DEVELOPMENT AND TESTING OF TRACTOR OPERATED BED FORMER FOR SEED BED PREPARATION IN KAIPAD REGION

By

RAJESH. A.N

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THESIS

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DECLARATION

I hereby declare that this thesis entitles **“Development and testing of tractor operated bed former for seed bed preparation in Kaipad region”** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

SYMBOLS AND ABBREVIATIONS

$	US. Dollar
%	Percentage
°C	Degree Celsius
ANOVA	Analysis of variance
cm	Centimeter (s)
DMRT	Duncan's Multiple Range Test
dS m^{-1}	DeciSiemens per meter
E	East
EC	Electrical conductivity
et. al	And others
Fig.	Figure
g	Gram (s)
g cm^{-3}	Gram per centimeter cube
ha	Hectare
ha h^{-1}	Hectare per hour
hp	Horse power
i. e.	that is
IS	Indian standard
K	Potassium
KCAET	Kelappaji College of Agricultural Engineering and Technology
kg	Kilo gram
kg cm^{-2}	Kilogram per centimeter square
kg ha^{-1}	Kilogram per hectare
kg_f	Kilogram force
km h^{-1}	Kilometer per hour

kN	Kilo Newton
kW	Kilo watt
l h^{-1}	Liter per hour
m	Meter (s)
MJ	Mega Joule
mm	Millimeter (s)
mmhos cm^{-1}	millimhos per centimeter
MS	Miled steel
PTO	Power Take Off
Rs	Rupees
Sq. km	Square kilometer
t ha^{-1}	Tons per hectare
USDA	United State Department of Agriculture
viz.	Versus
τ	Tau
Φ	Phi
σ	Sigma
ρ	Rho

Dedicated to

The farmers of Kaipad

CHAPTER I

INTRODUCTION

The rice plant, *Oryza sativa*, is a member of the grass family, *Poaceae (Gramineae).* Rice is tolerant to desert, hot humid, flooded, dry and cool conditions and grows in saline, alkaline and acidic soils. Rice is one of the leading cereal crops of the world and is the staple food for more than half of the world population. In Asia alone, about 60 to 70 per cent of people obtain their caloric intake from rice and its derived products.

India is the second largest producer of rice in the world after China. It is grown on about one-fourth of the total cropped area and provides food to about half of the country's population. Rice is the major food of more than 70 per cent of total population. Production of rice at present is 1895 kg per hectare. The country witnessed an impressive growth in rice production in the post-independence era due to the adoption of semi dwarf high yielding varieties coupled with the adoption of intensive input based management practices and suitable mechanization. Rice production was increased four times, productivity three times while the area increase was only one and half times during this period. To mitigate the growing population rate rice production should rise to 120 million tonnes by 2020. This could be achieved only through selective mechanization and increase of productivity as the area is plateau.

The regions cultivating paddy in India are distinguished as the western and eastern coastal strips covering all the primary deltas, Assam plains and surrounding low hills, foothills and Terai region along the Himalaya mountains and States like West Bengal, Bihar, eastern Uttar Pradesh, Himachal Pradesh, Punjab, Haryana, eastern Madhya Pradesh, Rajasthan, Maharashtra, Orissa northern Andhra Pradesh, Tamil Nadu and Kerala.

Rice forms the staple food of the people of Kerala and contributes a major share towards its economy. Kerala is a deficient state in rice production, while the estimated requirement of rice for the state is 35 to 40 lakh tons per year, it produces less than one-fifth of its requirement. The deficit in rice production is increasing year after year due to reduction in rice area arising out of the large scale conversion of paddy lands for raising other crops or for residential purposes. The total rice production of 12.8 lakh tones in 1980-81 had come down to 10.86 lakh tones in 1990-91 and 5.70 lakh tones by 2003-04. During this period, the share of rice in the total cropped area also showed a steep decline i.e., from 33.2 percent in 1960-61 to 12.01 percent in 2003-04. The situation slightly changed after 2006-07 over the last two years mainly due to the concerted effort of the Government. At present, rice is grown in a gross area of 2.34 lakh ha producing 6.25 lakh tones with a productivity of 2671 kg.

Rice is grown in a vast array of ecological niches, ranging from regions situated 3 meters below MSL level as in Kuttanadu to an altitude of 1400 m as in the high ranges. It is cultivated under 3 to 4 meters depth of water as well as in purely rain fed uplands with no standing water. Probably nowhere else in the world, rice crop is cultivated under such a diversity of conditions. The cultivation was in three seasons Viruppu, Mundakan and puncha. Kuttanad and Palakkad are called rice bowls of Kerala. The other typical rice production areas in the state are Kole and Pokkali extends in Thrissur, Malappuram, Ernakulam, Alappuzha, Kottayam districts and Kaipad in Kannur district.

1.1. Kaipad cultivation

Kaipad wetland ecosystem (spread over Eazhome panchayat between 12°2’0” N Latitude, 75°17’0” E Longitude and 12°00’8’’ N Latitude,75°17’34’’of Kannur district and adjacent to Pazhayagadi river, in North Kerala) consists of marshes, swamps, ponds and paddy fields.

These swampy and water logged areas experiences flood during monsoon and salinity during summer owing to their proximity to estuaries. Tidal currents enter the field during high tide and flow out during low tide. Saline water from the sea enters the estuaries during summer when the flow is low and it spreads in the low lying Kaipad wetlands and this water keeps the area moist even in summer months.

Agricultural operations are started with the drying of low lying Kaipad fields by draining the saline water completely in the month of April and left to dry for one month. The various rice varieties cultivated in the Kaipad area are *Kuthiru, Orkayama, mundon, Kandorkutty, Orpandy, Odiyan* and *Orissa* as traditional varieties and *Eazhome-1* and *Eazhome-2* as modern varieties. The tide flows are controlled by constructing bunds locally known as ‘chira’ or ‘kandy’. Normally only one crop of rice is raised in the area. Germinated rice seeds are sown on mounds known as ‘potta’ in the low to medium saline phase of the ecosystem. The soil mounds with a spacing of about 50 cm are prepared by the end of April. Two kinds of mounds are common: hemispherical mounds with 30 to 45 cm height and 50 to 60 cm diameter and long strips with 30 cm width. The mounds help to leach away the high salinity by the heavy rain and the fresh water from the river during monsoon. After the onset of southwest monsoon, 4 day old germinated seedlings are sown on the flattened tops of the mounds. After 45 days of vegetative growth, the mounds are dismantled mounds using spades. There are no cultural operations till harvest except weeding. While harvesting only the panicles are cut and the rest of the stalks are left to decay in the water, which in time become feed for the prawns that are grown subsequently (Chandramohanan and Mohanan. 2012).

1.2. Research requirements in seedbed former

Presently, even the Government of Kerala give major thrust in rice production, the high labour cost and shortage of labour made it difficult to materialize. As a result the price of rice in Kerala for the last three years has seen an unprecedented hike rate and it reached in the open market about Rs. 27 per kg in January 2011.

Carrying out timely operation and reducing cost of cultivation are the prerequisite for enhancing the production and productivity of rice as well as to make rice cultivation commercially viable and profitable enterprise for the farmers. The above mentioned constraints are to be over come to achieve this goal. The only possible solution to prevail over these problems is by filling the shortage of labour by selective mechanization.

In Kaipad rice cultivation, the conventional practice of raising nursery is by sowing pre germinated paddy seeds on manually prepared mounds (seed beds) using spade which is laborious, tedious, skill oriented and time consuming operation. The preparation of the soil mounds needs 40 man days per hectare and dismantling of mounds needs 20 man days per hectare which costs about Rs. 12000/- to Rs. 15,000/- (Chandramohanan and Mohanan. 2012). In this system 3000 mounds per acre per day has to be prepared. Due to labour shortage the area of Kaipad rice cultivation has reduced from 2500 ha to 600 ha (Nair *et.al*, 2002).

The clay content and sinking nature of the soil are the major constrains of introducing new soil working implements for making mounds in Kaipad rice cultivation. Hence an investigation was undertaken to assess the parameters which influence the seed bed preparation with a tractor operated seed bed former with the following objectives:

i. To investigate the relevant physical properties of Kaipad soil.

ii. To develop a prototype of tractor operated bed former suitable for Kaipad paddy cultivation.

iii. To compare its performance with tractor operated ridgers and conventional methods.

iv. To evaluate the field performance and work out the cost economics.

CHAPTER II

REVIEW OF LITERATURE

The past research works relating to the relevant aspects of seedbed former have been reviewed in this chapter. Many types of seedbed formers were developed and tested in different countries. To comprehend the research towards the development of a seedbed former, literature reviews were done and are grouped under the following headings.

1. Effects of different tillage tools on soil parameters
2. Development and performance evaluation of bed former
3. Effects of different tillage tools on crop parameters

2.1. Effects of different tillage tools on soil parameters

Edminister and Miller (1959) observed that the conventional tillage created a satisfactory medium for plant growth. But on the other hand it destroyed soil structure, increased soil compaction and reduced infiltration rate and soil organic matter. They further found that the minimum tillage reduced soil compaction as compared to conventional tillage, whereas the crop yield remained at par in the plots under minimum tillage treatment when compared wih that of conventional tillage.

Soehne (1963) has reported more soil pulverization in the case of powered harrow plough as compared to free rolling disc which resulted in big clods. It was also found that powered harrow plough gave better penetration.

Pop *et al.* (1968) observed that ploughing at a depth of 30 and 40 cm increased the water content of soil in spring was more than the depth at 20 cm and also led to increased development in wheat roots.

Bhushan *et al.* (1971) evaluated the influence of tillage tool geometry on cloudiness of seedbed and unit draft. The tool geometry variables such as nose and rake angle, various radius of curvature, tool height and width of tool were used. They found that the mean weight diameter of clod increased with increasing tool angle, nose angle, 50 degree rake angle and 60 degree nose angle. An increase in mean weight diameter of clod was associated with increase in radius of curvature and width of tool, whereas increase in height inversely affected the clod size.

Hendrick and Gill (1971) made a comparative study of the results of various researchers on rotary powered tillers. It was concluded that there is no consistent relation between the depth of cut and degree of pulverization. The clod size may decrease by increasing the rotary speed of the gang and forward speed proportionately.

Seikh *et al.* (1978) made a comparative study of five sets of tractor mounted tillage implements to access their performance for wheat crop under sandy loam soil and found no significant difference in dry density of soil for different tillage treatments.

Ellis *et al.* (1979) compared different tillage levels with zero-tillage and reported that at sowing the moisture content was greater in surface layers of soil of undisturbed land as compared other deep tillage levels. But below 10 cm moisture content was less and root penetration was greater in the uncultivated land

Ram *et al.* (1980) compared the performance of a tractor operated rotavator, disc harrow with three bottom and rotating auger plough to prepare seedbed for wheat in paddy harvested field under light, medium and heavy soil conditions. The treatments were: T1-auger plough + disc harrow, T2 – auger plough + rotavator; T_3 - Disc harrow + auger plough ; T_4 - Disc harrow + rotavator ; T_5 - Auger plough + planking x 2 and T_6 - Disc harrow x 3 After the experiment**,** it was reported that the rotating auger plough performed better than rotavator and disc harrow. It prepared a suitable seedbed in single pass in light and medium soils. The depth of operation was also higher than rotavator and disc harrow. It was also reported that the auger plough was covering crop residue up to about 90 percent whereas rotavator and disc harrow covered only 40 to 50 percent.

Estler and Schonhammer (1982) conducted an experiment for comparing the performance of a conventional implement with a PTO driven implement; it was found that with a PTO driven implement it is possible to obtain uniformly crumbled soil as compared to a conventional implement.

Seth and Gosh (1984) conducted a field experiment to estimate the energy and time requirement of tillage operation by using different tractor implements (disc harrow, harrow plough, disc plough, rotavator and roller) combination in wheat crop under paddy-wheat crop rotation. The result indicated that there was no significant variation in bulk density, cone index and moisture content in all the treatments. However, sieve analysis showed that soil was prepared more uniformly by using rotavator and roller as compared to other treatments. It was also observed that the minimum energy of 15306. 30 MJ ha^{-1} was consumed with harrow plough followed by rotavator and roller where as maximum energy of 17360.7 MJ ha^{-1} was consumed in harrowing followed by Harrow plough and roller. On the basis of grain yield and input-output ratio, it was concluded that the combination of rotavator and roller gave best performance.

Callebaut *et al.* (1985) conducted a study to determine the soil surface strength with a needle type penetrometer at intervals of 0.1mm over a depth of 15 mm in intact soil samples. It was observed that the effect of water content was stronger in dense than in loose soil. Also the seedling emergence was negatively correlated with the penetration resistance and positively with the water content.

Chaudhary *et al.* (1985) conducted a study on the effect of deep tillage on soil physical properties and maize yield on a loamy sandy soil. Sub soiling, mould board plough and deep digging at 45 cm were compared with conventional tillage. Plant height increased by 30 to 35 cm and yield increased by 80 to 90 percent in stover and 70 to 350 percent in grain.

Karwar (1986) studied the effect of four tillage systems (no till, chisel plough, moldboard plough and Para plough) on the variability of soil water tension and soil water content on a Webster silty clay loam soil for maize production. He observed that the chisel plough plots tend to have lower soil moisture contents in comparison to other tillage systems.

Ike and Arenu (1990) studied the effect of no-tillage hoeing and tractor power tillage methods on bulk density of soil in Nigeria for maize. They found that the bulk density was greater under tractor powered tillage and suggested that more intensive cultivation increased sub soil compaction.

Barnes and Moddux (1991) conducted long term tillage study to provide yield comparison between conventional, reduced and no tillage systems and investigated the soil properties and their relationship to compaction related by penetrometer resistance. They found that the no-tillage treatments had medium penetrometer resistance and conventional tillage treatments had least compaction. There was no relationship between the penetrometer resistance and reduced yields in no-tillage treatments.

Braunack and Mcphee (1991) conducted a study to determine the effects of initial water content and various tillage implements in producing a suitable seedbed tilth on a cracking clay soil. Finer tilth was produced at drier initial soil water contents with an increasing number of implement passes. Soil bulk density and cone index were reduced after tillage. The results inferred that soil water content is the controlling factor in producing a suitable seedbed tilth.

Islam *et al.* (1992) conducted trial to observe the effect of fitting with a PTO powered disc tiller on physical properties of clay soil. Five levels of speed viz. 1, 2, 3, 4 and 5 km $^{-1}$h and two gang angles (28 and 33 degree) were taken. The average soil moisture content was 26 percent. The effects of tilling were observed in terms of bulk density, cone index, clod size distribution, soil inversion and total porosity during first and second passes and were compared with unpowered mode at 28 degree gang angle after single pass. It was observed that the bulk density and cone index reduced and the total porosity, contents of clods of less than 15 mm diameter and soil inversion which increased with an increase in number of passes and forward speed. More soil inversion was observed in case of 33 degree than 28 degree gang angle.

