DESIGN, FABRICATION AND TESTING OF A POWER OPERATED JAB TYPE PADDY DIBBLER

By

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THESIS

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requirement for the degree of

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KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY
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DECLARATION

I hereby declare that this thesis entitled "**Design, fabrication and testing of a power operated jab type paddy dibbler**" 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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CERTIFICATE

Certified that this thesis entitled "**Design, fabrication and testing of a power operated jab type paddy dibbler**" is a record of research work done independently by **Ms. Maji G. Krishnan** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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Dedicated to my beloved parents

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SYMBOLS AND ABBREVIATIONS

Agric.	-	Agricultural
AIT	-	Asian Institute of Technology
AMA	-	Agricultural Mechanization in Asia, Africa and Latin America
ASAE	-	American Society of Agricultural Engineers
C	-	Celcius
CIAE	-	Central Institute of Agricultural Engineering
cm	-	centimetre
cm^2	-	square centimetre
cm^3	-	cubic centimetre
COV	-	Covariance
CV	-	Coefficient of variation
Engng	-	Engineering
Eqn	-	equation
et al.	-	and others
Fig.	-	Figure
FPME	-	Farm Power, Machinery and Energy
g	-	gram
GI	-	Galvanized Iron
h	-	hour(s)
ha	-	hectare(s)
hp	-	horse pow
i.e.	-	that is
IRRI	-	International Rice Research Institute
J.	-	Journal
KAU	-	Kerala Agricultural University

KCAET	-	Kelappaji College of Agricultural Engineering and Technology
kg	-	kilogram
km	-	kilometre
lit	-	litre
LWRCE	-	Land and Water Resources and Conservation Engineering
m	-	metre
m^2	-	square metre
m^3	-	cubic metre
min	-	minute
mm	-	millimetre
MS	-	Mild Steel
NCAM	-	National Centre for Agricultural Mechanization
No.	-	number
P	-	page
PP	-	pages
Rs	-	rupees
S	-	second
SD	-	Standard Deviation
t	-	tonne(s)
Trans	-	Transactions
Var	-	Variance
Viz	-	Namely
%	-	Percentage
/	-	Per
°	-	degree

Introduction

INTRODUCTION

Rice is a grass belonging to the genus *Oryza Linn.* Linnaeus named the genus to which rice belongs Oryza and gave the specific name to rice, *Oryza sativa* (Vaughan, 1989). Rice is the major dietary component for more than a third of the world population. It is primarily a high energy or high calorific food and provides two-third of the calories for more than two billion people in Asia. World rice production, consumption and trade are concentrated in Asia and its contribution is about 90-95% of world production. In India the rice production during 1993-94 was 79 million tonnes. In Kerala, rice is the most important and extensively grown food crop. Rice production in Kerala during 1994-95 was 9.75 lakh tonnes from 5.038 lakh hectares (Kumar, 1996).

Common cultivation practices of rice can be classified into direct sowing and transplanting. In direct sowing, the seeds are sown directly in the prepared field. Whereas, in transplanting, the seedlings are first raised in a nursery and then transplanted in the prepared field. The adoption of direct seeding eliminates the need for high-energy demanding operations like; puddling and transplanting. Further, direct sowing of rice in dry soil has been found the most appropriate alternative to transplanting.

Direct seeding can be done in both dry and wet soil. Common methods used for direct sowing are; broadcasting, drilling, check-row planting, hill dropping and dibbling. Broadcasting is the oldest and the simplest method of sowing. It is the random scattering of seeds in the prepared field. Usually higher seed rate is needed in this system. In drilling, seeds are dropped in furrows in a continuous flow and are covered with the soil. Seed metering is done either manually or mechanically. In check-row planting, the seeds are placed precisely in straight and parallel furrows. Here plant to plant and row to row distance are uniform. In hill dropping, a group of seeds are dropped at fixed spacing in the rows. Dibbling is the process of placing the seeds in holes made in seedbed at predetermined spacing and depth and covering them with soil.

Dibbling is considered the most effective method of direct sowing. Hand dibbling is a time consuming process. So, machines were developed for dibbling and the equipment is known as dibbler. In seed drills, furrows are opened continuously, but in dibblers only the holes are made at a fixed spacing. So the energy requirement is less. Dibbler provides accurate spacing between plants and rows. Further, in dibbling there is a reduction in the seed requirement and the cost of operation. Intercultural operations are comparatively easier in a dibbled field.

Labour shortage during planting season is one of the important constraints in agricultural activities, particularly in Kerala. Hence, there exists a need for mechanization of planting. An effective dibbler improves land and labour productivity and reduces the physical drudgery. Considering the numerous advantages in using a dibbler, it is essential to bring more area under dibbling.

Different models of the dibbler were developed by other research workers in previous years. A manually operated AIT Jab seeder was developed and tested in Nepal by Singh and Pariyar (1992). It eliminated the need for constant bending or squatting and thereby carried a saving of about one-fourth in labour use. A three-row manually operated dibbler (Bini, 1992) and a two-row two-column paddy dibbler (Dinesh and Maji, 1993) were developed and tested in the Kerala Agricultural University. In all these cases the field capacities of the machines were very low.

Jayarajan (1996) developed a power operated paddy dibbler. In this dibbler, there was, frequent clogging of the seed tube with soil and this prevented the free movement of plunger over the cam and also within the seed tube.

In view of the above facts, a study was undertaken at the Kelappaji College of Agricultural Engineering and Technology, Tavanur to develop a suitable jab type paddy dibbler with the following objectives.

1. To design and fabricate a jab type dibbling mechanism for paddy.

2. To incorporate a suitable metering mechanism in a multi-row dibbler.

3. To test and evaluate the performance of the jab type dibbler.

In order to fulfil the objectives, a single row jab type dibbler was developed and tested. The dibbling mechanism was operated by a cam-follower arrangement. It placed 4-6 seeds at a depth of about 4.0 cm in the holes made by the dibbler in the soil. It gave a seed rate of 80-90 kg/ha at a speed of 0.788 km/h. Inspite of these advantages, it was, however, felt necessary to modify it further for making it a commercially viable unit.

In the course of this study the research work carried out by other researchers in the field were reviewed, and some of the salient observations are presented in the following chapter.

Review of Literature

REVIEW OF LITERATURE

In this chapter, a brief description about the origin of rice, cultivation practices in paddy farming, different types of sowing techniques, metering mechanisms and development of dibblers are presented.

Rice is grown primarily for human consumption. It is the staple food of people in nearly all Asian countries and major source of livelihood in the rural economy.

The rice cultivated today, Oryza sativa, reportedly originated in Asia from the crosses between their wild ancestors (Chapman and Carter, 1982). Copeland (1924) reported that rice was first cultivated in the south east Asia. Vavilov (1926) suggested that India and Burma should be regarded as the centres of origin of cultivated rice.

Rice is grown under widely varying conditions of altitude and climate. Rice cultivation in India extends from 8 to 35°N latitude and from below sea level to as high as 3000 m. Rice crop needs a hot and humid climate. The average temperature required throughout the life period of the crop ranges from 21° to 37° (Singh, 1984).

The area under cultivation and the production of rice from it in India are presented in Table 2.1. The importance of this crop is evident from this. The rice production in India during 1995-96 was 81 million tonnes (Siddiq, 1996). After Thailand, India is the leading rice exporter in the world. About 15% of the exported rice in the world is contributed by India. During 1995-96, 30 lakh tonnes of rice was exported from India.

Rice also occupies a prominent place among the crops cultivated in Kerala. During 1974-75 rice production was only 8.81 lakh tonnes from 13.76 lakh hectares. Later, the production was raised to above 10 lakh tonnes (Kumar, 1996). The statistics related to the area under cultivation and production of rice in Kerala is presented in Table 2.1.

Table 2.1 Rice production in India and Kerala

	India		Kerala	
	Area ('000 ha)	Production ('000 tonne)	Area ('000 ha)	Production ('000 tonne)
1980-'81	40152	53631	801.699	1271.962
1985-'86	41137	63825	678.281	1173.051
1990-'91	42690	74290	559.450	1086.578
1991-'92	42640	74680	541.327	1060.350
1992-'93	41640	72610	537.608	1084.878

Source: Economic Review 1993, State Planning Board, Kerala, Table 4.10, Page 38.

Generally, rice can be grown as transplanted or directly sown crop during three seasons in Kerala depending on the climatic and field conditions. The three seasons are given below:

Crop season	Local name	Period
Autumn crop	Virippu	April/May - Sept/Oct.
Winter crop	Mundakan	Sept/Oct - Dec/Jan
Summer crop	Punja	Dec/Jan - March/April

2.1 Cultivation practices of paddy

Rice growing conditions prevailing in different regions of India largely determine the system of rice cultivation. Large variations exist in various cultivation practices. The three principal systems adopted in India are wet, semi-dry and dry system (Ram, 1986).

2.1.1 Wet System

In the wet system, the land is inundated and the crop grown in water from the time of planting until harvesting approaches. The land is ploughed thoroughly and puddled with 3-5 cm of standing water in the field. The sprouted seeds are either directly sown in the puddled soil or grown in a nursery and then transplanted into the prepared field. The wetland cultivation is not only a cumbersome operation but also lower the life and efficiency of farm machines as perfect sealing, of critical parts like bearings, brakes, power transmission elements, from standing muddy water is very difficult.

2.1.1.1 Transplanting

In transplanting, the seedlings are prepared in the nursery and then transplanted in the paddy field 1 to 3 days after ploughing, puddling and levelling of the field. Plant spacing is an important production factor in transplanted paddy. Planting of paddy closer than necessary increases the cost of transplanting and contributes to increased probability of lodging. On the other hand too wide spacing results in lower yield (De Datta, 1981)

2.1.2 Dry and Semi-dry System

The basic system of cultivation is the same for dry and semi-dry areas. The seed is directly sown in the prepared field by any one of the sowing methods. The main difference between dry and semi-dry system is that in the latter, the water is impounded in the field when the crop is 5-6 weeks old and thereafter it is converted into wetland system. The dryland method is stated to be necessary where rainfall is low or irrigation facilities are inadequate for puddling the soil.

2.1.2.1 Advantages of Direct Sowing

Though transplanting is considered to be a superior method, there are many advantages for direct sowing.

The main advantages of direct sowing are :

1. Cultivation cost is less

2. Dryland paddy is less likely to lodge than paddy in wetland. Even if it does lodge, the grain will not be spoilt by irrigation water.

3. Puddling and transplanting are avoided.

4. Crop matures earlier than transplanted crop which may be important for multiple cropping.

Direct sowing of paddy offers a convenient alternative to the traditional transplanting (Mabbayad and Obordo, 1970)

Brown and Quandril (1973) reported that the total time requirement per hectare for rice production was about 1300 man-hours by manual transplanting and was about 600-800 man-hours by mechanical means and 200-300 man-hours by direct sowing.

Chatterjee and Khan (1978) recorded 6% more wheat yield in an area which was previously under direct seeded rice compared with transplanted rice.

Ohja (1978) indicated that direct sowing is a labour saving and cost reducing system compared to transplanting.

In China, an average rice yield of 6.75 t/ha was recorded with direct dry cultivator by using one-third as much water and two-third as much manure as needed in the traditional method (Qinghua, 1985)

Fujioka (1986) carried out studies on the practice of drilling paddy directly in submerged paddy fields and in-line drilling of fertilizer by the side. Drilling rate was 100-150 grains/m^2 and seeding emergence was 60-120/m^2. Direct drilling gave 10 per cent saving in cost and 20 per cent saving in labour as compared to conventional transplanting. Drilling fertilizer by the side of seeds increased yield by an average of 5 per cent.

Another study in China showed that direct sowing of rice on dry soil saves about one-third of irrigation water and 90 man-hours compared to transplanted rice (Guo Yixian, 1986).

Muravarma (1987) carried out experiments in direct drilling of rice in submerged paddy fields. He showed that average yield was 1937.5 and 1570.0 kg/ha with direct drilling as compared with 1585.0 and 1097.5 kg/ha with transplanting. Also, the saving in cultivation time was 2.5 h/ha.

In an experimental study in Pakistan by Khan *et al.* (1989), transplanting produced a maximum paddy yield of 7875 kg/ha whereas the highest paddy yield of 8666 kg/ha was recorded in direct cultivation on dry soils with an increase of 10% over transplanting. Also, they pointed out that direct sowing is an alternative to paddy transplanting.

Majid *et al.* (1989) conducted a study in clay loam soil to determine the suitable direct sowing technique. The seeding techniques used were; puddling broadcasting (PB); dry-line sowing (DLS) and dry-broadcasting (DB). The sowing dates were; May 16 (ST_1), May 31 (ST_2), June 16 (ST_3) and June 30(ST_4). High grain weight of 22.2 and 25.8 g were associated with DLS and ST_1 treatments respectively. Maximum grain yields (4365.3 and 6373.2 kg/ha) were obtained from dry-line sowing on May 16.

Ahmed *et al.* (1994) indicated that direct drilling of wheat after paddy harvest produced 24% higher yield than the wheat sown in conventional tillage.

2.2 Methods of direct sowing

The common methods used for sowing crops in this system are discussed below.

2.2.1 Broadcasting

In the conventional practice of hand broadcasting, seeds are randomly scattered on the soil surface. This results in seed damage by birds and poor germination by insufficient soil moisture at the surface. The broadcast crop also lacks evenly spaced rows which hinder interculture and pesticide application. Broadcasting seeds over the broken soil and covering them with some type of harrow was the common method of planting until about 1840 (Smith and Wilkes, 1990)

2.2.2 Drilling

Seed drilling refers to the dropping of seeds in the furrow through seed tubes. The metering of seed may be done either manually or mechanically. Mechanically operated seed drill gives a very high accuracy in metering. In this method furrows are opened continuously in the soil and the seeds are placed at proper depth. The amount of seeds sown is more. The main disadvantage is that mechanical seed drills may cause damage to the seeds. Besides they are likely to get clogged during operation. This may result in irregular germination of the crop.

2.2.3 Check-row planting

Check-row planting or precision planting implies accurate spacing of single seeds in the row, precise control of planting and creating a uniform germination environment for each seed.

2.2.4 Hill dropping

In hill dropping seeds are sown in lines at fixed spacing and not in a continuous stream. Hence, the distance between the plants in a row is constant.

2.2.5 Dibbling

Among the different methods of direct sowing, dibbling is a better method because of its lower seed requirement and higher yield (Bini, 1992). It makes provision for the intercultural operations and reduces the labour requirement and the cost. In many aspects it resembles transplanting.

Dibbling refers to the placing of seeds in the holes made in the seed bed at definite depth. In hand dibbling the distance between the plants is maintained by the operator. Mechanical dibblers give more accurate sowing.

Buffon *et al.* (1986) reported that dibbling offers a promising way towards obtaining better crop establishment by achieving better control of the soil physical environment.

2.3 Seed rate and spacing requirements

The primary objective of any planting operation is to establish an optimum plant population and plant spacing, the ultimate goal being to obtain the maximum net return per hectare (Kepner *et al.*, 1987)

The spacing between the seeds is governed by the plant growth and their distribution per unit area. However, the space requirement of a plant is so adjusted between the rows that subsequent use of intercultural implements is made possible.

The seed to be sown per area depends up on the size of the seed, germination percentage, extent of cover at the maturity and expected use of plant as either fodder or for grain.

As per the Package of Practices (1993) of KAU, the seed rate for paddy dibbling is 80-90 kg/ha. The number of seeds per hill is 4-6 and the number of hills is $67/m^2$. This seed rate is specified for farmers fields on the basis of a minimum germination of 80 per cent.

2.4 Advantages and disadvantages of mechanical dibbling

The manual dibbling method is slow and tiring due to constant bending of the person while dropping the seeds. An effective mechanical dibbler will improve land and labour productivity and reduce physical drudgery and cost of operation.

Wurr et al (1985) reported that sowing with dibbler improves emergence and leads to a better harvest in most crops.

The main disadvantages of mechanical sowing equipment are the likely damage they cause to the seed, the interruption caused to the flow of seed in the metering mechanism and the clogging of seed and fertilizer tubes during operation. These result in irregular germination and poor stand of the crop.

2.5 Direct sowing equipments

Commonly used direct sowing equipments are seed drill, seed-cum-fertilizer drill, planter, pre-germinated seeder, broadcaster, and dibbler.

2.5.1 Dibbler

Dibbler is a mechanical device used to make holes in the soil to drop the seeds in these holes and to cover them with soil. Uniform spacing of plants can be maintained, using dibbler.

2.5.1.1 Development of dibblers

A variety of pointed sticks, some with metal tips, are reported to have been commonly used for dibbling. Manually operated walking stick and rotary injection jab planters are also used for both seeds and fertilizers.

Several hand dibblers are made with conical projections made in a frame. Jab planters are used in quite rough seed beds or uncultivated land.

Heinemann *et al.* (1973) stated that the concept of sowing seeds with dibbler was not new. Cylindrical dibblers either mounted on a wheel or actuated by a pneumatic device were used to form holes into which seeds were subsequently delivered.

Wilkins *et al.* (1979) showed the need to embed seeds at the bottom of the dibbled holes to improve moisture transfer to the seeds. Cylindrical magnetic dibblers were used to pick up seeds coated with iron oxide and to press them into the soil without covering. There were problems with seed placement but faster and greater emergence of seed was found compared to the use of a conventional drill.

A simple sowing machine was developed by Tambe (1981). The machine consisted of a fabricated steel/cast iron frame fitted with a platform for the operator to stand on. Two specially shaped plough shares provided underneath the platform made furrows of a typical shape (as holes). The sowing drum mounted on the axle was rotated by means of a toothed cast iron wheel. The drum had small cup-shaped cavities on its circumference. It picked up a few seeds from the seed container as it rotated and dropped all seeds at a time into the furrow at fixed intervals. This machine had 3 or 4 rows of plough shares and blades at 200-250 mm spacing in between them. The main advantages of this machine were the easy and quick operation and the uniform and economic sowing

The CIAE, Bhopal developed a Naveen seed dibbler (Devnani, 1982). The seed dibbler consisted of a dibbler bar, a seed hopper with wooden roller and an actuating linkage for dropping the seeds. When it was pushed into the soil, the seed was dropped into the hole made by the furrow opener. It could be operated by one person and the field capacity was 0.013 ha/h (Fig. 2.1).

A mechanical soybean seeder developed at the AIT Bangkok (Anonymous, 1986) made dry season soybean planting more convenient, economical and high yielding. The AIT seeder combines hole making and seeding into one operation. This device also allowed the labourer to work in an upright

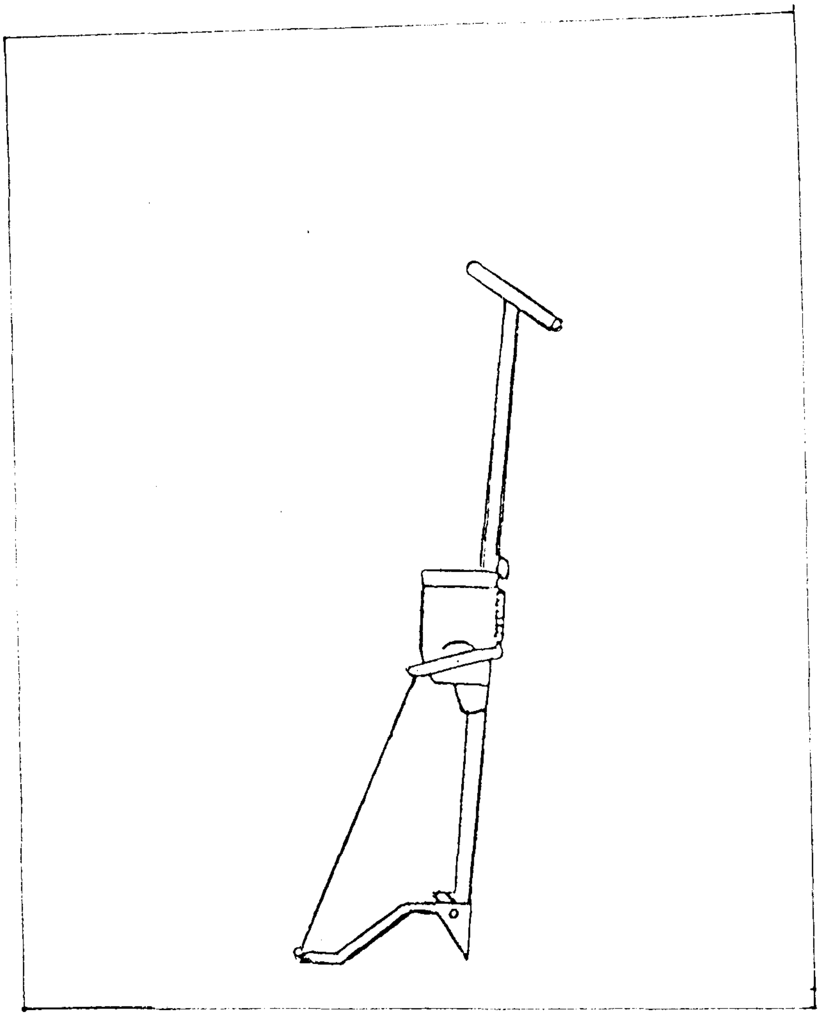


Fig. 2.1 Naveen dibbler

(Devnani, 1982)

position, making seed planting more comfortable and efficient operation. The seeder consisted of 1.5 m steel tube, in which the seeds were stored and an outer tube, equipped with a wedge shaped tip attached to a rolling metering device by a spring. When the seeder tip was pushed into the ground, the spring was compressed, activating the metering device which released 3-4 seeds into the hole. The seeder was free from the problem of breakage, seed jamming and soil clogging and weighs only 1.5 kg. The seeder cuts sowing time by half, from 46 man-days to 22 man-days/hectare.

