REFINEMENT OF A COMBINATION IMPLEMENT FOR DRY SEEDING AND HERBICIDE APPLICATION IN RICE

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PROJECT REPORT

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DECLARATION

We hereby declare that, this project entitled "**REFINEMENT OF A COMBINATION IMPLEMENT FOR DRY SEEDING AND HERBICIDE APPLICATION IN RICE**" is a bonafide record of project work done by us during the course of study, and that the report has not previously formed the basis for the award to us of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

Certified that this project report entitled **“REFINEMENT OF A COMBINATION IMPLEMENT FOR DRYSEEDING AND HERBICIDE APPLICATION IN RICE”** is a record of project work done jointly by Athira Thankachan, Indu Thulaseedharan and Shibina K.V. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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SYMBOLS AND ABBREVIATIONS

Mha	Million hectare
MT	Metric tone
FIB	Farm Information beauro
ai	Active ingredient
KAU	Kerala agricultural university
PoP	Package of practices
KVK	Krishi Vigyan Kendra
et al.	and others
hp	Horse power
h	Hour
IRRI	International Rice Research Institute
IGKV	Indira Gandhi Krishi Vishwavidyalaya
Rs	Rupees
CV	Coefficient of variation
eg.	Example
ISO	International Organization for Standardization
l	Litre
No.	Number
KCAET	Kelappaji College of agricultural engineering and Technology
db	Dry basis
bhp	Break horse power
DBHP	Drawbar horse power
M.S	Mild steel
3D	Three dimensional
CAD	Computer aided drafting

CHAPTER I

INTRODUCTION

Agriculture has been the backbone of the Indian economy and it will continue to remain so for a long time. About 70% of the population of India lives in villages. The core occupation of people living in villages is agriculture (farming). India has to support almost 17% of world population in 2.3% of world's geographical area and 4.2% of world's water resources. The present cropping intensity of 137% has registered an increase of only 26% since 1950-51.The net sown area is 142 Mha.

India is one of the world's largest producers of white rice and brown rice, accounting for 20% of all worlds' rice production system. Rice (*Oryza sativa*) is the most widely consumed staple food of the people of eastern and the southern parts of the country. Kerala is well suited for paddy cultivation because of its high rainfall and good climatic system. But Kerala has witnessed the steady decline in paddy cultivation since 1980's. This was likely to be due to the sharp fall in the area under cultivation and lack of mechanization. Modernization in agriculture can be achieved through proper mechanization. Benefits of mechanization which attracted the attention of farmers are timely field operations, higher field efficiencies, higher productivities and reduction in human drudgery. In 2013-14, the paddy production in Kerala was 5, 64,325 MT from an area of 1, 99,611 ha (FIB, 2013). Palakkad district is the major producer contributing 42.18% of the total rice production. There are three main rice-growing seasons in Kerala. The '*Virippu'* (First crop) season starts in April-May and extends up to September-October, '*Mundakan'* (Second crop) season starts in September-October and extends up to December-January, where as the '*Puncha'* (Third crop) season starts in December-January and extends up to March-April.

Establishment of a proper plant population is important in rice cultivation. To get high yields, the right amount of seeds should be placed at the right time at a predetermined depth and spacing in the soil. Depending upon the moisture availability, seed emergence capacity, type of soil, sowing methods may vary. In Kerala rice cultivation is usually done by three techniques, they are: direct dry seeding, direct wet seeding and transplanting. Direct dry seeding is the practice in which rice seeds are sown in a dry field where there is sufficient moisture for germination. In wet seeding, pre-germinated seeds are sown onto a puddled and levelled field. In transplanting system, seedlings are raised in a nursery and transplanted to the puddled main field either manually or mechanically.

Dry seeding is the method usually practiced for rainfed ecosystems. It is the common practice for '*Virippu'* crop in Kerala. Dry direct seeding is usually done by manual broadcasting. It is the random scattering of seeds in a well prepared field. Soon after broadcasting, they are covered by manipulating the soil and planking it over. For a broadcasted rice crop, intercultural operations like weeding can be done only manually like weeding hoe. Usually slightly higher rate of seeding is done in this method due to the uncertainity in germination.

Dry seeding by drilling involves dropping the seeds in a furrow through a seed tube. Seed drills use improved seed metering mechanisms and some of them give a very good accuracy in metering. In this method, accuracy of proper depth, spacing and seed rate are much higher than broadcasting. The only disadvantage of this method is that, few seeds may get damaged and sometimes the seed tube gets clogged during operation. This may result in irregular germination of the seedlings leaving gaps. Even though, dry seeding is a commonly used practice, it is more prone to weed competition as compared to direct wet seeding and transplanting systems as there is no standing water. The application of pre-emergent herbicides can overcome this problem to a certain extent. Pretilachlor (0.75 kg ai/ha) is a common pre-emergent herbicide and its application on the day of seeding or within 6 days is recommended by KAU (KAU, 2016). Manual spraying of herbicide is a laborious and time consuming operation and the uniformity and dosage may vary significantly.

In dry seeding practice, the conventional broadcasting has severe limitations. Sowing operation takes more time and more labour. Skill is required to ensure uniformity. As the depth of seed placement varies due to conventional planting practices, the germination also may be irregular. The conventional seeder attachment to tractor operated cultivator has limitations due to irregular depth of seed placement as well as clogging of boot. This lead to the development of a refined seeder and further a combination implement for dry seeding and herbicide application at KVK Palakkad. The conventional seeder is an attachment to 9 tyne cultivator and the cost of the cultivator is most often a dead investment as farmers seldom remove the seeder attachment and use the cultivator independently. The combination implement is simple and light weight and an electrically operated spraying mechanism is integrated with the seeder. Keeping in view of the high relevance of the implement, the present study was taken up for the evaluation and refinement of the combination implement developed at KVK Palakkad.

Objectives

Keeping in view of the above, the present investigation, **'Refinement of a combination implement for dry seeding and herbicide application in rice'** has been taken up with the following specific objectives:

1. To evaluate the combination implement developed at KVK Palakkad.
2. To suggest refinement to improve the performance.
3. To incorporate design modifications so as to refine the implement.

CHAPTER II

REVIEW OF LITERATURE

A review of previous research works related to the importance of rice cultivation, rice cultivation systems, mechanization in rice cultivation, development of rice seeding machines and pertinent aspects of herbicide application are discussed in this chapter.

2.1 Rice cultivation and food security

Karunakaran (2014) has discussed the trends of paddy cultivation in Kerala and its effects on food security. The statistical profile of Kerala agriculture since the nineteen sixties clearly indicated the decrease in area under paddy cultivation in the state. Time series analysis of acreage production and productivity data of rice in Kerala during the five decades from 1960-61 to 2009-2010 revealed the performance of this crop in terms of changes in area, production and productivity. The production of this major food crop has shown negative growth rates due to the decline in the area cultivated. Food security, particularly rice security is the vital issue for Kerala today. The data revealed that during 1960-61 Kerala had a shortage of rice of about 40.12%, which increased to 83.45% in 2009-10. The study clearly revealed the increase in demand for rice in Kerala in the coming years compared to the existing supply. This indicated the widening supply - demand gap of rice in Kerala for the future years.

2.2 Rice cultivation scenario in Kerala

Prabhakaran (2009) has reported that Palakkad district, called the rice bowl of Kerala, accounted for nearly 50 per cent of paddy produced in the state during 2008-2009 compared to its share of 46 per cent during 2007-2008. The increase is attributed to a rise in the area of cultivated land and productivity, said to be the results of a decade – long "silent revolution" initiated by local bodies, government agencies and farmers.

Mukesh (2015) conducted a study on the dynamics of paddy cultivation in Kerala. According to him agricultural production in Kerala is lowering and it may be a threat to Kerala's food security. The major causative problem identified by the social scientist is labour shortage and low price of paddy. Though the fertility of soil, favorable monsoon, and government policies helped the farmers, they have not completely engaged in paddy cultivation as it required timely manual labour. Hence, mechanization, or more availability of human labour alone will increase the paddy production in the study area.

Shiji (2016) studied about the shrinking rice cultivation in Kerala. He reported that the agricultural sector is an important sub- sector of' the primary sector in Kerala. The area under rice cultivation increased substantially during the first fifteen years after the State's formation – from 7,60,000 ha in 1955–56 to 8,80,000 ha in 1970–71. In 1965–66, rice accounted for the highest share of gross cropped area in Kerala (32 % of the total). However, a steady decline in the area under rice cultivation was observed from the 1980s onwards – from 8,50,000 ha in 1980–81 to 5,60,000 ha in 1990–91. Further, the rice area has declined from 3,22,368 ha in 2001–02 to 1,97,277 ha in 2012–13 (FIB, 2015)

2.3 Mechanization in rice

James (1989) reported that the steady decline in rice production in Kerala could be accounted to the lack of inadequate power availability in the farms. His contention was that there are no shortcuts to agricultural progress other than mechanization.

According to James *et al.* (1993), timely operations in agriculture are of utmost importance and agricultural machines are inevitable in ensuring timeliness and thereby enhancing yields. Agricultural mechanization also plays a very important role in changing the altitudes and uplifting the social status and dignity of those who labour in agriculture. The traditional Indian agriculture requires that sort of mechanical technology which can provide intensification of agriculture.