Singh (1994) compared conventional tillage with different reduced tillage treatments for rice and wheat and found that in case of wheat there was no significant change in bulk density at crown root initiation in second year but in first year, zero-tillage plots resulted in maximum bulk density of 1.44 g cc^{-1}. In second year also maximum bulk density of 1.41 g cc^{-1} was found in zero-tilled plots.

Braunack (1995) studied the effect of aggregate size and water content on the emergence of soybean and maize from a heavy cracking clay soil. Aggregates size was determined using sieve analysis with size less than less than 1, l to 2, 2 to 5 and 5 to 15 mm at soil water contents of 15, 20 and 25 g per 100 g. Greatest emergence occurred from the seedbeds of particle size l to 2 mm, compared with coarse seedbeds of size 5 to l5 mm. Soil strength decreased with increasing water content and shear strength was less on seedbeds of aggregate size l to 2 mm compared with seedbeds of aggregate size 5 to l5 mm. it was inferred that, good emergence of crops in heavy cracking clay soil seedbeds in an aggregate size of l to 2 or 2 to 5 mm for soybean and maize at a water content of 25 g per 100g respectively. .

Armstrong *et al.* (1996) studied the seasonal changes in the distribution of salt and water in both arable and grassland fields. The soil under study was clayey marine alluvium with clay content of 60 percent. The grassland and arable top soils had an exchangeable sodium percentage of 16.2 and 9.7 percent and an average electrical conductivity of 6.5 and 4.5 dS m^{-1} respectively. During winter rains, the water moving through the macrospores uniformly leached salt from the soil profile to a depth of 1.2 m, but in late summer the salt content of the grassland and arable soils increased by 11 percent and 35 percent respectively compared with their early spring salinity levels.

Prasad (1996) made a comparative study on the performance of a tractor operated rotavator with that of conventional tillage implement for seedbed preparation under wheat -soybean crop rotation. Four treatments were taken as: T1 - sweep cultivator x 2 + disc harrow x 1; T_2 – mould board ploughing x 1+ harrow x 2; T_3 - rotavator x 1 and T_4 - rotavator x 2. The soil bulk density after tillage in T3 and t4 was significantly lower than in T1 and 2. Pulverization was significantly affected by the rotavator. The clod mean- diameter in T3 and 4 was significantly smaller than in T1 and T2 for soya bean. The yield of both the crops was not affected by tillage operations.

Al-Janobi (1998) measured the draft of major primary tillage implements like offset disk harrow, a mould board plough, disk plough and three chisel ploughs of different shanks, operating in sandy loam soil and inferred that there was a significant increase in draft with an increase in depth. The result also showed that the draft is significantly affected by the speed and depth of the implement.

Kirchhof *et al.* (2000) determined the yield of rice under the traditional puddling techniques using draught animals. The results indicated that puddling with a roto tiller reduced the yield because of insufficient depth of puddling and also found that increasing puddling intensity tends to reduce the rice yield.

Carlos *et al.* (2001) developed a combined penetrometer coiled time domain reflectometry probe to find the effect of water content and bulk density on soil strength. The depth distribution of penetration resistance and water content in a soil profile were determined simultaneously and observed that penetration resistance decreased as water content increases.

Eduardo *et al.* (2008) evaluated the conventional and no-tillage treatments on soil physical properties, root growth and yield in wheat. Bulk density no significant affects by tillage treatment. Soil particle density at a depth of 15 cm was 2.69 and 2.87 g cm^{-3} under no-tillage and conventional tillage systems respectively. Vertical penetration resistance was higher under no-tillage 2.69 kg cm^{-2} as compared to conventional tillage. Soil aggregates of size greater than 2mm was more in no-tillage system. Root growth density at the top 5 cm was 3.43, 14.30 and 9.53 cm cm^{-3} and 1.34, 6.70 and 5.22 cm cm^{-3} for no-tillage and tillage systems respectively.

Ana *et al.* (2010) studied the conventional tillage changes far the soil physical properties and observed that porosity of the soil under conventional tillage system was 44 percent less compared to the surface condition. It inferred that soil under conventional system tends to stay saturated for longer period of time after each rainfall.

Obalum and Obi (2010) determined various physical properties of sandy loam soil using standard test procedures. The study was carried out to determine the effects of no-till and conventional tillage each with bare fallow and mulch cover on soil physical properties under three cropping systems. The physical properties namely soil organic matter, bulk density, total porosity, mean weight diameter and saturated hydraulic conductivity were observed respectively as 1.04 to1.06 percent, 1.34 to 1.51 mg m^{-3}, 46 to 52percent, 1.1 to 2.9 mm, and 8.12 to 57.0 cm h^{-1}. It inferred that total porosity and hydraulic conductivity increased in conventional tillage system.

2.2. Development and performance evaluation of bed former

Nagy *et al.* (1988) tested an animal drawn, mechanical ridge tier under on-farm, and farm managed conditions and evaluated its technical viability in the field, profitability and farmer acceptance in the cereal farming systems on the Mossi Plateau of Burkina Faso, West Africa. Mechanical ridge tier is a device attached to an animal drawn cultivator with four shovels of length 22.5 cm, ‘Y’ shaped frame of length 37.5 cm and one large middle sweep of width 30 cm. The ridging and tying of the ridge can be done simultaneously in one pass through each crop row or the operation can be done in two passes. Mean grain yield from manual treatments and mechanical ridge tier methods are 954.4 and 927 kg ha^{-1}. The net revenue for the manual treatments and mechanical ridge tier methods are $ 70.07and $ 67.14.

Kanetani *et al.* (1989) conducted an experiment by using a power driven disc plough and conventional rotary plough in paddy - wheat fields. In paddy fields a depth of 180 mm was obtained with the disc plough at 64 percent moisture content. The power requirement and drawbar resistance were 20-25 kW and 2 1-3 2 kN, respectively.

Shaji (1991) developed a power tiller operated bed former. The main components of the prototype unit of the power tiller operated bed former are the main frame, two pairs of forming boards, a hitching unit and a depth control cum transport wheel. The equipment was found capable of forming seed beds of heights 22, 18 and 15 cm respectively at a width ranging from 60 to 64 cm. Heights of 18 and 15 cm were obtained at a width range of 73 to 75 cm and 80 to 81 cm respectively. The draft of the implement ranges from 115.59 to 169.69 kg_f. The power utilization of the implement varies from 0.586 to 0.771 hp to the corresponding wheel slip of 46.76 per cent and 77.1 per cent respectively. The mean effective field capacity of the implement was 0.0996 $ha.hr^{-1}$ and the mean field efficiency was 46.3 percent. The total cost of production of the unit is Rs. 2000 and the cost of operation per hectare is Rs. 777.

Singh (1992) reported that the total energy for the cultivation of different crops varied from 8308 MJ ha^{-1} for wheat to 148201 MJ ha^{-1} for paddy. Out of this total energy 70 to 90 percent is required by three operations of seed bed preparation, irrigation, harvesting and threshing. In all three major energy consuming operations, the diesel energy component was found very high ranging from 33 percent for irrigation to 98 percent for seed bed preparation for paddy crop.

Singh *et al.* (1995) developed a powered harrow plough and tested it in a paddy field having silty clay loam soil with 26 to 36 percent moisture content, 1.64 g cc^{-1} bulk density and 8.94 N cm^{-2} cone indexes at the Pantnagar university farm. It was concluded that the powered one way plough consumed 50.76 percent less energy and reduced the operation time by 48.64 percent.

Sharma *et al.* (2001) developed a tractor drawn multicrop ridge furrow opener and a flat bed seeding machine to plant the seeds of different crops. The tractor drawn ridger cum seeder was improved and a multipurpose tractor drawn seeding machine was developed for sowing crops on flat bed as well as on ridge-furrow system. Also, a ridger cum seeder with slight modifications was developed and field tested. It consists of two bottom ridger-seeder, for making the ridges and furrows with seeding adjustments for seeding on ridges, sides of ridges or in the furrows as desired. In single operation, the nine shoe type combined furrow openers were used for seed-cum-fertilizer drill on flat beds. It was capable of sowing 5 to 6 ha day^{-1} depending on type of crop sown. There was 30 to 40 percent saving of irrigation water with its use as ridger cum seeder. It was also reported that about 12 to 15 percent higher yields were obtained during the last period.

El-Ashry *et al.* (2009) developed a conventional seed drill provided with six ridging bodies to make five soil ridges during sowing operation. Penetration angle of the ridger was 20° and width of the ridge was 60 cm. The implement was pulled by a 60 hp tractor. The effects of different planting methods, depth of ridge at 0.08, 0.12, and 0.16 m, forward speeds at 3.15, 4.1, 5.32, and 6.28 km h^{-1} and number of plant rows per ridge like single, double, and three row plants per ridge on crop yields were studied. It was observed that the modified ridger cum seeder had significant increase in plant height, germination ratio, and number of branches per plant compared to traditional seed drill. Also the seed yield was increased about 20 percent compared with conventional drill. The highest yield of seed and straw obtained under ridger seeder at 0.12 m ridging depth with two row plants per ridge were respectively 1050 and 2270 kg ha^{-1}. The ridger-seeder was recommended at a forward speed of 3.15km h^{-1}, ridging depth 0.12m and two rows per ridge to give the best results of planting density.

Gammoh (2011) fabricated a new double furrow with raised bed consisting of two disc bottoms of diameter 90 cm each and a leveling blade of width 45 cm. The discs were mounted on adjustable main frame to slide the discs horizontally in relation to each other. When the plough is drawn, the front right disc opens the first furrow of depth and width of 20 and 50 cm and moved the loosened soil to form a ridge of width 50 cm and height of 20 cm on the natural land level. Simultaneously the back left disc opens the second furrow and throw the loosened soil to fill the first furrows bottom forming a raised soil bed. The following blade then slid over to level the bed and to provide enough space for planting. He observed an increase in soil water content from 59 to 63 to 80 percent at a depth of 15, 30 and 45 cm.

2.3. Effects of different tillage tools on crop parameters

Gupta (1989) made a comparative study of different tillage tools for wheat after rice harvesting in silty clay loam soil. The treatments in tillage system were T1- One way x 1 + harrow x 4 + plank x1, T_2- One way x 1 + rotavator x 1 + plank x 1 ; T_3 - Rotavator x 1 + plank x 1 ; T_4 - Disk plough x 1 + harrow x 4 + plank x1; T_5 - Cultivator x 5 + plank x 1. It was concluded that T_3 treatment required least energy per hectare in seedbed preparation followed by T_2 treatment. The treatment T_3 also gave maximum yield and energy output - input ratio.

Singh (1992) compared conventional tillage treatment with different reduced tillage treatments in rice - wheat crop rotation and the effects were studied on the total productivity of the system. It was found that the yields were not influenced by various treatments while there was some difference in number of grains per panicle.

David (1999) conducted a study on comparison of soil-water distribution under ridge and bed cultivated potatoes. Crops were planted in ride of height 0.20 m and 0.75 m spacing at ridge top and planted at a depth of 0.14 m and a spacing of 0.15 m along each ridge. They were planted in beds of 1.25 m width, with 0.60 m wide and 0.20 m deep furrow on either side. Soil water content measured by the capacitance sensors at 0.15 and 0.25 m depth showed a soil water deficit in the ridge during the growing time of the crop and more water content in the beds. The change to bed cultivation for the second crop resulted in improvement in water penetration into the soil around the crops. The bed level surface allowed more water to be captured and held on the soil surface providing time for it to infiltrate.

Kumar and Ram (2003) conducted experiments on wheat crop to compare machines namely raised bed planter and seed cum fertilizer drill. The timely sown and late sown varieties were taken for the study. The seed rates were taken 90 kg ha^{-1} and 120 kg ha^{-1} for raised bed planter and seed cum fertilizer-drill respectively. They used fertilizers (N : P : K) in the ratio of 90 : 45 : 30 kg ha^{-1} in comparison to flat bed system of 120 : 60 : 40 kg ha^{-1} during the entire crop season. They found significant difference in the yield of crop in both machines and considerable saving in agricultural inputs like seed rate 25 percent, fertilizer 25 percent and irrigation water 35 percent in raised bed planter as compared to flat bed condition.

Choudhry *et al.* (2007) conducted a study on yield and water productivity of rice on raised beds. The crop were grown in six treatments viz. transplanted, wet seeded and dry seeded on raised beds with two water management practices, dry seeded on flat beds and on flat land. Raised beds were 37 cm wide separated by furrows of 30 cm wide and 22.5 cm deep. The water input in rice on raised beds was 38 to 42 percent less than flooded transplanted rice and 32 to 37 percent less than flooded wet seeded rice. The yield of rice was 3.2 t ha^{-1} from flat beds and raised beds and 5.5 t ha^{-1} from flooded transplanted rice. The yield of wheat was 2.9 t ha^{-1} from flat beds and 4.5 t ha^{-1} from flat land. The yields on flat land were 19 to 26 percent lower when 20 to 47 cm row spacing was adopted. Also the yields for same spacing dropped 12 to 17 percent from the yields with 20 cm row spacing on flat land. It was concluded that yields were significantly higher on raised beds than on flat land with same row spacing.

Singh *et al.* (2009) conducted a study on the performance of rice-wheat cropping system on permanent raised beds with conventional cultivation practices in sandy loam and loam soil. The raised beds had a size of 37 cm width, height of 15 cm and furrow width of 30 cm. Yield of conventionally tilled wheat ranged from 3.6 to 4.9 t ha^{-1} higher on the loam silt than sandy loam soil. The yield of wheat on permanent beds was similar to yield on conventionally tilled wheat. The rapid drying of the beds led to the poor crop growth on the permanent beds. Rice yield of transplanted rice on permanent beds were 50 percent less relative to yield of puddle transplanted rice.

Krause *et al.* (2009) conducted a study on sandy soil to examine the influence of soil properties affected by ridge compared to flat cultivation on growth of sugar beet. The mean daily temperature at the time of sowing was 7.0°C in the ridge and 6.1°C in the flat cultivated soil. It was observed that the total plant dry matter yield was 38.7% higher in ridge compared to flat cultivation. There was no significant difference in crop growth rate on second half of the growing season. The yield of white sugar in ridge cultivation practice increased by 8.4% compared to flat cultivation.

