land farming. Serrated blades of different sizes may be fitted on to the traditional blade hoe or blade harrow (bakhar). He reported that the serrated blades easily penetrated into the soil and helped in moisture conservation.

Biswas *et al.* (1999) reported that the animal drawn weeder worked between crop row spacing, the weeds left over along rows could be removed manually. The straight blades in traditional hoes removed weeds up to the working width of the blades. However, due to clogging of the straight edges, the output was adversely affected. So there was a need to study and use improved blades.

2.2.3.1.2 Manually operated mechanical weeders

Tiwari (1985) developed a manual weeder considering mechanical and ergonomic factors. He suggested that for better comfort, the weeding tools should be operated in an erect posture as far as possible. The saving in man power with the mechanical weeder was up to 79%.

Khan and Diesto (1987) reported the development of a push type cono weeder suitable for paddy uprooted and buried weeds in a single pass without requiring a back and forth movement. Manual weeding of paddy required on an average of 120 man hours per hectare.

Tiwari (1993) evaluated the field performance of five different configurations of weeding blades of a manually operated push-pull weeder on green gram crop which is infested by grassy weeds. The result indicated that the overall performance of a straight flat blade was best with high field efficiency, less crop damage and more weed removal per unit area. The average power requirement in operation was 21.3W. This weeder increased the work output of the worker by approximately four times compared with manual weeding.

Shiru (2011) reported that, a push-pull type of mechanical manual weeder was designed and fabricated. The weeder consisted of a main frame, handle, soil cutter (wedge), spikes, wheel bearing, bicycle chain and sprockets. It was quite simple, effective and the result was immediately observed. He reported that small scale farmers can take advantage of the improved weeder to control weeds on their farms.

2.2.3.1.3 Power Weeder

Power weeders are self-propelled walking type machines used for weeding especially in lowland rice. A petrol engine or petrol start kerosene engine, power the machine and weeding is done by means of weeding blades. It also consists of reduction gear box, clutch and power transmission system for smooth operation of the machine. The major role of weeding blades is to cut or uproot the weeds and to bury both the weeds and soil during operations. A good number of this machine are manufactured and used in India. These power weeders reduce human effort as compared to operation by hand weeding and bullocks. The comparative higher output of operation by the power weeders as compared to bullocks reduces the operational time and achieves timeliness in operation (Ragesh, 2015).

Ranga Samy *et al.* (1993) developed a power weeder and compared the performance with conventional method of manual weeding with hoe and manually operated dry land weeder. The field capacity of weeder was 0.04 ha h^{-1} with weeding efficiency of 93% and the performance index was 453. The cost of operation per hectare with the power weeder amounted to be Rs. 250 as against Rs. 490 by dry land weeder and Rs. 720 by manual weeding with hoe. Saving in time was 93% while saving in cost was 65%.

Pitoyo *et al*. (2000) developed a power weeder for mechanical control of weeds in the rice field. The machine is driven by two stroke engine of 2 hp (6500 rpm) with a performance of 15 h ha^{-1} capacity at travelling speed 1.8 km h^{-1}. The mass of the machine was 24.5 kg.

Pannu *et al.* (2002) evaluated a self-propelled, diesel engine operated power weeder of 3.8 hp (2600 rpm). This weeder was found to be suitable for weeding in wider row crops like maize, cotton, sugarcane etc. The moisture content of the soil at the time of evaluation was 17-18%, the depth of operation ranged from 4-7 cm and the weeding efficiency was obtained as 88%.

Parida (2002) modified the IRRI cono weeder and evaluated its field performance in paddy fields. Results revealed that under experimental conditions, field capacity and field efficiency of the weeder were found to be 0.2 hah^{-1} and 80%, respectively.

Victor *et al*. (2003) designed and developed a rotary power weeder for wetland paddy powered by 0.5 hp petrol engine. The rotary unit was equipped with 4 L-shaped standard blades for cutting. Two big traction wheels were used to make the operation smooth and a gauge wheel was provided for depth adjustment of the cutting unit. The field capacity of the machine varied between 0.04-0.06 ha h^{-1} with field efficiency of 71% and weeding efficiency of 90.5%.

Manuwa *et al*. (2009) designed and developed a power weeder with working width of 0.24 m for weeding in row crop planting. Effective field capacity, fuel consumption and field efficiency of the machine were 0.53 ha h^{-1}, 0.7 l h^{-1} and 95%, respectively.

Olaoye *et al.* (2012) developed and evaluated a rotary power weeder to reduce the drudgery and ensure a comfortable posture of the operator during weeding. The results of field performance evaluation showed that, field capacity and weeding efficiency of the rotary power weeder were 0.0712 ha h^{-1} and 73% respectively. The cost of operation with this weeder was estimated as Rs. 2,700 against Rs. 12,000 for manual weeding.

Kankal (2013) designed a self- propelled weeder on the basis of agronomic and machine parameters. The main features of prototype self-propelled weeder were, a 4 hp petrol start kerosene run engine, power transmission system, weeding blade (Sweep) and cage wheel. The rated engine speed of 3600 rpm was reduced to 23 rpm of the cage wheel by using chain and sprocket mechanism in three steps.

2.2.4 Biological weed control method

According to Weed Science Society of America, biological control of weeds is broadly defined as the use of an agent, a complex of agents, or biological processes to bring about weed suppression. All forms of microbial and microbial organisms are considered as biological control agents.

Bajwa (2014) suggested that weed control through living organisms is as effective weed management practice and specific combination of organisms may control weeds very effectively in any crop. He also suggested that a large number of predators, pathogens and other plant competitors of weeds are exploited to kill or suppress the weeds.

2.2.3.5 Integrated Weed Management (IWM)

IWM is a science-based decision-making process that coordinates the use of environmental information, weed biology and ecology, and all available technologies to control weeds by the most economical means, while posing the least possible risk to people and the environment (Sanyal, 2008). It focuses on keeping weed populations below a certain threshold level by optimizing the control measures in an organized way by integration of numerous practices, right from sowing method to chemical control.

Integrated weed management has been employed for weed management and reported as a sustainable approach that controls weeds without reducing crop yield (Swanton and Weise, 1991).

2.3 Brush cutters and different attachments

Langton (2007) studied on design of a brush cutter blade and its integration into a semi-mechanised harvesting system. The aims for the project were, first, to design a blade that can be attached to a brush cutter to cut sugarcane effectively and efficiently and, second, to integrate the brush cutter into an economically and ergonomically sound sugarcane harvesting system. A harvester called the Illovo sugarcane harvester was developed and trials were conducted to assess its performance, efficiency, economics and blade durability. Results were favourable and clearly showed that there was less stress and strain on the back when this system was used, compared to manual harvesting.

Reddy *et al* (2010) studied on the design and analysis of revised grass trimming device. They presented the design methodology for fabrication and testing of petrol operated grass trimming device. Components like drive shaft spindle, its bushed sleeve and trimming head system were developed from available workshop scrap materials. Rate of fuel consumption using metallic cuter was comparatively low (22%).

Handaka *et al* (2011) conducted a study of grass cutter into a small rice harvester. Modifications that had been made were (1) replacing the cutter blade into rotary blade; (2) changing the dynamic balance of dynamic machine into mower type; (3) adding a guide, a propeller and an operator belt.

Qiu Lei Du *et al* (2014) studied on the design of lawn brush cutters. Their investigations on the mechanism and principle of brush cutter was done to ensure the safe design of brush cutter and to improve efficiency and comfort of the machine.

2.4 Mini tiller

Ahmad (2012) developed a rotating tine weeding mechanism for intra row weeding and found that the rotating tine mechanism had potential for low power weeding at slow travel speeds.

Bowman (1997) conducted a study on rotating type cultivators such as rotary tilling cultivators and rotary tillers, which were commonly used for inter-row weed control. However, the latter machine was found to be more expensive, since was designed for multiple functions including other tillage applications such as strip-planting over cover crops and preparing permanent plant beds.

Tupkar *et al* (2013) developed three types of soil tiller weeder, viz.push type, pull type and general purpose type.Bullock drawn implements required the hand and body pressure to achieve depth and alignment of the implement in use, whereas in soil tiller and weeder, the implements are mostly self-guided. This reduced human drudgery to a great extent.

