PERFORMANCE EVALUATION OF TRACTOR OPERATED YARROW BUND MAKER FOR PADDY CULTIVATION

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KERALA, INDIA

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TAVANUR-679 573, MALAPPURAM
KERALA, INDIA

2022

DECLARATION

We hereby declare that this project report entitled "**PERFORMANCE EVALUATION OF TRACTOR OPERATED YARROW BUND MAKER FOR PADDY CULTIVATION**" is a bona-fide 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.

Place : Tavanur

Date : 15/06/2022

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CERTIFICATE

Certified that this project report entitled **"PERFORMANCE EVALUATION OF TRACTOR OPERATED YARROW BUND MAKER FOR PADDY CULTIVATION"** is a record of project work done jointly by **Ms. Aashna M.S**, **Ms. Adithya Devaraj, Ms. Amana C and Ms. Ashitha Thomas** under our guidance and supervision and that it has not previously formed the basis for any degree, diploma, fellowship or associate ship or other similar title of another University or Society.

Place: Tavanur

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DEDICATED TO OUR PROFESSION

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Symbols And Abbreviations

Abbreviation/ Notation		Description
<	:	Less than
>	:	Greater than
%	:	Per cent
±	:	Plus or minus
×	:	Multiplication
÷	:	Division
≤	:	Less than or equal to
≥	:	Greater than or equal to
°	:	Degree
°C	:	Degree Celsius
A	:	Quality of feed index
ANOVA	:	Analysis of variance
ASAE	:	American society of Agricultural engineers
cm	:	Centimeter
cm^2	:	Square centimeter
cm^3	:	Cubic centimeter
DAP	:	Days after planning
db.	:	Dry basis
DI	:	Multiple
index et al.	:	and others
etc.	:	Et cetera
Fig.	:	Figure
g	:	Gram
ha	:	Hectare

hah^{-1}	:	Hectare per hour
I_p	:	Precision index
IS	:	Indian standards
KCAET	:	Kelappaji College of Agricultural Engineering and Technology
kg	:	Kilogram
$kgha^{-1}$	:	Kilogram per hectare
kgm^3	:	Kilogram per cubic meter
kgf	:	Kilogram force
kmh^{-1}	:	Kilometer per hour
kW	:	Kilowatt
l	:	Liter
lpm	:	Liter per minute
m	:	Meter
$mmin^{-1}$	:	Meter per minute
ms^{-1}	:	Meter per second
m^2	:	Square meter
m^3	:	Cubic meter
mm	:	Millimeter
mm^2	:	Square millimeter
M	:	Missing index
MS	:	Mild steel
N	:	Newton
psi	:	Pounds per square inch
PVC	:	Polyvinyl chloride
q	:	Quintal
rpm	:	Revolution per minute
SD	:	Standard deviation

Sl. No.	:	Serial number
t	:	Tons
viz	:	Namely
wb	:	Wet basis
π	:	Pi
ρ	:	Rho

Introduction

CHAPTER-I

INTRODUCTION

Agriculture sector is the mainstay of the Indian economy, contributing about 20 percent of national Gross Domestic Product (GDP) according to the Economic survey 2020-2021. India is the world's second-largest producer of rice, and the largest exporter of rice in the world and produced about 120 million tons in 2021-22. About half of India's population is wholly or significantly dependent on agriculture and allied activities for their livelihood. India ranks first in the world with highest net cropped area followed by US and China. The economic contribution of agriculture to India's GDP is steadily declining with the country's broad-based economic growth.

Status of farm mechanization in India

Decline in the use of animal and human power in agriculture is obvious and paved the way for the mechanization of agriculture. Shortage of agricultural labour and the need to enhance farm productivity are among the main reasons for increasing farm mechanization in India. The projected value of the Indian farm mechanization market in the year 2019-20 is 40000 crores. Among the farm operation, harvesting registered the highest mechanization level (65%) followed by land preparation (40%). The loss in mechanization occurs in seed sowing, planting and weeding operations. In earlier days mechanization was only through tractors and power tiller nowadays it is through combine harvester and other equipment like paddy transplanters and combine harvesters, threshers, rotavator, transplanters, reapers, zero till drills, laser levellers and power weeders.

Mechanization in paddy cultivation

Rice is a labour-intensive crop which requires a work-concentrated harvest. For one hectare area, it need around 850-900 man-hours for cultivation. Mechanization in rice cultivation is getting momentum due to growing labour scarcity and raising labour wage. The timeliness of operation is adversely affected by labour scarcity during the peak period of the season, adversely affect the crop yield. Nowadays tractor, power tiller, paddy transplanter, cono weeder, power sprayer, combine harvester, thresher, etc. are the part of paddy mechanization. Due to the high cost of tractors, paddy transplanters, combine harvesters and threshers, most of the farmers are not able to buy those machineries though loans are available for this purpose, and instead they hire those machineries. Transplanting, weeding and harvesting and threshing operations are the most labour-intensive operations in paddy cultivations with 38%, 19% and 32% respectively and hence thrust should be given for mechanizing these operations in order to reduce the labour requirement in paddy cultivation.

At present the mechanization reached to different operations like land preparation (60%), transplanting (5%), irrigation (50%), fertilizer application (25%), harvesting (3%) and threshing operations (20%) respectively. More emphasis may be given to transplanting, harvesting and weeding operation to attain the desired level of mechanization.

Mechanization saves time in completing different operations, which gives the crop sufficient time to mature, allows the farmer to be more flexible in his farming operations and facilitates multi and relay cropping. The transition from animal power to mechanical power has made agriculture capital intensive. Mechanization of harvesting and threshing save 4-5% losses over the conventional method. It also increases productivity by facilitating timely sowing of crop, efficient control of weeds and reduce human drudgery. In addition, recent modern days tools like Zero-till seed drill, Laser leveller, Happy seeder, Rotavator, etc., helps in conservation of natural resources like water, soil and air.

Testing of agricultural machineries

The use of modern agricultural machinery and improved farming technique have definitely increased the production and productivity in agriculture as well as generated better job opportunities. Farm machines supplied to the farmers must ensure functional and life reliability. For this, testing of machines according to a well-established standardization procedure is important. This will help to ensure quality of machines reaching farmer as well as pin pointing improvement need for higher efficiencies or enhanced quality of manufacturing. Testing is defined as analysis of behaviour of machine when compared with standard codes or norms under ideal and repeatable conditions in the laboratory and field.

Objectives of testing agricultural machineries are:

- To test agricultural machinery, engines, pumps, etc. manufactured in the country with a view to assess their functional suitability and performance characteristics under different agro climatic conditions, so that, the published test results would:

  a) Serve as a basis to decide the type of machinery best suited for Indian conditions, which could be encouraged for production and popularization.

  b) Help the farmers and other prospective purchasers in determining the comparative performance of machinery available in the market.

  c) Provide material to researchers, designers for undertaking development work on agricultural machinery, engineers and extension workers for guiding farmers and other users in the proper selection of equipment.

  d) Form basis for standard specifications to be used by the manufacturers and distributors.

  e) Help financial institutions in recommending financial assistance to the manufacturers as well as the farmers.
- To carryout trials on machinery and implements which have proven successful in other regions of the World with a view to explore the possibility of their introduction in the region or country.
- To provide feedback to the manufacturers through "Users' Survey" aiming at the farmers response and the standard of after sales service provided by them.
- To assist Bureau of Indian Standards in the formulation of various standards on agricultural implements and machines. To carry out allied research development on agricultural machines and implements.

Bund or ridge preparation

Bund or ridges preparation is a difficult task which local farmers had been practicing for centuries and is an important part of land preparation in paddy wetlands. Farm bunds are the retaining walls along the boundary of agricultural fields. The functions of the field bunds are to stop the rainwater in the field itself, retaining soil moisture for longer time, reducing soil erosion during heavy rain. Farm bunds are rapidly responsive and a high adoption intervention. They are useful for both dry and high rainfall regions. In dry regions they hold rainwater in the fields and improve the soil moisture, whereas in heavy rainfall areas they hold water in the fields and protect from soil erosion. In both situations, the farmers get the benefit of increased crop yield, protection from soil erosion and improvement in soil moisture.

