EVALUATION AND MODIFICATION OF SPIKE-TOOTH AND RASP-BAR TYPE PADDY THRESHERS

By

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THESIS

Submitted in partial fulfilment of the requirement for the degree

Master of Technology in Agricultural Engineering

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Dedicated to
Kith and Kin

DECLARATION

I hereby declare that this thesis entitled "Evaluation and Modification of Spike-tooth and Rasp-bar Type Paddy Threshers" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

SYMBOLS AND ABBREVIATIONS

Agril.	-	Agricultural
ASAE	-	American Society of Agricultural Engineers
CIAE	-	Central Institute of Agricultural Engineering
cm	-	centimetre(s)
Co.	-	Company
contd.	-	continued
Dept.	-	department
dia	-	diameter
Engng.	-	Engineering
Engr.	-	Engineer
e.g.	-	for example
etc.	-	et cetera
et al.	-	and other people
Fig.	-	Figure
FIM	-	Farm Implements and Machinery
GI	-	Galvanized Iron
g	-	gram(s)
GCA	-	Gross Cropped Area
h	-	hour(s)
ha	-	hectare(s)
hp	-	horse power
hp/h	-	horse power per hour
hp/ha	-	horse power per hectare
HYV	-	High Yielding Varieties

ICAR	-	Indian Council of Agricultural Research
i.e.	-	that is
IRRI	-	International Rice Research Institute
ISAE	-	Indian Society of Agricultural Engineers
ISI	-	Indian Standard Institutions
J.	-	Journal
KAU	-	Kerala Agricultural University
KCAET	-	Kelappaji College of Agricultural Engineering and Technology
kg	-	kilogram(s)
kg/h	-	kilogram per hour
kg/ha	-	kilogram per hectare
km	-	kilometre(s)
lit	-	litre(s)
lit/h	-	litre per hour
Ltd.	-	Limited
m	-	metre(s)
m.c.	-	moisture content
min	-	minute(s)
mm	-	millimetre(s)
m/min	-	metre per minute
m/s	-	metre per second
man-h/ha	-	man hour per hectare
MS	-	Mild Steel
No.	-	Number
O.D.	-	Outer Diameter

p	-	page
pp	-	page
Pvt.	-	Private
RNAM	-	Regional Network for Agricultural Machinery
rpm	-	revolution per minute
Rs.	-	rupees
s	-	second(s)
wt	-	weight
&	-	and
ø	-	diameter
/	-	per
%	-	percentage
@	-	at the rate of

Introduction

INTRODUCTION

In a country like India agriculture continues to contribute a major share of the national economy. Profession of agriculture is as old as civilization and for centuries mankind is engaged in developing it to match with the requirements. The development of machinery and mechanical power to make one's efforts more effective and productive is one of the most prominent features of development.

Human power is the most expensive power compared to all other forms of power. So it becomes more economical if the human power is replaced by other suitable forms of power.

During the last two decades the Indian agriculture has undergone tremendous change and the food grain production in 1990-91 reached an all time high of 177.5 million tonnes (Venkataramani, 1991). Nevertheless, the demand of improved implements has not been so encouraging and therefore, a new look has to be given to enhance the demand of improved implements. Agricultural production of a country depends to a very large extent on power available for farming. It has been established that there is a direct relationship between the production of crop per unit area and the amount of power used per unit area. According to a world wide survey, the optimum power, needed for improved agriculture is 0.8 hp/ha. The power, required for intensive agriculture should have the power capacity of 1 hp/ha (Sahay, 1977). The present power availability in India is only 0.40 hp/ha (Report of National Commission, 1976). So the power availability should be increased to meet the requirement of the country.

Paddy (*Oryza sativa*) is the staple food for the majority of population of Asia. India is the second largest paddy growing country in the world having 40.2 million ha under paddy crop alone (Venkateswarlu, 1989). The annual rice production in India is 75.95 million tonnes contributing about 42.79 per cent of total food grains (Venkataramani, 1991). Paddy is the most important food crop of Kerala State. It is an unavoidable food grain for each and every meal for people of Kerala. Out of 38,85,000 ha of total geographic area, 5,83,390 ha is under paddy (Farm Guide, 1992). The climatic and environmental conditions are well suited for its cultivation as the state receives the benefit of two monsoons. Further the network of rivers, canals and backwaters offer facilities for irrigation and drainage. In spite of these favourable conditions, the annual production amounts to only 1.14 million tonnes of paddy from 5,83,390 ha (Farm Guide, 1992). This is insufficient to meet the need of 29 million inhabitants.

Nowadays Kerala is facing a serious problem of reduction in area as well as production for paddy cultivation. The year-wise production of paddy has declined from 1.33 million tonnes to 1.14 million tonnes during the period 1975-76 to 1989-90 (Farm Guide, 1992). This is because of high cost of production of paddy and the low price for the produce. Hence the farmers are trying for the gradual shifting of paddy fields to plantation crops like coconut. In Kerala - which is well known for mixed and multiple cropping - further increase in gross cropped area is not possible. To get higher crop production the only alternative is to introduce an element of dynamism in the State agriculture for maximising the crop output. The dynamism in State agriculture can be achieved with farm mechanization. With farm mechanization speedy farm operations can be achieved so the crop damage chances and also the postharvest grain losses become less and thus the farm operations become more economic and efficient.

The present status of agricultural mechanization in Kerala is still in the infant stage. It is necessary to promote the use of agricultural equipments in different vicinities in order to get the sufficient yield from every unit of land per unit cost. Labour is the expensive single input in rice cultivation, contributing to about 55 to 60 per cent. The wages of labourers have increased tremendously but the increase in price of paddy is not in a proportional manner. So to make paddy cultivation a success, reduction in labour cost is essential. It is very difficult to get sufficient numbers of labourers especially during peak periods of farm operations like transplanting, harvesting and threshing. Moreover the new generation lacks the skill and efficiency. Because they shun to accept the drudgery and physical exertion of farm works. The main target in paddy cultivation is to reduce the labour input and increase labour productivity. So the mechanization of any one of the farm operations proves hopeful.

Threshing is one of the critical postharvest operations in paddy cultivation which is laborious, involving more man hours and human drudgery. Moreover in adverse seasons like rainy season threshing has to be finished as early as possible, otherwise a great amount of grain loss will result due to shedding, wetting and seed germination. These will deteriorate the marketing quality of the grain. Particularly in double-cropping areas the farm operations - the harvesting and threshing of the first crop and the land preparation and transplanting of the second crop - come so close together that it is often difficult to handle these operations with the existing traditional postharvest facilities. Threshing is the only one freeland operation among these operations and also comes in the middle of harvesting and transplanting operations. The design of mechanical threshers are independent of soil conditions unlike the harvesters and transplanters. So it is most essential and easy to mechanise the threshing operation. Mechanical threshers offer significant advantages over the traditional methods of threshing. They reduce the drudgery of threshing to a great extent. They, handle large volumes of paddy crop at a time so as to protect the crop against weather hazards and for the timely sowing of the next crop. Adoption of mechanical threshing has resulted in avoiding 6 to 12 per cent of grain lost during the threshing operation (Pillaiyar, 1988). The use of these mechanical threshers is based on a functional requirement, level of performance and economy.

In India, the development of mechanical threshers started with imported designs in 1956. Indigenous prototypes like Ludhyana threshers (1956-57), Sherpur threshers (1967-70) and flow through multicrop threshers enjoyed the confidence and popularity among wheat farmers. Meanwhile revolutionary designs of IRRI changed the outlook, concept and application in crop threshing. Nowadays the popularity of threshers are incresed and there are various types of threshers available in the market. But in Kerala the threshers are not popular. The pedal operated hold-on threshers were introduced in Kerala in 1970's. These threshers are introduced for Tainan-3 variety of paddy which is more resistant to shedding. Most of the farmers are still depending upon the traditional methods of

Government organizations like Kerala Agro Industries Corporation had purchased different types of paddy threshers of both spike tooth and rasp-bar types from other states for popularization in Kerala. These threshers are having many problems due to change in crop conditions in Kerala. The changes in crop conditions are as follows:

1. High moisture content of the crop
2. More green matter present in the crop
3. Crop length is too much
4. Larger area under traditional varieties

Because of these reasons the existing threshers are not performing well. But there are no studies conducted to evaluate the performance of these threshers in Kerala condition. Without evaluation or modification of these threshers, popularization programme of threshers among Kerala farmers will not be successful.

With this view of finding a suitable thresher for Kerala condition study of evaluation of the rasp-bar and spike tooth type paddy threshers has been taken up with the following objectives:

1. To study the different methods of paddy threshing in Kerala.

2. To evaluate the spike tooth and rasp-bar type paddy threshers critically for different crop conditions in Kerala.

3. To identify and carry out suitable modifications for efficient paddy threshing.

Review of Literature

REVIEW OF LITERATURE

A brief review of paddy cultivation, harvesting, traditional threshing methods, different types of mechanical threshers and the parameters affecting threshing efficiency are presented in this chapter.

2.1 Paddy cultivation

The system of paddy cultivation in various paddy growing areas of the country are largely dependent upon the various conditions prevalent in the respective regions. The principal systems followed in India are 'dry', 'semidry' and 'wet land' cultivation (ICAR, 1980). For dryland paddy the seeds are either drilled or broadcasted on a well prepared friable soil bed. However, due to inherent water stress situation and weed problems, the yield of dryland paddy is lower than that of wetland condition. Whenever adequate or excess water is available from wells, canals or rain, paddy is cultivated under wetland condition. Paddy nursery is raised separately on dry or puddled soil. When the seedlings are at about four leaves stage, they are uprooted and transplanted in the puddled field. Generally two or three seedlings are manually transplanted at 10 to 20 cm spacings (Datt, 1992).

Depending upon the water availability and local conditions there are three major crop seasons in Kerala as shown below:

Virippu	-	First (Autumn) crop April-May to September-October
Mundakan	-	Second (Winter) crop September-October to December-January
Punja	-	Third (Summer) crop January-February to March-April

2.2 Harvesting

Harvesting is an important operation in the crop production process. It is done with the view to recover the desired part of the plant to meet the needs of man and animal kingdom, such as food, feed, fuel and fibre. This process is accomplished with the help of tools, implements and machines operated by human, animal, diesel engines, power tillers, tractors and with combine harvesters.

According to Sahay (1977) it is observed that if paddy is harvested at about 24 per cent moisture content and grain dried mechanically in stages by three or four passes of heated air, the milling losses are minimum. Tomar (1985) reported that the harvesting should be done about 30-35 days after 50 per cent of flowering. At this stage the moisture content in the grains should be around 16 to 20 per cent. Early or late harvesting deteriorates the seed quality.

Pandey (1985) reported that some of the studies done at Ludhiana reveal that delay in harvesting can increased the shattering losses upto 10 per cent of the yield. It is also established that the harvesting of crop before physiological maturity leads to reduction in yield. According to Michael and Ojha (1987), losses due to shedding and shattering of grains in the field can be considerably reduced when paddy is harvested between 23 and 25 per cent moisture content. Have (1963) on observing moisture content at maturity for seven varieties of paddy, over a period of several years, found moisture content of 17 to 21 per cent for different varieties at the time of maturity. According to Govindaswamy and Ghosh (1969) optimum harvesting time for the early varieties (120 days duration) is between 25 and 33 days after flowering, and for medium and late varieties (over 125 days) between 33 and 39 days.

Pillaiyar (1988) reported that the main methods of harvest in India are manual cutting of stalks by hand with a sickle or knife near the ground level and threshing immediately or after leaving on the stubbles for a few days. Yadav (1992) reported that the manual harvesting by sickle is followed by majority of farmers because of socio-economical and agrotechnological reasons. Different types of sickles are used in different parts of the Country.

2.3 Threshing

According to RNAM (1983) threshing is the first post-harvest operation for separating the grain. It is generally laborious and the harvesting in rainy season introduced by the double or multicropping would have the danger of deteriorating the quality of grain, if crop is not threshed within a prescribed time. Temporary labour shortage and reduced turn-around time have inevitably forced farmers to turn to mechanical grain threshers. Majumdar (1985) reported that the threshing may be defined as removal of grain or other usable products from the crops, earheads, cobs, pods or any other parts with minimum loss and damage. Rautaray (1988) explained that the threshing operation depends on the availability of a particular method of technology, urgency because of the weather conditions which may result in crop losses, the necessity of making the field free for the next crop and the cost of operation.

Threshing originally meant a simple operation of knocking grain free from the ears, but the term now embarasses the processes of separating the grain or seed from the mixture of grain, chaff, impurities and finally grading it ready for use (Srivasthava, 1990).

Datt (1992) reported that the manpower required for threshing increases with increase in yields of crop. In India due to introduction of HYV the yields have increased resulting in increased demand for threshers.

2.4 Threshing methods

Traditionally the following methods are used in India.

1. Manual threshing
   a. Hand beating
   b. Hand/feet rubbing
   c. Beating with stick
2. Bullock treading
3. Tractor treading
4. Mechanical threshing

Threshing can be achieved by three days of action (i) rubbing action, (ii) impact and (iii) stripping. The rubbing action occurs when paddy is threshed by trampling with men, animals or tractors. It is not an efficient method of threshing. The impact method is the most popular in which threshing is done by beating small hand-held bundles of paddy stalks against a solid object such as stone or log. About four to six blows are required to remove all the grains from the sheaves. Most mechanical threshers primarily utilize the impact principle for threshing, although this also involves some stripping action. The third type stripping has also been used in paddy threshing by drawing small bundles of panicles across forked spikes. Some impulsive stripping occurs ordinarily with impact threshing in conventional threshing cylinders (Pillaiyar, 1988).

2.4.1 Manual threshing

Nowadays in India manual threshing is done at very limited scale as it is costly, laborious, time consuming and strenuous (Majumdar, 1985). But in certain parts of the country like Kerala, particularly where the harvest is in small quantity, threshing is done by beating the crop with sticks, also the paddy crop is gernerally threshed by hitting the ears against bamboo ladder or stones (Plate I). It is also threshed by feet rubbing (Plate II), (Michael and Ojha, 1987). Over 80 per cent of the paddy threshing is by manual threshing in Kerala.

A paddy threshing bench cum groundnut pod stripper was developed at APAU, Hyderabad (Fig.1). The prototypes were fabricated for its popularization and supplied to extension agencies and manufacturers (Annual Report-1989, CIAE).

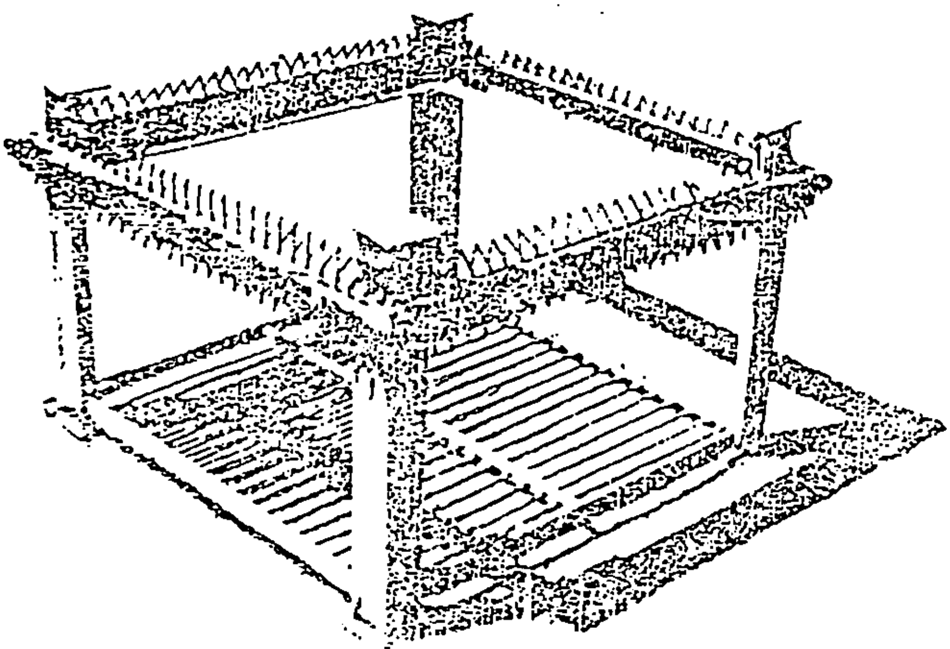


FIG.1 PADDY THRESHING BENCH CUM GROUNDNUT POD STRIPPER

2.4.2 Bullock treading

Threshing by bullocks was a very common method in villages. But it was time consuming and involves drudgery. After the harvest, crop is allowed to dry fully before being spread on the threshing floor in circular heaps. The bullocks are tied in line, 3 to 4 in rows move round and round on the harvest and trample them continuously till the grains are completely separated from straw (Sahay, 1977 and Michael and Ojha, 1987). Less than 5 per cent of the total crop in Kerala is threshed by this method.

Peter (1965) reported that there are some special methods for threshing such as tree branch threshing, punched sheet threshing, disk harrow threshing and Olpad threshing.

The Olpad thresher has been widely used in wheat growing areas for threshing winter crops (Fig.2). It is pulled around by a pair of bullocks over the dried crop spread in a circular charge on the threshing floor. Usually after the first charge is partially broken, one or more charges of dried crop are spread. Treshing is continued till the entire material becomes a homogenous mixture of grain and chaff. A pair of bullocks can thresh about 550 kg of grain and 1100 kg of chaff in about 16 hours. The Olpad thresher consists of 20

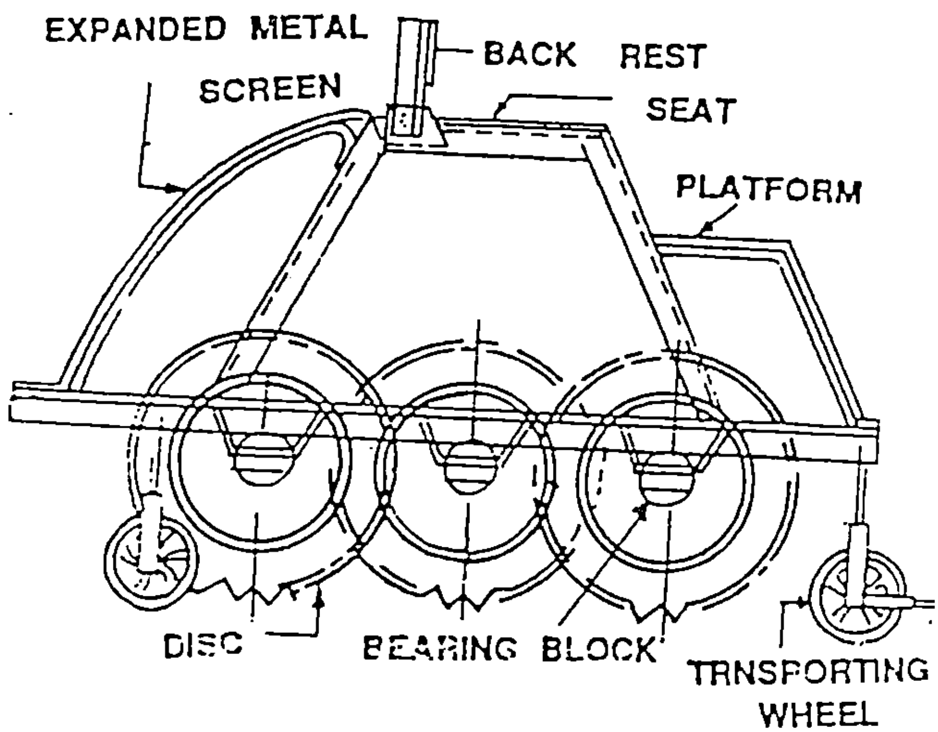


FIG.2 OLPAD THRESHER

circular disks each of 45 cm diameter and 3 mm thickness placed 15 cm apart in three rows. All the disks are mounted staggered to give more effective cutting of the straw. This method is used for wheat only.

2.4.3 Tractor treading

Like bullock treading or Olpad threshing, the tractor tyre is used for threshing in limited scale in our country. But this is also inefficient method of power utilisation. In addition disk harrow or other types of accessories can be used to improve the threshing operation (Michael and Ojha, 1987).

Trampling by bullocks and beating of the crop on a stone or wooden log have been the most popular methods of threshing till mechanical threshing devices were introduced in the country during early 1960's (CART, 1986).

2.4.4 Mechanical threshing

A mechanical device used for removal of grains from crop is called mechanical threshing. The machine may also have the arrangements for cleaning, grading and bagging of grains (Majumdar, 1985). Mechanical threshers have widely been accepted in Indian agriculture today due to their high efficiency and capacity.

Chauhan and Verma (1977) reported that timely threshing of the crop with the help of an efficient machine system leads to saving in the cost, time and reduces grain loss due to over ripening, bad weather, birds and rodents. Rautaray (1988) reported that the cost of threshing by mechanical power thresher was lower than those of threshing by Olpad thresher, bullock treading and by manual threshing.

Prasad (1988) stated that proper testing and evaluation of threshers will be necessary in assessing its performance. He has given the required testing procedures in accordance with the Indian standards. Bharadwaj (1988) explained the advantages of mechanical threshing as follows over the traditional methods of threshing.

a. It separates the grain from straw with speed.

b. It produces clean grain, which can be sent directly to the market for sale.

c. Its operation is independent of weather.

d. It produces chaff of superior quality which is used as animal feed.

e. It reduces energy use.

f. Mechanical threshers are portable and thus can be moved from one threshing floor to another or other sites easily.

g. These can be operated with different power sources like tractor, electric motor and oil engines.

h. It reduces drudgery of threshing without any hazard to operators.

i. Almost all the principal crops can be threshed with mechanical threshers.

j. Cost of threshing become minimum with higher hours of usages and

k. Higher output per unit time is achieved.

Kanafojski and Karwanski (1976) reported about the invention of mechanical threshers. In 1785 Andrew Meikle, A Scotchman was the first to replace the heavy and laborious threshing work with hand rasp-bars by mechanical work. The peripheral speed of the drum amounted to 4.6 m/sec and the threshing machine was driven by a hand crank. With the passage of time the threshing unit became the subject of modification. In 1835 an American named Turner was the first to employ a peg-tooth drum.

The development of thresher in India started principally for threshing of wheat with the introduction of Olpad thresher in 1940's. The subsequent cleaning and separation was done by traditional methods by winnower. Much development took place after independence and in mid 1950's, the first indigenous commercial power thresher was developed at Ludhiana which is known as 'Ludhiana thresher'. The thresher employs the hammer mill principle and facilitated cleaning and bagging. In 1965-66 a 'Drummy' thresher was developed in Punjab which is simple in construction and was in a position to thresh and winnow the wheat (Bhardway, 1988).

Allahabad Agricultural Institute developed a 5 hp unit spike tooth multicrop thresher, which was later commercialised under the trade mark 'Sherpur thresher'. This type of thresher with minor modification is most common and popular still with Indian farmers.

After these developments the research on thresher has been continued in various research organizations and universities as well as at manufacturer's level. There are over 8 lakh threshers in India and every year about 60,000 being added (Verma *et al.*,1978).

2.5 Classification of threshers

Majumdar (1985) reported that the mechanical threshers may be classified in view of many considerations.

A. According to power source:

(i) Manual operated: These threshers are operated by human power - Rotary or pedal operated paddy threshers.

(ii) Animal operated: These threshers are operated by animal power - Olpad threshers.

(iii) Power operated: These threshers are operated through some mechanical/electrical power - diesel engines, motors, tractors, power tillers.

B. According to the threshing cylinder:

(i) Drummy type

(ii) Regular beater or hammer mill type

(iii) Syndicator type

(iv) Spike-tooth type

(v) Rasp-bar type

C. According to the crop threshed:

(i) Paddy thresher

(ii) Wheat thresher

(iii) Multicrop thresher

D. **According to the feeding unit:**

(i) Chute type feeding unit
(ii) Self feeding thresher
(iii) Bulk feeding hopper type thresher

According to Srivastava (1990) the mechanical threshers can be classified into the following types by the method of feeding.

(i) Throw-in type: A type of thresher where the cut crops are fed into the machine in full.

(ii) Hold-on type: A type of thresher where the heads of the cut crops are fed into the threshing drum with the lower part of straw being manually or mechanically held.

Datt (1992) reported that the power threshers may be classified as given below according to the point of contact and motion of grain and straw between concave and threshing cylinder along the direction of axis of the cylinder.

(i) Hammer mill type

In these threshers the straw and grain are allowed to come out of the concave and cylinder only when the size of straw becomes about 5 cm long and passes through the space between bars of concave.

(ii) Straight through type

In these threshers the grain and straw are passed between concave and rotating cylinder only once and the long straw comes out.

(iii) Axial flow type

These threshers rotate the crop between the cylinder and concave for two or three rounds before troughing the straw out. During these rotations the crop is moved axially.

2.6 Common types of threshers

In almost all the threshers the basic job of threshing is accomplished due to impact, rubbing, size reduction or a combination of these actions. The impact plays a dominant role in detaching the grains from the earheads in beater-type, spike - tooth cylinder type and wire-loop type threshers. The rubbing and impact play the main role in threshing in rasp-bar type thresher. In syndicator-type threshers, the chopping of the material into smaller size along with impact and rubbing help in threshing of the crop.

The threshing mechanisms of the existing threshers of the following types:

1. Pedal type and power operated wire-loop type threshing cylinder

2. Rasp-bar type threshing cylinder with wiremesh concave

3. Spike-tooth thresher

   a. With wiremesh concave

   b. With spike concave

4. Beater type and drummy thresher

5. Syndicator thresher (chaff cutter-cum-thresher for wet wheat)

Chauhan and Verma (1977) reported the common types of threshers used in India. Salient specifications of available paddy threshers are given in Appendix-I.

