DEVELOPMENT AND TESTING OF AN ARECANUT HARVESTER CUM SPRAYER

By

NIMMI RACHEL GEORGE

PREETHA. T. J.

PROJECT REPORT

Submitted in partial fulfilment of the requirement for the degree

Bachelor of Technology in Agricultural Engineering

Faculty of Agricultural Engineering and Technology

Kerala Agricultural University

Department of Farm Power Machinery and Energy

KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY

TAVANUR - 679 573, MALAPPURAM

KERALA

1998

DECLARATION

We hereby declare that this project entitled **"Development and Testing of an Arecanut Harvester Cum Sprayer"** is a bonafide record of project work done by us and that this work has not previously formed the basis for the award of any degree,diploma, associateship, fellowship or other similar title to us, of any other university or society.

Tavanur,
21st May 1998

Nimmi Rachel George

Preetha T. J

CERTIFICATE

Certified that this project report, entitled "**Development and Testing of an Arecanut Harvester Cum Sprayer**" is a bonafide record of project work done jointly by Nimmi Rachel George and Preetha T. J under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to them.

Tavanur,

21st May 1998

Er.Jayan P R
Assistant professor
Project Guide
Dept. of FPME

ACKNOWLEDGEMENTS

We have immense pleasure to express our deep sense of gratitude, indebtness and respect to our project guide **Sri. Jayan, P.R.,** Asst. Professor, Department of Farm Power Machinery and Energy for his valuable guidance, constructive criticism and constant encouragement and advice throughout this project work.

We are greatly indebted to **Dr. K.John Thomas,** Dean, KCAET, Tavanur, Prof. Mohammad C.P., Head, Department of FPME, Sri Jippu Jacob, Associate Professor, Department of FPME, Sri. M. Sivaswami, Associate Professor, Department of FPME, Sri. Anil K.R., Assistant Professor, Departmenet of IDE, Sri. Joby Bastian, Assistant Professor, Department of FPME, and Sri. Sathyajith Mathew, Assistant Professor, Department of FPME for their constant encouragement, valuable advices and sustained interest at every stage for the investigation and fabrication of the project.

We gratefully appreciate the timely help that is rendered from Sri. P.K. Koshy, Joint Director, CPCRI, Kayamkulam. We are also thankful to Sri. K.G. Mathew, Department of Economics and Statistics, Trivandrum.

We acknowledge our gratitude to staff members of KCAET workshop, especially to Sri.T P Aboobacker and Sri. K T Ramachandran, Technical Supervisors, Machine shop, KCAET for extending their help throughout the progress of our work. We are specially indebted to Sri. K.C Joy Technician for his invaluable help towards fabrication of the unit. We also thank Sri. Gopalakrishnan Nair, Padikkal House, Tavanur, for providing us facilities for the testing of the device.

We avail this opportunity to express our sincere thanks to National Computer Centre, Kuttippuram for the neat typing of this project report.

Our sincere thanks are also due to Dhalin.D, Kingsling Das J., Vidhu.K.P. and Vinod Kumar. B, students of this college for their immense help during this work.

At this moment we also extend our heartful gratitude to our parents for their help and encouragement.

At the most, we bow our head before the Almighty for all the blessings showered upon us.

Nimmi Rachel George

Preetha T .J

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

SYMBOLS & ABBREVIATIONS

Al	-	Aluminium
BHC	-	Benzene Hexa Chloride
C	-	Inital cost
cm	-	Centimeter(s)
CPCRI	-	Central Plantation Crop Research Institute
$CuSO_4$	-	Copper sulphate
Dia	-	diameter
Dept.	-	Department
Engg	-	Engineering
et al.	-	and others
Fig.	-	Figure(s)
FPME	-	Farm Power Machinery and Energy
G I	-	Galvanized Iron
g	-	Acceleration due to gravity
ha	-	hectare
H	-	Annual working hours
hr	-	hour(s)
IDE	-	Irrigation and Drainage Engineering
i.e.	-	that is
j.	-	journal
K.A.U.	-	Kerala Agricultural University
K.C.A.E.T.	-	Kelappaji College of Agricultural Engineering and Technology
Kg	-	kilogram
Kgf/cm^2	-	kilogram force per square centimetre
l	-	Litre
L	-	Useful life period
m	-	metre(s)
min	-	minute(s)

SYMBOLS & ABBREVIATIONS

Al	-	Aluminium
BHC	-	Benzene Hexa Chloride
C	-	Inital cost
cm	-	Centimeter(s)
CPCRI	-	Central Plantation Crop Research Institute
$CuSO_4$	-	Copper sulphate
Dia	-	diameter
Dept.	-	Department
Engg	-	Engineering
et al.	-	and others
Fig.	-	Figure(s)
FPME	-	Farm Power Machinery and Energy
G I	-	Galvanized Iron
g	-	Acceleration due to gravity
ha	-	hectare
H	-	Annual working hours
hr	-	hour(s)
IDE	-	Irrigation and Drainage Engineering
i.e.	-	that is
j.	-	journal
K.A.U.	-	Kerala Agricultural University
K.C.A.E.T.	-	Kelappaji College of Agricultural Engineering and Technology
Kg	-	kilogram
Kgf/cm^2	-	kilogram force per square centimetre
l	-	Litre
L	-	Useful life period
m	-	metre(s)
min	-	minute(s)

mm	-	millimetre
MS	-	Mild Steel
No.	-	Number(s)
Pp	-	Page
rpm	-	revolutions per minute
Rs	-	rupees
S	-	Salvage value
Sec	-	second(s)
TNAU	-	Tamil Nadu Agricultural University
Viz.	-	namely
VMD	-	Volume Mean Diameter
Vs	-	versus
W	-	Weight
Yrs	-	Years
&	-	and
μ	-	Micron
/	-	per
%	-	percentage
ρ	-	Density

INTRODUCTION

Arecanut palm (*Areca catechu Linn*) is one of the important plantation crop grown largely in the states of Kerala, Karnataka, Assam and Meghalaya. Though it is concentrated in the south western and north eastern regions of the country, arecanut in tender, ripe or processed form is chewed by all kinds of people, young and old, men and women all over the country. The commodity is thus an important masticatory item of trade. Arecanut industry provides livelihood for nearly 6 million people in India. Arecanut cultivation is now looked upon as a profitable venture.