Bakker *et al.* (2010) conducted a study on productivity of water logged and salt affected land in a Mediterranean climate using bed- furrow system. The various treatments were cropping and pasture each with no beds (Control), no-tilled beds and raised beds. The raised beds and no-till beds were made using a commercial bed former with a seed bed width of 138 cm, furrow width of 45 cm and depth of 25 cm and spaced at 183 cm. The pasture biomass declined under winter and summer due to salinity about (EC) 10 dS m^{-1}. Bed furrow system did not generate higher yield compared to control but improved the yield of the crop in water logged areas.

CHAPTER III

MATERIALS AND METHODS

In this study, a tractor operated bed former for seed bed preparation for sowing pre germinated paddy seeds in Kaipad fields was developed and field tested. In Kaipad paddy cultivation, a custom practice of preparing seed bed to leach out the salts from the soil is made for making the soil neutral and for easy establishment of the crop. The raised seed beds are prepared by using a tractor operated Kaipad bed former, which cuts the soil in trapezoidal cross section and gathers it. In traditional method seed beds are prepared by the skilled labour using spades (Plate. 3.1). Seed beds are made as conical shaped soil mounds of height 450 mm and bottom width of 600 mm (Fig. 3.1).

In this chapter, the methods followed to determine the physical properties of the soil are detailed. The development of the tractor operated bed former and its field evaluations compared with the traditional method and conventional ridger are also summarized.

3.1. Physical and chemical properties

The physical properties of the soil affect directly or indirectly at the soil-tool inter phase as well as the growth of the crop. The six properties, viz, moisture content, shear strength, soil texture, pH, electrical conductivity and bulk density of the soil were determined. Soil samples of 5 kg each from different parts of the experimental plot were collected in clean and closed containers to determine the present status of the soil. The tests were conducted in the Soil and Water Laboratory at K.C.A.E.T, Tavanur and Soil Science laboratory at Regional Agricultural Research Station, Pattambi.

Plate. 3.1. Conventional method of mound making

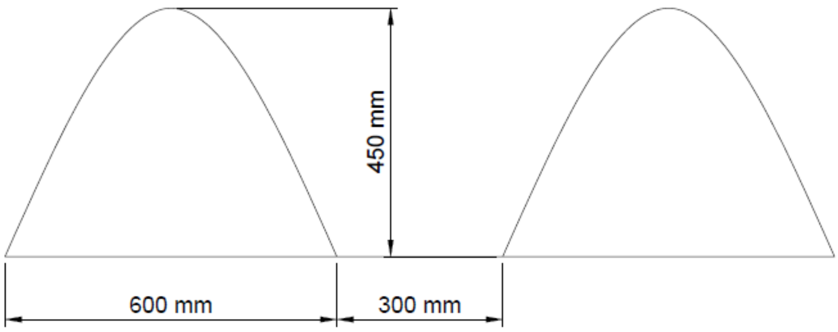


Fig. 3.1. Mounds formed by conventional method

3.1.1. Moisture content

It is the percentage of water in a given soil sample. It is found out by standard test procedures and using the equation,

$$\text{Soil moisture content} = \frac{Mi - Mf}{Mi} \times 100 \qquad \text{.......... (3. 1)}$$

Where,

M_i - initial weight of the soil, kg

M_f - final weight of the soil, kg

Oven drying method was used to determine the moisture content of the soil sample. In this study, a soil sample of 50g was collected in a clean container and placed in an oven under controlled temperature between 105°c to 110°c for a time period of 24 hours. The experiment was replicated for three samples from different parts of the field and the mean value was calculated.

3.1.2. Shear strength

Shear strength of the soil is defined as the maximum resistance offered by soil to shearing stresses (Awadhwal, 1985). As per coloumb's theory, the shear stress can be determined by using the formula,

$$\tau = c + \sigma \tan\Phi \qquad \text{................ (3. 2)}$$

Where,

τ – Shear stress, kg cm^{-2}

c – Cohesion coefficient

σ – Normal stress, kg cm^{-2}

Φ – Angle of shearing resistance, degree

Direct shear test was conducted using shear-box apparatus. The experiment was replicated with three samples of three different locations at the field and the mean value was calculated.

3.1.3. Soil texture

The percentage of various size of particles in a given dry soil sample is found out by sieve analysis. The sieves used were 2.0 mm, 1.0mm, 600, 425, 300, 212, 150 and 75 micron respectively (IS: 460-1964) (Punmia, 2005).

3.1.4. Bulk density

The bulk density or moist density is the total mass (M) of the soil per unit of its total volume (V). Core cutter method was used to determine the bulk density of the soil. The bulk density is found out by using the formula,

$$\rho = \left(\frac{M}{V}\right) \qquad \text{…………… (3. 3)}$$

Where,

ρ – Bulk density, g cm^{-3}

M – Mass of the soil, g

V – Volume of the soil, cm^3

3.1.5. pH

pH value is the measure of the hydrogen ion concentration in soil or natural water to determine the alkalinity or acidity. A pH value of 7 indicates a neutral condition, i.e., it is neither alkaline nor acidic. The value of 7.5 to 8 indicates the presence of carbonates of calcium and magnesium. The value of 8.5 or above indicates the presence of exchangeable sodium in the soil medium. It is determined by using a standard electrode with glass rod. The experiment was replicated for three samples from different parts of the field and the mean value was calculated.

3.1.6. Electrical conductivity

Electrical conductivity (EC) in soil water system is the measure of concentration of soluble salts. The extent of soil salinity was measured using a conductivity meter and indicated as mmhos cm^{-1}. Electrical Conductivity Bridge was used to determine the EC of the given soil sample. The experiment was replicated with three samples taken from different locations of the selected field and the mean value was calculated. The experiment was also replicated in the subsequent growing stages of the crop.

3.2. Development of tractor operated bed former

In this study, two plough bottoms with adjustable forming boards fixed on a standard was developed to test its performance under field conditions (Plate. 3.2). Plough bottom is the most important component of the bed former. The function of the plough bottom is to open a furrow and throw the soil outward at the appropriate depth. This bed former make seed beds at a spacing of 600 mm. The plough bottom was made of MS sheet and two forming boards are attached on either sides of standard. The bottom end of the standard was made as share, which actually penetrates into the soil. The share angle was set at 45 degree. The two forming boards are jointed together by means of two slotted plates at the rear end (Plate. 3.2).

3.2.1. Main frame

Main frame was developed to support the plough bottom and its accessories. It was fabricated with ISMC 75 to make a rectangular frame of 2000 X 560 mm. A three point category-I hitch was welded on the top of the frame to mount the unit to the tractor (Fig. 3.2).

3.2.2. Plough bottom

Plough bottoms cut and gather the soil. It consists of three components namely, forming boards, leveling plates and standard. Forming boards are made of 4 mm thick mild steel in triangular shape with sharp curved cutting edges through its periphery. Cutting angle of the plough bottoms is set to 40 degree with horizontal for the better cutting of the soil (Fig. 3.3). Plough bottoms are having a size of 700 x 480 x 420 mm.

3.2.3. Forming board

Forming boards are two MS sheets made of 4mm thick. It is curved towards top to turn the soil, originating from the bottom of the forming boards. The forming boards are set at 40 degree, so as to get a gently smooth curve on either sides and welded together and is attached to the standard using nuts and bolts (Fig. 3. 3).

3.2.4. Leveling plate

Leveling plates are made of 2 mm thick and 200 X 300 mm size mild steel rectangular sheets (Fig. 3. 2). This component is welded with forming board. Forming boards will cut and sweep the soil into sides when it moves forward. Soil on top of the bed made by forming board has a natural tendency to slide down due to the inclination of the bed. Function of the leveling plate is to compact the soil on the top of the bed by pushing the soil on to the top of the heap from its two sides.

3.2.5. Standard

Forming boards are attached to the standard with nut and bolt. Standards are made of 22 mm thick rectangular mild steel bar (Fig. 3. 3).

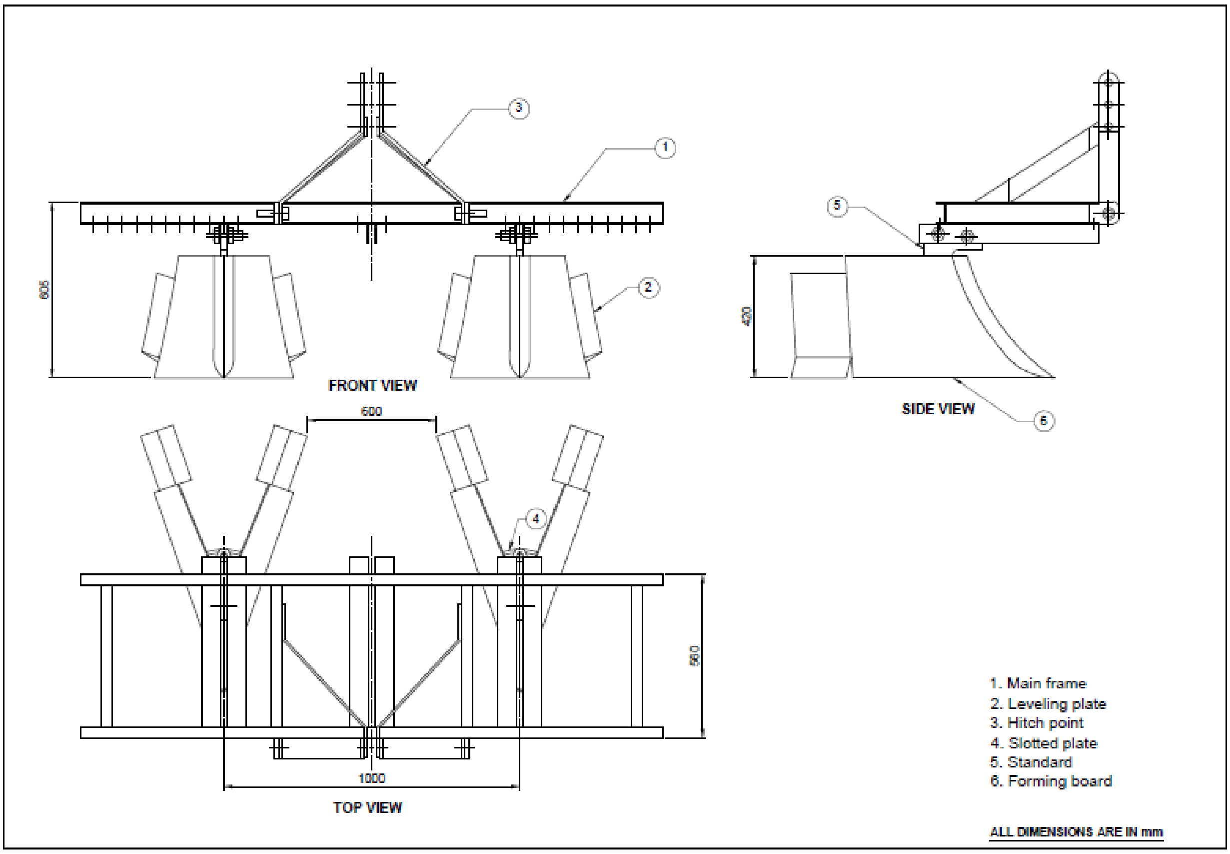


Fig. 3. 2. Kaipad bed former

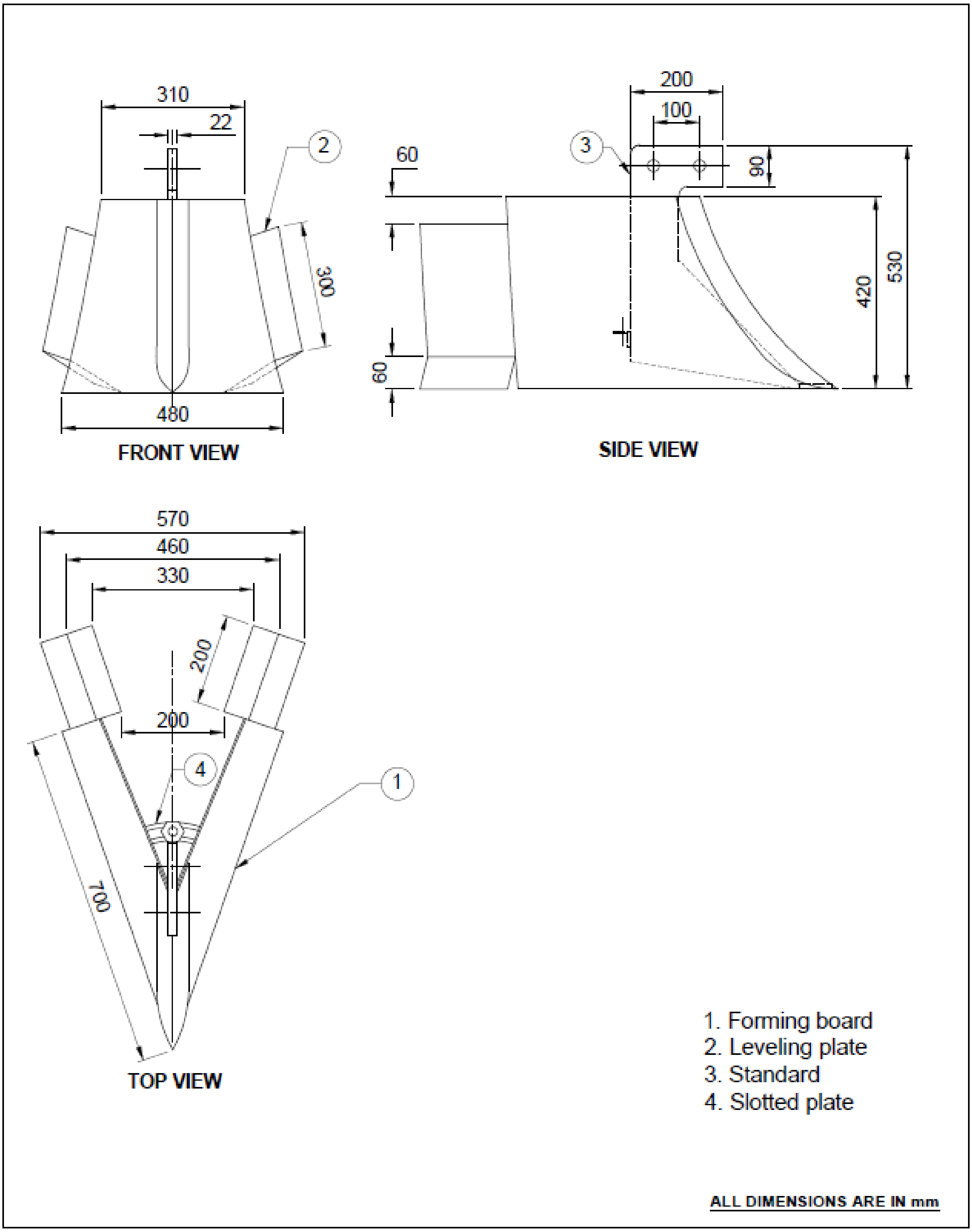


Fig. 3. 3. Parts of plough bottom

Plate. 3. 2. Tractor operated Kaipad bed former

Plate. 3. 3. Angle adjustment of the plough bottom

3.3. Selection of variables

The machine parameters viz., angle of the plough bottom, speed and depth of operation influence the formation of seed beds. These parameters have to be optimized to achieve the most suitable seed beds during the seed bed preparation. Hence the in depended parameters selected for the study includes, angle of the share, angle of plough bottom, speed and depth of operation.