2.6.1 Pedal type and power operated wire loop type paddy thresher

Pedal type paddy threshers (Fig.3) were originally developed in Japan and were introduced in India more than two decades back. These threshers are head feeding type and the whole crop is not required to be passed through threshing mechanism. The threshing cylinder is of wire loop type. Such a thresher can be operated by revolving the threshing drum with a foot-pedal. The diameter of the cylinder is kept about 45 cm and the threshing speed ranges from 350 to 450 rpm. The

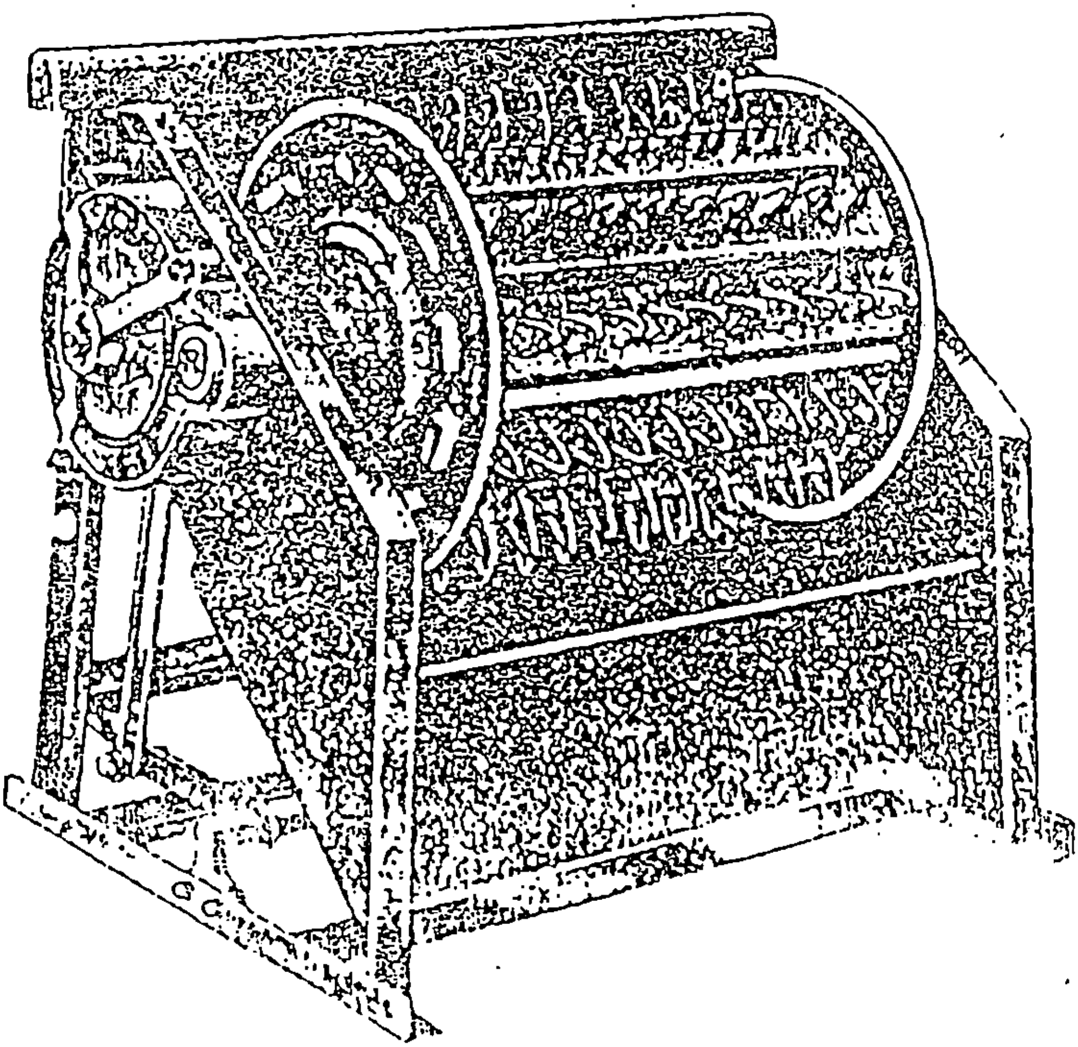


FIG.3 JAPANESE PEDAL PADDY THRESHER

output capacity of these machines is about 60 kg per hour. People rejected this thresher because of inefficient pedal threshing. But nowadays to cope up with the high labour cost motorised pedal threshers are being used.

A drum type power thresher was developed at IRRI during 1967-68 with wire-loop threshing cylinder and was operated by 4 hp engine. It had a 180 cm long hollow threshing drum which was mounted within a sheet metal housing. Rubber flaps were placed in spiral arrangement on the drum to sweep the housing bottom and to deliver the threshed material to the rear mounted rotary screen separator. The machine was capable of threshing both dry (14 per cent moisture content) and wet (more than 30 per cent moisture content) paddy.

Chauhan and Verma (1977) reported that the pedal paddy thresher can be operated by means of a prime mover of 2 to 3 HP. The output capacity of the power operated thresher is about 300 kg per hour.

The threshing of paddy was done with a power tiller operated wireloop type paddy thresher. Totally, four persons were required for the threshing operation. Threshing capacity was observed about 200 kg/h. The threshing cost by manual beating method is about Rs.27.00 per quintal against power thresher of Rs.12.70 per quintal (Annual report-1988, CIAE).

Dash and Das (1989) reported that a power operated wire loop type paddy thresher which was developed by them had higher output and maximum threshing efficiency. The cylinder diameter is 45 cm at the tip of wire loop. The length of shaft between two bearings is 130 cm, but the length of the cylinder between two end disks is kept 110 cm. Twelve equally spaced wooden slats of 7 cm width, 1.5 cm thickness and 110 cm length are fixed on the end disks over a rim of 3 mm thickness and 25 mm width welded to the disks. The diameter of end disks is 31 cm. The threshing wire loop is of 4 mm diameter of GI wire. It was found that net unit threshing cost per quintal of paddy was Rs.2.11 when threshed by this thresher as compared to Rs.3.96 per quintal when threshed by a pedal thresher.

John (1991) reported that a portable thresher with wire loop type threshing drum operated by a 0.5 hp electric motor has been developed and tested.

2.6.2 Beater type and drummy thresher

The threshing mechanism of this type of machine comprises radially arranged arms made of mild steel square sections. These arms commonly known as beaters, rotate inside a closed casing, the lower half of which is perforated. The threshing is achieved due to repeated impacting of the material by the beaters. These types of machines are closed concave type. The material to be fed in these threshers should be bone-dried. These machines are made in various sizes and capacities and are operated by prime movers ranging from 3 to 30 hp. These machines are of two types.

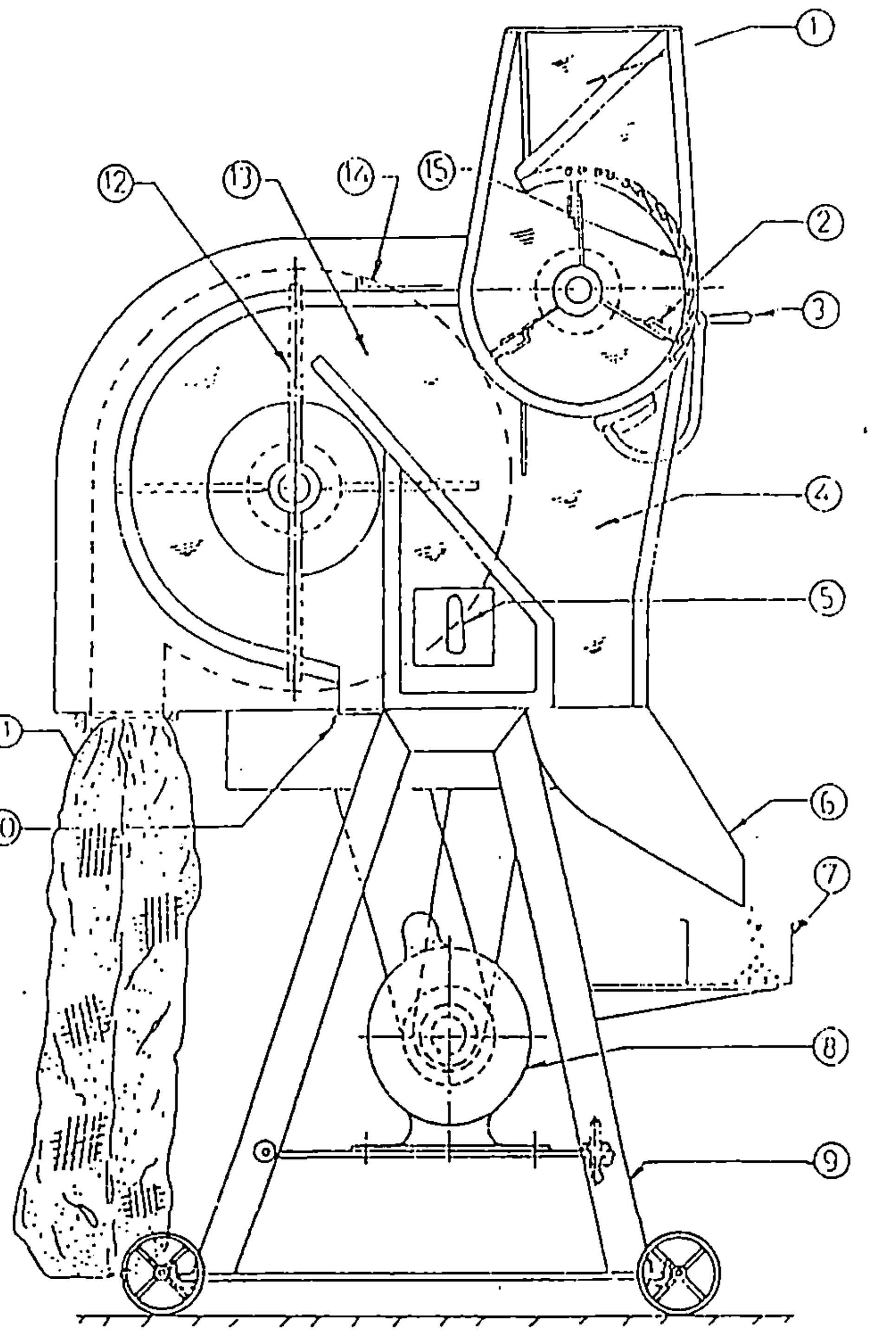
a. In which there is no provision of complete separation and cleaning of the grain and chaff. These are usually known as 'drummies' and do not have the sieves provided in the system.

b. Those with provision of complete separation and cleaning of the grain and chaff. A blower and a set of 2 to 3 sieves are provided for the purpose. The output capacity of these machines varies from 20 to 25 kg per hp/h.

A single earhead beater thresher (Fig.4) was developed in 1988 at CIAE, Bhopal. The unit was evaluated for wheat, gram, lentil, soyabean and paddy (Appendix-II) and found to high threshing and cleaning efficiencies and low seed damage (CIAE, Annual report, 1988).

2.6.3 Chaff cutter-cum-thresher (Syndicator thresher)

The basic principle of threshing in these machines is a combination of impact, rubbing and size reduction. The size reduction is accomplished by means of chopping knives provided



1 INLET	2 CYLINDER BEATER	3 LEVER
4 ASPIRATION COLUMN	5 ELECTRIC SWITCH	6 GRAIN OUTLET
7 TRAY FOR GRAIN	8 ELECTRIC MOTOR	9 FRAME
10 GATE OF INLET CHAMBER	11 TRASH BAG	12 BLOWER FAN
13 AIR PASSAGE	14 AIR CONTROL GATE	15 CONCAVE

FIG.4 SINGLE EAR THRESHER

on a corrugated wheel rotating inside a closed casing. In these the crop need not be absolutely dried and as such these are capable of threshing the wheat crop with a moisture content of 10 to 12 per cent. The frequent sharpening of the chopping knives is one of the drawbacks of these machines. Besides, a large number of accidents have been reported on these machines.

Lawrence *et al.* (1987) reported the studies on the cutting and threshing mechanism of chaff-cutter type thresher indicated that it would save total power and net power in the range of 26.1 to 32.8 per cent and 32.9 to 40.0 per cent respectively, in the grain moisture range of 8.9 to 23.6 per cent at optimum length of cut of 17.1 mm. It has a very high threshing efficiency of 99.5 per cent, less grain crackage and split straw percentages.

2.6.4 Rasp-bar type thresher

Material delivered to the drum is struck by the rasp-bars, pulled by them into the working slit and shifted through this slit with a varying speed. Between the surface of the rasp-bars and the shifted material there occurs a certain slip the value of which, at the inlet opening in account of low pressures of the rasp-bars is the highest. With increasing convergence of the working slit and pressure of the rasp-bars, this slip decreases reaching its lowest value at the outlet of the working slit. The concave bars, on the other hand, restrain the speed of travelling of stalks clamped by rasp-bars to the concave surface. The rasp-bars move in the working slit with a varying speed in relation to the shifted mass of material which simultaneously shifts with a varying speed with respect to the concave. As a result, the material layer is struck several times by rasp-bars causing threshing of the predominent amount of grains. This causes mutual rubbing of the ear stalks, as well as rubbing of the ears against the edges of the concave bars.

Singh and Joshi (1977) reported that a rasp-bar thresher of 28.5 cm drum diameter and 32 cm width gave an output of 139 kg/h of clean paddy with peripheral speed of 5.96 m/sec. The energy needed per quintal for threshing and cleaning was 0.44 hp/h of manual and 0.72 hp/h of electric energy.

Das (1981) and Shanmugham (1981) reported that a power operated rasp-bar type paddy thresher was designed and developed at Coimbatore. It is operated by 5 hp motor and requires three persons to operate. It is suitable for all varieties of paddy and output is 675 kg/h for a peripheral velocity of 22.7 m/sec. The threshing efficiency is 99 per cent.

The performance evaluation of three numbers of commercially avilable rasp-bar threshers (Appendix III) were studied and compared the maximum feed rate, peripheral speed, output and threshing efficiencies (CIAE, Annual Report, 1991).

2.6.5 Spike-tooth cylinder threshers

As the name implies these machines employ a cylindrical drum with a number of spikes or pegs mounted on its periphery. The grain is threshed due to impact by these pegs on crops against the concave. These are usually provided with a complete separation and cleaning system comprising a blower and a set of sieves.

Peter and Garg (1968) developed a spike-tooth type power thresher operated by 5 hp electric motor and is suitable for wheat, sorghum, gram and barley. The weight of the thresher was 400 kg. It has 96.9 per cent threshing efficiency and 99.8 per cent cleaning efficiency.

Datt (1987) and Annamalai and Datt (1991) reported that on axial flow peg-tooth thresher which was designed by IRRI are being used in many South-East Asian countries with minor modifications for threshing paddy . But the sales of these machines remained much limited mainly because the straw is cut into pieces which is not acceptable to the farmers. To overcome this problem straight through peg-tooth type thresher model IEP-2 has been developed at Coimbatore (Fig.5). The

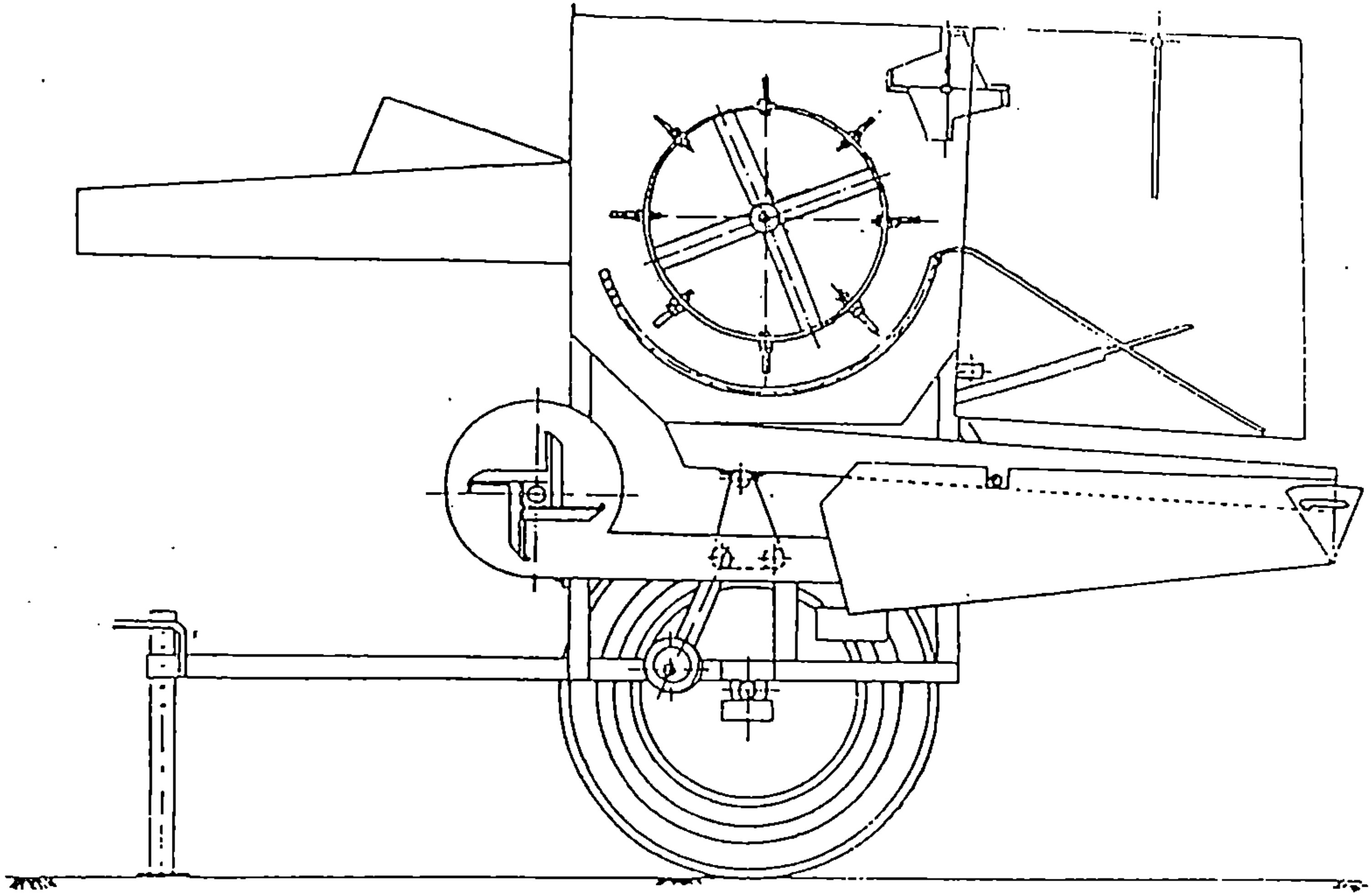


FIG.5 IEP-2 THRESHER

salient features of the thresher are its threshing efficiency of 99.9 per cent, output of 640 kg/h, cleaning efficiency of 98.0 per cent, low cost and low power requirement (6 hp). In South India the rasp-bar thresher have problems like low threshing efficiency, loss due to unthreshed grain going out with the straw, choking of threshing cylinder when used for threshing wet paddy crop without drying.

2.6.6 Axial flow type paddy thresher

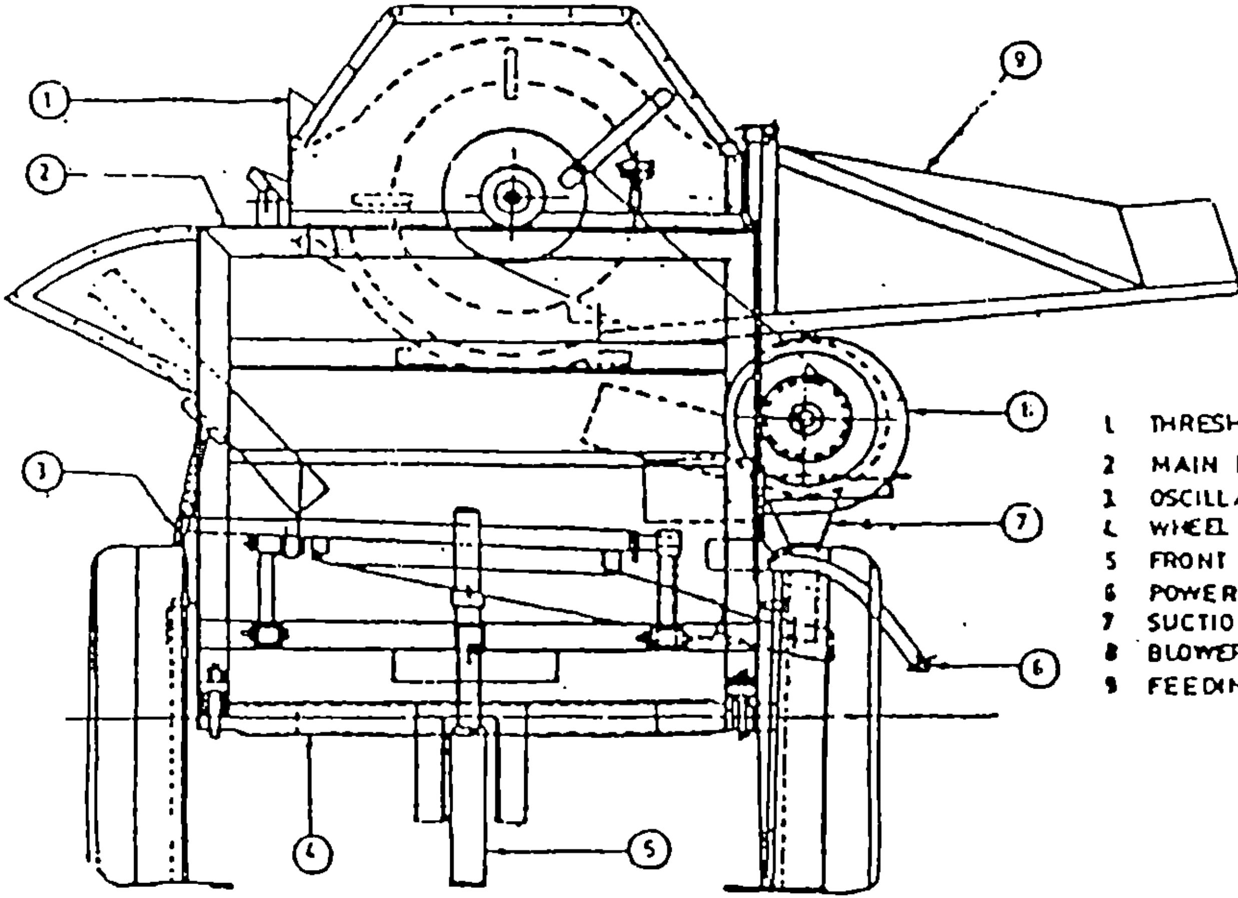
This type of thresher has been introduced recently in several countries in South-East Asia. The basic design has been evolved at the IRRI, Philippines. This machine has a conventional spike-tooth type cylinder with adjustable deflection baffles in the housing to move the threshed material along the axis of this cylinder. The adjustments on the deflecting baffles also controls the degree of threshing under varying crop conditions. The machine has primarily been designed for paddy and it is claimed that it can thresh other crops as well.

IRRI (1972) developed a throw-in type multicrop axial flow thresher with wire-loop type threshing drum. A. 6.5 hp engine was used as prime mover. An axial flow thresher with peg-tooth type drum gave better performance and long life with the same thresher. Chabbra (1975) developed and tested an axial flow peg-tooth thresher on the basis of IRRI axial flow thresher. He found that it can thresh paddy and wheat quite efficiently. In paddy threshing at 13.2 m/sec peripheral velocity the threshing efficiency was 100 per cent and feed rate was 710 kg/h gave an output of 213 kg of clean paddy per hour.

Khan (1977) developed IRRI-Pak axial flow multicrop thresher. The prime mover was an 8 hp diesel engine. The threshing mechanism of this thresher is spike-tooth type threshing cylinder and bar type concave. At peripheral velocity 32.6 m/sec the output is 519 kg/h of paddy (Fig.6).

Joshi and Singh (1980) developed a multicrop spike-tooth thresher named as Pantnagar-IRRI multicrop thresher with the 120 numbers of fixed pegs on 38 cm diameter rings and spike height being 15 cm on 4 cm long and 0.5 cm thick flats. It is operated by a 7.5 hp motor with 3 persons. It is suitable for paddy and wheat. The threshing capacity is 600 kg/h for paddy at a peripheral velocity of 28.5 m/sec (Fig.7).

Three types of paddy threshers were developed at IRRI, Philippines viz. IRRI portable, IRRI TH-7 and IRRI TH-8 threshers (Figs.8, 9). The capacity of these threshers are 600 kg, 500 kg and 1000kg per hour respectively at peripheral velocities 9.5 m/sec, 9.5 m/sec and 12.3 m/sec respectively. For operation of these threshers 5 hp, 7 hp and 10 hp engines respectively are required (IRRI, 1981). IRRI portable thresher retains the throw in and hold on features with axial movement of the materials inside the thresher.