A five-row bullock drawn dibbler was developed by John (1989) for sowing paddy. The dibbler consisted of main frame, shaft, ground wheel, seed box, seed tubes, metering mechanism, furrow opener, furrow coverer and clutch mechanism. Power from the ground wheel was transmitted to the shaft through a jaw clutch. Cams and agitators which were the integral part of the metering mechanism were fitted on the shaft. The agitator dropped the seeds from seed box which was closed with a hinged gate. A cam and follower arrangement opened the seed tube instantly and dropped seeds into the furrows. Since the seed tubes were kept as close as possible to the ground, soil clods blocked the opening of the seed tube. The furrow coverer fitted at the back of the frame deflected the loose soil over furrow. The maximum draft when operated at 1.5 km/h was 33.5 kg. The power required was 0.22 hp which a pair of bullock could easily develop. The labour requirement was 12 man-h/ha and field efficiency was 76 per cent. Compared to manual dibbling, the cost of sowing was reduced by about 4.8 times. The effective field capacity of the machine was 0.089 ha/h at 1.55 km/h speed.

Kim *et al.* (1989) developed a vacuum type 2-row drill as an attachment to a powered tiller to mechanize the sowing operation for various crops in upland areas. In this machine it was possible to adjust the row space (30-80 cm) and sowing distance (10-15 cm) according to the seed bed conditions. Missed seed did not occur for sesame, radish or soyabean. The working performance was 0.14-0.21 h/ha which was 2.0-2.4 times lower than the manual sowing.

A manually operated 3-row paddy dibbler for dry sowing was developed and tested at the Kerala Agricultural University (Bini, 1992). The machine consisted of seed box, roller with metering mechanism, seed tube with furrow opener, frame, handles and marker (Fig.2.2). When the dibbler was operated, the roller passing vertically through the centre of the box would move upward due to the soil pressure against the spring pressure. As the roller was moved upward, the portion of the roller having the vertical slot would come in contact with seeds and the seeds are moved and carried to this slot. When the equipment was taken out from the soil, the soil pressure on the roller was released. Due to the spring pressure the roller was moved downward and the seeds carried in the slot

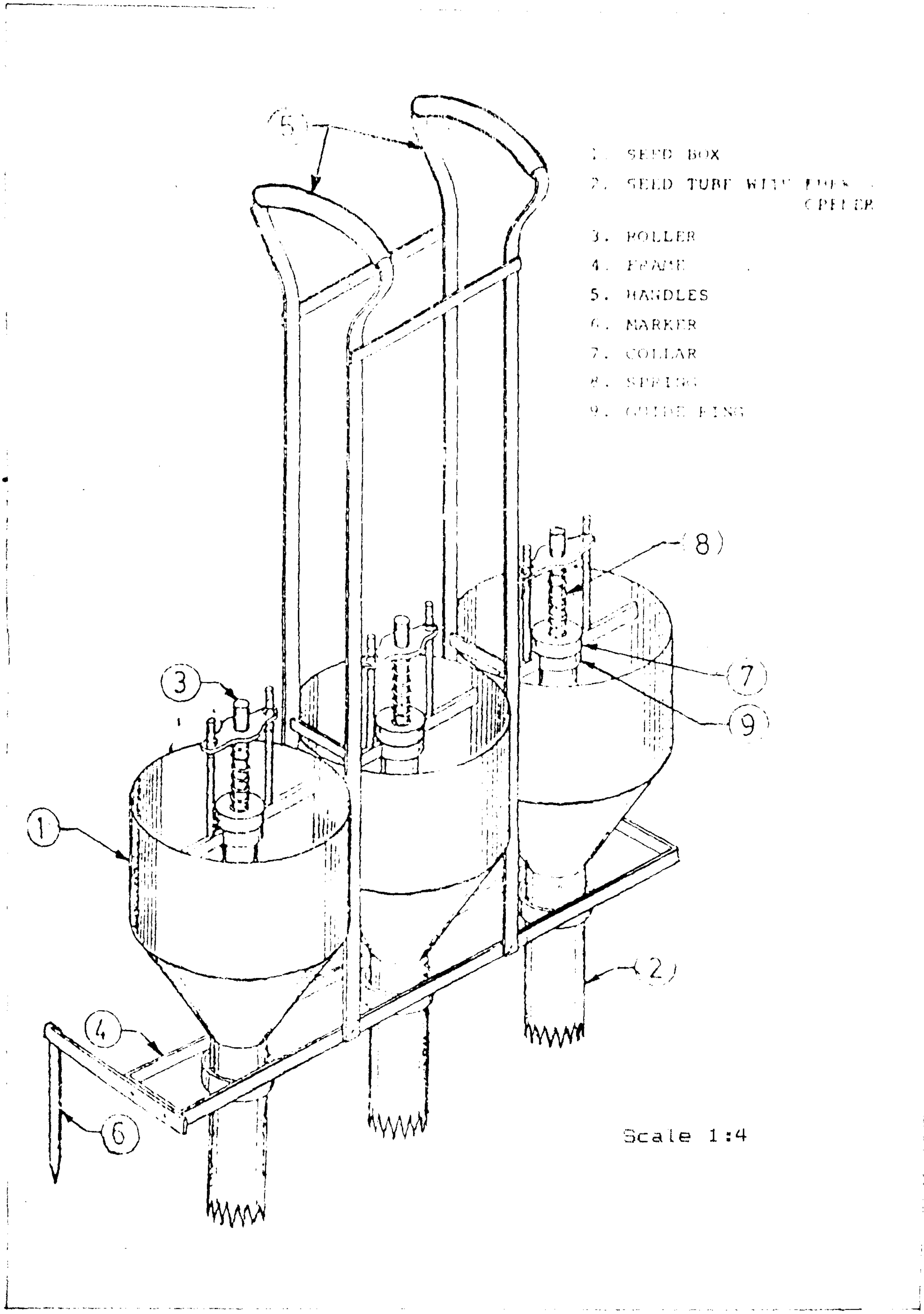


Fig. 2.2 Manually operated paddy dibbler
(Bini, 1992)

were released which then fell through the seed tube by gravity into the soil. Due to the downward travel of the roller and seed tube, a hole was made in the soil for dropping the seeds. The covering of the seeds with soil was carried out automatically when the equipment was taken out from the soil. The number of seeds dropped were in the range of 4-6 per hill. Loss of viability due to mechanical damage during metering was more. Field capacity of this machine was 0.022 ha/h.

A manually operated seeder named AIT jab seeder was fabricated by Singh and Pariyar (1992) in Nepal using locally available materials (Fig.2.3). This seeder saved about one-third in labour use and consequently, improved the timeliness of operation. The seeder is convenient to be used by both men and women and reduced drudgery by eliminating the frequent bending or squatting. This could also be used as a multicrop seeding device. The germination percentage was more than 90. The cost of seeder could be recovered in one cropping from one hectare of maize and soyabean. But, the field capacity of the machine was very low i.e. 0.011 ha/h.

A two-row, two-column dibbler mainly consisting of a fluted roller seed metering mechanism and plungers reciprocating within the seed tubes was designed, fabricated and tested in KCAET (Dinesh and Maji, 1993). The seed tube together with plunger acted as the punch for making the holes. The plunger in its upward stroke uncovered the farther end of

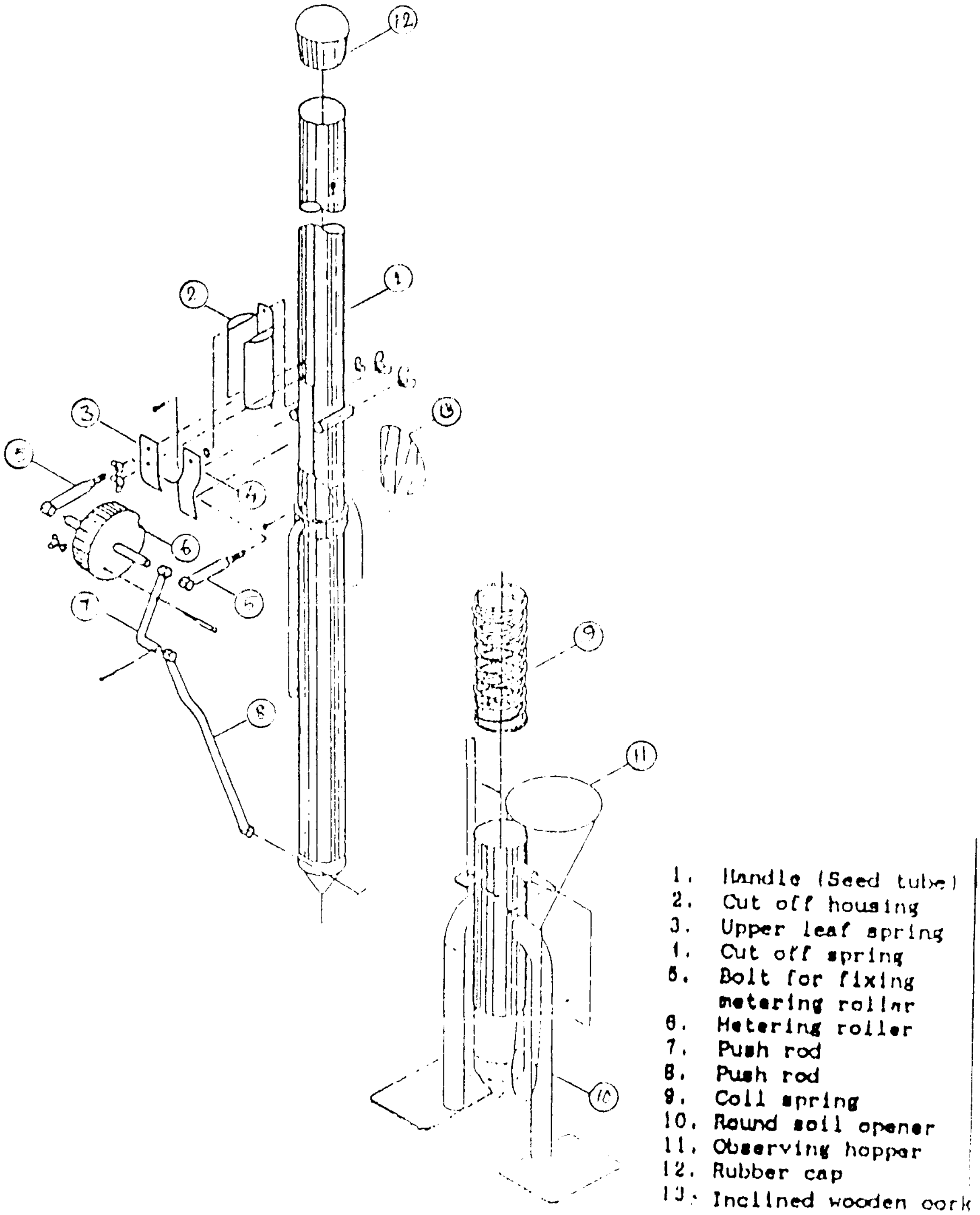


Fig. 2.3 Exploded view of AIT jab seeder

(Singh and Pariyar, 1992)

the seed transfer tube and transferred the seeds into the seed tube and then into the holes. In the downward stroke the plunger closed the seed transfer tube. Simultaneously the fluted roller transferred the seeds from the hopper to the seed transfer tube. The average number of seeds/hill was 2.67. The seed rate obtained was 31.37 kg/ha. The seeds were placed within the confines of the holes of 19.7 mm diameter. There was absolutely no scattering. The depth of placement varied from 4.7 to 5 cm. Field capacity of this machine was as low as 0.0084 ha/h since it was manually operated.

Borlagdan (1994) developed four prototypes of upland seeder for sowing upland crops namely; semi-automatic seeder automatic seeder, plough attached seeder, and power tiller attached multi-crop seeder (Fig.2.4). These could be used for sowing maize, soybean and mugbean. The prototypes were tested for maize and these gave a capacity of 0.03, 0.024, 0.136 and 0.183 ha/h respectively. A feasibility analysis showed a benefit-cost ratio of 2.45, 1.08, 1.24, and 1.00 with a corresponding break-even point of 0.30, 0.60, 0.53, and 2.63 ha respectively. The semi-automatic seeder could be used for sowing both in zero tillage and in cultivated soil conditions. The number of seeds per hill is determined by the operator.

A dibber drill developed by Brown *et al.* (1994) offered both high speed operation upto 2 m/s and variable spacing of successive seeds within the row. All moving parts were housed

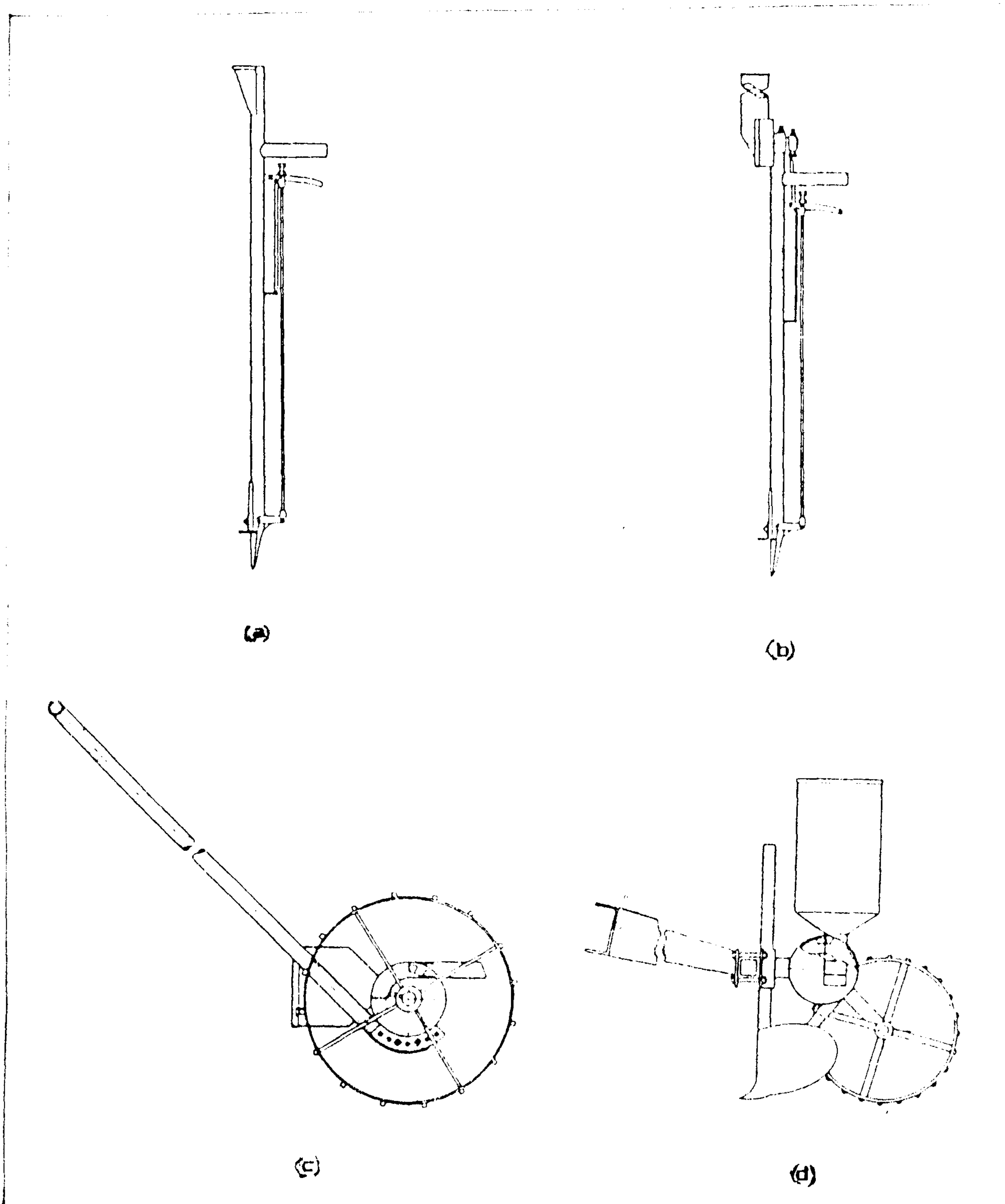


Fig. 2.4
a. Multi-crop seeder
b. Automatic multi-crop seeder
c. Push type seeder converted from plow-attached seeder
d. Power tiller attached multicrop seeder.

(Borlagdan, 1994)

within the dibber wheel, which was mounted on a tool bar via trailing arm. The dibber wheel was a land wheel driven through a lay shaft and V-belt drive. The dibber wheel contained 24 equi-spaced stainless steel plungers of 12.5 mm diameter. As the wheel rotated, each plunger in turn moved radially inward from the surface of drill ready to accept a seed some 55° before bottom dead centre. After transfer of seed to the cavity created by the withdrawal of plunger it moved outward to press the seed to the required depth. An external shoe prevented premature release of the seeds.

Ladeinde and Verma (1994) conducted a study to compare the performance of three different models of jab planters viz, Italian jab planter, AIT jab planter and NCAM semi-automatic hand planter, for the traditional method of planting. The results showed that all the three planters had the advantage of eliminating the backache problem encountered in the traditional method of planting. The Italian jab planter and AIT jab planter had the advantage of planting the seeds faster. The jaws of NCAM planter were clogged with soil if the soil was too wet and heavy. The metering device of AIT jab planter was clogged with seeds frequently. The plant-hill spacing were not uniform in respect of AIT jab planter and the traditional method (Fig 2.5).

Fig. 2.5

a. Italian fully automatic manually operated jab planter in operation
b. AIT fully automatic manually operated jab planter in operation
c. NCAM Semi-automatic manual seed planter

(Ladeinde and Verma, 1994)

A six-row power tiller operated pre-germinated paddy seeder was developed by Sahoo *et al.* (1994). The effective field capacity of this seeder was 0.168 and 0.114 ha/h for 9.9 and 25.3 cm hardpan depth respectively. The row to row spacing was 9.95 cm with 3-5 seeds per hill. A net saving of Rs 327/ha and Rs 452/ha could be obtained by using the power tiller operated paddy seeder instead of the manual hill-dropping and transplanting methods. By operating the seeder at higher hardpan depth, operational difficulties were experienced due to clogging and slippage of ground wheels.

Jayarajan (1996) developed a two-row power operated paddy dibbler. The main components of the dibbler were two seed boxes, plungers reciprocating within the seed tubes, fluted roller, seed metering mechanism, dibbler wheels, stationary cam, frame, and transport wheel. The seed tubes were fixed radially around the dibbler wheel with 45 mm of it projecting outwards for penetrating the soil. The plunger was actuated by a stationary cam as the dibbler wheel rotates and during its upward stroke it uncovered the farther end of the seed transfer tube. Then it transferred the seeds into the seed tubes and into the holes made in the soil. In the downward stroke the plunger closed the seed transfer tube. Simultaneously the fluted roller transferred the seeds from the hopper to the seed transfer tube. The average speed of operation of the dibbler was 1.32 km/h and its field capacity and efficiency were 0.031 ha/h and 78.13 per cent respectively. The average number of seeds dropped per hill was 5 and the seed rate obtained was 78 kg/ha. The seeds were placed within the confines of the holes made by the seed tube and plunger. The depth of placement varied from 3.8 to 4.8 cm. The operating cost of the dibbler was Rs 502.58/ha. In this dibbler, there is a chance of clogging due to the entry of soil in the seed tube, which prevents the free movement of plunger over the cam.