In manual bund formation, the labourers make use of spades to cut soil from both the sides of the existing bunds (from the previous season) and use this soil to plaster the sides and top of the bunds. After plastering both sides of the bund, the top is pressed with the blade of the spade to flatten it, and a bund with trapezoidal cross section is formed. However the cross section of the bund is not uniform throughout its length. The operation is performed by male labourers, who can form an average of about 375 to 450 metres of bund per day. The prevailing wage rate for such labourers is Rs. 800/- to Rs. 850/- per day of six hours. (Suma Nair, 2018)

Bund formation is usually done in two steps at the beginning of each crop season. First, the bund should be cleared from weeds. During initial plough. Then the bund should be formed with a layer of mud after the second plough. Good bunds help to limit water losses by seepage and under bund flows. Bund should be well compacted and any rat holes should be plastered with mud. Manually, an average skilled person can trim and plaster 90-120 m of bund per day. Normally, a person can pack or firm the formed bund 100-150 m length in an hour (Singh *et al.* 2016). An average former would take approximately 30 minutes for single side bund clearing and 45 minutes for double side bund forming of an 18 meters long bund (Pathirana *et al.* 2010). The traditional manual or ridge forming work is characterized by low efficiency, low strength, high cost and directly affects the profitability of rice farming. Moreover manually made bunds that are not properly aligned and compacted, not long lasting and causes rodent problem. Therefore, the main objective of bund former is to mechanize this bund making process, since it could be very helpful for farmers to save time, physical energy and make their work easy. The attachments for bund clearing and forming should consists of the following features:

- Good quality.
- Reliable mechanism.
- Ease of operation.

- Easy maintenance.
- It can be used for dry and wetland operations.
- Spare parts available.

Bund or ridge forming machine simplifies the process of making strong and wider ridges in agricultural garden or wet lands with optimum moisture content for irrigation, man walking and field bordering purpose.

The paddy cultivation are strictly time bound, and move forward through the different stages in a rhythmic and systematic pattern. The tillage, bund forming, levelling and liming activities have to be completed within seven to ten days, depending on the sequence of dewatering of fields, water level, man and machine availability. The scarcity of skilled labour during the peak period of bund formation protract the entire process. To overcome this problems mechanization of farm bunds maybe a remedy for paddy cultivation. Keeping this in consideration the study has been fabricated with the following objectives:

1. To study about the machine.
2. To evaluate the performance of bund former.
3. To compare manually and mechanically formed bunds.

Review of literature

CHAPTER 2

REVIEW OF LITERATURE

This chapter gives a comprehensive review of the research work done by various research workers related to bund making, machinery for bund formation and performance evaluation.

The present chapter deals with the work that has been carried out so far regarding the development and performance evaluation of bund forming machine. bund formation is one of the primary operations in paddy wetlands and is presently being performed manually by skilled male labourers. The process is tedious, requires skill and there is a severe dearth of labour for bund formation during the peak period. As cultivation in paddy wetlands is time bound, the need for a mechanized alternative is being urgently felt by the rice farmers.

2.1 Rice cultivation

India is an important centre for rice production and is cultivated on the largest areas in the country. Produced about 120 million tons in FY 2021-22

Government of Kerala (2016) reported that rice is the staple food crop and is grown in 7.46% of the total cropped area. Drastic decrease is being observed in the area under rice cultivation since the 1980s. The area under rice has come down from 8.82 lakh hectares in 1974-75 to 1.96 lakh hectares in 2015-16, showing a 77% decrease. A corresponding decrease in production is also seen from 13.76 lakh MT in 1972-73 to 5.49 lakh MT in 2015-16.

Adhikari *et al.* (2006) attempts to elucidate the current scenario, strategies and agro-techniques for seed as well as grain production, quality parameters and economic aspects of hybrid rice in India. As the seed production of hybrid rice is knowledge and labour intensive, different agro-techniques need to be adopted to make it more successful.

2.2 Bund making

Bund making is a land preparation activity done prior to sowing. Bunds are for demarcating boundaries, for irrigation purposes and to prevent leaching of fertilizers in standing water.

Pathirana *et al.* (2010) developed and tested a bund making machine with bund clearing and height adjusting mechanism for dry and slightly wet soil. A rotary blade arrangement of machine acts as soil cutting unit for existing bund or the ground, and also as a soil collecting unit. A rotating drum was provided to compress the soil to form a new bund. The compaction of the field bund varies with the rotary speed of the drum. Moisture content have a significant effect on bund making. A plastering technique was also attached to the machine to convey the mud towards the bund as the tractor moves forward. The cost of fabrication of machine approximates Rs.30,000.

Patil *et al.* (2011) stated that when new bunds were laid over existing paddy fields, the plough sole in the under bund soil profile was retained which restrict the percolation through bunds. As the finer soil particles get deposited near the puddling depth, a plough sole between 10 to 25 cm of soil depth was formed. Bunds or small dykes were constructed around paddy fields to offer restriction to the horizontal flow of water.

Singh *et al.* (2016) reported that bunds in the paddy fields are for demarcating boundaries, for irrigation purposes and to prevent leaching of fertilizers in standing water. Tractor operated bund formers are usually disc type, mould board type or forming board type. However, the bunds formed by these bund formers must be shaped and packed, which was usually performed using spade or feet. This activity was reported to be labour intensive and time consuming.

2.3 Machinery for bund formation

Mechanization in bund making is gaining interest recently. Several research works have been done in developing bund making machines according to various aspects namely, nature of soil, soil-implement interface, efficiency, quality of work, etc.

Spoor (1969) reported that the soil engaging implements changes the state of the soil depending on the nature of soil and the soil-implement interface. A soil engaging tool, which manipulated the soil to the required amount efficiently but with minimum effort, was usually observed as the best design of the tool.

James (1991) developed a power tiller operated bed former. The main components of the prototype were two pairs of forming boards fitted, a hitching unit and a depth control-cum-transport wheel. Seed beds of heights 22, 18 and 15 cm were respectively formed at widths ranging from 60 to 64 cm. Heights of 18 and 15 cm were obtained for widths ranging from 73 to 75 cm and 80 to 81 cm respectively. The range of power utilization was from 0.586 to 0.771 hp and the range of draft was from 115.59 to 169.69 kgf. Wheel slip was found to range between 46.76 % and 77.1% . The mean effective field capacity of implement was 0.0996 hah^{-1} and mean field efficiency was 46.3 %. The total cost of production of the unit was Rs.2000/- and the cost of operation per hectare was Rs.777/-.

Sharma *et al.* (2001) developed a tractor operated multicrop ridge furrow opener and a flatbed seeding machine to plant seeds on both flat beds and ridge-furrow system. The implement had two bottom ridger-seeder, for making the ridges and furrows, with seeding adjustments to place seeds in furrows, on ridges or on the sides of ridges. Nine shoe type combined furrow openers were used in a single operation on flat beds. The implement had a field capacity of five to six hectare per day depending on the crop type sown. The implement could achieve 30 to 40 % of savings in irrigation water and gave 12 to 15 % higher yields.

Bernik and Vucajnk (2008) mentioned that drawn cultivators or ridgers were suitable for well-structured light soils. The PTO operated cultivators or ridgers created the largest cross-sectional area of the ridge, could crush soil aggregates in inter row spaces, was efficient in ridge shaping and led to lower cone resistances in the ridge centre. However, they required more energy to perform the same operation when compared to the drawn implements.

Jai Singh (2008) designed and developed prototypes of the bullock-drawn and tractor-drawn "Irrigation Channel-cum-Bund Former". This implement can make desired size of the channels and bunds in a single operation without disturbing the sown seed and the level of the field. From the field trials the cost of making the channels and bunds has been worked out to be Rs.7/- to Rs.9/- per hectare with the Channel Former in reference and that by manual labour to Rs.30/- to Rs.33/- per hectare plot by making alternate channels and bunds crosswise and 6 metres apart.