1 THRESHING DRUM
2 MAIN FRAME
3 OSCILLATING TRAY
4 WHEEL AND AXLE
5 FRONT WHEEL
6 POWER TRANSMISSION
7 SUCTION DUCT ASPIRATOR
8 BLOWER
9 FEEDING TRAY

FIG.6 IRRI-PAK AXIAL FLOW MULTICROP THRESHER

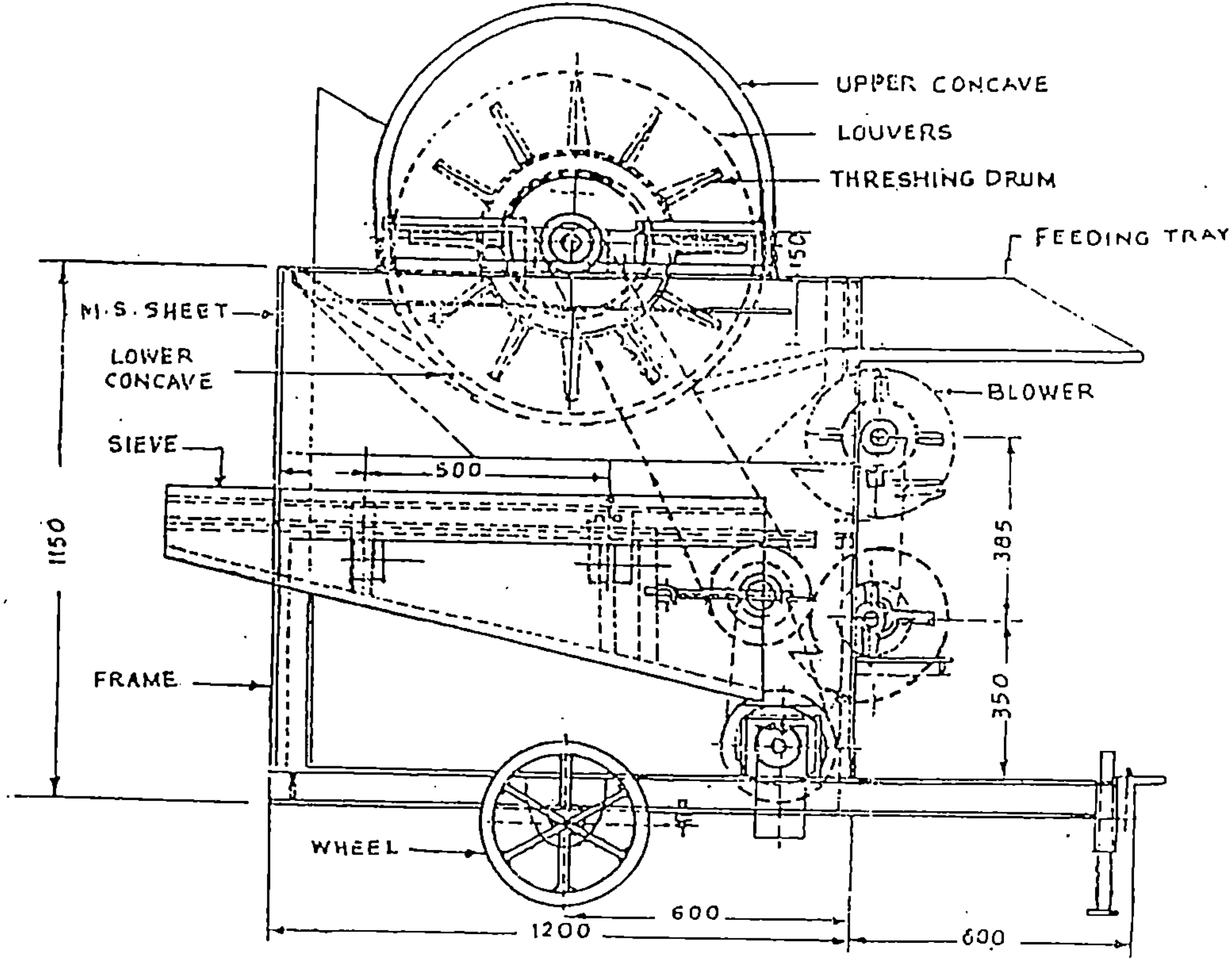


FIG.7 IRRI-PANT AXIAL FLOW MULTICROP THRESHER

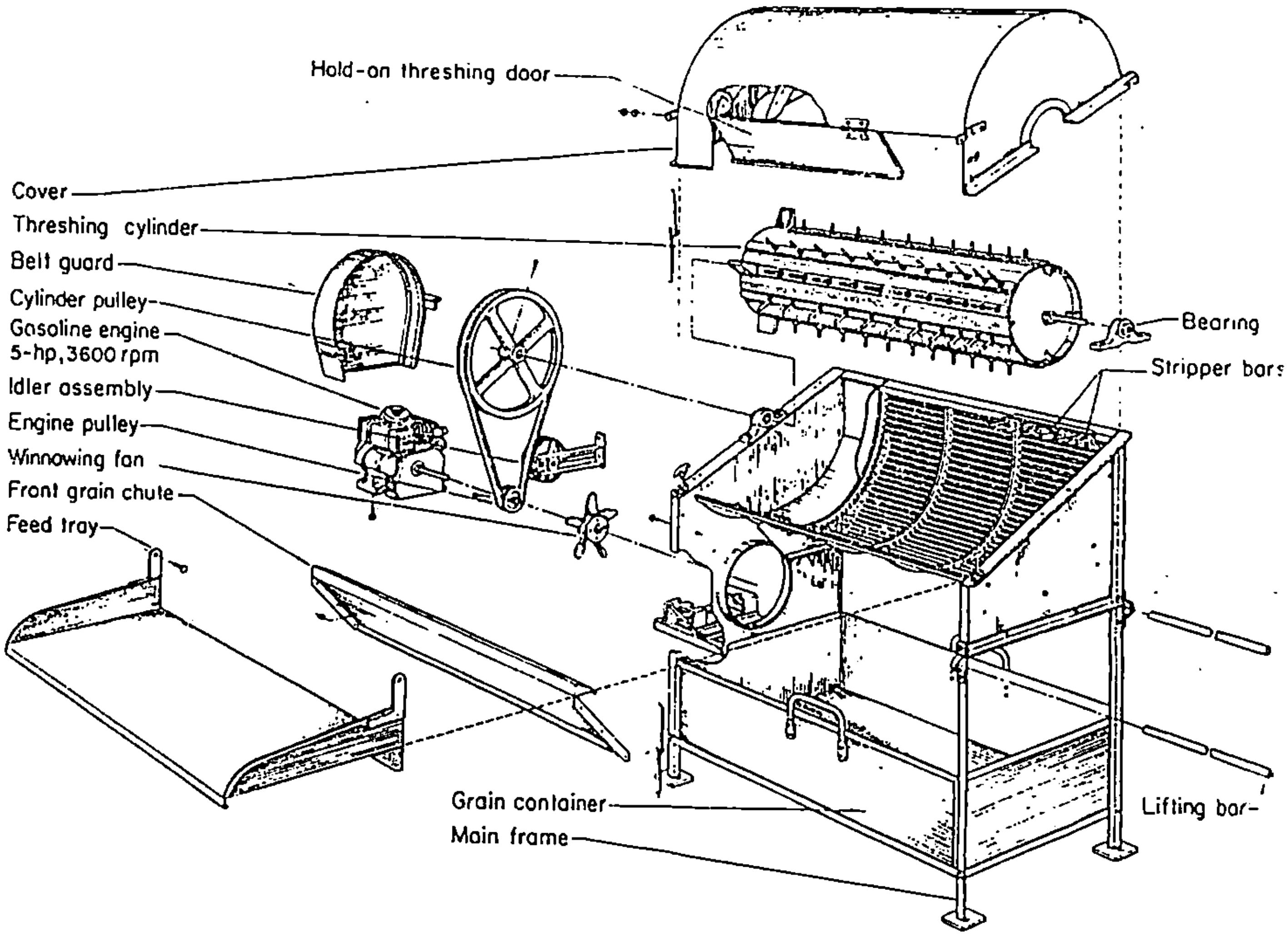


FIG. 8 EXPLODED DRAWING OF IRRI PORTABLE THRESHER

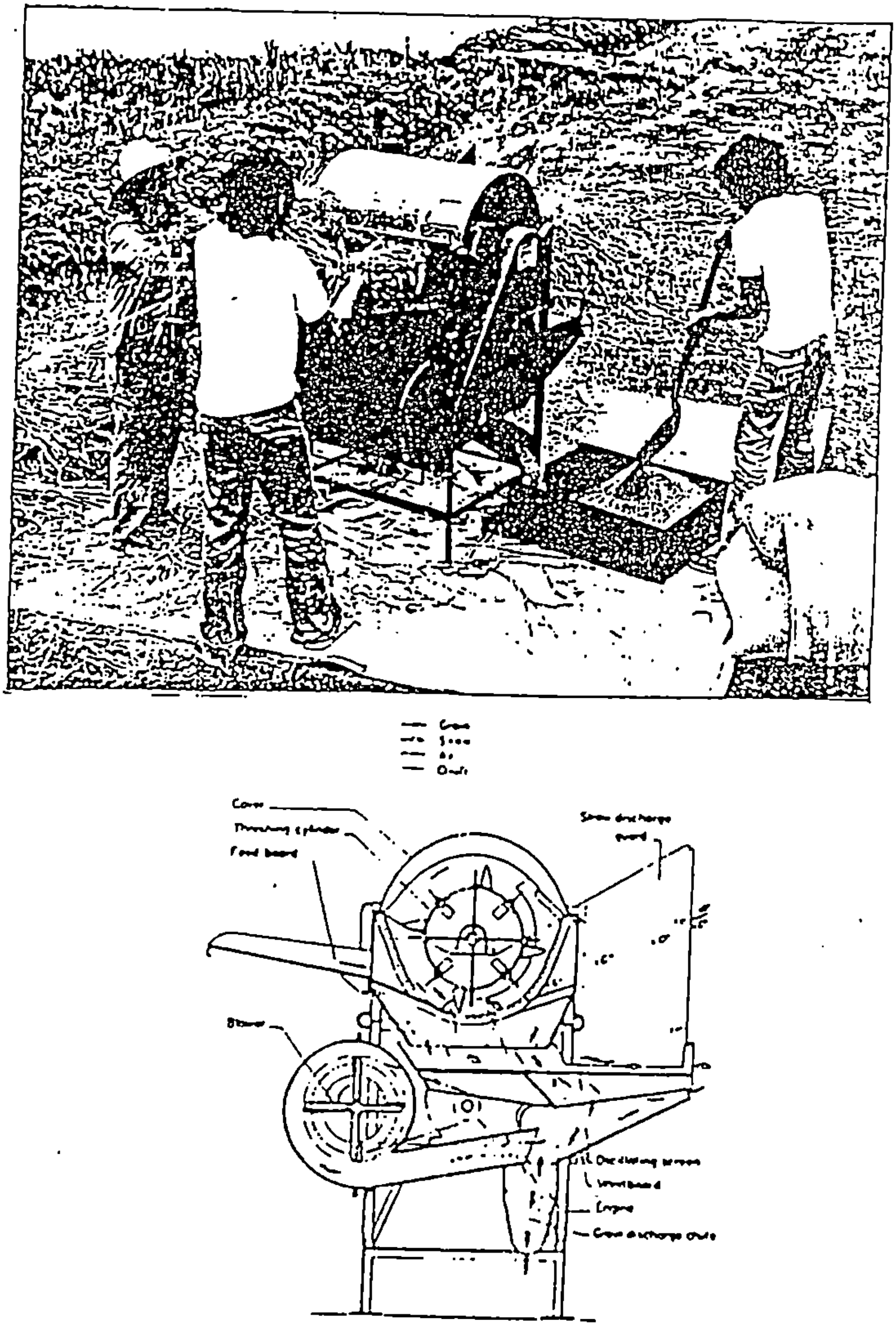


FIG.9 IRRI TH 7 AXIAL FLOW THRESHER

Threshers of mini and straight type have been developed at Pakistan in 1979. The standard thresher requiring 12 hp diesel engine gave a threshing output of 450 kg/h on dwarf varieties and 225 kg/h on Basmati rice. Ahuja *et al.*(1986) reported that the IRRI-Pak axial flow thresher could save about 120 man h/ha as compared to traditional manual method of paddy threshing, when the yield levels are 7500 kg/ha and low grain losses. The machine has high cost in comparison to a similar capacity paddy thresher in view of its satisfactory performance of paddy alone.

Hien (1991) reported that an axial flow thresher was introduced to Southern Vietnam in 1974 by the Vietnam Agricultural Machinery Company according to IRRI drawings. The main modifications had been different shapes and arrangement of threshing teeth and a simple yet effective cleaning system. Its output was 700 kg/ha using 7 hp diesel engine.

2.6.7 Oscillating straw walkers (rack) type threshers

A rasp-bar or a spike tooth type cylinder thresher with an open concave is provided with straw walkers. Nearly 80 per cent of the grain is separated in the concave itself and the remaining accompanying the straw is placed on the oscillating straw-walkers racks. The straw in these machines is not broken and as such the separation is much easier. These also have a blower and a set of adjustable sieves for cleaning of the grain from the chaff. Threshers of this design can be used for threshing wheat, paddy and other crops (Chauhan and verma, 1977).

2.6.8 Multi-crop threshers

Farmers need a suitable thresher which can thresh all crops from their farm and the multi-crop thresher is the only solution.

Roy (1970) developed a multi-crop thresher with spike tooth cylinder having a fixed cylinder-concave clearance. The cylinder tip speed ranged between 20 to 23.3 m/sec resulting in less than 0.1 per cent unthreshed grain. Between 13.3 to 16.7 m/sec resulted in less than 0.1 per cent visible damage. The thresher has the problem of straw cut.

Peter (1970) developed a multi-crop thresher for paddy, wheat, sorghum and pearl millet. The threshing capacity of this thresher for paddy was 200-400 kg/h. A 3.5 hp engine was used for its operation.

Nirmal and Sirohi (1976) developed a multicrop (5 hp) thresher named as Pusa 40 thresher at New Delhi. Five persons were required for its operation and it was designed to thresh wheat, paddy, barley, pearl millet, safflower and sorghum. The threshing capacity was 200 kg of wheat/h.

Singh (1976) designed a multicrop thresher at Jabalpur with 2 hp electric motor. It is a modified wire loop thresher with closed concave to thresh wheat, paddy and soyabean. Two persons are required for its operation and the output was 200 kg of paddy grain per hour.

Sharma *et al.* (1983, 1984) reported that a multicrop thresher was developed with a rasp-bar threshing and separating mechanism and optional bruising attachment which can be removed while threshing maize and paddy. It has rasp-bar threshing cylinder, concave and aspirating blower. The output was 400 kg of paddy per hour. Sharma developed spike tooth type multicrop thresher named as PAU wheat cum paddy thresher. The threshing drum divided into three portions and have different diameter spikes. It has also louver on the upper casing for conveying of the material. The machine can thresh wheat as well as paddy with minor adjustments. The machine when operated by 5 hp electric motor gave 400 kg of paddy per hour.

Majumdar (1990) reported that a multicrop thresher was designed and developed in 1982 and was evaluated during 1982 to 1985 on different crops and necessary modifications incorporated. It was a spike tooth cylinder thresher operated by a 5 hp motor. The output was 392 kg of paddy per hour. Later the thresher was modified and a high capacity multicrop thresher was developed. A hopper type feeding device was provided to the thresher for easier feeding of the crop. The threshing cylinder was fitted with flat spikes welded on 8 angle irons in staggered fashion. The thresher needed a 20 hp electric motor and the output capacity of the machine was 1000-1500 kg/h.

Khan (1990) reported that a dual mode thresher that has been developed in Egypt under the USAID supported National Agricultural Research Project (NARP) could be operated both as a beater or an axial flow type machine. This machine could thresh all the popular cereal crops that are grown in the developing countries and can also make fodder from straw. Two units of the modified dual mode all-crop thresher were tested on wheat and paddy during the 1989 harvesting seasons. A threshing output of 390 kg/h of wheat and 634 kg/h of paddy was obtained.

2.7 Paddy combines

A combine performs the unit operations like cutting of crop, transportation, threshing, winnowing, cleaning and delivering of grain when it works in the field. Smaller hp combines are popular in Japan whereas higher hp combines are used in Western countries. Both of these combines were tested in India and because of several limitations they achieved only limited popularity.

Vaugh (1962) reported that the combine harvester replaced all harvesting equipment for small grains in the West. The drawbacks are its higher initial cost, unadoptable for mixed farming, it cannot work in small fields, operating and maintenance costs are higher and it does not save the straw which often worth half to two-thirds as much as grain in the market. Because of these drawbacks combines are not popular for paddy crop in India except in Punjab and Western U.P. for wheat crop.

Gill and Mittal (1972) reported that the combine operation is associated with several problems. Saijpaul (1983) explained the drawbacks of combine operation such as need of large space for operation and losses increased exponentially with feed rate.

Behl *et al.* (1987) reported the reliability estimates for combine harvesters which are important for reducing the downtime for repairs. Klenin *et al.* (1989) reported that a comparative experimental investigation took place in the Central Machine Experimental Testing Station, USSR. The department improved the design of the conventional combine to decrease the grain losses.

Mawla (1990) reported that two combines, the conventional all-crop combine harvester and the special rice combine imported from Japan, were compared in harvesting rice in Egypt. Grain losses in the conventional combine are relatively higher than for the rice combine. But the total costs of harvest for the conventional combine are less than for the rice combine.

2.8 Grain separating and cleaning systems

Singh (1988) has explained that for cleaning different crop grains and to remove the straw, needed different terminal velocities. For wheat it is 7.9 to 11.5 m/s and for straw butts it is 2.0 to 3.3 m/s. Datt (1992) reported the different systems used in threshers for cleaning and separation of grain from straw.

a. Sieves and aspirator (commonly found on hammer mill type wheat threshers)

b. Sieves and blower (commonly found on axial flow threshing)

c. Sieves, blower and straw walkers (commonly found on straight through threshers)

2.9 Ergonomics

The thresher should be designed considering all the ergonomic factors to suit the potential user population. The thresher workers are subjected to various stress agents like vibration, noise, dust, extreme weather conditions which cause ill health. So necessary actions are to be taken for comfort operation and thus to avoid accidents.

2.9.1 Safe feeding systems for power threshers

Verma *et al.* (1979) reported that about 800 to 1000 persons sustain serious injuries while working on the power threshers in India every year. This amounts to roughly 20 accidents per 10,000 machines in use. A survey on thresher accidents revealed that the maximum accidents took place on the drummy-type threshers (45.2 per cent) followed by the syndicator type (37.4 per cent), regular beater type (14.2 per cent), spike tooth cylinder type (1.3 per cent) and miscellaneous types of threshers (1.9 per cent). No accident was reported on the bulk feed hopper type threshers. The survey also revealed that human factors were responsible for 73 per cent of the thresher accidents, machine factors accounted for nearly 13 per cent including unsafe feeding system, poor quality of material and faulty design of thresher components, crop conditions were responsible for 9 per cent of accidents and the situational factors were accounted for 5 per cent of the total accidents.

Srivastava and Thyagraj (1982) reported that introduction of power threshers brought a chain of accidents of farm workers resulting in their temporary or permanent disability. The study have shown that lack of proper safe feeding device was mostly responsible for such accidents. Singh (1988) showed that feeding chute with adequate safety measures were compulsory to be provided on power thresher. Design requirements of a feeding system is as follows:

a. It should facilitate smooth feeding of the material with minimum force.

b. It should be safe to prevent injury to the hands and other body parts of the operator.

c. It should, as far as possible, form an integral part of the thresher to eliminate chances of its detachment.

d. It should be simple in design and construction and easy to manufacture with locally available materials.

e. It should have no sharp corners to prevent injuries to the operators.

f. Its cost in relation to the thresher should be low.

g. It should not bend or break under the weight of the material being fed.

h. Its size should be adequate to permit desired feed rate to achieve the rated output capacity.

i. It should not lead to back feeding of the material.

The common types of threshing and feeding systems used in India have been indicated and shown in Appendix-IV and Fig.10.

2.10 Factors affecting threshing effectiveness

The factors which affect the quality and efficiency of threshing are classified into the following groups: (Kanafojiski and Karwanski, 1976).

A. Properties of threshed material

a. Its type and variety

b. Moisture content of grain and straw

c. Addition of green matter as impurity

d. Ratio of grain to straw weight

B. Technical conditions

a. Type of threshing cylinder

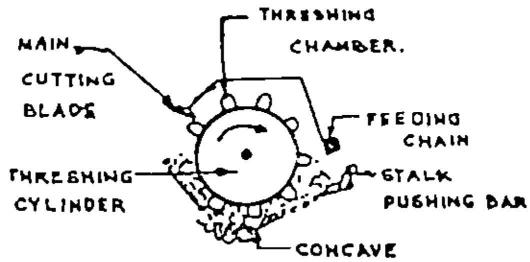
b. Peripheral speed of cylinder
(Number of revolutions and its diameter)

c. Number of rasp-bars, pegs, hammers and their shape

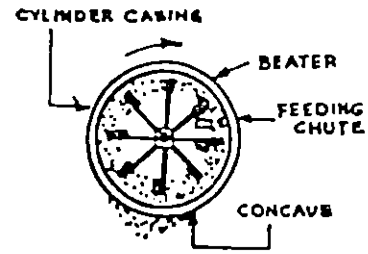
d. Angle of wrapping of the concave (or length of concave)

e. Size of the working slit at its inlet and outlet opening

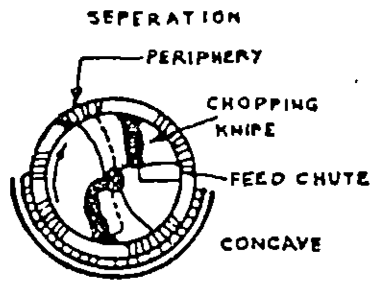
f. Shape and distribution of the concave bars



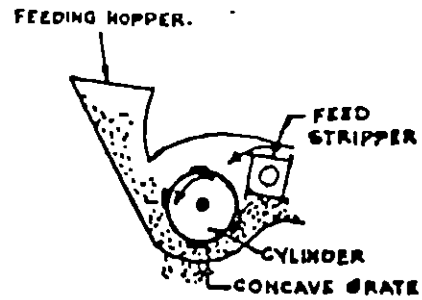
JAPANESE-TYPE THRESHER WITH FEEDING CHAIN



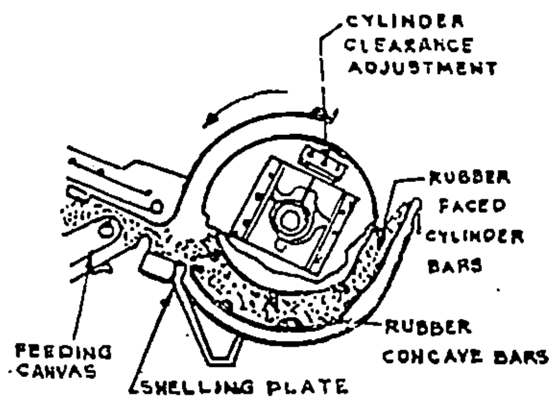
BEATER-TYPE AND DRUMMY THRESHER



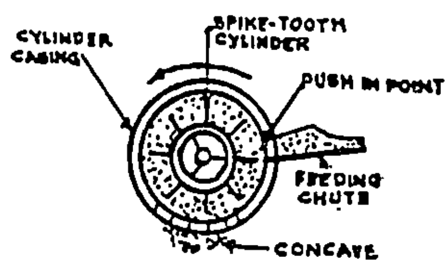
SINDICATOR-TYPE THRESHER



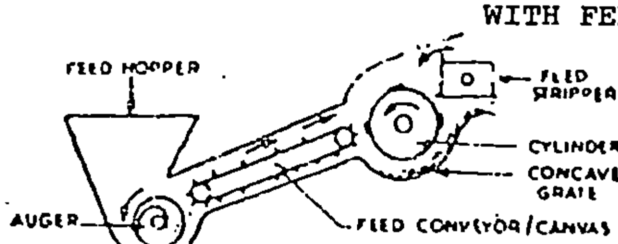
SPIKE-TOOTH THRESHER WITH HOPPER-FEEDING



ANGLE BAR CYLINDER THRESHER



SPIKE-TOOTH THRESHER WITH FEEDING CHUTE



RASP-BAR/SPIKE-TOOTH THRESHER WITH HOPPER, AUGER AND CONVEYOR FEEDING

FIG.10 DIFFERENT TYPES OF THRESHERING AND FEEDING SYSTEMS

C. **Delivery of material to the drum**

a. Rate and method of feeding

b. Number of rotations of crop in axial flow threshers

c. Positioning of stalks with respect to the drum axis at the time of feeding

d. Point of contact of the crop layer with the drum circumstances

A Japanese type power thresher was evaluated at Kharagpur to study the effect of cylinder speed on threshing of paddy. Speed of the threshing cylinder was found to be the important factor affecting threshing efficiency. Higher speed of cylinder results in more seed damage and grain loss whereas lower speed causes low output. The output of paddy was directly proportional to the speed of the cylinder. For maximum output the threshing should be performed within the range of 550 to 650 rpm. For minimum grain loss the threshing should be done at 550 rpm (Trivedi and Arya, 1966).

Paul *et al.* (1967) reported that from the test results with paddy, it was evident that the threshing efficiency was not affected much by the speed range selected for the test, but higher moisture content tends to decrease the threshing efficiency. Prasad and Gupta (1973) found that when the moisture content increases, the paddy grain sustained more impact force for the same amount of deformation. The explanation for such behaviour of paddy grain was the water molecules present in the grain absorbing a part of the impact energy and therefore the deformation of solid constituent of paddy grain was less at a higher moisture content under the same impact force.

Lawrence *et al.* (1987) reported that threshing efficiency decreased with increase in moisture content, decrease in feed rate and increase in length of cut. Kulkarni (1987) reported that seed damage increased with decrease in the moisture content. Brittleness of seed at low moisture content was found to be the cause for high mechanical damage.

Das (1988) presented the capacity and energy requirements in different threshing methods for threshing various crops. He also found out the correct drum speed for spike tooth as 16 m/s and for rasp-bar it was 25 m/s. This required the cylinder speed of 14-16 m/s, blower speed of 720 mm of O/D is 800 rpm and the top sieve hole diameter of 7.8 mm.

Das and Dash (1989) reported that a power operated wire loop type paddy thresher was tested. It was observed that maximum threshing efficiency can be achieved by threshing the paddy crop at 16.5 per cent moisture content at peripheral velocity of 10.4 m/sec. It was also found that the threshing efficiency decreases with the increase of peripheral velocity since the impact force exerted by the teeth to the crop detaches the earhead along with the grains. At high moisture content, the crop requires high threshing force in order to separate the grains. But at low moisture content, greater number of earheads broke thereby increasing the amount of unthreshed grain. Capacity increases non-linear with the increase in peripheral velocity. The losses increased with the increase of peripheral velocity of the thresher. At low peripheral velocity the losses were greater due to less threshing force.