James *et al.* (1995) reported that the potential and role of agricultural mechanization technology in employment generation have not attracted much attention from the policy makers. A 'Selective Mechanization Strategy' (SMS) with the intention of increasing productivity and labour use efficiency was recommended by them. The study was limited to the mechanization of paddy cultivation in Kerala and possible levels of mechanization were predicted on the basis of technical and socio economic factors. They concluded that mechanization of paddy cultivation on line with SMS does not displace labour as it was possible to generate additional employment opportunities to the extent of 3.5 million man days in the manufacture, marketing and service of improved implements and machinery. They recommended that any further development of cultivation of paddy can be made possible only through selective mechanism of paddy group farmers.

James *et al.* (1996) studied the effect of selective mechanization on the economics of rice production in three cultural systems. It was revealed that mechanization can reduce the cost of all operations especially the labour intensive operations like transplanting and harvesting. They concluded that the human labour input was accountable for the major share of production cost in all the non-mechanized systems and in mechanized systems, material input cost ranked first. The benefit cost ratio was higher under selective mechanization in all the three cultural systems. It was evident that selective mechanization of paddy group farmers can only sustain the rice cultivation in Kerala.

James *et al.* (1998) conducted a study on emerging rice farm mechanization strategy in Kerala. They pointed out that rice cultivation in Kerala cannot be sustained without the introduction of appropriate farm machines. The requirements of high yielding varieties like, proper land preparation, correct planting depth, optimum plant population, spacing etc cannot be achieved without mechanisation. As the agriculture in Kerala is highly dependent on climate there are some short period of intense crop production activity during which the farmer face an acute shortage of labour. By using modern machineries the time taken for the operation is substantially reduced. The post-harvest loss can be brought down to a considerable extent by timely harvest and efficient handling of harvested crops with appropriate machinery. Selective mechanization is a solution to the problems such as economic backwardness of farmers, high cost of machines, small holding size and rural unemployment.

James and Regina (2015) carried out an investigation on techno-economic appraisal for strategic planning of rice mechanization in Kerala. The economic superiority of high level mechanization over low level mechanization was spectacular in the analysis. The highly vulnerable position of system under low level of mechanization did not permit any development of rice cultivation. Their inference that transplanted rice production system under high level of mechanization was economically attractive depicted a proactive sign for sustaining rice cultivation in Kerala. Thus, it was evident that mechanization is the prime factor for ensuring food security and preserving the wet lands in this ecologically fragile state of Kerala.

2.3.1 Seeding and sowing machines for rice

John (1989) developed a five row bullock drawn dibbler for paddy. The machine consisted of main frame, shaft, ground wheel, seed box, seed tube, metering mechanism, furrow opener, furrow closer and a clutch mechanism. The power from the ground wheel was transmitted to the shaft through a jaw clutch. Cams and agitators formed an integral part of the metering mechanism, which were assembled to the shaft. The agitator dropped the seeds from the seed box to the seed tube, which was closed with a hinged gate. The cam and followers arrangement opened the seed tube and dropped the seeds instantly into the furrow. The furrow closer fitted to the frame deflected loose soil over the furrow to cover the seeds. The power required was 0.22 hp. The labour requirement was 12 man h/ha and field efficiency was76%.

Sam (1992) developed a three row manual paddy dibbler. It consisted of seed box, roller with metering mechanism, seed tube with furrow opener, handles and marker. When dibbler was operated, the roller passing vertically through centre of the box would move upward by the soil pressure against spring tension. As the roller move upward, the portion of the roller having the vertical slot would come in contact with seeds and the seeds were picked into this slot. When the equipment was taken out from the soil, the soil pressure on the roller was released and due to the release in tension, the roller moved downward and the seeds carried in the slot were released and would fall through the seed tube by gravity into the soil. The seeds were covered with soil automatically. The numbers of seeds dropped were in the range of 4-6 seeds per hill.

Gupta *et al*. (1992) developed a direct paddy seeder to match a two wheel tractor. The seeder had a working width of 2 m and 8 rows. For each row, there was a seed hopper, a fluted seed metering roller and a double disc furrow opener. Two lugged driving wheels rotated the metering rollers mounted on a common shaft. Each flute in a metering roller could pick up 3-5 paddy seeds and place them in a furrow through a seed guide to the desired depth of 20-70 mm. The seeder was provided with a foot operated clutch to disengage the metering mechanism. It had a field capacity of about 0.5 ha/h at a forward speed of 0.81 m/sec and field efficiency of 78%. The seed rate was 15 to 20 kg/ha. No damage was observed in pre-germinated seeds for roller type metering mechanism.

Dinesh and Maji (1993) developed and tested a manually operated paddy dibbler. This dibbler was capable of dibbling four hills at a time to a depth of 50 mm and spacing of 200× 200 mm. It consisted of two ground wheels, frame with handles, and seed box of capacity 2.4 kg of seed with a fluted roller mechanism, four seed tubes with a plunger reciprocating in it. When the plunger was at the bottom of seed tube, it closed the seed inlet opening and made a hole in the soil. After the hole was made, the plunger was lifted by the operator. Thus, the seed inlet opening uncovered and seeds were transferred to the holes. They found that average number of seeds per hill was 2.67 and seeding rate was 31.37 kg/ha for hole size of 19.17 mm. There was no scattering of seeds during dibbling. The field efficiency was 91%.

Balasubramanian *et al.* (1996) studied the performance of a bullock drawn upland direct paddy seeder. A simple bullock drawn seed drill was developed with an orifice flow seed metering devices and runner type furrow opener. The performance of orifice flow metering device was tested by varying the orifice diameter, agitator disc diameter, clearance between agitator and top of orifice plate and speed of agitator disc. It was found that the clearance between agitating rotor and metering plate of the seed drill should be 1 mm or less for maximum discharge of seeds. The performance of the bullock drawn paddy seeder was tested in black cotton soil to compare the performance with mechanical broadcaster and manual sowing. The germination of paddy in plot using direct paddy seed drill was 49% and 33% higher than that of manual broadcasting. The agitating disc diameter of 90 mm gave consistent discharge of seeds.

Jinfu *et al*. (1997) developed a new direct paddy seeder. The seeder had a working width of 3 m and 14 rows. The test result showed that damage rate due to metering mechanism was 0.045% ,the field capacity was 0.67-0.8 ha/h ,fuel consumption was 1.2-1.5 kg/ha. As compared with mechanical transplanting, manual broadcasting and manual transplanting, drilling with the seeder raised yield by 12.72-14.48%, reduced production cost by 1.0-15% and saved labour by 16%. James *et al.* (1998) recommended the use of seeder in dry seeded system of rice cultivation in Kerala as it will help to sow the seeds in lines so that mechanical weeding can be done.

Kumar *et al*. *(*2014) reported the design and development of a power tiller operated seed-cum-ferti till-drill machine. In order to minimize the soil moisture loss and turn-around time and energy loss during seed bed preparation and seeding operations, a seeding attachment was designed and developed for riding type of power tiller at Faculty of Agricultural engineering, IGKV, Raipur, India. The main design consideration was to place the seed and fertilizer with tractive type of tines while rotavating the field with rotary tiller. Thus seeding and tilling was accomplished in a single pass with conservation of energy and in-situ soil moisture in addition to saving of time and cost of operation. The developed machine consisted of a seed cum fertilizer box, four fluted feed rollers, four rigid tines mounted on the tool bars with reversible shovels, ground wheel and adjusting devices. Fabrication cost of the machine was worked out about Rs. 6000/- per unit and its total weight was 32 kg.

Dongarwar *et al.* (2015) conducted a study on tractor operated seed drill for sowing of paddy. The field tests were conducted on sandy loam soil. The treatments were random transplanting of Seedlings at 35 to 45 days, with two hand weeding (T1), and direct drilling of paddy seeds in friable soil by a seed drill at the onset of monsoon with pre-emergence application of Pendimethalin at 1.0 kg/ha and one hand weeding (T2). Paddy sowing using seed drill showed better results over farmers practice and recorded higher yield. The field capacity and average yield was found to be 0.67 ha/h and 33.15 q/ha, respectively compared to 0.125 ha/h and 25.73 q/ha observed with conventional method. The treatment with tractor operated seed drill was found to be better compared to conventional method of manual transplanting of paddy seedlings.

Verma *et al.* (2015) evaluated the performance of a cultivator mounted seed metering mechanism. The cultivator-cum-seed drill with shovel type furrow openers was tested for sowing of paddy. The performance parameters of the machine such as field capacity, field efficiency, energy requirement and cost of operation was evaluated in relation with conventional seed drill in the laboratory as well as in the field. The seed rate of cultivator-cum-seed drill was found to be 80.87 kg/ha and that of conventional seed drill was found to be 80.26 kg/ha. When seed drill was half filled and flute exposure was 14.9 mm and 13.8 mm. The standard deviation for inter row variation for sowing paddy with cultivator-cum-seed drill was 0.46 with CoV of 1.8 % and that for conventional seed drill was 0.41 and 1.5 % respectively. The effective field capacity of the cultivator-cum seed drill was 0.537 ha/h with field efficiency of 82.8 % as compared to conventional seed drill which was 0.596 ha/h and 82.32 %. The cost of operation and energy requirement for cultivator-cum-seed drill was marginally higher than that for the conventional seed drill.

Ahmed and Choudhary (2015) developed a low cost seed drill named “seed sowing cart”. The special features of these machine were depth and width control mechanism as well as control of linear distance between seeds. The Linear distance between seeds can be altered according to different seeds by changing the diameter of gear 3, different distances of 2 cm, 3 cm; 4 cm, 5 cm, etc can be achieved by altering the gear simply. The proposed design of machine is economical to fabricate, and have greater design simplicity than its counterpart, with proper seed placement at desired depth, distance between rows with special feature to alter linear distance between seeds, proper spreading of fertilizer and compaction of soil.