Ashry *et al.* (2009) developed a tractor drawn, five-ridge conventional seed drill, with six ridging bodies. The implement formed ridges 0.60 m wide and had a penetration angle of 20 degrees. Studies were conducted to evaluate the effects of different depths, planting methods and forward speeds and number of rows of plant per ridge. They concluded that the modified ridger cum seeder had a significant positive influence on plant height, germination ratio and number of branches per plant as compared to a traditional seed drill.

Nawale *et al.* (2009) developed a tractor operated an earthing-up cum fertilizer applicator for sugarcane for interculture, earthing-up and fertilizer application simultaneously. The developed machine weighed 250 kg consisting of a ridger with sweeps for earthing-up, fertilizer box of 60 kg capacity and ground wheel of 40 cm diameter. The average effective field capacity of the machine was 0.330 ha h^{-1} with 82.70 % field efficiency. The average depth of operation was 10.20 cm with average ridge height of 22.35 cm. The cost of operation was Rs.88.99 h^{-1} and there was a net saving of Rs.3261.61 ha^{-1} over the conventional method.

Gammoh (2011) developed a double-furrower with raised bed made up of a levelling blade 45 cm wide and two disc bottoms with 90 cm diameter each were mounted on an adjustable frame. This frame permitted the discs to slide horizontally in relation to each other. A furrow of depth 20 cm and width 50 cm was opened first by the front right disc. The soil so loosened was moved to form a ridge having a width of 50 cm and height of 20 cm on the natural land level. The second furrow was simultaneously opened by the back left disc and the loose soil was thrown to fill the bottom of the first furrow, forming a raised bed.

Rajesh (2012) fabricated a tractor operated *kaipad* seedbed former. The seedbeds formed had the maximum height when the tractor was operated at a forward speed of 2 km h^{-1} and depth of 0.20 m. However the operational speed and depth of operation was set at 1.5 kmh^{-1} and 0.15 m to reduce draft. The performance of the *kaipad* bed former and the tractor operated ridger were compared and it was observed that the average top width and heights of seedbeds obtained were 34.7 cm, 18.4 cm and

29.4 cm, 23.2 cm respectively. The *kaipad* seedbed former also had a field efficiency of 73.9 % with a wheel slip of 19.79 %.

Raghavendra *et al.* (2013) developed a tractor drawn ridge planter for cotton. They reported an optimum performance at forward speed of operation of 1.25 ms^{-1}, the average draft required was 2300 N and fuel consumption was 3.83 lh^{-1}. The ridger planter had a field capacity of 0.89 hah^{-1} with field efficiency of 73.55%. The planting depth was 30 mm.

Joseph (2015) evaluated the performance of the PTO driven tractor operated ridge plastering machine (Model RRM700) in sandy loam soil and was observed that the machine could perform satisfactorily only in a limited range of water content. The bunds were not formed in extreme soil conditions. The machine formed bunds of height upto 30 cm and had a field capacity of about one kilometre of bund formed per hour. The weight of the machine is a constrain to operate it in the kole lands, which itself would hinder its usage to form bunds in the soft soils of the *kole* lands.

Liping *et al.* (2015) designed and manufactured a kind of rotary and building ridge combined work machine. It includes transmission system, lifting parts, soil collecting device, pressing and molding device. The machine can be directly attached to 70~ 90 kW wheeled tractor, which can complete tillage and at the same time building a ridge. The machine has the advantages of high efficiency, low cost, good effect of ploughing and building ridge, which has important practical significance to paddy field mechanization and provides technical support and guarantee for rice production.

Patil (2016) developed a raised bed seed cum fertilizer drill for dry paddy. It consisted of seed and fertilizer hopper, seed metering mechanism, fertilizer metering mechanism, drive wheel, furrow openers, bed former, bed shaper and cut-off device. The implement formed beds with average top width, bottom width and depth of bed formed of 58 cm, 78 cm and 11 cm respectively with furrow width of 22 cm. The average depth of seed placement was 4.2 cm for raised bed system and 3.3 cm for flatbed system and fertilizer was placed at a 6.1 cm for raised bed and 4.9 cm for flatbed system. The operational speed of 2 kmh^{-1} was found better and the implement had a field capacity of 0.125 hah^{-1}, and field efficiency of 78.37%.

Singh *et al.* (2016) developed a bund former cum packer, which was made up of a disc type bund former, a rectangular tool bar frame and packing unit, to carry out the operations of bund formation and packing in a single pass. The equipment had a field capacity of 1.4 hah^{-1} at a tractor speed of 2.93 kmh^{-1} and the labour requirement was reduced by about 96 %. A tractor operated wide bed former, having a rotary tiller and a bed forming setup with a top width of 1000 mm and height of 130 mm, was developed and evaluated, at soil moisture contents of 12.5 to 16 % (db).

Dixit *et al.* (2018) stated that a forward speed of 2.75 kmh^{-1} was found suitable for bed formation. The average fuel consumption was found to be 5.91 lh^{-1} and field capacity 0.31 ha h^{-1}.

Rahul *et al.* (2018) evaluated the performance of tractor drawn ridge plastering machine in sandy loam soil with a moisture content of 13.87 % (db). The machine can be operated with 40-70 hp tractors. The rotavator pulverises the soil, the leveller levels the soil, and the rotating disc trims the bund and plasters it with pulverised soil. The roller attached to the rotating disc compresses the soil. During the field study they observed that, the field capacity of the machine was 1000 mh^{-1} at an average speed of 1.0 kmh^{-1} with the height and width of bund was 25 cm and 45 cm respectively. The angle between ground and the side wall of the bund is 1200. The fuel consumption of the machine was 4 lh^{-1}. The cost of operation of the machine observed was Rs.712h^{-1}. The cost saving was Rs.2248/- over conventional method. This technology will save the energy and time involved in field preparation.

2.4 Soil parameters

Many soil parameters are influential in a soil machine environment. Soil properties are static or inherent to its nature, and dynamic, which come into play as it moves. The soil moisture content, bulk density, type of soil, the consistency limits, resistance to penetration and shear strength are factors which play an important role in the behaviour of a soil working implement.

Hillel (1980) reported that the bulk density of soil is a function of soil moisture content at any given amount of compactive effort. When wetness of soil increases, the inter-particle bonds are weakened. This led to swelling and reduction in internal friction, making soil more workable. When the soil reached near to saturation, the volume of air that could be expelled from the soil decreased and the soil could not be compacted to the same degree as earlier with the same compactive force. The soil wetness which is just enough to expel all air from soil is the optimum moisture content and the corresponding density is the maximum dry density.

Daddow and Warrington (1983) stated that root growth was stopped as the soil was compacted to the growth limiting bulk density values, because roots were not able to exert pressure to overcome this mechanical resistance and move the soil particles. The growth limiting bulk density of a soil was influenced by its texture, the property which affects the average pore size and mechanical resistance of compacted soil. A soil consisting of large amount of fine particles exhibits smaller pore diameter and greater penetration resistance at lower bulk densities. Coarse textures soils have a greater value of growth limiting bulk density as compared to fine textured soil.

Kepner *et al.* (1990) stated that implement work efficiencies were directly associated to the inherent physical and mechanical properties of soil such as moisture content, soil texture, shear strength, compaction and frictional forces. Wet soils compacted easily till near saturation and then could not be compressed further. For the different soils in the study, the difference in soil compaction was greater at dry conditions, while soils in wet conditions showed greater changes on shear strength (O'Sullivan and Robertson, 1996).

Zadeh (2006) concluded that the energy consumed during tillage depends on soil, tool and operating parameters.

Kumar *et al.* (2012) reported that the soil cone index is the soil penetration resistance measured using a cone penetrometer. The cone index was an indicator for soil compaction, crop root development, soil water infiltration, draft on tillage tools, and performance of tractors.

2.5 Machine parameters

The relative movement, in the direction of travel, at the mutual contact surface of a traction device and the support surface is termed as wheel slip (ASAE, 1983).

Slip on ground wheels, high planting speeds and non-uniform seed size were causes of irregular planting, as reported by Bjerkan (1947). They suggested an average value of slip as 5 % for rubber tyres and 15 % for steel wheels.