Hien (1991) reported about the improvements on IRRI TH8 thresher by a new tooth profile by reducing the number of teeth with axial flow and overlapping angles.

2.11 Selection of suitable thresher

Chauhan and Verma (1977) conducted a study on threshers and gave the following criteria for selecting a thresher.

(i) The size of the thresher should be matching to the hp of the prime mover available with the user.

(ii) The output capacity of the thresher per horse power hour should be higher and the threshing and other losses should be minimum.

(iii) The need for making straw or otherwise should be decided before hand.

(iv) The machine should have a feeding tray of proper size.

(v) The thresher should have proper grease cups for greasing of the different bearings.

(vi) A thresher with a fly wheel mounted on the principal shaft should be preferred for better performance.

(vii) It is better to buy a thresher for which the test report is available from a testing agency.

(viii) A machine should be bought from a manufacturer with established reputation.

(ix) A multicrop thresher to be preferred to a single-crop machine.

(x) A machine which has proper protective device over the moving belts should be preferred.

Materials and Methods

MATERIALS AND METHODS

Various paddy threshing methods in Kerala were studied from different villages where these methods are practised. The study of available paddy threshers, their construction details and the experimental programme are presented in this chapter.

The traditional methods of threshing are costly, laborious, time consuming and strenuous. Now-a-days, in northern states of our country the threshing by mechanical methods is becoming most popular due to modernisation of agricultural farming. But for Kerala the threshers are not getting popularized, and the farmers still follow the traditional methods of threshing which involve high level of human drudgery. The reasons for non-popularization of paddy threshers are listed below:

1. Lack of knowledge about the availability of power operated threshers.

2. Doubt about its field performance efficiencies.

3. Higher initial cost.

4. Its complicated design and lack of local repairing facilities.

5. Fear about destruction of straw.

6. Small paddy farms - hence unable to have own power paddy threshers.

But recently the situations are changed. Serious labour scarcity is prevailing especially for peak period like harvesting, threshing and transplanting. The available labour force in Kerala is not willing to take up heavy farm works like harvesting, threshing and transplanting. Most of the time the threshing operations are not completed in time contributing high loss of grain in the field. It demanded the feasibility studies of thresher performance in Kerala condition for the introduction of threshers.

3.1 Traditional methods used in Kerala

In various parts of Kerala threshing is accomplished by treading the grain under the feet of men or striking the sheaves against a stone, striking the earheads with stick or treading the grain under hooves of bullocks or by tractor types.

In southern parts of Kerala hand beating (Plate I) is the method used for threshing. The study with the hand beating method was conducted at different farms of two villages in Trivandrum District and the details of operations are collected (Table 1). Among the twelve farms visited, most of the farms are about one kilometre away from the houses and the trasportation for threshing is mainly by head loading. Area of farms varying from 0.2 ha to 0.8 ha and sheaf weight varying from 0.9 to 1 kg. For harvesting, transportation and threshing operations two men and three women labourers are needed for a 0.2 ha farm. For threshing one sheaf with stone beating about 15 seconds was needed. About 400 sheaves from a 0.2 ha farm. So for threshing 100 min is needed and for cleaning these grains need 90 min. The wages for a man is Rs.45 per day and for a woman is Rs.35 per day. But usually it is given as 'Patham' in 1:6 ratio of the total output. With stone beating proper threshing can not be achieved, so some part of the grains would stuck to the straw. The straws were beaten with stick and the total grains were taken as wages. Between two seasons of *virippu* and *mundakan* there is no significant difference for wages of different operations.

In central Kerala feet rubbing (Plate II) is the common method of threshing. So the study was conducted for this method at farms of two villages in Alleppey district. The details of operations are taken from eight farms visited (Table 2). Most of the farms are about 1.0 to 1.5 km away from the houses and the threshing operation is done in the field itself during summer season and otherwise in nearby areas. The threshed and cleaned paddy is transported

Plate I Threshing by hand beating method

Plate II Threshing by feet rubbing method

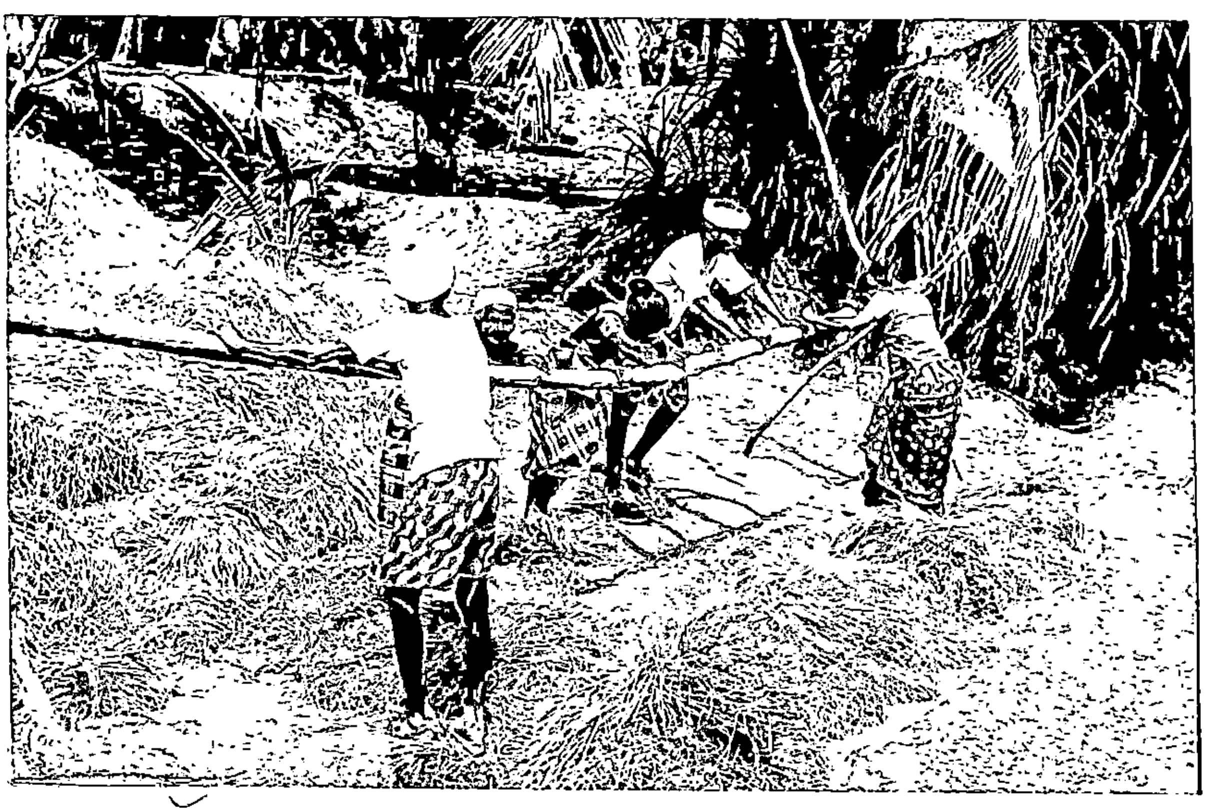


Table 1. Details of hand beating method of threshing obtained from the survey of Trivandrum district

Sl. No.	Description	Unit	*Virippu*			*Mundakan*			Average
			1	2	3	1	2	3	
1.	Area harvested	ha	0.2	0.4	0.8	0.2	0.4	0.8	
2.	Total output	kg	645	1185	2305	550	1240	2560	
3.	Man hours used	h	35.5	70.3	144.0	26.0	63.3	133.3	
4.	Man hours used/ha	h/ha	177.5	175.8	180	130	158.3	166.6	164.7
5.	Cost of threshing/ha	Rs/ha	887.5	879	900	650	791.5	833	823.5
6.	Output capacity of Threshing/h	kg/h	18.2	16.9	16.0	21.2	19.6	19.2	18.5
7.	Cost of threshing/kg	Rs/kg	0.275	0.297	0.312	0.236	0.255	0.260	0.273
8.	Cost of threshing/h	Rs/h	5	5	5	5	5	5	5

Daily wages for men = Rs.45/day   Daily wages for women = Rs.35/day

Average wage/labourer = Rs.40/day of 8 hours.

Table 2. Details of feet rubbing method of threshing obtained from the survey of Alleppey District

Sl. No.	Description	Units	*Virippu* 1	*Virippu* 2	*Virippu* 3	*Mundakan* 1	*Mundakan* 2	*Mundakan* 3	Average
1.	Area harvested	ha	0.2	0.4	0.8	0.2	0.4	0.8	
2.	Total output	kg	808	1610	3220	640	1275	2550	
3.	Man hours used	h	68	135	290	58	118	235	
4.	Man hours used/ha	h/ha	340.0	337.5	362.5	290.0	295.0	293.8	319.8
5.	Cost of threshing/ha	Rs/ha	1700.0	1687.5	1812.5	1450.0	1475.0	1468.8	1599.0
6.	Output capacity of threshing/h	kg/h	11.88	11.93	11.10	11.03	10.81	10.85	11.27
7.	Cost of threshing/kg	Rs/kg	0.421	0.419	0.450	0.453	0.463	0.461	0.445
8.	Cost of threshing/h	Rs/h	5	5	5	5	5	5	5

Daily wages for men = Rs.45/day Daily wages for women = Rs.35/day

Average wage/labourer = Rs.40/day of 8 hours to the house by mini lorries. For threshing one sheaf an average of 40 sec is needed by the method of feet rubbing. The wage per day is same as that of Trivandrum district.

In eastern parts of Kerala, i.e., in Palghat district bullock or tractor treading was also used for threshing in olden days along with hand beating against stone or rubbing with feet. As it was not found suitable, now-a-days these systems were not followed. Due to increase in the cost of fuel as well as tractor hire charges, tractor treading is also not followed in Kerala.

In northern Kerala mainly beating on stone is used and in some places feet rubbing method is also used for threshing.

3.3 Study on available paddy threshers

An axial flow peg tooth type thresher (Fig.11) and a flow through rasp-bar type paddy thresher (Fig.12) are available at K.C.A.E.T., Tavanur for paddy threshing. The specification details of these threshers are given in Appendix-V.

3.2.1 Description of the thresher components

The details of the main components of two types of threshers are described below:

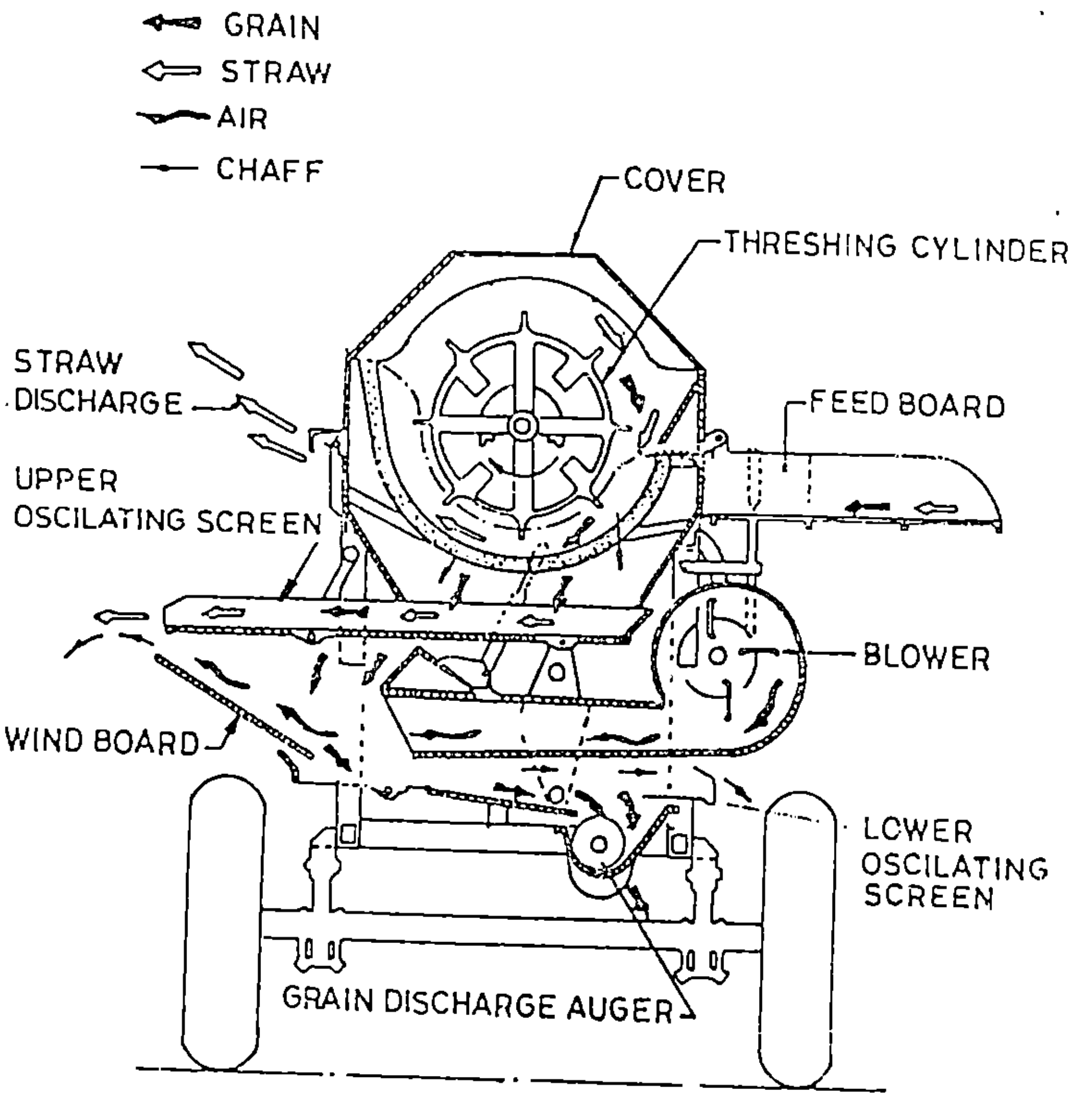
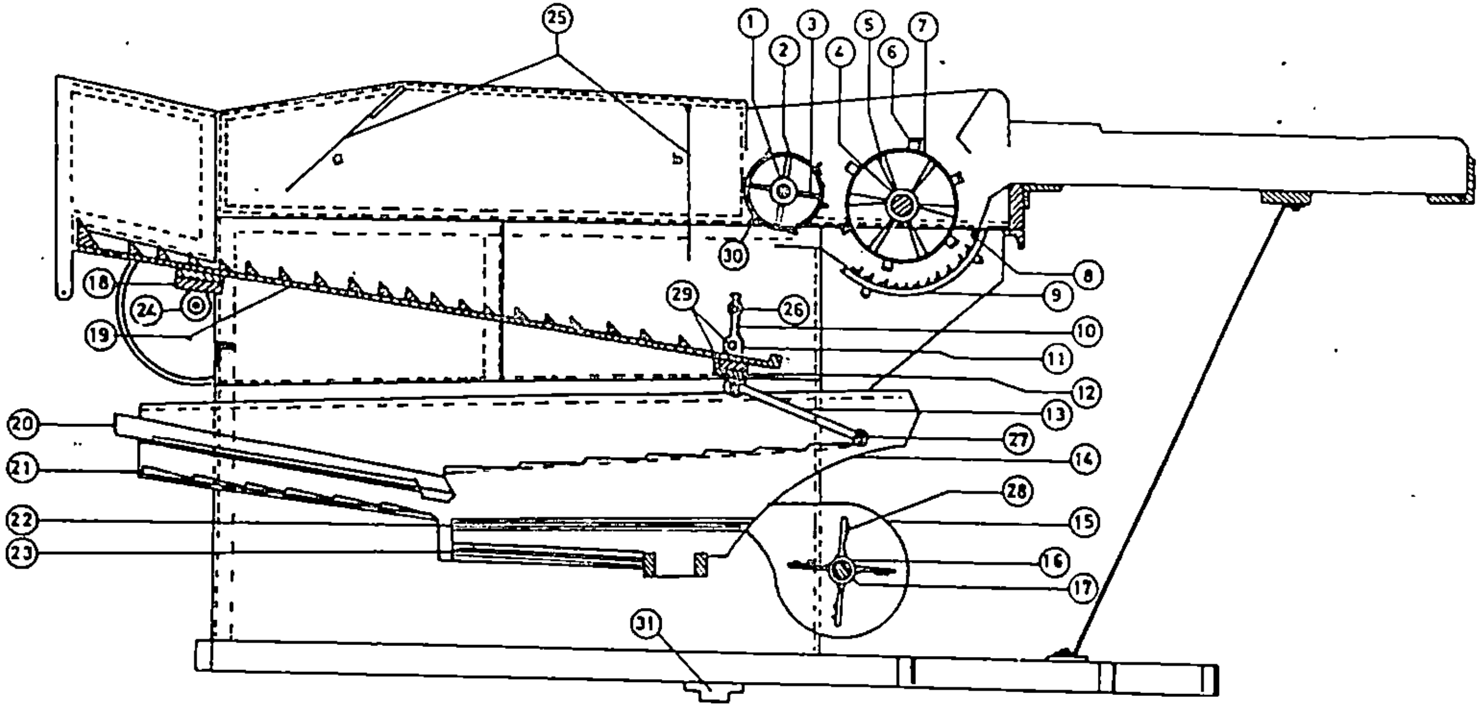


FIG.11 TH 8 AXIAL-FLOW THRESHER



1. Doffing Cylinder Shaft
2. Doffing Cylinder
3. Doffing Cylinder Hub
4. Main Cylinder Shaft
5. Main Cylinder Hub
6. Rasp bar
7. Main Cylinder
8. Concave Bars
9. Concave
10. Straw Walker Suspension Lever
11. Straw Walker Suspension Lever Block
12. Oscillation box connecting rod block
13. Oscillation box Connecting Rod
14. Oscillation box Connecting Slider
15. Winnowing Fan
16. Winnowing Hub
17. Winnowing Shaft
18. Crank Shaft Bearing Block
19. Straw Walkers
20. Wooden Sieve
21. Oscillating box bottom Slider
22. Upper Sieve
23. Lower Sieve
24. Crank Shaft
25. Louver Plates
26. Straw Walker Suspension Shaft
27. Oscillating box draft Shaft
28. Winnower Hub
29. Lever Pins
30. Doffing Cylinder Angle bar
31. Axle

FIG.12 FLOW THROUGH RASP-BAR THRESHER

(i) Feeding tray

A folding type feeding tray was provided with the axial flow spike tooth type thresher. But in straight through rasp-bar type thresher unfolding type feeding tray was used. A man had to sit on thresher and feed the sheaves continuously by hand to the threshing cylinder in the rasp-bar type thresher. In the case of axial flow thresher a man had to stand near the tray and feed the crop by hand continuously.

(ii) Threshing cylinder

Both threshers were provided with a closed type threshing cylinder. For axial flow thresher the length and diameter of the threshing drum was 111 cm and 39.3 cm respectively and eight bars with twelve/thirteen spikes were fitted on the drum parallel to the axis. The drum is powered with a belt and pulley system from the blower pulley. In the case of rasp-bar type thresher, six rasp-bars were fitted on the threshing cylinder which had the length and diameter of 55 cm and 33.5 cm respectively. A doffing cylinder is provided in front of the threshing cylinder to prevent the rerotation of threshed materials. The rasp-bar threshing cylinder is powered from the engine pulley and the doffing drum is powered from the threshing drum pulley in the left side of the threshing drum.

(iii) Concave

For axial flow threshers, the concave was made of 0.6 cm diameter steel rods with 1.6 cm spacing, and the concave width and clearance were 95 cm and 3-5 cm respectively. For rasp-bar type thresher the concave was made of 0.7 cm diameter steel bars with 1.5 cm spacing and the concave width and clearance were 56.5 cm and 1.5-3 cm respectively. In rasp-bar type thresher the clearance can be adjusted with moving concave positions in or out and hold in position by pins. Such an arrangement was not provided in axial flow thresher.

(iv) Straw walker

Straw walkers were not provided with axial flow type thresher. In rasp-bar type thresher, the threshed materials from the threshing drum came to three straw walkers having width of 15 cm and length 180 cm. The long straw was transmitted by the walker outward and the threshed grains were dropped to the sieve through the spacings in walkers. The upper surface of each walker was in serrated form. The up and down motion of the straw walker was with a crank shaft which was driven by a cross flat belt from the threshing drum pulley.

(v) Blower and sieves

Separation and cleaning of the grain was accomplished by blowers and a set of reciprocating sieves. In the case of axial flow threshing, two blowers were provided below the threshing system and was powered with a V belt from the engine. The diameter and length of blower were 34 cm and 35cm respectively. The blower speed was 800 rpm and it was opened to the reciprocating sieves for straw and chaff removal. The inner end side of the sieves were fixed to the oscillating arrangement from the screw conveyor shaft. A top sieve and bottom sieve of hole size 1.6 cm diameter and 0.95 cm diameter was provided. Top sieve was for the removal of stones and the bottom sieve allowed the fine particles to pass through the sieve. Main grain outlet was provided from bottom sieve to the right hand side.

In the case of rasp-bar type thresher, the blower was provided below the threshing system and was powered with a flat belt from the threshing drum pulley in the motor side. The blower diameter and length were 30 cm and 50 cm respectively. The blower was driven with a flat belt from the pulley in the left side of threshing drum. The blower was opened to the reciprocating sieves for chaff removal. The inner end shaft of the sieve cover was fixed to the inner end of the middle walker with one end fixed oscillating arrangement, thus reciprocating motion was attained by the sieves while in operation. Three oscillating sieves were provided. Wooden sieve with 1.8 cm diameter hole to remove straw and the top perforated sheet with 0.5 cm diameter and 2 cm long slot to remove stones and the bottom perforated sheet with 0.15 cm diameter and 1.5 cm long slots to remove soil and other fine particles to pass through the sieve. The main grain outlet is provided from the bottom sieve to the left hand side of the thresher.

(vi) Power system

The 8 hp Lombardini diesel engine was used as a power source and V-belts were used for power transmission for axial flow threshers. In the case of rasp-bar type thresher an electric motor of 7.5 hp or a Kubota diesel engine of 10 hp was used as a power source and flat belts and V-belts were used for power transmission. The specifications of the engines used in threshers are given in Appendix-VI.

(vii) Transport wheels

Both the threshers used two pneumatic wheels for easy transportation by tractor or jeep or a pair of bullocks. For axial flow thresher the wheel diameter was 64 cm and for rasp-bar type thresher it was 74 cm diameter.

3.3 Test procedure for the performance evaluation of the thresher

All the parameters related to the performance of the thresher were determined according to the RNAM Test Code. Two types of tests (a) test at no load (b) test at load for long duration (2 h) were conducted. The parameters related to the performance of the machine were recorded as follows:

(i) Speed of the moving parts

The speed of the rotating parts were observed by a hand tachometer (Appendix-VII) thrice during each test.

(ii) Feed rate

Crop samples were kept near the machine before start. The feed rate were controlled by regulating the quantity of crop to be fed without choking of cylinder/blower/sieve to obtain the maximum feed rate.

(iii) Power consumption

Power requirement was observed two times during the test at no load condition by using a three phase wattmeter for motor (Appendix-VIII) and the fuel consumption at load condition for the engine.

(iv) Sample collection during test

During each performance test three sets of samples were collected from main grain outlet, blower outlet and straw walker outlet. Later on unthreshed grain,broken grain, clean grain and foreign material were separated from each sample manually and were weighed by a precision balance. The weight of scattered grain was also noted.

(v) Equations for calculation

Efficiencies, power requirements and capacities were calculated as follows as per the RNAM test code.

1. Total grain input

$$A = B + C + D$$

where,

A = Total grain input per unit time (kg)

B = weight of clean grain from all outlets per unit time (kg)

C = weight of broken grain from all outlets per unit time (kg).

D = weight of unthreshed grain from all outlets per unit time (kg)

2. Percentage of broken grain at all outlets

$$= \frac{E}{A} \times 100$$

where,

E = quality of broken grain collected at all outlets per unit time

3. Percentage of blown grain

$$= \frac{F}{A} \times 100$$

where,

F = quantity of whole grain collected at chaffed straw outlet per unit time

4. Percentage of scattered grain

$$= \frac{G}{A} \times 100$$

where,

G = weight of whole grain, damaged grain and unthreshed grain as scattered grain per unit time

5. Percentage of unthreshed grain

$$= \frac{H}{A} \times 100$$

where,

H = weight of unthreshed grain per unit time

6. Percentage threshing efficiency

= 100 - percentage of unthreshed grain

7. Percentage cleaning efficiency

$$= \frac{I}{J} \times 100$$

where,

I = weight of whole grain per unit time at the main grain outlet

J = weight of whole material per unit time at the m.in outlet

8. Output capacity (kg/h)

= Total weight of the harvested grain received at the main grain outlet(s)

9. Corrected output capacity

To avoid the variation of moisture content of grain and the grain ratio the output capacity obtained was corrected by the following formula for the standard moisture content and grain ratio,

$$Wc = \frac{(100 - M)\ Rs}{(100 - Ms)\ R} \times W$$

where,

Wc = corrected output capacity

W = output capacity obtained

Ms = standard moisture content of grain, 14 per cent

M = observed moisture content of grain

R = observed grain ratio

Rs = standard grain ratio (0.5 for short duration varieties)

3.4 Field observations of axial flow and rasp-bar type threshers

Field observations of axial flow spike tooth type thresher and the rasp-bar straight through type threshers were done for two seasons and are shown in Tables 3, 4, 5 and 6.

Annamalai and Datta (1991) conducted a study on mechanical power threshers for paddy threshing and was found that 7 mm concave clearance gave the best threshing efficiency. So this study was conducted with 7 mm concave clearance.