3.3.1. Angle of plough bottom

Angle of the plough bottom affects the draft of the implement and size of the seed bed. The angle between the forming boards was measured in degrees. Three levels of angle of plough bottom viz., 30, 35 and 40 degrees were selected for the study.

3.3.2. Speed of operation

Operation speed of the implement affects the size of the seed beds. When the speed increases the accuracy in forming seed beds will decrease. The operation speeds of the implement were selected as 1.0, 1.5 and 2.0 km h^{-1} respectively.

3.3.3. Depth of operation

Depth of operation affects the draft of the implement and size of the seed beds. Depth of the operation is generally set at one- third size of the implement. The levels of depth of the operation selected were 10, 15 and 20 cm respectively for the study.

3.4. Levels of variables

By considering the operational constraints of the field, the levels of independent parameters affecting the formation of seed beds were selected. The three parameters viz., angle of plough bottom, speed and depth of operation were replicated three times for two treatments such as formation of seed beds using tractor operated ridger and the developed bed former. The angles of the plough bottom viz., 30, 35 and 40 degrees, depths of the operation viz., 10, 15 and 20 cm and speeds of operation viz., 1.0, 1.5 and 2 km h^{-1} respectively were selected. Three replications were carried out for each consecutive level of variables and hence the total numbers of experiments are 3 x 3 x 3 x 3 = 81.

3.5. Development of a test bed

Formation of the seed beds may be influenced by the angle of plough bottom, speed and depth of operation. Height of the seed bed is particularly affected by the angle between the forming boards and depth of operation. These may result in variations in bed size. Hence this analysis is deemed necessary. In order to determine the optimum angle of plough bottom, speed and depth of operation a test bed was developed to study the effect of formation of seed bed mounds. The test bed was made in 50 cents of specially demarcated Kaipad land at Eazhome padashekharam, near to the actual field.

In order to test the performance of the bed former, Kubota 34 hp four wheel drive tractor was used to carry the whole assembly. To test the bed former at different angles of the plough bottom, a slotted plate was welded in the forming board Plate. 3.3. By adjusting the slotted plates, different angles such as 30, 35 and 40 degrees were varied and respective observations were taken on the size of the forming seed beds. The different forward speeds tested were 1.0, 1.5 and 2.0 km h^{-1}. To measure the depth of operation, indicating marks were made on the forming boards. By adjusting the position control levers of the tractor hydraulics, the depth levels were varied.

3.6. Performance evaluation of bed former under dynamic conditions

The performance of the bed former was evaluated in the test bed. First the plough bottom was adjusted to 30 degrees. The forward speed of the unit set at 1.0 km h^{-1} and depth of the implement was set at 10 cm. The height and top widths were observed. The experiment was repeated three times. Similarly experiments were conducted for the treatment combination (81) as shown in Table 3.1.

Table 3.1. Factors selected for the experiment

Sl.No.	Angle of plough bottom (degree)	Depth of operation (cm)	Speed of operation (km h^{-1})
1	**30**	**10**	**1.0**
2	**35**	**15**	**1.5**
3	**40**	**20**	**2.0**
Number of replication - 3			

Total number of experiments - 3 x 3 x 3 x 3 = 81

3.7. Optimization of machine parameters

The design parameters of the bed former were optimized based on the formation of seed beds of required height and top width. Three factor Completely Randomized Design (CRD) was used to analyze the data thus to find out the interaction between the factor combinations. MSTAT statistical software was used to do analysis of variance and mean comparison table was obtained. Duncan's Multiple Range Test (DMRT) was used to determine the rank order of the interaction. The mean comparison table was analyzed to observe the treatment which yields the desired angle of plough bottom, speed and depth of operation.

3.8. Field performance evaluation

The tractor operated bed former and ridger was tested and compared the actual field conditions. The trials were conducted at

Eazhome and Kannome panchyaths of Kannur district. These areas were selected as it represents ideal Kaipad region of the State. The soil type of this area is a typical hydromorphic saline soil. The tests were conducted during third week of May 2011 i.e. just before the onset of south west monsoon. Soil was ploughed with rotavator and made it for fine tilth (Plate. 3. 4). Soil samples were collected randomly and conducted various soil tests for finding physical characteristics. The dynamic performance of the developed bed former (Plate. 3. 5) and conventional ridger (Plate. 3. 6) was conducted at plough angles of 30, 35 and 40 degrees, forward speeds of 1.0, 1.5 and 2.0 km h^{-1} and depths of operation at 10, 15, 20 cm respectively. The height of the bed and top width of the bed were observed. The performance of three methods of mounds making by traditional, tractor operated ridger and Kaipad bed former were evaluated.

3.8.1. Height and top width of the bed formed

After making the seed beds by Kaipad bed former and tractor operated ridger, the dimensions were measured with a steel tape of least count 1 mm in order to compare the size of the seed beds. The dimensions of the seed beds viz., top and bottom widths and height were measured at various test conditions.

3.8.2. Draft of the implement

Draft is the horizontal component of pull. A strain gauge type dynamometer is attached to the front of the tractor on which the implement is mounted. Another auxiliary tractor pulls the implement mounted tractor which is in neutral gear while the implement in the operating position. The draft and the time taken to traverse the field were observed and recorded. Also the draft without the implement was observed. The difference gives the draft of the implement.

Plate. 3. 4. Tillage by rotavator

Plate. 3. 5. Field performance of tractor operated Kaipadbed former

Plate. 3. 6. Field performance of tractor operated conventional ridger

3.8.3. Draw bar power

It is the power, which is available for pulling loads at the draw bar. The time required to cover a definite distance was noted and speed of the operation was calculated. The draw bar horse power required at different speed and draft conditions were found out by using the formula,

$$\text{Draw bar horse power} = \frac{D \times S}{75} \qquad \text{………… (3. 4)}$$

Where,

D – Draft, kg_f

S – Speed, km h^{-1}

3.8.4. Fuel consumption

Fuel consumption of the tractor is the amount of fuel required to cover a known distance with implement. An external fuel tank was attached with the tractor to determine the fuel consumption of the tractor. The tank was filled to full capacity before and after each test trial. The volume of fuel refilled after the test is the fuel consumption for the operation.

3.8.5. Theoretical field capacity

It is the theoretical area covered per hour by an implement at rated speed. The width of the implement and operating speeds were measured as explained earlier. The theoretical field capacity in ha hr^{-1} is calculated using the formula,

$$\text{Theoretical field capacity} = \frac{W \text{ X } S}{10} \qquad \text{………. (3. 5)}$$

Where,

W – Implement width, m

S – Operating speed, km h^{-1}

3.8.6. Actual field capacity

The actual field capacity was determined by observing the actual area covered per hour with standard test procedures.

3.8.7. Field efficiency

The field efficiency was calculated from the theoretical and effective field capacity using the formula,

$$\text{Field efficiency (\%)} = \frac{\text{Effective field capacity}}{\text{Theoretical field capacity}} \times 100 \qquad \ldots (3.6)$$

3.8.8. Wheel slip

It is the relative movement of the wheel in the direction of travel for a given distance under load and at no load condition. To determine the wheel slippage, the drive wheel of the tractor was marked with a chalk to facilitate the counting of wheel revolutions. A corresponding position on the ground was also marked when tractor was moving forward with implement at load. As the tractor wheel completed 10 revolutions, the position on the ground was again marked. The distance travelled by the tractor wheel in 10 revolutions while working in the soil with and without load was measured with a measuring tape. The slip (%) was calculated using the formula.

$$\text{Slip (\%)} = \frac{OL - NL}{OL} \times 100 \qquad \ldots\ldots\ldots\ldots (3.7)$$

Where,

OL- number of rotation of the rear wheel with load

NL- number of rotation of rear wheel at no load

3.8.9. Yield of the crop

The yields of the crop from the three treatments such as mounds prepared using conventional method tractor drawn ridger and Kaipad bed former were observed and recorded. Randomized Block Design (RBD) was used to check the significant different between the treatments at 5 percent level.

3.8. 10.Cost economics

The field capacity of the implement was observed and the cost of operation was calculated. The saving in cost in the field operation with Kaipad bed former was worked out in comparison with the conventional method of mound making.

CHAPTER IV

RESULTS AND DISCUSSION

The main objective of the mound making is to improve the leaching. The relevant physical and leaching properties of Kaipad soil are determined and summarized. The soil machine parameters, mainly, angle of the plough bottom, speed and depth of operation were optimized in terms of draft and fuel consumption. A prototype tractor operated seed bed former was developed for Kaipad area based on optimized machine parameters. The performance of the unit under dynamic conditions was also evaluated. The field performance of the bed former along with cost economics is also presented.

4.1. Physical and Chemical properties

The physical properties such as the moisture content, shear strength, soil texture and bulk density of the soil which influence the performance of the bed former were determined. The soil chemical properties such as electrical conductivity and pH were also found out.

4.1.1. Moisture content

Moisture content was determined as percentage by weight by oven drying method. Soil samples from three different experimental plots at different day intervals were determined using the equation 3.1. The average moisture content found out was 25.63 percent.

4.1.2. Shear strength

Shear strength was determined randomly using direct shear apparatus at the three locations of the study area. The average shear stress "τ" of the soil from the experimental plot was found out as 0. 621 kg cm^{-2}.

4.1.3. Soil texture

The results of the soil textural analysis are given in Appendix I. The results of the mechanical analysis were plotted to obtain particle size distribution curve in semi log graph as shown in Fig. 4.1. In this curve, the percentage finer "N' was taken as ordinate and particle diameter (mm) as the abscissa on logarithmic scale.

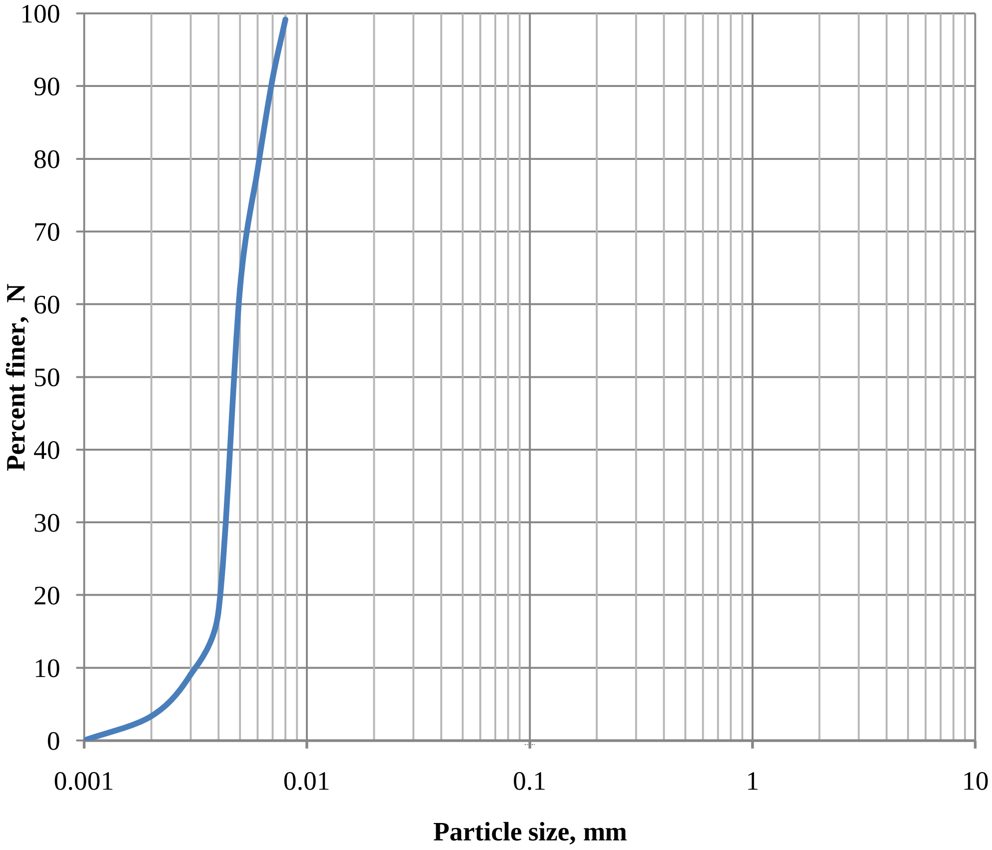


Fig. 4.1. Particle size distribution curve.

From the figure, it is obvious that the soil sample consisted of 91.7 percent silt having size range from 0.002 to 0.05 mm, and the remaining part 8.3 percent clay of size 0.002 mm. According to the USDA classification chart, the textural class of the soil was found to be silt.

4.1.4. Bulk density

The bulk density of the soil in the experimental field was found out by core cutter method. The mean bulk density of the soil was found to be 1.76 g cm^{-3}.

4.1.5. Soil pH

The pH analysis of the soil samples collected from the experimental plots is given in Table 4. 1. The various treatments conducted in the field for forming seed beds are by using conventional method, tractor operated ridger and Kaipad bed former. The experiments were conducted during April- July 2011 period. The soil acidity of the study area during April 2011 showed an acidic range with pH values of 5.6 in conventionally mound prepared plot. Whereas, in the plots operated with tractor operated ridger and Kaipad bed former, the pH value obtained where 5.5 and 5.4. The pH values in the three plots under different treatments were not same. This may due to the field condition even though the experimental plots were in the same location. As there was no rain or irrigation given to the plot in May 2011, the pH remains constant in these three different treatments. The acidity of the soil in June 2011 slightly decreased from the pH value of 5.6 to 5.7 in conventionally mound prepared plot. Also it decreased from the pH value of 5.5 to 5.7 in first plot and 5.4 to 5.8 in second plot in tractor operated ridger and Kaipad bed former trialed plots respectively.

The reduction in acidity of soil may be due to the South West monsoon and subsequent washing away of salt from the heaped soil. The experimental plots have maximum reduction of acidity in July 2011, as the soil pH values indicated an increasing trend from 5.6 to 5.9 in conventionally mound prepatred plot. Whereas in the plots operated with tractor operated ridger and Kaipad bed former, the pH value reduced from 5.5 to 5.9 and 5.6 to 6.3. From these results it is revealed that the maximum reduction in acidity of soil was occurred in the field plots operated by Kaipad bed former.