Arecanut tree has got multifarious uses. Medicinal properties of arecanut are well acclaimed and used for treating coughs, fits, anaemia, obesity etc. Arecanut tannins are of commercial importance in the manufacture of dyes, fibres, etc. Arecanut husk fibres are used for making boards, cushions, fabrics etc. Throw away cups and plates, briefcases, bags, spectacle cases etc, made from leafsheath of areca tree are now gaining popularity.

The most valuable product from areca tree is its valuable nuts. The production of scented supari and gutka spread over length and breadth of the country with small and attractive sachets even in the petty shops brought popualrity for masticatory item such as areca. The prohibition slogans of tobacco products like cigarette and beer added feather to the prices in areca. Data collected from the Directorate of Economics and Statistics, Thiruvananthapuram shows a production capacity of 17,466 million nuts in an year from an area of 71676 hectares in Kerala during 1994-'95 (**Table 2.1 and Table 2.2**).

The altitude at which the arecanut palm can be successfully grown varies to some extent according to the latitude of the place. Though it grows at altitudes upto 1000 m above the sea level, at higher altitudes it is not at all productive. Based on the yield levels obtained, the fertile valley soils surrounded by hillocks and with an adjacent forest ecosystem is ideal for the areca plams growth and yield well in open

textured and well drained laterite, sandy loam and sandy clay loam soils having higher organic matter content. Good monsoon rains, high humidity and assisted irrigation during summer months are necessary for obtaining high yields. Exposed table lands, ill drained marshes, eroded slopy lands, soils with rocky substrata should be avoided. The cultivation is mostly confined to 28^{O} north and south of the equator. It is unable to withstand extreme temperature and wide diurnal variations. The range of temperature at which it can flourish is from 15^{O} to 38^{O} C. The spacing of the area areca trees in a form in recommended as per the package of the practices, KAU, (1997) is about 2.7 x 2.7m.

Cultivation practices for arecanut are varied throughout the year. During January to March, irrigation may be adopted once in 3 to 5 days. Sparying against mites attack is also necessary as a plant protection measure. Harvesting and curing of tender nuts, planting new seedlings, cleaning and deepening of drainage channels and plant protection are the important operations to be taken up during the period of April to October and digging taken up before the end of November. Harvesting and drying of ripe nuts may commence then. Incidence of mites amd spindle bug on palms of all ages must be prevented by spraying.

The pre-bearing age of the the palm ranges from 5 to 8 years. The colour of the fruit during its growth changes from green to different shades of yellow and red during ripening. In some places, tender nuts are harvested whereas in other regions, only mature nuts are harvested. Both immature and mature nuts are harvested in some other places.Areca is a monocotyledon tree. However, the real break through in agricultural production was effected through the introduction of high-yielding dwarf varieties. A very popular semi-tall early-bearing variety has been released by the Central Variety Release Committee under the name 'Mangala' yielding about 70% more than the local variety.

Climbing palms is necessary for harvesting nuts and plant protection measures. By and large, it is done by professional climbers who get trained from

their younger days. Since it is a strenous and risky job, and with the changed socio-cultural outlook, fewer young men are taking it up and this has caused a scarcity of palm climbers.

Timely harvesting can be as assured by the availability of skilled labourers. The number of people available is dwindling day by day and labour charge is also high. The main intercrops like pepper and betel vines increase the difficulty in the climbing of the palm.

Several pests attacking areca tree has been reported, (**Appendix I**) of which 'Mahali' is the most baneful disease that causes fruit rot. The conventional method of plant protection done against'Mahali' is by applying bordeaux mixture manualy with the help of rocker sprayer. Spraying has to be done just before and after the monsoon as a precautionary measure. It is very difficult to apply chemicals on the fruit bunches of areca tree because it is unusually tall compared to other crops. The spraying is done using a rocker sprayer involving two persons, one operating the sprayer from the ground and the other climbing the tree with the boom with nozzle. But this method is very tedious, time consuming and uneconomic. Above all, skilled labourers are required to do this operation and they are exposed to the chemical they apply.

Hence due to non availability of skilled labourers, high wage rates and for timeliness of operation, a novel technology has to be developed for harvesting and spraying of arecanut crop. With this in view the specific objectives of the project are,

1. Preliminary investigations on harvesting and spraying methods of arecanut.
2. To develop the arecanut harvester cum sprayer.
3. To test the device for the field conditions.

REVIEW OF LITERATURE

Drudgery in the field of harvesting and plant protection lead to the study of previous works done in this field. The review of literature pertaining to the statistics of cultivation of arecanut in Kerala state, development of lifting device, harvesting device and spraying device is briefed here under.

2.1 Origin and distribution

The origin of arecanut is an issue of controversy in "The origin of cultivated plants", De candolle (1886) reported that the country of origin of arecanut remain unknown. But at the same time, he pointed out the possibilities of origin in Sunda Islands.

Beccari (1919) considered Philippines as the origin of arecanut. Also he revealed the existance of four cultivers of Areca catechu and nine other species in Philippines and the absence of reports on similiar species in other parts of the world.

Petelot *et al.* (1926) reported of the existence of arecanut in Indonesia. Other nations in which existence of arecanut was reported were India, Sri lanka (Blatter, 1926) South China (Hisiao-Liang, 1936), Taiwan (Yama Moto, 1936) and Jawa (meijee, 1948).

2.2 Harvesting of tree crops

Various methods of detachment employed are either hand or mechanical harvesting. These generally involve cutting, pinching, pulling, bending or snapping, twisting or some combination of these actions. Machines that shake the plant, develop detachment forces as a result of inertia. Bending and twisting as well as a direct pull may be induced by the shaking. Harvesting methods which donot necessarily involve direct contact between removal device and the fruit or stem are often referred to as man-harvest systems.