The TH 8 axial flow spike tooth and flow through rasp-bar type threshers were used in K.C.A.E.T. farm, local farmer's fields and at State Seed Farm, Tavanur (PlatesIII and IV). But the farmers are not satisfied with TH 8 axial flow thresher because the straw was delivered as cut pieces and was very difficult for the farmer for handling and also the quick decaying of cut straw. But in the case of rasp-bar type paddy thresher there was only a minimum of cut straw and has high output per hour. Moreover the average fuel consumption for the axial flow thresher and rasp-bar type thresher was 1.34 lit/h and 0.99 lit/h respectively. In the case of axial flow thresher fuel consumption was high and also broken grains were present during the threshing operation. The vibration of the thresher while in operation was very high even with a high

Plate III Axial flow spike-tooth (TH-8) thresher during threshing operation

Plate IV Flow-through rasp-bar thresher during threshing operation

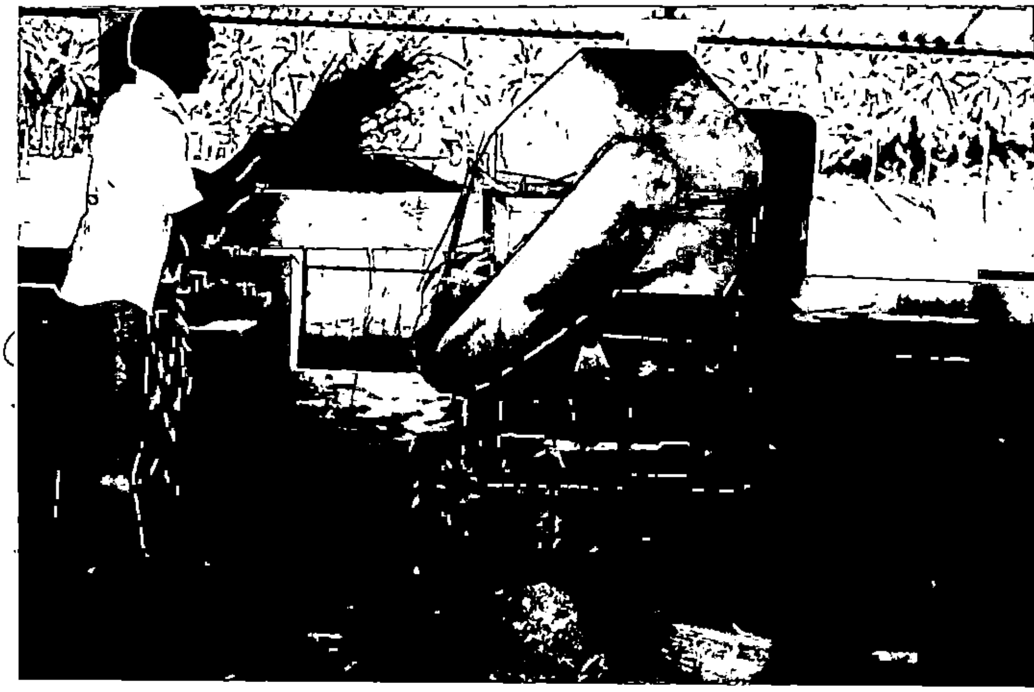


Table 3. Observations of field trials on the TH-8 thresher on *virippu* season

Sl. No.	Description	Units	Trials 1	2	3	4	5	Average
1.	Duration of trial		8-10 (AM)	2-4 (PM)	9-11 (AM)	2-4 (PM)	9-11 (AM)	
2.	Crop and variety		------------	Paddy - Jyothi	------------			
3.	Weight of crop threshed	kg	1932	1961	2088	1970	2060	2002.2
4.	Grain straw ratio		0.89	0.83	0.79	0.81	0.9	0.84
5.	Grain output	kg	728	760	740	696	780	740.8
6.	Straw moisture content (wb)	%	71.34	69.72	72.23	71.34	72.31	71.39
7.	Grain moisture content (wb)	%	19.42	19.09	20.13	19.42	20.26	19.66
8.	Number of labourers		5	5	5	5	5	5
9.	Total operation time	h	2	2	2	2	2	2
10.	Cylinder speed	rpm	450	470	450	420	490	456
11.	Broken grain	kg	1.84	1.07	2.3	1.21	2.94	1.87
12.	Blown grain	kg	4.95	1.98	4.76	7.42	3.81	4.58
13.	Scattered grain	kg	12.38	16.08	39.88	1.64	37.22	21.44
14.	Unthreshed grain	kg	51.86	45.35	33.64	58.58	41.54	44.59
15.	Grain inut	kg	799.03	824.48	820.58	756.85	865.51	813.28
16.	Fuel consumption	lit	2.6	2.84	2.6	2.52	2.8	2.68

Table 4. Observations of field trials on the TH-8 thresher on *mundakan* season

Sl. No.	Decription	Units	Trials 1	2	3	4	5	Average
1.	Duration of trial		8-10 (AM)	10-12 (AM)	9-11 (AM)	2-4 (PM)	8-10 (AM)	
2.	Crop and variety			--------	Paddy - Triveni	-------		
3.	Weight of crop threshed	kg	1972	2081	1979	1954	2077	2018.6
4.	Grain straw ratio		0.75	0.83	0.93	0.66	0.71	0.90
5.	Grain output	kg	772	870	885	715	797	807.8
6.	Straw moisture content (wb)	%	56.2	56.3	58.1	60.5	59.7	58.16
7.	Grain moisture content (wb)	%	15.4	15.1	14.9	16.2	15.1	15.34
8.	Number of labourers		5	5	5	5	5	5
9.	Total operation time	h	2	2	2	2	2	2
10.	Cylinder speed	rpm	460	460	465	470	465	464
11.	Broken grain	kg	2.2	1.91	2.07	1.7	1.82	1.94
12.	Blown grain	kg	5.1	4.6	3.9	2.8	4.3	4.14
13.	Scattered grain	kg	27	23.1	25.9	18.9	20.1	23
14.	Unthreshed grain	kg	35.8	43.1	37.9	38.2	41.1	39.2
15.	Grain output	kg	842.1	942.71	954.77	776.6	864.32	876.1
16.	Fuel consumption	lit	2.8	2.65	2.65	2.55	2.6	2.65

virippu season (with normal concave)

Sl. No.	Description	Unit	Trials 1	2	3	4	5	Average
1.	Duration of trial		10-12 (AM)	2-4 (PM)	8-10 (AM)	2-4 (PM)	9-11 (AM)	
2.	Crop and variety			Paddy-Jyothi				
3.	Weight of crop threshed	kg	4138.1	4406.6	4645.46	4395.3	4556.2	4428.3
4.	Grain straw ratio		0.93	0.86	0.78	0.79	0.82	0.84
5.	Grain ouput	kg	1966	2005	1997	1909	2018	1979
6.	Straw moisture content (wb)	%	76.1	79.4	69.2	78.3	72.4	75.08
7.	Grain moisture content (wb)	%	20.2	20.5	19.7	19.8	19.1	19.86
8.	Number of labourers		5	5	5	5	5	5
9.	Total operation time	h	2	2	2	2	2	2
10.	Cylinder speed	rpm	900	920	950	960	920	930
11.	Broken grain	kg	Nil	Nl	Nil	Nil	Nil	Nil
12.	Blown grain	kg	1.81	1.08	1.85	1.72	1.77	1.65
13.	Scattered grain	kg	1.4	6.3	13.4	4.4	7.0	6.5
14.	Unthreshed grain	kg	24.8	25.1	23.4	24.7	26.1	24.82
15.	Grain input	kg	1994.01	2037.48	2035.65	1939.82	2052.9	2011.97
16.	Fuel consumption	lit	2.2	1.95	2.05	1.95	1.9	2.01

(with normal concave) on *mundakan* season

Sl. No.	Description	Unit	Trials 1	2	3	4	5	Average
1.	Duration of trial		9-11 (AM)	2-4 (PM)	9-11 (AM)	2-4 (PM)	9-11 (AM)	
2.	Crop variety		-------- Paddy - Triveni --------					
3.	Weight of crop threshed	kg	4635	4287	4655	4507	4700	4556.86
4.	Grain straw ratio		0.87	0.99	0.91	0.95	0.90	0.91
5.	Grain output	kg	2119	2105	2186	2156	2200	2153.2
6.	Straw moisture content (wb)	%	59.4	63.1	58.2	58.1	58.7	59.5
7.	Grain moisture content (wb)	%	16.3	16.2	15.9	15.6	16.1	16.02
8.	Number of labourers		5	5	5	5	5	5
9.	Total operation time	h	2	2	2	2	2	2
10.	Cylinder speed	rpm	1130	920	1050	900	950	990
11.	Broken grain	kg	Nil	Nil	Nil	Nil	Nil	Nil
12.	Blown grain	kg	1.94	1.07	0.89	2.2	1.56	1.53
13.	Scattered grain	kg	9.70	9.61	9.99	13.19	4.46	9.39
14.	Unthreshed grain	kg	25.88	17.06	21.07	24.15	20.03	21.64
15.	Grain input	kg	2156.52	2132.74	2217.95	2195.54	2226.05	2185.76
16.	Fuel consumption	lit	1.9	2.1	1.95	1.98	1.95	1.98

speed engine (3000 rpm). The spike tooths were found to worn out quickly in every season.

In the case of rasp-bar type thresher vibration was not recorded much during operation. And the straw cut and grain damges were not seen. Very little quantity of separated paddy was moved along with straw or chaff, compared to the axial flow thresher. The safety arrangements were good with the rasp-bar type thresher and enough length of feeding chute was provided to avoid any accident during feeding and all the belts were provided with belt covers.

Because of these reasons, detailed studies were taken up on rasp-bar type thresher. In *virippu* season, crop is normally green, longer and wet while harvesting. The length and the moisture content of the crop were not affected the performance when we use the axial flow paddy thresher. It was observed choking between concave and cylinder when the very long and moist crop was fed in the rasp-bar paddy thresher. To overcome this problem studies were undertaken to modify the design and construction of concave and its arrangement in the rasp-bar thresher.

3.5 Modification of concave in rasp-bar type paddy thresher

The details of the normal and modified concaves are given in the Appendix-IX and Fig.13 and 14 (Plate V).

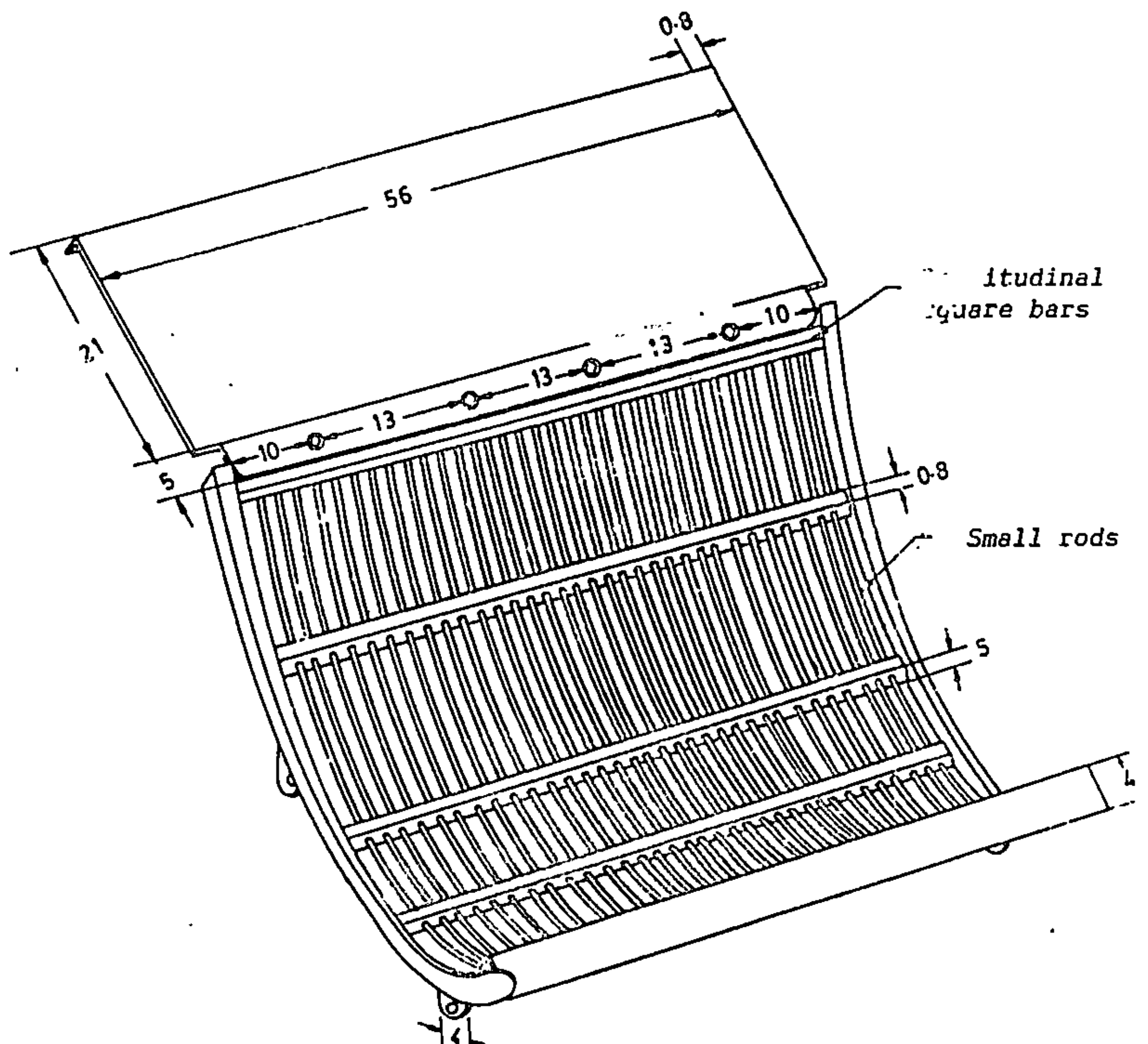


FIG.13 CONSTRUCTION OF NORMAL CONCAVE ON THE RASP-BAR THRESHER

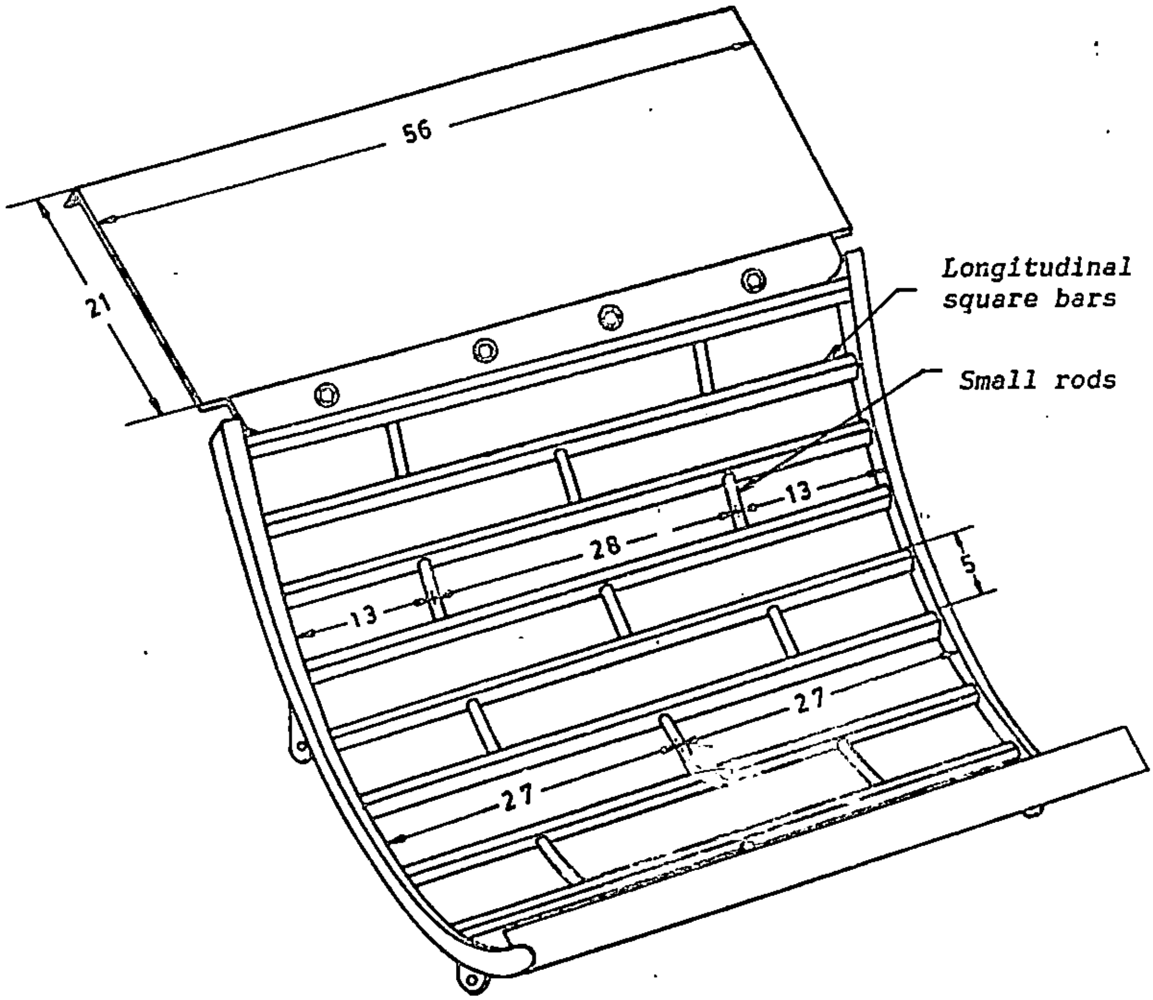


FIG.14 CONSTRUCTION OF MODIFIED CONCAVE ON THE RASP-BAR THRESHER

Plate V Modified and normal concaves used in the flow-through rasp-bar thresher

On our intensive studies carried out, to improve the threshing for the long and moist paddy crop, a new concave had been designed and fabricated and this had been fitted with thresher and trials had been taken with longer and moist paddy crops. In the normal concave only 5 long square bars placed horizontal to the axis of the threshing cylinder and were connected by a number of small bars, through the holes in the bars. The disadvantages of this concave were listed below:

1. Choking was the problem in this concave when used for moist and longer crops.

2. Removal of choked crop was not possible without loosening of the concave.

3. Fabrication is difficult because a number of small bars were to be passed through the thick square bars.

4. If rectangular longitudinal bars were worn out, the concave should be replaced entirely.

5. Less contact area with the crops.

In the case of modified concave, nine longitudinal square bars placed horizontal to the axis of the threshing cylinder are connected with thick rods welded to it. The advantages of the modified concave are listed below:

1. No choking, even with moist and long straw crop.

2. If it is worn out, it is easier to weld with additional square bars.

3. Contact area is maximum, because it touches with a minimum of six longitudinal rectangular bars.

4. If choking occurred due to over feeding it would be easier to remove the choked crop from the bottom without loosening of the concave.

The observations were taken in modified concave for 10 hours of operation for two season and no choking was observed. The observations are shown in Tables 7 and 8.

?.6 Optimum operating conditions in rasp-bar thresher

To increase the efficiency of operation for the rasp-bar thresher, observations to be followed are listed:

1. The thresher should be operated on a level ground. If the level ground is not available, the four adjustment bolts provided for the sieve shaker should adjusted to keep atleast the sieve shaker in a level.

2. Always position the straw-walker in the windward direction to help the bowler and the movement of straw over the straw-walker.

Table 7. Observations of field trials on rasp-bar type paddy thresher on *virippu* season with modified concave

Sl. No.	Description	Unit	Trials 1	2	3	4	5	Average
1.	Duration of trial		9-11 (AM)	2-4 (PM)	9-11 (AM)	2-4 (PM)	9-11 (AM)	
2.	Crop and variety		Paddy - Triveni					
3.	Crop length	cm	75.2	74.69	74.2	75.6	75.9	75.12
4.	Weight of crop threshed	kg	4638	4684	4406	4511	4312	4510.2
5.	Grain straw ratio		0.92	0.91	0.98	0.95	0.99	0.95
6.	Grain output	kg	2192	2196	2149	2157	2118	2162.4
7.	Straw moisture content (wb)	%	95.6	97.2	97.6	94.2	99.8	95.9
8.	Grain moisture content (wb)	%	21.3	22.6	29.7	24.1	28.5	25.2
9.	Total operation time	h	2	2	2	2	2	2
10.	Cylinder speed	rpm	950	990	970	990	920	964
11.	Broken grain	kg	Nil	Nil	Nil	Nil	Nil	Nil
12.	Blown grain	kg	1.28	1.09	1.54	0.96	1.14	1.2
13.	Scattered grain	kg	11.0	12.0	9.9	9.4	9.1	10.28
14.	Unthreshed grain	kg	20.3	20.6	19.8	24.7	19.4	20.96
15.	Grain input	kg	2224.6	2229.7	2180.2	2192.1	2147.6	2194.8
16.	Fuel consumption	lit	2.2	1.98	1.98	1.95	2.2	2.06
17.	Number of labourers		5	5	5	5	5	5

Table 8. Observations of field trials on rasp-bar type paddy thresher on *mundakan* season with modified concave

Sl. No.	Description	Unit	Trials 1	2	3	4	5	Average
1.	Duration of trial		8-10 (AM)	2-4 (PM)	9-11 (AM)	2-4 (PM)	9-11 (AM)	
2.	Crop and variety				Red Triveni			
3.	Crop length	cm	77.1	75.3	78.0	75.6	79.1	77.02
4.	Weight of crop threshed	kg	4670	4661	4778	4550	4504	4632.6
5.	Grain straw ratio		0.98	0.95	1.01	0.93	0.97	0.97
6.	Grain output	kg	2277	2236	2367	2161	2185	2245.2
7.	Straw moisture content (wb)	%	52.1	53.1	51.7	48.2	49.1	[illegible]0.84
8.	Grain moisture content (wb)	%	16.2	15.9	16.7	15.8	16.4	16.[illegible]
9.	Total operation time	h	2	2	2	2	2	2
10.	Cylinder speed	rpm	965	965	960	964	960	962.8
11.	Broken grain	kg	Nil	Nil	Nil	Nil	Nil	Nil
12.	Blown grain	kg	2.1	1.41	0.91	2.3	1.1	1.56
13.	Scattered grain	kg	15.3	19.29	18.59	18.8	13.6	17.1
14.	Unthreshed grain	kg	16.8	14.1	14.6	10.3	18.2	14.8
15.	Grain input	kg	2311.2	2270.8	2401.1	2192.4	2217.9	2278.7
16.	Fuel consumption	lit	2.1	2.05	1.98	1.99	1.98	2.02
17.	Number of labourers		5	5	5	5	5	5

3. The thresher should be kept on two wooden planks on sand bags after removing the pneumatic wheels to avoid vibration.

4. There should be slight downward slope to the wooden sieve towards the chaff outlet.

5. A ladder like structure is to be provided for easy flow of the straw from the straw walker.

6. Maximum care should be given to the adjustments and clearance between the cylinder and concave. The concave should be positioned in such a way that feeding is easier.

7. If the sieve shaker is not properly aligned good paddy may be coming along with the chaff or chaff may not be coming out of the wooden sieve, the stone collected in the first metal sieve will not be delivered and it will be become full inside the sieve box. Hence the first metal sieve will not function properly. If the sieve shaker is not aligned the second metal sieve will not deliver the cleaned paddy, properly.

8. By considering the variety and moisture content of the crop the flap opening of the blower should be adjusted to give the correct amount of wind velocity for winnowing.

9. The feeding should be continuous and the crops should go covering the entire length of the threshing drum. Immediately after starting the prime mover feeding should not be given, in other words, the crop should be fed to the threshing cylinder only aft r it has reached the stable and standard rpm.

10. After stopping the feeding of cro wait for some time to switch off the prime mover. With this time thresher would get cleaned itself.

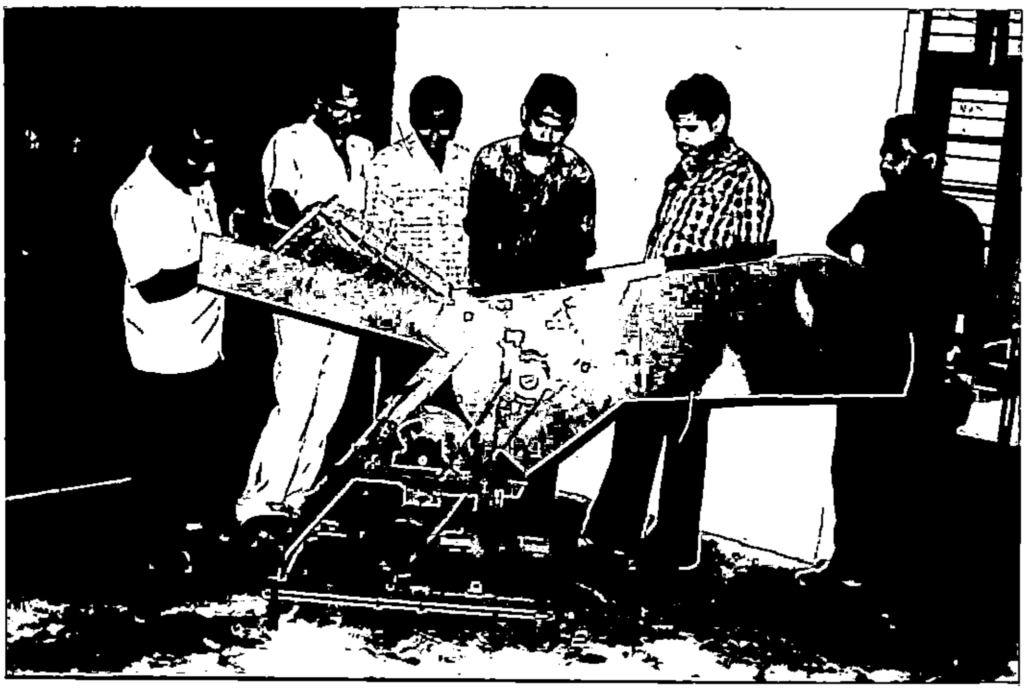
The axial flow spike tooth type and the straight through type rasp-bar are commercially developed threshers and bought for threshing purpose in the instructional farms. So the detailed studies were done with the prototype thresher which was developed in K.C.A.E.T., Tavanur.