Zoerb and Popoff (1967) reported that maximum tractive efficiency is observed in the wheel slip range of 10 to 15 %. In their study, they report the different methods of slip measurement. In the conventional method of drive wheel slip measurement, first the base unloaded distance (B) for a given number of wheel revolutions was recorded. Then the loaded distance (L) for the same number of revolutions was also recorded. Percentage slip was calculated as equal to 100 x (B-L)/B. In another method stated by them, as per the University of Nebraska official drawbar test the total wheel revolutions to traverse a fixed distance is counted under load (R) and under no load (r) conditions and percentage slip is calculated as equal to [100(R-r)/R]. The equation is also a part of the agricultural tractor test code. A direct reading slip indicator was developed in the study.

Fernandes *et al.* (2007) stated that slip influences fuel consumption negatively; however it is required to increase the tractive efficiency and drawbar power. Hence an optimum range of slip is required for efficient tractor operation. They determined from their study that for a tractor with rated power of 89.7 kW, when slip is 18 %, there is a variation in fuel consumption of 5.36 lh^{-1}, which is about 23 % of the annual average fuel consumption value. Hence by reducing slip, the fuel consumption could be reduced.

Fathollahzadeh *et al.* (2010) cited that the fuel consumption using mould board ploughs to be 30 lha^{-1} in wet soils and 23 lha^{-1} in dry soils. They also reported an average fuel consumption of 30 lha^{-1} in common ploughing depth of 0.2 to 0.25 m, when a John Deere 3140 tractor was used with a three bottom tractor operated mould board plough in loamy soils. They also found an increase in fuel consumption of the tractor with depth.

Tayel *et al.* (2015) also reported the increase fuel consumption and slip with increase in soil moisture and tillage depth in sandy soils.

Jebur and Alsayyah (2017) conducted a study in silt clay loam to study effect of soil moisture content and speed on slip, pull force and effective field capacity. They found that when soil moisture content was reduced from 18-20 % to 14-16 %, slip decreased by 31.34 %, and pull force decreased by 26.14 % but the effective field capacity was found to increase by 12.5 %. As the forward speed increased the wheel slip increased.

Suma and Ramachandran (2018) developed a low cost, tractor drawn bund forming and strengthening implement for paddy wetlands. Shear strength of the bunds formed is considered as one of the parameters for assessing effectiveness of bunds. Shear strength were measured for the mechanically formed bunds and compared with the manual bunds formed at three different locations.

Laxman *et al.* (2020) developed a mini tractor operated ridge plastering machine and evaluated it in sandy loam soil with a moisture content of 31%. The blades on the periphery of the disc pulverises the soil, the leveller levels the soil and the rotating disc trims the bund and plasters it with pulverised soil. The roller attached to the rotating disc compresses the soil. This machine is suitable for both dry and wet conditions. During the field study, they observed that, the field capacity of the machine was 833 mh^{-1} with an average speed of 1.0 kmh^{-1}. Overall dimensions of bund was 178 mm height and 288 mm width respectively. The cost of operation of the machine was Rs.700-800 h^{-1}. The cost saving was Rs.2000-2500 h^{-1} over conventional method. It helped to bring down the cost. Hence, a simple, effective and indigenous mini tractor operated ridge plastering machine was developed for small and marginal farmers.

2.6 Testing of farm machineries

Testing is defined as analysis of behaviour of machine when compared with standard codes or norms under ideal and repeatable conditions in the laboratory and field.

Paraforos *et al.* (2013) stated that, during the last decades fatigue life of agricultural machinery is gaining more interest as the transport and working conditions have changed. Transport and working speed have increased since advanced and more powerful tractors are being offered. In order to compensate for longer operation periods on large farms, manufacturers have developed bigger implements with higher capacity. Factors like higher speed and machine weight affect the durability of agricultural machines with high economic loss in the case of a breakdown. In order to assess agricultural machine durability a new analysis approach is needed to combine field and road surface mapping and dynamic strain and load measurements. In the present paper strain data from critical points of a four rotor swather were recorded as well as the accelerations on the main axle. In addition the surface data that produced the a fore mentioned load were also obtained to describe the dynamic input loads.

Mehta (2014) coined about the agricultural mechanization and testing of machineries. Agricultural mechanization helps to remove drudgery, improve working comfort, enhance timeliness, and reduce losses and increase production and productivity. Accordingly, use of better power viz., tractors and different types of agricultural machines in Indian agriculture has risen sharply on Indian farms to boost food and fibre production. But to safe guard the user s interest, to ensure better quality and reliability of machines and for sustained growth of farm machinery industry, there is a need for sound scientific testing and evaluation of farm machines by using instrumentation and accepted methodology. Thus, testing and evaluation holds the proper key to standardization and quality control of agricultural machinery for better acceptability and sustained farm production. To satisfy the genuine need of different sectors, this book has been prepared. It is expected to serve as a textbook for the students of agricultural engineering degree and postgraduate degree programme. It may also serve the needs of professional engineers, scientists, testing institutions and research organizations dealing with testing and evaluation of agricultural machinery.

Agnieszka and Giulio (2015) stated that the safety of agricultural machinery is a key aspect in carrying out agro-technical treatments. Appropriate testing of machines and equipment guarantees better protection of life or health. Applicable conformity assessment procedures do not require (except for particularly dangerous machines) participation of the third party– a professional, specialized, accredited, notified testing laboratory what raises a common fear of the dangers arising from ignorance of manufacturers.

2.7 Performance evaluation of bund former

Various studies have been done to evaluate the performance of bund former machine. Basic parameters evaluated were field capacity and operation time.

Jadav *et.al* (2020) evaluated the performance of a manually operated bund former. The forward speed and actual field capacity were found to be 0.472 ms^{-1} and 0.044 hah^{-1}, respectively. The mean effective operation time for the hand operated bund former on a 1 ha field of a sandy loam soil at 13.42 % moisture content was found 22.64 h. The average field efficiency with the equipment was 74.05 % at tractor speed of 1.7 kmh^{-1}.

Ashish *et al.* (2022) assessed the performance of tractor-operated bund former for mulched field to observe the effects of rotor speed ratios (3:1, 4:1, 5:1), opening width of bund forming plates (270, 340, 410 mm), and straw loads (4.0-4.5, 6.0-6.5 t.ha^{-1}) on the pulverization index (mm), height of bund (mm), width of bund (mm), fuel consumption (lh^{-1}) and field capacity (hah^{-1}) of the machine. The effects of rotor speed ratio, opening width of bund forming plates, and straw load were significant ($p< 0.05$) on pulverization index, bund height, bund width, and fuel consumption. Best performances were obtained at rotor speed ratio of 4:1 and bund forming plates opening width of 340 mm under both straw loads. This combination gave the optimum height of bund (277.6 mm), bund width (720 mm), pulverization index (12.76 mm), and fuel consumption (7.05 lh^{-1}) under both straw loads. The effective field capacity of the tractor-operated bund former was 1.17 hah^{-1} at forward travel speed of 1.5 kmh^{-1}. The operational cost of the bund former was Rs.792.36 ha^{-1}.

Materials and methods

CHAPTER III

MATERIALS AND METHODS

This chapter explains methodology used for the testing and evaluation of the bund former. It simplifies the process of making strong and wider bunds in wetlands with optimum moisture content for irrigation, man walking and field bordering purpose.

3.1 METHOD OF SELECTION OF MACHINE

Based on comparing the performance of different bund formers, tractor operated bund former manufactured by Yarrow Farms was selected for conducting this study.

3.2 SPECIFICATION

3.2.1 Technical specifications

The technical and functional parameters of the machine is mentioned here. The selected machine is able to finish soil covering, bund forming and compaction by once-off. The ridge will be hard, straight and smooth after the ridge forming machine works. The power required to operate the machine is about 40-70 hp. The general specifications of the machine is tabulated in the table 3.1

Table 3.1 General specifications

Item	**Specification**
Name	Yarrow HD DLX bund forming machine
Machine type	Tractor operated ridge forming machine
Model	YRF HD330
Height of form bunds	425 mm
Width of roller	310 mm
Operating speed	Below 1.8 kmh^{-1}
Width of tilling	140 mm
Speed of rotor	230 rpm
Rotor diameter	750 mm
Plaster disc diameter	825 mm
Tractor specifications	40-70 hp
PTO speed	540 rpm
Dimensions	1050 x 2330 x 1000
Weight	380 kg
Salient features	Hydraulic transportation Lock depth adjustment for plaster disc.