2.4 Need for herbicide application

Gianessi (2013) reported the increasing importance of herbicides in worldwide crop production. For successful crop production, weeds have to be controlled. The human drudgery for hand weeding is one of the first tasks readily given up by workers as countries industrialize. He reported that inefficient hand weeding resulted in significant yield losses. Compared to hand weeding, herbicide application is more efficient and economical for sustainable crop production.

Munbeen *et al.* (2014) studied the effects of seeding time and weed control methods in direct seeded rice. The study was conducted during the two year period from 2008 and 2009 to determine the effects of three seedling dates and seven weed control methods in direct seeded rice (DSR). The herbicides, penoxsulam and bispyribac-sodium were safe for use in rice as there was no significant damage to plants. The results suggested that weed density was influenced by seeding time. When rice was seeded late, more weed density was recorded compared to early seeding. Penoxulam or bispyribac-sodium applied alone was effective to reduce weed density compared with the non treated control, but it was more effective when followed by hand hoeing.

CHAPTER III

MATERIALS AND METHODS

The methodology adopted for evaluating the combination implement for seeding and herbicide application and its refinement are discussed in this chapter.

3.1 Evaluation of the existing combination implement

3.1.1 Description of the implement

The combination implement (Fig. 3.1) developed at KVK, Palakkad consisted of a seed box with cup feed type seed metering mechanism driven by a ground wheel and mounted on a rectangular frame on to which the nine tyne furrow opener assembly was attached. The tool bars were adjustable and the seeds were dropped through the flexible hose type seed tubes through the boot behind the shoe type furrow openers. A battery operated sprayer with flat fan nozzles was integrated with the implement which enabled simultaneous herbicide application along with seeding. The ground wheel mounted on the right side of the frame transmitted power to the shaft of the seed metering device by a chain and sprocket drive. A 60 L capacity tank fitted with a positive displacement pump was mounted on the frame to draw the spray liquid and deliver it through three flat fan type nozzles.

Fig. 3.1 Combination implement developed by KVK Palakkad

Apart from the conventional seeder attachment to cultivator in which seeder attachment is mounted on a normal spring loaded cultivator, a light weight furrow opener- frame assembly was used in this implement so as to reduce the weight and cost. The implement was successful in simultaneous seeding and spraying pre-emergent herbicide (pretilachlor) in the fields.

3.1.2 Laboratory Testing

The seeder of the combination implement was tested in the laboratory before taking for field evaluation. For testing, the seed variety selected was (MO- 21) having a red bran colour and long bold grain type with a duration of 100-110days.

3.1.2.1. Germination test

It determines the percentage of seeds that are alive in any seed lot. The level of germination in association with seed vigor provides a very good estimate of the potential field performance. While the speed of germination varies slightly across, seed should absorb moisture within two days and produce a root and the first leaves within four days. At this point, the seed is considered to have germinated.

A germination test is often the only test a farmer can conduct on the seed to determine if it is suitable for planting. When seed is stored in traditional open system, the germination rate of most rice seed begins to deteriorate rapidly after six months. Many varieties have dormancy period immediately after harvest that may last for one or two months. By knowing the germination rate, farmers can adjust their seed rate to attain the desired plant population n the field.

The test was conducted by taking a known quantity of seed in a Petri dish filled with soaked tissue paper (Fig. 3.2). The test period where taken as two weeks. Germination rate is the average number of seeds that germinate over the desired time period

$$\text{Germination (\%)} = \frac{\text{Number of seeds that germinated}}{\text{Number of seeds on the tray}} \times 100$$

Fig. 3.2. Germination test

3.1.2.2 Calibration of seeder

The seeder with cup feed type metering mechanism was calibrated for paddy sowing. The seeder was placed on a level ground and jacked up to facilitate the rotation of ground drive wheel freely. The weight of seeds dropped for 25 revolution of ground drive wheel was noted. The following steps were followed for calibration of seeder (Sahay, 1990).

a) Determine the nominal width (W) of drill, W, m = M x S

Where M is the number of furrow openers and S is the spacing between the openers in meter and W is in m

b) Find the length of a strip (L) having nominal width W necessary to cover 1/25th of a hectare L $= \frac{10000}{W} \times \frac{1}{25} = \frac{400}{\mathrm{W}}$ metres.

c) Determine the number of revolutions (N) the ground wheel has to make to cover the length of strip (L).

$$\Pi \text{ x D x N} = \frac{10000}{W} \times \frac{1}{25}$$

$$= \frac{400}{\pi \times D\, W} \text{ rev/min}$$

d) Jack up the seeder so that the ground wheel turns freely. Make a mark on the drive wheel and a corresponding mark at a convenient place on the body of the seeder to help in counting the revolutions of the drive wheel.

e) Fill the selected seed in the seed box to the proper level. Place a sack or a container under each boot for seeds.

f) Rotate the drive wheel at the speed N
N = 400/(πDXW) rev/min

g) Weigh the quantity of seed dropped from each boot and record on the data sheet

h) Calculate the seed dropped in kg/ha and record on the data sheet.

i) Repeat the process for accuracy.

3.1.2.3. Forces acting upon a furrow opener

While pulling the implement, three types of forces act on the implement (Kepner *et al*, 1987*)*:

i. Force of gravity
ii. Soil reaction on the implement
iii. Pull of power unit

These must be in equilibrium for satisfactory operation of the implement. F is the force exerted by the power unit which can have components in all the major planes and associated with it is a couple. The force F can be resolved into three components L, V and S in the three planes. The component L represents the draft of the implement which is used for pulling the load. Horizontal component of the pull parallel to the direction of motion is called draft.

In order to know soil force acting on the single furrow opener draft measurement was done using a simple mechanism shown in Fig 3.3. A single tyne from the existing combination implement was taken for this test. The equipment consisted of two wheels connected by an axle with a cylindrical pipe fixed at the middle. The tyne could be clamped to the cylinder and pulled through a wire rope and spring balance.

Fig. 3.3 Draft measuring device without tyne

Fig. 3.4 Draft measuring device

3.1.2.4. Assessment of spray uniformity and nozzle selection

The selection of nozzle type and size is essential for proper herbicide application. Nozzle is a major factor in determining the amount of spray applied to an area, uniformity of the application, the coverage obtained on the target surface and the amount of potential drift. Nozzles determine the amount of spray volume at a given operating pressure, travel speed, and spacing. Drift can be minimized by selecting nozzles that produce the largest droplet size while providing adequate coverage at the intended application rate and pressure. Minimizing drift is especially important for herbicide application.

3.1.2.4.1. Nozzle description

Nozzle type commonly used in low pressure agricultural sprayer includes flat fan, flood, raindrop, hollow-cone, full-cone, and others. Special features, or subtypes such as “extended range”, are available for some nozzle types. Flat fan nozzles are widely used for spraying of herbicides. This nozzle produces a tapered edge, flat fan spray pattern. Flat fan nozzles have several subtypes, such as standard flat fan, even flat fan, low pressure flat fan, extended-range flat fan, and some special types such as off-center flat fan and twin-orifice flat fan. It serves the purpose of spraying on to a surface or an object moving in a transverse direction of the jet.

3.1.2.4.2. Spray patternator

Assessment of spray uniformity and nozzle selection was carried out by using patternator shown in Fig. 3.4. A patternator is used for measuring the lateral distribution of liquid from the nozzles and also to quantify the amount of spray emitted from a sprayer and visualize its pattern. For measuring lateral distribution of liquid from a single nozzle, the nozzle with a spray angle of 105 degree was kept at a height of 60 cm above the patternator table. The liquid from the individual channels on the patternator table was collected in test tubes for 25 seconds and was measured. Considerable variation in pattern occurred between successive runs with individual nozzles. The coefficient of variation from different nozzles was obtained. The arrangement of nozzles in the combination implement is shown in Fig. 3.5.

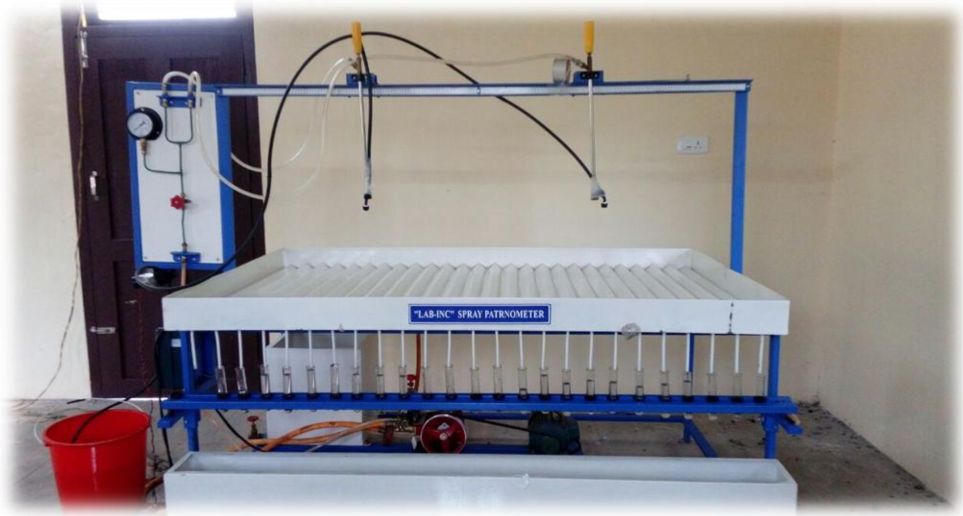

Fig. 3.5 Patternator

Fig. 3.6 Nozzle arrangement in the implement

3.1.3. Field studies

The field studies were conducted for assessing the field performance of the combination implement. Observations are required for the determination of effective field capacity, field efficiency, seeding uniformity, population per m^2 and weed population and its dry weight, and biometric features of the crop were taken.