Veeranguoda *et al* (2009) introduced the concept of using power tiller drawn wheeled multipurpose tool carrier as it was a development over the animal drawn wheeled tool carrier. Though, the initial cost of equipment was slightly high, it offered several advantages like timeliness in farm operation, quality and precision of work, increased work rate, efficient utilization of machine power, reduction in human drudgery and allowed for year round use due to its multipurpose utility. The popularity of these models among farmers was limited. The multipurpose tool carrier could be used for different operations like ploughing, harrowing, tillage etc. by attachment with suitable implements.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The methodology used for the study and assessment of existing powered paddy weeders, mini tillers and the development procedure for paddy weeding attachment to a mini tiller for wet land paddy weeding are described in this chapter.

3.1 Agronomic characteristics of machine transplanted rice relevant to weeding

Three different category of rice transplanters are recommended for Kerala (KAU, 2016).

a) Eight row single wheel riding type
b) Walk behind type
c) Four wheel riding type

Chinese eight row self-propelled riding type rice transplanter was recommended for areas where the field bunds are not high. Four row walk behind transplanters were recommended for small fields as they are easy to operate and transport. Four wheel riding type transplanters with six or eight rows were also suitable for group cultivation.

Table 3.1 Row spacing of rice transplanters used in Kerala

Sl. No.	Type of transplanter	Row to row spacing, cm
1.	Chinese eight row self-propelled riding type	23.7
2.	Walk behind type	30
3.	Four wheel riding type	30

3.1.1 Manually operated mechanical weeders

Double rotor cono weeder and single rotor finger type paddy weeders were recommended for wetland weeding in transplanted rice with row spacing of 23.7 cm or 30 cm (James, 2017).

3.1.2 Power weeders for transplanted paddy

TNAU two-row power weeder for transplanted paddy was studied by AIRCP on Farm Implements and Machinery and was not recommended due to the difficulty in field operation.

3.2 Assessment of powered weeders for paddy weeding

3.2.1 Testing of Three-row power weeder for paddy

Three row power paddy weeders are self-propelled walking type machines used for weeding in lowland rice. A petrol engine or petrol start kerosene engine, power the machine and weeding is done by means of rotary blades. These weeders also have reduction gear box, clutch and power transmission system for smooth operation of the machine. The three row power weeders are recommended to be suitable in wetland weeding of machine transplanted rice with a row spacing of 30 cm.

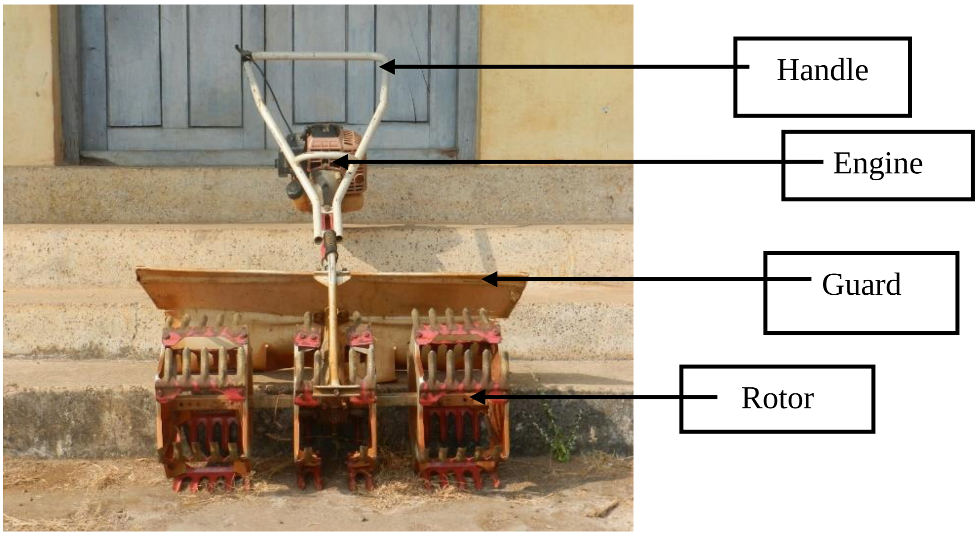


Fig.3.1 Three-row power weeder

3.3 Assessment of rotary weeder attachment to brush cutter

3.3.1 Study of brush cutters and their attachments

Brush cutter consists of a long shaft with a handle and sometimes a shoulder strap at the end of which the cutting head is mounted. The power is taken from an internal combustion engine which is at the other end of the long shaft. The trigger on the handle is used to control the operation. A safety cover unit is also provided. The cutting head can be modified so that it can perform many operations other than grass cutting. The long handle permits the operator to operate the trimmer from a distance.

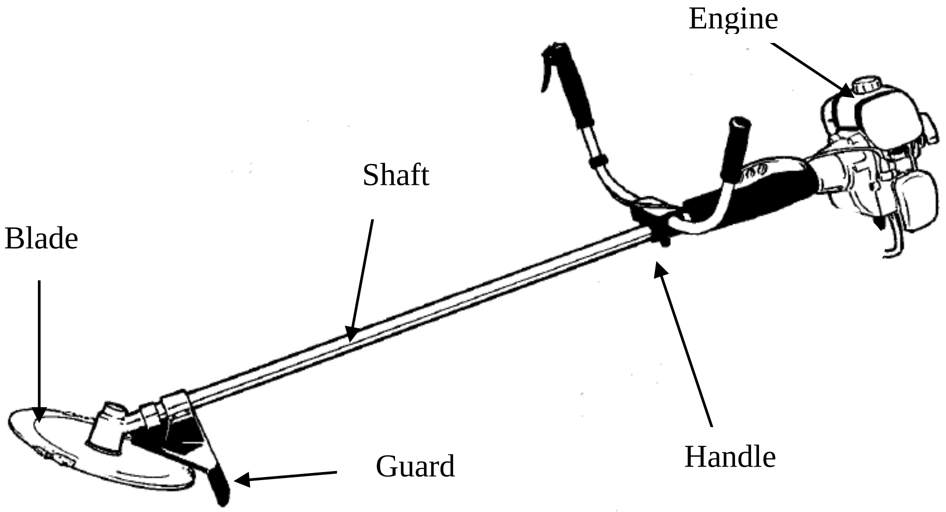


Fig.3.2 Brush Cutter

3.3.1.1 Two stroke simple brush cutter

The Honda brush cutter was studied. Two stroke engines are preferred as they produce higher power for the same weight. Using a brush cutter for long period of time weight is a consideration and they are provided with an easy grip loop handle and a light weight rigid shaft, which makes it the ideal tool for domestic uses.

Table.3.2 Specifications of two stroke brush cutter

Sl. No.	Parameter	Details
1.	Type of engine	Single cylinder two stroke
2.	Weight (w/o fuel), kg	4.1
3.	Power, kW	0.65
4.	Engine rpm	7000

Fig.3.3 Two stroke simple brush cutter

3.3.1.2 Kombi brush cutter system

Kombi Brush Cutter System has generally a more powerful petrol engine with a choice of combination tool attachments for trimming hedges, edging lawns, turning borders or sweeping paths, it will take the effort out of all tough garden jobs. With the help of a quick release coupling, it is possible to inter-change the different tools very easily.

Fig.3.4 Kombi brush cutter and its attachments

A reputed manufacturer, STHIL is marketing a combination system with different attachments. The ‘KM-AC Attachment’ is designed for moving and trimming around obstacles. It weighed 1.2 kg with an overall length 94 cm. The “KM-MB Attachment” designed for mowing heavy grass and weeds is having a metal grass cutting blade MB 230-2. It is also provided with a safety guard. For quick pruning of trees and shrubs the “KM-HT Attachment” is used. It is having an oil tank cap with retainer which helps from loosing the cap. Optional shaft extension is also provided. It weighed 1.8 kg with an overall length of 126 cm. The different tools in the set are generally:

- Edge trimmer
- Brush cutter with grass trimming blade
- Hedge trimmer 135 degree
- Blower
- Brush cutter with mowing head
- Pick tine

- Bristle brush
- Pole pruner

3.3.1.3 Backpack engine brush cutter

These types of brush cutters have the engine arranged as a back pack and are provided with large ventilated pad and straps for operators comfort. They have a flexible shaft for transmitting the power from the engine to the working tool. These machines have clutch assemblies and gear-cases with necessary safety guards to protect the operator.