3.7 Experimental programme of the prototype thresher

The prototype thresher (Plate VI) consists of a threshing system of rasp-bar type and spike tooth type drums which are capable of replacing one another. The specification details of the thresher are given in Appendix-X.

As per the reviews, the peripheral speed of the spike tooth type cylinder which gave the maximum efficiency was 14-18 m/sec and for the rasp bar type cylinder was 16-22 m/sec.

Plate VI Prototype thresher developed at K.C.A.E.T., Tavanur



For the experiment the threshing cylinder pulleys were selected to suit the peripheral speed of the drum between 10-21 m/sec. The pulleys used were with 7.6 cm, 10.15 cm and 12.7 cm diameter. The motor pulley diameter was 6.35 cm and rpm of motor was 1440.

For each time of feeding 10 kg of sheaves were taken. Each drum was tested with varying peripheral speeds. Then the samples were collected from the threshed grain and straw. Then various efficiencies and capacities were calculated. Time of threshing was noted with a stopwatch and the weight was taken by a precision balance. A platform balance was used for taking the weight of the sheaves. Oven drying method (Appendix-XI) was used for finding the moisture content.

3.8 Definition of terms

1. Classification of thresher

Mechanical threshers are classified into the following types by the method of feeding.

Throw-in type: A type of thresher where the cut crops are fed into the machine in full.

Hold-on type : A type of thresher where only heads of the cut crops are allowed for threshing while the lower part of straw being manually or mechanically held.

2. Whole grain

Mature and unbroken grain.

3. Damaged grain

Threshed grain which is partially or wholly broken and dehulled.

4. Unthreshed grain

Whole grain attached to straw after threshing.

5. Chaffed straw

Straw being discharged from threshing chamber in the throw-in type which is usually crushed, cut and different from original straw in appearance.

6. Foreign material

Inorganic and organic material other than grain which includes sand, gravel, clay, mud, metal chip, chaff and straw, weed, weed seed and other grains.

7. Grain ratio

Ratio of grain to the harvested crop by weight under the same moisture content of straw and grain.

8. Scattered grain

Grains dropped outside the thresher.

9. Grain mixture

The whole material received, at main grain outlet which include whole grain, damaged grain, and foreign material.

10. Optimum feed rate

The maximum feed rate at which reasonable threshing efficiency, recovery and cleanliness can be attained.

11. Output capacity

The weight of grain (whole and damaged) received per hour at main grain outlet.

12. Threshing recovery

Threshed grain at main grain outlet with respect to total grain input expressed as per cent by weight.

13. Threshing efficiency

The threshed grain received at all outlets with respect to total grain input expressed as per cent by weight.

14. Cleaning efficiency

The whole grain with respect to grain mixture at main grain outlet expressed as per cent by weight.

15. Main grain outlet

The outlet to deliver the threshed grain.

16. Straw outlet

The outlet where the threshed straw is left in case of the throw-in type thresher.

17. Chaffed straw outlet

The outlet where the threshed straws are blown in case of the throw-in type thresher.

18. Chaff outlet

The outlet where the chaff separated by blower or from the grain, dropped through concave are forced out.

19. Immature grain outlet

The outlet which collects the poor quality grain such as immature small grain.

Results and Discussion.

RESULTS AND DISCUSSION

The results of the field survey about the traditional methods of threshing practised in Kerala, the performance evaluation of the available threshers, further modifications carried out and their economics and suitability are discussed.

4.1 Study of traditional methods used in Kerala

In various parts of Kerala the methods of threshing and the time of threshing after harvest were different. In the case of southern part of Kerala the harvested crops were transported in the same day to the owner's house immediately after the harvest. So the grain losses occurred during the transport is minimum. The harvested crops were threshed in the same day of harvesting or in the following day itself. Due to scarcity of labourers harvesting could not be done in the proper time of maturity. This caused high rate of grain loss. Due to early harvesting detachment of grain are found difficult whereas in late harvesting shedding of grains occur. In Table 9 it is shown that the output of hand beating was only 18.5 kg/h. Cost of threshing for hand beating method was high and it was Rs.823.5 per hectare.

In central Kerala the harvested crop is placed in the field or nearby dry areas during summer season. The threshing

Table 9. Cost of operation of threshing for different methods of threshing such as hand beating, feet rubbing, axial flow spike tooth thresher and flow through rasp-bar thresher

Sl. No.	Method of threshing	Man hours needed per ha (h/ha)	Output per hour (kg/h)	Cost of threshing		
				per hour (Rs/h)	per kg of paddy (Rs/kg)	per hectare (Rs/ha)
1.	Hand beating	164.7	18.50	5	0.273	823.5
2.	Feet rubbing	319.8	11.27	5	0.445	1599.0
3.	Axial flow spike tooth thresher	35.0	400.00	57	0.143	400.0
4.	Straight through rasp-bar thresher	17.5	1050.00	59	0.056	207.0

operation after one or two days was carried out by feet rubbing method. In Table 9 it is shown that the capacity of feet rubbing method was 11.27 kg/h only and the cost of threshing for feet rubbing method was high and it was Rs.1599.0 per hectare.

It is found that 164.7 and 319.8 man hours per hectare are required to manual threshing by hand beating and feet rubbing methods respectively and can be reduced to a minimum of 17.5 man hours if we employ mechanical paddy threshing. Hence the available labour force can be diverted for the timely harvesting of the paddy fields.

4.2 Study on spike-tooth and rasp-bar type paddy threshers

The axial flow spike-tooth type thresher available at K.C.A.E.T., Tavanur had been taken for threshing purpose in nearby farms. The tests were conducted for two seasons viz. *virippu* and *mundakan* during the period 19.9.90 to 30.9.90 and 28.12.90 to 20.1.91 respectively and the results are given in Tables 10 and 11. The tests were conducted with an average peripheral velocity and feed rate of 9.55 m/s and 1009.3 kg/h respectively for *mundakan* season and 9.38 m/s and 1001.1 kg/h respectively for *virippu* season. The percentage of broken grains, percentage of blown grains, percentage of scattered grains, percentage of unthreshed grains, threshing efficiency,

Table 10. Performance of the TH-8 spike tooth axial flow paddy thresher on *virippu* season

Sl. No.	Description	Unit	Trials 1	2	3	4	5	Average
1.	Feed rate	kg/h	966.0	980.5	1044.0	985.0	1030.0	1001.1
2.	Grain input	kg	799.03	824.48	820.58	756.85	865.51	813.38
3.	Grain ratio		0.41	0.42	0.39	0.38	0.42	0.40
4.	Grain output	kg	728	760	740	696	780	740.8
5.	Total operating time	h	2	2	2	2	2	2
6.	Cylinder peripheral speed	m/s	9.26	9.67	9.26	8.64	10.08	9.38
7.	Percentage of broken grains	%	0.23	0.13	0.28	0.16	0.34	0.23
8.	Percentage of blown grains	%	0.62	0.24	0.58	0.98	0.44	0.57
9.	Percentage of scattered grains	%	1.5	1.95	4.86	0.22	4.3	2.57
10.	Percentage of unthreshed grains	%	6.49	5.5	4.1	6.68	4.8	5.51
11.	Threshing efficiency	%	93.51	94.5	95.9	93.32	95.2	94.49
12.	Cleaning efficiency	%	93.3	93.6	93.13	91.7	92.4	92.8
13.	Output capacity	kg/h	364	380	370	348	390	370.4
14.	Fuel consumption	lit/h	1.3	1.42	1.3	1.26	1.4	1.34
15.	Grain moisture content (wb)	%	19.42	19.09	20.13	19.42	20.26	19.66
16.	Corrected output capacity	kg/h	415.93	425.6	440.5	429.04	430.49	428.3

Table 11. Performance of the TH-8 spike tooth axial flow paddy thresher on *mundakan* season

Sl. No.	Description	Unit	Trials					Average
			1	2	3	4	5	
1.	Feed rate	kg/h	986.0	1040.5	989.5	977.0	1038.5	1009.3
2.	Grain input	kg	842.1	942.71	954.77	776.6	864.32	876.1
3.	Grain ratio		0.43	0.45	0.48	0.39	0.42	0.44
4.	Grain output	kg	772	870	885	715	797	807.8
5.	Total operating time	h	2	2	2	2	2	2
6.	Cylinder peripheral speed	m/s	9.47	9.47	9.57	9.67	9.57	9.55
7.	Percentage of broken grains	%	0.26	0.20	0.22	0.22	0.21	0.22
8.	Percentage of blown grains	%	0.61	0.49	0.41	0.36	0.49	0.47
9.	Percentage of scattered grains	%	3.21	2.45	2.71	2.43	2.33	2.63
10.	Percentage of unthreshed grains	%	4.25	4.57	3.97	4.92	4.76	4.49
11.	Threshing efficiency	%	95.75	95.43	96.03	95.08	95.24	95.5
12.	Cleaning efficiency	%	93.7	92.90	94.30	93.80	93.20	93.58
13.	Output capacity	kg/h	386.0	435.0	442.5	357.5	398.5	403.9
14.	Fuel consumption	lit/h	1.40	1.33	1.33	1.28	1.30	1.33
15.	Grain moisture content (wb)	%	15.4	15.1	14.9	16.2	15.1	15.34
16.	Corrected output capacity	kg/h	441.5	477.2	456.1	438.7	468.3	456.36

cleaning efficiency, output capacity, fuel consumption and corrected output capacity were 0.22 per cent, 0.47 per cent, 2.63 per cent, 4.49 per cent, 95.5 per cent, 93.58 per cent, 403.9 kg/h, 1.33 lit/h and 515.3 kg/h respectively for *mundakan* season and for *virippu* season these were 0.23 per cent, 0.57 per cent, 2.57 per cent, 5.51 per cent, 94.49 per cent, 92.8 per cent, 370.4 kg/h, 1.34 lit/h and 410.7 kg/h respectively.

4.2.1 Test results of the straight through rasp-bar type thresher

The straight through rasp-bar type thresher available at K.C.A.E.T., Tavanur has been taken for threshing purpose in nearby farms. The tests were conducted for two seasons viz., *virippu* and *mundakan* during the period 24.9.91 to 15.10.91 and 10.1.92 to 25.1.92 respectively and the results are given in Tables 12 and 13. The tests were conducted with an average peripheral speed and feed rate of 16.31 m/s and 2214.15 kg/h respectively for *virippu* season and for *mundakan* season these were 17.37 m/s and 2278.43 kg/h respectively. The percentage of blown grains, percentage of scattered grains percentage of unthreshed grains, threshing efficiency, cleaning efficiency output capacity, fuel consumption and corrected output capacity were 0.081 per cent, 0.32 per cent, 1.23 per cent, 98.77 per cent, 97.52 per cent, 989.5 kg/h, 1.01 lit/h and 1107.6 kg/h respectively for *virippu* season and these for

Table 12. Performance of the rasp-bar type paddy thresher on *virippu* season with normal concave

Sl. No.	Description	Unit	Trials 1	2	3	4	5	Average
1.	Feed rate	kg/h	2069.05	2203.3	2322.8	2197.65	2278.1	2214.15
2.	Grain input	kg	1994.01	2037.48	2035.65	1939.82	2052.9	2011.97
3.	Grain ratio		0.48	0.49	0.44	0.44	0.45	0.46
4.	Grain output	kg	1966	2005	1997	1909	2018	1979
5.	Total operating time	h	2	2	2	2	2	2
6.	Cylinder peripheral speed	m/s	15.79	16.14	16.66	16.84	16.14	16.31
7.	Percentage of broken grains	%	Nil	Nil	Nil	Nil	Nil	Nil
8.	Percentage of blown grains	%	0.09	0.05	0.09	0.09	0.086	0.081
9.	Percentage of scattered grains	%	0.07	0.31	0.66	0.23	0.34	0.32
10.	Percentage of unthreshed grains	%	1.24	1.23	1.15	1.27	1.27	1.23
11.	Threshing efficiency	%	98.76	98.77	98.85	98.73	98.73	98.77
12.	Cleaning efficiency	%	97.8	97.1	98.1	97.7	96.9	97.52
13.	Output capacity	kg/h	983	1002.5	998.5	954.5	1009	989.5
14.	Fuel consumption	lit/h	1.1	0.975	1.025	0.975	0.95	1.01
15.	Grain moisture content (wb)	%	20.2	20.5	19.7	19.8	19.1	19.86
16.	Corrected output capacity	kg/h	950.1	945.6	1059.5	1011.5	1054.6	1004.3

Table 13. Performance of the flow through rasp-bar type paddy thresher on *mundakan* season with normal concave

Sl. No.	Description	Unit	Trials 1	2	3	4	5	Average
1.	Feed rate	kg/h	2317.5	2143.5	2327.5	2253.5	2350.0	2278.43
2.	Grain input	kg	2156.52	2132.74	2217.95	2195.54	2226.05	2185.76
3.	Grain ratio		0.47	0.497	0.48	0.49	0.47	0.48
4.	Grain output	kg	2119	2105	2186	2156	2200	2153.2
5.	Total operating time	h	2	2	2	2	2	2
6.	Cylinder peripheral speed	m/s	19.82	16.14	18.42	15.79	16.66	17.37
7.	Percentage of broken grains	%	Nil	Nil	Nil	Nil	Nil	Nil
8.	Percentage of blown grains	%	0.09	0.05	0.04	0.1	0.07	0.07
9.	Percentage of scattered grains	%	0.45	0.45	0.45	0.6	0.2	0.43
10.	Percentage of unthreshed grains	%	1.2	0.8	0.95	1.1	0.9	0.99
11.	Threshing efficiency	%	98.8	99.2	99.05	98.9	99.1	99.01
12.	Cleaning efficiency	%	97.1	98.3	99.2	95.2	97.4	97.44
13.	Output capacity	kg/h	1059.5	1052.5	1093	1078	1100	1076.6
14.	Fuel consumption	lit/h	0.95	1.05	0.975	0.99	0.975	0.99
15.	Grain moisture content (wb)	%	16.3	16.2	15.9	15.6	16.1	16.02
16.	Corrected output capacity	kg/h	1096.98	1031.77	1113.39	1079.5	1141.6	1092.6

mundakan season were 0.07 per cent, 0.43 per cent, 0.99 per cent, 99.01 per cent, 97.44 per cent, 1076.6 kg/h, 0.99 lit/h and 1140.3 kg/h respectively. In the case of the rasp-bar type thresher visible damage of grains were not observed. So the percentage of broken grains was nil both for *virippu* and *mundakan* seasons. During *virippu* the straw length is longer (approximately 0.75 to 1.5 m) and the crop moisture content is higher (approximately 20 to 30 per cent). These factors are responsible for choking of straw and rolling over the cylinder.

4.2.1.1 Modification of concave in rasp-bar type paddy thresher

For continuous operation of the thresher choking was the problem with the normal concave when used for moist and longer crops. Hence the concave was modified as given in the Appendix-IX. The power requirement for the unit operations of the rasp-bar paddy thresher at no load was found out and is given in the Table 14. The tests were conducted with modified concave for two seasons viz., *virippu* and *mundakan* during the period 1.9.92 to 15.9.92 and 29.12.92 to 10.1.93 respectively and the results are shown in Tables 15 and 16. The tests were conducted with an average peripheral speed and feed rate of 16.92 m/s and feed rate 2255.1 kg/h respectively for *virippu* season and for *mundakan* season. These were 16.9 m/s and 2316.3 kg/h respectively. The percentage of broken grain was nil for

Table 14. Power used for unit operations in the rasp-bar paddy thresher

Sl.No.	Thresher parts	Power need	
		KW	hp
1.	Motor	1.400	1.88
2.	Threshing drum	0.200	0.27
3.	Blower	1.300	1.74
4.	Doffing cylinder	0.075	0.10
5.	Straw walker	0.125	0.17
6.	Sieves	0.200	0.27
	Total (without load)	3.3	4.43

Table 15. Performance of the rasp-bar type paddy thresher on *virippu* season with modified concave

Sl. No.	Decription	Unit	Trials 1	2	3	4	5	Average
1.	Feed rate	kg/h	2319	2342	2203	2255.5	2156	2255.1
2.	Grain input	kg	2224.6	2229.7	2180.2	2192.1	2147.6	2194.8
3.	Grain ratio		0.48	0.48	0.49	0.49	0.498	0.49
4.	Grain output	kg	2192	2196	2149	2157	2118	2162.4
5.	Total operating time	h	2	2	2	2	2	2
6.	Cylinder peripheral speed	m/s	16.7	17.37	17.01	17.37	16.14	16.92
7.	Percentage of broken grains	%	Nil	Nil	Nil	Nil	Nil	Nil
8.	Percentage of blown grains	%	0.06	0.05	0.07	0.04	0.05	0.054
9.	Percentage of scattered grains	%	0.49	0.54	0.45	0.43	0.42	0.47
10.	Percentage of unthreshed grains	%	0.91	0.92	0.91	1.13	0.90	0.95
11.	Threshing efficiency	%	99.09	99.08	99.09	98.87	99.1	99.05
12.	Cleaning efficiency	%	97.3	98.1	96.7	98.3	96.1	97.3
13.	Output capacity	kg/h	1096	1098	1074.5	1078.5	1059	1081
14.	Fuel consumption	lit/h	1.1	0.99	0.99	0.98	1.1	1.03
15.	Crop length	cm	75.2	74.69	74.2	75.6	75.9	75.12
16.	Grain moisture content (wb)	%	21.3	22.6	29.7	24.1	28.5	25.24
17.	Corrected output capacity	kg/h	1044.76	1029.38	896.3	971.26	883.98	965.1

Table 16. Performance of the rasp-bar type paddy thresher on *mundakan* season with modified concave

Sl. No.	Description	Unit	Trials 1	2	3	4	5	Average
1.	Feed rate	kg/h	2335	2330.5	2389.0	2275.0	2252.0	2316.3
2.	Grain input	kg	2311.2	2270.8	2401.1	2192.4	2217.9	2278.7
3.	Grain ratio		0.49	0.49	0.50	0.48	0.49	0.49
4.	Grain output	kg	2277	2236	2367	2161	2185	2245.2
5.	Total operating time	h	2	2	2	2	2	2
6.	Cylinder peripheral speed	m/s	16.93	16.93	16.84	16.9	16.84	16.9
7.	Percentage of broken grains	%	Nil	Nil	Nil	Nil	Nil	Nil
8.	Percentage of blown grains	%	0.09	0.06	0.04	0.1	0.05	0.07
9.	Percentage of scattered grains	%	0.66	0.85	0.77	0.86	0.6	0.75
10.	Percentage of unthreshed grains	%	0.73	0.62	0.6	0.47	0.82	0.65
11.	Threshing efficiency	%	99.27	99.38	99.4	99.53	99.18	99.35
12.	Cleaning efficiency	%	98.2	99.01	97.1	98.6	98.9	98.4
13.	Output capacity	kg/h	1138.5	1118.0	1183.5	1080.5	1092.5	1122.5
14.	Fuel consumption	lit/h	1.05	1.025	0.99	0.995	0.99	1.01
15.	Crop length	cm	77.1	75.3	78.0	75.6	79.1	77.02
16.	Grain moisture content (wb)	%	16.2	15.9	16.7	15.8	16.4	16.2
17.	Corrected output capacity	kg/h	1132.0	1115.6	1146.3	1101.96	1083.69	1115.9

both the seasons. The percentage of blown grains, percentage of scattered grains, percentage of unthreshed grains, threshing efficiency, cleaning efficiency, output capacity, fuel consumption and corrected output capacity were 0.054 per cent, 0.47 per cent, 0.95 per cent, 99.05 per cent, 97.3 per cent, 1081 kg/h, 1.03 lit/h and 992.7 kg/h respectively for *virippu* and for *mundakan* season. These were 0.07 per cent, 0.75 per cent, 0.65 per cent, 99.35 per cent, 98.4 per cent, 1122.6 kg/h, 1.01 lit/h and 1130.04 kg/h respectively.

4.2.2 Comparison of axial flow spike tooth and straight through rasp-bar type threshers

The impact of spikes on the crop cause the detaching of the grains from earheads in spike tooth cylinder type threshers. But in the case of rasp-bar type threshers both rubbing and impact of the rasp-bar with the crop cause the threshing of the grains. The comparison of the test results for both the drums are represented and shown in Fig.15 and 16. The output capacity per hp of the axial flow spike tooth thresher was much lower than that for straight through rasp-bar type thresher. In the case of spike tooth thresher the output capacity in *virippu* and *mundakan* seasons were 370.4 kg/h and 403.9 kg/h respectively. But output capacity for rasp-bar type thresher in *virippu* and *mundakan* seasons were 989.5 kg/h and 1076.6 kg/h respectively. So the axial flow