Investigation on field capacity and field efficiency of the seeder involved continuous observation and timing of each activity and time losses for turning at head lands, removal of clogs and adjustments. Three plots approximately 0.12 ha area were selected. Two plots were seeded with the combination implement and one plot was manually broadcasted. After 24 days of sowing, plant population per square meter was observed in the plots. Weed population per square meter from each plot were noted to compare the effectiveness of herbicide application attachment. It was important to collect data on various growth and yield parameters which facilitated to interpret the results. Growth parameters such as plant height, tiller production, and dry matter productions were recorded. The growth and yield parameters were recorded at different growth stages and also at the time of harvest.

The test conditions during the assessment of seeder are shown in Table 3.1.

Table 3.1 Test condition during assessment of seeder

Sl. No.	Particulars	2016-2017
1	Farming situation	Rain fed
2	Location	KCAET Farm
3	Type of soil	Sandy clay
4	Field preparation	Ploughing with rotavator for making soil friable before direct dry seeding

3.1.3.1. Machine parameters

The machine parameters evaluated included theoretical field capacity, effective field capacity, field efficiency, seeding uniformity, population per m^2 and weed population, weed dry weight and biometric features of the crop.

3.1.3.1.1. Theoretical field capacity (TFC)

Theoretical field capacity is the rate of field coverage of the implement, based on 100% of time at the rated speed and covering 100% of its rated width.

$$TFC = (\text{width (m)} \times \text{speed (m/hr)})/1000$$

3.1.3.1.2. Effective field capacity (EFC)

It is the actual area covered by the implement, based on its total time consumed and its width.

$$EFC = \text{Total area / Total time}$$

3.1.3.1.3 Field efficiency

It is the ratio of effective field capacity and theoretical field capacity expressed in percentage.

$$\text{Field efficiency} = (EFC / TFC) \times 100$$

3.1.3.2. Weed population and its dry weight

The efficiency of sprayer herbicide applicator was evaluated through observing the weed population. For this, weed samples were randomly collected from plots of one square meter area. The numbers of weeds were noted and their dry weights were found by oven drying method.

3.1.3.3. Crop parameters

. Weed populations and first set of biometric observations (plant height and population in square metre) were collected after 24 days of sowing. Data on tiller production (both productive and unproductive) were collected after 64 days of sowing. Harvesting was done after 115 days of sowing. Before 2 days of harvesting second biometric observations were taken. In order to compare the yield from two plots, grain weight (db) and straw weight (db) were recorded from crop cuts (one m^2 area) taken randomly. Observations were recorded from the machine operated plots as well as from broadcasted fields.

3.2 Refinement of existing combination implement

When the existing combination implement was field tested some aspects for further refining the implement were noticed.

They were as given below:

i. There was no provision to adjust the seed rate with the cup feed type of mechanism used with the existing implement,. The germination of seeds available to the farmers often varied. Different variety of seeds had differences in weight of single seed, resulting in difference in number of seeds filled in a single cup. A variation of seed rate was also possible between seed tubes. So it was decided to replace the cup feed mechanism was by fluted roller type mechanism.

ii. Another problem was the possible damage of tynes when obstacles are encountered. A tipping mechanism was designed to overcome this problem.

iii. The present machine could be operated only with a single row to row spacing of 20 cm. providing an additional row to row spacing of 25 cm will be highly useful for farmers.

iv. There was no chain cover for the chain and sprocket drive. It was decided to have a chain cover for increased operator safety as well as durability of the chain.

v. It was also decided to redesign the furrow opener with modified wings so as to exclude chances of soil clogging in the boot.

Hence the implement was redesigned to incorporate the above refinements.

3.2.1. Design of seeder

(A) Size of seeder

From a 35 hp tractor, total power available at drawbar of tractor is 75% of bhp

Or DBHP = 35×75/100

Also,

DBHP = Draft (kg) × speed (m/min) / 4500

Draft = ((35×75)/100)×4500/4× 1000)× 60

= 1770 kg

The draft requirement per meter width of seed drill = 150kg. (Source: CFMT and TI, Budni)

Therefore, width of seed drill = 1770/150 kg/m

= 11.8 m

But, designing a 11.8 meter. wide seed drill have buckling effect and will create problem in transportation and handling. Therefore, it was decided to design a seed drill with 9 furrow openers having replaceable 20cm spacing between the furrow openers, the seed drill was intended to be used for sowing paddy.

Therefore working width of seed drill $= 20 \times 9$

$= 180$ cm

(B) Design of seed box

The seed box may be MS sheet. The length of sheet is given by

Lb = Working width of seed drill-2b

Where, Lb = length of box, cm

b = distance between the side box wall and ground wheel. (Let b =10 cm)

Therefore length of box = 200-(2×10) = 180cm

Seed drill may be designed for the seed application rate ranging 10-210kg/ha.

Actual field capacity of drill

$$= \frac{\text{speed (km/hr)} \times \text{working width of drill(m)} \times \text{field efficiency}}{10}$$

Let speed = 4km/hr and field efficiency be 70%

Actual field capacity of drill (Area covered/hr) = $\frac{4 \times 2 \times 0.7}{10} = 0.56$ha/hr

The size of the seed box was fixed so that the capacity will ensure uninterrupted operation for two hours or it require refilling of seed after two hours.

Therefore,

Weight of seed to be used in two hours = seed rate (kg/ha) × area covered/hr×times(hrs)

$= 210 \times 0.56 \times 1$

$= 117.6kg$

$\sim 100kg$

$$\text{Volume of seed box} = \frac{\text{Weight of seed in (kg)}}{\text{Bulk density (kg/m}^3\text{)}}$$

$$= \frac{100}{642}$$

$= 0.156\ m^3$

(Assume bulk density of paddy as 642 kg/m³)

Consider spillage losses of 10% therefore total volume of seed box is

Volume of seed box (V_{S}) $= 0.156 + 0.0156$

$= 0.1716\ m^3$

Let the seed box may be of trapezoidal section

The volume of seed hopper is given by

$$V_s = \frac{(a+b)}{2} \times h \times l_b$$

Where, V_s = volume of seed hopper having trapezoidal section (V_S), m³

a = bottom width of seed hopper, m (let it be 17 cm)

b = top width of seed hopper, m

l_b = length of seed hopper, m

Also $b = a+2l$

h = height of seed hopper

Putting the values of b in equation

$$V_s = \frac{(a+a+2l)}{2} \times h \times l_b$$

$$V_s = \frac{(2a+2h\cot\theta)}{2} \times h \times l_b \qquad h/l = \tan\theta$$

θ = angle of repose of seed

$$V_S = (a + h\cot\theta) \times h \times l_b$$

The angle of repose for paddy range from 23° to 28°. The design of seed box should be such that 'θ' is more than 28° for easy flowing of seeds. Therefore, θ = 81°

Putting the value in equation $V_S = (a + h\cot\theta) \times h \times l_b$

$$0.1716 = 0.25h + 0.158h^2$$

$$h = 30 \text{ cm}$$

$$l = h\cot\theta$$

$$b = a + 2l$$

$$= 17 + 8$$

$$= 25 \text{ cm}$$

The thickness of seed box is given by

$$t_s = \sqrt[3]{\frac{3\times\rho\times a\times a\times h\times h}{4\times a\times b}}$$

Where, t_s = thickness of seed box, cm

ρ = bulk density, kg/cm^3

a = bottom width of seed box, cm

h = height of seed box, cm

b = bending stress, kg/cm^2 (let $b_s = 1000\ kg/cm^2$)

Putting the values in equation we get

$$= \sqrt[3]{\frac{3\times0.00642\times17\times17\times30\times30}{4\times17\times1000}}$$

= 4 mm

= 2 mm (say)

Thus,

The specifications of seed box are:

Length of seed box	= 180 cm
Bottom width of seed box	= 17 cm
Top width of seed box	= 27 cm
Height of seed box	= 30 cm
Angle of repose	= 81°
Thickness of seed box	= 2 mm
Material	= MS sheet

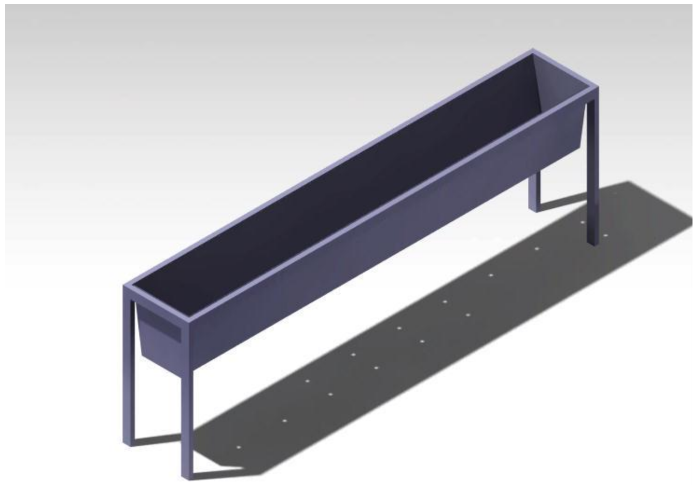

Fig 3.7.3D CAD image of seed hopper

(C) Design of fluted roller

The seed metering mechanism is the most vital component of the seed drill. The performance of a seed drill is mainly dependent on the type of metering device. In addition to this, the type of soil and field condition, preparation of seed bed, speed of operation and power source also affect the performance of the seed drill (Kepner et al., 2000). The fluted wheel (also known as the fluted roller) is driven by a square shaft. Fluted rollers are provided with longitudinal grooves along the outer periphery and can be shifted on the shaft sideways. The fluted rollers, which are mounted at the bottom of the seed box, receive the seeds into longitudinal grooves and pass on to the seed tube through the seed hole. By shifting the rollers sideways, the length of the grooves exposed to the seed, can be increased or decreased and hence the amount of seed sown is changed. The number of rollers on a drill is the same as the number of furrow openers. Fluted roller is a simple, low cost, trouble free device suitable for bulk metering.