3.2.2 Functional components:

The major functional components are (1) Three Point Linkage, (2) Gear box for rotary disc, (3) Plastering disc, (4) Ditching blade, (5) Swing cylinder, (6) Primary gear box, (7) Gear box for plastering disc, (8) Rotor disc, (9) Plastering & Ditching unit guard, (10) Coulter disc are shown in figure 3.1.

Fig 3.1 Yarrow HD DLX Bund Maker

3.2.3 Working of the machine

It is a tractor mounted PTO powered machine. The machine receives the drive from tractor PTO through universal telescopic shaft. The PTO drives primary gearbox which transmit the power in to secondary gear box. The secondary gear box transmit the power in to both plastering unit and rotor disc. The rotor disc unit attached with" J" shaped blades which ditches and throw the soil in to right side. The thrown soil is pressed against the bund wall and the roller pipe presses the top land of the bund and plasters the top surface.

3.2.4 Propeller shaft

A universal telescopic type propeller shaft is used to transmit the power from PTO to primary gearbox of the machine. Its length is varying from 550 mm to 830 mm. A safety clutch is provided in the unit.

3.2.5 Power input connection of implement

The unit was analysed as per the figure 3.2. The specification of the unit is mentioned in table 3.2.

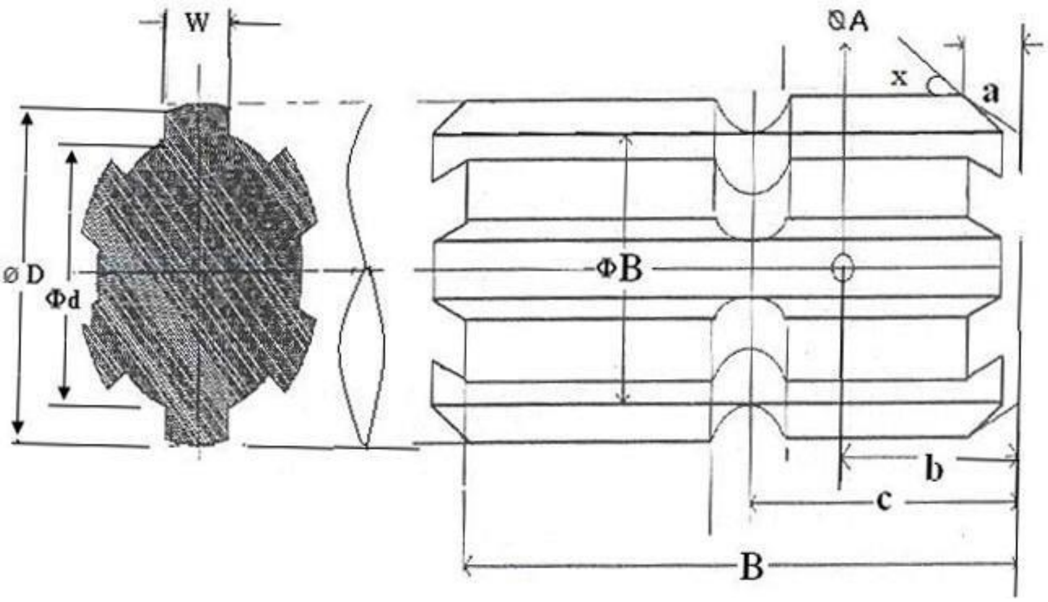

Fig 3.2 Dimensions of Power Input Connection (PIC) of implement

Table 3.2 Dimensions of splined end of pinion shaft

Specification	**As per IS 4931:1995**
Nominal speed (rpm)	540±10 optional 1000 rpm
No. of splines	6
Direction of rotation	Clockwise
Dimensions (mm)	

D Φ	34.79 ± 0.06
d Φ	28.91 ± 0.05
B Φ	29.4 ± 0.1
A Φ	8.3 (Optional)
W	8.69 – (0.09 to 0.16)
A	7.0
B	25 ± 0.5
C	38
X	30 degree
B	76 (Min)
Horizontal distance between PIC and lower hitch point	150* (IS 10318:2002)
Vertical distance between PIC and lower hitch point	100 ± 100* (IS 10318:2002)

3.2.6 Hitch pyramid

The data of the hitch pyramid is tabulated in the table 3.3. The specifications of hitch pyramid as per IS: 4468 (Pt-I)- 1997 is given in the table 3.4.

Table 3.3 Details of hitch pyramid

Specification	Dimension
Constructional details	Hitch is welded on primary gear box with the help of MS box & MS plate
Type	Three point linkage

Size of MS plate	470 × 118× 10 (t) - 2Nos
Size of MS box	120 × 60 × 60

Table 3.4 Specifications of hitch pyramid as per IS: 4468 (Pt-I)- 1997

SL No.	Notation	Specification	As per IS: 4468 (Pt-I)- 1997
1.	D	Diameter of hitch pin hole	25.7+0.2
	b_1’	Width between inner surfaces of yoke	52 (min)
	b_2’	Width between outer surfaces of yoke	86 (Max.)
2.	**Lower hitch point (Cat -II)**		
	D	Diameter of hitch pin	28-0.2
	$B’_3$	Linch pin hole distance	49 (Min.)
	I	Lower hitch point span	825± 1.5
3.	d’	Diameter of linch pin -For upper hitch pin, min	12
		-For lower hitch pin, min	12
	H	Mast height	610 ± 1.5

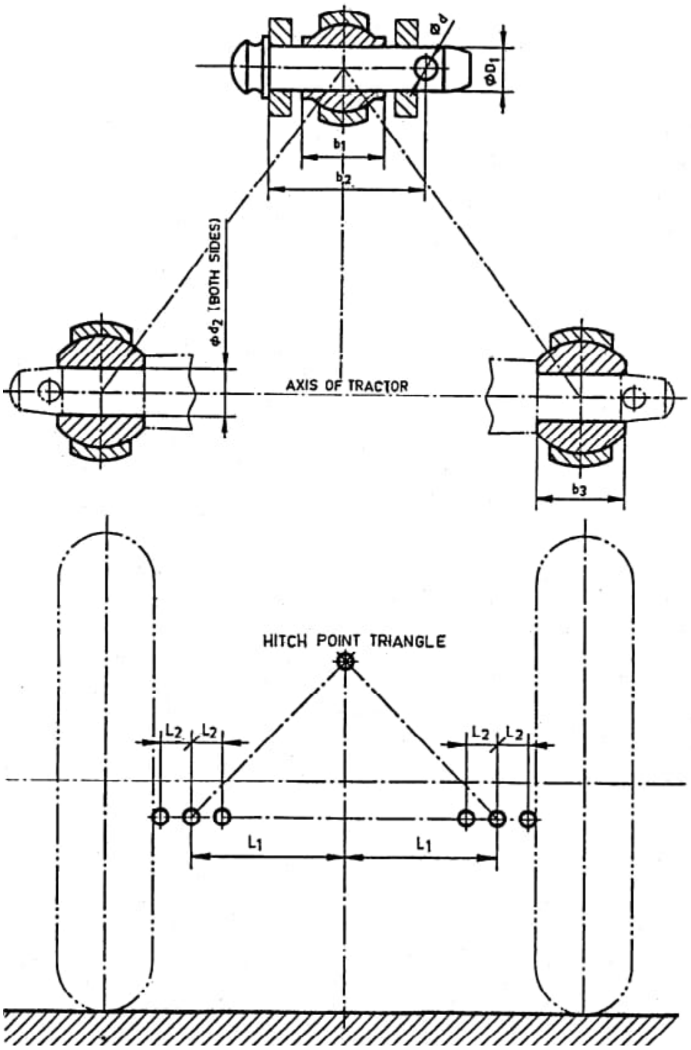

Fig 3.3 Dimensions of hitch point

3.2.7 Power transmission system

In this machine, propeller shaft receives drive from tractor PTO and transmits the power to bund maker through primary & secondary gear boxes respectively.