Tractor mounted cable shakers, fixed stroke boom shakes, and boom type impact knockers were originally developed for nuts. Impact knockers are still used to a considerable extent on old almond trees because these trees are large and relatively rigid. An impact knocker delivers discrete axial impacts or impulses by mechanical, pneumatic or hydraulic means, rather that having a continous oscillating motion. Inertia type shakers have largely replaced fixed-stroke shakers except in large nut trees. With an inertia shaker, the exciting force is derived from the accelaration of a reciprocating man or two opposite rotating, eccentric masses. An inertia shaker is attached to the supporting structure through flexible mounts or hangers, thereby isolating the vibration. Hydraulic motor drives are employed. These shakers may be attached to the trunk to shake only a portion of the tree at a time. Trunk shakers are faster than limb shakers because attachment is easier and is needed at only one place per tree. In a shake-catch harvesting system catching units have low-profile collection surfaces that extend under the tree. Stationary surfaces are usually sloped towards a belt or draper-type conveyor, but some units have pans that are mechanically dumped onto the conveyor. Another arrangement, requiring a minimum of vertical clearence but more labour, has roll-out canvas sheets that are retracted towards the conveyor when loaded. Effective packing of all hard collection surfaces and deflector panels are necessary to avoid excessive damage to easily bruised fruits apples, citruis etc. (Srivasthava, 1990)

Another mass harvest concept that has been investigated for citrus is the use of an oscillating air blast to shake the foliage. In one arrangement, air at 160 kmph is discharged from two side-by-side outlets 254 mm wide and 6.1 m high, directed toward one side of the tree as the machine moves down the row at about 0.4 kmph mechanically moved deflectors in the outlets change the air direction at a frequency of 60 to 70 cycles per minute. Fruit removal percentage ranges from 60-90% with some leaf damage. (Srivasthava, 1990)

The traditional method of harvesting of mango is time and labour intensive. To overcome these difficulties three models of improved mango fruit harvestor, impact, shear type, and impact cum shear type have been developed by Sapovadia

and Patel (1995). The main parts of the mango harvester are handle, cutting tool, and conveying net. The handle was fabricated from conduit pipe. To attach the conveying net to the handle a ring of appropriate size was provided. The performance parameters were compared with that of the local harvester. Impact type model was found to be the best among all.

A jack fruit harvester was developed at K.C.A.E.T Tavanur (Mohammed, 1996). The harvester was a manually operated one. A special feature of the product was that two men harvest a jack fruit in 4-5 minutes from the ground. The harvester consist of a long telescopic handle with a hook knife at the top. A basket of net type is there to bring down the jackfruit safely. The operation is so simple that a layman can harvest the jackfruit easily.

2.3. Arecanut cultivation - area and production:

India is the largest producer and consumer of arecanut in the world. Trends in area and production of arecanuts in Kerala is presented in **Table 2.1**. **and Table 2.2** respectively. The total aracanut area has expanded rapidly since 1956-57 from 94,800 ha to 2,20,400 ha in 1991-'92. For the country as a whole, there was a three fold increase in production.(74.7 thousand tonnes in 1956-57 to 243.2 thousand tonnes in 1991-92). Till 1971 to 1972 the increase in production of arecanut was mainly due to a rapid increase in area whereas in yield further increase was significantly contributed by the increase in yield levels of areca plantations. Gross area of arecanut under irrigation is shown in **Table 2.3**. Statewise area and yield of arecanut cultivation is presented in **Table 2.4**. Nearly 95% of the arecanut area is accounted by the three principal area growing states namely Karnataka, Kerala and Assam. Area wise Kerala was the leading state in the beginning and now it has gone to third position both in area and production. Karnataka has come on the top in area and production since the very beginning. Other areca growing states are Maharastra, Goa, West Bengal, Meghalaya, Tripura, Andhrapredesh, Tamil nadu and Andaman which together account only about 5% of the total area of the

Table 2.1 AREA UNDER ARECANUT (ha)

DISTRICT	86-'87	87 - '88	88-'89	89 - '90	91 - '92	92 - '93	94-' 95
Trivandrum	2865	2311	2511	2119	1674	1640	1315
Quilon	2823	2235	2156	1986	1929	2024	1846
Pathanamthitta	1360	1520	1613	1467	1207	1126	1128
Alleppey	2133	1900	1799	1652	1704	1622	1703
Kottayam	2145	1768	1772	1665	1307	1272	946
Idukky	2333	1974	2029	1898	1695	1745	2054
Ernakulam	5259	4485	4785	4251	3475	3148	2741
Trichur	5982	6569	6023	5420	5421	5721	6637
Palaghat	2090	2369	2370	2614	2578	2777	2948
Malappuram	8865	9941	10420	11398	12214	11485	12635
Kozhikode	5288	5110	5349	5629	6156	5996	8364
Wayanad	1243	1516	1546	1428	1785	2084	2667
Kannur	6441	8708	9121	9895	11252	12028	13375
Kasargod	8907	10127	10978	11407	11140	11261	13317
State	**57734**	**60535**	**62472**	**63179**	**63437**	**63929**	**71676**

(Source : Department of Economics and Statistics Publications , Trivandrum)

Table 2 .2 PRODUCTION OF ARECANUTS (million nuts)

DISTRICT	86 '87	87 - '88	88-'89	89 - '90	91 - '92	92 - '93	94 - ' 95
Trivandrum	430	305	271	276	214	187	139
Quilon	481	351	356	383	339	353	313
Pathanamthitta	378	338	295	298	332	274	307
Alleppey	422	264	128	132	209	188	236
Kottayam	361	304	230	256	191	175	143
Idukky	319	321	545	459	498	540	645
Ernakulam	1323	1111	912	828	603	527	516
Trichur	1178	1340	1250	1092	1475	1400	1982
Palaghat	237	226	273	321	338	364	447
Malappuram	1374	1371	1751	1924	2341	2426	2479
Kozhikode	1009	840	966	1084	1045	239	2299
Wayanad	286	324	297	278	343	460	475
Kannur	1096	1558	1974	2263	2651	2788	3272
Kasargod	1669	2012	2212	2370	2537	2722	4213
State	**10563**	**10665**	**11450**	**11964**	**13116**	**13643**	**17466**