2.7 Types of seed metering mechanism

2.7.1 Fluted feed mechanism

It is a seed metering device with adjustable fluted roller to collect and deliver seeds into the seed tube. Fluted feed type of mechanism consisted of a fluted wheel feed roller, feed cut-off, and adjustable gate for different sizes of grains (Fig.2.6). The feed roller and cut-off device are mounted on a shaft, running through the feed cups. The roller carries grooves throughout its periphery and while rotating throws the grains through the adjustable gate from where it falls into the seed tube. The fluted rollers which are mounted at the bottom of the seed box receive seeds into its longitudinal grooves and pass on to the seed tube through the holes provided for this purpose. By shifting the fluted wheel sideways, the length of the grooves exposed to the seeds can be increased or decreased and hence the seed rate is controlled. Seed rate can also be varied byadjusting

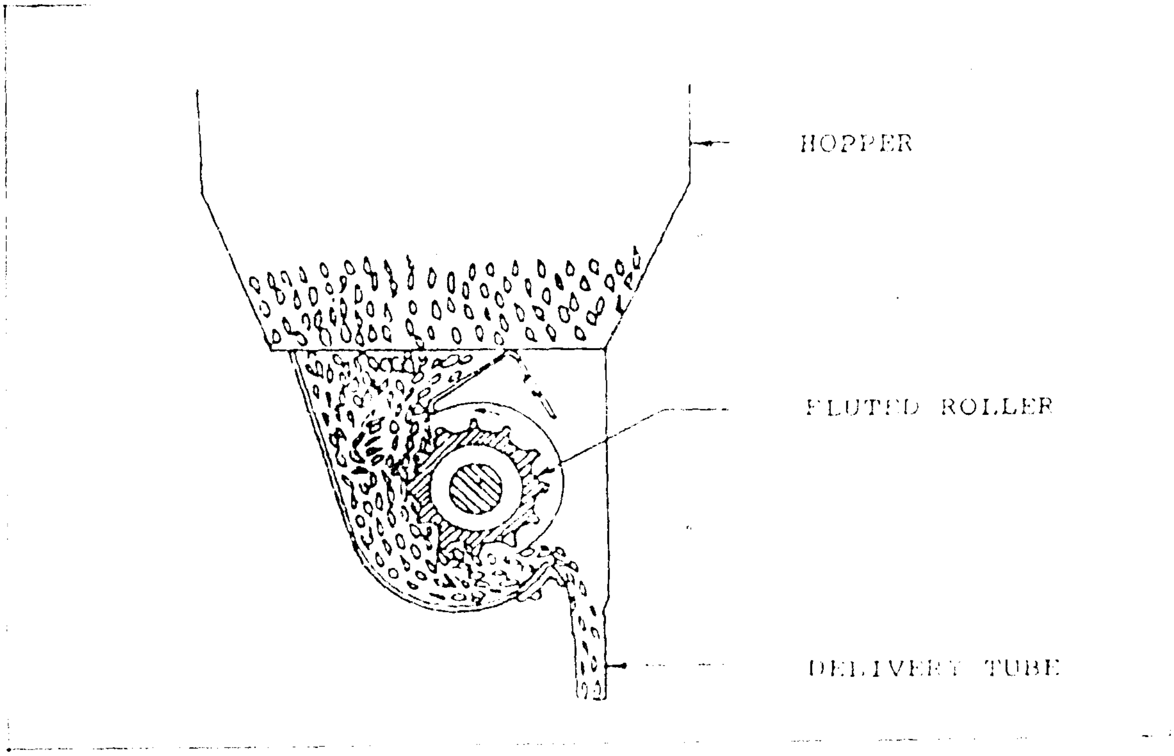


Fig. 2.6 Fluted roller or external forced feed

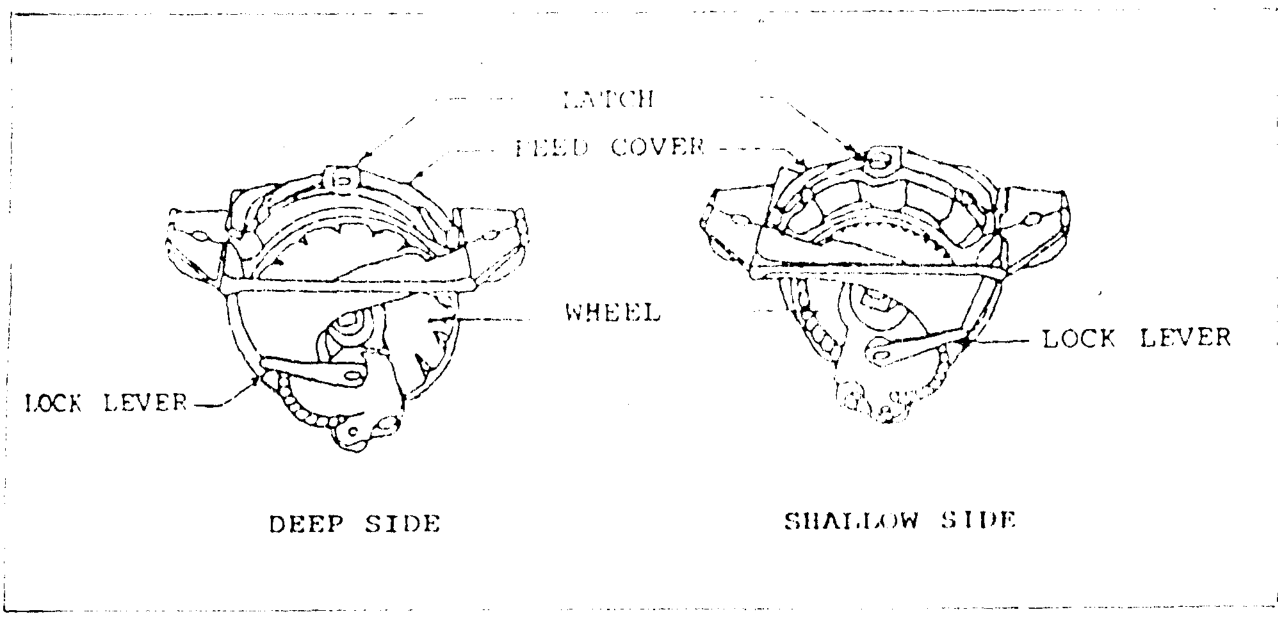


Fig. 2.7 Double run or internal forced feed

the gate and changing the sprockets on the ground and feed shaft. Michael and Ojha (1996) indicated that there is more crushing of seeds in this type of metering mechanism. This is due to the rotation of the fluted roller at the bottom of the seed box. The overlying seeds cause interlocking and prevent the free rotation of the fluted roller. At times, this interlocking is overcome by the roller by crushing the seeds. Besides, this mechanism is unsuitable for dibblers as the discharge of seeds is continuous.

2.7.2 Internal double run feed

The internal double run feed has a double faced wheel: one face having a larger opening for larger seeds such as peas, oats, and wheat, and the other face having smaller opening for smaller seeds such as grass seeds, oil seeds etc (Fig.2.7). A flap gate is provided at the bottom to block the opening when not in use. Feed is controlled by changing the speed of the internal feed wheel through a shaft which gets its drive from a gear box. This mechanism delivers seeds almost in a continuous flow. Metering mechanism delivering seeds in a continuous flow is unsuitable for dibbling.

2.7.3 Cup feed mechanism

It is a mechanism consisting of cups or spoons at the periphery of a vertical rotating disc which pick up the seeds from the hopper and deliver into the seeds tubes (Fig.2.8).

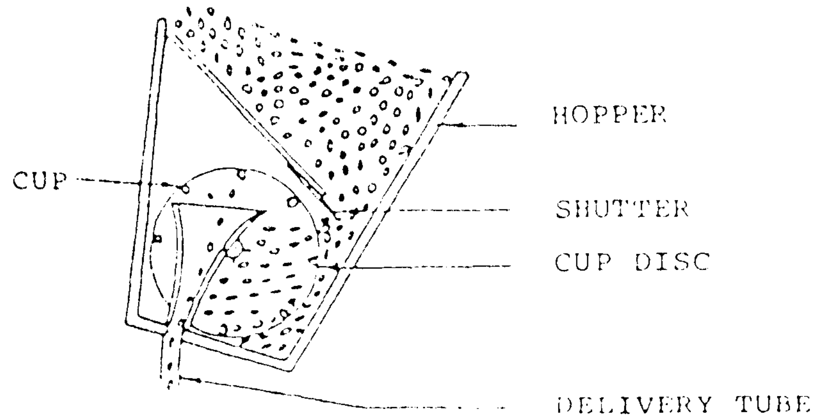


Fig. 2.8 Cup feed mechanism
(Gite et al., 1981)

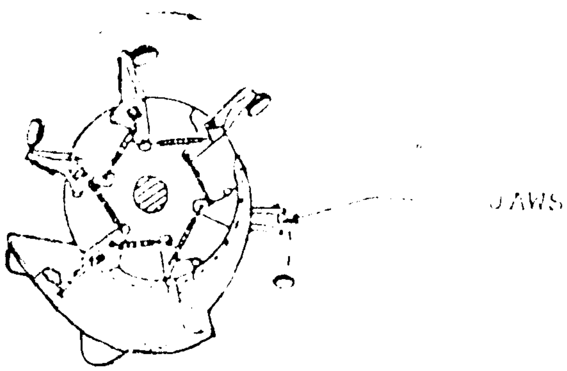


Fig. 2.9 Picker wheel mechanism
(Gite et al., 1981)

It consists of a seed hopper which has two compartments. The upper one is grain box and the lower one is the feed box. Shutters are provided to connect these boxes. The seed delivery mechanism consists of a spindle carrying a number of discs with a ring of cups attached to the periphery of each disc. The spindle with its frame and attachment is called seed barrel. When the spindle rotates, one disc with a set of cups rotates and picks up few seeds and drops them into small hoppers. The cups have two faces; one for larger seeds and the other for smaller seeds. The seed rate is controlled by the size of cups and the rate at which the seed barrel revolves. This type of mechanism is common on British seed drills. This mechanism is used where precise control of seed rate and plant population are desired (Michael and Ojha, 1996). Seed damage is also less. This mechanism is suitable for use in a dibbler. In some seed drills the two compartments of the seed hopper are placed side by side. This system with some modifications is considered for use in dibbler under study.

2.7.4 Cell feed mechanism

It is a mechanism in which seeds are collected and delivered by a series of equally spaced cells on the periphery of a circular plate or wheel. This mechanism is also used for precise control of seed rate (Michael and Ojha, 1996). The percentage of damaged seeds increases as the cell speed is increased (Kepner *et al.*, 1987).

2.7.5 Brush feed mechanism

It is a mechanism in which a rotating brush regulates the flow of seeds from the hopper. A number of bullock drawn planters in the country have brush feed mechanism. It is not suitable for hill dropping as the discharge of seeds is continuous.

2.7.6 Auger feed mechanism

This mechanism consists of an auger which causes the seeds to flow evenly in the field through an aperture at the base or on the side of hopper. Only continuous flow of seed is obtained by this mechanism.

2.7.7 Picker wheel mechanism

In this mechanism a vertical plate is provided with radially projecting arms which drop the larger seeds like potato in furrows with the help of suitable jaws (Fig. 2.9). This mechanism is used in automatic potato planter. There is no evidence of the use of this type of mechanism in seed drills for cereals.

2.7.8 Star wheel mechanism

It is a feed mechanism which consists of a toothed wheel, rotating in a horizontal plane and conveying the fertilizer through a feed gate below the star wheel (Fig. 2.10). This

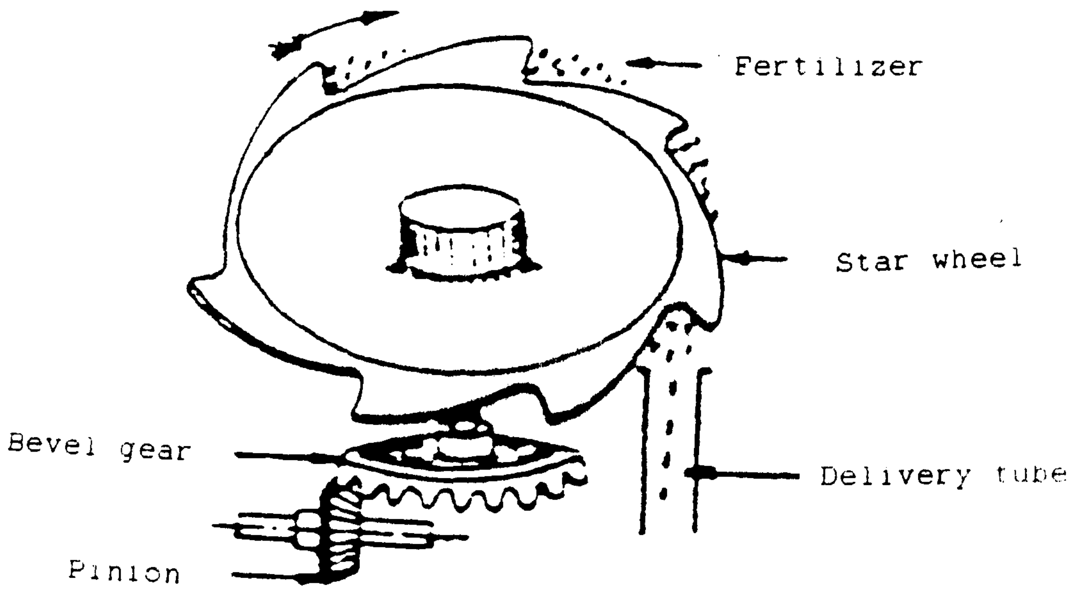


Fig. 2.10 Star wheel mechanism (Srivastava, 1990)

mechanism is commonly used in fertilizer drills. Though this mechanism is capable of distributing seeds, evidences on its uses in seed drills are not seen.

The review of the literature on seed metering mechanisms lead to the selection of a cup feed mechanism for use in the dibbler under study, because of its apparant advantages.

2.8 Testing of sowing machines

Patterson (1963) proposed a detailed test procedure for seed sowing machines. It includes testing for stationary metering calibration, assessment of seed damage, segregation and spacing. Field testing was carried out to assess the quality and rate of work, ease of operation and adjustment, power requirement and suitability of construction.

CIAE (1979) prepared a test code for testing and evaluating planting machines based on the Indian Standard Test Code (IS: 6316-1971) and the Test Codes followed by the different ICAR sponsored organization.

The review of literature carried out in this study lead to the conclusion that the jab type dibblers developed so far though have specific advantages are still inadequate in meeting the requirements in the field of sowing paddy due to the drawbacks exists in them. Considering the fact that the jab type dibbler developed by Jayarajan (1996) is comparatively better, it was choosen in this study for further modification and evaluation. The details of materials and methods used in this study are presented in the next chapter.

Materials and Methods

MATERIALS AND METHODS

This chapter deals with design, fabrication and performance evaluation of the power operated jab type paddy dibbler.

According to the Package of Practices (1993) of KAU, the seed rate recommended for dibbling in farmers fields, on the basis of a minimum germination of 80 per cent, is 80-90 kg/ha. The row to row and hill to hill spacing adopted by the farmers in dibbling medium duration varieties of paddy (viz., Aswathy, Jayanthi etc.) are 20 cm and 15 cm respectively for the first crop. These are 20 cm and 10 cm respectively for the second crop. For the short duration varieties, these spacings are 15 cm and 10 cm for both the first and second crops. The number of seeds dibbled in each hill is 4-6.

The dibbler under study was developed to take care of the needs of the medium duration varieties. As it was difficult to vary the hill to hill distance in the dibbler to suit the first and second crops, the distance of 20 cm which otherwise is the common row to row distance was adopted as the hill to hill distance. Correspondingly the row to row distance can be changed to 15 cm or 10 cm.

Based on this criteria, a power operated jab type paddy dibbler was designed and developed at the Kelappaji College of Agricultural Engineering and Technology, Tavanur.

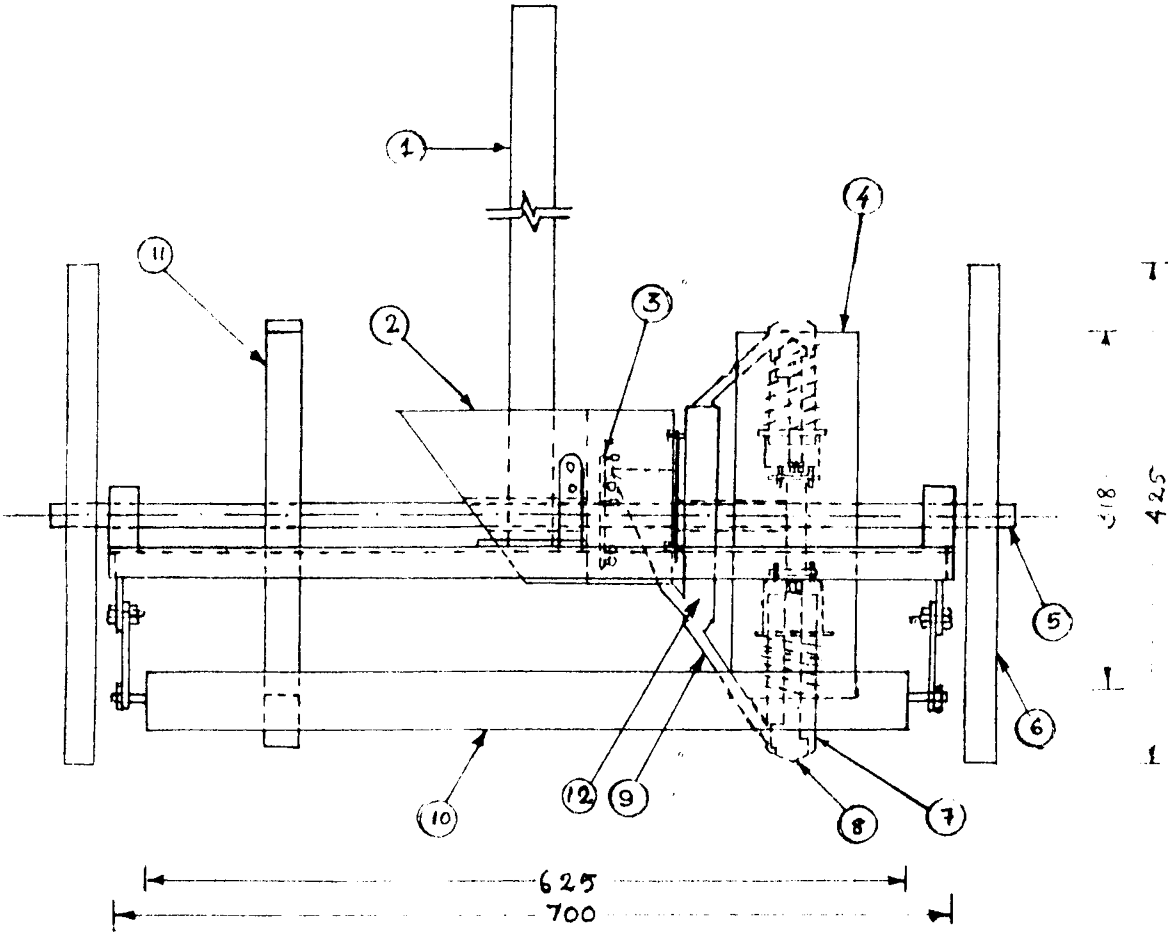
3.1 Constructional details

Major components of the paddy dibbler developed were; seed box, seed metering mechanism, seed transfer tube, seed tube with plunger, dibbler wheel, dibbling mechanism, frame, supporting wheel, covering device, transport wheel, and hitch arrangement. The general layout of the machine is shown in Fig. 3.1 - 3.3

3.1.1 Seed box

Seed box was used to store the seed during operation. It was made up of GI sheet of 20 gauge thickness. Capacity of the seed box was calculated (Appendix A). Accordingly, the volumetric capacity of seed box was 1.5 X $10^{-3} m^3$ which accommodated at an average of 1.2 kg of seed.

It had two compartments, a grain box and a feed box (Fig 3.4). Paddy was put in the grain box and allowed to flow into the feed box through the slot at the bottom of the divider wall between the two boxes. The area of opening could be varied by adjusting the vertical plate that separated the grain box and the feed box.



1. Hitch arrangement
2. Seed box
3. Cup feed mechanism
4. Dibbler wheel
5. Shaft
6. Transport wheel
7. Seed tube
8. Plunger
9. Seed transfer tube
10. Covering device
11. Supporting wheel
12. Distribution wheel