Design procedure is as follows:

Volume of seed dropped per rotation of feed roller, m^3 (v_{roller})

(Vroller) $= \pi DgRwSr \times 10^{-5} / \rho \times g_r$

Where, D_g = diameter of ground wheel, m.

R_w = inter row width, cm.

S_r = seed rate, kg/ha.

ρ = bulk density, kg/m^3.

$$g_r = \text{gear ratio} = \frac{\text{N o of teeth in metering shaft}}{\text{No of teeth in ground wheel shaft}}$$

Let g_r = 37/14 = 2.64

D_g = 40 cm

R_w = 20 cm

$$V_{roller} = \frac{\pi \times 0.4 \times 20 \times 210 \times 10^{-5}}{624 \times 2.64}$$

$= 32\ cm^3$

Now, number of flutes on the metering roller's periphery can be decided from the formula given below:

$$N_f = \frac{\pi \times Dg}{x \times gr}$$

Where, N_f = number of flutes or slots / roller

D_g = diameter of ground wheel, cm

X = linear spacing of seeds on the ground, cm

g_r = gear ratio = 2.64

Let x = 5 cm

$$N_f = \frac{\pi \times 40}{5 \times 2.64}$$

$$= 9.5 \sim 10$$

Working volume released by fluted roller in one rotation (V_{roller}) is given by

$$V_{roller} = V_{slot} + V_{active}$$

Where V_{slot} = Volume of seeds falling in slots, cm³

V_{active} = Volume of seeds thrown out from the active layer, cm³

$$V_{roller} = V_{slot} + V_{active}$$

$= L_f \times N_f (A_f + A_a)$ L_f = Length of flute

$32 = L_f \times N_f \times 1.7A_f$ N_f = Number of flutes per roller

$$32 = 4.5 \times 10 \times 1.7A_f$$

$$A_f = 0.42\ m^2$$

Let the diameter of fluted roller = 60 mm

N_f = 10

Circumference of fluted roller = πD

= 188.49 mm

Let the ratio of slot to slot wall = 2:1 (8:4)

$\emptyset$ = 360/10

= 36°

$\emptyset_0 = \emptyset_1 + \Delta\emptyset$

$36 = 2\Delta\emptyset + \Delta\emptyset$

$\Delta\emptyset$ = 36/3 = 12°

$\emptyset_1 = 2 \times 12 = 24°$

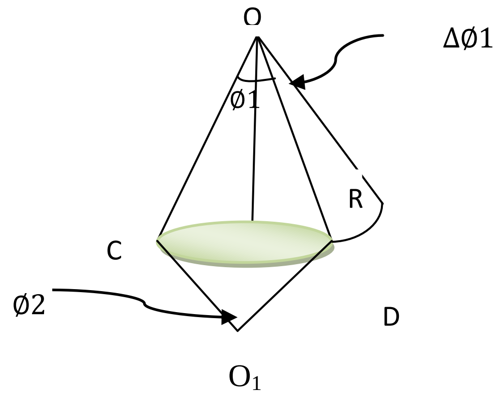

Fig. 3.8 Illustration of fluted roller

From right triangle OCA

$$\sin\left(\frac{\emptyset 1}{2}\right) = \frac{AC}{OA}$$

$$0.21 = \frac{\left(\frac{b}{2}\right)}{30}$$

B = 12 mm

Δb = 6 mm

Now cross-sectional area of flute (A_f) = $f_1 + f_2$

$$A_f = \frac{R^2}{2}\left(\frac{\pi}{180}\phi_1 - \sin\phi_1\right) + \frac{r^2}{2}\left(\frac{\pi}{180}\phi_2 - \sin\phi_2\right)$$

$$42 = \frac{30^2}{2}\left[\frac{\pi}{180} \times 24 - \sin 24\right] + \frac{r^2}{2}\left[\frac{\pi}{180} \times 90 - \sin 24\right]$$

$$42 = 5.46 + r^2 \times 0.28$$

$$r = 11.42 \text{ mm}$$

Thus the radius of curvature of slot

= 8.9 mm

Fig. 3.9 3D CAD image of fluted roller

3.2.2 Provision for changing number and spacing between rows.

The main frame of the implement was fabricated by using M.S. square pipe. The size of the frame was 1.8.× 0.5 m. In order to change the number of rows and spacing between them, cross bars were bolted to the frame. Here it was arranged in such a manner that the spacing could be adjusted either as 20 cm or 25 cm.

3.2.3 Standards for furrow openers.

3.2.3.1 Design of standards for furrow opener

The resistance force acting on one furrow opener = 90 N

Maximum bending moment on standard = 90×0.3

= 27 Nm

The standard was assumed to be made of galvanized iron with dimension 3.75 ×3.75 cm with a thickness of 3mm

Moment of inertia I $= \frac{a^4 - b^4}{12}$

Where a = 3.75 cm, b = 3.15 cm

$$= \frac{(0.0375^4 - 0.0315^4)}{12}$$

$= 8.27\times 10^{-8}\ m^4$

Distance from the neutral axis to extreme fiber, Y = a/2

= 0.01875 m

Using flexural equation, $\frac{M}{I} = \frac{f}{y}$

Bending stress f $= \frac{M}{I}\ y$

$$= \frac{27\times 0.01875}{8.27\times 10^{-8}}$$

$= 6.12\times 10^6\ N/m^2$

This was less than the maximum allowable bending stress for galvanized iron, 590 MPa, so the design was safe.

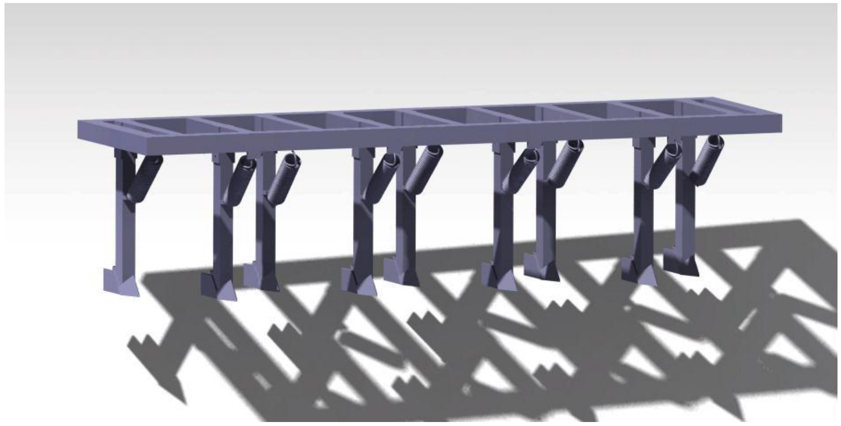

Fig.3.10 3D CAD image showing tipping mechanism

3.2.3.2 Calculation of spring tension

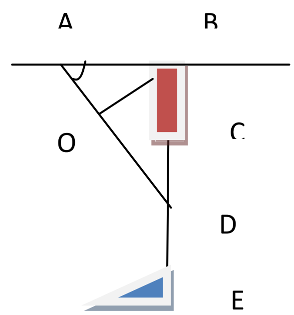

Fig. 3.11 Illustration of tyne

BE = 45 cm

AB = 15 cm

Assume BC = 10 cm, BD = 20 cm, CD = 10 cm, AD = 25 cm

F = 9 kg

From Δ ABD,

$$\sin\theta = 20/25$$

$$\theta = \sin^{-1}(20/25)$$

$$\theta = 53°$$

From ΔABO

$\sin\theta$ = OB/15

OB = sin 53 ×15

= 12 cm

Taking moment about C

$$40\times 9 = 12\times F$$

$$F = \frac{40\times 9}{12}$$

$= 30$ kg

$= 300$ N which is the available spring tension

Load acting on the spring P = 300 N

Maximum shear stress s_s = 120 N/mm^2 (design data book-1982)

Modulus of rigidity G = 0.78×10^5 N/mm^2

Spring index C = 5

Spring rate K = 1.31

$$S_s = \frac{8KPC}{\pi d^2}$$

$$d^2 = \frac{8\times 1.31\times 300\times 5}{\pi\times 0.78\times 10^5}$$

d = 6.4 mm = 0.64 cm

C = D/d

D = C d

$= 5\times 0.64$

$= 3.2$ cm

Deflection of spring δ = 12 mm

Number of turns $n = \frac{\delta G d^4}{8ePD^3}$

$= \frac{12\times 0.78\times 10^5\ 6.4^4}{8\times 300\times 32^3}$

= 20

Type of end = plain end

Length of spring = nd+n-1

= (20×6.4) + (20-1)

= 147 mm

Fig 3.12 3D CAD image of spring

3.2.4 Modification of furrow opener

Furrow openers are provided on the seeder to facilitate the placement of seed at a desired uniform depth. Furrow openers have to play a very significant role in placing the seed at the moist zone of the soil but not too deep to cause difficulty in seed emergence. Hence, the selection of the furrow openers must be done carefully. Two main types of furrow openers are rotating type and fixed type. Here one among the fixed type openers was selected (shoe type).