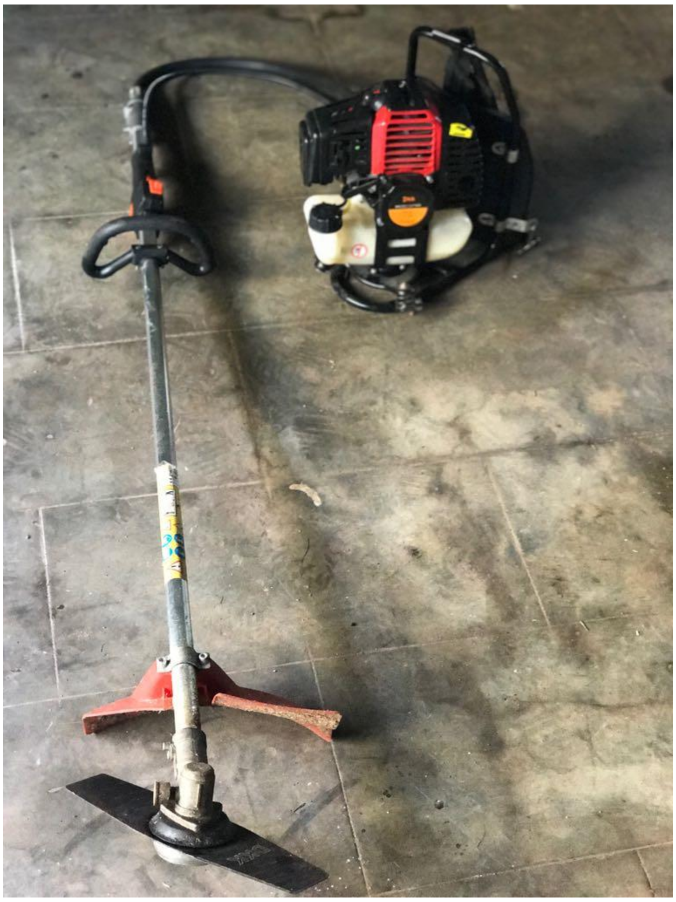


Fig.3.5 Backpack brush cutter

3.3.2 Study of existing soil working attachment to 'Kombi' brush cutter

'Sthil Kombi' brush cutters can be attached with a rotary soil working tool "BK-MM Bolo tines" with a working width of 22 cm and a weight of 2 kg. It was provided with a suitable gear reduction unit in order to reduce the engine rpm. The forward movement of this tool was achieved by means of rotation of the tines. The manufacturers claim that these are designed for a minimum of clogging and the curved bolo tines are perfect for garden as they reach deeper into the ground, loosening and mixing the soil. The tines are designed to cultivate in sandy, rocky and clay-like compacted soil.

Fig.3.6 Kombi brush cutter with bolo tines

3.3.3 Suitability of existing soil working attachment for paddy weeding

3.3.3.1 Identification of agronomic requirements for mechanical paddy weeding

The most important agronomic parameters which influence the weeding operation were identified as row spacing, plant spacing and the height of the crop. The soil parameters also influence the performance of weeding and the design of weeders.

The row spacing for different transplanters recommended by KAU are as discussed in section 3.1.

3.3.3.2 Preliminary testing of rotary weeding attachment

i. **Dry soil condition**

   Machine was operated in a small plot of dry soil in between the standing crops.

ii. **Wet soil condition**

   Machine was operated in a puddled paddy field with 6-7 cm of standing water maintained in the field. The machine was operated in forward direction in a straight line.

3.4 Refinement of powered mini tiller

3.4.1 Study of powered mini tiller

The mini tillers are ideal for weeding and inter-cultivation of vegetable crops. They are popularly used not only for weeding but also for light tilling works in small area because of its low cost. They manipulate the soil using rotating blades or rotary tines and works best in loose soil free of clogs or stones. The width of these tillers ranges from 30-32cm.These mini tillers have forward rotating tines located at the front of the machine.

The mini tiller available with AICRP on Farm Implements and Machinery at KCAET Tavanur was used for the study.

Fig.3.7 Mini tiller cultivator

3.4.1.1Suitability of existing powered mini tiller for paddy weeding

The machine was operated in a small plot of dry soil with its existing rotor attachment and was tested for its performance. The rpm of the rotor was measured.

3.4.2 Development of paddy weeding attachment to mini tiller

3.4.2.1 Design of weeding rotor

A suitable configuration for the rotor was developed so as to enable wet land paddy weeding. For the selection of suitable blades for weeding operation, the diameter of the rotor and number of blades required were fixed. Based on the engine power and paddy height during weeding, the rotor diameter was fixed. For fixing the number of blades, trajectory path diagram for blades were drawn. Based on the fixed diameter and number of blades, weeding rotor for mini tiller was selected.

3.4.2.2 Design of power transmission shaft

A hollow shaft was designed for extending the shaft from gear reduction unit.

3.4.2.3 Design of guards

For plant protection and minimum plant damage as well as for operator's safety suitable guards were designed.

3.4.2.4 Fabrication and attachment of rotary weeding attachment

The existing mini tiller was dismantled for the attachment of the fabricated rotary weeding attachment. To enable wet land paddy weeding the existing rotary tines were replaced with weeding rotors. Two hollow shafts of mild steel were fabricated.

3.4.2.5 Fabrication and attachment of guards

Guards are provided in a weeding machine for providing protection to both plants and the operator. Plastic guards were fabricated for protecting the paddy from damage. Guards made of galvanized iron sheets were fabricated and fixed as a shield in between the rotor assembly and the engine. Plastic guards were also fabricated for operator's safety and attached above the weeding rotors. A suitable frame, made of GI pipe, was provided for the attachment of plastic guards. A skid was attached at the rear end of the machine for supporting it during operation. Once the machine reaches the end of a row, it needed to be lifted for shifting to the next row. Hence a handle was provided at the front for easy handling.

3.4.3 Evaluation of the developed weeding attachment

For field testing, the mini tiller was first operated on the field at Thirunavaya, Malappuram. The machine was made to run between the paddy crops having a row to row spacing of 30cm. The plant height was measured to be 35-40 cm.

Another field testing was made at Kalavappadam, Vadakkancherry, Palakkad. The crop was machine transplanted with a row to row spacing of 30 cm. The plant height was in the range of 40-45 cm.

3.4.3.1 Lab studies

Overall dimensions and weight of the machine was observed. The engine rpm was measured using a tachometer.

3.4.3.2 Field evaluation

Field observations as well as machine parameters were recorded during the performance evaluation.

a) Field capacity

Effective field capacity is the actual average rate of coverage by the machine, based upon the total field time. It is a function of the rated width of the machine, the percentage of rated width actually utilized, speed of the travel and the amount of field time lost during the operation. Effective field capacity is usually expressed as hectare per hour.

$$EFC = \frac{A}{T_P + T_i}$$

Where, EFC = Effective field capacity, ha h^{-1}

A = Actual area covered.

Tp = Productive time, h

Ti = Non-productive time, h

b) Fuel consumption

Fuel consumption can be defined as the rate at which an engine uses fuel, expressed in the unit as litre per hour. It was measured by top fill method. The fuel tank was filled to full capacity before testing by keeping the machine on a levelled surface. After completion of test operation, amount of fuel required to top fill again is the fuel consumption for the test duration.

c) Overall ease of operation

d) **Field efficiency**

Field efficiency is the ratio of actual field capacity to the theoretical field capacity.

e) **Weeding efficiency**

It is the ratio between the number of weeds removed by power weeder to the number of weeds present in a unit area before operation and is expressed in percentage. The samplings were done by quadrant method, by random selection of spots in a square quadrant of 1 m^{-2}.

$$n_w = \frac{(w_1 - w_2)}{w_2} \times 100$$

Where, w_1= Number of weeds counted per unit area before weeding operation

w_2 = Number of weeds counted in same unit area after weeding operation

f) **Plant damage**

It is the ratio of the number of plants damaged after operation in a unit area to the number of plants present before operation in the same unit area. It is expressed in percentage.

$$R = \frac{Q \times 100}{P}$$

Where, R = Plant damaged (%)

P = Total number of plants per unit area before the weeding operation

Q = Total number of plants damaged in the same unit area after weeding

g) **Cost of operation**

The field capacity of the machine and the cost of operation were calculated. The savings in the field operation with mini tiller weeder was worked out.

The cost of operation of power weeder is divided into two heads known as fixed cost and variable cost, where fixed cost is independent of operational use while variable cost varies proportionally with the amount of use (Kamboj *et al*., 2012).

The fixed cost includes depreciation and interest on the capital cost. Operation cost includes, fuel, lubricants, repair and maintenances cost, wages. Cost of operation of mini tiller weeder was calculated in Rs.ha^{-1} (Kepner *et al*, 2005).