(Source : Department of Economics & Statistics Publications , Trivandrum)

Table 2.3 GROSS AREA OF ARECANUT UNDER IRRIGATION (ha)

DISTRICT	86 '87	87 - '88	88-'89	89 - '90	91 - '92	92 - '93
Trivandrum	1	1	4	4	22	14
Quilon	9	1	3	2	64	8
Pathanamthitta	2	1	2	1	3	32
Alleppey	49	37	43	37	277	263
Kottayam	-	-	-	40	7	2
Idukky	2	2	2	1	1	1
Ernakulam	688	735	705	681	753	1024
Trichur	2670	3613	4427	3787	3179	4460
Palaghat	1849	1868	1903	1813	1982	1921
Malappuram	1972	2684	3291	2910	3717	3899
Kozhikode	119	62	87	100	271	244
Wayanad	4	5	5	3	7	20
Kannur	318	820	1216	1399	2843	2916
Kasargod	8986	5754	8952	6650	7761	7591
State	**11669**	**15583**	**20690**	**17428**	**20887**	**22395**

(Source : Department of Economics & Statistics Publications, Trivandrum)

Table 2 .4 STATE WISE PRODUCTION OF AREACANUT IN INDIA (1994 - 1995)

STATE	AREA ('000ha)	YIELD('000 tonnes)
Andhra pradesh	0.2	0.2
Assam	70.3	71.2
Goa, Daman &Diu	1.3	1.5
Karnataka	77	103.3
Kerala	63.9	70.3
Maharashtra	1.9	3.6
Meghalaya	8.8	8.8
Mizoram	0.1	0.1
Pondicherry	0.1	0.2
Tamil Nadu	4	4
Tripura	1.2	2.2
West Bengal	5.3	7

(Source : Economics & Statistics Advisor, New Delhi)

country. Trends in area, production and productivity of arecanut in India is shown in **Table 2.5.**

2.4. Import and Export

Arecanut import and export statistics is presented in **Table 2.6**. India was importing large quantities of arecanut in 1950's and 1960's mainly from Singapore, Malaysia and Sri Lanka. The quantity of imports came down gradually from 90 tonnes to 36 thousand tonnes by 1971-72 and since then our country is only exporting arecanut. Exports showed a rising trend from 1976-77 with about 603 tonnes to aboutt 800 tonnes currently. However the export of arecanut is not significantly to cast any change in the production target and to expand the area under arecanut.

2. 5 Traditional harvesting methods.

There are expert professionals who can scale tall trunks even without using ankle rings or waist rings. The labourer climbs up through one stem to reach the crown of a palm and swings it horizontally to reach the crown of the neighbouring palm.

In Cuba, the difficult to climb royal palm (Oreodoxa regia) is shinned by certain professional climbers who used two rope rings (Hodge, 1958).

In Ivory Coast,(Anon.1963,1966) for climbing oil palms, spiked boots, and flexible steel around the body of the climber and tree are used.

Corner (1966) has given drawing of climbers in action in different countries using ankle and/or waist rings.

For climbing palmyrah palms (Anon.1967) a ladder type device was developed for harvesting palms.

Table 2.5 TRENDS IN AREA PRODUCTION AND PRODUCTIVITY OF AREACANUT IN INDIA (AT FIVE YEARLY INTERVELS SINCE 1956-'57 TO 1994-'95)

YEAR	AREA (ha)	PRODUCTION (tonnes)	PRODUCTIVITY (kg/ha.)
1956 - '57	94,800	74,700	789
1961 -'62	1,16,830	95,170	816
1966 -'67	1,42,100	1,30,100	916
1971 -'72	1,73,800	1,47,100	846
1976 -'77	1,70,700	1,65,100	967
1981 - '82	1,82,600	1,93,800	1061
1986 -87	1,76,300	2,09,400	1188
1991 - '92	2,20,400	2,43,200	1103
1992 - 93	2,22,300	2,48,400	1117
1993 - 94	2,35,500	2,75,100	1168
1994 - '95	2,35,500	2,72,400	1156

(Source : CPCRI, Kasargod)

Table 2.6 TRENDS IN IMPORT AND EXPORT OF ARECANUT IN INDIA.

YEAR	IMPORT (tonnes)	EXPORT (tonnes)
1946 - 47	36,762	675
1951 -52	45,397	170
1956 - 57	39,879	227
1961 - 62	10,041	123
1966- 67	597	219
1971 - 72	90	292
1976- 77	-	603
1981-82	-	579
1982-83	-	695
1983 -84	-	535
1984-85	-	783
1988-89	-	669
1992-93	-	629
1993-94	-	640
1994 -95		800

(Source : CPCRI, Kasargod)

2.6 Macaque for harvesting palms

In parts of Malaysia, Indonesia and Thailand, monkeys, the most common species being *Mecaca nemestrina* are used for harvesting areca palms (Davis, 1970). While climbing, the primate is provided with a long chain through which the trainer conveys instructions as to which bunch the monkey has to harvest and which not to pluck. Harvesting is done either by kicking the fruits or twisting them off the spikes. A monkey is capable of harvesting over 60 palms per day.

2.7 Improved palm climbing devices :

Swamy and patil (1975) developed a much simpler device which consists of movable supports for legs and hands and lifted alternatively while the other one is gripped for climbing cocunut.

The palm bicycle used for coconut palm (Davis, 1977) in its simplest form consist of an an ankle iron frame work with a wooden platform on which the operator rides, while friction rollers pressed against the trunk of the palm by his weight carry him to the top when he turns the handle.

Improvised oval rings have been used for scaling tall forest trees in Czechoslovakia, Poland, Soviet Union and Germeny (Davis, 1977).

Dwivedi (1977) developed a manually operated portable device that can be used to climb on palms. It consists of 4 concentric rectangular pipes made of aluminium (**Fig.2.1**). It was designed so as to raise the man standing on the platform to a desired height above 5 m. The hand-winch is operated by another man. Leaving apart the skill this could not solve the scarcity of labourers. More over the device should support the weight of a man.

At TNAU, Coimbatore also attempts were made towards developing the bicycle (1981) for climbing coconut.