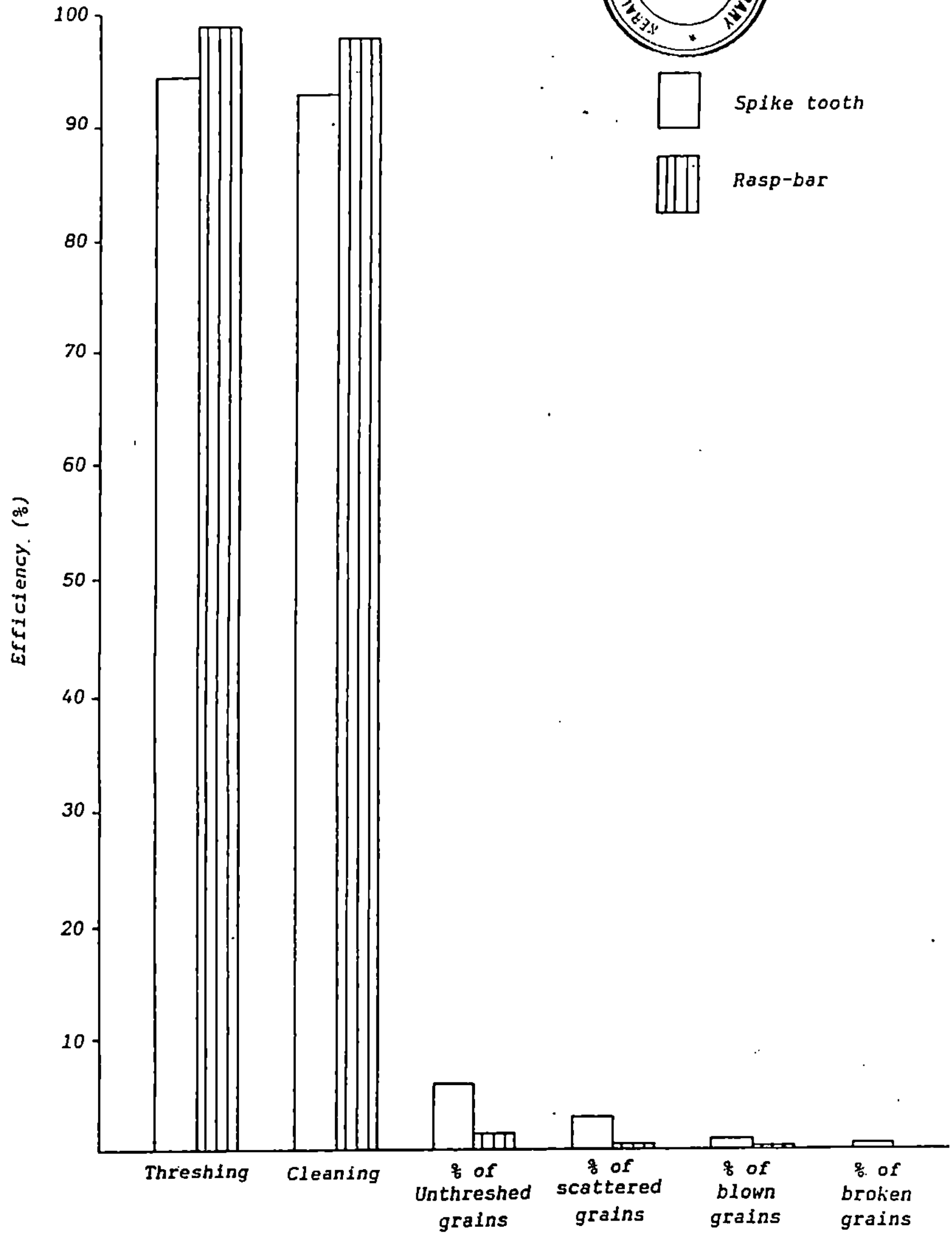


FIG.15 COMPARISON OF SPIKE-TOOTH AND RASP-BAR THRESHER PERFORMANCE ON 'VIRIPPU' SEASON

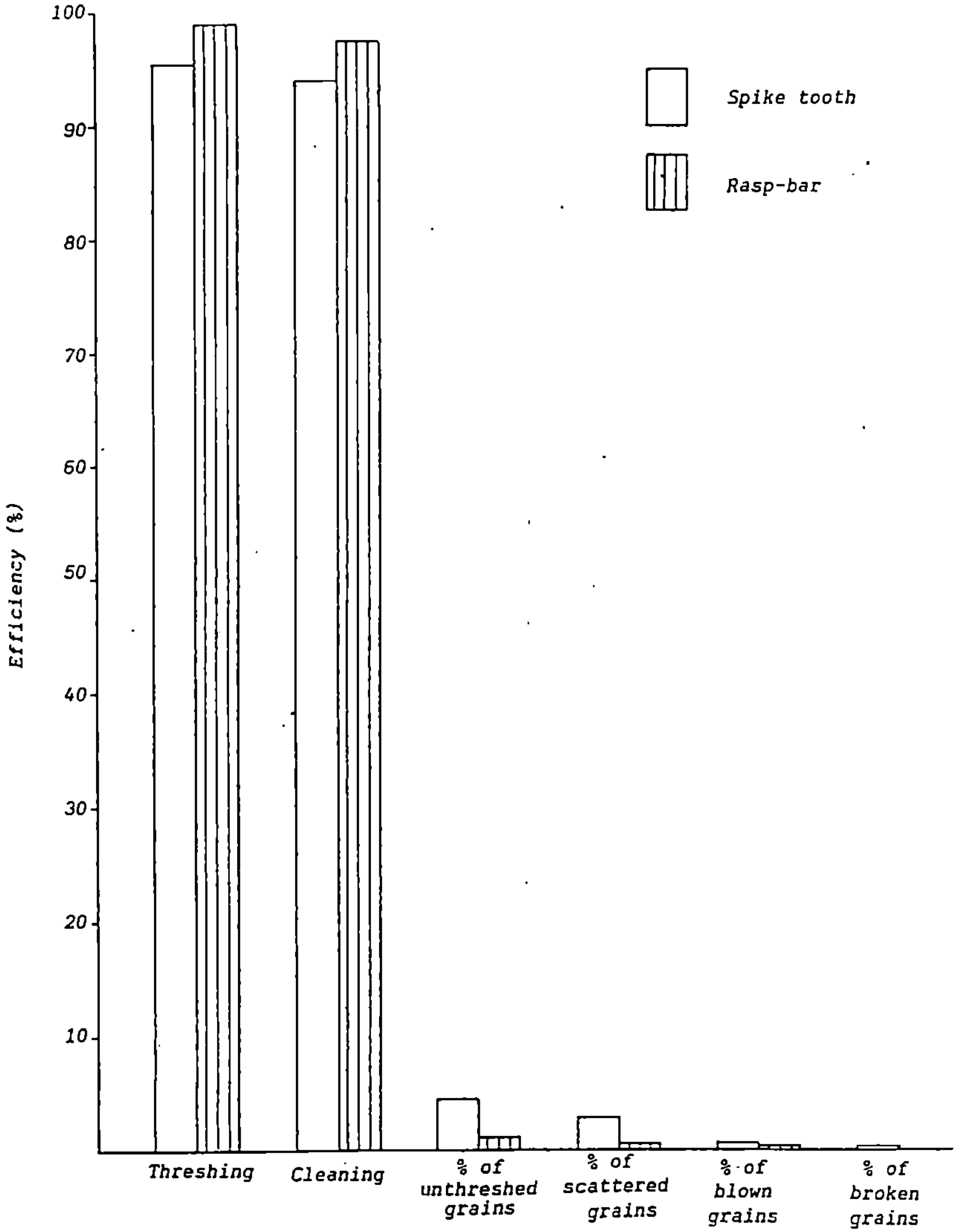


FIG.16 COMPARISON OF SPIKE-TOOTH AND RASP-BAR THRESHER PERFORMANCE ON 'MUNDAKAN' SEASON

spike-tooth thresher need more time for threshing the paddy crop than that need for the straight through rasp-bar type thresher. Percentage of unthreshed grain was more for axial flow, spike tooth thresher than that for rasp-bar type thresher. The average values of percentage of unthreshed grains for *virippu* and *mundakan* seasons were 5.51 per cent and 4.49 per cent respectively for spike tooth thresher and 1.23 per cent and 0.99 per cent for rasp-bar type thresher. The threshing efficiency was found to be higher for the straight through type rasp-bar thresher. Mechanical damage was not seen in the rasp-bar type thresher. But only a little damage was noticed in the case of spike tooth thresher. So the percentage of broken grains for the axial flow spike tooth type thresher in *virippu* and *mundakan* seasons were 0.23 per cent and 0.22 per cent respectively. The rasp-bar type thresher with straw walkers, box type oscillating sieves and blower the cleaning system was more efficient than that of spike tooth type, so completely cleaned paddy is delivered from the rasp-bar type thresher. In *virippu* and *mundakan* seasons the cleaning efficiencies obtained for rasp-bar type thresher were 97.52 per cent and 97.44 per cent respectively. But in the case of axial flow spike tooth type thresher cleaning system comprises of oscillating sieves and blower only. The foreign matter present in the threshed grain from main grain outlet was higher. The cleaning efficiencies obtained for spike tooth thresher for *virippu* and *mundakan* seasons were 92.8 per cent and 93.58 per cent respectively. Fuel consumption for spike tooth thresher for *virippu* and *mundakan* seasons were 1.34 lit/h and 1.33 lit/h respectively and that for rasp-bar type thresher were 1.01 lit/h and 0.99 lit/h respectively and hence the fuel consumption also high for axial flow spike tooth type thresher than that for rasp-bar type thresher.

4.2.3 Effect of moisture content on threshing

During *virippu* season the moisture content of the harvested crop was found more than that for the *mundakan* season. With higher moisture content the unthreshed grain was more for both the threshers. The threshing efficiency of axial flow spike tooth thresher for *virippu* season was 94.49 per cent and for *mundakan* season was 95.50 per cent. This is because of the ability of water particles to absorb the impact energy. A part of the impact force is carried away by the water particles and due to this a high impact force is required for the grain to get detached from the earhead at high moisture content, thus the unthreshed grains are found more when the moisture content is higher. The rasp-bar thresher had threshing efficiency of 98.77 per cent of *virippu* season and 99.01 per cent for *mundakan* season. The output capacity and the cleaning efficiencies were also increased with less moisture content i.e., at *mundakan* season for both the threshers. This is because of the property of adhesion of the water particles with straw and other foreign materials. The increased moisture content increases the adhesive force and hence the foreign matters were sticking to the grain and much cleaning was not obtained and the cleaning efficiency became less. For *virippu* season the cleaning efficiency in axial flow thresher was 92.8 per cent and for rasp-bar type thresher it was 97.52 per cent. But for *mundakan* season these were 93.58 per cent and 97.44 per cent for spike tooth and rasp-bar threshers respectively. The output capacity of the spike tooth thresher in *virippu* and *mundakan* seasons were 370.4 kg/h and 403.9 respectively and that for rasp-bar type thresher was 989.5 kg/h and 1076.6 kg/h respectively. It indicated that the increase in the duration of threshing with the increase of moisture content.

4.3 Test results on prototype thresher

The prototype thresher developed at K.C.A.E.T., Tavanur was tested with rasp-bar cylinder and spike tooth cylinder during *virippu* and *mundakan* seasons by varying the peripheral velocity.

4.3.1 *Virippu* season

During the *virippu* season (at 20.1 per cent moisture content) the increase in the peripheral velocity increased from 12.65 m/sec to 21.72 m/sec, the threshing efficiency was increased from 83.27 per cent to 90.55 per cent, but the spike tooth cylinder had not shown any improvement in the threshing efficiency. But compared to the maximum efficiency of 90.55 per cent for rasp-bar cylinder the spike tooth had the maximum threshing efficiency of 92.73 per cent whereas the output capacity reduced from 266.3 kg/h to 218.9 kg/h (Tables and 17 and 18).

4.3.2 *Mundakan* season

At reduced moisture content level (15.9 per cent) during *mundakan* season no relationship was established for the change in the peripheral velocity on the threshing efficiency on both rasp-bar and spike tooth threshers. But decrease in peripheral speed increased the output capacity from 280.1 kg/h to 305.7 kg/h with rasp-bar cylinder whereas the grain output reduced from 256.5 kg/h to 225.2 kg/h for spike tooth cylinder (Tables 19 and 20).

When the moisture content of the crop was increased from 15.9 per cent to 20.1 per cent, it was found a reduction of 95.88 per cent to 90.55 per cent in the value of maximum threshing efficiency for rasp-bar cylinder. In the case of spike-tooth, the increase in the moisture content value from 15.9 per cent to 20.1 per cent had no much influence in the

Table 17. Performance of prototype thresher with rasp-bar type drum on *virippu* season (moisture content = 20.1 per cent)

Sl. No.	Test No.	Peripheral speed (m/sec)	Weight of crop (kg)	Threshing time (sec)	Weight of threshed grain (kg)	Weight of unthreshed grain (kg)	Percentage of unthreshed grain (%)	Threshing efficiency each (%)	Output capacity each (kg/h)	Grain ratio	Corrected output capacity each (kg/h)
1.	1	21.72	10	65	4.850	0.530	9.85	90.15	268.6	0.54	231.3
2.	2	21.72	10	62	4.600	0.523	10.21	89.79	267.1	0.51	243.5
3.	3	21.72	10	65	4.750	0.430	8.30	91.70	263.1	0.52	235.3
Average								90.55	266.3		236.7
4.	1	16.51	10	81	5.050	0.541	9.68	90.32	224.44	0.56	184.37
5.	2	16.51	10	78	4.990	0.625	11.13	88.87	230.31	0.56	189.18
6.	3	16.51	10	79	4.980	0.550	9.95	90.05	226.94	0.55	189.80
Average								89.75	227.23		187.78
7.	1	12.65	10	63	4.510	0.952	17.43	82.57	257.70	0.55	215.50
8.	2	12.65	10	61	4.240	0.825	16.29	83.71	250.20	0.51	225.70
9.	2	12.65	10	60	4.120	0.813	16.48	83.52	247.20	0.49	232.10
Average								83.27	251.70		224.40

Table 18. Performance of prototype thresher with spike tooth type drum on *virippu* season (moisture content = 20.1 per cent)

Sl. No.	Test No.	Peripheral speed (m/sec)	Weight of crop (kg)	Threshing time (sec)	Weight of threshed grain (kg)	Weight of unthreshed grain (kg)	Percentage of unthreshed grain (kg)	Threshing efficiency each (%)	Output capacity each (kg/h)	Grain ratio	Corrected output capacity each (kg/h)
1.	1	21.72	10	73	4.920	0.391	7.36	92.64	242.6	0.53	210.6
2.	2	21.72	10	73	4.890	0.603	10.41	89.59	241.2	0.58	193.3
3.	3	21.72	10	72	4.950	0.420	7.82	92.18	247.5	0.54	210.8
Average								91.47	243.8		204.20
4.	1	16.51	10	79	4.805	0.370	7.15	92.85	218.9	0.52	193.6
5.	2	16.51	10	78	4.900	0.283	5.46	94.54	226.2	0.52	200.4
6.	3	16.51	10	80	4.700	0.476	9.20	90.80	211.5	0.52	200.8
Average								92.73	218.9		193.60
7.	1	12.65	10	76	4.980	0.303	5.74	94.26	235.9	0.53	204.7
8.	2	12.65	10	76	4.900	0.499	9.24	90.76	235.2	0.54	200.4
9.	3	12.65	10	77	4.950	0.371	6.97	93.03	231.4	0.53	200.8
Average								92.68	234.2		201.97

Table 19. Performance of prototype thresher with rasp-bar type drum on *mundakan* season (moisture content = 15.9 per cent)

Sl. No.	Test No.	Peripheral speed (m/sec)	Weight of crop (kg)	Threshing time (sec)	Weight of threshed grain (kg)	Weight of unthreshed grain (kg)	Percentage of unthreshed grain (kg)	Threshing efficiency each (%)	Output capacity each (kg/h)	Grain ratio	Corrected output capacity each (kg/h)
1.	1	21.72	10	70	5.500	0.346	5.92	94.08	282.9	0.58	239.0
2.	2	21.72	10	72	5.600	0.320	5.41	94.59	280.0	0.59	232.5
3.	3	21.72	10	72	5.550	0.305	5.21	94.79	277.5	0.59	230.5
Average								94.49	280.1		234.0
4.	1	16.51	10	62	5.000	0.162	3.14	96.86	290.3	0.52	273.6
5.	2	16.51	10	61	5.050	0.145	2.79	97.20	298.0	0.52	280.8
6.	3	16.51	10	67	5.500	0.378	6.43	93.57	295.5	0.59	245.4
Average								95.88	294.6		266.6
7.	1	12.65	10	62	5.400	0.287	5.05	94.95	313.5	0.57	269.5
8.	2	12.65	10	65	5.450	0.292	5.09	94.91	301.8	0.57	259.4
9.	3	12.65	10	65	5.450	0.181	3.21	96.79	301.8	0.56	264.1
Average								95.55	305.7		264.3

Table 20. Performance of prototype thresher with spike tooth type drum on *mundakan* season (moisture content = 15.9 per cent)

Sl. No.	Test No.	Peripheral speed (m/sec)	Weight of crop (kg)	Threshing time (sec)	Weight of threshed grain (kg)	Weight of unthreshed grain (kg)	Percentage of unthreshed grain (%)	Threshing efficiency each (%)	Output capacity each (kg/h)	Grain ratio	Corrected output capacity each (kg/h)
1.	1	21.72	10	70	5.200	0.494	8.68	91.32	267.4	0.57	229.9
2.	2	21.72	10	72	5.100	0.496	8.86	91.14	255.0	0.56	223.1
3.	3	21.72	10	75	5.150	0.489	8.67	91.33	247.2	0.56	216.3
Average								91.26	256.5		223.1
4.	1	16.51	10	79	5.050	0.427	7.80	92.2	230.1	0.54	208.8
5.	2	16.51	10	76	5.250	0.328	5.88	94.12	248.7	0.56	217.6
6.	3	16.51	10	68	5.000	0.324	6.09	93.91	264.7	0.53	244.7
Average								93.41	247.8		223.7
7.	1	12.65	10	81	5.000	0.416	7.68	92.32	222.2	0.54	201.6
8.	2	12.65	10	80	5.025	0.439	8.06	91.94	226.1	0.54	205.2
9.	3	12.65	10	80	5.050	0.447	8.18	91.82	227.3	0.55	202.5
Average								92.03	225.2		203.1

maximum value of threshing efficiency but remained around 93 per cent.

The increase in the moisture content reduced the grain output for both the rasp-bar and spike tooth cylinders, but the reduction was more predominent for rasp-bar thresher (from 305.7 kg/h to 266.3 kg/h), compared to spike tooth thresher. The corrected output capacity which was based on standard moisture content and standard grain ratio was found maximum for rasp-bar cylinder compared to spike tooth cylinder.

Considering the output of the thresher from Fig.17, the rasp-bar was found to give the maximum value of 305.7 kg/h and the spike tooth gave the maximum value of 256.5 kg/h. Both the cylinders were found to give maximum values for the *mundakan* season. Considering the threshing efficiency of the thresher from Fig.18 the rasp-bar was found to give the maximum value of 95.9 per cent and the spike-tooth gave the maximum value of 93.4 per cent. In this case also both the threshing cylinders were found to have maximum values for the *mundakan* season. Both the threshing cylinders were found to have the maximum threshing efficiency values at the peripheral velocity of 16.51 m/sec during the two seasons.

4.4 Economic analysis

The cost of operation for different threshing methods were calculated and shown in Table 9 and Appendix-XII & XIII.

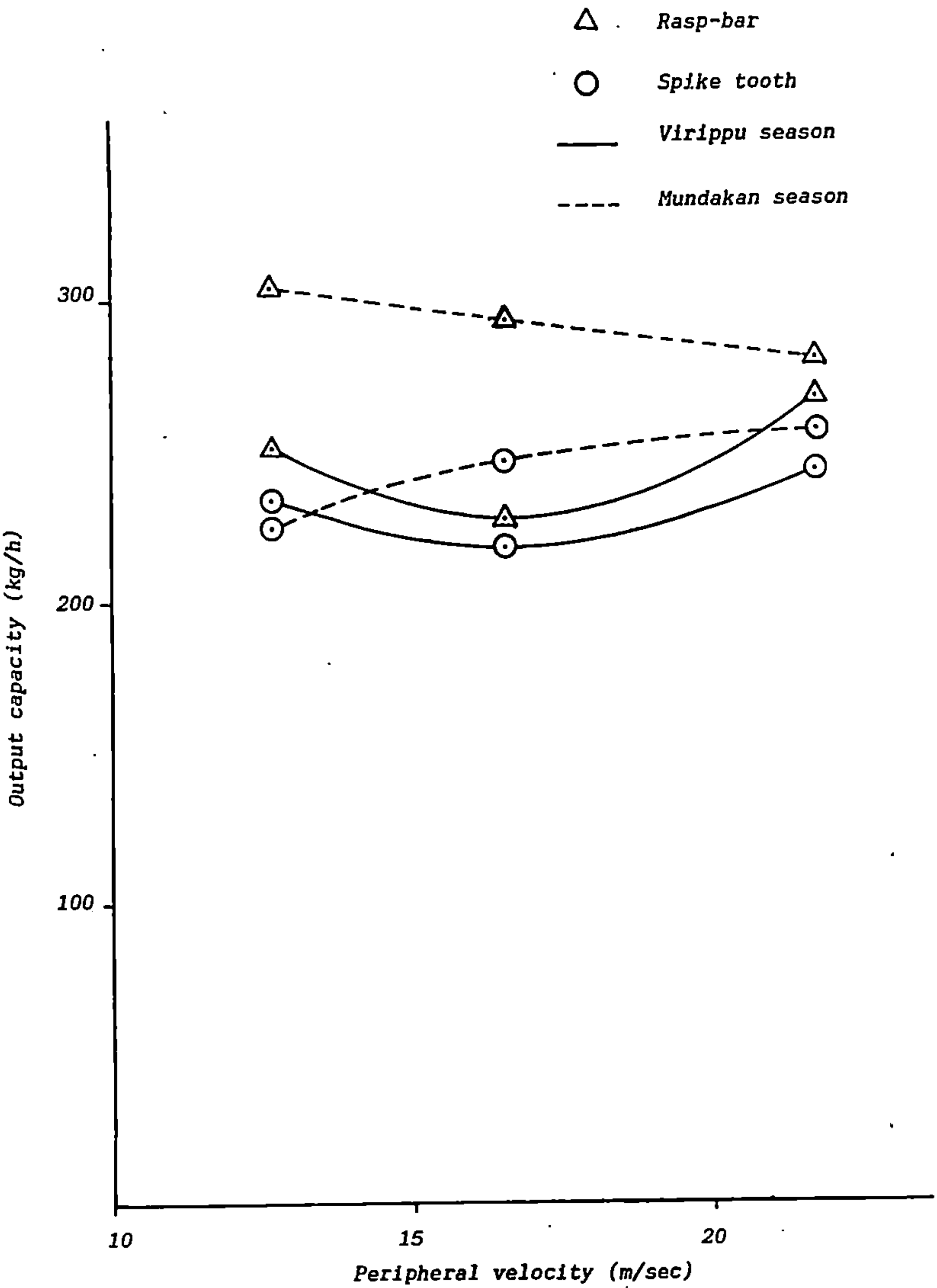


FIG.17 PERFORMANCE OF PROTOTYPE THRESHER, OUTPUT CAPACITY Vs PERIPHERAL VELOCITY

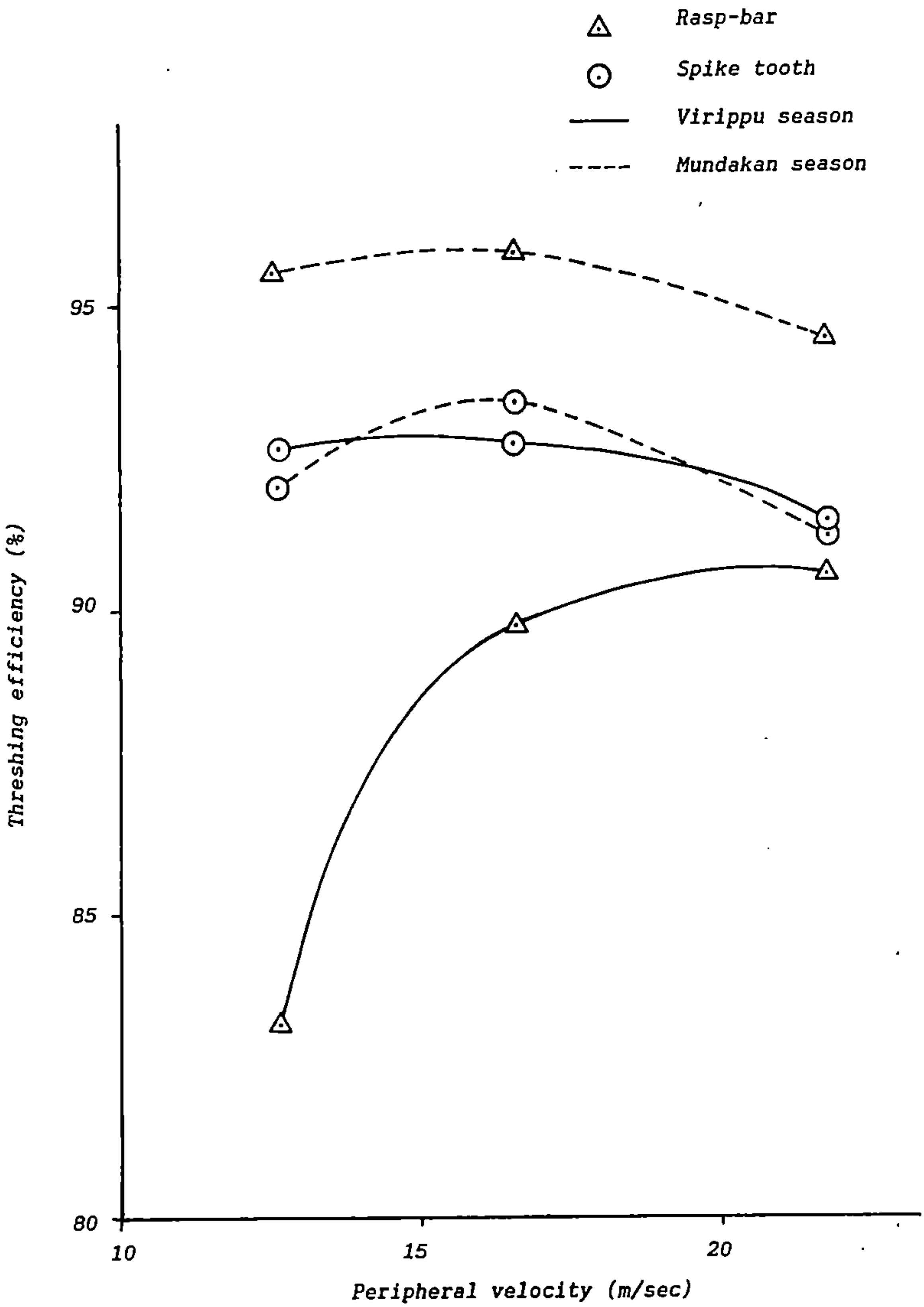


FIG.18 PERFORMANCE OF PROTOTYPE THRESHER, THRESHING EFFICIENCY Vs PERIPHERAL VELOCITY

From that it is evident that the traditional methods utilised more labourers and required higher cost viz., Rs.823.5/ha for hand beating method and Rs.1599.0/ha for feet rubbing method. Cost of operation for axial flow spike-tooth thresher was Rs.400/ha and for rasp-bar type thresher it was Rs.207/ha. So the straight through rasp-bar type thresher with modified concave is more economic for threshing operations than any other methods. It was found also to give an amount of Rs.616.5/ha as net saving compared to hand beating which was amounting to a net saving of 74.9 per cent in cost of threshing.

Considering the savings in labourers which is more relevant for the present labour shortage during the harvesting seasons a net labour saving of 147.2 man hours/ha was achieved by employing straight flow rasp-bar thresher (a net saving of 89.4 per cent). The reduction in labour is necessary for the distribution of the available labourers for the other farm works like harvesting, land preparation and transplanting.

Because of savings in labour and cost of threshing the rasp-bar paddy thresher with modified concave is highly suitable for the farmers of group farming as well as for hiring the thresher through agricultural co-operative societies.

Summary

SUMMARY

Reduction in the cost of cultivation of the paddy crop by employing labour saving equipments is the need of the hour in Kerala. The harvesting, threshing and transplanting for the next season which consumes maximum labour come at the same time. The introduction of a power paddy thresher is inevitable to reduce the shortage of labour and to save the grain loss. For introducing the suitable type of thresher, studies were carried out on the available paddy threshers at K.C.A.E.T., Tavanur.

5.1 Study on traditional threshing methods

From the field studies the hand beating method which is more common in southern parts of Kerala needed 164.7 man hours/ha with an average output of only 18.5 kg/man hour, requiring Rs.823.5/ha. In central Kerala where feet rubbing method is common required Rs.1599.0/ha and needed 319.8 man hour/ha with an average output of 11.27 kg/man h. The other methods like bullock treading and tractor treading were not found common in Kerala.

5.2 Study on spike-tooth paddy thresher

The axial flow spike tooth (TH-8) thresher was evaluated during *virippu* in 1990 and *mundakan* in 1991 as the moisture content of the crop is widely varied during these seasons. During *virippu* at an average peripheral velocity of 9.38 m/s, the output was 370.4 kg/h having threshing efficiency 94.49 per cent and cleaning efficiency 92.8 per cent. During *mundakan* season because of reduction in moisture content the output was increased to 403.9 kg/h with threshing efficiency of 95.5 per cent and cleaning efficiency of 93.5 per cent. Eventhough the percentage of broken grains and blown grains are within the reasonable limits, the thresher is not getting popularized as the straw was cut into pieces and consumed a lower grain output per hp h consumption (average of 50 kg/ha h). This is because of movement of the crop axially towards the straw outlet as well as the use of screw conveyor to transport the grains.

5.3 Study on rasp-bar paddy thresher

The straight through rasp bar paddy thresher was also tested at K.C.A.E.T., farm during the above two seasons. For an average peripheral speed of 16.31 m/s an output of 989.5 kg/h with threshing efficiency of 98.77 per cent and cleaning efficiency of 97.52 per cent were achieved. The output was increased to 1076.6 kg/h with threshing efficiency of 99.01 per cent and cleaning efficiency 97.44 per cent during *mundakan* season. The thresher was found to give a higher grain output of 107 kg/hp h compared to the spike-tooth thresher and the straw was not broken into pieces. The percentage of broken grains was found to be nil for the thresher. But the long and green paddy crop was fed, choking in between the cylinder-concave clearance was noticed, necessitating improvement in the concave design.