3.2.7.1 Primary reduction

It consists of input drive shaft and two idle gears, one driven gear, driven gear and output shaft. From the PTO the drive (power) is transferred from shaft to the main gearbox and it splits the power for the power to the idle gears. The idle gears transmit power to the rotating blades and plastering disc. The details of primary reduction is shown in table 3.5.

Table 3.5 Details of primary reduction

Specification	Dimension
No. of gears	05
Type of gear	Spur
No. of teeth on drive gear	11
No. of teeth on driven gear	19
No. of teeth on idle gear	21
Reduction ratio	1.72:1
Oil capacity, (l)	6
Grade of oil	SAE 140 Grade
Oil change period, (h)	First after 50 hrs. then subsequently after every 250 hrs. of operations Provided
Oil level checking bolt	08
No. of bearing	Ball bearing (6208-06Nos., 6309-2 Nos.)
Oil drain plug	Provided

2. Drive for plastering disc

It takes drive from primary gear box through a splined shaft with beveled pinion and drive goes to plastering disc by propeller shaft. The details of plastering unit is given in table 3.6.

Table 3.6 Details of plastering unit

Specification	Dimension
No. of gears	2
Type of gear	Beveled
No. of teeth on drive gear	14

No. of teeth on driven gear	19
Reduction ratio	1.35:1
Oil capacity, (l)	0.300
Grade of oil	SAE 140 Grade
Oil change period, (h)	First after 50 hrs. then subsequently after every 250 hrs. of operations
Provision of breather cap	Provided
Oil level checking bolt	Provided
No. of bearing	6 Taper roller bearings (32009-2 Nos., 33109- 2 Nos., 32208- 02Nos.,)

3.2.8 Ditching unit

Ditching unit consists of 4 pairs of ‘J’ type blades made of high carbon steel which are mounted on the blade holder, and are welded together with rotor disc. The guard cover is provided above the ditching blades. The details of ditching unit is given in table 3.7.

Table 3.7 Details of ditching unit

Specification	**Dimension**
Material of blade	High carbon steel
No. of blades	8
Type of blade	J-type blade (hatchet blade)
Size of blades	
Thickness of blade, mm	11.24
Thickness at beveled edge, mm	1.79
Size of rotor disc	
Diameter, mm	480
Thickness, mm	8

Dia. of rotor disc shaft	45.30
Speed of the ditching rotor corresponding to the PTO speed 540 rpm	218 rpm

3.2.9 Plastering unit

3.2.9.1 Plastering unit

Plastering unit consists of a plastering disc and a forming roller fitted on a common drive shaft of 45.18 mm diameter driven by a gear drive system. The soil thrown by the ditching unit at desire place is plastered and finishes the top portion of the bund height of the plaster disc can adjust by using rotating screw rod handle. Lowering and raising the implement is done with the hydraulic control lever of tractor.

Plastering disc

Plastering disc is formed by the trapezoidal plates fastened in a circular manner around a formed disc plate. The details of the plastering disc is shown in table 3.8.

Table 3.8 Details of plastering disc

Specification	Dimension
Effective diameter of the plastering disc	670.0
Dimension of the plastering disc blade, mm	
Short base	50
Long base	220
Angle of inclination of the plate with the horizontal axis	45.7 degree
Speed of the plastering disc corresponding to the tractor PTO speed 540 rpm	203 rpm

3.2.10 Roller pipe

Roller pipe consists of cylindrical pipe mounted on the plastering unit drive shaft. Length and diameter of the roller pipe are 434 mm and133 mm.

3.2.11 Plastering & ditching unit guard

It is fabricated by MS sheet to cover the plastering and ditching unit with a size of 1430 mm ×775 mm × 4 mm.

3.2.12 Coulter disc

The coulter disc it consists of MS flat disc & roller welded on disc. There are six holes given to adjust the depth and it's supported by ball bearing (6307- No.). The function of the coulter assembly is to adjust the depth of operation by interchange bolting holes in frame to move upwards and downward vertically.

Size of MS flat, mm : 530 × 136× 10 (t)
Diameter of hole, mm : 13.41
Depth adjustment : up to 80 mm

3.2.13 Swing cylinder

One side is mounted on top side of primary gear box and other side on ditching unit guard.

Make : Lorven
Bore dimension, mm : 60 × 40
Piston rod details : 40 mm, 12" stroke × 22" center with two side bush & 25 mm pin hole

3.2.14 Pipe details

Pipe details are shown in the table 3.9

Table 3.9 Pipe details

Specifications	Dimensions
Make	Xibrli
Diameter, mm	18.12

Length, mm	1405
Size of adapter, mm	16.70
Inner diameter, mm	6.42

3.2.15 Overall dimensions:

Overall dimensions of the machine are given in table 3.10

Table 3.10 Overall dimensions of the machine

Specifications	**Dimensions**
Length (mm)	2400
Width (mm)	1100
Height (mm)	935
Mass (operational) (kg)	360
Color	Orange & Green

3.3 TEST PROCEDURE OR CODES

There is no specific BIS or international code for testing the ridge plastering machine. The test procedure has been followed as agreed between the applicant and the testing authority. However the following codes were referred for the testing of the machine.

i)	IS 4468(Part-1):1997 (Reaffirmed: 2012)		Agricultural wheeled tractors-rear mounted three point linkages.
ii)	IS 4931:1995	:	Agricultural tractors-rear mounted power take off types 1, 2 and 3 (third revision)
iii)	IS 6690:1981 (Reaffirmed 2012)	:	Specification for blades for rotavator for power tillers.

3.4 LABORATORY TEST

Before conducting the performance evaluation of the tractor- operated bund former in the field, laboratory test were carried out to check out the specifications and to compare it with the specification given by the manufacture. The parameters which are not affected by the ground conditions were considered. The laboratory test includes the testing of the following in lab condition:

- Vibration measurement
- Noise Measurement
- Turning Ability

3.4.1 Vibration measurement

Vibration of the machine was measured using vibration meter or analyzer. Magnetic end of vibration meter was connected to gear lever, steering wheel, mud guard plastering machine and hitch point to measure the vibrations in corresponding points. The vibration meter and vibration measurement are shown in plate 3.1 and 3.2. The sensor will issue a voltage signal due to vibration of the object. Then the velocity and acceleration at these points were measured.

Plate 3.1 Vibration meter

Plate 3.2 Vibration measurement.

3.4.2 Noise measurement

Noise level was measured with a noise meter at three points. (a) Noise level at background, (b) Operator's ear level with tractor only, (c) Operator's ear level with tractor operating ridge plastering. The noise meter is shown in plate 3.3. In order to measure the background noise level, noise meter was hold near the bund former as shown in plate 3.4. To measure noise at operator's ear level with tractor only, a person sitting on driver's seat has to hold the noise meter. To obtain noise at operator's ear level with tractor operating ridge plastering, same steps adopted for noise level measurement at operator's ear level with tractor only were repeated along with operating bund former.

3.4.3 Turning ability

Turning ability shall be tested either on a test track or on a horizontal and compact area. The test conducted by turning the tractor to right and left directions with and without using the steering brakes. After each turn (right or left), the minimum turning diameter and minimum clearance diameter or turning space were noted as shown in plate 3.5.

Plate 3.3 Noise meter

Plate 3.4 Noise measurement

Plate 3.5 Turning ability measurement

3.5 FIELD PERFORMANCE TEST

3.5.1 Study area

The field performance test of the machine was conducted at the selected field in the farm of KCAET, Tavanur campus.

3.5.1.1 Site selection

Field experiments were performed to evaluate the tractor-operated Yarrow bund former in field condition. A paddy field after the harvest was selected for bund forming. The plot was divided into two plots and the bund making was done. The soil type was sandy loam with adequate drainage and sunlight.

Field which is located at the instructional farm in KCAET campus, Tavanur village, (latitude 10.8544º N, 75.9886º E) Malappuram District, Kerala was selected. The testing site is shown in plate 3.6.

Plate 3.6 Testing site - Instructional farm in KCAET campus, Tavanur

3.5.1.2 *Site Layout*

A field of 85 x 35 m size is selected. The field layout for the testing of Yarrow Bund former is shown in fig 3.4.