Table 4. 1. pH analysis of the soil samples collected from April to July 2011

Plot No.	April 2011			May 2011			June 2011			July 2011		
	Plots operated by											
	CM	TR	KB	CM	TR	KB	CM	TR	KB	CM	TR	KB
1	5.6	5.5	5.6	5.6	5.5	5.6	5.7	5.7	5.9	5.9	5.9	6.3
2	5.9	5.9	5.4	5.9	5.9	5.4	6.2	6.1	5.8	6.5	6.4	6.2
3	5.9	5.8	5.7	5.9	5.8	5.7	6.0	6.3	5.9	6.3	6.3	6.5

CM- Conventional method, TR- Tractor operated Ridger, KB- Kaipad bed former.

4.1.6. Electrical conductivity

The electrical conductivity (EC) analysis of the soil samples collected from the same experimental plots as explained in 4.1.5 and is given in Table 4. 2. The electrical conductivity was measured during April- July 2011 period. The soil salinity of the study area during April 2011 showed maximum EC values of 15.7 mmhos cm^{-1} in conventionally trailed second plot. Whereas in the plots operated with tractor operated ridger and Kaipad bed former, the maximum EC was 15.8 mmhos cm^{-1} in first and second plots. As there was no rain or irrigation given to the plot in this period the salinity remains constant in these three different treatments. The EC of the soil in June 2011 slightly decreased from 15.7 to 8.1 mmhos cm^{-1} in conventionally trailed plot. Also it decreased from 15.8- 7.9 mmhos cm^{-1} in second plot and from 15.8 to 6.3 mmhos cm^{-1} in third plot in tractor operated ridger and Kaipad bed former trailed plots respectively (Armstrong, 1996).

Leaching of salts was very high in the month of July 2011 due to the heavy rain fall. Leaching in conventionally trailed plot, tractor operated ridger and Kaipad bed former was respectively as 2.1, 3.5 and 2.1 mmhos cm^{-1}. From these results it is understood that there was the maximum reduction of soil salinity occurred in the field plots operated by tractor operated Kaipad bed former. This may be due to the effect of soil pulverization by mechanical method compared to the conventional method. It also helped to increase pore space of the soil which in turn increased the leaching effect.

Table 4. 2. Electrical Conductivity of the soil samples collected from April to July 2011

Plot No.	April 2011			May 2011			June 2011			July 2011		
	Plots operated by											
	CM	TR	KB	CM	TR	KB	CM	TR	KB	CM	TR	KB
1	15.4	15.7	15.8	15.4	15.7	15.8	7.9	7.5	6.3	3.4	3.3	2.1
2	15.7	15.8	15.5	15.7	15.8	15.5	8.1	7.9	7.7	2.1	3.5	2.4
3	15.2	15.1	15.1	15.2	15.1	15.1	6.7	6.6	6.8	3.3	3.2	3.3

CM- Conventional method, TR- Tractor operated Ridger, KB- Kaipad bed former.

4.2. Optimization of machine parameters under dynamic conditions

The optimization tests of the tractor operated bed former were conducted in an experimental test plot near to the main field. These tests were conducted to optimize the angle of the plough bottom, speed and depth of operation with respect to the height and top width of the seed beds and draft of the bed former. The various plough bottom angles tested were at 30, 35 and 40 degrees and its effects were recorded with respect to various speeds and depth of operations. The speeds selected were 1.0, 1.5 and 2.0 km h^{-1} and the depths were varied at 10, 15 and 20 cm respectively. The average values of the measured parameters were found out and are given

Table 4.3. Optimization of machine parameters under dynamic conditions

Sl. No.	Treatment	Angle of the plough bottom (degree)	Speed of operation (km h⁻¹)	Depth of operation (cm)	Height of bed (cm)	Top width of bed (cm)	Draft of implement (kg_f)
1	$A_1 S_1 D_1$	30	1.0	10	26.9	31.5	389.2
2	$A_1 S_1 D_2$	30	1.0	15	27.8	30.3	389.6
3	$A_1 S_1 D_3$	30	1.0	20	28.8	29.6	390.0
4	$A_1 S_2 D_1$	30	1.5	10	27.4	29.0	391.3
5	$A_1 S_2 D_2$	30	1.5	15	28.2	28.4	391.8
6	$A_1 S_2 D_3$	30	1.5	20	29.2	27.6	392.4
7	$A_1 S_3 D_1$	30	2.0	10	27.1	26.8	392.8
8	$A_1 S_3 D_2$	30	2.0	15	28.8	26.1	393.1
9	$A_1 S_3 D_3$	30	2.0	20	29.2	25.9	393.5
10	$A_2 S_1 D_1$	35	1.0	10	28.0	25.4	394.1
11	$A_2 S_1 D_2$	35	1.0	15	29.2	25.2	394.5
12	$A_2 S_1 D_3$	35	1.0	20	29.6	24.9	395.3
13	$A_2 S_2 D_1$	35	1.5	10	29.3	24.6	395.9
14	$A_2 S_2 D_2$	35	1.5	15	29.6	23.8	397.2
15	$A_2 S_2 D_3$	35	1.5	20	30.3	23.4	397.6
16	$A_2 S_3 D_1$	35	2.0	10	30.3	22.4	398.0
17	$A_2 S_3 D_2$	35	2.0	15	30.9	21.3	397.9
18	$A_2 S_3 D_3$	35	2.0	20	31.8	20.4	398.4
19	$A_3 S_1 D_1$	40	1.0	10	32.1	19.8	399.2
20	$A_3 S_1 D_2$	40	1.0	15	32.8	19.5	400.6
21	$A_3 S_1 D_3$	40	1.0	20	33.2	18.6	400.9
22	$A_3 S_2 D_1$	40	1.5	10	33.9	18.8	401.7
23	$A_3 S_2 D_2$	40	1.5	15	34.7	18.4	402.6
24	$A_3 S_2 D_3$	40	1.5	20	35.2	18.4	402.8
25	$A_3 S_3 D_1$	40	2.0	10	34.2	17.6	403.3
26	$A_3 S_3 D_2$	40	2.0	15	34.7	17.7	404.1
27	$A_3 S_3 D_3$	40	2.0	20	35.5	17.4	405.6

Angle, degrees - A1= 30; A2= 35; A_3= 40

Speed, km h^{-1} - S_1= 1.0; S_2= 1.5; S3= 2.0

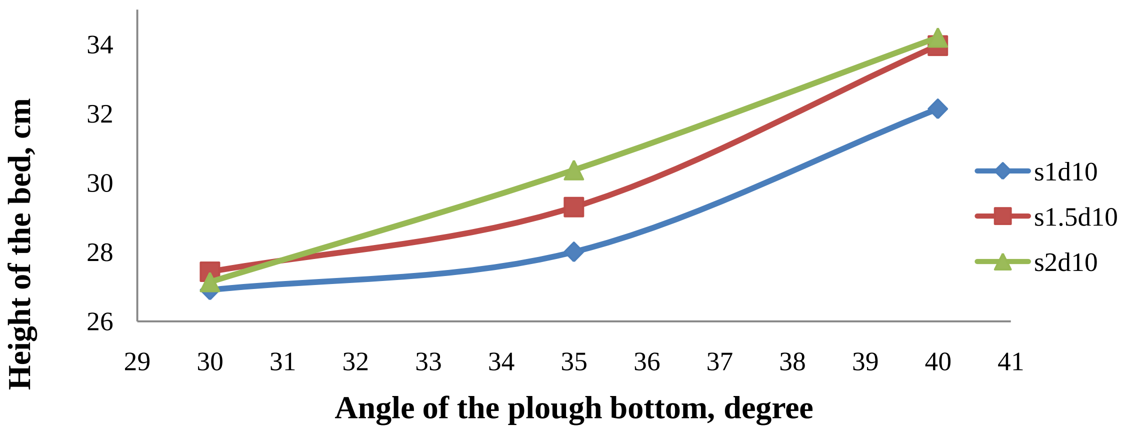
Depth, cm - D_1= 10; D2= 15; D_3= 20 in Table 4.3. Implement draft on the formation of beds is also briefly explained.

4.2.1. Angle of plough bottom

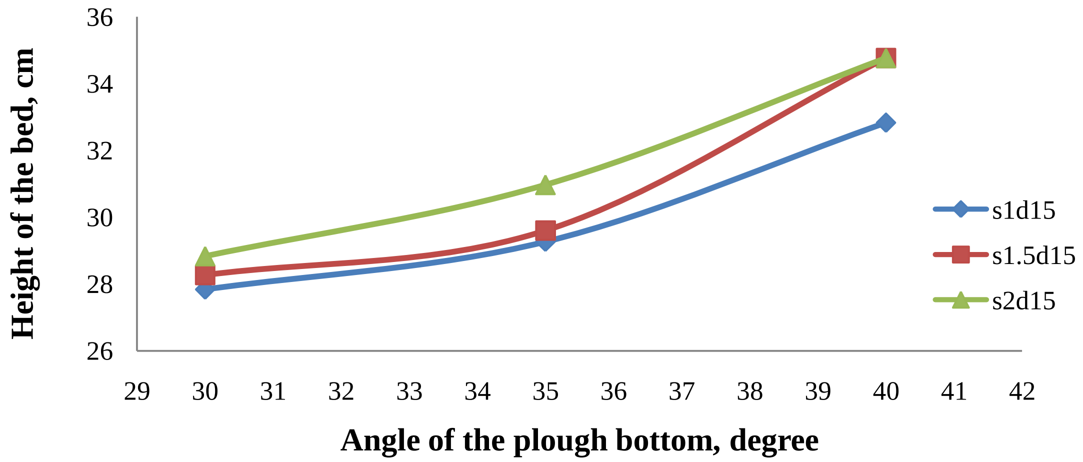
The analysis of variance for the height of the bed with respect to different angles of the plough bottom, speed and depth of the operation is given in Table 4.3 and 4.4. From the Table, it was inferred that the effect of treatment combinations of angle of the plough bottom and effect of speed and depth of operation are significant at one percent level. The interaction A x B is significant, indicating that angle of the plough bottom and the speed of operation affect the height of the bed. Hence it is concluded that, for getting maximum height of the seed bed, the angle of plough bottom needs to be set at 40 degree and speed of operation at2.0 km h^{-1}.

Height of the bed at an angle of 30 degree of plough bottom at all the selected speeds and depths of operation was lesser than the angles at 35 and 40 degrees. Maximum bed height of 35.5 cm was obtained at an angle of 40 degree. The speed of operation was 2.0 km h^{-1}. During the speed of operation at 1.0 km h^{-1} and 1.5 km h^{-1} the height of the seed bed formed was lower than the speed at 2.0 km h^{-1}. The same trend was observed at 30 and 35 degrees of plough bottom (Fig. 4.2.).

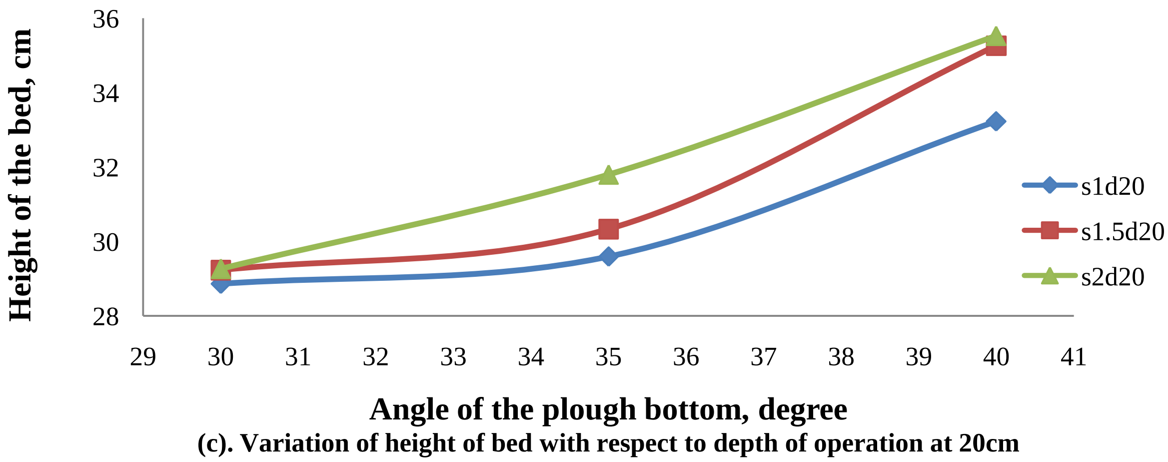
The maximum height of bed was obtained at speed of operation at 2.0 km h^{-1}, the angle of operation 40 degrees and at all depths of 10, 15 and 20 cm. This effect may be due to the effect of accumulation of soil particles by more effective depth of operation and high impact velocity of the implement on the soil. Also the increased angle of operation gathers more soil from the sides and transforms it to the centre of the bed. Hence it is decided to fix the operation angle at 40 degree and speed of operation at 2.0 km h^{-1}. According to the analysis of variance (ANOVA), the depth of operation is not significant at one percent level. Though there is an effect



(a). Variation of height of bed with respect to depth of operation at 10 cm



(b). Variation of height of bed with respect to depth of operation at 15 cm



(c). Variation of height of bed with respect to depth of operation at 20cm

Fig. 4.2. Effect of height of bed at different angles of plough bottom, different speed and depth of operation

due to depth of operation it could not fix its level due to the non significant effect.