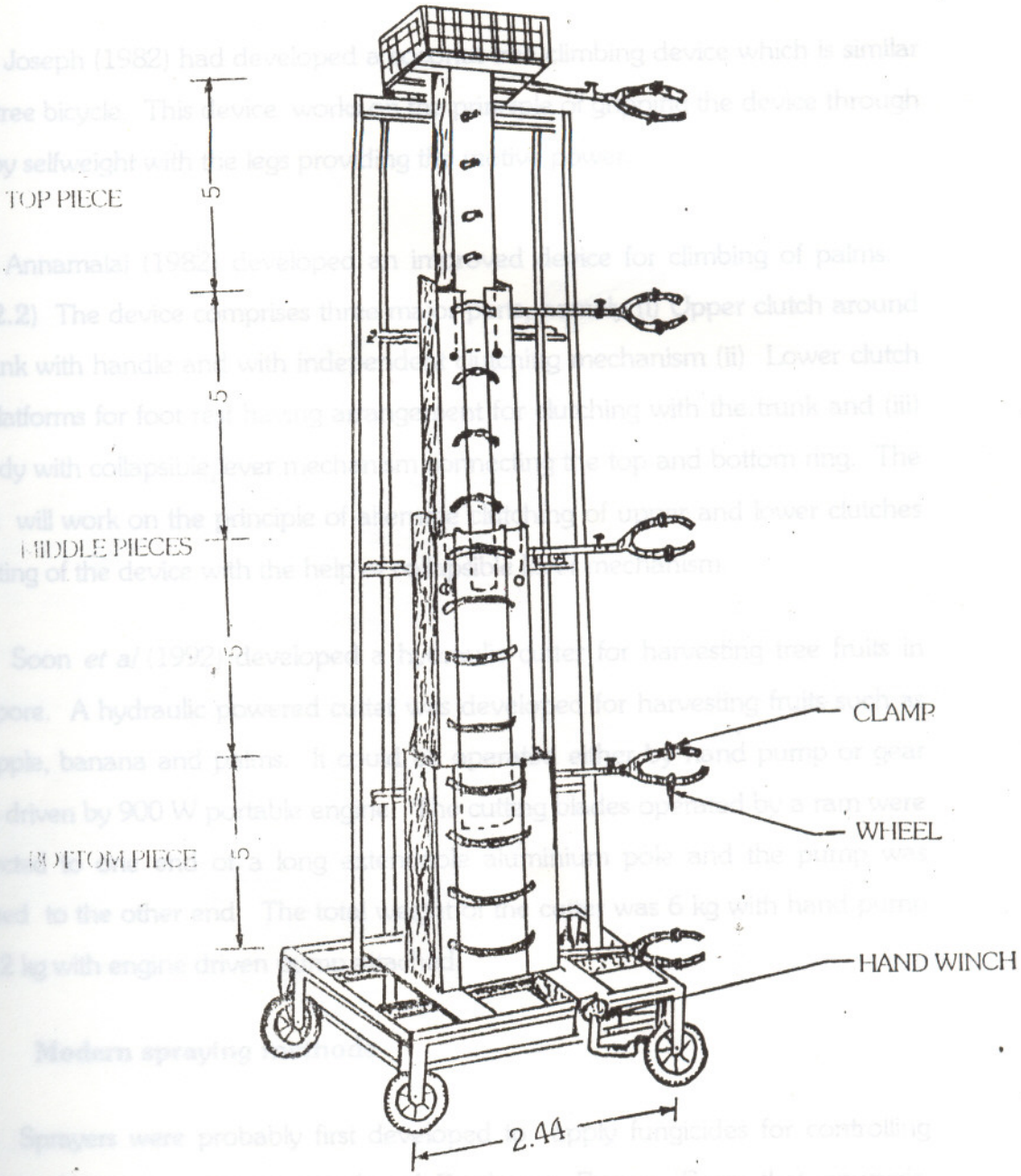


Fig. 2.1 MANUALLY OPERATED PALM CLIMBING DEVICE DESIGNED BY DWIVEDI AT C PCRI.

ALL DIMENSIONS IN M

Joseph (1982) had developed a coconut tree climbing device which is similar to the tree bicycle. This device works on the principle of gripping the device through rings by selfweight with the legs providing the motive power.

Annamalai (1982) developed an improved device for climbing of palms. (**Fig. 2.2**) The device comprises three major parts, namely (i) Upper clutch around the trunk with handle and with independent clutching mechanism (ii) Lower clutch with platforms for foot rest having arrangement for clutching with the trunk and (iii) the body with collapsible lever mechanism connecting the top and bottom ring. The device will work on the principle of alternate clutching of upper and lower clutches and lifting of the device with the help of collapsible lever mechanism.

Soon *et al* (1992) developed a hydraulic cutter for harvesting tree fruits in Singapore. A hydraulic powered cutter was developed for harvesting fruits such as Pineapple, banana and palms. It could be operated either by hand pump or gear pump driven by 900 W portable engine. The cutting blades operated by a ram were connected to one end of a long extendable aluminium pole and the pump was attached to the other end. The total weight of the cutter was 6 kg with hand pump and 12 kg with engine driven pump attached.

2.8 Modern spraying methods

Sprayers were probably first developed to apply fungicides for controlling diseases of grapes in the vineyards, of Bordeaux, France. From that onwards, tremendous improvements have occured in the field of pesticide application equipments and methods. Improvement of application equipments and techniques to permit the effective use of smaller dosages of chemicals and to reduce drift and harmful residues has become increasingly important as one means of minimizing pollution caused by chemical pesticides.