3.5 Economics of weeding attachment in comparison to hand weeding

The economic advantage of using the developed paddy weeding attachment to mini tiller was assessed with respect to manual weeding of paddy, which is the conventional method.

3.6 Comparative economics of weeder attachment to mini tiller

The cost of operation of the mini tiller weeder was compared with that of a TNAU two-row power weeder and three row power weeder for one, two and three hectares of holding sizes. It was assumed that in a year, weeding was done twice during one crop season and there were two crops grown in a season.

The following data were used for the cost analysis (Anon, 2016):

Table.3.3 Field evaluation data on TNAU two-row power weeder and three-row power weeder

Sl. No	Type of weeder	Field capacity (ha h^{-1})	Fuel requirement (l h^{-1})	Initial cost (Rs.)
1.	TNAU two-row power weeder	0.125	0.75	Rs.35000
2.	Three-row power weeder	0.08	0.75	Rs.60000

RESULTS AND DISCUSSIONS

CHAPTER IV

RESULTS AND DISCUSSIONS

This chapter deals with the results of the investigations which lead to the development of a paddy weeding attachment to a mini power tiller.

4.1 Agronomic requirements of wet land paddy weeders for transplanted rice

The four-row walk behind type and four-wheel six row riding type transplanters having a row spacing of 30 cm are most common in the study area. The Chinese model eight row riding type single wheel transplanters have a row spacing of 23.7 cm.

The cono weeder commonly used in transplanted paddy fields has two conical rotors in tandem with opposite orientation. Smooth serrated blades alternately on the rotor uproot and bury the weeds. The single rotor rotary weeder with finger type tines also was suitable for fields transplanted with all type of weeders. Manually operated mechanical weeders have not become popular due to the drudgery involved in the operation.

4.1.1 Manually operated mechanical weeders

Single rotor weeders were suitable in heavy soils where cono weeders were difficult to be pushed. The Japanese type three-row power weeder was recommended to be suitable in wetland weeding of machine transplanted rice with a row spacing of 30 cm (James, 2017).

Fig.4.1 Cono weeder

Fig.4.2 Single rotor finger type paddy weeder

4.1.2 Power weeders for transplanted paddy

TNAU two-row power paddy weeder was difficult to be operated in the field condition along straight rows and there were damage of seedlings.

Fig.4.3 TNAU Two-row paddy weeder

4.2 Assessment and testing of three-row power weeder

The three-row power weeder with finger type rotor was found suitable for weeding of paddy transplanted at a row spacing of 30 cm. The results of the field evaluation are given in Table 4.1.

Table 4.1 Salient aspects of three-row power weeder

Sl. No.	Parameters	Average value
1	Fuel consumption, ml h^{-1}	600-900
2	Actual field capacity, ha h^{-1}	0.09-0.12
3	Field efficiency, %	59.3
4	Average weeding efficiency, %	72
5	Cost of operation, Rs. h^{-1}	200
6	Unit area weeding cost, Rs. h^{-1}	2500

: 

Fig.4.4 Working of three row power weeder

While operating the three-row power weeder it was observed that the weeds were removed effectively. But certain constrains were observed in its operation. Continuous weeding was not possible with this weeder as there was frequent failure in its gear reduction unit. So after operating for 8-10 hours, the machine required maintenance.

Another adverse aspect was that when the paddy weeding was completed, the machine was not in use for the remaining part of the year. These forbid the marginal farmers from purchasing the three-row power weeder. Even though they were interested in hiring these weeders, they were not available with custom hiring centers.

4.3 Study of brush cutters

Three different brush cutters were studied. The biggest constraint faced was the noise and vibration hazard.

- While operating 2-stroke simple brush cutters, one of the biggest disadvantage was the noise hazard. The operator could also feel the vibrations of the engine which was another discomfort.
- The Kombi brush cutter was a versatile multi-tasking tool so that more work could be done in less time. It was possible to expand the system by adding more tools. Using the pruner attachment, branches of trees could be pruned safely. The machine had reduced noise levels and vibrations and was more comfortable during prolonged use. So this could be used a better alternative for paddy weeding by providing a suitable weeding attachment
- With backpack brush cutters, the operator's hands were free to allow easier control and manoeuvrability. With good ergonomic designs prolonged use can be easier and more comfortable. Being versatile, there is a possibility to attach different tools.

Table.4.2 Vibration and noise hazard of brush cutters

Sl. No.	Type of brush cutter	Engine rpm	Noise hazard	Vibration hazard
1.	Two stroke simple brush cutter	6000	6-7	7-8
2.	Stihl Kombi brush cutter	13000	3-4	4-5
3	Backpack engine brush cutter	10000	5	5-6

4.3.1 Suitability of the existing soil working attachment of brush cutter for paddy weeding

The gear reduction unit enables to reduce the speed as per the requirement. Specifications of 'bolo tines' manufactured by Stihl are as follows:

Width of the rotor- 22 cm

Diameter of rotor- 15 cm

Thickness of the tine- 2.2 mm

Rotational speed of the tine- 220 rpm

When the machine was operated in dry soil, the bolo tines crushed and crumbled the compacted soil. There was a minimum of soil clogging. But there was a considerable entangling of weeds which were uprooted and had to be removed manually at frequent intervals. The tines could crumble large sods of earth thus spreading fine sandy soil for marking rows in the soil. It removed the weeds between the standing crops.

Fig.4.5 Working of Kombi brush cutter in dry land

The machine was tested in a puddled soil within the marked boundaries of 25 cm and 30 cm to understand the ease of operation of this machine through transplanted paddy. While working in the puddled soil, the machine removed the weeds. Considerable force had to be applied on the handle with the attachment, for pressing the tines into the soil. It was difficult to operate the machine between the marked boundaries. Later, the machine was operated in wetland paddy fields at Vadakkancherry, Palakkad.

Fig.4.6 Working of Kombi brush cutter in wetland

During the entire operation the operator faced certain constrains due to the vibrations of the machine. Since it had a single row operation, more time was required to cover the entire field. Thus, prolonged operation would bring more difficulty to the operator. Brush cutter provides the same field capacity as that of a cono weeder. Even though it was powered by an engine, man power was also required in order to attain weeding. Therefore it was observed that it was not beneficial to use this brush cutter attachment for paddy weeding.

4.4 Refinement of powered mini tiller

4.4.1 Preliminary study of mini tiller

While operating the mini tiller, muscle power was required to engage the tines into the soil to operate the machine and to control the tilling depth. During weeding or tilling process, the forward rotating tines helped to propel the machine forward. Rear mounted support wheels allowed the operator to adjust the depth of operation of the tines. This also enabled the easy movement of the machine in the field. Being light weight and manoeuvrable, this was observed to be suitable for modification with a wet land paddy weeding attachment.

Specifications:

Engine – 2 stroke

Engine power – 1.52 kW

Width – 30-32 cm

Model – GK-MT2S

Fuel tank capacity– 0.7 l

4.4.1.1 Preliminary testing for assessing suitability of the existing mini tiller for paddy weeding

The machine with its rotary tines was found to be suitable for dry soil alone. The rpm was measured to be 400-600 rpm. For wet land paddy weeding a suitable configuration of the rotor and blades were done, taking into account the row to row spacing and height of paddy at the proper stages for weeding.

4.4.2 Development of paddy weeding attachment to mini tiller

4.4.2.1 Design of weeding rotor for mini tiller

Based on the preliminary studies with the three row power weeder, it was observed that paddy crop having a height 30-45 cm could be operated with a 30 cm diameter rotor without damaging the plants. The average speed of operation was observed to be 1.4 kmph. Hence the rotor diameter was fixed as 30 cm.

The number of tines required was fixed by observing the trajectory of the tines at the design rpm at the design forward speed.

A trajectory diagram was drawn for the blade rpm measured as 540(rpm) at 5:1 scale. The design forward speed of the operator with the machine was taken as 1.4 kmph. The trajectory diagrams for rotors with number of blades varying from two to six were drawn. From this it could be inferred that six blades were suitable.