Table 4. 4. Analysis of variance for the height of the bed

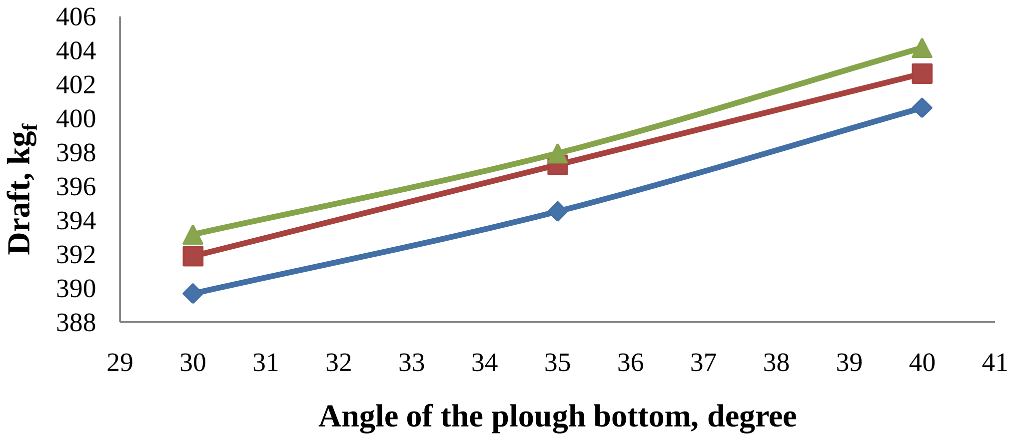
Source	DF	SS	MS	F	
Angle of plough bottom (A)	2	493.879	246.939	582.4714	**
Speed of operation (B)	2	34.887	17.443	41.1447	**
A x B	4	11.179	2.795	6.5923	**
Depth of operation (C)	2	31.442	15.721	37.0824	**
A x C	4	1.417	0.354	0.8356	NS
B x C	4	0.336	0.084	0.1979	NS
A x B x C	8	1.316	0.165	0.3881	NS
Error	54	22.893	0.424		
Total	80	597.349			

C. V. = 2.12%, ** Significant at 1% level, NS- not significant

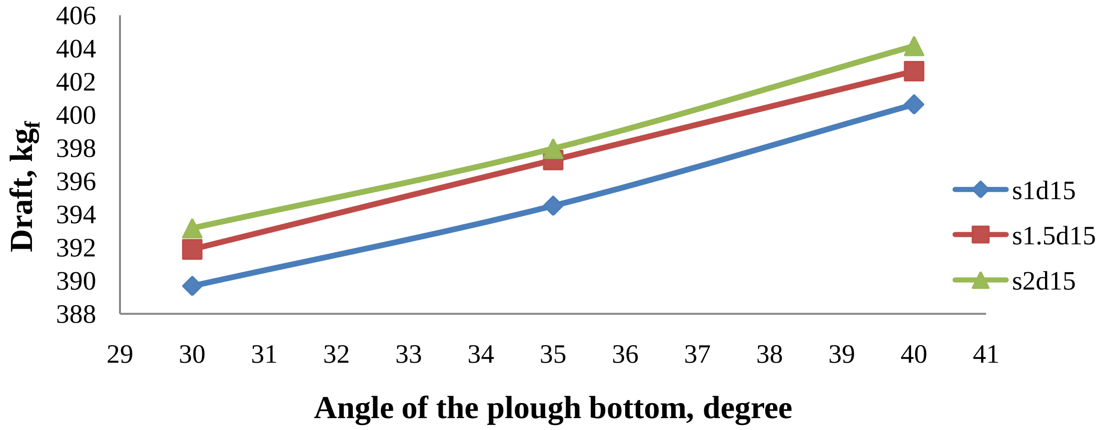
4.2.2. Speed and depth of operation

Analysis of variance (ANOVA) for the top width of the seed bed with respect to different angles of plough bottom, speed and depth of operation are given in Table. 4.5. From the table, it is inferred that the effect of treatment combination of angle of plough bottom and speed is significant at one percent level. The interaction Ax B is significant indicating that angle of plough bottom and the speed of operation affect the formation of top width of the seed bed. The effect of depth of operation is significant. The treatment combination of speed, depth and angle of the plough bottom are not significant.

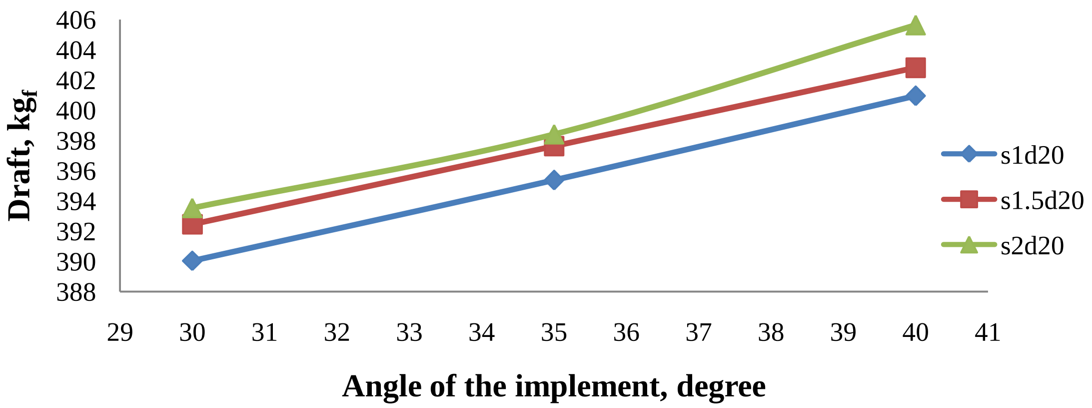
The maximum top width of 31.5 cm was obtained at an angle of 30degree, speed of operation at 1.0 km h^{-1} and depth of operation at 10 cm. At the same speed, the top width of the seed bed was minimum at 10 and 15 cm, this may due to increasing the height of the seed bed. At lesser speeds 1.0 and 1.5 km h^{-1} and depth of operation at 20 cm the top width of seed bed are found to decrease. Also at these combinations, the top width of the bed formed was found out to decrease when the height of bed increases. Hence it is concluded that for getting maximum top width of all



(b). Variation of draft with respect to the depth of operation at 10 cm



(b). Variation of draft with respect to the depth of operation at 15 cm



(c). Variation of draft with respect to the depth of operation at 20 cm

Fig. 4.3. Draft of the implement at different angles of plough bottom, different speed and constant depth of operation

the three parameters such as angle of plough bottom, speed and depth of operation are necessarily be at maximum possible levels. The beds with maximum top width will form at 40 degree of plough bottom, 2.0 km h^{-1} operating speed and depth at 20 cm respectively. But the ultimate aim of using Kaipad bed former is to make seed beds at maximum height.

Table 4. 5. Analysis of variance for the top width of the bed

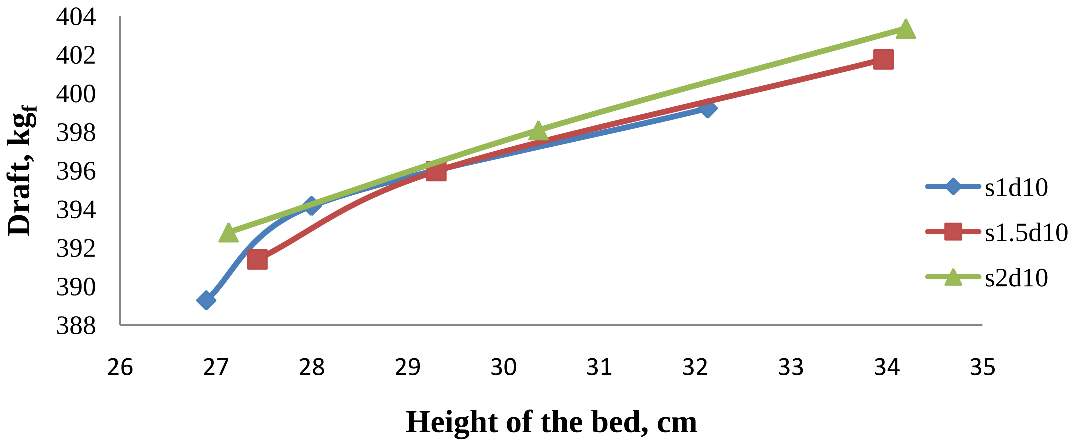
Source	DF	SS	MS	F	
Angle of plough bottom (A)	2	1319.254	659.627	2253.4695	**
Speed of operation (B)	2	142.747	71.373	243.8317	**
A x B	4	18.119	4.530	15.4749	**
Depth of operation C	2	15.704	7.852	26.8245	**
A x C	4	1.924	0.481	1.6434	NS
B x C	4	0.178	0.044	0.1516	NS
A x B x C	8	3.934	0.492	1.6801	NS
Error	54	15.807	0.293		
Total	80	1517.666			

C. V. 2.31%, ** Significant at 1% level, NS- not significant

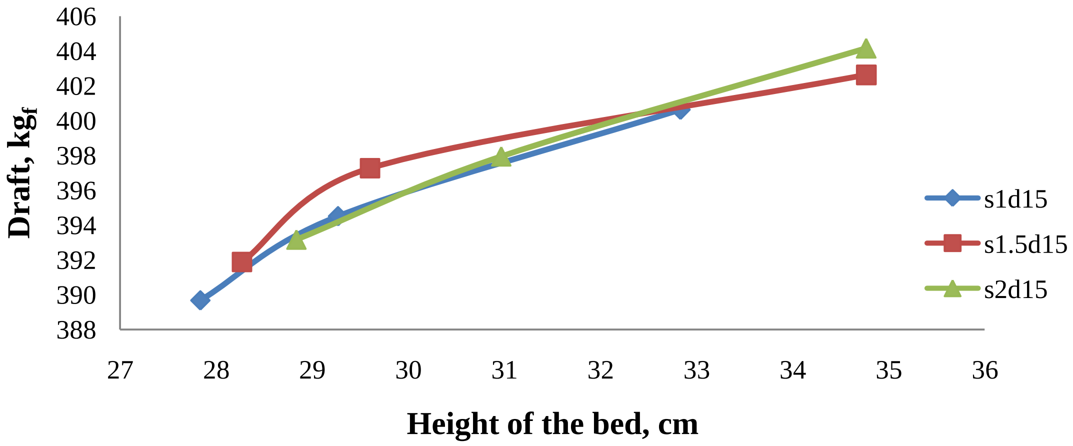
4.2.3. Draft of the implement

The analysis of variance for the best treatment combination yielding minimum draft of the implement with respect to operating angle of the plough bottom, speed and depth of operation are presented in Table. 4.6. From the table, it is inferred that the effect of treatment combinations of angle of the plough bottom, speed and depth of operations are significant at one percent level. Also all the interactions of these type treatments are significant except between speed and depth of operation.

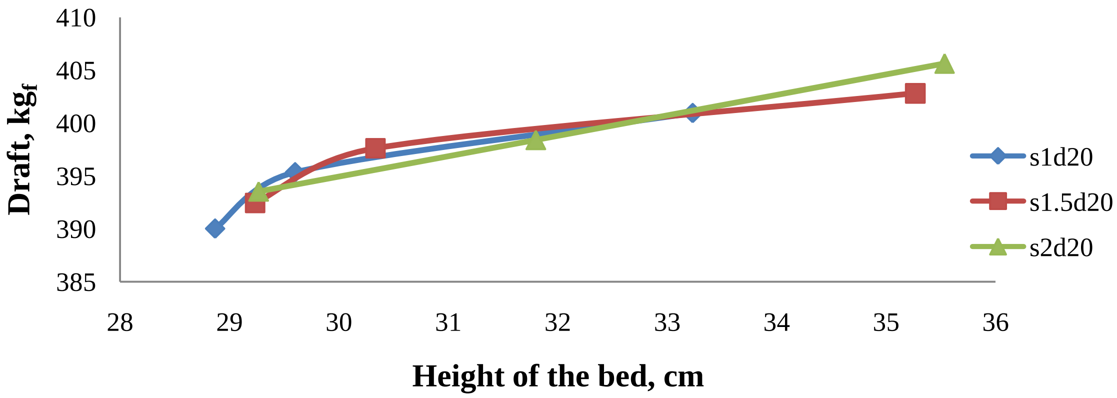
The effect of angle of the plough bottom, speed and depth of operation on the draft of the implement is illustrated in Fig 4. 3 (a to c). Similar to the previous analysis, the three levels of angle of the plough bottom, speed and depth of operation are fixed at levels of 30, 35 and 40; 1.0, 1.5 and 2.0 km h^{-1} and 10, 15 and 20 cm respectively.



(a). Variation of draft with respect to the depth of operation at 10 cm



(b). Variation of draft with respect to the depth of operation at 15 cm



(c). Variation of draft with respect to the depth of operation at 20 cm

Fig. 4.4. Draft of the implement at different height of the bed at different speed and constant depth of operation

Table 4. 6. Analysis of variance for the draft of the implement

Source	DF	SS	MS	F	
Angle of the plough bottom (A)	2	1567.236	783.618	7113.4467	**
Speed of operation(B)	2	186.975	93.487	848.6498	**
A x B	4	1.977	0.494	4.4859	**
Depth of operation C	2	19.203	9.601	87.1584	**
A x C	4	1.851	0.463	4.1997	**
B x C	4	0.759	0.190	1.7225	NS
A x B x C	8	3.480	0.435	3.9492	**
Error	54	5.949	0.110		
Total	80	1787.428			

C. V. 0.08%, ** Significant at 1% level, NS- not significant

From the Fig 4.3 (a), it is inferred that the draft increased as the angle of the plough bottom, speed and depth of operation increased (Al-Janobi, 1998). It was found out that the maximum draft of 405.6 kg_f at an angle of plough bottom at 40 degree, speed of operation at 2.0 km h^{-1} and depth of operation at 20 cm. The minimum draft was 389.2 kg_f at angle of operation 30 degree, speed of operation 1.0 km h^{-1} and depth of operation 10cm. The same trend was observed when the depth of operation varied between 15 to 20 cm and angle of plough bottom varied between 30 and 40 degrees. The draft increased mainly because of the increased depth of operation. It may also due to the increase of speed of operation (Gill *et al*, 1968).

It was also observed that the draft increased as the height of bed increased. This phenomenon is shown in the Fig. 4.4 (a to c). The draft was maximum when the height of the bed formed was 35.5 cm. Also the speed and depth of operation were respectively as 2.0 km h^{-1} and 20 cm and angle of the plough bottom was at 40 degree. At the speed of 1.0 km h^{-1} and all other depth of operation, the maximum height of bed obtained lies between 32 and 33 cm. In all other speed of operation, height of the bed increased from 33.5 to 35.5 cm with increased draft.

At the depth of operation 15 cm and speed of operation 1.5 and 2.0 km h^{-1}, the height of the bed formed is the same and is at 34.9 cm. The draft during the speed 1.5 km h^{-1} was 402.6 kg_f and at the speed of 2.0 km h^{-1}, it was 404.1 kg_f. A same trend was observed in Fig. 4.3 (c). Hence it is concluded that, a minimum draft of 402.6 kg_f was obtained at the speed of 1.5 km h^{-1} and depth of operation at 15 cm.

From the section 4.2.1, it is concluded that for getting maximum height of bed of 35.5 cm, the plough bottom was operated at 40°. But at this angle of plough bottom, the draft was very high and was about 405.5 kg_f. This is not admissible as it increased the effort of tractor to operate at safer conditions. The draft should be as minimum as possible to increase the field efficiency with the tractor operated bed former. Results on the effect of speed of operation on the maximum height of seed bed formation revealed that, it was possible at the maximum speed of 2.0 km h^{-1}. But at this speed, the draft was maximum of 405.6 kg_f. These effects are illustrated in Fig. 4. 4 (a) to (c). It cannot be admissible as minimum draft is desirable especially with the soil working implements and machineries. Hence lower speed of operations of 1.0 and 1.5 km h^{-1} were considered better for much reduced draft. At the speed of operation 1.0 km h^{-1}, the height of bed formed was very less which was not to the desired level for better leaching effect. Hence the speed of operation was optimized at 1.5 km h^{-1}, under these conditions, it is concluded that the optimum speed of operation as 1.5 km h^{-1}, depth of operation at 15 cm and angle of the plough bottom at 40 degrees.