Scale 1: 6
All dimensions in mm

Fig. 3.1 Rear view of the jab type paddy dibbler

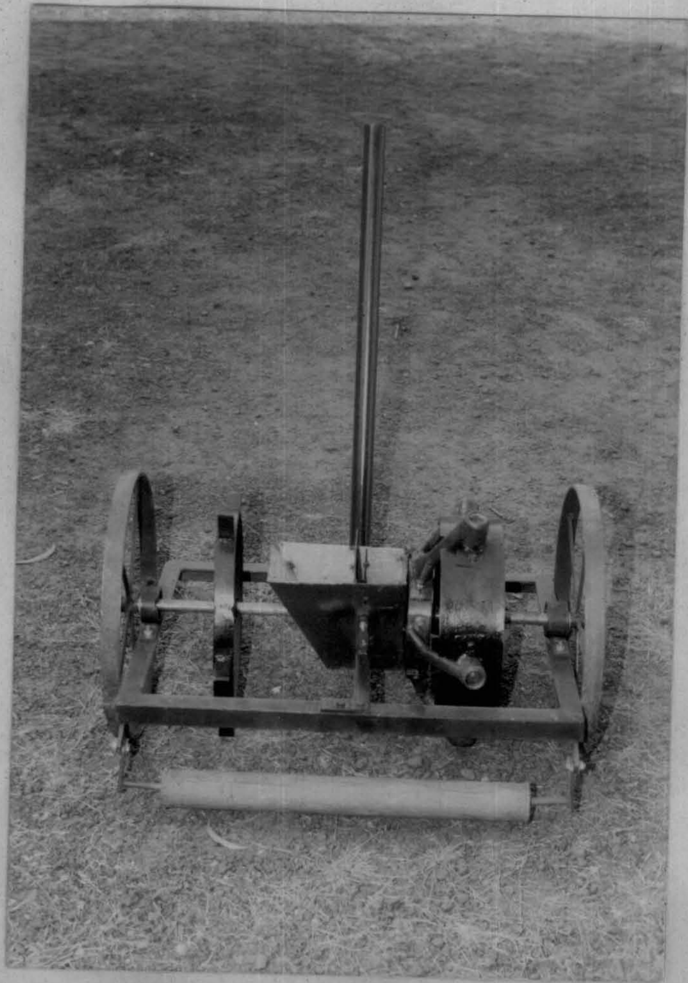


Plate 3.1 Front view of the jab type paddy dibbler

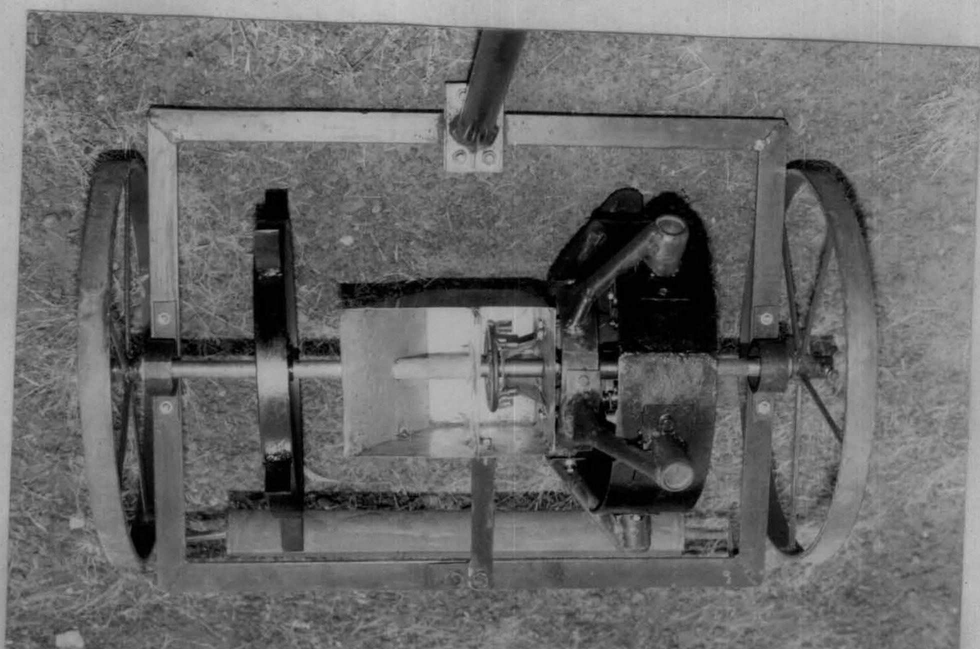
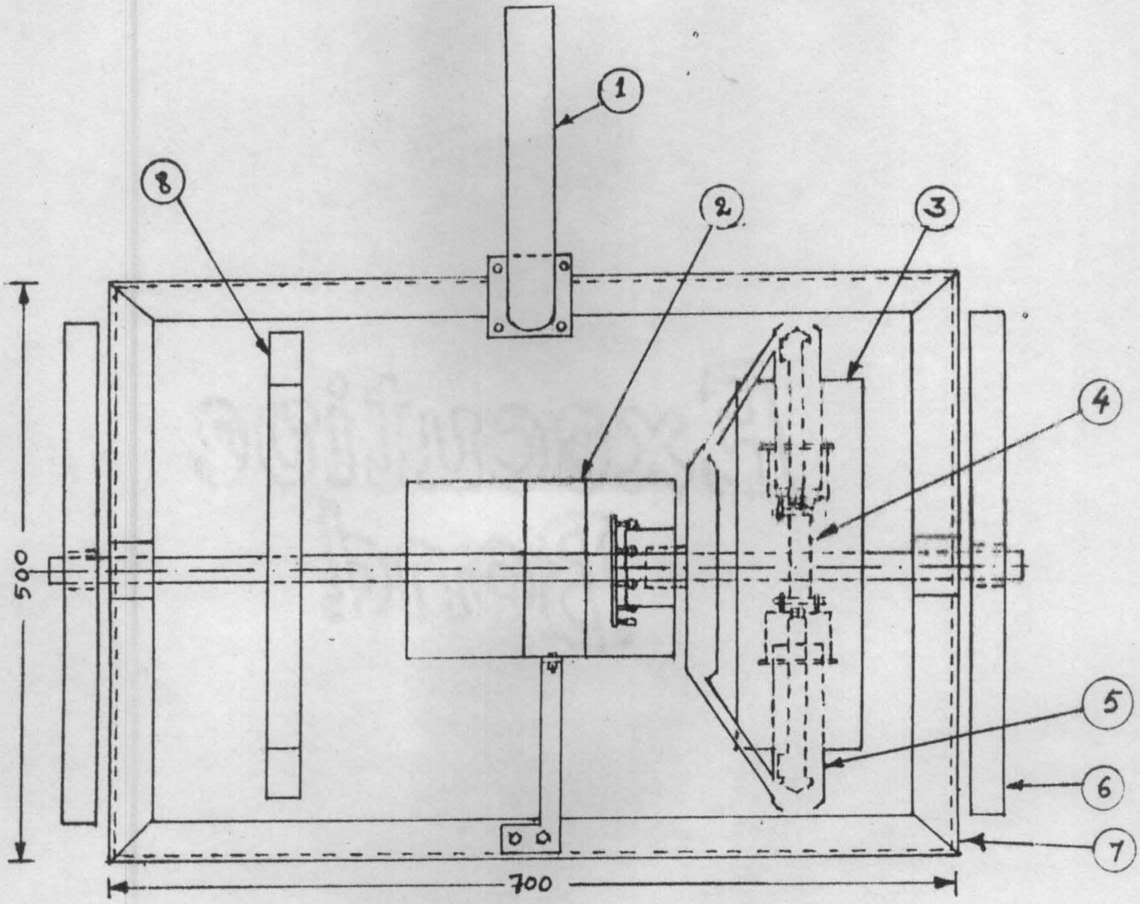


Plate 3.2 Top view of the jab type paddy dibbler



1. Hitch arrangement
2. Seed box
3. Dibbler wheel
4. Cam
5. Seed tube
6. Transport wheel
7. Frame
8. Supporting wheel

Scale 1: 6
All dimensions in mm

Fig. 3.2 Top view of the jab type paddy dibbler

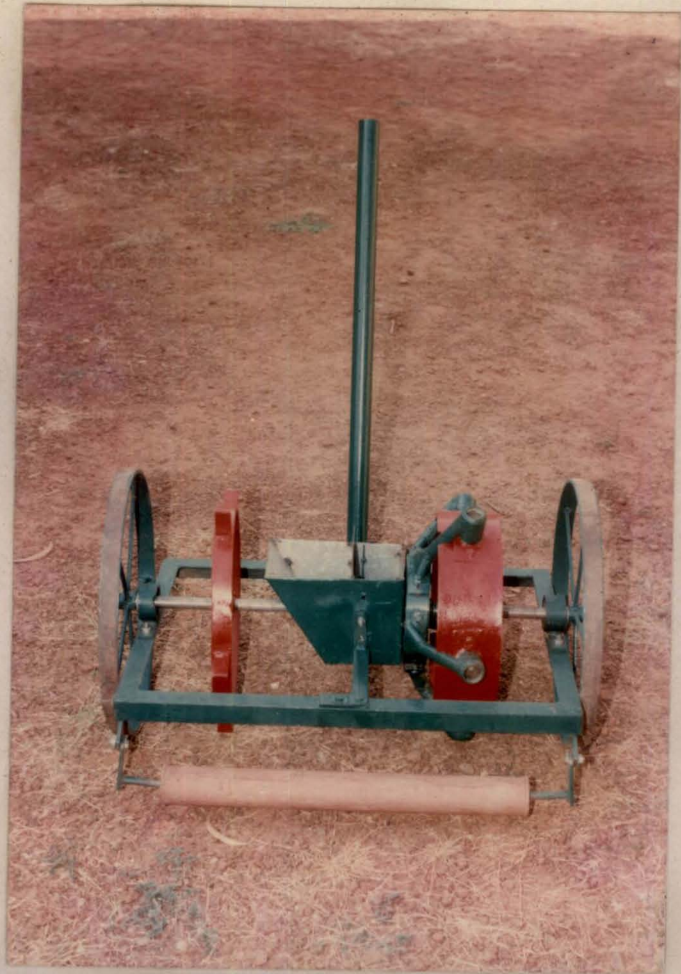


Plate 3.1 Front view of the jab type paddy dibbler

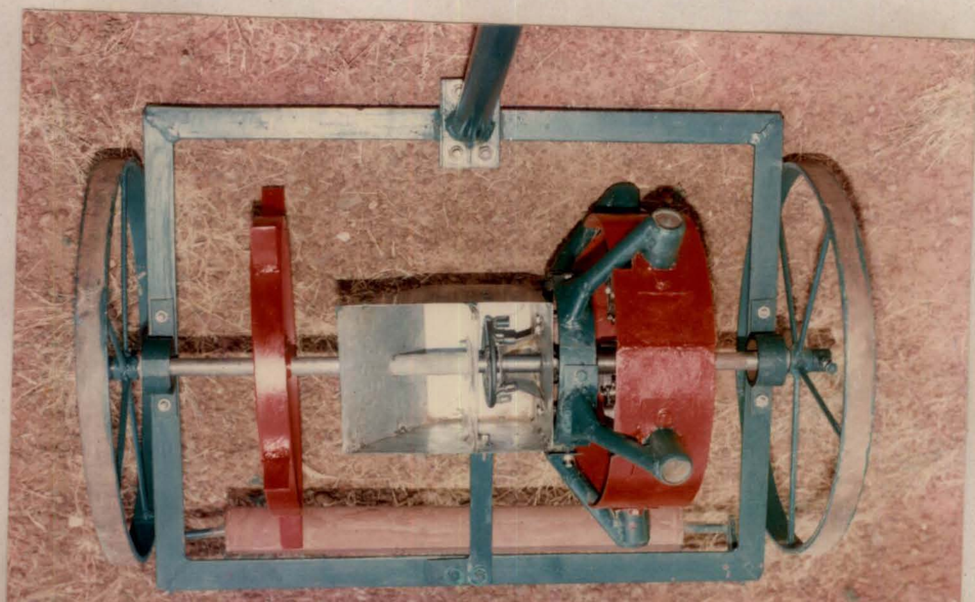


Plate 3.2 Top view of the jab type paddy dibbler

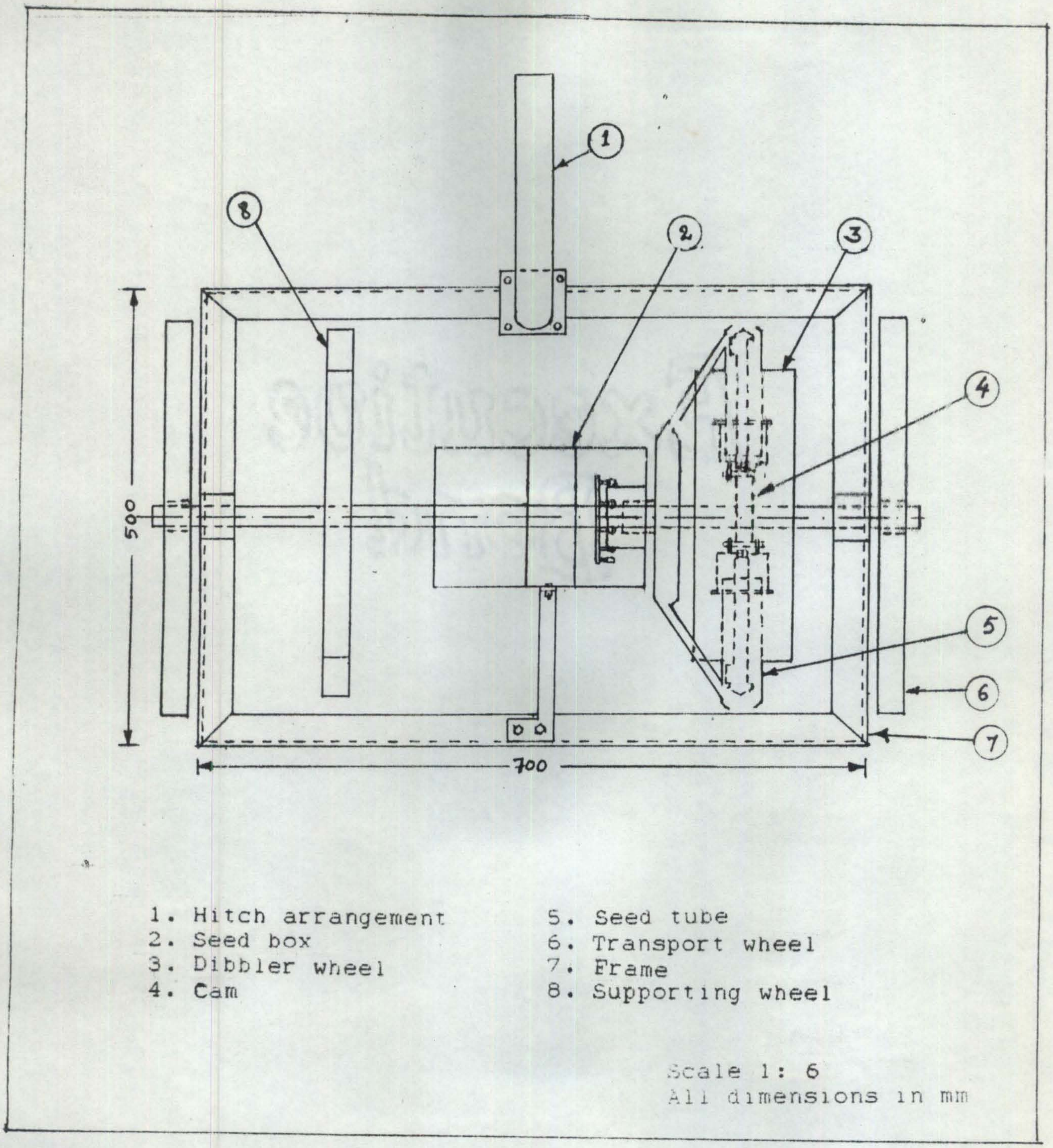


Fig. 3.2 Top view of the jab type paddy dibbler

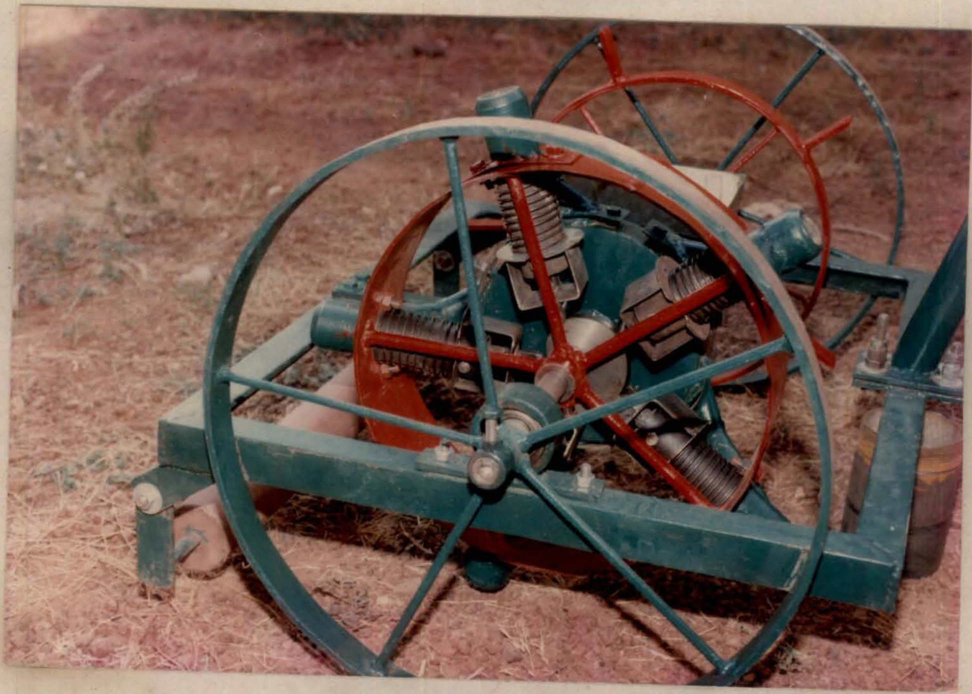


Plate 3.3 Side view of the jab type paddy dibbler

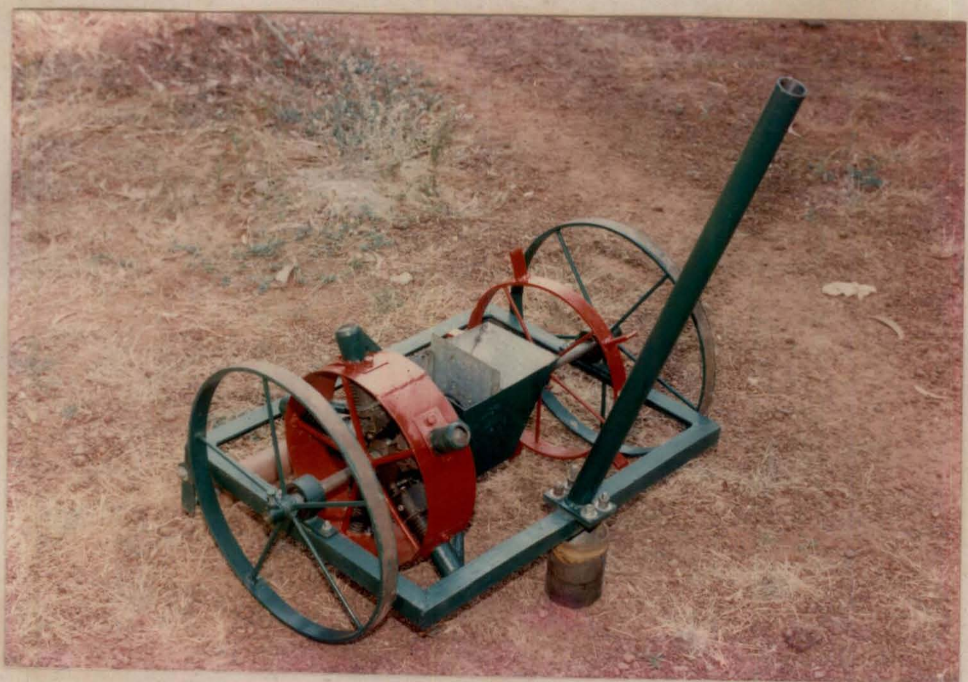
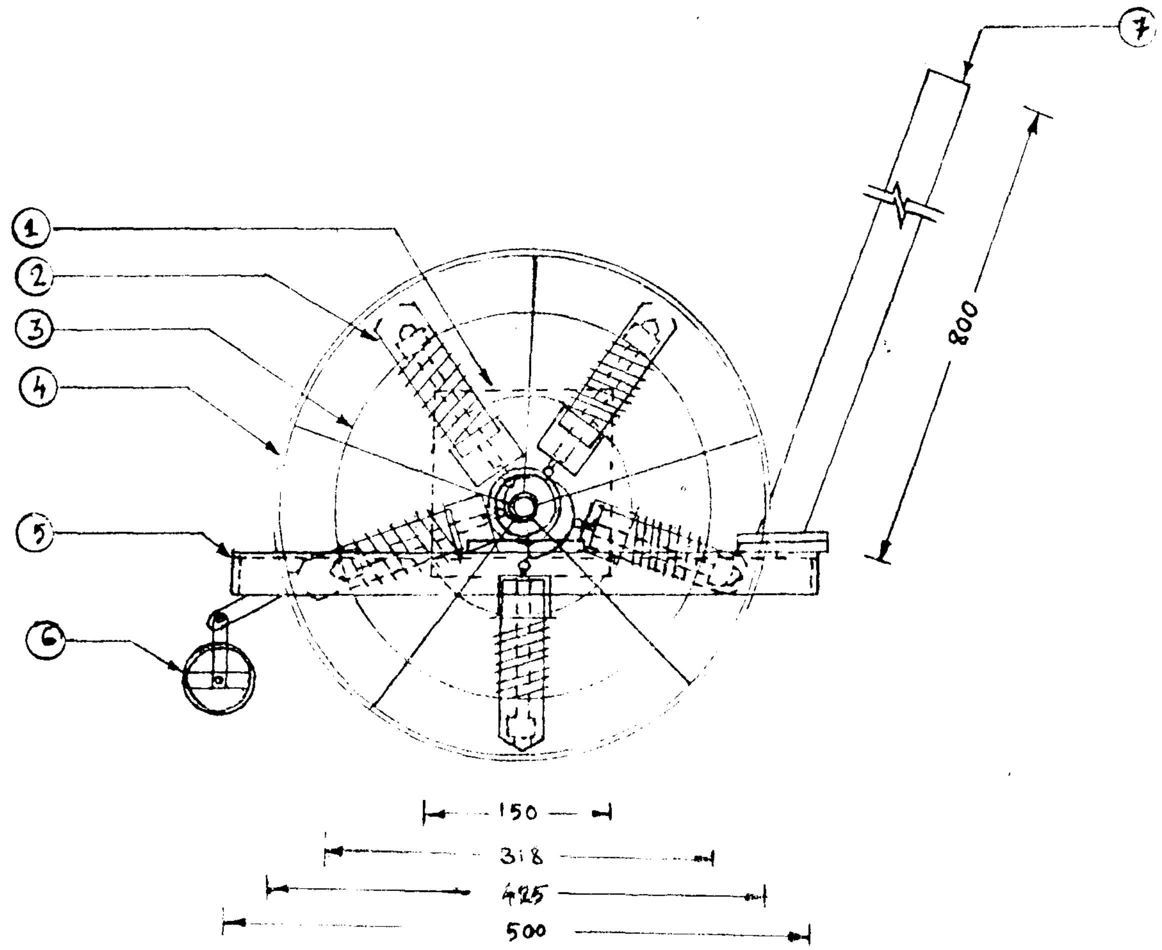


Plate 3.4 Overall view of the jab type paddy dibbler



1. Seed box
2. Seed tube
3. Dibbler wheel
4. Transport wheel
5. Frame
6. Covering device
7. Hitch arrangement

Scale 1:6
All dimensions in mm

Fig. 3.3 Side view of the jab type paddy dibbler

The seed box had a height, 150 mm, and width, 150 mm. The grain box was 150 mm high, 150 mm wide, 150 mm long at the top and 50 mm long at the bottom. The feed box had a length, 70 mm, width, 150 mm and height, 150 mm. The seed box was fixed to the frame.

3.1.2 Seed metering mechanism

As stated earlier, the cup feed type metering mechanism was selected for use in the dibbler under study. Seed metering was done by means of five cups, mounted on a circular disc at equal intervals. Diameter of the circular disc was fixed as 90 mm and it rotated inside the feed box about the shaft.