Shoe type furrow openers work well in trashy soil where the seed beds are not smoothly prepared. They are made from two curved runners with their cutting edges on the ground and meeting at the front. At the rear, they are connected to a common boot through which the seeds drop in the furrow. The width of the furrow opener = 7 cm, length = 8 cm height = 8 cm, cone angle=40°

By providing wings on both sides of the furrow openers, we can reduce clogging in the seed tube since they help to disperse the soil on both sides. Due to this action, falling of large lumps on seeds can also be minimized.

The wing size selected was:

length = 13 cm and width = 6 cm

3.3 Testing of the refined implement

The designed combination implement was fabricated and subjected to testing.

3.3.1 Lab study

3.3.1.1 Calibration of refined model

The refined machine was calibrated at varying seed rate adjustments. observed the readings.

3.3.2 Field study

After refinement, the combination implement was subjected to a preliminary run for testing.

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Evaluation of the existing combination implement

The results of various laboratory as well as field tests conducted to evaluate the combination implement are discussed in the following sections.

4.1.2 Laboratory tests.

Laboratory tests were carried out for obtaining the germination capacity of the seed variety, seed rate, spray uniformity and draft on the tine as explained in section 3.1. The results of these tests are discussed below.

4.1.2.1 Germination test.

Out of the 100 seeds taken for germination test only 72 germinated.

Therefore percentage of germination $= \frac{72}{100} \times 100 = 72\%$

4.1.2.2 Calibration of seeder

Calibration was done as outlined in the procedure in section 3.1.2.2. The weight of the seeds collected from each seed tube gave a picture of the seed rate as well as the uniformity between seed tubes (Table 4.1).

Table 4.1 weight of seed collected from each tube

Seed tube number	Weight of grain collected(g)
1	73.5
2	80
3	79
4	89
5	61.5
6	85
7	85.5
8	48.5
9	80.5
Mean	75.83

Total number of furrow openers = 9

Radius of ground wheel = 36 cm

Spacing between two rows = 20 cm

Effective width of seeder = 2 m

Circumference of wheel = $\pi \times D$

$= \pi \times 72$

$= 2.26$ m

Area covered per revolution $= 2 \times 2.26$

$= 4.52\ m^2$

Number of revolution for one hectare $= 10000\ m^2/4.52\ m^2$

$= 2212$

Mean weight of seeds dropped from one tube in 25 revolutions

$= 81.78$ g

Total weight of seeds dropped from the metering device

$= 9 \times 81.78$

$= 736.02$ g

Total seeds dropped per hectare $= \frac{736.02}{25} \times 2212$

$= 65123$ g

$= 65.12$ kg

Weight of seeds dropped in one revolution $= \frac{81.78}{25}$

$= 3.27$ g

Weight of 100 seeds $=2$ g

Number of seeds dropped per m $= \frac{3.27}{2.26 \times 0.02}$

$= 72$

(Weight of one grain = 0.02 g)

Number of seed dropped per m^2 $= 72 \times 4.5$

$= 324$

Considering percentage of germination,

Number of seed dropped per m^2 $= 324 \times \frac{72}{100}$

$=234$

Weight of seeds collected for 25 revolution of ground wheel in each tube showed much variation. This was due to the design imperfections in the cup. Replacing cup feed metering mechanism by a fluted roller metering mechanism better uniformity in seeding can be maintained. The seed rate obtained from the calibration was 65.12 kg/ha with a germination of 72%. It was necessary to change the seed rate since germination can vary to a great extend for seeds available with the farmers. Hence there was a needed for changing the seed rate depending upon the germination percentage of the seed sample.

4.1.2.3 Draft measurement

The following data were obtained in the test conducted for draft measurement,

Width of tyne	= 8 cm
Depth of tyne	= 9.5 cm
Projected area	= 76 cm
Measured draft	= 4 kg

By providing a factor of safety of 2 design draft was taken as 9 kg.

Soil resistance $= \frac{9}{76}$

$= 0.1$ kg/cm^2

4.1.2.4 Assessment of spray uniformity and nozzle selection using spray patternator.

The experiment was done by the procedure given in 3.1.2.4 and the volumes of spray liquid collected in different tubes are shown in Table 4.2.

Table 4.2 Volume of liquid collected from each tube of Patternator

Volume of liquid collected in each tube(cm^{3})			
Left side		Right side	
L1	63.6	R1	57.82
L2	51.45	R2	36.75
L3	30.38	R3	22.78
L4	20.58	R4	20.58
L5	15.19	R5	23.03
L6	13.72	R6	20.33
L7	13.72	R7	15.19
L8	19.11	R8	22.54
L9	26.95	R9	18.62
L10	6.86	R10	0
L11	0	R11	0
L12	0	R12	0
L13	0		

The spray uniformity could be assessed by plotting the spray volume at different points individually as well as by providing different levels of overlap. The co efficient of variation of spray liquid at different points at each overlap position were estimated. The plots (Fig 4.1 to 4.3) depict variation in spray volume at different degrees of nozzle overlap.

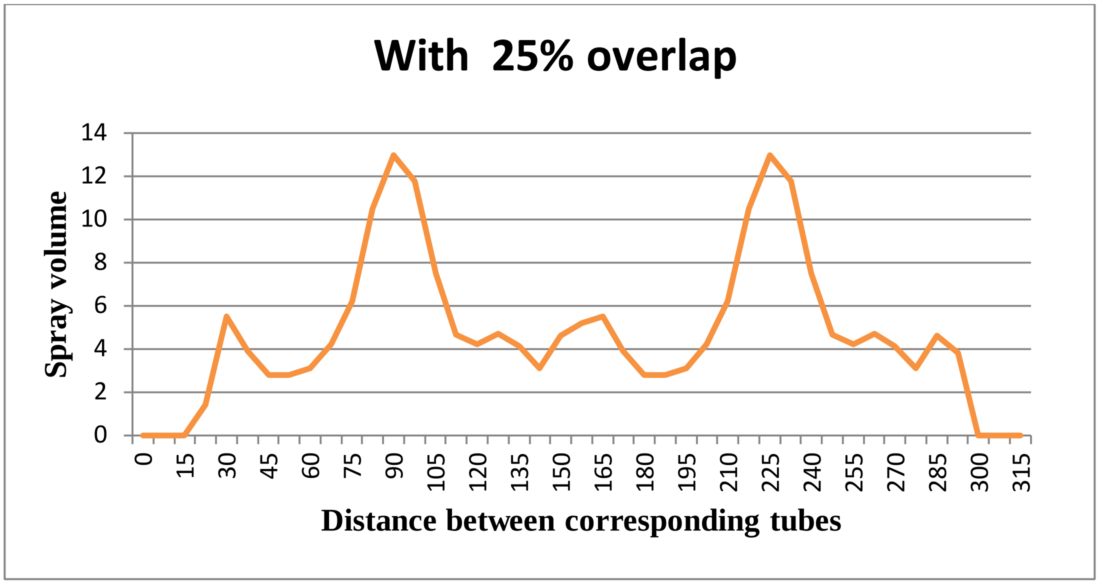

Fig 4.1 Spray volumes at different points at 25% overlap.

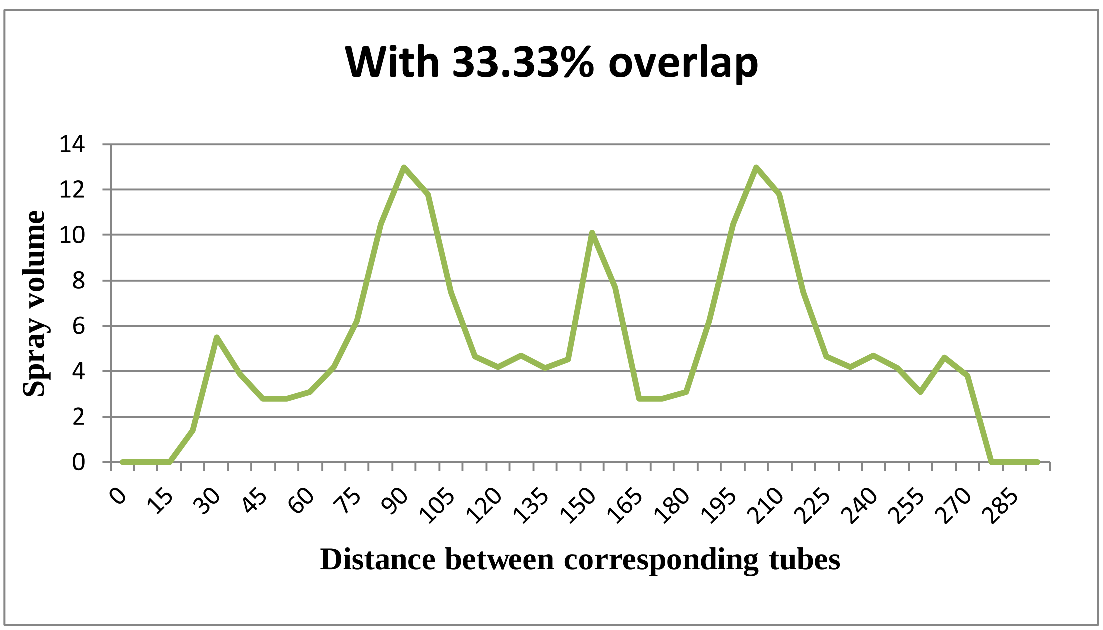

Fig 4.2 Spray volumes at different points at 33.33% overlap.