The reduced draft was occurred at the intermediate levels of speed and depth of operation. This analysis was further treated by means of Duncan’s Multiple Range Test (DMRT) to found the most suitable combination of the operation and is presented in Table 4.7. The test method reviewed fourteen sub groups of treatments [a,b,c,……….n] for the width of the seed bed, fourteen for the height of the seed bed [a,b,c,………..n]

Table 4. 7. Three factor interaction of means (A x S x D) for selected angles of plough bottom, speed and depth of operation

Sl. No.	Treatment	Height of bund	Top width of bund	Draft of the implement
1	$A_1 S_1 D_1$	26.90^{n}	31.53^{a}	389.3^{s}
2	$A_1 S_1 D_2$	27.83^{lmn}	30.37^{b}	389.7^{rs}
3	$A_1 S_1 D_3$	28.87^{jkl}	29.60^{bc}	390.0^{r}
4	$A_1 S_2 D_1$	27.43^{mn}	29.03^{cd}	391.4^{q}
5	$A_1 S_2 D_2$	28.27^{klm}	28.40^{de}	391.9^{q}
6	$A_1 S_2 D_3$	29.23^{ijk}	27.60^{ef}	392.5^{p}
7	$A_1 S_3 D_1$	27.13^{mn}	26.87^{fg}	392.8^{op}
8	$A_1 S_3 D_2$	28.83^{jkl}	26.10^{gh}	393.2^{no}
9	$A_1 S_3 D_3$	29.27^{ijk}	25.97^{gh}	393.5^{n}
10	$A_2 S_1 D_1$	28.00^{lmn}	25.40^{hi}	394.2^{m}
11	$A_2 S_1 D_2$	29.27^{ijk}	25.23^{hi}	394.5^{m}
12	$A_2 S_1 D_3$	29.60^{ij}	24.97^{i}	395.4^{l}
13	$A_2 S_2 D_1$	29.30^{ijk}	24.63^{ij}	396.0^{k}
14	$A_2 S_2 D_2$	29.60^{ij}	23.83^{jk}	397.3^{j}
15	$A_2 S_2 D_3$	30.33^{hi}	23.40^{k}	397.6^{ij}
16	$A_2 S_3 D_1$	30.37^{hi}	22.40^{l}	398.1^{hi}
17	$A_2 S_3 D_2$	30.97^{gh}	21.30^{m}	397.9^{hi}
18	$A_2 S_3 D_3$	31.80^{fg}	20.40^{n}	398.4^{h}
19	$A_3 S_1 D_1$	32.13^{ef}	19.83^{n}	399.2^{g}
20	$A_3 S_1 D_2$	32.83^{ef}	19.53^{no}	400.6^{f}
21	$A_3 S_1 D_3$	33.23^{de}	18.60^{pq}	400.9^{f}
22	$A_3 S_2 D_1$	33.97^{cd}	18.80^{p}	401.8^{e}
23	$A_3 S_2 D_2$	34.77^{abc}	18.43^{pqr}	402.6^{d}
24	$A_3 S_2 D_3$	35.27^{ab}	18.43^{pqr}	402.8^{d}
25	$A_3 S_3 D_1$	34.20^{bcd}	17.63^{qr}	403.4^{c}
26	$A_3 S_3 D_2$	34.77^{abc}	17.77^{qr}	404.1^{b}
27	$A_3 S_3 D_3$	35.53^{a}	17.47^{r}	405.6^{a}

Angle, degrees - A_1= 30; A2= 35; A_3= 40

Speed, km h^{-1} - S_1= 1.0; S_2= 1.5; S3= 2.0

Depth, cm - D_1= 10; D2= 15; D_3= 20 and nineteen sub groups of treatments [a,b,c,...........s] for the draft of the implement. Treatment combination A_3 S_2 D_1, A_3 S_2 D_2, A_3 S_2 D_3, A_3 S_3 D_1, A_3 S_3 D_2 and A_3 S_3 D_3 were on par. Among these treatments the combination number 23 i.e. angle of the implement 40 degree, speed of operation 1.5 km h^{-1} and depth of operation at 15 cm was chosen as the most suitable combination because of speed and depth of operation reduced the draft.

4.3. Field performance evaluation of bed former

The field performance of the tractor operated Kaipad bed former was evaluated by making mounds at three different locations in Eazhome panchyath, during May 2011. Tests were carried out in one acre each in the selected location at farmer's fields. The performance of the tractor operated Kaipad bed former was studied based on the optimized values of speed, depth of operation and angle of the plough bottom. Its performance was compared with the conventional method and tractor operated ridger. Height and top width of the bed, draft, drawbar power, fuel consumption, field efficiency and wheel slippage of the bed former were evaluated. Emergences of the seedling under the three treatments are shown in plates 4.1, 4.2 and 4.3

4.3.1. Height and top width of the bed formed

The average height and top width of the seed bed obtained with the Kaipad bed former was 35.3 cm and 18.5 cm. It was 29.4 cm and 23.2 cm when operated with tractor operated ridger. The results indicated that the height and top width obtain with the Kaipad bed former is agreeable with the farmers requirement. Also it favors for leaching of salts and to bring down the soil pH to the neutral condition for better crop yield.

4.3.2. Draft of the implement

The draft of the implement in the actual field was measured as explained in 3.11.1. The minimum draft obtained with the Kaipad bed former and tractor operated ridger was 401.97 kg_f and 398.6 kg_f respectively at field trials. This is in accordance with the optimum machine parameters under dynamic test conditions. The draft with the tractor operated ridger is significantly higher than that with the tractor operated ridger at one percent level of significant. This may be due to the large area of contact of the plough bottom of the Kaipad bed former.

4.3.3. Draw bar power

Draw bar power of the tractor operated Kaipad bed former was 8.03 hp using equation 3.4. When operated with the tractor operated ridger it was 7.8 hp. The draw bar power of the Kaipad bed former is significantly higher than the tractor operated ridge former at one percent level of significance. This is due to the higher draft requirement as explained in 4.3.2.

4.3.4. Fuel consumption

The fuel consumption with the tractor operated Kaipad bed former was measured as 6.8 *l* h^{-1}, while it was 6.6 *l* h^{-1} with the tractor operated ridger under field conditions.

4.3.5. Field efficiency

Field efficiency of the Kaipad bed former was determined using the equation 3.7. The theoretical and actual field capacities of the Kaipad bed former and tractor operated ridger were respectively as 0.234 ha h^{-1}, 0.173 ha h^{-1} and 0.234 ha h^{-1}, 0.165 ha h^{-1}. Hence the field efficiency of the Kaipad bed former was 73.9 percent compared to 70.5 percent for the tractor operated ridger.

4.3.6. Wheel slippage

Wheel slippage of the tractor operated Kaipad bed former was determined using the equation 3.5. It was found out as 19.79 percent for Kaipad bed former and 17.7 percentages for tractor operated ridger. This may be due to the higher loading effect in Kaipad bed former than in the tractor operated ridger.

4.3.7. Crop yield

The crop yield for the three treatments conducted in field trials are illustrated in Fig. 4.5. From the figure, it is implied that the average yield obtained from the plots operated with Kaipad bed former was maximum and it is about 2800 kg ha^{-1} from all the plots. But the average yield obtained from the plots operated with conventional method and tractor operated ridger was respectively as 2625 kg ha^{-1} and 2766 kg ha^{-1}. From the results of yield data, it is inferred that higher yield was obtained at the plots operated with Kaipad bed former is significantly higher than the other two methods at 5 percent level of significance Table. 4.8. This may be due to the sufficient leaching out of salts and attainment of neutral pH in the field as; the mounds were formed with the help of Kaipad bed former. And also due to the formation of mounds at maximum height and top width. The yields obtained from the other treatments viz., operation by conventional and tractor operated ridger, emphasized that leaching of salts from the soil was minimum and could not bring down the soil pH even at same rain fall rate and irrigation.

4.3.8. Cost economics

The field coverage of the Kaipad bed former was 0.19 ha hr^{-1}. Seed beds making by conventional method requires 60 man power per hectare, at the present wage rate of Rs 200 per day, the total cost of operation is Rs 12000 per ha. In mechanical methods there are two processes, pulverization by rotavator costs Rs 910 per ha and mound making by Kaipad bed former costs Rs 1570 per ha. Hence the total cost of operation is Rs 2480 per ha (Appendix iv). Hence the savings over conventional method of mound making is Rs 9520 per ha.

Table. 4.8. Analysis of variance for yield data

Treatments	**Replication-1**	**Replication-2**	**Replication-3**	**Total**	**Average**
Conventional method	2670	2597	2608	7875	2625
Tractor operated ridger	2733	2754	2811	8298	2766
Kaipad bed former	2826	2794	2780	8400	2800
Total	8229	8145	8199	0	0
Average	2743	2715	2733	0	0

ANOVA

Source	**DF**	**SS**	**MS**	**F- Ratio**	**Tab- val**	**Remarks**
Blocks	2	1204	602	0.38	6.94	NS
Treatments	2	51656	25828	16.48	6.94	*
Error	4	6268	1567			
Total	8	59128				
						CD=89.72

NS- Not significant, * Significant at 5 % level

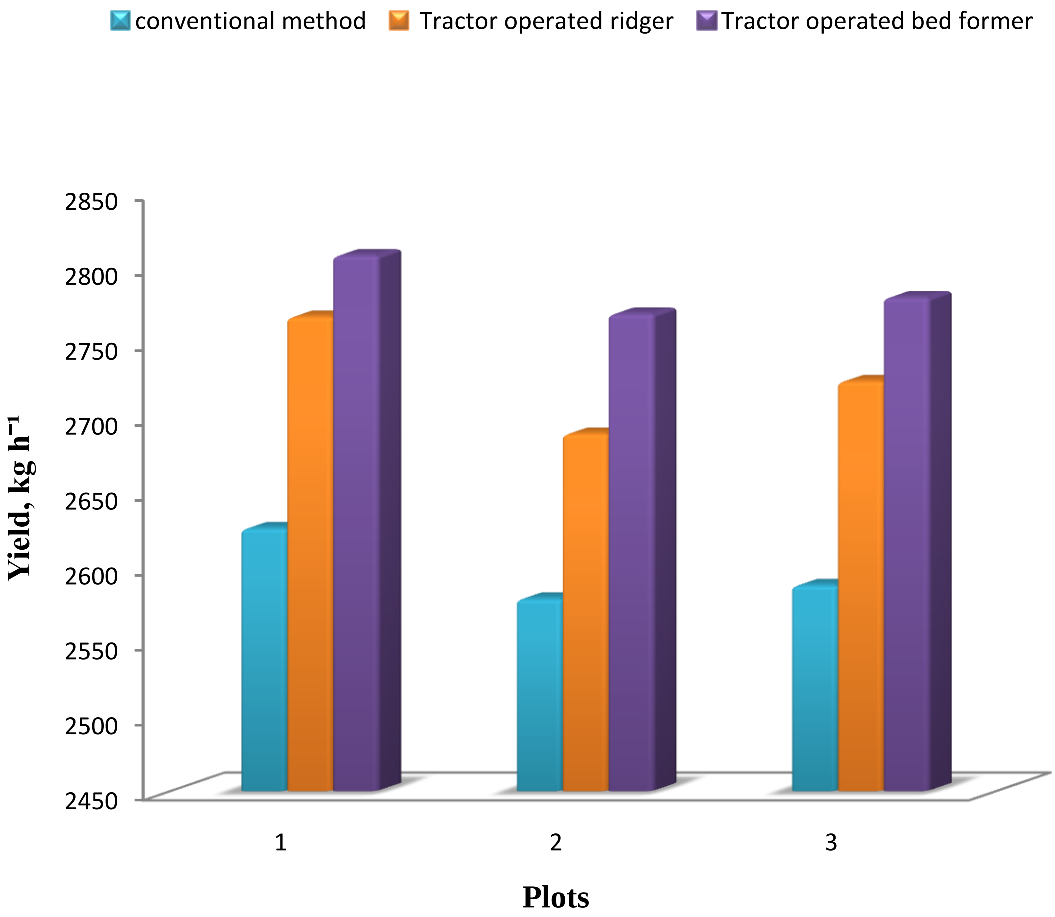


Fig. 4. 5. Comparison of crop yield under three treatments

Plate. 4.1. Rice seedlings on seed beds made by manual method

Plate. 4.2. Seed beds made by tractor operated ridger

Plate. 4.3. Rice seedlings on seed bed made by Kaipad bed former

CHAPTER V

SUMMARY AND CONCLUSIONS

Rice (*Oryza sativa*) is one of the leading cereal crops of the world and is the staple food for more than half of the world population. In Asia alone, about 60 to 70 per cent of people obtain their caloric intake from rice and its derived products. Paddy cultivation was considered to be a part of the proud culture of Kerala State and is grown in three seasons' viz., Viruppu, Mundakan and puncha. Kaipad cultivation is an age old practice of growing medicinal rice varities viz., *Kuthiru, Orkayama, mundon, Kandorkutty* and *Orpandy* .Kaipad land is a wet land severely affected by the tidal water. Hence, the rice cultivation in the Kaipad region needs proper soil management, especially the control of soil salinity and pH. In order to achieve these controls, mounds are prepared conventionally using spades. This tillage operation is tedious, hazardous, labour and time consuming. A tractor operated seed bed former was hence developed to make mounds in this study. It consisted of a plough bottom mounted on a main frame.

Appropriate instrumentation and methodologies were developed to conduct experiments on the following aspects.

i. The relevant physical properties of the soil were determined using the standard test procedures.
ii. An experimental test plot was developed to optimize the soil machine parameters and that influence the performance of the bed former.
iii. A prototype tractor operated seed bed former using the optimal design parameters was developed.
iv. The field performance of the developed bed former was evaluated and the cost economics worked out

The following conclusions were drawn from the study.