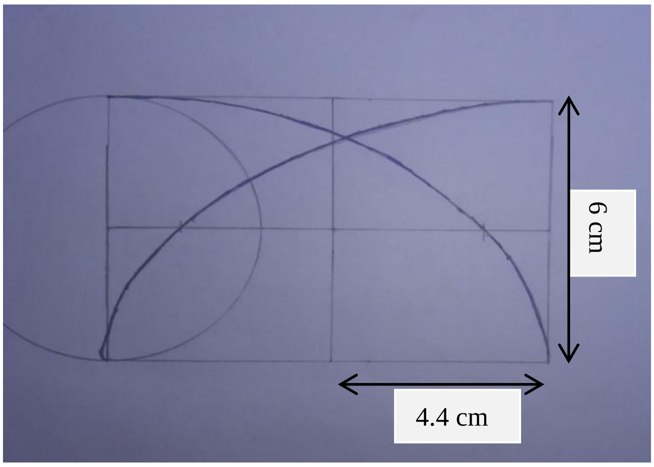


Fig.4.7 Trajectory diagram for two number of blades

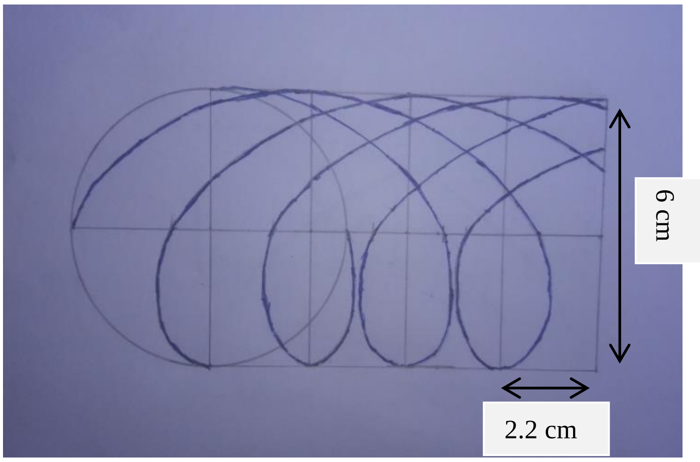


Fig.4.8 Trajectory path diagram for 4 number of blades

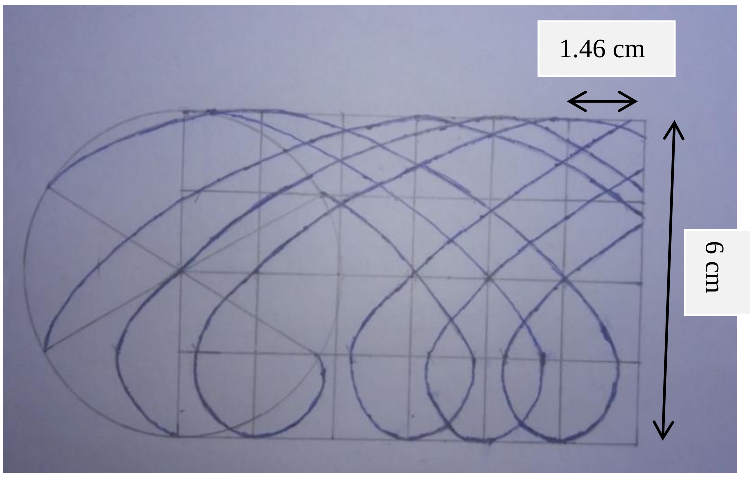
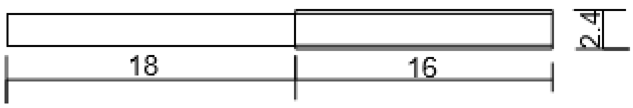


Fig.4.9 Trajectory path diagram for 6 number of blades

When the number of blades were two and four, uniform and continuous weed removal was not possible as shown in Fig.4.7 and Fig.4.8. It can be observed that there exist gaps between the points at which the tips of tines touch the ground. For two tines, the gaps are wide apart where as for four tines, they are closer. But there can be untouched weeds in the gaps. When the number of blades were eight or twelve overlapping was more, i.e., the same area was worked twice or thrice. In the six tines configuration no such gap was observed (Fig.4.9) and this was selected. Based on the fixed diameter and number of blades, weeding rotor for mini tiller was selected.

4.4.2.2 Design of power transmission shaft

In order to extend the shaft from the gear reduction unit, two hollow shafts were fabricated. The internal diameter was same as that of the existing shaft from the gear reduction unit and the outer diameter was increased by 2 mm for attaching the weeding rotors. The existing shaft of the mini tiller was modified by providing an extension.



All dimensions are in cm

Fig.4.10 Design of power transmission unit

4.4.2.3 Design of guards

GI guards of suitable sizes were designed for operators safety taking into account the rotor diameter. These were replaced with plastic guards for better performance. Plastic guards for plant protection were designed based on the average plant height during weeding.

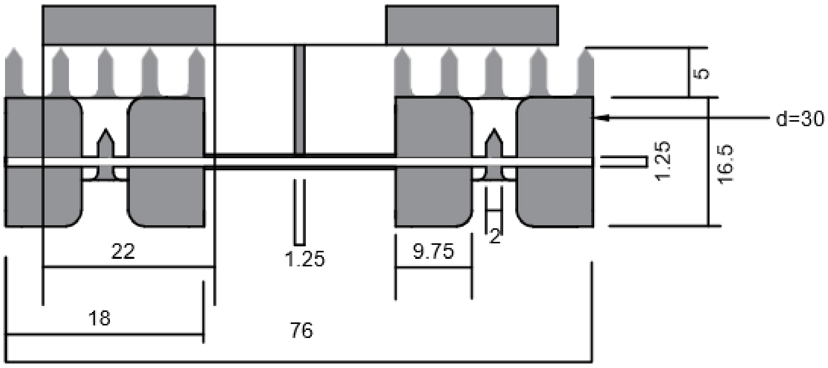


Fig.4.11 Design of guards

4.4.2.4 Fabrication and attachment of rotary weeding attachment

Weeding rotors were adopted from three-row power weeder with required diameter 30 cm and six number of finger blades. As this was readily available in the market there was no need of fabricating a separate rotor.

Two hollow shafts each of length 34 cm, 2.4 cm outer diameter and 2 cm internal diameter were fabricated and attached to the shaft from gear reduction unit by means of suitable pin. Through the holes drilled on the hollow shaft, the rotor was attached to the mini tiller.

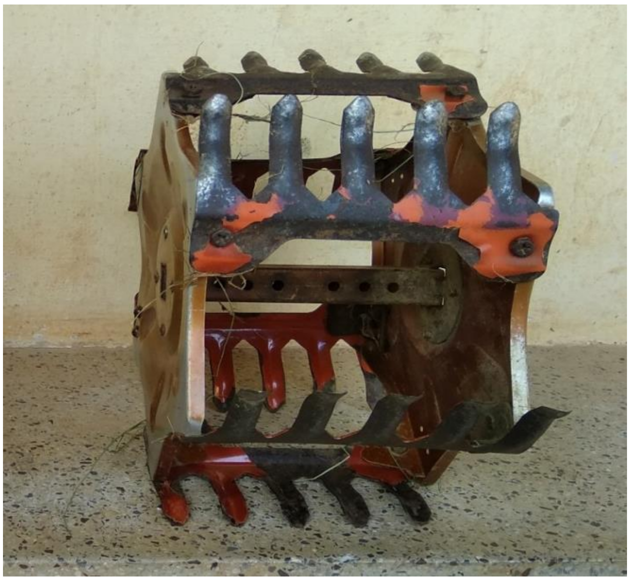


Fig.4.12 Weeding rotor

Fig.4.13 Hollow shafts

4.4.2.5 Fabrication and attachments of guards

Galvanized iron (GI) guards fabricated were mounted on the top of weeding rotors. For the latter, 2 sheets of 22 x 29 cm, 22 x 14.5 cm and 2.5 x 22 cm, each was cut from GI sheet. The two GI sheets of 22 x 14.5 cm were bolted to the framework made below the engine. 22 x 29 cm sheets were attached on both sides of the latter by means of small cut piece from GI sheets. The 2.5 x 22 cm sheets were welded on to the front portion of this guard with a slight bend.

The plastic guards were fabricated from PVC sheets. Guards of 22 x 29 cm were cut and fixed to the frame made of GI pipe, provided at the front, to restrict the plants from getting entangled by the rotor.

Fig.4.14 Plastic guards fixed to GI frame

Fig.4.15 Modified mini tiller weeder

4.4.3 Evaluation of the developed paddy weeding attachment to mini tiller

4.4.3.1 Lab studies

Overall dimensions: The diameter of the rotor used was 30 cm. The total width of this machine was 70 cm. The total weight of the machine was found to be 17.50 kg.

Rpm of blades: The rpm of the blades was measured as 540 rpm.