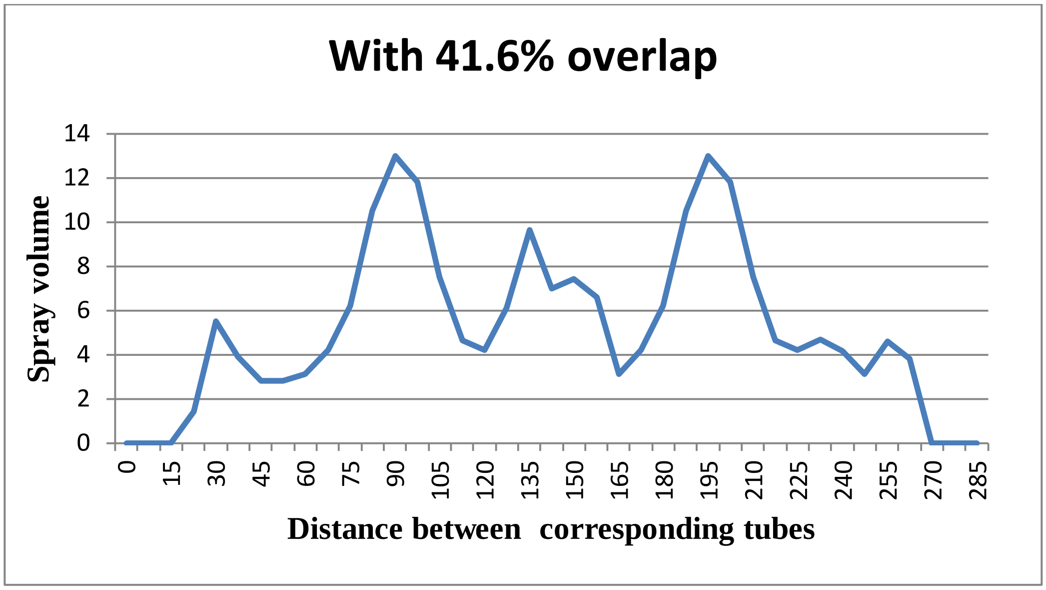

Fig 4.3 Spray volumes at different points at 41.6% overlap.

On comparing the values of COV and spray uniformity at three different nozzle spacing, better uniformity was obtained at a spacing of 105 cm. It is shown in figure 4.4.

Table 4.3 Comparison of spray volume with overlap percentage and its corresponding CoV.

Sl.No.	Overlap percentage (%)	CoV (%)
1	25	54.55
2	33.3	53.89
3	41.6	51

Table 4.3 shows the co-efficient of variation at different overlap position. It was observed that more CoV occurred when percentage of overlap is 25% and CoV is

lesser for 41.6% overlap. It was evident that spray uniformity was satisfactory at an overlap of 75 cm between the spray cones of adjacent nozzles placed at a distance of 105 cm as shown in figure 4.4.

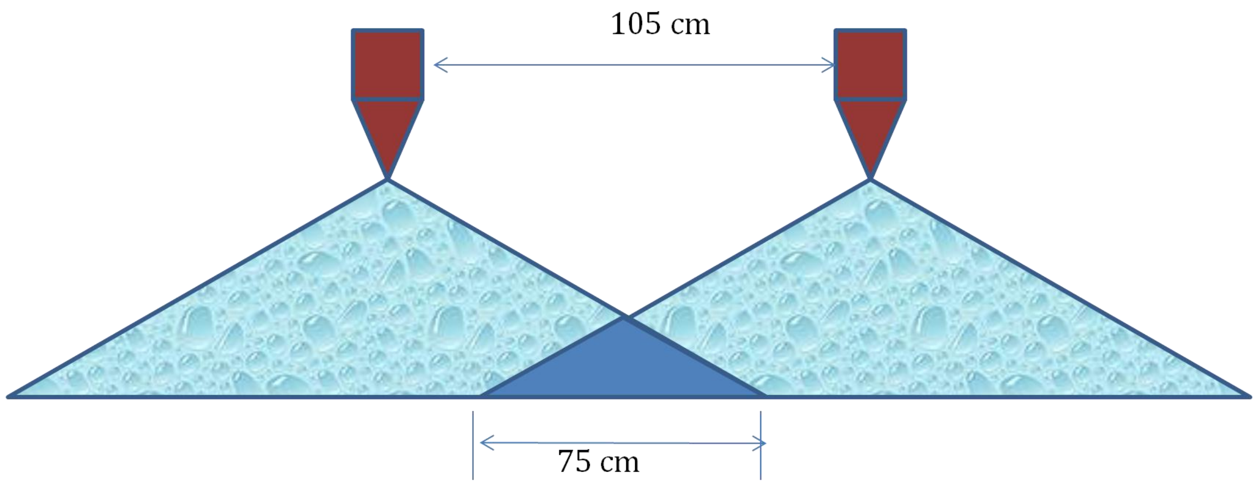

Figure 4.4 Nozzle arrangement for better uniformity

4.1.3.1 Machine parameters

Table 4.4 Field performance parameters of combination implement for dry seeding and herbicide application

Particulars	Width of operation (m)	Speed (m/h)	Area (ha)	Time (h)	Field capacity (ha/h)
Theoretical	2	2280	0.0597	0.15	0.456
Actual	2	2280	0.0597	0.18	0.3316
Field efficiency (%)					72.7

4.1.3.2 Weed population and its dry weight

Comparison of weed population and dry weight per unit area of experimental plots is given in Table 4.5.

Table 4.5 Weed population and weed dry matter per unit area of experimental plots

Sl. No.	Weed population, no's/m^2		Weed dry matter, g/m^2	
	Plot 1	Plot 2	Plot 1	Plot 2
1	3	13	0.04	8.5
2	4	17	0.32	12.5
3	9	14	0.08	5.5
4	0	15	0	4.5
5	6	25	0.41	22.5
Mean	4.4	16.8	0.17	10.7

It was seen that weed population in plot 2 was nearly 4 times that in plot 1. The weed dry matter in plot 2 was about 70% as that in plot 1. The weed population as well as weed dry matter was found higher in plot 2. It indicated the effectiveness of pre-emergent herbicide in the plot operated with combination implement.

4.1.3.3 Crop parameters

By comparing the values of plant density, it was observed that plant population was more in broadcasted field (Plot 2) compared to that of the plot operated with the combination implement (Plot 1) by about 70% (Table 4.5). The seed rate was probably much higher than the recommended rate in plot 2. Hence there was an unhealthy population increase.

Table 4.6 Plant population in experimental plots.

Plant population, numbers/m^2		
Sl. No.	Plot 1	Plot 2
1	70	120
2	98	119
3	80	133
4	70	136
5	77	161
Mean	79	134

The plant heights at different growth stages are shown in table 4.7. It was observed that plant height was more in Plot 2 in the two growing stages. Imenand plant population in plot 2 has resulted in increased height. But this is not an indication of good growth, because this is likely to reduce grain yield and increase straw yield.

Table 4.7 Plant height at two stages of growth

Sl. No.	Height of plant after 24 days of sowing (cm)		Height of plant before 2 days of harvest (cm)	
	Plot 1	Plot 2	Plot 1	Plot 2
1	35.5	30	130	119
2	30	32	120	105
3	29	29	125	105
4	32	38	115	115
5	29	36	110	113
6	32	30	120	117
7	31	33.5	110	110
8	34	30.5	120	125
9	30	38	115	119
10	33	33	120	120
11	29	36	100	104
12	31	42	120	112
13	35	38	130	101
14	32	33	115	105
15	28	35	118	118
16	29	27	119	111
17	32	35	121	113
18	34	35.5	115	119
19	34	35	130	100
20	30	31	115	121
Mean	31.47	33.87	118.4	112.6

4.7 gives the details of tiller production in two experimental plots.

Table 4.8 Number of tillers in the experimental plots

Sl. No.	No of tillers	
	Plot 1	Plot 2
1	13	9
2	11	10
3	10	10
4	11	7
5	12	9
6	7	11
7	9	8
8	10	13
9	13	8
10	14	7
Mean	11	9.2

From the table it is clear that tiller production is much higher in plot 1.The yield data and the dry matter production given below further confirm the superiority of the plot in which the combination implement was operated.

Table 4.9 Yield and dry matter production in the experimental plots

Sl. No.	Yield (g)		Dry weight of straw(g)	
	Plot 1	Plot 2	Plot 1	Plot 2
1	565.7	540.5	378.4	446.5
2	587.8	482.6	472.9	443.9
3	630.5	567.5	259	446.1
4	585.6	581	426	342
5	632.5	566	451.9	361.6
6	604.5	512.8	424	417.5
7	682.5	589.9	280	134.2
8	815	670.2	318	569
9	593.7	607	496	432.2
10	624.9	582.8	377.8	691.1
Average	632.7	570.03	388.32	422.2

Result showed that tiller production and yield are more in combination implement operated field. Grain to straw ratio for plot1was 6: 4 and that of plot 2 was 5.7: 4.2. Grain biomass was more than that of straw biomass in plot 1. Since plot 1 was operated with weeder, soil got proper aeration which enhanced better root growth and absorption leading to better growth and yield. In plot 2 proper spacing could not be achieved resulting in more plant population. Hence straw biomass was more with reduced grain yield.