Bronson and Anderson (1952) defined the function of sprayer as to break the liquid into droplets of effective size and distribute them uniformly over the surface or

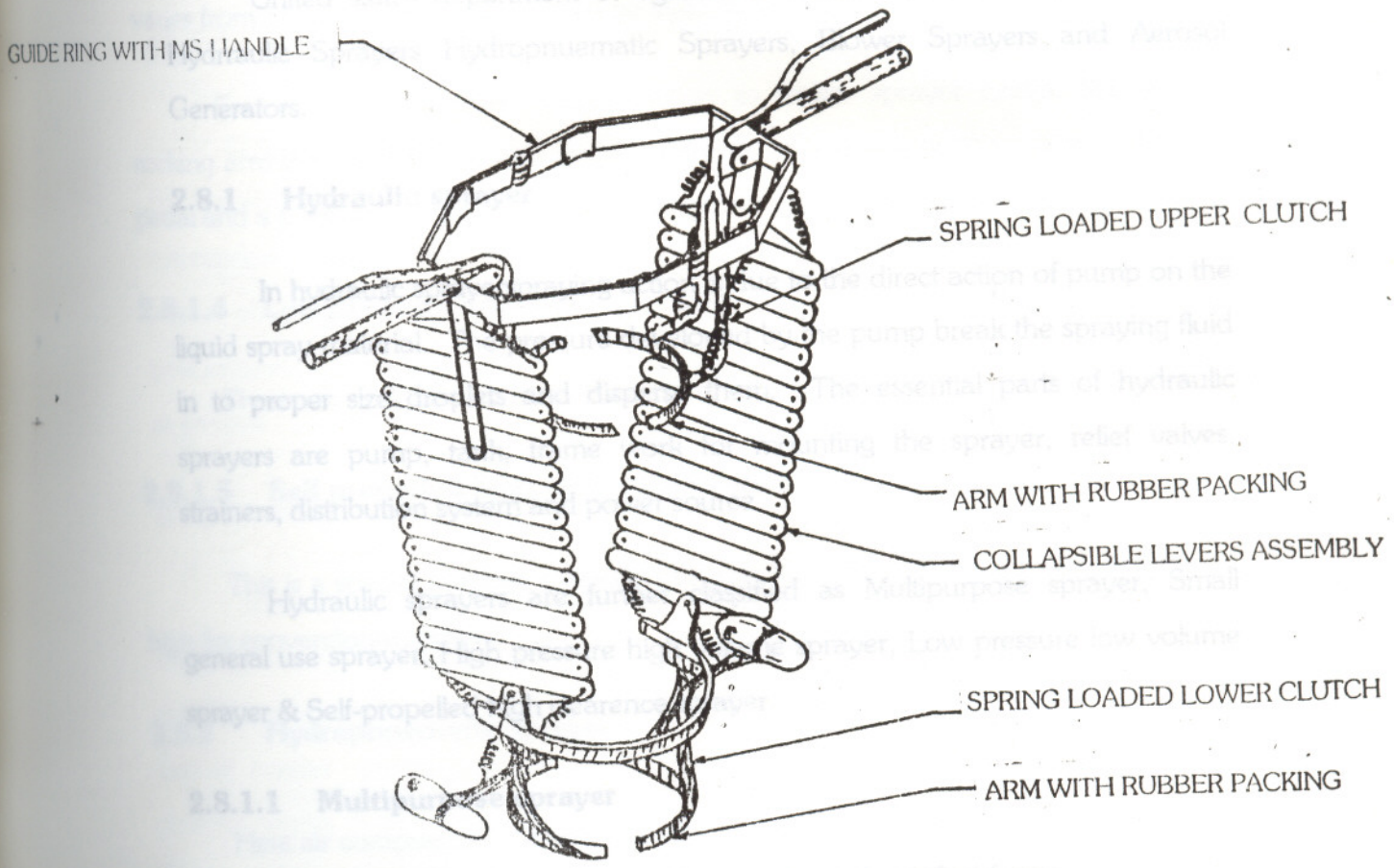


Fig. 2.2 ARECANUT PALM CLIMBING DEVICE DESIGNED BY ANNAMALAI AT CPCRI.

space to be protected. Another function is to regulate the amount of insecticide to avoid excessive application to prevent wastage and pollution.

United states department of agriculture classifies present day sprayers as Hydrraulic Sprayers Hydropnuematic Sprayers, Blower Sprayers and Aerosol Generators.

2.8.1 Hydraulic sprayer

In hydraulic sprayerspraying action is due to the direct action of pump on the liquid spray material. The pressure developed by the pump break the spraying fluid in to proper size droplets and disperse them. The essential parts of hydraulic sprayers are pump, tank, frame work for mounting the sprayer, relief valves, strainers, distribution system and power source.

Hydraulic sprayers are further classified as Multipurpose sprayer, Small general use sprayer, High pressure high volume sprayer, Low pressure low volume sprayer & Self-propelled high clearance sprayer.

2.8.1.1 Multipurpose sprayer

This is versatile to meet the spraying needs on diversified forms

2.8.1.2 Small general purpose sprayer

This type sprayers are used for spraying job, that is too large for hand equipments.

2.8.1.3 High pressure high volume sprayers

These are used for complete spray coverage of high growing fruit and shade trees. Pressures ranging from 27 to 69 kg/cm^2 with discharge ranging from 30 to 225 1/min could be developed using these sprayers. Rocker sprayers & foot sprayers are some examples of these sprayers.

Rocker sprayer consists of a pump assembly, a plat form, an operating lever, a pressure chamber, a suction hose with strainer, a delivery hose and spray nozzle. The rocking motions develops required pressure. Usual range of pressure developed varies from 14 to 18 kg/cm^2 and if may go upto 36 kg/cm^2.

Foot sprayer is similar in construction to rocker sprayer except that the rocking arm is replaced by a foot pedal. Pressure is built up, by the action of foot pedal and a pressure ranging from 17 to 21 kg/cm^2 could be developed.

2.8.1.4 Low pressure low volume sprayer

These are designed for low volume field sparying.

2.8.1.5 Self propelled high clearance sprayer

This is a special purpose machine to spray field and row crops which are too high for conventional sprayer.

2.8.2 Hydropnuematic sprayer

Here air compressor is used to develop spraying pressure. It is a low pressure low volume sprayer.

2.8.3 Blower sprayer

Also known as mist or concentrated sprayer, is used to apply pesticide in concentrated form. these sprayers are economical due to reduction in labour and due to reduced run off from foliage. But wind velocity and direction may cause drift of spray.

2.8.4 Aerosol generators

These machines disperse the spray material in the fine droplets in the range of 1-50 M.