5.4 Modifications of concave in the rasp-bar thresher

The conventional concave found in the rasp-bar paddy thresher have only five cross bars of 8 mm square bars and 34 numbers of 6.35 mm rods with 12.5 mm spacings. The moist and longer paddy straw was found to enter and stick in the gap of the horizontal bars. This problem was eliminated by increasing the number of horizontal bars to nine and substituting single and double 15 mm diameter bars arranged alternatively between square bars for 34 small rods. The increase in the number of cross bars tried to pull the sticking straw as the increased number of rasp-bars are found to strike the concave, the new concave was also found to have its own self clearing tendency.

The rasp-bar type paddy thresher with improved concave was tested at K.C.A.E.T. farms during *virippu* and *mundakan* seasons. The output was 1081.0 kg/h and the threshing and cleaning efficiencies were 99.05 per cent and 97.3 per cent respectively for *virippu* season. For *mundakan* season the output capacity was 1122.6 kg/h with threshing and cleaning efficiencies 99.35 per cent and 98.4 per cent respectively.

5.5 Study on prototype thresher

The prototype paddy thresher developed at K.C.A.E.T., Tavanur was tested with rasp-bar, spike tooth type drums for *virippu* and *mundakan* seasons with three peripheral velocities.

The thresher was tested with rasp-bar cylinder for paddy crop at 20.1 per cent moisture content and found to give the maximum threshing efficiency of 90.55 per cent during *virippu* season with a maximum paddy output of 266.3 kg/h (Table 17) while the maximum threshing efficiency for spike tooth cylinder (92.68 per cent) was achieved with a lesser output of 234.2 kg/h (Table 18), the rasp-bar cylinder performed efficiently at the higher peripheral velocity of 21.72 m/sec while for spike tooth cylinder the maximum threshing efficiency was at 12.65 m/sec.

When the cylinders were tested for *mundakan* season at 15.9 per cent moisture level, the rasp-bar cylinder was found to give the maximum efficiency of 95.88 per cent compared to 93.41 per cent for spike tooth cylinder at peripheral velocity of 16.5 m/sec (Tables 19 and 20). This indicated that for higher moisture levels the spike tooth cylinder and for lower moisture levels the rasp-bar cylinder was found better.

The output per hp h was found to be the maximum for prototype thresher with rasp-bar cylinder (305.7 kg/hp h) compared to the 8 hp spike tooth thresher and 10 hp rasp-bar thresher. This was because of the simple design of the thresher without providing the straw walker and cleaning sieves.

Based on the field surveys conducted on the threshing practices in Kerala and the evaluation of the 8 hp spike tooth thresher evaluation and modification of 10 hp rasp-bar type thresher and evaluation of 1 hp prototype thresher with rasp-bar and spike tooth cylinders, the following conclusions are made:

a. Manual threshing is the common method of threshing paddy in Kerala which is the costliest compared to the threshers. The hand beating method which is followed in southern Kerala had only an output of 18.5 kg/man h involving an amount of Rs.823.5/ha as cost of threshing as it needed 164.7 man h/ha.

b. In central Kerala where feet rubbing method was common having an output of 11.27 kg/man h needed only 319.8 man h/ha and required an amount of Rs.1599.0/ha as the cost of threshing.

c. The 8 hp axial flow spike tooth thresher (TH 8 model) was found to give 403.9 kg/h during *mundakan* season with 95.5 per cent threshing efficiency at a peripheral velocity of 9.55 m/sec.

d. The threshing efficiency was reduced for the axial flow spike-tooth thresher to 94.49 per cent during *virippu* season with an output of 370.4 kg/h at the peripheral velocity of 9.38 m/sec, which gave an output of only 50 kg/hp h.

e. A higher paddy output of 989.5 kg/h and 1076.6 kg/h was recorded for the flow through rasp-bar type paddy thresher during *virippu* and *mundakan* seasons with an average output of 107 kg/hp h.

f. The maximum threshing efficiency of 98.77 per cent and 97.44 per cent were recorded for the flow through rasp-bar thresher during *virippu* and *mundakan* compared to only 95.50 per cent and 94.49 per cent respectively for spike-tooth thresher.

g. A new concave was designed and fabricated for the rasp-bar paddy thresher to eliminate the sticking and choking during operation with high moist and long paddy crop. The simplified construction of the concave also improved the output to 1081 kg/h and 1130 kg/h during *virippu* and *mundakan* seasons which was an increase of 9.25 per cent and 4.96 per cent respectively.

h. The prototype paddy thresher developed at K.C.A.E.T., Tavanur was also tested with rasp-bar and spike-tooth cylinders during the two seasons. The maximum threshing efficiency of 95.88 per cent was achieved with 294.6 kg/h with rasp-bar cylinder compared to the 93.41 per cent with 247.8 kg/h with spike tooth cylinder during *mundakan* season. But for *virippu* the maximum efficiency was obtained by spike-tooth cylinder (95.68 per cent) with only an output of 234.2 kg/h.

i. A maximum output of 305.7 kg/hp h was obtained for the prototype thresher with rasp-bar cylinder, compared to 107 kg/hp h with flow through rasp-bar thresher and 50 kg/hp h with axial spike tooth thresher.

j. The cost of operation for the axial flow spike tooth thresher was found to be Rs.400/ha and for rasp-bar thresher it was only Rs.207/ha with a net saving of Rs.616.5/ha compared to hand beating method.

The following points were observed and recommended for future studies on threshers:

a. There is great scope to reduce the cost of cultivation of paddy for introduction of power paddy threshers.

b. The axial flow spike tooth thresher which deliver the straw into small pieces could be modified into a straight flow thresher before introducing to Kerala.

c. The flow through rasp-bar threshers should be simplified before introduction in Kerala by eliminating the heavier straw walker and cleaning sieves.

d. Popularization of rasp-bar paddy threshers in Kerala could be taken up only with the modified concave to achieve maximum efficiency even with moist and longer crop.

e. Different types of threshing cylinders instead of rasp-bar and spike-tooth type cylinders may be developed to get the maximum threshing efficiency and higher output per hp h for the moist and longer paddy crops.

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* Originals not seen

Appendices

Appendix-I

Salient features of available threshers

Sl. No.	Type of threshing/ Name of machine	power	rpm	Grains output (kg/h)
1.	By hand beating	1 man	--	17-20
2.	Bullock driven pedal thresher	1 bullock + 4 men	--	150
3.	Bullock driven pedal thresher	2 bullocks + 4 men	--	230
4.	Bullock threshing	9 bullocks + 3 men	--	200
5.	Tractor trampling	--	--	750
6.	Kawable pedal thresher (Japan)	2 men	370	30
7.	Peepal pedal thresher	2 men	210	20
8.	Nahan pedal thresher	2 men	180	20
9.	Akshat pedal thresher	2 men	260	20
10.	Kayee pedal thresher	2 men	350	30
11.	Pedal thresher , Japan	3 men	--	50
12.	Pedal thresher converted for bullock drive	50 kg draft	450	250
13.	Kubota semi automatic (Japan)	2 hp	750	100
14.	Kubota automatic (Japan)	5 hp	600	300
15.	IRRI Table thresher	4 men	215	350
16.	Allahabad power thresher	3 hp	--	200
17.	Naini Junior	2.5 hp	725	200
18.	Sherpur thresher	5 hp	--	500

Contd.

19.	Kissan sewak	5 hp	1100	300
20.	JNKVV multicrop thresher	3 hp	--	200
21.	RTTC paddy thresher, Coimbatore, Tamil Nadu	2 hp	250	130
22.	RTTC Rajendra Nagar, AP, Double drum 10 ft length	4 hp	400	250
23.	LCT multicrop grain cum paddy thresher	7.5 hp	--	1500
24.	PAU multicrop thresher	30-35 hp tractor	800-1260	1000
25.	Pantnagar multicrop thresher	20 hp tractor	--	600
26.	APAU all crop thresher	7.5 hp	--	500-600
27.	Pusa 40 thresher	5 hp	--	200
28.	Double drum paddy thresher, APAU	5 hp	--	350
29.	GBPUAT, axial flow paddy thresher	7.5 hp	--	550
30.	TNAU paddy thresher	6 hp	1150	675
31.	Modified AKSHAT paddy thresher, Bhubaneswar	2 men	--	70
32.	CIAE thresher	7.5 hp	300-800	392
33.	High capacity (PAU) multicrop thresher	30-35 hp tractor	800-1260	1000

Appendix-II

Summary of performance data for threshing of paddy on single ear thresher during 1988

Sl.No.	Crop →	Paddy
	Crop parameters	
1.	Variety	Pusa-21
2.	Moisture content of grain (db) %	11.11
3.	Moisture content of starw (db) %	12.4
4.	Percentage of grain in crop-moisture setting	68.5
5.	Threshing beater speed - rpm	600
	mpm	6.25
6.	Blower speed - rpm	1860
7.	Clearance (mm)	5.0
8.	Pulley diameter for thresher (mm)	150
9.	Motor pulley diameter (mm)	62
	Performance results	
10.	Threshing efficiency (%)	100
11.	Average cleaning efficiency (%)	99.50
12.	Average visible seed damage (%)	2.98
13.	Average germination (%)	99.0
14.	Grain at blower inlet (%)	7.18
15.	Grain at blower outlet (%)	0.94

Appendix-III

Comparative test results of power paddy thresher

Sl. No.	Particulars	Thresher		
		LCT	SBI	Swathi
A.	**Crop factor**			
	1. Crop variety	IR 60	IR 60	IR 60
	2. Date of testing	9.3.1991	10.3.1991	15.3.1991
	3. Straw grain ratio	1:2.3	1:2.3	1:2.3
	4. Straw moisture (%)	58.9	58.0	56.9
	5. Grain moisture (%)	19.7	19.6	19.0
B.	**Operational data**			
	1. Number of labourers	3	3	3
	2. Duration of operation(h)	1.5	1.5	1.5
	3. Cylinder speed (rpm)	980	1030	780
	4. Blower speed (rpm)	1900	2000	1520
	5. Feed rate (kg/h)	1960	2200	1400
	6. Power requirement (Kw)	5.6	6.0	3.75
C.	**Performance data**			
	1. Broken grain (%)	0.70	0.80	0.60
	2. Blown grain (%)	0.80	1.20	1.09
	3. Spilled grain (%)	0.30	0.40	0.48
	4. Threshing efficiency(%)	99.5	99.2	98.8
	5. Cleaning efficiency(%)	94.9	96.8	93.3
	6. Output capacity (kg/h)	580	641	364
D.	**Cost of operation**			
	1. Operating cost of the machine (Rs/ha)	31.63	40.62	27.26
	2. Cost of operation per tonne of grain (Rs)	53.53	63.36	75.09
E.	**Performance index**	10.15 K	9.71 K	4.42 K

Appendix-IV

Power threshers and their feeding systems

Sl. No.	Type of thresher	Brief description	Feeding system used	Bottlenecks of feeding system if any	Recommended feeding system
1.	Hammer-mill or beater type	Beaters mounted on shaft rotating inside a closed casing and concave. Requires axial feeding of material	Feeding chute	Inadequate length of chute, lack of upper covering and improper slope	Chute
2.	Drummy	-do- But the separation is only partial	-do-	-do-	-do-
3.	Syndicator	A fly-wheel with corrugations on periphery and sides, with chopping knives rotating inside a closed casing and concave. Requires radial feeding of material	Feeding chute or feeding conveyor with positive feed rollers with or without feed reversing mechanism	Inadequate length of feeding chute, lack of upper covering adjacent to the feed rollers and lack of feeding reversing mechanism	Feed-rollers with chute/ conveyor with feed reversing device
4.	Spike-tooth cylinder type	Spike fixed on a cylinder. Requires radial feeding.	Feeding chute, bulk feed hopper or feed conveyor	Inadequate length of feeding chute, lack of covering from above and improper slope	Chute, hopper or conveyor

Contd.

5.	Hopper-fed thresher	Spike tooth or rasp-bar type thresher with a feeding trough. Requires radial feeding of material	Bulk-feeding through a hopper with or without feed regulator/ auger/conveyor	--	Feed hopper
6.	Rasp-bar type	Rasp-bars mounted axially on the periphery of the cylinder with concave grate and concave bars	Feeding chute or feed conveyor with or without feed regulator/ feed-auger	Inadequate length of feeding chute/feed conveyor and lack of upper covering of adequate length	Chute, hopper or conveyor
7.	Japanese type	Cylinder with wire-loops on the periphery	Feed platform with feeding chain and crop pushing bar	--	Feeding chain

Appendix-V

Specification details of axial flow spike tooth and flow through rasp-bar type paddy threshers

Description	A.F. thresher	R.B. thresher
a. General		
1. Make	Valampuri Industries Coimbatore	Sri Bhuvaneswari Industries, Coimbatore
2. Model	TM 8 (IRRI)	Three walker model
3. Type	Spike-tooth	Rasp-bar
b. Power unit		
1. Type of prime mover	8 hp Diesel engine	10 hp Kubota diesel engine
2. Recommended power, hp	8 hp	7.5 hp
3. Type of drive	V-belt drive	Flat belt
c. Threshing unit		
1. Type	Spike tooth	Rasp-bar
2. Construction features	Cylindrical drum	Cylindrical drum
3. Diameter	39.3 cm O.D.	33.5 cm O.D.
4. Width	111 cm	55.0 cm
5. Recommended speed	600 rpm at load	1000 rpm at no load
6. Number of projections	8	6
7. Number and type of bearings	2 ball bearings	2 ball bearings
d. Concave		
1. Type	0.6 cm diameter steel rods with 16 mm spacing	0.7 cm diameter steel rods with 15 mm spacing

	2. Width	95 cm	56.5 cm
	3. Concave, clearance range	3-5 cm	1.5-3 cm
	4. Method of concave clearance adjustment	--	Concave position can be moved in or out.
	5. Methods of fixing	Hold in position with nut and bolts	Hold in position by pins
e.	Sieve		
	1. Type	Two punched sheets	A wooden sieve and two punched sheets
	2. Number	2	3
	3. Effective length and width	76 x 50 cm 76 x 60 cm	56 x 49 cm
	4. Size of hole		
	Wooden sieve	--	1.8 cm dia holes to remove straw
	Upper sieve	1.6 cm dia.	0.5 cm - 2 cm slots to remove stones
	Lower sieve	0.95 cm dia.	0.15 cm x 1.5 cm slots to remove soil and other smaller particles
	5. Sieve clearance	30.6 cm	6 cm
	6. Screen slope range	28°	2°
f.	Straw walker	--	Crank type straw walker three numbers having width 15 cm and length 180 cm

Contd,

g. Blower		
1. Number	2	1
2. No. of blades	4	4
3. Size of blades	32 x 8 cm	42 x 10.5 cm
4. Diameter	34 cm	30 cm
5. Length	35 cm	50 cm
6. Speed	800 rpm	2300 rpm
h. Transport		
1. Type	Pneumatic wheels	pneumatic wheels
2. Number of wheels	2	2
i. Fuel consumption	0.9 lit/h	0.8 litre diesel per hour
j. Type of feeding	Continuous manual feeding	Continuous manual feeding
k. Crops for which the machine is adoptable	Paddy	Paddy, wheat, sorghum, sunflower etc.
l. Overall dimensions		
1. Length with tray	190 cm	340 cm
2. Width	150 cm (tray folded up)	120 cm
3. Height	178 cm (tray folded up)	165 cm

Appendix-VI

Specification of engines used in threshers

(i) Axial flow spike tooth thresher

Make	:	Greaves Lombardini
Model	:	LDA 1510 Single cylinder diesel engine (Vertical air cooled) delivering 8.3 hp at 3000 rpm.
Sl.No.	:	13 12 15534

(ii) Flow through rasp-bar thresher

Make	:	KAMCO ER 90 N diesel engine
Model	:	HP 9 - 12 rpm 3600
Sl.No.	:	91/31696

Appendix-VII

Specification of Tachometer

Make	:	Prestige Counting Instruments (P) Ltd., Bombay
RMM range	:	30 to 50000 rpm

Appendix-VIII

Specification of Wattmeter

Make	:	Nippen Electrical Instruments Co., Bombay - 58
Model	:	NTW 5-10 A/500 V
No.	:	3700/A/68
		3 ph 3 wires BAL.

Maximum power range : 0 - 4.2 KW

Appendix-IX

Details of normal and modified concaves

Sl.No.		Details	Normal concave	Modified concave
1.		Horizontal square bars		
	a.	Length	54 cm	54 cm
	b.	Width	5 cm	5 cm
	c.	Thickness	0.8 cm	0.8 cm
	d.	Number(s)	5	9
	e.	Spacing	10 cm	5 cm
2.		Longitudinal rods		
	a.	Diameter	1.5 cm	0.635 cm
	b.	Number(s)	34	Single and double rods are arranged alternatively between horizontal square bars
	c.	Spacing	1.25	
	d.	Type of connection with square bars	Passing through the holes in square bars	By welding
3.		Length of concave	56 cm	56 cm

Appendix-X

Specifications of the prototype paddy thresher

Threshing unit	: Rasp-bar and spike tooth type drums can be used. Rasp-bar type: Drum with 26.67 cm diameter and length 31.75 cm fixed with 3 bars each of the bar with height 3.8 cm and length 31.75 cm. Spike tooth drum: Open type with the same diameter and length of rasp-bar type drum and fixed with 6 rows of spikes. Spikes arranged in zigzag manner in alternate rows and spacing is 5.08 cm. Spike length is 3.8 cm and diameter is 0.95 cm.
Threshing cylinder shaft diameter and number and type of bearings	: 2.54 cm diameter shaft is used. Two ball bearings.
Concave	: 0.6 cm bars welded across axis between flats. There is no concave adjustment. Clearance varies from 4 to 0.7 cm.
Power unit	: 1 hp electric motor
Power transmission	: V-belt
Transport of thresher	: By two small steel rollers
General dimensions of the thresher	
Total length	: 208.28 cm
Total width	: 34.29 cm
Total height	: 111.76 cm
Blower	: A blower with 4 blades and diameter 26 cm used for straw removal.

Appendix-XI

Specification of Hot Air Oven

Make	:	Sri. Rudran Instruments Co.
Temperature	:	250°C
Rating	:	1800 W
Voltage	:	230
Sl. No.	;	2360 10. 91

Appendix-XII

Cost of operation of threshing for axial flow spike tooth thresher

Cost of paddy thresher	=	Rs.14,500
Prime mover (8.0 hp engine)	=	Rs.15,000
Total (P)	=	Rs.29,500

Other assumptions are:

a. Working hours per year (H) = 500 h

b. Life of the thresher (L) = 10 years

c. Salvage value 10% of the cost of the thresher (s) = Rs.2950

I **Fixed cost**

1. Depreciation per hour

$$= \frac{P-S}{LxH} = \frac{29500 - 2950}{10 \times 500}$$

$$= Rs.5.31/h$$

2. Interest per hour @ 12% per year on average investment

$$= \frac{P+S}{2} \times \frac{12}{100} \times \frac{1}{H}$$

$$= \frac{29500 + 2950}{2} \times \frac{12}{100} \times \frac{1}{500}$$

$$= Rs.3.89/h$$

3. Taxes, insurance and shelter charges per hour @ 2% of initial cost of the thresher

$$= \frac{P}{H} \times \frac{2}{100}$$

$$= \frac{29500}{500} \times \frac{2}{100}$$

$$= Rs.1.18/h$$

4. Repair and maintenance charges per hour @ 10% of initial cost of the thresher

$$= \frac{P}{H} \times \frac{10}{100}$$

$$= \frac{29500}{500} \times \frac{10}{100}$$

$$= Rs.5.9/h$$

Total fixed cost per hour = 5.31 + 3.89 + 1.18 + 5.9

= Rs.16.28/h

II Variable cost

1. Labour charges

   Number of labourers = 5

   Working hours per day = 8 h

   Labour charges per man day = Rs.40

   Labour charges per hour = $\frac{5 \times 40}{8}$

   = Rs.25/h

2. Fuel cost

   Fuel consumption per hour = 1.4 lit/h

   Fuel cost per litre = Rs.7.50/lit

   Fuel cost per hour = 1.4 x 7.5

   = Rs.10.5/h

3. Lubrication charges @ 15% of fuel cost = $\frac{15}{100} \times 10.5$

   = Rs.1.58/h

   Total variable cost = 25 + 10.5 + 1.58

   = Rs.37.08/h

   Total cost of threshing per hour = I + II

   = 16.28 + 37.08

   = Rs.53.36/h

   An establishment charge of @ 5% of total cost of threshing is assumed = $53.36 \times \frac{5}{100}$

   = Rs.2.67/h

Total cost of threshing operation per hour	= 53.36 + 2.67
	= Rs.56.03/h ≃ Rs.57/h
Capacity of the thresher	= 400 kg/h
Cost of threshing per kg	= Rs. $\frac{57}{400}$
	= Rs.0.143/kg
Time taken to thresh one hectare of paddy	= 7 h
Cost of threshing per hectare	= 57 x 7
	= Rs.399/ha
	= **Rs.400/ha**

Appendix-XIII

Cost of operation of threshing for straight through rasp-bar thresher

Cost of thresher	=	Rs.22,750
Prime mover	=	Rs.18,600
Total (P)	=	Rs.41,350

Other assumptions are:

a. Working hours per year (H) = 500 h

b. Life of the thresher (L) = 10 years

c. Salvage value 10% of the cost of the thresher (S) = Rs.4135

I Fixed cost

1. Depreciation per hour

$$= \frac{P-S}{L x H} = \frac{41350 - 4135}{10 \times 500}$$

$$= \text{Rs.}7.44/h$$

2. Interest per hour @ 12% per year on average investment

$$= \frac{P + S}{2} \times \frac{12}{100} \times \frac{1}{H}$$

$$= \frac{41350 + 4135}{2} \times \frac{12}{100} \times \frac{1}{500}$$

$$= \text{Rs.}5.46/h$$

3. Taxes, insurance and shelter charges per hour @ 2% of initial cost of the thresher

$$= \frac{P}{H} \times \frac{2}{100}$$

$$= \frac{41350}{500} \times \frac{2}{100}$$

$$= \text{Rs.}1.65/h$$

4\. Repair and maintenance charges per hour @ 10% of initial cost of the thresher

$$= \frac{P}{H} \times \frac{10}{100}$$

$$= \frac{41350}{500} \times \frac{10}{100}$$

= Rs.8.27/h

Total fixed cost per hour = 7.44 + 5.46 + 1.65 = 8.27

= Rs.22.82/ha

II Variable cost

1\. Labour charges

Number of labourers = 5

Working hours per day = 8 h

Labour charges per day per person = Rs.40/-

Labour charges per hour $= \frac{5 \times 40}{8}$

= Rs.25/h

2\. Fuel cost

Fuel consumption per hour = 0.9 lit/h

Fuel cost per litre = Rs.7.50/lit

Fuel cost per hour = 0.9 x 7.5

= Rs.6.75/h

3\. Lubrication charges @ 15% of fuel cost $= \frac{15}{100} \times 6.75$

= Rs.1.01/h

Total variable cost = 25 + 6.75 + 1.01

= Rs.32.76/h

Total cost of threshing per hour = I + II

= 22.82 + 32.76

= Rs.55.58/h

An establishment charge of @ 5% of total cost of threshing is assumed	=	$55.58 \times \frac{5}{100}$
	=	Rs.2.78/h
Total cost of threshing operation per hour	=	55.58 + 2.78
	=	Rs.58.36 = Rs.59/h
Capacity of the thresher	=	1050 kg/h
Cost of threshing per kg	=	Rs. $\frac{50}{1050}$
	=	Rs.0.056/kg
Time taken to thresh one hectare of paddy	=	3 hours 30 minutes
Cost of threshing per hectare	=	59 x 3.5
	=	Rs.206.5/ha
	=	**Rs.207/ha**

EVALUATION AND MODIFICATION OF SPIKE-TOOTH AND RASP-BAR TYPE PADDY THRESHERS

By

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ABSTRACT OF THE THESIS

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ABSTRACT

The field survey conducted on the threshing practices of paddy in Kerala revealed that the hand beating method which is more common in southern parts of Kerala needed 154.7 man h/ha with an average output of 23.5 kg/man h requiring an amount of Rs.823.5/ha whereas in central Kerala the feet rubbing method required Rs.1560.0/ha and needed only [illegible] man h/ha with an average output of 11.27 kg/man h.

The 8 hp axial flow spike-tooth type and 10 hp flow through rasp-bar type threshers were evaluated and found an average output of 50 kg/hp h and 10[illegible] kg/hp h respectively. The maximum threshing efficiency of 98.77 per cent and 97.[illegible] per cent were recorded for the flow through rasp-bar thresher during *virippu* and *mundakan* seasons compared to only 95.50 per cent and 94.49 per cent respectively for spike-tooth thresher. The high moist and long paddy crops used to stick and choke in between cylinder and concave clearance and hence the concave was successfully improved to eliminate these problems. The improved concave also improved the output to 1081 kg/h and 1122.6 kg/h with an increase of 9.25 per cent and 4.27 per cent respectively during *virippu* and *mundakan* seasons. A maximum output of 305.7 kg/hp h was obtained for the 1 hp

prototype thresher with the rasp-bar cylinder compared to the output of 256.5 kg/hp h for spike tooth cylinder.

The cost of operation for the commercially available axial flow spike tooth and the flow through rasp-bar threshers was found to be Rs.400/ha and Rs.207/ha respectively. The rasp-bar thresher with improved concave could save an amount of Rs.616.5/ha which accounted to a net saving of 74.9 per cent in the cost of threshing compared to the hand beating method.