The size and shape of cup or spoon were such that it could hold 4-6 paddy seeds at a time. The dimensions of the cup were fixed by trial and error method. The pick-up chamber or cup was channel shaped with semi-circular cross-section so as to facilitate the seed pick-up from the bottom of the chamber. The cups measured 9 mm long, 3mm wide, and 1.5 mm high.

3.1.3 Distribution wheel

The seed metered from the hopper was delivered into the distribution drum or wheel which rotated along with the dibbler wheel. The wheel was made from MS flat and the inner surface of the wheel was made smooth for easy sliding of the

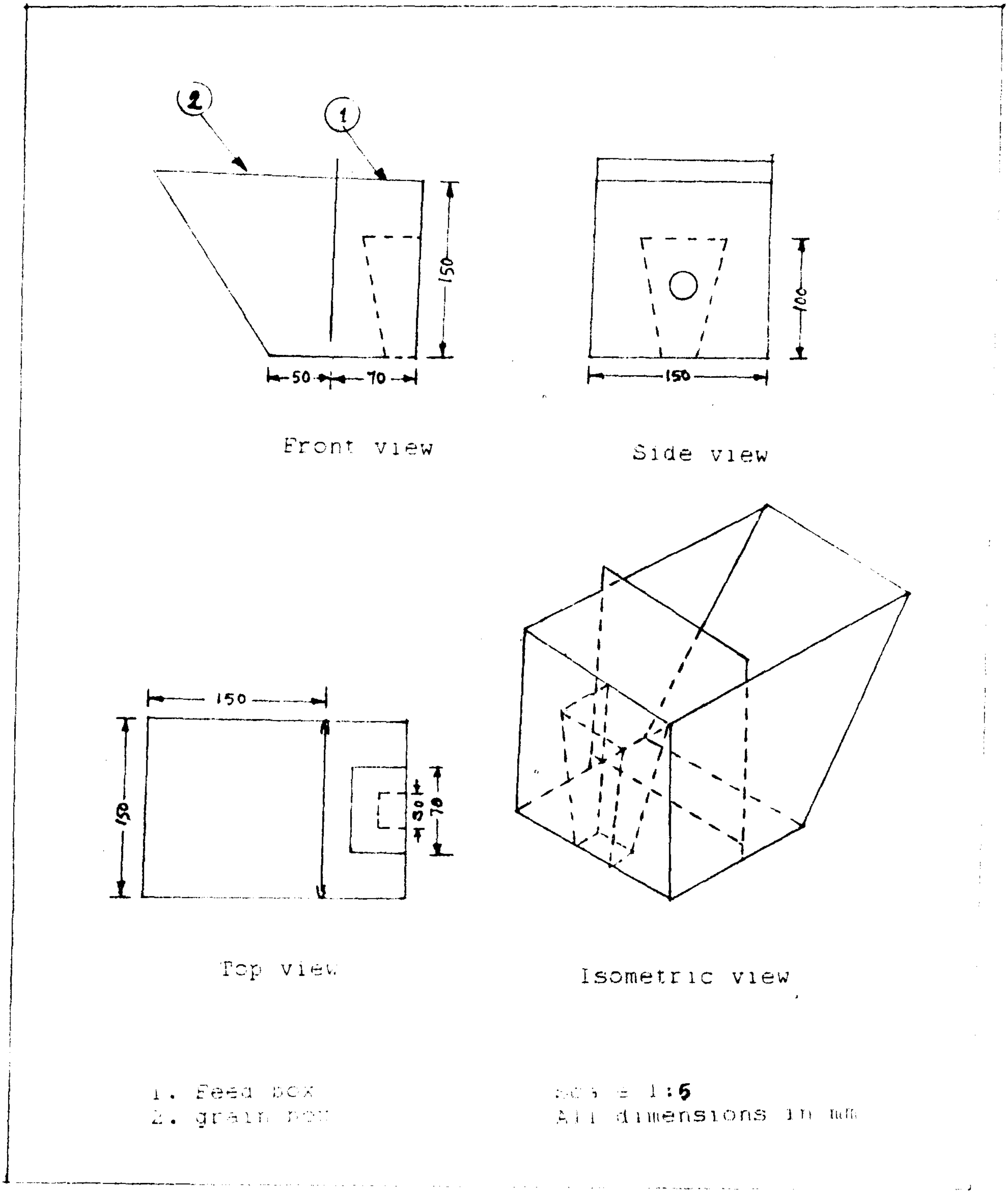


Fig. 3.4 Seed box

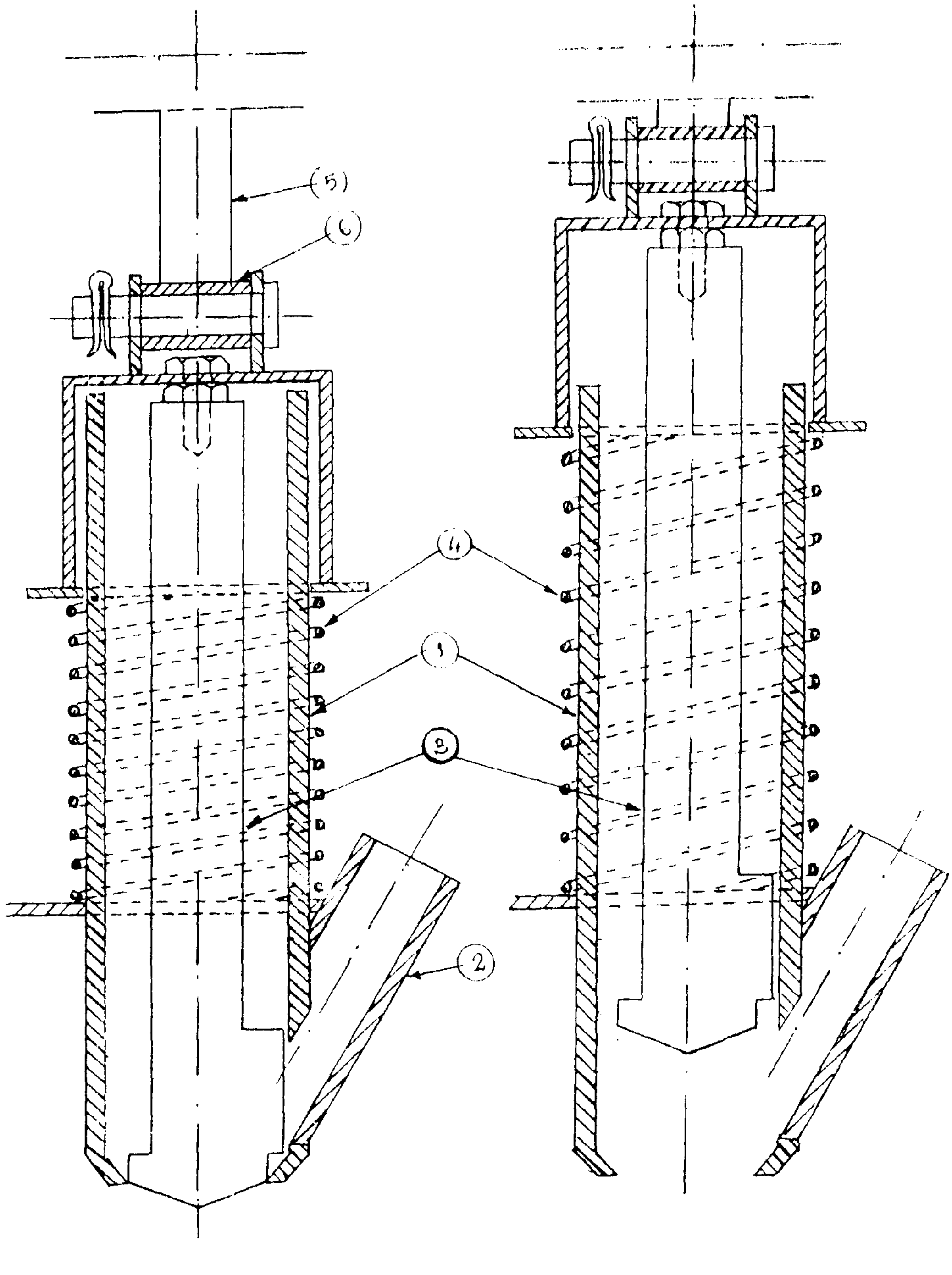
seed. One side of the wheel was covered by using GI sheet. It had a diameter of 180 mm with five openings on the periphery. Each opening was connected to the seed tube through a seed transfer tube. The opening had a rectangular shape and the dimensions was 50 mm long and 20 mm wide. The opening was large enough to provide easy entry for the seed into the seed transfer tube from the distribution wheel.

3.1.4 Seed transfer tube

This tube connected the distribution drum to the seed tube. One end had rectangular shape and other circular. It had a total length of 130 mm.

3.1.5 Seed tube with plunger

The dibbling unit consisted of a plunger moving to and fro inside the seed tube (Fig. 3.5). Seed tube was made up from MS pipe having 32 mm diameter. The seed entered the seed tube at a height of 5 mm. It had a total length of 145 mm. At the bottom end, it had a diameter of only 25 mm which allowed the dibbling unit to penetrate the soil easily. The plunger (Fig.3.7) was made from MS pipe having outer diameter 16 mm. The lower portion of the plunger was specially designed. The maximum radius of the plunger unit was 16 mm at a height of 10 mm and this portion prevented the entry of seed from the seed transfer tube to the seed tube when the plunger was at the lowest position. Top of the plunger was connected to a



1. Seed tube
2. Seed transfer tube
3. Plunger
4. Spring
5. Cam
6. Roller follower

Scale 1:1.3
All dimensions in mm

Fig. 3.5 Seed tube with plunger

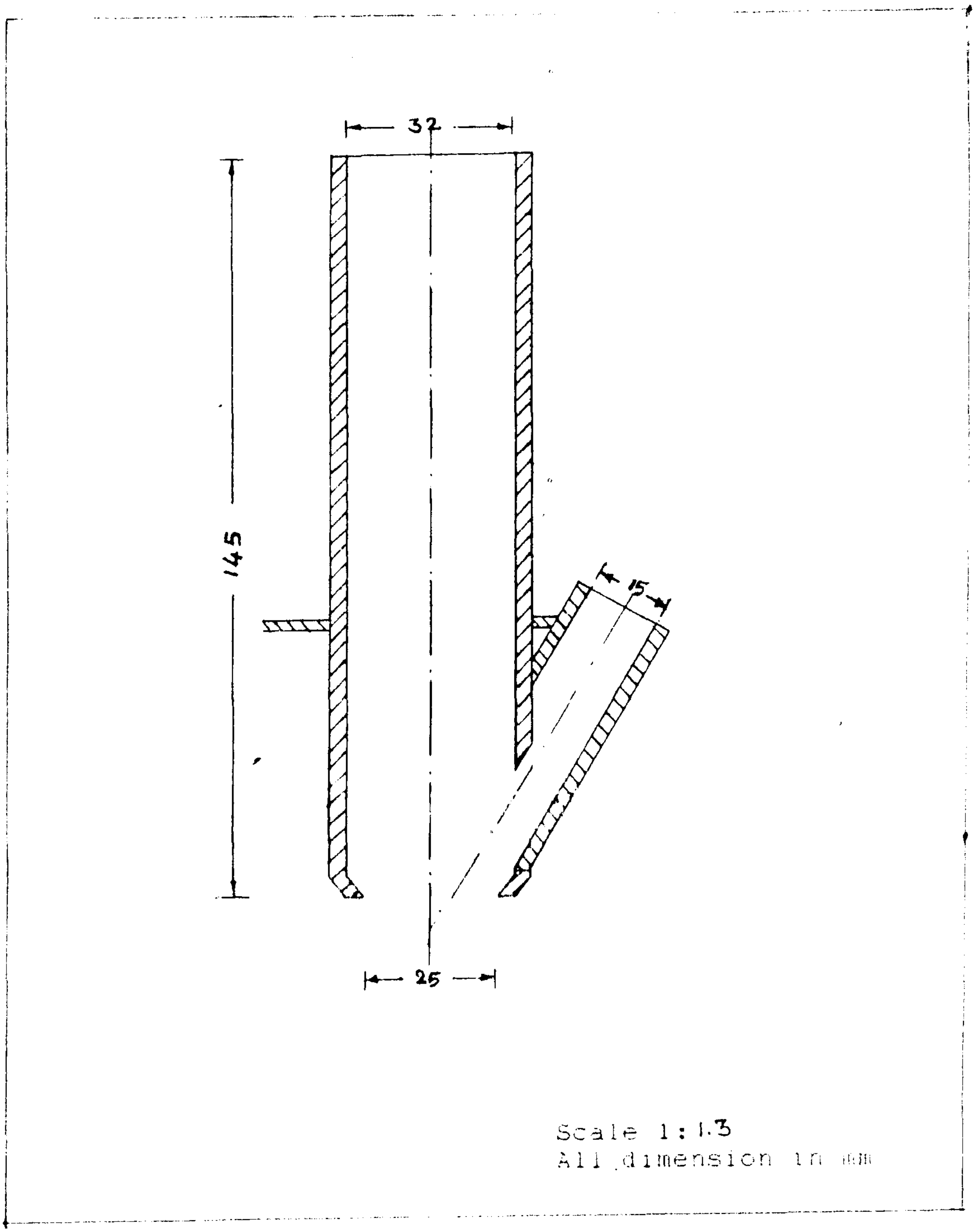


Fig.3.6 Cross-section of seed tube

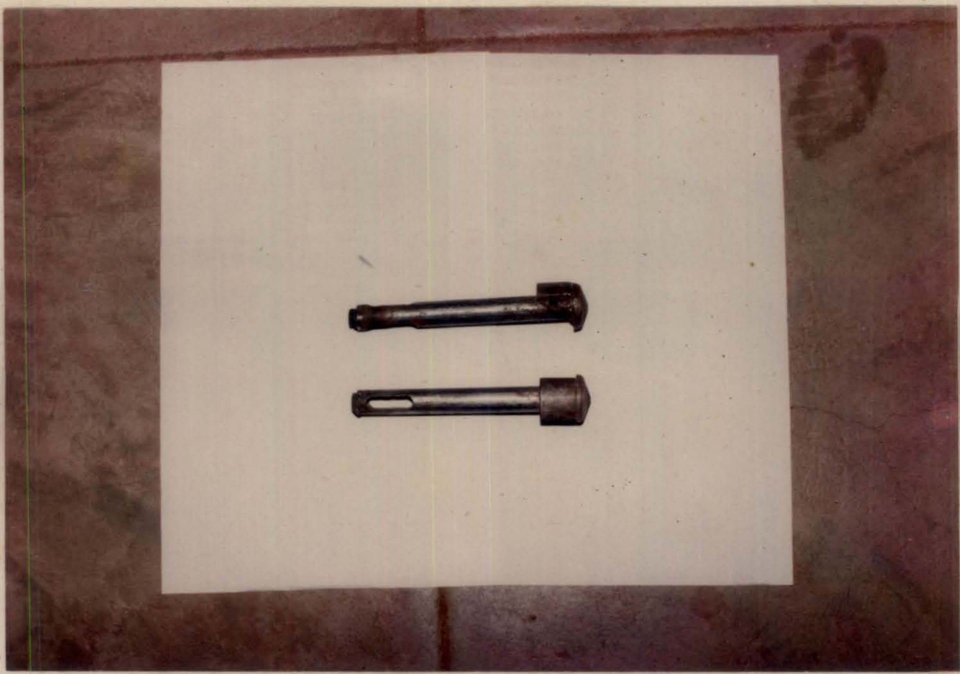


Plate 3.5 Plungers

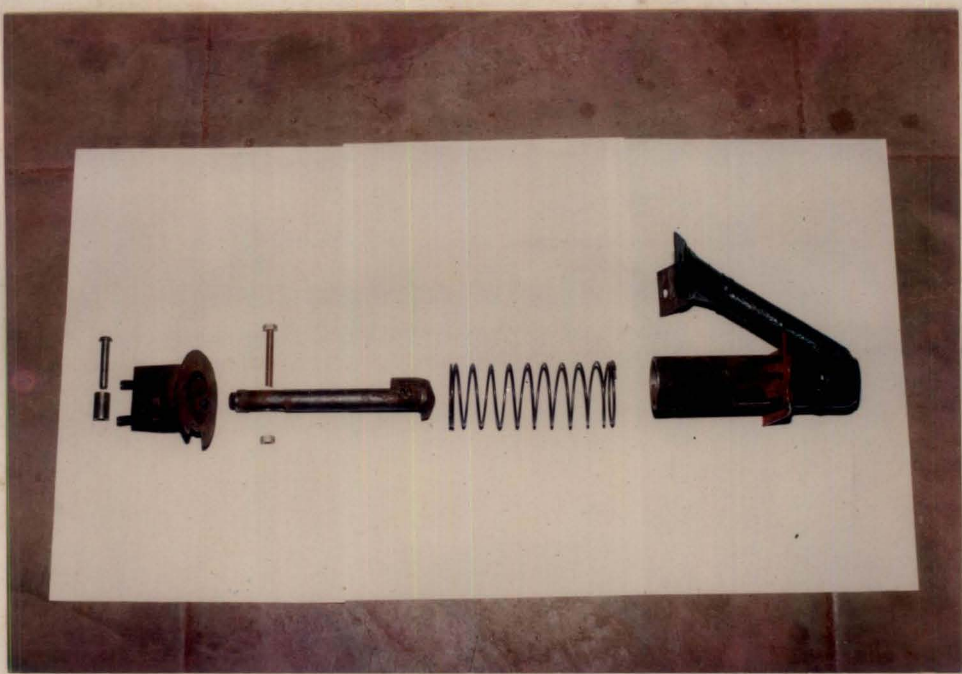


Plate 3.6 Exploded view of the dibbling unit

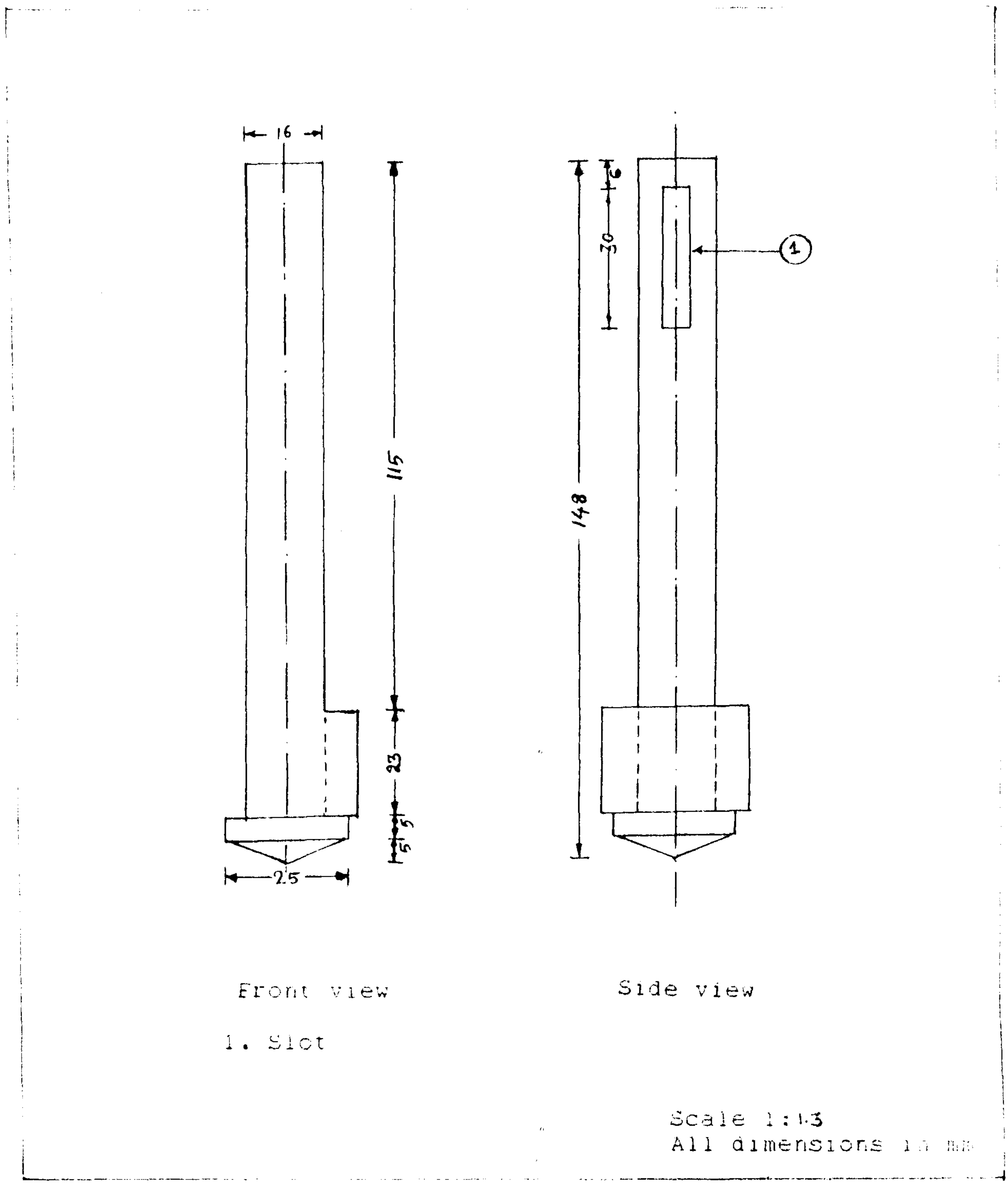


Fig. 3.7 Plunger

roller follower. The plunger was spring loaded. The spring was placed around the seed tube. Internal diameter of the spring was 40 mm. A circular disc attached to the cap acted as a stopper for the spring.