2.8.5 Aerial spraying

An aeroplane is used to apply the spray material. It is economical only if target area is large, with crops of thick canopy. But it is highly susceptible to drift.

2.9 Sprayer nozzles

Nozzles are atomizing devices for disintegration of spray fluid into fine spray. For efficient distribution of spray fluid at the crown of areca tree, selection of appropriate nozzle is very important. Droplet sizes and spray drift are two major factors affecting the application efficiency. A nozzle capable of giving satisfactory performance is to be selected. Following types of nozzles are available in the market, at present.

2.9.1 Hydraulic energy nozzle

These types of nozzles break up fluid coming at high pressure into fine droplets of high velocity. Based on spray pattern, they can be classified into jet nozzle, impact nozzle, flat fan nozzle, swirl nozzle & tripple action nozzles. Jet and impact nozzles produce coarse droplets. Fan nozzle have a fan shaped spray pattern, where swirl nozzles produce cone shaped spray pattern. In triple action nozzles, jet as well as cone shaped spray pattern can be produced.

2.9.2 Gaseous energy nozzles

For producing spray droplets, air or other gas is made use of.

2.9.3 Centrifugal energy nozzle

These are also called spinning disc or rotary nozzle. Which are used for producing fine sprayers, mists or aerosol sized droplets. Here, spray fluid is fed centrally to a rotating disc, which force out due to the centrifugal force towards the periphery.

2.10 Sprayer performance

The basic principles underlying the pesticide application are coverage of target area, deposition efficiency and uniformity of deposition. To achieve the efficiency aimed to obtain from spraying, it has to meet certain specific requirements. Many research workers have under taken detailed studies about the general performance requirement needed for efficient spraying. A brief description to these works, with special reference to areca tree spraying is described below.

The spray distribtion (Number of droplets per unit area), the diameter of droplets and the active ingredient (the amount of pesticide) are all important. Atomization influences distribution of the spray and the loss due to evaporation, drift and convection. Accurate measurement of spray atomization is essential for assessing equipment and methods of application and for developing the spray equipment for specific sizes of droplets.

In 1953 Edwards and Rippee reported that an inflatable rubber boom cover can be used for reducing the drift.

Kepner *et al.* (1955) recomended that nozzle distribution pattern can be determined in laboratary by spray and surface that consist of a series of adjacent spraying v-trough and measuring, liquid collected from each trough

The drift can also be reduced by using hoods or shields. Courshee (1959) mentioned about a simple deflector to confine the spray.

Byass (1963) studied on spray drift on orchard and concluded that drifts deposits contribute to an important extent to spray cover especially on upper surface of leaves.

Yates and Akesson (1963) showed that measurement of tracers such as copper or flourocent material can be correlated with measurement of active compound in assessing pesticide deposition.

A system involving combination of a hood and low pressure nozzles has also been developed to reduce the drift (Yates and Akesson, 1973).

Droplets smaller than 100 μm in diameter are more efficient for insecticide and fungicide spray. Electrostatic forces may become effective, when droplets are smaller than 100 μm (Mathes, 1979).

Transport of droplets to plant is greatly influenced by size and velocity of droplets, dynamics of spray vehicle, weather conditions and physical properties of plants (Merchant, 1980).

Griffith *et al.* (1981) found that systematic chemicals can be applied electrostatically in open canopy at reduced dosages without much loss in biological efficiency. But at closed canopy, uncharged spray form hydraulic nozzles perform better.

Cartton *et al.* (1981) suggested that direct and most reliable method of assessing total deposition on a surface is sampling leaf tissue and processing it for analysis of active pesticide.

Cayley *et al* (1984) found that total chemical deposit was more for charged spray than that from hydraulic nozzle uncharged spray.

Increased uniformity of target plant surface may improve control of insects or disease or may improve chemical uptake (Lake and Merchant, 1984).

In spray application, reflection and wetting difficulty can hinder droplet retention by plant surfaces. To overcome, surfactants are added to formulations but are found to be in effective sometimes. Dynamic surface tension is found to be more reliable than equilibrium surface tension as a measure of surface effectiveness. High surfactant concentration may reduce droplet reflection (Rechard, 1988) but may cause phytotoxicity (Lownds, 1988).

Accuracy of deposition rate, i.e. amount of formulation deposited per unit area, depends om metering accuracy of formulation ASAE 1989.

Guptha *et al.* (1992) reported that deposition pattern of charged spray from spinning disc sprayer gave better result than uncharged spray from spinning disc sprayer as well as hydraulic nozzles sprayer.

Drift of the pesticide contributes to the problem of environmental pollution and make chemical control of pest inefficient, uneconomical and hazardous. The control of drift in the application of pesticide is a pressing problem. The conventional spray appliances produce a wide range of droplets sizes. The droplets below 50 μm are generally prone to drift the amount of such droplets varies in different kinds of pesticide application.

Shields have been reported to be used for reducing drift (Smith *et al.* 1992).

Variables that influence drift are inital droplet size, velocity, height of discharge, in a wind velocity turbulance, intensity, relative humidity and volatality of liquid (Richard *et al.*, 1992).

Zho *et al.* (1994) reports except at low temperature and high relative humidity, all 50 μm diameter and smaller droplets evaporated before depositing 0.5 μm below. Drift distance increased with increasing wind velocity and discharge heightm but decreased with increasing initial downward droplet for 100 μm diameter and larger droplet. For droplets less than 200 μm, shield for airjets are used for drift reduction. With high nozzle velocity, slow initial downward velocity and high wind velocity, droplets larger than 200 μm are used to reduce drift.

Small spray droplets, which rely primarily on electrostatic and gravitational forces for transportation and deposition are highly susceptible to drift and penetration in plant canopy is inadequate. So air assisted charged spray of V.M.D. of 90 μm were collected in wind tunnel with velocity upto 5 m/s. Then the target

area and amount of spray deposited increase and better penetration (Almekinders *et al.*, 1994).