Theoretical field capacity: The theoretical capacity was calculated as 0.08 ha h^{-1} and is given in APPENDIX I.

4.4.3.2 Preliminary testing

When the machine was operated in the paddy fields of Thirunavaya, Malappuram, it was found that plants were getting entangled due to the absence of guards in front the weeding rotors. The machine could move smoothly between the paddy rows and weeding was efficiently done. The machine was provided with plastic guards at the front and skid at the rear end in order to rectify the problems mentioned earlier.

Fig.4.16 Weeding operation at Thirunavaya

4.4.3.3 Final testing

The machine was then tested in the paddy fields at Kalavappadam, Vadakkanchery, Palakkad district. Having a robust design it could move well between the paddy rows with minimum plant damage. The aluminium guards guided the rice plants and prevented them from getting entangled into the rotor. Weeds were removed effectively and the weed removal efficiency was about 70%. At first, the aluminium guards fabricated and attached to the machine got damaged.

Fig.4.17 Weeding operation at Kalavappadam

Further testing and assessment of the machine was done at Kizakkancherry, Palakkad after replacing the guards with newly fabricated PVC guards. Weeding was done in a field transplanted with a walk behind transplanter at a row spacing of 30 cm. The crop stage was at 20 DAT (days after transplanting).

Table.4.3 Salient results of field evaluation

Sl. No	Parameters	Average value
1.	Field capacity, ha h^{-1}	0.10

2.	Fuel consumption, ml h^{-1}	600
3.	Field efficiency, %	80
4.	Weeding efficiency, %	72.5
5.	Plant damaged, %	4
6.	Cost of operation, Rs. h^{-1}	2254

Fig.4.18 Weeding operation at Kizakkancherry fields

The salient results of the evaluation are given in Table 4.3 and it could be inferred that:

Field capacity: The effective field capacity was higher than three row paddy weeder. Field capacity of mini tiller weeder was calculated and given in APPENDIX I.

Fuel consumption: The fuel consumption was similar to that of three row paddy weeder.

Ease of operation: It was easy to operate the mini tiller the between the paddy rows for weeding than a power weeder. The operator could feasibly operate the machine.

Field efficiency: The machine had higher field efficiency than three row paddy weeder (60%) and the field efficiency calculated was given in APPENDIX I.

Weeding efficiency: The results from the field study conducted to assess the weed removal efficiency of the weeder are shown in Table 4.4.

Table 4.4 Weeding efficiency

Sl. No	Weed population before weeding	Weed population after weeding	Weeding efficiency, %
1.	168	46	72
2.	124	33	73.3
3.	158	47	70
4.	147	38	74.1
5.	98	24	75

From Table 4.4, it can be observed that the developed weeder was satisfactory in removing the weeds in between the rows in transplanted rice. The weed removal efficiency of 70-75% was better than the values reported by Annual Report for FIM testing by AICRP (2017) for TNAU two-row weeder. The efficiency obtained was also comparable to the efficiency values reported by Annual Report for FIM testing by AICRP (2017) for three row power weeder. The weeding efficiency calculations are given in APPENDIX II.

Fig.4.19 Observation of weed population

Plant damage: The results of the field study conducted to assess the plant damage by the weeder are shown in Table 4.5. Plant damage was relatively high (4%) while working the machine at Kizakkancherry. This was due to the improper alignment of paddy crops while transplanting.

Table 4.5 Plant damaged

Sl. No.	Total number of plants per unit area before weeding, P	Total number of plants damaged in the same unit area after weeding, Q	Plant damaged, R (%)
1.	240	9	3.75
2.	248	8	3.2
3.	223	12	5.3
4.	236	10	4.2
5.	245	11	4.48

During hand weeding, weeds are pulled out manually by farm labourers. As a result, plant damaged was low to due to circumspection in weeding. In case of mini tiller weeder, when it was operated without guards at Thirunavaya fields, considerable plant damage was observed (7-8%). But when suitable guards were provided at front, the plant damage was reduced as shown in APPENDIX III which was comparatively less than that of three-row paddy power weeder.

Cost of operation: The field capacity of the modified mini tiller weeder was 0.1 ha h^{-1} and its cost of operation was about Rs. 2254 per hectare and the estimations are given in APPENDIX IV. This is lower than the cost of operation of TNAU two-row power weeder. This enables the mini tiller weeder to be more popular and beneficial among marginal farmers.

4.5 Economics of mini tiller weeder compared to hand weeding

In conventional hand weeding method, the man-hours per hectare is 192. Therefore, cost of weeding operation is Rs 8662.5, considering labour charges as Rs 200/day. Comparatively, the cost of weeding by powered mini tiller weeder is 26% lower than that of manual weeding cost.

4.6 Economic aspects of mini tiller weeder compared to other power weeders

The economics of the paddy weeder attachment to mini tiller was analyzed for different holding sizes in comparison with TNAU two-row power weeder and three-row power weeder (APPENDIX V). Due to the increase in annual hours of use, the fixed cost factor is decreasing when the operational area is increased.

The hourly cost of operation (Rs. h^{-1}) was minimum for mini tiller weeder as compared to the other two weeders as evident from Fig.4.20. The significant difference in hourly cost is due to the increased annual hours of use for the mini tiller as it is used for other purposes also. The hourly operational cost for the three power weeders and the TNAU power weeder were similar.

The unit area operation costs (Rs. ha-1) of the three machines are shown in Fig. 4.21. The unit area operation cost for three row power weeder is notably higher than the other two weeders. The cost for mini tiller weeder and

TNAU weeder are similar but the mini tiller weeder has significantly low operational expenses when the operational areas are small. The field capacity of TNAU two row weeder was higher than that of a three-row weeder and hence its unit area cost of operation was much lower than three-row power weeder. The increase in field capacity was primarily due to the fact that the operator will be moving at a greater speed with the two-row TNAU weeder compared to the three row weeder.

For three hectares of land the cost of operation (Rs. ha^{-1}) was almost similar for mini tiller weeder. But multi-purpose utility and ease of operation of mini tiller weeder makes it superior in performance to TNAU two-row power weeder.

The final cost of operation of mini tiller weeder was estimated as Rs 2254 per hectare. This was lower than the cost of operation of TNAU two-row power weeder and three-row power paddy weeder reported by (AICRP on FIM testing, 2016). This indicated that the mini tiller weeder can be more beneficial to the marginal farmers.

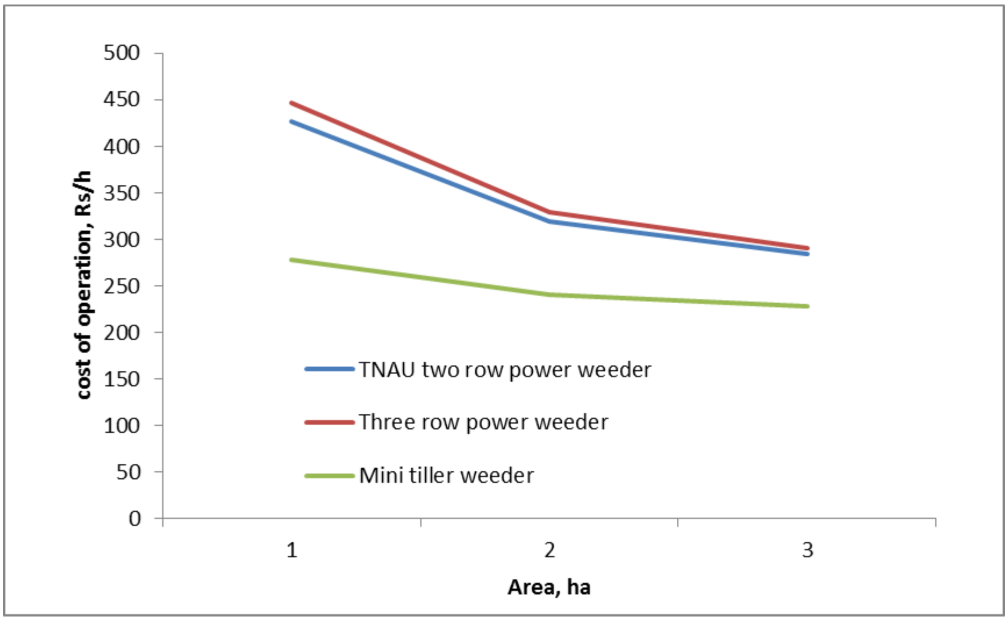


Fig.4.20 Hourly cost of operation of Mini tiller weeder in comparison to other power weeders