The seed tube along with the plunger acted as a solid shaft when the plunger was at the bottom most position. This helped to make holes in the soil. After making the holes, the plunger was raised and this uncovered the opening in the seed tube and the seeds were transferred from the seed transfer tube to the seed tube then into the hole made in the soil. The plunger was actuated by means of a cam and roller follower arrangement.

3.1.6 Dibbler wheel

The dibbler wheel was made from 12 gauge MS sheet. Five dibbling units were fixed radially on the dibbler wheel at a spacing of 20 cm. So, the diameter of the wheel was fixed as 318 mm and width was 100 mm. The dibbler wheel along with seed tube and plunger rotated about the cam. During operation, the distribution wheel was also rotated with this dibbler wheel.

3.1.7 Dibbling mechanism

Dibbling units, seed tube and plunger were mounted on the periphery of the dibbler wheel. The dibbling action of the plunger was obtained by means of a mango cam and roller

Plate 3.7 Cam

Plate 3.8 Jab type paddy dibbler with power-tiller in operation

follower arrangement. The cam was made of MS rod and was mounted on a hollow shaft which was fixed on the seed box. It was designed in such a manner that the maximum lift of the plunger was 30 mm. The width of the cam was 12 mm (Appendix B).

Due to the special design of cam, the seed transfer tube opened 20° before the plunger fully penetrated the soil. Then the cam slowly pushed down the plunger and the seed transfer tube was fully closed at 270° and remained there in the dwell position upto 340°.

The roller follower was fixed on top of the plunger and was spring loaded. Since a rolling motion take place between the contacting surfaces, the rate of wear was greatly reduced. The diameter of the roller follower was 12 mm. A "C"-shaped cap provided over the plunger prevented the deposition of soil on the cam surface.

3.1.8 Supporting wheel

A supporting wheel was made of MS flat of 35 mm X 5 mm size to balance the dibbler while in operation and was mounted on the shaft. This was required because the dibbler had only one dibbler wheel. The diameter of this wheel was the same as that of the dibbler wheel (Fig.3.2). Five pegs were provided on the periphery of wheel at a spacing of 20 cm and which was the same as that of the spacing between the dibbling units in the dibbler wheel. The length of each peg was 50 mm.

3.1.9 Frame

The frame was made by using MS angle of 35 mm X 35 mm X 3 mm size. Length of the frame was 700 mm and width, 500 mm. The dibbler units were firstly mounted on a shaft made of MS rod. The diameter of the shaft was 20 mm and length 800 mm. The shaft was then fixed on the frame by using a pair of bearings (6204 ZZ). The seed box was fixed to the frame by using nuts and bolts.

3.1.10 Transport wheel

Two transport wheels were provided on both ends of the shaft, and were used for transporting purpose. These wheels were removed before the dibbler was operated in the field. The wheels were made from MS flat having 35 mm X 5 mm size and had a diameter of 425 mm. Five spokes were provided for supporting the wheel.

3.1.11 Covering device

It was a device to refill the hole with soil after the seed had been placed in it. It consisted of a freely rotating hollow GI pipe of diameter 50 mm. It had a length of 600 mm. It was attached to the frame on the rear side.

3.1.12 Hitch arrangement

Hitch arrangement was made from a hollow pipe of length 800 mm and 40 mm diameter. It was mounted on the main frame at an angle of 70 degree. It was made to connect the dibbler with the rear wheel socket of a power-tiller.

The specifications of the dibbler are given in Appendix-G.

3.2 Testing of the machine

The dibbler was tested both in the laboratory and in the field for evaluating its performance.

3.2.1 Laboratory test

The paddy dibbler was tested under laboratory conditions by metering paddy for uniformity of distribution, mechanical damage to the seeds, and seed rate. The paddy variety used for testing was Kanchana.

3.2.1.1 Calibration

The main objective of this was to evaluate the performance of the metering mechanism.

The dibbler was kept in a level surface and the seed box was filled with paddy. Then the dibbler wheel was rotated for 5 revolutions and the seed dropped through the seed tube was collected and counted. This was repeated 10 times. The seed rate was calculated as shown in Appendix C.

3.2.1.2 Seed distribution

For determining the seed distribution under laboratory condition, the dibbler wheel was turned manually, after filling the seed box with paddy and the seeds dropped through each seed tube was collected and counted. This was repeated for 20 revolutions. From the data collected, SD, CV and average number of seeds/hill were calculated.

3.2.1.3 Mechanical damage

Mechanical damage was assessed by both the visual observation and the germination test.

3.2.1.3.1 By visual observation

In this test, the dibbler wheel was rotated and the seeds were allowed to drop from each seed tube. After steady state was achieved, the seeds dropped from each seed tube in one rotation was collected. This was repeated 20 times. The total number of seeds and number of damaged seeds in each sample were noted and the percentage of damaged seeds was calculated.

3.2.1.3.2 By germination

A sample of 50 seeds from the original seed sample, i.e. before the test was taken and tested for its germination capacity. Then, a sample was taken from the metered seeds and tested for determining the percentage of germination. From the two values, percentage deviation was also found out.

3.2.2 Field test

Field performance test was conducted to obtain actual data on overall machine performance. Field evaluation included seed distribution, seed rate, labour requirement, power requirement, and cost of operation. The field selected was a regular paddy field in the instructional farm of KCAET, Tavanur. This field is located in sandy loam belt located on the left bank of the Bharathapuzha. The experiments were carried out in the period March 1997. The second crop of the year had been harvested in the month of January 1997. The field was prepared using a power-tiller with rotavator unit twice. Bulk density of the soil varied from 1.8 to 1.85 g/cm^3. This is in agreement with the value reported by Mary (1992).

In order to conduct various field tests except the test for power requirement the dibbler was hitched to a power-tiller through its tail wheel socket and operated in the field. While measuring the draft requirement in the determination of power requirement the dibbler was pulled manually.

3.2.2.1 Seed rate

The dibbler was operated in the prepared field for 15 m length at four different speeds, i.e. 0.788, 1.152, 1.530 and 1.778 km/h. The length of 15 m could give the data for 10 revolutions at steady state condition. The number of seeds dropped through each seed tube was counted by digging out the seeds. The seed rate was then calculated from using Equation (4) in Appendix C.

3.2.2.2 Seed distribution

The dibbler was operated in the prepared field for 15 m length without the covering device. The number of seeds dropped from each seed tube was noted by digging out the seeds. From the values obtained, the average number of seeds/hill, SD and CV were calculated. The number of missing hills was also noted. This was repeated for four different speeds of operation.

3.2.2.3 Depth of placement

Depth of placement was measured after operating the dibbler in the field without the covering device. The depth of placement of seeds for each hill was measured from the ground surface using a scale as in a depth gauge. Average depth of placement was then calculated. This was repeated for the four different speeds. For each speed 10 readings were taken.

3.2.2.4 Germination percentage

The number of plants emerged was counted and then seeds not germinating and emerging in the soil were dug out and counted in each 1 m length of the rows in one run. It was done at a stage when almost all the plants had grown upto 3 leaves. Ten sampling areas were selected.

$$\text{Germination percentage (\%)} = \frac{E}{N+E} \times 100 \quad \ldots\ldots (3.1)$$

where

E = Number of established plants in a sample area

N = Number of non-emerged seeds in a sample area

3.2.2.5 Power requirement

The power requirement was calculated using the equation

$$hp = \frac{\text{Draft (kg)} \times \text{Speed (m/s)}}{75} \qquad \ldots\ldots (3.2)$$

The draft requirement was measured using a spring dynamometer (Range 0-50 kg, accuracy - 0.2 kg). One end of the spring dynamometer was attached to the hitch pipe and the other end to a cross-bar which was pulled manually. As the dynamometer reading was not constant, the maximum and minimum values were noted and the average draft was determined and recorded. The average speed was determined by noting the time taken by the dibbler in travelling a distance of 15 m. A stop watch was used to record the time. The draft was measured at 5 different speeds.

3.2.2.6 Labour requirement

The labour requirement is the number of man-hours used to cover one hectare of effective field area. The labour requirement was determined from the number of labourers used and the effective field capacity.

3.2.2.7 Economic analysis

The cost of operation of the jab type paddy dibbler was calculated. This cost included fixed cost and variable cost. Fixed cost included depreciation, interest on the capital, housing, and insurance charges. Operating cost included the repair and maintenance, and wages. The annual use and average life of the equipment were taken as 250 hours and 10 years respectively. For calculating the depreciation, the salvage value was taken as 10% of the capital. The capital cost included the material and the fabrication cost.

For power-tiller, the annual use and average life of the equipment were taken as 800 hours and 10 years respectively. The fixed cost included depreciation, interest on the capital, insurance and housing charges. Operating cost included repair and maintenance, fuel cost, oil cost and labour charge.

The cost of mechanical dibbling using the jab type paddy dibbler was also compared with the cost of manual dibbling to study the economic feasibility of the machine.

Results and Discussion

RESULTS AND DISCUSSION

Results of the various tests conducted both in the laboratory and in the field are presented and discussed under the following major heads in this chapter:

1. Calibration of dibbler
2. Uniformity in seed distribution
3. Mechanical damage
4. Depth of placement
5. Germination percentage
6. Power requirement
7. Labour requirement
8. Economic analysis

4.1 Laboratory test

Tests were conducted in the laboratory to calibrate the dibbler and also to evaluate the uniformity in the distribution of seeds in each of the hills formed by the dibbler. In addition, the mechanical damage caused to the seeds while in operation was evaluated and is presented below.

4.1.1 Calibration of dibbler

Results of the calibration test conducted in the laboratory are presented in Table 4.1. It is seen that the

Table 4.1 Calibration details of seed dibbler (Laboratory test)

Variety of paddy : Kanchana

Trial No.	No. of seeds dropped in 5 revolutions	Seed rate (kg/ha)
1	138	86.48
2	147	92.20
3	131	82.09
4	136	85.23
5	145	90.86
6	140	87.73
7	144	90.24
8	135	84.60
9	137	85.85
10	142	88.98
Total	1395	
Average seed rate		87.50
Maximum seed rate		92.20
Minimum seed rate		82.09
SD		2.60
CV (%)		2.97

mean seed rate of 87.5 kg/ha is well within the seed rate of 80-90 kg/ha recommended by the Package of Practices (1993). The results also show that in three cases, the seed rates obtained were marginally more than the range recommended by the Package of Practices (1993). The seed rate varied from 82.09 to 92.20 kg/ha. This is because of the imperfections and the random behaviour of the seed metering mechanism. Some times the cups carried more than 6 seeds and in a few cases it carried less. However, in 70 per cent of the cases, the seed rate was well within the recommended range.

4.1.2 Uniformity in seed distribution

The number of seeds in each hill was counted for determining the uniformity in seed distribution by each seed tube. The results are shown in Table 4.2. The average rate of 5.6 seeds/hill is well within the range of the 4-6 seeds/hill recommended by the Package of Practices (1993). The average number of seeds/hill for each rotation and for all the seed tubes in the wheel varied from 4.8 to 6.4. The higher average of the number of seeds/hill obtained in few cases are because of the random behaviour of the system. The average number of seeds/hill for each seed tube for 20 revolution was also obtained. The average number of seeds dropped by the fourth and fifth seed tubes, viz. 6.75 and 6.5 respectively are more than the recommended rate of 4-6 seeds/hill. This is also due to the random behaviour of the

Table 4.2 Seed distribution from seed tubes based on single rotation (Laboratory test)

Variety of paddy : Kanchana.

Rotation No.	No. of seeds dropped					Average No.of seed/ hill	SD
	1st seed tube	2nd seed tube	3rd seed tube	4th seed tube	5th seed tube		
1	5	4	6	6	9	6.0	1.67
2	6	5	3	6	4	4.8	1.17
3	8	4	3	7	5	5.4	1.85
4	5	2	3	10	6	5.2	2.78
5	6	4	3	8	6	5.4	1.74
6	5	3	5	7	9	5.8	2.03
7	7	4	6	5	6	5.6	1.02
8	4	6	5	9	7	6.2	1.72
9	6	4	5	5	8	5.6	1.36
10	4	5	5	6	6	5.2	0.77
11	5	3	4	10	6	5.6	2.42
12	4	6	7	9	6	6.4	1.63
13	5	4	6	7	7	5.8	1.17
14	6	3	5	6	7	5.4	1.36
15	5	7	6	5	6	5.8	0.75
16	6	6	5	6	8	6.2	0.98
17	5	5	7	6	6	5.8	0.75
18	4	5	4	5	6	4.8	0.75
19	4	5	7	6	7	5.8	1.17
20	7	5	6	6	5	5.8	0.75
Mean	5.35	4.5	5.05	6.75	6.5	5.6	
SD	1.11	1.14	1.33	1.58	1.25	0.48	
CV (%)	20.74	25.33	26.34	23.41	19.23	8.57	

system. The number of seeds/hill, when considering all the 100 hills varied between 2 and 10. In the cases of 31 hills this is outside the limits of the number of seeds/hill recommended by the Package of Practices (1993). This is mainly due to the imperfections in the construction of the metering mechanism and the random behaviour of the system. This can be overcome by using appropriate jigs and fixtures in the fabrication of the seed metering mechanism.

4.1.3 Assessment of mechanical damage

1) Visual observation

Mechanical damage was determined by visual observation in the laboratory. The mean of the percentage of seeds mechanically damaged is 0.89 with a SD of 1.94 and its CV is 218 per cent (Table 4.3). The mechanical damage is more in first and fifth seed tube whereas it is least in the fourth seed tube. There is no mechanical damage to seeds in the second and third seed tubes. The percentages of the number of seeds damaged in the Ist, 2nd, 3rd, 4th and 5th seed tubes are 1.87, 0, 0, 0.74 and 1.54 respectively. The mechanical damage caused to the seed by the machine is therefore only negligible. This reduction in mechanical damage is due to the fact that all the passages are fully open when the seeds are passing through them.

Table 4.3 Extent of mechanical damage to seeds based on visual observation (Laboratory test)

Variety of paddy : Kanchana

Trial No.	No. of seedsdropped in one rotation					Total No. of seeds dropped	No. ofseeds damaged in one rotation					Quantity of damaged seeds	
	1st	2nd seed	3rd tube	4th	5th		1st	2nd seed	3rd tube	4th	5th	No.	%
1	5	4	6	6	9	30	0	0	0	0	0	0	[illegible]
2	6	5	3	6	4	24	0	0	0	0	0	0	[illegible]
3	8	4	3	7	5	27	0	0	0	0	0	0	[illegible]
4	5	2	3	10	6	26	0	0	0	0	0	[illegible]	
5	6	4	3	8	6	27	1	0	0	0	1	2	[illegible]
6	5	3	5	7	9	29	0	0	0	0	0	0	
7	7	4	6	5	6	28	0	0	0	0	0	0	[illegible]
8	4	6	5	9	7	31	0	0	0	0	0	0	[illegible]
9	6	4	5	5	8	28	0	0	0	0	0	0	[illegible]
10	4	5	5	6	6	26	1	0	0	0	0	1	[illegible]
11	5	3	4	10	6	28	0	0	0	0	0	0	[illegible]
12	4	6	7	[illegible]	6	32	0	0	0	1	0	1	[illegible]
13	5	4	6		7	29	0	0	0	0	1	1	[illegible]
14	6	3	5	6	7	27	0	0	0	0	0	0	[illegible]
15	5	7	6	5	6	29	0	0	0	0	0	0	[illegible]
16	6	6	5	6	8	31	0	0	0	0	0	0	[illegible]
17	5	5	7	6	6	29	0	0	0	0	0	0	[illegible]
18	4	5	4	5	6	24	0	0	0	0	0	0	[illegible]
19	4	5	7	6	7	29	0	0	0	0	0	0	[illegible]
20	7	5	6	6	5	29	0	0	0	0	0	0	
Total	107	90	101	135	130	563	2	0	0	1	2	5	17.84
Mean	5.35	4.50	5.05	6.75	6.50	28.15	0.1	0.0	0.0	0.05	0.10	0.25	[illegible]
SD	1.11	1.14	1.33	1.58	1.25	2.02	0.3	0.0	0.0	0.22	0.3	0.54	1.94
CV (%)	20.74	25.33	26.34	23.41	19.23	7.18	300			440	300	216	218

2) Germination test

Germination percentage of seeds was tested in the laboratory. The average germination before metering was 74 per cent (Tables 4.4). The germination percentage of seeds, after metering, varied between 66 and 78 with mean at 70.8. The percentage deviation is 3.77 per cent. Therefore loss of viability due to mechanical damage is not large. This confirms the fact derived from visual observation that the mechanical damage caused to the seeds by this machine is negligible.

As this machine is intended for operations in the field, tests were carried out in the field. The results are presented below.

4.2 Field test

Tests were conducted, to find out the seed rate in the actual field at different speeds, uniformity in seed distribution, germination percentage, power required to operate the dibbler, labour requirement, and cost of operation. The results are presented below.

4.2.1 Seed rate

Tests conducted in the prepared field at four different speeds, viz., 0.788, 1.152, 1.530 and 1.778 km/h yielded

Table 4.4 Extent of mechanical damage to seeds based on germination (Laboratory test)

Variety of paddy : Kanchana

Trial No.	Total No. of seeds taken	Germination before metering (%)	Germination after metering (%)	Percentage deviation (%)
1	50	72	68	5.56
2	50	68	66	2.94
3	50	76	72	2.63
4	50	72	70	2.86
5	50	82	78	4.87
Mean	50	74	70.8	3.77
SD	0	4.73	4.11	1.20
CV (%)	0	6.39	5.81	31.83

average seed rates of 87.1, 74.6, 68.0 and 61.1 kg/ha (Tables 4.5 through 4.8).

At 0.788 km/h speed, the seed rates vary from 78.33 to 103.39 kg/ha (Table 4.5). The result show that the mean seed rate of 87.1 kg/ha achieved at this speed is close to the average seed rate of 87.5 kg/ha obtained in the laboratory tests. This also shows that the seed rate is well within the range of the 80-90 kg/ha recommended by the Package of Practices (1993).

Tests at a speed of 1.152 km/h yielded an average seed rate of only 74.6 kg/ha (Table 4.6). The seed rate vary from 81.47 to 65.8 kg/ha. The occurrence of a seed rate of 80 or 80 plus is only in a couple of cases out of the 10 repetitions. This shows that the speed of 1.152 km/h is not suitable for obtaining the recommended seed rate.

At 1.530 km/h the average seed rate was 68.0 kg/ha (Table 4.7). Results show that the mean seed rate is not within the recommended seed rate. The seed rate obtained vary from 53.27 to 90.86 kg/ha. Occurrence of the seed rate within the recommended rate was obtained only once out of the 10 tests.

Tests conducted at a speed of 1.778 km/h yielded an average seed rate of 61.1 kg/ha with a SD of 8.3 (Table 4.8). The seed rate obtained vary from 50.13 to 72.07 kg/ha. It is

Table 4.5 Seed rate at a speed of 0.788 km/h (Field test)

Variety of paddy : Kanchana

Trial No.	No. of seeds dropped	Seed rate (kg/ha)
1	27	84.60
2	27	84.60
3	32	100.26
4	26	81.47
5	25	78.33
6	31	97.13
7	25	78.33
8	25	78.33
9	33	103.39
10	27	84.60
Total	278	
Average seed rate		87.10
Maximum seed rate		103.39
Minimum seed rate		78.33
SD		9.05
CV (%)		10.39

Table 4.6 Seed rate at a speed of 1.152 km/h (Field Test)

Varity of Paddy : Kanchana

Trial No.	No. of seeds dropped	Seed rate (kg/ha)
1	24	75.19
2	21	65.80
3	21	65.80
4	24	75.19
5	25	78.33
6	23	72.07
7	26	81.47
8	24	75.19
9	26	81.47
10	24	75.19
Total	238	
Average seed rate		74.60
Maximum seed rate		81.47
Minimum seed rate		65.80
SD		5.20
CV (%)		0.97

Table 4.7 Seed rate at a speed of 1.530 km/h (Field test)

Variety of paddy : Kanchana

Trial No.	No. of seeds dropped	Seed rate (kg/ha)
1	21	65.80
2	23	72.07
3	22	68.93
4	29	90.86
5	20	62.67
6	27	84.60
7	17	53.27
8	18	56.40
9	22	68.93
10	18	56.40
Total	217	
Average seed rate		68.00
Maximum seed rate		90.86
Minimum seed rate		53.27
SD		11.56
CV (%)		17.00

Table 4.8 Seed rate at a speed of 1.778 km/h (Field test)

Variety of paddy : Kanchana

Trial No	No. of seeds dropped	Seed rate (kg/ha)
1	23	72.07
2	16	50.13
3	17	53.27
4	20	62.67
5	21	65.79
6	16	50.13
7	17	53.27
8	22	68.93
9	23	72.07
10	20	62.67
Total	195	
Average seed rate		61.10
Maximum seed rate		72.07
Minimum seed rate		50.13
SD		8.30
CV (%)		13.58

seen from the results that the mean, maximum and minimum seed rates are not within the recommended seed rate. From the results it is observed that as the speed increases from 0.788 km/h, the seed rate decreases and falls below the recommended seed rate (Fig 4.1). From the readings, a regression equation for the best-fit line was calculated (Appendix D). The equation obtained is given below.

$$S.R = 102.63 - 22.87\ S \quad \ldots\ldots\ldots\ldots \quad (4.1)$$

and $r^2 = 0.799$

where

S.R - seed rate, kg/ha; and

S - speed of operation, km/h.

r^2 - coefficient of determination

Accordingly, the speed range corresponding to the seed rate range 80-90 kg/ha, is 0.55 to 1 km/h. The decreased seed rate at higher speeds is due to the increased speed of the cups of the metering mechanism and their corresponding failure to pick up the seeds from the box. Further, the vibration caused at higher speeds tends to shake off the seeds from the cup leading to reduction in the seed rate.