1. The average moisture content found out for the experimental pot was 25.63 percent.
2. The shear strength of the Kaipad soil was observed as 0.621 kg cm^{-2}.
3. Soil type of Kaipad was silt with 91.7 percent silt and 8.3 percent clay.
4. Bulk density of the soil is obtained as 1.76 g cm^{-3}
5. The maximum soil acidity of the experimental plot under traditional method of mound making in April 2011 was 5.6 and it decreased in to a pH value of 5.9 in July 2011.
6. In tractor operated ridger, the maximum soil acidity was found out as 5.5 in April 2011 and it decreased in to a pH value of 5.9 in July 2011.
7. In tractor operated Kaipad bed former, the maximum soil acidity was observed as 5.6 in April 2011 and it decreased in to a pH value of 6.3 in July 2011.
8. The reduction in soil acidity was maximum in the seed beds prepared by tractor operated Kaipad bed former.
9. The maximum soil salinity observed in of the plot under traditional method of mound making in April 2011 was 15.7 mmhos cm^{-1} and it decreased in to 2.1 mmhos cm^{-1} in July 2011.
10. In tractor operated ridger, the maximum soil salinity was found as 15.8 mmhos cm^{-1} in April 2011 and it decreased in to 3.5 mmhos cm^{-1} in July 2011.
11. In tractor operated Kaipad bed former, the maximum soil salinity was observed as 15.8 mmhos cm^{-1} in April 2011 and it decreased in to 2.1 mmhos cm^{-1} in July 2011.
12. The maximum leaching of salts was observed in the mounds prepared by tractor operated Kaipad bed former.

13. The maximum height of the seed bed was formed at 40 degrees for all the speeds and depths of operation.
14. At speed of 1.0 km h^{-1}, the height of bed formed was lower than that of the speed at 1.5 and 2.0 km h^{-1}.
15. The maximum height of bed formed was at speed of 2.0 km h^{-1}. To decrease the draft and, at the same time, to keep the height of bed at maximum, speed of operation was set at 1.5 km h^{-1}.
16. Maximum height of bed was formed at 20 cm depth. To decrease the draft and, at the same time, to keep the height of bed at maximum, depth of operation was set at 15 cm.
17. The tractor operated bed former based on the optimal parameters was developed.

The field performance of the tractor operated Kaipad bed former was evaluated and compared with the tractor operated ridger and conventional method. The average height and top width of the seed bed obtained with the Kaipad bed former were 35.3 cm and 18.5 cm respectively. The corresponding values were 29.4 cm and 23.2 cm when operated with tractor operated ridger. The minimum draft required for the Kaipad bed former and tractor operated ridger were 402.6 kg_f and 398.6 kg_f respectively at field trials. Draw bar power of the tractor operated Kaipad bed former and ridger were measured as 8.0 hp and 7.8 hp respectively. The fuel consumption with the tractor operated Kaipad bed former was measured as 6.8 *l* h^{-1}, while it was 6.6 *l* h^{-1} with the tractor operated ridger. Field efficiency of the Kaipad bed former were 73.9 percent compared to 70.5 percent for the tractor operated ridger. Wheel slippage was found out as 19.79 percent for Kaipad bed former and 17.7 percent for tractor operated ridger. The average yield obtained from the plots operated with Kaipad bed former was maximum and was found as 2800 kg ha^{-1} from all the plots. Yield obtained from the plots operated with conventional method and tractor operated ridger was respectively as

2625 kg ha^{-1} and 2766 kg ha^{-1}. Total cost of operation for mound making by conventional method and tractor operated bed former are respectively as Rs.12000 and Rs. 2480 per ha. The total cost of operation with the tractor operated Kaipad bed former was Rs. 1560 per ha. Savings over conventional method of mound making is Rs 9520 per ha.

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APPENDIX I

Particle size distribution of soil

Mass of dry soil sample (M) =300 g

Sl. No.	IS sieve	Mass retained (g)	% retained	Cumulative % retained	Cumulative % finer
1	2 mm	0	0	0	0
3	1 mm	2.5	0.83	0.83	99.16
3	0.60 mm	25	8.33	9.16	90.83
4	0.425 mm	37	12.33	21.5	78.50
5	0.3 mm	49	16.33	37.83	62.16
6	0.212 mm	134	44.66	82.50	17.50
7	0.15 mm	25.5	8.50	91	9
8	0.075 mm	17	5.66	96.66	3.33
9	Pan	4	1.33	98	2

APPENDIX II

Specifications of the tractor

Maker		:	KUBOTA
Model		:	D 1703-M-DI
Type		:	Direct injection, vertical, Water-Cooled 4 cycle diesel
Number of cylinder		:	3
Bore and stroke	(mm)	:	87 x 92.4
Total displacement	(L)	:	1.647
Engine gross power	kW (HP)	:	25.9 (34.7)
Engine net power	kW (HP)	:	24.8 (33.3)
Engine rated revolution	(rpm)	:	2700
Maximum torque	(N-m)	:	108.3
Battery		:	75D26R, 12V 52Ah, AC : 123 min, CCA (-18°c) : 490 A
Fuel		:	Diesel fuel No. 2-D
Fuel tank capacity	(L)	:	34
Overall length (without 3p)	(mm)	:	2925
Overall width	(mm)	:	1430
Wheel base	(mm)	:	1610
Weight	(kg)	:	1115
Front tires		:	8- 16
Rear tires		:	12.4- 24
Clutch		:	Dry type Single stage
Steering		:	Integral type power steering
Transmission		:	Gear shift, 8 forward and 4 reverse
Brake		:	Wet disc type
Minimum turning radius (with	(m)	:	2.5

brake)			
Hydraulic control system		:	Position control system
Pump capacity	(L min^{-1})	:	23.9
Three point hitch		:	Category 1
Maximum lift force at lift points	(kg)	:	906
Maximum lift force 610 mm behind lift points	(kg)	:	651
System pressure	(Mpa)	:	16.2
Rear PTO		:	SAE 1-3 /8, 6-splines
PTO power	kW (HP)	:	22.4 (30.0)

APPENDIX III

Cost of fabrication of Kaipad bed former

a	Materials	Quantity (Kg)		Cost (Rs per kg)
	2.5” x 1.5” C channels	50	:	2400
	2.5” angle	19	:	817
	1.5” angle	9	:	387
	2.5” flat	18	:	774
	4 mm MS sheet	26	:	1248
	22 mm MS sheet	46	:	2392
	1” nuts and bolts	1	:	65
	0.5” nuts and bolts	0.5	:	32
	Paint		:	95
	Total material cost		:	8210
b	Labour cost		:	9865
c	Intellectual cost		:	800
	Total cost (a + b + c), Rs		:	18875

APPENDIX IV

Cost of operation with Kaipad bed former

1. Tractor

A. Basic information

(i)	Cost of the tractor, Rs	:	4,00,000
(ii)	Useful life, year	:	12
(iii)	Hours of use per year	:	1,000
(iv)	No. of skilled labours required	:	1
(v)	Rate of interest	:	10 %
(vi)	Salvage value (10 % of investment cost)	:	40,000
(vii)	Field capacity of bed former, ha h^{-1}	:	0.19
(viii)	Fuel requirement, l h^{-1}	:	3

B Cost items

I Fixed cost

(i) Depreciation cost per year, Rs :

$$\frac{(\text{Initial cost} - \text{Salvage value})}{\text{Useful life}}$$

$$\frac{(4{,}00{,}000 - 40{,}000)}{12} = 30{,}000$$

(ii) Interest on investment per year, Rs :

$$\frac{(\text{Cost of tractor} + \text{Salvage value})}{2} \text{ X Intrest rate}$$

$$\frac{(4{,}00{,}000 + 40{,}000)}{2} \text{ X } 0.10 = 22{,}000$$

(iii) Taxes, insurance and shelter per year, Rs : Cost of tractor X 0.02 = 8,000

(iv) Total fixed cost per year, Rs : 30,000 + 22,000 + 8,000 = 60,000

(v) Total fixed cost per hour, Rs :

$$\frac{\text{Total fixed cost per year, Rs}}{\text{Hours of use per year}} = 60$$

II Variable cost

(i)	Repair and maintenance per hour, Rs	:	$\frac{\text{Cost of tractor x 0.05}}{1000} = 20$
(ii)	Fuel cost per hour, Rs	:	Fuel requirement x rate of fuel 123.9
(iii)	Cost of lubricant per hour, Rs	:	Fuel cost x 0.20 24.78
(iv)	Labour cost per hour, Rs	:	50
(v)	Total variable cost per hour, Rs	:	20 + 123.9+ 24.78 + 50 = 218.68

III	Total cost per hour, Rs	:	Fixed cost + variable cost 60 + 218.68 = 278.68
	Round to the value, Rs	:	280

2. Rotavator

A. Basic information

(i)	Cost of the rotavator, Rs	:	1,15,000
(ii)	Useful life, year	:	8
(iii)	Hours of use per year	:	750
(iv)	Rate of interest	:	12 %
(v)	Salvage value (10 % of investment cost)	:	11,500
(vii)	Field capacity of rotavator, ha h^{-1}	:	0.35

B Cost calculation

I Fixed cost

(i) Depreciation cost per year, Rs

$$= \frac{(\text{Initial cost} - \text{Salvage value})}{\text{Useful life}}$$

$$= \frac{(1{,}15{,}000 - 11{,}500)}{8} = 12{,}937$$

(ii) Interest on investment per year, Rs

$$= \frac{(\text{Cost of rotavator} + \text{Salvage value})}{2} \text{ X Intrest rate}$$

		=	$\frac{(1,15,000 + 11,500)}{2}$ X 0.12 = 7,590
(iii)	Taxes, insurance and shelter per year, Rs	=	Cost of rotavator X 0.02 = 2,300
(iv)	Total fixed cost per year, Rs	=	12,937 + 7,590 + 2,300 = 22,827
(v)	Total fixed cost per hour, Rs	=	$\frac{\text{Total fixed cost per year, Rs}}{\text{Hours of use per year}} = 30.43$

II Variable cost

(i)	Repair and maintenance per hour, Rs	=	$\frac{\text{Cost of rotavator x 0.05}}{750} = 7.67$
(i)	Total variable cost per hour, Rs	=	7.67

III Total cost per hour, Rs	=	Fixed cost + variable cost
	=	30.43 + 7.67 = 38.10
IV Total cost per hectare, Rs	=	$\frac{\text{Total cost per hour for rotavator + Tractor}}{\text{Field capacity}}$
	=	$\frac{38 + 280}{0.35} = 908.57$
Round to the value, Rs	=	910

3. Bed former

A. Basic information

(i)	Cost of the bed former, Rs	:	18,875
(ii)	Useful life, year	:	10
(iii)	Hours of use per year	:	250
(iv)	Rate of interest	:	12 %
(v)	Salvage value (10 % of investment cost)	:	1,887.5
(vii)	Field capacity of bed former, ha h^{-1}	:	0.19

B Cost calculation.

I Fixed cost

(i) Depreciation cost per year, Rs : $\frac{(\text{Initial cost} - \text{Salvage value})}{\text{Useful life}}$

$$\frac{(18{,}875 - 1887.5)}{10} = 1{,}698.75$$

(ii) Interest on investment per year, Rs : $\frac{(\text{Cost of bed former} + \text{Salvage value})}{2}$

X Intrest rate

$$\frac{(18{,}875 + 1887.5)}{2} \text{ X } 0.12 = 1{,}245.75$$

(iii) Taxes, insurance and shelter per year, Rs : Cost of rotavator X 0.02

= 377.5

(iv) Total fixed cost per year, Rs : 1,698.75+ 1,245.75+ 377.5 = 3,322

(v) Total fixed cost per hour, Rs : $\frac{\text{Total fixed cost per year, Rs}}{\text{Hours of use per year}} = 13.28$

II Variable cost

(i) Repair and maintenance per hour, Rs : $\frac{\text{Cost of bed former x } 0.05}{250} = 3.77$

(ii) Total variable cost per hour, Rs : 3.77

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

13.28+ 3.77 = 17.05

Total cost per hectare, Rs : $\frac{\text{Total cost per hour for bed former} + \text{Tractor}}{\text{Field capacity}}$

$$\frac{280 + 17.05}{0.19} = 1563.42$$

Round to the value, Rs : 1570

Total cost of mound making per hectare, Rs = Total cost of operation tractor with rotavator + bed former

910 + 1570 = 2480

DEVELOPMENT AND TESTING OF TRACTOR OPERATED BED FORMER FOR SEED BED PREPARATION IN KAIPAD REGION

By

RAJESH. A.N

(2009 – 18 – 101)

ABSTRACT OF THE THESIS

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ABSTRACT

Paddy cultivation in Kerala is mainly done in dry and wet lands. Kuttanadu, pokkali, Kole and Kaipad lands are mainly lying below sea level and needs much attention especially during bund preparation and nursery raising periods. Kaipad is a land lay in Kannur district of the state extending to an area of 600 ha. It is under the tidal effects of sea water carrying severe salinity and high pH. Paddy cultivation in this region is made on seed beds of about 45 cm height to bring down the salinity and acidity of the soil through leaching. However, manual method of mound making is very laborious intensive and has become a deterrent for the farmers to continue rice farming. Keeping this in view, a tractor operated Kaipad bed former was developed to prepare the seed beds and field tested. Also the cost of operation was compared with the conventional and tractor operated ridger.

The height of the seed beds was dependent upon the angle of the plough bottom, speed and depth of operation. To optimize these three factors, tests were conducted under dynamic condition in a test plot. The height of the seed bed was observed to be the maximum at 40 degrees of the plough bottom. The maximum height of bed was formed at a speed of 2.0 km h^{-1} and depth of 20 cm. To reduce the draft of the implement the speed was set at 1.5 km h^{-1} and depth of operation at 15 cm.

The field performance of the bed former based on the optimized machine parameters, the Kaipad bed former was evaluated and compared with the tractor operated ridger and conventional method. The average height and top width of the seed bed obtained with the Kaipad bed former and ridger were 34.7 cm, 18.4 cm and 29.4 cm and 23.2 cm respectively. The minimum draft required for the Kaipad bed former and tractor operated ridger was 402.6 kg_f and 398.6 kg_f and draw bar power was 8.03 hp and 7.8 hp respectively.

The fuel consumption with the tractor operated Kaipad bed former was found as 6.8 *l* h^{-1}; while it was 6.6 *l* h^{-1} with the tractor operated ridger. Field efficiency of the Kaipad bed former was 73.9 percent compared to 70.5 percent for the tractor operated ridger. Wheel slippage was found out as 19.79 percent for Kaipad bed former and 17.7 percentages for tractor operated ridger. With the tractor operated Kaipad bed former, the soil acidity and salinity could be reduced from a pH value of 5.7 to 6.5 and 15.7 mmhos cm^{-1} to 2.1 mmhos cm^{-1}. Yield obtained from the plots operated with conventional method, tractor operated ridger and Kaipad bed former was respectively 2625 kg ha^{-1}, 2766 kg ha^{-1} and 2800 kg ha^{-1}. Total cost of operation for mound making by conventional method and tractor operated bed former are respectively Rs.12000 and Rs. 2480. The cost of the tractor operated Kaipad bed former is Rs. 18875.