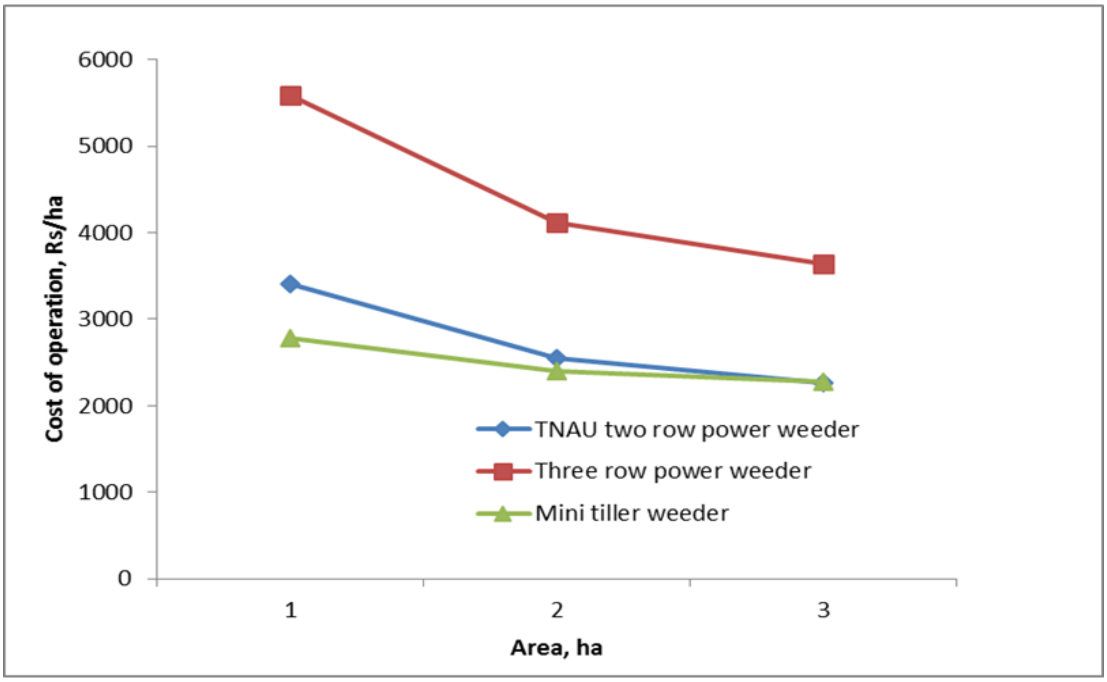


Fig.4.21 Unit area cost of operation of Mini tiller weeder in comparison to other power weeders

SUMMARY AND CONCLUSIONS

CHAPTER V

SUMMARY AND CONCLUSION

Efficient weed management practises needs to be adopted for increased crop productivity in paddy cultivation. Conventionally, manual hand weeding is followed in paddy cultivation. Recently, efforts were taken to popularise manually powered mechanical weeders like cono-weeder, consequent to the popularisation of machine transplanting of paddy. But manual hand weeding is uneconomical and due to drudgery of operation and more consumption of time, manually operated mechanical weeders are to be replaced with power weeders. Among power weeders two row and three row paddy weeders are common. But these power weeders had constraints in their use for paddy weeding. Hence different options were examined for weeding of transplanted paddy crop. Brush cutters and their existing attachments were assessed for its suitability for paddy weeding. But they were not found beneficial for weeding operation in paddy cultivation. The economic and technical constraints of Japanese three row power weeder and the operational problems of TNAU two-row power weeder were preventing their popularity among farmers. As an approach to overcome these, an attempt was done to design and develop a paddy weeding attachment to a mini power tiller. The modified mini tiller with paddy weeding attachment was subjected to laboratory as well as field tests to assess its performance. Economic aspects of the developed unit were compared with the three-row power weeder and TNAU two-row power weeder. The potential of the developed mini tiller weeder was analysed on the basis of weeding efficiency, plant damaged, field efficiency and ease of operation. Weeding by modified mini tiller weeder was found satisfactory for weeding of machine transplanted paddy crop due to the higher weeding efficiency and field efficiency, lowest plant damage and operational cost. Thus on the basis of this investigation, the following conclusions could be drawn:

1. The rotary soil working attachment to brush cutter was unsuitable for replacing the manually operated mechanical paddy weeders.

2. The TNAU two-row weeder had excessive vibration and was difficult to be operated in straight rows.
3. The economic aspects of Japanese three-row power weeder were not attractive as the capital involved was high and the machine could be used only for limited hours in a year.
4. The mini tiller was modified by considering the agronomic requirements of weeding in machine transplanted paddy.
5. A two row paddy weeding attachment to mini power tiller was developed and field tested
6. The mini tiller weeder for paddy crop was tested in the experimental plots with different age and it was compared with three row weeder for weeding operation.
7. The cost of operation of mini tiller was lower than conventional manual hand weeding, TNAU two-row power weeder and three-row power weeder.
8. The mini tiller weeder is promising equipment which can help the small and medium farmers to avoid the problems like frequent maintenance of existing power weeders.
9. Mini tiller will find year round usage compared to the other weeders as the machine can be used for other operations and other crops like vegetables.

SUGGETIONS FOR FUTURE RESEARCH WORK

. The machine has the potential to function as an effective multipurpose tool carrier if suitable attachments are developed. The following points may be considered for future line of work:

- The modified mini tiller weeder can be tested in different soil conditions and for different row spacing by providing suitable rotor configurations.
- The machine can be provided with a grass cutter attachment for homestead weeding.

- Suitable attachments such as sprayer, bund former etc. may be developed.

REFERENCES

REFERENCES

- Agarwal, J.P. and Singh, O.P. (1968). All about weeds. Actual Publishing House, Aligarh.
- Ahmad, M.T. (2012). Development of automated intra-row weeder for vegetable crops. Iowa State University, Ames, Iowa.
- Anonymous (1997). CIAE self propelled weeder. Annual report. Central Institute of Agriculture Engineering, Bhopal.
- Anonymous (2016). Testing and evaluation of three-row power weeder. Annual report. All India Coordinated Research Project.
- Basavaraj and Surendrakumar, A. (2016). Study of Agronomical and soil parameters in paddy field for development of paddy weeder. Agricultural Machinery Research Centre, AEC&RI, Tamil Nadu Agricultural University, Tamil Nadu.
- Bhardwaj, K.C., Ganesan, S., Pandey, M.M., Singh, G. (2004). Equipment for weeding and inter-cultivation. Directory of Agricultural Machinery and Manufactures. NATP. Prototype Manufacturing of Agricultural Implements. Central Institute of Agricultural Engineering. Bhopal.146-156.
- Biswas, H.S. (1984). Weed control techniques. Technical bulletin No, CIAE/84/46, Central Institute of Agricultural Engineering, Bhopal.
- Datta, S.K., Aragon, K.L. and Mlabugoe, J.A. (1974). Varietal differences in cultural practices for upland rice. Seminar processing in rice breeding and varietal environment. *West Africa Rice Development Association, Manoroviabilaria: 35-73.*
- Duff, B. and Orcino, N. (1971). Economic research in the department of agricultural engineering. IRRI Seminar. Los Banos, Philippines: 9.
- Fagade, S.O. (1980). Performance of some herbicides in the control of upland rice weeds in Nigaria. *WARDA Technical News Letter, 2(2):9-10.*
- Government of Kerala. (2016), Kerala Economic Review 2016, State Planning Board, Thiruvananthapuram.