4.2.2 Uniformity in seed distribution

Uniformity in distribution of seeds was tested in the field at the four speeds and the results are given in

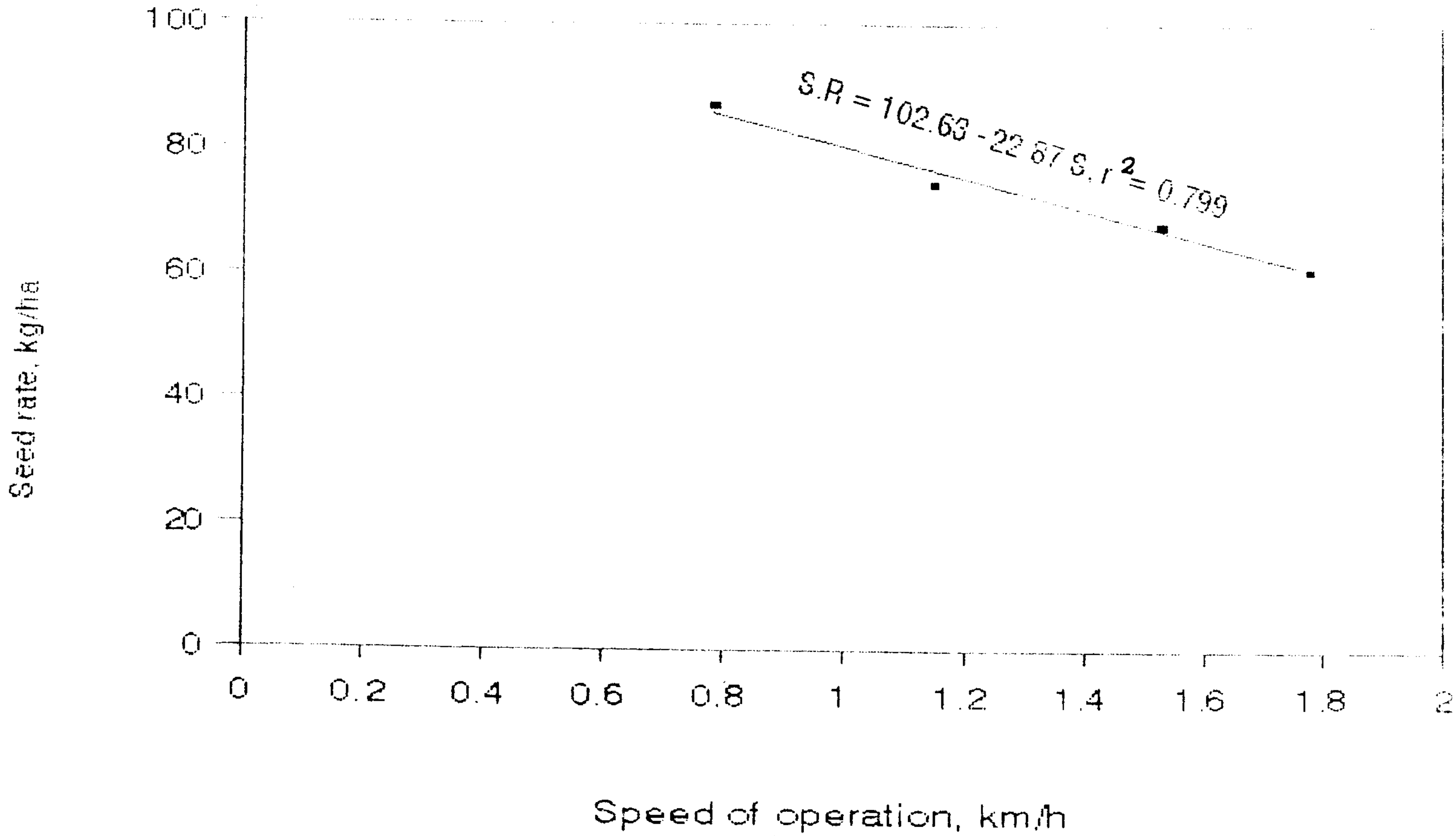


Fig. 4.1 Speed of operation Vs Seed rate

Tables 4.9 through 4.12. The average number of seeds/hill is 5.6 with a SD of 0.58 for a speed of 0.788 km/h and CV is 10.36 per cent (Table 4.9). Average number of seeds/hill for each rotation varied from 5 to 6.4. For seed tubes 1, 2 and 3 the average no. of seeds/hill is well within the range of 4-6 seeds/hill, recommended by the Package of Practices (1993). For the seed tubes 4 and 5, the number of seeds/hill is outside the recommended range. This is due to the imperfections in the construction of metering mechanism, and the random behaviour of the system and also due to the vibration.

Tests conducted at the speed of 1.152 km/h gave an average number of seeds/hill as 4.8 with a SD of 0.33 and its CV is 6.88 per cent (Table 4.10). Average number of seeds/hill for each rotation is within the recommended range. But, the number of seeds for seed tubes 2 and 4 were outside the limits of the numbers recommended by the Package of Practices (1993).

At the speed of 1.530 km/h, the average number of seeds/hill is obtained as 4.34 with a SD of 0.7 and CV is 16.13 per cent (Table 4.11). For each rotation the average no. of seeds/hill is within the recommended range and it vary from 3.4 to 5.8 . But, for the second seed tube, the seeds/hill obtained is outside the recommended range of 4-6 seeds/hill.

Table 4.9 Seed distribution pattern at a speed of 0.788 km/h (Field test)

Trial No.	No. of seeds dropped					Average No. of seeds/hill	SD
	1st	2nd seed tube	3rd	4th	5th		
1	6	4	5	7	5	5.4	1.02
2	5	3	6	6	7	5.4	1.36
3	7	3	5	9	8	6.4	2.15
4	4	7	4	6	5	5.2	1.67
5	4	6	4	6	5	5.0	0.89
6	6	6	5	7	7	6.2	0.75
7	4	3	5	5	8	5.0	1.67
8	6	4	4	6	5	5.0	0.89
9	5	6	6	8	8	6.2	1.20
10	5	5	4	6	6	5.4	1.02
Mean	5.2	4.7	4.8	6.7	6.4	5.6	
SD	0.97	1.43	0.75	1.10	1.28	0.58	
CV(%)	18.65	30.43	15.63	16.42	20.00	10.36	

Table 4.10 Seed distribution pattern at a speed of 1.152 km/h (Field test)

Trial No.	No. of seeds dropped					Average No. of seeds/hill	SD
	1st	2nd	3rd seed tube	4th	5th		
1	5	5	3	6	5	4.8	0.98
2	5	3	4	5	4	4.2	0.75
3	4	0	4	8	5	4.2	2.56
4	3	5	5	8	3	4.8	1.88
5	4	3	5	6	7	5.0	1.41
6	5	4	3	6	5	4.6	0.81
7	4	5	6	5	6	5.2	0.75
8	6	2	4	7	5	4.8	1.72
9	4	5	4	8	5	5.2	1.47
10	4	4	5	5	6	4.8	0.75
Mean	4.4	3.6	4.3	6.4	5.1	4.8	
SD	0.80	1.56	0.90	1.20	1.04	0.33	
CV(%)	18.18	43.33	20.93	18.75	20.39	6.88	

Table 4.11 Seed distribution pattern at a speed of 1.530 km/h (Field test)

Trial No.	No. of seeds dropped					Average No. of seeds/hill	SD
	1st	2nd	3rd seed tube	4th	5th		
1	5	3	4	3	6	4.2	1.17
2	4	6	4	6	3	4.6	1.21
3	2	3	8	7	2	4.4	1.70
4	7	5	7	6	4	5.8	1.17
5	2	3	5	5	5	4.0	1.27
6	8	5	2	8	4	5.4	2.33
7	5	2	2	5	3	3.4	1.36
8	4	4	5	0	5	3.6	1.85
9	5	5	4	5	3	4.4	0.80
10	4	3	0	6	5	3.6	2.05
Mean	4.6	3.9	4.1	5.1	4.0	4.34	
SD	1.80	1.32	2.26	2.12	1.18	0.70	
CV(%)	39.13	33.85	55.12	41.56	29.50	16.13	

Table 4.12 Seed distribution pattern at a speed of 1.778 km/h (Field test)

Trial No.	No. of seeds dropped					Average No.of seeds/hill	SD
	1st	2nd	3rd seed tube	4th	5th		
1	5	3	4	6	5	4.6	1.02
2	1	9	0	2	4	3.2	3.18
3	2	0	3	6	6	3.4	2.33
4	3	4	2	5	6	4.0	1.41
5	6	3	4	5	3	4.2	1.17
6	4	2	3	7	0	3.2	2.32
7	3	1	2	5	6	3.4	1.50
8	3	5	2	5	7	4.4	1.74
9	3	3	6	7	4	4.6	1.63
10	6	3	5	4	4	4.0	1.41
Mean	3.6	3.3	3.1	5.2	4.3	3.9	
SD	1.56	2.32	1.64	1.40	2.05	0.55	
CV(%)	43.33	70.30	52.90	26.92	47.67	14.10	

For 1.778 km/h speed, the average number of seeds/hill is 3.9 with a SD of 0.55 and CV is 14.10 per cent (Table 4.12). Average number of seeds/hill for each rotation vary from 3.2 to 4.6. From the results it is seen that the average number of seeds/hill and means for the seed tubes 1, 2 and 3 are outside the limits of the number of seeds/hill recommended by the Package of Practices (1993).

These results show that as the speed increases number of seeds/hill decreases. Uniformity in seed distribution was statistically verified by using Student's 't' distribution (Appendix E). From hypothesis testing, the maximum uniform distribution of seed obtained is for 1.530 km/h speed. However, at the speed of 0.788 km/h the uniformity in distribution in the first three seed tubes are better. This was the only speed, among the four speeds, which gives the recommended seed rate. The non-uniformity in the 4th and 5th seed tubes were due to the imperfections . By improving the techniques of fabrication it is possible to obtain more uniformity in distribution for all seed tubes.

Further, the observations on missing hills show that the number of missing hills/m^2 increases as speed increases. Total number of missing hills are 0,1,2, and 3 at the speeds 0.788, 1.152, 1.530 and 1.778 km/h respectively, when considering all the 50 hills (Tables 4.9 to 4.12).

In this dibbler, it was observed that there was absolutely no scattering of seeds. The seeds were placed within the confines of the holes.

4.2.3 Depth of placement

The design of the dibbler was such that it should place the seeds at a depth of 5 cm for all types of soil and soil conditions. Results of the test conducted to evaluate the performance of the dibbler in placing the seeds at the pre-determined depth showed that the average depth of placement at the speed of operation of 0.788, 1.152, 1.530 and 1.778 km/h were 4.2, 4.1, 4.0 and 4.0 cm respectively (Tables 4.13 through 4.16). This indicated that the depths of placement decreases with increase in speed. Certain minimum time is required for a soil working tool to penetrate the soil to a particular depth. If the time allowed for the tool to penetrate the soil is shortened, then the depth of penetration is reduced. So in this study, as the speed is increased from 0.788 km/h, the time allowed for the hole opener (seed tubes and plunger) to penetrate the soil is reduced. However, it is seen from the Tables 4.13 through 4.16 that the maximum and minimum depth of placement are 4.3 and 3.8 cm respectively. Therefore, the depths of placement was almost uniform and is within the recommended range of 3-5 cm (IS code 6316-1971).

Table 4.13 Depth of placement of seeds at a speed of 0.788 km/h (Field test)

Trial No.	Depth of placement of seeds (cm)					Average depth (cm)
	1st	2nd	3rd seed tube	4th	5th	
1	4.3	4.2	4.0	4.3	4.4	4.2
2	4.2	4.1	4.0	4.3	4.4	4.2
3	4.4	4.1	4.1	4.2	4.3	4.2
4	4.3	4.2	4.2	4.3	4.3	4.3
5	4.2	4.2	4.1	4.2	4.2	4.2
6	4.2	4.2	4.1	4.2	4.3	4.2
7	4.3	4.1	4.2	4.3	4.2	4.2
8	4.3	4.1	4.1	4.2	4.3	4.2
9	4.2	4.0	4.1	4.3	4.3	4.2
10	4.4	4.1	4.2	4.3	4.3	4.3
Mean	4.3	4.1	4.1	4.3	4.3	4.2
SD	0.08	0.06	0.07	0.04	0.06	0.03
CV(%)	1.86	1.46	1.71	0.93	1.40	0.71

Table 4.14 Depth of placement of seeds at a speed of 1.152 km/h (Field test)

Trial No.	Depth of placement of seeds (cm)					Average depth (cm)
	1st	2nd	3rd seed tube	4th	5th	
1	4.2	4.1	4.0	4.1	4.3	4.1
2	4.2	4.2	4.1	4.0	4.2	4.1
3	4.1	4.0	4.1	4.2	4.0	4.1
4	4.0	4.1	4.1	4.2	4.2	4.2
5	4.1	4.1	4.0	4.1	4.1	4.1
6	4.2	4.1	4.0	4.1	4.1	4.1
7	4.1	4.1	4.1	4.1	4.2	4.1
8	4.1	4.0	4.2	4.0	4.2	4.1
9	4.1	4.0	4.0	4.1	4.2	4.1
10	4.0	4.0	4.0	4.1	4.1	4.0
Mean	4.1	4.1	4.1	4.1	4.2	4.1
SD	0.07	0.06	0.06	0.06	0.08	0.03
CV(%)	1.71	1.46	1.46	1.46	1.91	0.73

Table 4.15 Depth of placement of seeds at a speed of 1.530 km/h (Field test)

Trial No.	Depth of placement of seeds (cm)					Average depth (cm)
	1st	2nd	3rd	4th	5th	
		seed tube				
1	4.1	4.1	4.0	4.0	4.2	4.1
2	4.2	4.0	3.9	4.1	4.1	4.1
3	4.0	4.0	4.1	4.1	4.1	4.1
4	4.0	3.8	4.0	4.0	4.1	4.0
5	4.1	4.0	3.9	4.0	4.1	4.0
6	4.1	4.0	3.9	4.0	4.0	4.0
7	4.0	4.1	4.0	4.1	4.0	4.0
8	4.0	4.1	4.0	4.1	4.1	4.1
9	4.0	4.0	4.0	3.9	4.1	4.0
10	4.1	4.0	4.0	4.1	4.0	4.0
Mean	4.1	4.0	4.0	4.0	4.1	4.0
SD	0.07	0.08	0.06	0.07	0.06	0.04
CV(%)	1.71	2.00	1.50	1.75	1.46	1.00

Table 4.16 Depth of placement of seeds at a speed of 1.778 km/h (Field test)

Trial No.	Depth of placement of seeds (cm)					Average depth (cm)
	1st	2nd	3rd seed tube	4th	5th	
1	4.0	3.9	3.9	3.9	4.1	4.0
2	4.1	4.0	4.0	4.0	4.1	4.0
3	3.9	4.0	3.9	4.0	3.9	3.9
4	3.9	3.8	3.9	3.9	4.0	3.9
5	4.0	3.9	3.8	4.0	4.0	3.9
6	3.9	3.8	4.0	3.8	3.9	3.9
7	4.0	4.0	3.9	3.9	4.1	4.0
8	3.9	3.9	3.9	4.0	4.1	4.0
9	4.0	3.9	4.0	4.0	4.1	4.0
10	3.9	3.9	3.9	3.9	4.0	3.9
Mean	4.0	3.9	3.9	3.9	4.0	4.0
SD	0.08	0.07	0.06	0.08	0.08	0.03
CV(%)	2.00	1.79	1.54	2.05	2.00	0.75

4.2.4 Germination Test

Germination percentage was observed to be 61.83 per cent (Table 4.17). Averages of the number of seeds/hill for each of the seed tubes are 5.0, 4.3, 5.4, 5.2 and 4.7 whereas the number of plants/hill for these seed tubes are 2.8, 2.7, 3.1, 3.9 and 2.9. The reduction in the germination percentage may be due to the unfavourable weather conditions.

4.2.5 Power Requirement

The draft varied between 9.5 and 17.4 kg and the corresponding power requirement was 0.047 and 0.158 hp (Table 4.18). The average draft obtained is 13.52 kg and its corresponding power is 0.093 hp (Table 4.18). The speed of operation varied from 0.367 m/s to 0.68 m/s with an average value of 0.492 m/s with a SD of 0.109 and CV is 36.56 per cent. The power requirement is quite less. A bullock also can be used for towing the equipment.

4.2.6 Labour requirement

This dibbler was operated in the field by one man. The effective fie. capacity vary from 0.011 to 0.024 ha/h at different speeds and has an average value 0.018 with a SD of 0.005. Therefore, the labour requirement vary from 41.67 to 90.91 man-h/ha and has an average value of 60.68 man-h/ha with a SD of 19.03 (Table 4.19).

Table 4.17 Germination percentage (Field test)

Trial No.	No. of seed dropped					Total No. of seeds dropped	No. of plant/hill					Total no. of plants	Germination percentage (%)
	1st	2nd	3rd	4th	5th		1st	2nd	3rd	4th	5th		
	seed tube						seed tube						
1	7	3	2	4	8	23	6	2	0	0	6	14	60.87
2	2	2	2	3	2	11	0	1	1	3	1	6	54.55
3	3	4	6	6	1	20	1	1	5	5	0	12	60.00
4	4	4	6	6	4	24	3	3	4	5	3	18	75.00
5	3	7	9	8	6	33	0	7	7	8	4	26	78.78
6	9	3	6	2	4	24	7	0	5	0	2	14	58.33
7	3	5	7	5	9	29	3	4	4	1	5	17	58.62
8	9	3	4	7	7	30	5	1	0	5	6	17	56.67
9	5	4	5	10	3	27	3	1	0	10	1	15	55.56
10	5	8	7	2	3	25	0	7	5	2	1	15	60.00
Total	50	43	54	52	47	246	28	27	31	39	29	154	
Mean	5.0	4.3	5.4	5.2	4.7	24.6	2.8	2.7	3.1	3.9	2.9	15.4	61.8[illegible]
SD	2.32	1.79	2.10	2.49	2.53	5.78	2.40	2.25	2.46	3.20	2.10	4.78	7.8[illegible]
CV(%)	46.40	41.63	38.89	47.89	53.83	23.50	85.71	83.33	79.36	82.05	72.41	31.04	12.61

Table 4.18 Power requirement

Distance moved - 15 m

Trial No.	Average draft (kg)	Time taken (s)	Average speed of operation (m/s)	Horse power required (hp)
1	9.5	41.0	0.367	0.047
2	11.3	36.0	0.417	0.063
3	13.6	32.5	0.462	0.084
4	15.6	28.0	0.536	0.113
5	17.4	22.0	0.680	0.158
Mean	13.52	31.9	0.492	0.093
SD	2.87	6.52	0.109	0.034
CV(%)	21.23	20.44	22.15	36.56

Table 4.19 Labour requirement

Area covered - 0.000225 ha
No. of labourers engaged - 1

Trial No.	Time taken (h)	Effective field capacity (ha/h)	Labour requirement (man-h/ha)
1	0.0209	0.011	90.91
2	0.0143	0.016	62.50
3	0.0108	0.021	47.62
4	0.0093	0.024	41.67
Mean	0.0138	0.018	60.68
SD	0.005	0.005	19.03
CV(%)	36.23	27.78	31.36

The usual method of sowing behind the plough use an indigenous plough to open a furrow in soil into which a man or woman following the plough drops the seed by hand. So two labourers are required in this dibbling. The results show that mechanical dibbling requires less number of labourers for operating the dibbler.

4.2.7 Economic analysis

The operating cost of the paddy dibbler was calculated and are presented in Appendix F. The operating cost worked out to be Rs 86.07/h. Total cost of operation is Rs 7825/ha when operated at a speed of 0.788 km/h including the cost of power source.

The cost of manual dibbling behind the plough is reported as Rs 979/ha (John, 1989). This was compared with the mechanical dibbling using jab type dibbler operated at a speed of 0.788 km/h. Results show that the cost of operation for mechanical dibbling at this speed is very high due to the low field capacity of this particular dibbler. Field capacity of this dibbler can be increased by increasing the number of rows. Further 0.788 km/h speed was taken for comparison among the four speeds because only this speed gave the seed rate recommended by the Package of Practices (1993).

Based on the performance evaluation, of the jab type paddy dibbler developed in this study, it is concluded that, the range of speed recommended for obtaining the recommended seed rate is 0.55-1 km/h. The number of seeds mechanically damaged, caused by the metering mechanism is negligible. The summary of the research work done and the suggestions for improvements are presented in the chapter that follows.

Summary

SUMMARY

Rice is the staple food of more than sixty per cent of the world's population. It is one of the major crops in Kerala too. The crop is raised in both dryland and wetland conditions. In wetland cultivation, the seedlings are transplanted in the main field. But, in dryland cultivation, the seeds are directly sown in the prepared field.

Among the different direct sowing methods, dibbling is considered a better method. Dibbling is the placement of one or more number of seeds in holes made to a pre-determined depth in the soil and covering it with soil. This helps to reduce the energy requirement. Other advantages of dibbling are its lower seed requirement, facility to make intercultural operations easier, and ability to provide better yield. It also reduces labour requirement and the cost.