4.2 Refinement of existing combination implement

The specifications of the refined combination implement obtained by the design procedure outlined in section 3.2.1 are summarized below:

Table 4.10 Specifications of refined combination implement

Sl. No.	**Component**	**Parameter**	**Dimension**
1	Seed drill	Working width of drill	2 m
		Number of furrow openers	9
		Spacing between furrow openers	20 cm
		Draft requirement	9 kg
		Field capacity	0.3316 ha/hr
2	Seed box	Top width of seed box	27 cm
		Height of seed box	30 cm
		Angle of repose available	81°
		Thickness of seed box	2 mm
		Material	M.S. Sheet
3	Seed metering	Type of seed metering	Fluted
		Number of slots/roller	roller
		Length of roller	10
		Diameter of roller	4.5 cm
		Radius of curvature	60 mm
			8.9 mm

4	Spring	Tension	300 N
		Diameter of coil	320 mm
		Diameter of wire	64 mm
		Length of spring	147 mm
		Deflection	12 mm

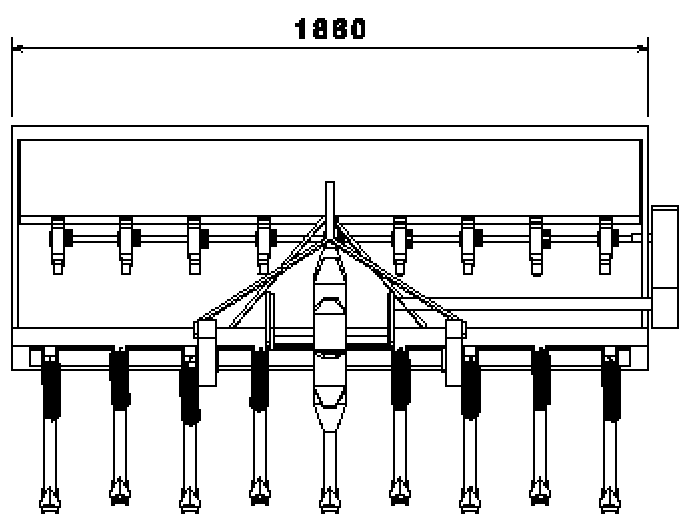

fig:4.5 front view of the combination implement

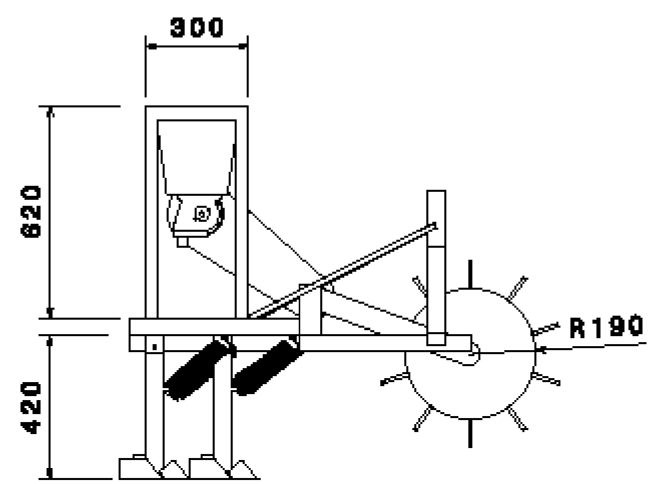

fig:4.6 side view of the combination implement

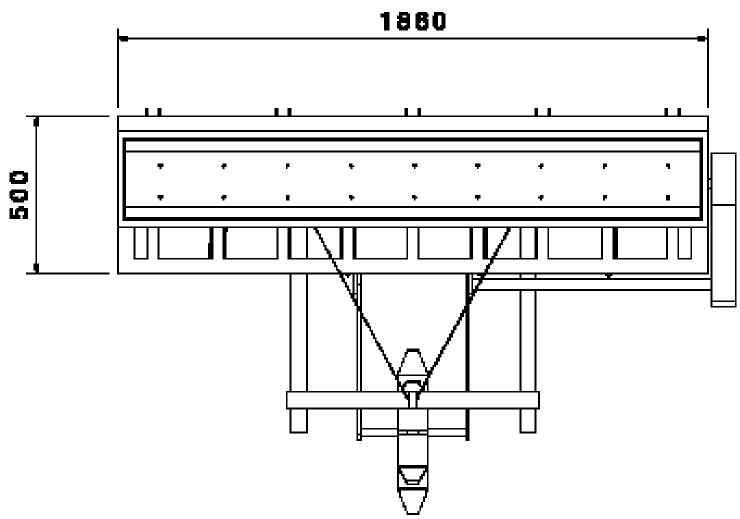

fig:4.7 top view of the combinaton implement

Fig 4.8 Refined combination implement

Fig 4.9 Preliminary testing of refined implement

Fig 4.10 Germination of seedlings in field operated with refined combination implement

During preliminary run, working of each part was observed carefully. Both seeding and herbicide application was done simultaneously. It was found that metering mechanism worked properly. The spring tension was sufficient to sustain load on the tine. Wings on either side of furrow opener helped to prevent clogging in boot. Ground wheel was not showing any slippage which indicated proper alignment. Chain cover was very useful in the safety aspects of the operator.

CHAPTER V

SUMMARY AND CONCLUSION

Agriculture has been the backbone of the Indian economy and it will continue to remain so for a long time. Paddy is a widely cultivated field crop in Kerala .According to FIB (2013) the rice production in Kerala was 5,64,325 MT and the area under rice was 1,99,611 ha in 2013-14. Paddy cultivation is usually done in Kerala by direct wet seeding, direct dry seeding or transplanting. Dry seeding is the common practice in *kharif* (*virippu*) rice. But it is more prone to weed competition compared to other practices. The application of pre-emergent herbicides can overcome this problem to a certain extent and application of pretilachlor on the day of seeding or within 6 days is recommended by KAU (PoP, 2011). Mechanical weeding is possible only in line sown crop. There are also problems in the use of conventional seeder attachment to cultivator. The depth of seed placement is sometimes uncontrolled which affects germination. Clogging of boot often affects the uniformity of seeding. In order to overcome the above problems and to reduce the cost, a combination implement for dry seeding and herbicide application in rice was developed at KVK Palakkad. The main advantage of this seeder was that it could perform seeding and herbicide (pre-emergent) application simultaneously.

Hence a study was undertaken with the objectives of evaluating the existing combination implement, suggest refinements to improve the performance and also to develop a new model by incorporating the modifications. Evaluation of combination implement was conducted by both lab and field studies. Lab studies involved germination test to ascertain the germination of the seed sample, calibration of seeder to analyze the seed rate and uniformity, draft measurement, assessment of spray uniformity and nozzle selection using patternator. Field studies were conducted to determine the performance parameters, seedling uniformity and plant population,

population and dry weight of weeds and the biometric observations of the crop at various stages of growth. The selected seed sample had a germination percentage of only 72. The cup feed mechanism, which was not able to adjust seed rate showed a constant seed rate of 65.12 kg/ha. Better uniformity of spraying was observed at a nozzle spacing of 105 cm. Draft was measured separately by a using a simple mechanism developed at KCAET Tavanur and it was observed that the soil offers low resistance of 0.1 kg/m^2 during dry seeding since the plots are well pulverized by rotavator. Results of the field studies indicated that the plot operated with combination implement had better plant uniformity, more yield and more profit compared to broadcasted field. The field operated with combination implement had a specified row to row spacing (20 cm) which facilitated easy operation of weeder resulting less weed growth. Operation of weeder helped to get proper aeration. These factors helped to produce proper growth and better yield in the plot run by combination implement. By comparing grain to straw ratio in two plots, it was observed that more grain weight was observed in the field operated with combination implement whereas more straw weight was seen in broadcasted plot. More straw weight in broadcasted plot was due to more seedlings in it. At the same time, broadcasted field had more weed population, weeding cost, more straw (42 % of total biomass) and weed biomass.

Considering the results, a refined model of combination implement was developed by incorporating certain design modifications. A metering mechanism (fluted roller) for adjusting the seed rate and a spring loaded tool bar were the major modifications. Provision for changing the spacing between rows, that is 20 cm and 25cm was another feature of this model. In order to eliminate clogging of the boot the furrow opener was modified by providing wings on either side. By proper realignment of nozzle, better uniformity of spray could also be obtained.

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ABSTRACT

The combination implement for dry seeding and herbicide application developed at KVK Palakkad was studied successfully. Several drawbacks of this machine were observed from the laboratory and field test results. The machine consisted of simple frame, tines, seed box, seed tubes, cup feed metering mechanism, power transmission unit, furrow opener, hitching attachments and herbicide sprayer units. Variation of seed rate in different seed tubes, damage occurring in the tine when an obstacle is encountered, cup cannot be adjusted with various varieties of paddy, clogging of seed tube and cannot change the spacing between rows are the problems raised during the test. By correcting all these faults new machine were proposed, designed, and fabricated. Refined machine can be operated by changing the row to row spacing either as 20 cm and 25 cm, cup feed metering mechanism was replaced by fluted roller for more uniformity, seed rate can be vary according to the size and seed variety, spring was provided in each Tool bar as a tipping mechanism. The effective field capacity, theoretical field capacity and field efficiency was observed as 0.3316 ha/hr, 0.456 ha/hr, and 72.7%. The seed rate of the machine can be vary in the range of 17-210 kg/ha. For better uniformity of spray the flat fan nozzles are spaced 105 cm apart with an overlapping distance of 75 cm.