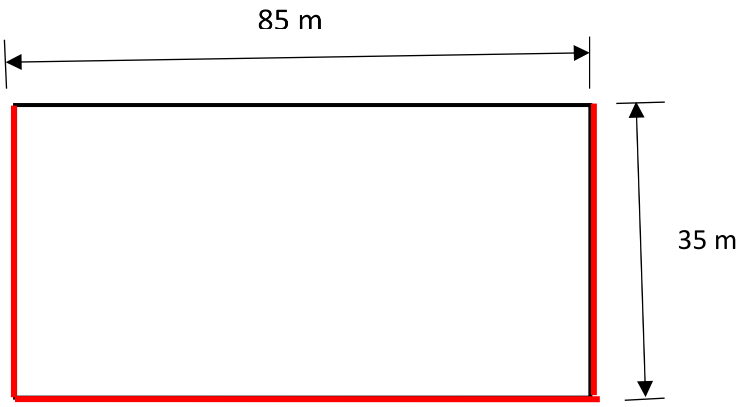

Fig 3.4 Experimental site layout-(The field test was conducted in the portion marked red.)

3.5.2 Field performance test

John Deere tractor 4W, 5310 (55 hp) was used to hitch the implement for the field test (specification of the prime mover is given in the Appendix I). The tractor driver and two operators were employed for checking and regulating the bund forming in the field. Field performance and suitability of machine for bund making were done with reference to IS 4931:1995. Rate of work, quality of work, soil moisture content, bulk density, fuel consumption, field efficiency, wheel slip, ease of operation, maintenance and adjustments, defects, breakdown and repairs, labour requirement, soundness of construction were observed during the field test.

Tractor was filled with full tank fuel. At the onset of engine starting, timer was set to check the total time consumed during the working of the tractor. After moving the tractor into the field the hitch assembly was lowered to bring the bund former to a height that is requisite for the preparation of bund. Time taken for making bund, height, width and length of the bunds formed were measured and tabulated. For comparing the performance of two field bunds, made by two of the mechanical and traditional methods were taken.

3.5.2.1 Rate of work

The rate of work is defined as the actual length of bunds formed during actual time of operation of the implement and is expressed in mh^{-1}. To determine the rate of work, bund making time for corresponding length were measured. The tractor-implement combination was operated over a specified area to form the bunds and the actual time taken for the operation, including time lost in stopping, turning were noted.

$$\text{Rate of work} = \frac{\text{Length of bund formed}}{\text{Time taken for bund formation}}$$

3.5.2.2 Quality of work

Quality of work was assessed by measuring the height and width of the formed bund. It was measured using a measuring tape. Height was measured from top of the bund to the ground vertically. Width was measured across the bund.

3.5.2.3 Soil moisture content

Soil moisture of the field was measured using soil moisture meter. The probe of the meter was pierced into the soil and the readings were noted. Moisture measurement is shown in plate 3.7.

Plate 3.7 Moisture measurement

3.5.2.4 Fuel consumption

The fuel tank of the tractor was filled to full capacity before and after the test. Fuel consumed for the particular operation is the rate of fuel used to refill the tank up to fuel after the operation. To avoid the errors, the tank should be filled top up without leaving any empty space. The fuel consumption (lh^{-1}) and the time taken for the field operations were calculated. The fuel consumption was found out by the following formula:

$$\text{Fuel consumption} = \frac{\text{Amount of fuel consumed , l}}{\text{Time taken to cover the area, hr}}$$

3.5.2.5 Wheel slip

The number of rotations of the tractor drive wheel taken to cover a fixed distance marked out in the field under load and no load condition were recorded. A visible mark was made on the drive wheel periphery, at a point, so that the rotations could be counted. The wheel slip was calculated as follows:

$$\text{Wheel slip} = \frac{(N - N0)}{N} \times 100$$

N_0 = number of rotations of the drive wheel at no load condition

N = number of rotations of the drive wheel at load condition

3.5.2.6 Labour requirement

It is the total man hours required to cover a particular distance and was measured using man hr.Km^{-1}.

3.5.2.7 Ease of operation, maintenance and adjustment

All repairs and adjustments were made during the test shall be reported, together with comments on any practical defects or shortcomings. This should not include those maintenance jobs and adjustments which are performed in conformity with the manufacturer's recommendations.

3.5.2.8 Defects, breakdowns and repairs

Defects or breakdown occurred during entire period of lab and field test were noted.

Result and discussion

CHAPTER IV

RESULT AND DISCUSSION

This chapter deals with the details of field experiment conducted to evaluate the performance of the tractor operated bund former.

4.1 LABORATORY TEST

The laboratory test of the bund former was carried out at Farm Machinery Testing Center, KCAET, Tavanur. And the results obtained are discussed here.

4.1.1 Vibration test

Date of test : 28.05.2022

Name & Model : Lutron & VB-8203

Location of test : Tavanur, Kerala

Type of accelerometer: Contact type

The velocity and acceleration values obtained by the vibration meter at gear level, steering wheel, mud guard – plastering machine, and hitch point are their given in the table 4.1.

Table 4.1 Vibration calculation

Location	Velocity, mms^{-1}	Acceleration, ms^{-2}
Gear lever	8.5	2.8
Steering wheel	23.5	7.5
Mud guard – plastering machine	40.4	19.4
Hitch point	9	6.6

The maximum acceleration and velocity were observed at mud guard-plastering unit, and were observed as 19.4 ms^{-2} and 40.4 mms^{-1} respectively. The calculation of average of vibration values are given in Appendix IV.

4.1.2 Noise measurement

Noise level at three conditions are tabulated in table 4.2.

Table 4.2 Noise calculation

Sl. No	Parameter	Value
1	Date of test	28.05.2022
2	Name &Model	METRAVI SL-4010
3	Location of test	Tavanur, Kerala
4	Background noise level, (dB)	79.8
5	Noise at operator's ear level with tractor only, (dB)	88
6	Noise at operator's ear level with tractor operating ridge plastering, (dB)	89.6

The permissible noise level for a duration of 8 hours per day is 90 dB. Here the maximum value obtained was at operators ear level with tractor operating ridge plastering and was observed as 89.6 dB.

4.1.3 Turning ability

The minimum turning diameter and minimum clearence diameter on both right hand side and left hand side were measured and are tabulated in the table 4.3.

Table 4.3 Turning ability calculation

Characteristics	Minimum turning diameter, m	Minimum clearance diameter, m
LHS	5.6	6
RHS	4.25	4

4.2 FIELD PERFORMANCE TEST

The performance evaluation of the selected implement was carried out at Instructional farm, KCAET, Tavanur. The result of field test is shown in table 4.4. The operating speed of the tractor was 1.44 kmh^{-1} and the wheel slip was obtained as %. Average rate of bund making was 20.81 -25.89 m min^{-1} with an average height 35.5 cm and top width of 31.1 cm. The fuel consumption founded was 3.91 lh^{-1}.

Table 4.4 Summary of field performance test

Sl. No	Parameters	Observed values
1	Tractor used	John Deere
2	Gear used	L-2
3	Type of soil	Sandy loam
4	Soil moisture (%)	10-12%
5	Speed of the tractor measured for 20 m, kmh^{-1}	1.44
6	Wheel slip, (%)	6.8 %
7	Rate of bund making, m/min	20.81 -25.89
8	Avg. height of bund, cm	35.5
9	Top width of bund, cm	31.1
10	Fuel consumption, lh^{-1}	3.91

4.2.1 Rate of work

The average value of rate of bund making obtained was 23.86 $Km.hr^{-1}$ respectively. Calculation of rate of work is given in Appendix II. The rate of work is tabulated in table 4.5.

Table 4.5 Rate of work

SI. No	Length (Km)	Time (hr)	Rate of bund making (Km/hr)
1	0.031	0.021	1.476
2	0.084	0.067	1.253
3	0.026	0.0168	1.547
		Average	1.425

Pathirana *et al.* (2010) reported that approximately 1.25 hours is required to plaster one side of a 0.018 Km long bund. By using yarrow bund former, bunds can be prepared at a rate of 1.425 km/h. The bund maker makes the process of bund making easier and saves time and labour effectively.