Labour shortage during planting is one of the constraints in the agricultural activities particularly in Kerala. Hence, there existed a need for mechanization of planting. But, dibblers suitable for accurate placement of seeds without scattering were not available to the farmers. A review of the literature on past studies also confirmed of the need for developing an effective dibbler for paddy. It was also concluded that a jab type dibbler is a better option among the

dibblers. Therefore, a study was undertaken at the Kelappaji College of Agricultural Engineering and Technology, Tavanur to develop a power operated jab type paddy dibbler.

The dibbler consisted of mainly a seed box, metering and distribution assembly, dibbler assembly, frame and support assembly, covering device and hitch assembly.

The seed box comprised two compartments; a grain box, and a feed box. The capacity of grain box was 1.5 X 10^{-3} m^3, and was enough to store approximately 1.2 kg of paddy. The seed was transferred from the grain box to the feed box through the slot at the bottom of the divider wall between the two boxes.

A cup feed mechanism was incorporated as the metering device. It consisted of five cups mounted on the periphery of a disc of 90 mm diameter. It rotated in the feed box. The seeds collected in the cups were discharged into a funnel which led into the seed distribution wheel. When the seed distribution wheel was rotated by the main shaft, the seeds were transferred to the successive seed tubes one after the other through the openings at the periphery of the seed distribution wheel.

The dibbler mechanism consisted of a stationary mango-cam, rigidly fixed by the side of the seed box. Five seed tubes of length 145 mm were mounted radially on the dibbler wheel of 318 mm diameter. Outer end of the seedtube was extended beyond the periphery of the dibbler wheel by fixing a truncated hollow cone tube of height 25 mm. Lower end of the seed transfer tube was connected to one side of the seed tube and the top end to the seed distribution wheel. A plunger operating in the seed tube covered and uncovered the lower end of the seed tube and also the lower end of the seed transfer tube in a certain sequence during its to and fro motion. Upper end of the plunger was fitted with a roller follower which rolled on the mango-cam. As the dibbler wheel was rotated the seed tubes along with the plunger also rotated. The plunger reciprocated in the sleeve according to the cam profile. The position of the cam was so arranged that the lower end of the seed tube remained closed by the plunger for the wheel's rotation from 270 to 340 degrees, considering zero degree position as its position when the seed tube was vertically downward. During the next 20° of rotation the plunger moved upward uncovering the seed tube and the seed transfer tube allowing the transfer of seeds already trapped in the seed transfer tube into the hole created by the dibbler. As the rotation of the wheel continued, the seed tube was lifted from the ground. During its next 270° of rotation the follower ascended on the cam thereby gradually closed the tip of the seed tube. The spacing of the holes made in the soil were at a distance of 200 mm.

The covering device consisted of a freely rotating hollow pipe fixed on the rear end of the main frame.

A hollow pipe of length 800 mm and diameter 40 mm was mounted on the main frame nearly vertical at an angle of 70° to enable the hitching of the implement to the rear wheel socket of a power tiller. Two wheels were provided on the main axle to facilitate the transportation of the dibbler.

The dibbler was tested both in the laboratory and field to evaluate its performance. The test results are summarised below.

1. The calibration tests conducted in the laboratory showed that the dibbler was capable of giving an average seed rate of 87.5 kg/ha whereas that obtained in the field test were 87.1, 74.6, 68.0 and 61.1 kg/ha at the speeds of 0.788, 1.152, 1.530, 1.778 km/h respectively. From the best-fit equation the range of speeds recommended for obtaining the recommended seed rate is 0.55 - 1.00 km/h.

2. The average number of seed/hill was 5.6 in the laboratory tests and 5.6, 4.8, 4.3 and 3.9/hill in the field tests at the four speeds of 0.788, 1.152, 1.530 and 1.778 km/h. These are within the accepted quantity.

3. The average depth of placement of seeds in the field were 4.2, 4.1, 4.0 and 4.0 cm for the four speeds of 0.788, 1.152, 1.530 and 1.778 km/h. These are also in agreement with the recommended depth, i.e. 5 cm.

4. The number of seeds mechanically damaged was only 0.89 per cent of the total number of seeds discharged and the loss of viability due to mechanical damage was only 3.77 per cent. This is negligible.

5. The draft requirement ranged from 9.5 to 17.4 kg. The average horsepower required to pull the dibbler was 0.093 hp. Total weight of the implement is 32.5 kg.

6. The germination percentage obtained was 61.83 percent in the field. This is low and was due to the inclement weather.

7. Labour requirement was less compared to manual dibbling and its average value is 60.68 man-h/ha.

8. Cost of operation of the dibbler was Rs 86.07/h including the cost of power source for 0.788 km/h speed. Fabrication cost of the dibbler was Rs 1500/-.

9. The jab dibbler is convenient to be used by both men and women because it ensures easy and comfortable operating position.

This dibbler was found to be suitable for paddy. However modifications are required for improving its performance further. These are suggested for future work.

1. Increase the number of rows of the jab type dibbler, considering the available power and width of power tiller and ease of control.

2. Incorporate suitable modifications to the cup feed mechanism to get more uniform distribution of seeds.

3. Incorporate suitable clutch mechanism to disengage the plunger during turning of the dibbler and in transportation.

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Appendices

APPENDIX-A

Calculation of capacity of seed box

Capacity of seed box was calculated using the equation,

$$Q = \frac{TWVR}{ND} \qquad \text{(John, 1989)}$$

where Q = capacity of seed box, cm^3;

T = time between two consecutive filling, h;

V = speed of operation, m/h;

W = effective width of the machine, m;

R = seed rate per hectare, kg/m^3;

N = number of seed boxes; and

D = density of seed, kg/m^3

Substituting the respective values in equation,

$$Q = \frac{0.5 \times 0.15 \times 2 \times 1000 \times 85 \times 10^{-4}}{1 \times 800}$$

$$= 1.50 \times 10^{-3}\ m^3$$

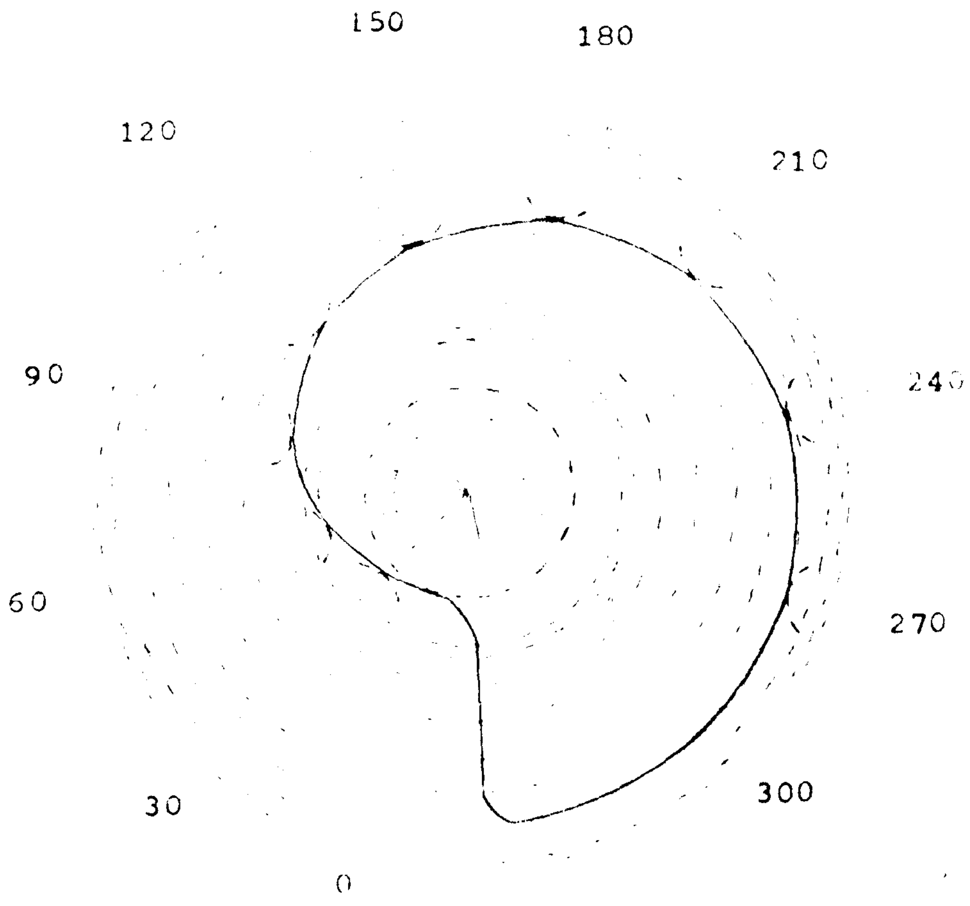
Therefore,

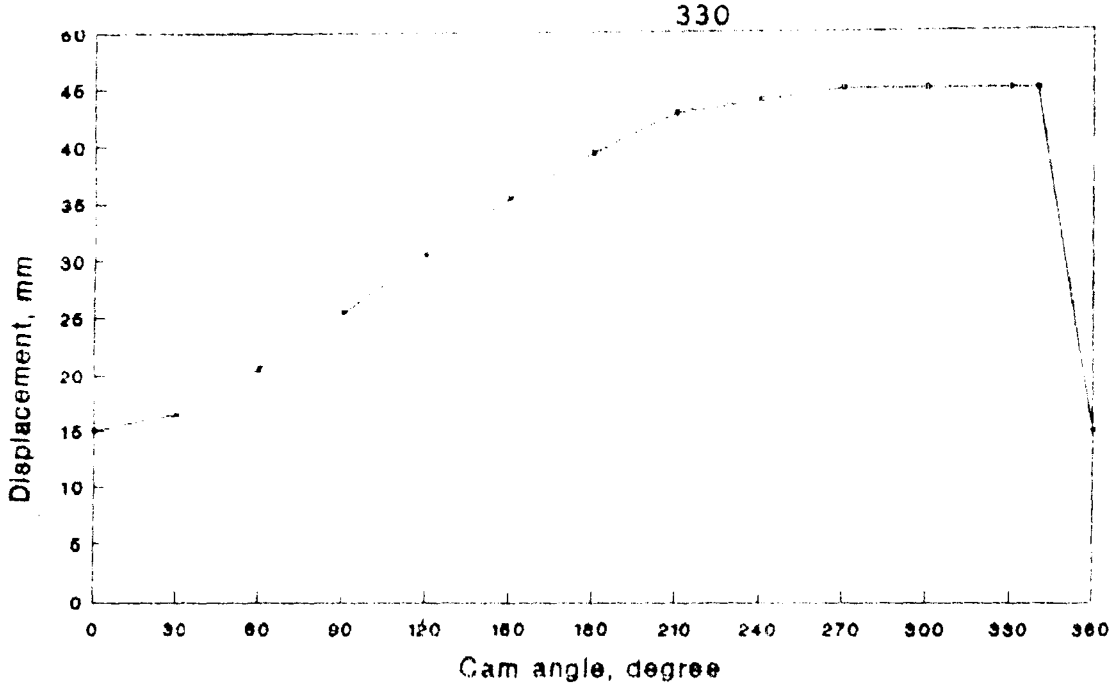
weight of paddy stored in one seed box $= 1.5 \times 10^{-3} \times 800$

$= 1.2$ kg

APPENDIX B

Cam profile





Cam angle vs Displacement

APPENDIX-C

Equation for calculation of seed rate

Assumptions:

No. of revolutions = N

Total number of seeds for N revolution = X

Mean weight of 1000 grains = W = 47.5 g

Row to row spacing = S = 15 cm

Hill to hill spacing = L = 20 cm

No. of hills made per revolution = a = 5

Therefore, No. of seeds/hill = n = $\frac{X}{Nxa}$ ----- (1)

Substituting the values of N and a in Eqn. (1)

$$n = \frac{X}{5x5}$$

No. of hills/ha = b = $\frac{10000}{SxL}$ ----- (2)

where 1 ha = 10000 m^2

Substituting the values of S and L in Eqn.(2)

$$b = \frac{10000}{0.15x0.20} = 333,333$$

Therefore, seed rate; kg/ha = R = $\frac{b \times n \times W}{1000}$ ----- (3)

Substituting the values of b and n in Eqn.(3)

$$R = \frac{333,333 \times X \times W}{N \times a \times 1000} \quad \text{----- (4)}$$

APPENDIX-D

Development of a regression equation for the relationship between the speed of operation and the seed rate.

Regression equation S.R on S is given as

$$S.R - \overline{S.R} = \frac{Cov(S.R, S)}{Var(s)} \cdot (S-\bar{S})$$

$$r^2 = \frac{\Sigma\ (SR-\bar{SR})}{\Sigma\ (SR-\bar{SR})}$$

Where S.R - seed rate, kg/ha;

S - speed of operation, km;

$\overline{S.R}$ - mean of seed rate, kg/ha; and

$\bar{S}$ - mean of speed of operation, km/h

r^2 - co-efficient of determination

S	S.R	S^2	S X S.R	SR	$(SR-\overline{SR})^2$	$(SR-\bar{SR})^2$
0.788	87.10	0.62	68.64	84.61	142.56	208.23
1.152	74.60	1.33	84.94	76.28	13.03	3.73
1.530	67.99	2.34	104.03	67.64	25.30	21.90
1.778	61.00	3.16	108.46	61.96	114.70	136.19
5.248	290.69	7.45	367.0	290.49	295.59	370.05

$$\bar{S} = \frac{5.248}{4} = 1.31$$

$$\bar{S}.\bar{R} = \frac{290.69}{4} = 72.67$$

$$Cov(S.R, S) = \frac{367.07}{4} - 1.31 \times 72.67$$

$$= 3.43$$

$$Var(s) = \frac{7.45}{4} - (1.31)^2$$

$$= 0.15$$

Therefore $(S.R - 72.67) = \frac{3.43}{0.15}(S-1.31)$

Therefore, $S.R = 102.63 - 22.87\,S$

$$r^2 = \frac{295.59}{370.05} = 0.799$$

APPENDIX-E

Statistical analysis for determining uniformity in the seed distribution pattern of each seed tube at various speeds

The uniformity in seed distribution was checked by using Student's 't' distribution at 1% level of significance.

$$t = \frac{\bar{x} - \mu}{S\sqrt{n-1}}$$

where $\bar{x}$ - sample arithmatic mean;

μ - population A on hypothesis, μ = 5;

s - SD of the sample; and

n - number of observation.

Speed (km/h)	t'- value calculated 1	2	3	4	5
0.788	0.619	-0.629	-0.800	4.636	3.28
1.152	-2.250	-2.800	-2.300	3.500	0.288
1.530	-0.667	-2.500	-1.190	-0.142	2.54
1.778	-2.690	-2.198	-3.475	-0.429	-1.024

't' value obained from the table is,

$$t_{0.01}(9) = 3.25$$

APPENDIX-F

Calculation of operating cost of the Jab type Paddy Dibbler

a. Power tiller

Initial cost of power tiller	=	C = Rs.90000/-
No. of working hours/year (anticipated)	=	H = 800 h
Expected life of power tiller	=	L = 10 years
Fuel consumption	=	1 lit/h
Cost of fuel	=	Rs 12.9/lit
Cost of oil	=	1/3 of fuel cost
Salvage value (@ 10% of initial cost)	=	S = Rs.9000/-
Interest on investment	=	12% per annum
Insurance	=	1% per annum
Housing charge	=	1% per annum
Repair and maintenance charge	=	@ 7.5% of the initial cost of the machine

1. Fixed cost

1. Depreciation, D

$$= \frac{C-S}{L.H}$$

$$= \frac{90000-9000}{800x10}$$

$$= Rs\ 10.13/h$$

2. Interest on average, investment

$$I = \frac{C+S}{2} \times \frac{i}{H}$$

$$= \frac{90000+9000}{2} \times \frac{12}{100} \times \frac{1}{800}$$

= Rs 7.43/h

3. Insurance

$$= \frac{90000}{100 x 800}$$

= Rs 1.13/h

4. Housing charge

$$= \frac{90000}{100 x 800}$$

= Rs 1.13/h

Total fixed cost = 10.13 + 7.43 + 1.13 + 1.13

= Rs 19.82/h

2. Variable cost

1. Labour cost = Rs 25/h

2. Repair and maintenance charge

$$= \frac{90000 \times 7.5}{100 \times 800}$$

= Rs 8.44/h

3. Cost of fuel = 1 x 12.9

= Rs 12.9/h

4. Cost of oil = 1/3 x 12.9

= Rs 4.3/h

Total variable cost = 25 + 8.44 + 12.9 + 4.3

= Rs 50.64/h

Total operating cost of power tiller = 19.82 + 50.64

= Rs 70.46/h

b. **Jab type paddy dibbler**

Fabrication cost of the dibbler including cost of material.	= C = Rs1500/-
Number of working hours/year (anticipated)	= H = 250 h
Expected life of dibbler	= L = 10 years
Salvage value (@ 10% of initial cost)	= S = Rs150/-
Labour charges	= Rs14/h
Interest on investment (i)	= 12% per annum
Insurence	= 1% per annum
Housing charge	= 1% per annum
Repair and maintenance charge	= @ 7.5% of the initial cost of machine

1. **Fixed cost**

1. Depreciation, D

$$= \frac{C-S}{L.H}$$

$$= \frac{1500-150}{10 \times 250}$$

$$= \text{Rs } 0.54/h$$

2. Interest on average investment

$$= \frac{C+S}{2} \times \frac{i}{100}$$

$$= \frac{1500+150}{2} \times \frac{12}{100} \times \frac{1}{250}$$

$$= \text{Rs } 0.05/h$$

3. Insurence $= 1500 \times \frac{1}{100} \times \frac{1}{250}$

= Rs 0.06/h

4. Housing charge $= 1500 \times \frac{1}{100} \times \frac{1}{250}$

= Rs 0.06/h

Total fixed cost = 0.54 + 0.5 + 0.06 + 0.06

= Rs 1.16/h

2. Variable cost

1. Labour cost = Rs 14/h
2. Repair and maintenance charge $= \frac{1500 \times 7.5}{100 \times 200}$

= Rs 0.45/h

Total variable cost = 14 + 0.45

= Rs 14.45/h

Total operating cost of the dibbler = 1.16 + 14.45

= Rs 15.61/h

Therefore, total operating cost of power operated jab type paddy dibbler : = 70.46 + 15.61

= Rs 86.07/h

Area covered/ha for a speed of 0.788 km/h = 0.011 ha

Therefore, total cost of operation of 0.788 km/h speed : $= \frac{86.07}{0.011}$

= Rs 7824.55/ha

= Rs 7825/ha

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APPENDIX-G

Major specifications of the jab type paddy dibbler

Volumetric capacity of seed box	= 1.5×10^{3} m^{3}
No. of rows	= One
No. of dibbling units/wheel	= 5
Spacing between dibbling units	= 200 mm
Type of metering mechanism	= cup feed
Diameter of distribution wheel	= 180 mm
Length of seed transfer tube	= 130 mm
Seed tube:	
Length	= 145 mm
Diameter at top	= 32 mm
Diameter at bottom	= 25 mm
Plunger:	
Maximum radius	= 15 mm
Maximum lift	= 30 mm
Diameter of dibbler wheel	= 318 mm
Cam:	
Type	= Mango
Width	= 12 mm
Follower:	
Type	= roller
Diameter	= 12 mm
Diameter of supporting wheel	= 318 mm

Shaft:

Diameter	=	20 mm
Length	=	800 mm
Type of bearing	=	6204 ZZ
Diameter of transport wheel	=	425 mm
Diameter of covering device	=	80 mm
Hitch arrangement (pipe):		
Length	=	800 mm
Diameter	=	40 mm
Total length of the machine	=	700 mm
Total width of the machine	=	500 mm
Weight of the machine	=	32.5 kg
Material of construction	=	Mild steel
Fabrication cost of the dibbler	=	Rs 1500/-
Power requirement	=	0.093 hp
Average no. of seeds/hill	=	4-6
Seed rate recommended	=	80-90 kg/ha
Labour requirement	=	60.68 man-h/ha
Speed of operation recommended	=	0.55 to 1 km/h

DESIGN, FABRICATION AND TESTING OF A POWER OPERATED JAB TYPE PADDY DIBBLER

By

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ABSTRACT OF THE THESIS

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ABSTRACT

A power operated jab type paddy dibbler developed and tested at K.C.A.E.T, Tavanur is described. A cup feed type metering mechanism, discharged the seeds into the distribution wheel. Rotation of this wheel caused the transfer of seeds from the distribution wheel to the seed tubes. The to and fro motion of the plungers inside the five seed tubes closed and opened the port between the seed transfer tube and seed tube at predetermined intervals. A cam and follower arrangement fitted on the main shaft regulated the to and fro motion of the plungers.

In operation, the rotation of the dibbler wheel caused the tip of seed tubes to make holes in the soil. At the time of penetration the plunger occupied a position farthest to the main shaft thus keeping the tip of seed tube closed. This prevented the entry of soil into the seed tube. After the seed tube has reached the maximum depth the plunger is moved up quickly transferring the seeds into the holes.

The dibbler gave seed rates of 87.1, 74.6, 68.0, and 61.1 kg/ha at the speeds 0.788, 1.152, 1.530 and 1.778 km/h respectively in the field. It placed at an average 3.6 seeds in a hill at a depth of 4-4.2 cm. The number of seeds mechanically damaged was only 0.89 per cent and loss of

viability due to mechanical damage was only 3.77 per cent. The average power required was 0.093 hp. Labour requirement was 60.68 man-h/ha. Cost of operation of this dibbler was Rs 86.0/h including the cost of power source. The jab type dibbler is convenient for use by both men and women.