- Kankal, U.S. (2013). Design and development of self-propelled weeder for field crops. *International Journal of Agricultural Engineering, 6(2).*
- Kepner, R.A., Bainer, R. and Barger, E.L. (1978). Principles of farm machinery. 3er edition, CBS Publications and Distributors, New Delhi.
- Manuwa, S.I., Odubanjo, O.O., Malumi, B.O., and Olofikua, S.G. (2009). Development and performance evaluation of raw-crop mechanical weeder. *Journal of Engineering and Applied Science, 4(4):236-239.*
- Olaoye, J.O., Samuel, O.D. and Adeknye, T.A. (2012). Performance evaluation of an indigenous rotary power weeder. *Energy and Environmental Engineering Journal, 1(2):94-97.*
- Pannu, C.J.S., Dixit, A. Garg, I.L. and Dogra, D. (2002). Feasibility evaluation of rotary power weeder on wider raw crop like cotton, maize, sunflower and soybean. *Annual Report, Punjab Agricultural University, Ludhiana. 18-26.*
- Ragesh, K.T. (2015). Design modification of power weeder for paddy crop. Indhira Gandhi Krishi Vishwa Vidhyalaya, Raipur.
- Rangasamy, K., Balasubramanian, M. and K.R. Swaminathan. (1993). Evaluation of power weeder performance. *Agricultural Mechanisation in Asia, Africa and Latin America, 24(4):16-18.*
- Rao, V.S. (2000). Principles of weed science. Second edition. Oxford and IBH Publication, New Delhi.
- Raut, V.D., Deshmukh, B.D. and Dekate, D. (2013). Review paper on various aspects of weeders for economical cultivation. *International Journal of Modern Engineering Research, 3(5):3296-3299.*
- Shaji James, P., Suresh Kumar, V.K. and Balachandran Pillai, G. (1996). Effect of selective mechanisation on the economics of rice production. Kelappaji College of Agricultural Engineering and Technology, Kerala.
- Tupkar, A.B., Amegh, V.T., Akhtar, A.R. and Aquib Naque, Md. (2013). Design, development and fabrication of soil tiller and weeder. P.C.E. Nagpur, Maharashtra.

- Veerangouda, M., Sushilendra, E.R. and Anantchar, M. (2009). Development and evaluation of multipurpose tool carrier for power tiller. College of Agricultural Engineering, Raichur, Karnataka.
- Victor, V.M. and Verma, A. (2013). Design and development of power-operated rotary weeder for wet-land paddy. *Agricultural Mechanisation in Asia, Africa and Latin America, 34(4):27-29.*

APPENDICES

APPENDIX I

1. **Determination of theoretical field capacity**

   Width of operation = 0.6 m

   Speed of operation = 1.368 km/h

   $$TFC = \frac{w \times s}{10}$$

   = (0.6 x 1.368)/10

   = 0.082 ha/h

2. **Determination of field capacity**

   Area covered = 0.028435 ha

   Time taken = 0.283 h

   FC = A/P

   = 0.028435/3.529

   = 0.1 ha/h

3. **Determination of field efficiency**

   Field efficiency = (field capacity / theoretical field capacity) x 100

   = (0.1 / 0.082) x 100

   = 80%

APPENDIX II

No. of weeds before weeding	No. of weeds after weeding	Weeding efficiency (%)
168	46	72
124	33	73.3
147	38	74
158	47	70
98	24	75.5

1. **Determination of weeding efficiency**

Sample calculation:

No. of weeds before weeding = 168

No. of weeds after weeding = 46

$$\text{Weeding efficiency} = \frac{(168-46) * 100}{168}$$

$$= 72\%$$

APPENDIX III

1. Determination of plant damage

Total number of plants per unit area before the weeding operation, p	**Total number of plants damaged in the same unit area after weeding, q**	**Plant damaged, R (%)**
240	9	3.75
248	8	3.2
223	12	5.3
236	10	4.2
245	11	4.48

Sample calculation:

p = 240

q = 9

R = (q *100)/ p

= (9 * 100)/240

= 3.75

APPENDIX IV

1. Cost analysis of mini tiller weeder

A. Basic information

(i)	Cost of the mini tiller weeder, Rs	:	35000
(ii)	Useful life, year	:	10
(iii)	Hours of use per year	:	300
(iv)	No.of skilled labours required	:	1
(v)	Rate of interest	:	10%
(vi)	Salvage value(10% of investment cost)	:	3500
(vii)	Field capacity, ha h^{-1}	:	0.1
(viii)	Fuel requirement, *l* h^{-1}	:	0.6

B. Various costs

I. Fixed cost

(i) Depreciation cost per year, Rs : $\frac{initialcost - salvagevalue}{usefullife}$

: $\frac{35000-3500}{10}$

: 3150

(ii) Interest on investment per year, Rs : $\left(\frac{initial\ cost + salvage\ value}{2}\right) * interest\ rate$

: $\left(\frac{35000+3500}{2}\right) * 0.1$

: 1925

(iii) Total fixed cost per year, Rs : 3150 + 1925

: 5075

(iv) Total fixed cost per hour, Rs : $\frac{Total fixed cost per year}{hours of use per year}$

: 5075/300

: 16.92

II. Variable cost

(i) Repair and maintenance per hour, Rs : $\frac{initial\ cost \text{x } 0.05}{300}$

: $\frac{35000 \text{x } 0.05}{300}$

: 5.83

(ii) Fuel cost per hour, Rs : Fuel requirement x rate of fuel

: 0.6 x 67.5

: 40.5

(iii) Cost of lubricant per hour, Rs : Fuel cost x 0.30

: 67.5 x 0.3

: 12.15

(iv) Labour cost per hour, Rs : 150

Total variable cost : 208.48

III. Total cost per hour, Rs : Fixed cost + variable cost

: 16.92 + 208.48

: 225.4

IV. Total cost per hectare, Rs : $\frac{totalcostperhour}{fieldcapacity}$

:(225.4) / **(**0.1)

: 2254

APPENDIX V

Economics of mini tiller weeder in comparison with TNAU two-row power weeder and three-row power weeder.

	One hectare land			Two hectare land			Three hectare land		
	TNAU two row power weeder	Three row power weeder	Mini tiller weeder	TNAU two row power weeder	Three row power weeder	Mini tiller weeder	TNAU two row power weeder	Three row power weeder	Mini tiller weeder
Annual working hours	32	50	90	64	100	180	96	150	270
Fixed cost per hour	158.6	174	56.38	79.3	87	28.19	52.86	58	18.79
Variable cost per hour	267.46	272.75	222.09	240.12	242.77	212.37	231	232.77	209.13
Total cost of operation per hour	426.06	446.75	278.47	319.41	329.77	240.56	283.86	290.77	227.9
Total cost of operation per hectare	3408.5	5584.4	2784.7	2555.3	4122.2	2405.6	2270.9	3634.6	2279

ABSTRACT

DEVELOPMENT OF PADDY WEEDING ATTACHMENT TO MINI TILLER

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ABSTRACT

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ABSTRACT

Rice is the staple food of Kerala and is the most important food crop grown. However, the area under paddy cultivation has come down from 8.82 lakh ha in 1974-75 to 1.96 lakh ha in 2015-16. Adoption of mechanized farming is a widely accepted solution for the reversal of this trend. In view of the present scenario, machinery use in the intercultural operations in paddy cultivation, mainly weeding, is of much importance. Traditionally, the most common method of weed control is manual hand weeding by labourers. Recently, mechanical and chemical weed control methods are becoming popular. But the environmental problems associated with chemical weeding and the high initial cost and maintenance cost of power weeders limits their use, especially among marginal farmers. To overcome this, brush cutters were tested and assessed to know its suitability for paddy weeding. But due to the vibration hazards and discomfort to the operator, prolonged use was not possible. Even if a suitable configuration of the rotor is done, man power was needed for weeding. Thus, brush cutters were not suitable for paddy weeding. Another approach to wetland paddy weeding introduced was the refinement and development of a weeding attachment to mini tiller. Hence, a study was undertaken with the following objectives:

- Assessment of powered weeders for paddy weeding.
- Development of a wetland paddy weeding attachment to mini tiller.
- Evaluation of the developed paddy weeding attachment to mini tiller.

The methodology used for the study of three row paddy weeder, brush cutters and its attachments and the study and development of weeding attachment to mini tiller for paddy weeding included:

- Agronomic characteristics of machine transplanted rice
- Assessment of powered three row weeder for paddy weeding
    - Laboratory tests
    - Field evaluation

- Study of brush cutters and their attachments
- Study of existing soil working attachment to kombi type brush cutter
- Study of powered mini tiller
- Suitability of existing powered mini tiller for paddy weeding
- Development of paddy weeding attachment to mini tiller
- Fabrication of rotary weeding attachment
- Fabrication of guards
- Attachment of the rotary weeding unit and guards to mini tiller
- Evaluation of the developed weeding attachment
- Economics of weeder

The salient results

A paddy weeder attachment to mini tiller was designed and fabricated. The developed weeder was found to be superior to the existing paddy power weeders viz. TNAU two row weeder and three row power paddy weeder. Cost of operation per hectare of mini tiller weeder was lowest compared to three-row power weeder and TNAU two row power weeder. With limited constructional modifications, the mini tiller can be used as a multi-purpose implement for different operations such as minor tillage, weeding of vegetable crop as well as paddy weeding which can improve the annual working hours of the machine.