4.2.2 Quality of work

The average height and top width of the bund was 35.5 cm and 31.1 cm respectively. The values are tabulated in Table 4.6.

Table 4.6. Calculation of average height & top width of bund

Sl. No	Length(m)	Height(m)	Width(m)
1	26.20	0.35	0.31
2	31.65	0.325	0.315
3	84.66	0.39	0.31
	Average	0.355	0.311

It is seen that the average height and top width of bund formed by mechanical bund former was obtained as 25.05 cm and 15.15 cm in a study conducted by Suma Nair (2018) at Athalur, Tavanur. Bunds formed by Yarrow bund former has an average height and top width as 35.5 cm and 31.1 resulting in better quality of work.

4.2.3 Moisture content

The soil moisture content of the bund was measured at five different places in the field using soil moisture meter. The rotating unit of bund former lifts the soil from about 30cm depth and uses it to plaster the bund. The roller pipe makes the bund more compacted. Thus the formed bund has a moisture content in the range of 10-12%. The average value of moisture content obtained as 10.42 %. The values are tabulated in table 4.7.

Table 4.7 Moisture content

Sl. No	Soil moisture content (%)
1	9.4
2	10.6
3	9.1
4	12
5	11
Average	10.42

It is seen thst the moisture content obtained was 12.5-16% in a study conducted by Singh *et al.* for a bund former cum packer (2016) for .This machine showed 10-12% moisture content with better compactness.

4.2.4 Fuel consumption

The fuel consumption of the bund former obtained during the test was 3.91 lh^{-1}. The calculation of fuel consumption is given in Appendix III. The average fuel consumption found by Dixit *et al.* for a tractor mounted bed former was 5.91 lh^{-1} which is comparatively higher than that of yarrow bund former. This shows that this machine is more fuel efficient.

4.2.5 Wheel slip

The average wheel slip of the tractor with the implement was obtained as 6.8%. In general case, the permissible wheel slip for a tractor is in the range of 10-15%. In this study, with the use of four wheel drive tractor, the slip was found lower than that of permissible level which implies the implement safe for operation.

4.2.6 Labour requirement

One skilled operator to drive the tractor and to operate the implement and one labour to patch up works for the bund if some breakage happens.

4.2.7 Ease of operation, maintenance and adjustment

No difficulty was obtained during the operation and adjustment of yarrow bund former.

4.2.8 Defects, breakdowns and repairs

No defects or breakdown was occurred during entire period of lab and field test.

Conclusion

CHAPTER V

CONCLUSION

The performance of the tractor operated yarrow bund former was tested in both the laboratory and field conditions respectively. The field test was conducted in instructional farm of dimension 85 x 35 m size in KCAET campus, Tavanur village. The parameters such as type of soil, soil moisture, wheel slip, and rate of bund making, field efficiency, dimensions of bund formed such as average height, length and width were obtained through the field performance test. Laboratory test of yarrow bund former was done to obtain vibration measurement, noise measurement and turning ability.

Performance evaluation was conducted in wet sandy loam soil. The machine was operated with 55 hp tractor. The blades on the periphery of the disc pulverizes the soil, the leveller levels the soil, and the rotating disc trims the bund and plasters it with pulverized soil. The roller attached to the rotating disc compresses the soil. The soil moisture of formed bund was 10.42 %. A noise level of 89.6 dB was obtained at operator's seat level during the operation of bund former. During vibration test velocity of 40.4 ms^{-1} and acceleration of 19.4 ms^{-2} was obtained at the bund former. A minimum turning diameter of 5.6 m and 4.25 m was obtained on LHS and RHS respectively. Field efficiency of the machine was 82.2 % with an average speed of 1.48 kmh^{-1}. Overall dimensions of bund was 355 mm height and 311 mm width respectively. The rate of bund making was observed as 23.86 $mmin^{-1}$. The fuel consumption of the machine was 3.9 lh^{-1}.

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APPENDIX

Appendix I

Specifications of tractor

Sl No.	Item	Specification
1.	Make	John Deere
2.	Model	5310
3.	Chassis Serial No.	1VY5310EPNA020667
4.	Engine Serial No.	PY3029H179060
5.	Max. PTO Power Kw / HP	36.4 / 49.5

Appendix II

Calculation of rate of work

a) Length of bund formed = 31.65 m

Time taken for the bund formation = 1.2755 min

Rate of work= $\frac{\text{Length of bund formed}}{\text{Time taken for bund formation}}$

$= \frac{31.65}{1.2755}$

$= 24.88\ \text{mmin}^{-1}$

b) Length of bund formed = 84.66m

Time taken for the bund formation = 4.0685 min

Rate of work= $\frac{\text{Length of bund formed}}{\text{Time taken for bund formation}}$

$= \frac{84.66}{4.0685}$

$= 20.81\ \text{mmin}^{-1}$

c) Length of bund formed = 26.20 m

Time taken for the bund formation = 1.0117 min

Rate of work = $\frac{\text{Length of bund formed}}{\text{Time taken for bund formation}}$

$$= \frac{26.20}{1.0117}$$

= 25.89

$$\text{Average rate of work} = \frac{24.88+20.81+25.89}{3}$$

= 23.86 $mmin^{-1}$

Appendix III

Calculation of fuel consumption

Fuel consumed during the test = 2.86 L

Total time taken during the test = 0.73

$$\text{Fuel consumption} = \frac{\text{Amount of fuel consumed , l}}{\text{Time taken to cover the area, hr}}$$

= 2.86/0.73

= 3.91 lh^{-1}

Appendix IV

Sl. No	Location	Velocity	Acceleration
1.	Gear lever		
		8.5	2.8
		8.8	2.9
		8.2	2.4
	Average	**8.5**	**2.8**
2.	Steering wheel		
		24.3	7.8
		25.5	7.5
		27.5	7.6
	Average	**23.5**	**7.5**
3.	Mud guard – plastering machine		
		40.4	19.4
		39.9	20
		41	19.5
	Average	**40.4**	**19.4**
4.	Hitch point		
		9	6.7
		8.8	6.5
		8.7	6.8
	Average	**9**	**6.6**

PERFORMANCE EVALUATION OF TRACTOR OPERATED YARROW BUND MAKER FOR PADDY CULTIVATION

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ABSTRACT

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in

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Faculty of Agricultural Engineering and Technology

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ABSTRACT

Mechanization of bund or ridge forming is an important land preparation process in paddy cultivation. The land will be thoroughly pulverized and the field buds will be well plastered before the transplanting. At present, bund making, plasters or adjusting is done by manually and which is time & energy consuming operation. The traditional bund/ ridge forming work is a low efficient, less strength, and high cost operation. It makes the paddy cultivation more expensive. The scarcity of skilled labour during bund formation causes great difficulty to the soil near the bunds and corners of the field are prepared manually which is consuming more energy and time. The traditional manual bund/ ridge forming work is characterized by low efficiency, low strength, high cost and directly affects the profitability of rice farming. More over manually made bunds are not properly aligned and compacted thus it does not last for long. The scarcity of skilled labour during peak period of bund formation causes great difficulty to the farmers. This urges the need of mechanisation in bund forming and plastering.

A tractor operated bund former developed by Yarrow farms was evaluated for its performance in wet sandy loam soil. The machine was operated with 55 hp tractor. The blades on the periphery of the disc pulverizes the soil, the leveller levels the soil, and the rotating disc trims the bund and plasters it with pulverized soil. The roller attached to the rotating disc compresses the soil. During the field study, it was observed that, the soil moisture of formed bund is 10.42%. Field efficiency of the machine was 82.2% with an average speed of 1.48 kmh^{-1}. Overall dimensions of bund was 35.5 cm height and 31.1 cm width respectively. The rate of bund making was observed as 23.86 $mmin^{-1}$. The fuel consumption of the machine was 3.9 lh^{-1}. The soil moisture of formed bund was 10.42%. A noise level of 89.6 dB was obtained at operator's seat level during the operation of bund former. During vibration test velocity of 40.4 ms^{-1} and acceleration of 19.4 ms^{-2} was obtained at the bund former.