Based on these studies, a suitable compromise has to be made between drift and application efficiency while selecting a nozzle for areca tree, after weighing various parameters influencing spray performance. Areca tree being tall, susceptibility of drift at the top is more. So unless for close spraying, hydraulic nozzle is preferred for spraying areca tree top. But the option of close spraying is time consuming and tedious. So hydraulic nozzle is preferred here. Also hydraulic nozzle is comparatively cheap over other forms of atomizing devices.

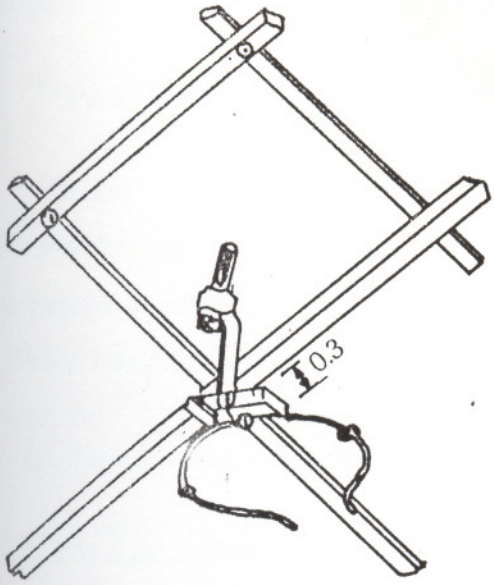
2.11 Development of spraying mechanism.

Abraham (1975) had developed an applicator for placing pesticide granules inthe leaf axils of an arecanut palm from a position just below the crown. However this applcator is suited only for young palms of height not more than 5 m. So this had only limited application.

Udupa (1991) developed an areca sprayer. The lifting mechanism utilized the principle of telescopic tubes with external rope mechanism. The spray fluid is being pressurised by a rocker sprayer can cover upto a height of 16 m.

A prototype of areca tree sprayer was developed at TNAU utilizing the principle of telescopic tubes. The sprayer was reported to give satisfactory spray performance (Anon. 1996).

Anil, *et al.*, (1997) developed a collapsible type arecanut sprayer (**Fig. 2.3**) which vould bring spray only upto 5.6 m though it was very light.



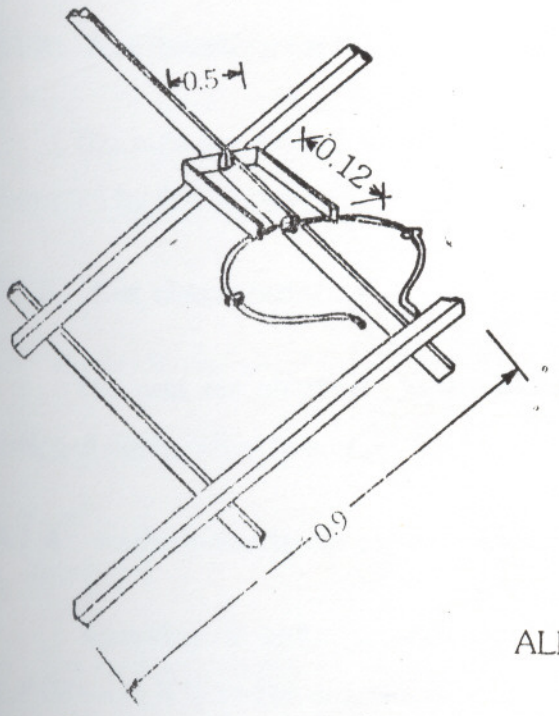


Fig. 2.3 LIFTING DEVICE OF ARECANUT SPRAYER DEVELOPED AT KAU.

MATERIALS AND METHODS

In this chapter the materials used and the procedure adopted for the fabrication and testing of arecanut harvester cum sprayer are discussed.

3.1 Preliminary Investigations

Before developing the equipment some preliminary investigations like, tree characteristics, nut location on tree, nut characteristics and anthropometrical observations were taken for deciding appropriate size, shape, strength and capacity of differen components of the equipment.

3.1.1 Tree characteristics

It is a mono cotyledon plant grown at altitudes up to 1000 m above the sea level. It is having fibrous root system. The height of the tree varies from 5 to 15m, depending upon the variety. The diameter of the trunk is approximately 15 cm.

3.1.2 Nut location on the tree

The nuts are located at the end of leafsheath. So their harvesting is not obstructed by the canopy.

3.1.3 Nut characteristics

The nuts are attached to a common peduncle whereby it facilitate easy cutting of the bunch at its end.

3.1.4 Anthropometrical observations

According to anthropometric data for farm equipment design collected by L.P.Gite and B.G.Yadav, olecranon height is in the range of 99-104.1 cm. Average palm size is 21cm x 9cm. Olecranon height was taken into consideration while fixing the reel assembly. Palm size aided to select the pipe diameter

3.2 Development of Model of the lifting mechanism

It was found that telescopic arrangement of pipes was more erect and sturdy. Two models were fabricated in order to study its feasibility.

3.2.1 Model I - External rope system

It consistes of 3 concentric G.I pipes of diameters 38.1mm, 25.4mm and 12.7mm, each of 50 cm length coupled together by reducers (**Fig. 3.1**). In the bottom most pipe, a slot of $\frac{3}{4}^{th}$ of its length leaving $1/8^{th}$ of its length as clearance at each end was provided. This facilitates the movement of second pipe by rope and pulley mechanism tied to the block attached at the bottom of the second pipe. The upper pipe was lifted with the help of a push rod by rope and pulley mechanism tied to the end of the push rod, **Plate 3.1**.

The system has many advantages as this lifting mechanism consisted of external rope system this is easily repairable without dismantling the entire system. Since there is very less wear and tear in the rope, nylon rope can be used which is economical. The disadvantages of the system includes in its inticate design and as the rope system provided is not continuous it is laborious to operate also as the slot is provided along the whole length of the bottom most pipe it reduces the strength of the pipe.

3.2.2 Model II - Internal rope system.

It consistes of 3 concentric G.I. pipes of diameters 38.1mm, 25.4mm and 12.7mm, each of 50 cm length (**Fig 3.2**) coupled together by sockets having rope way drilled in it.

The continuous rope system was wound on a reel which was operated by a handle. This is shown in **Plate 3.2**.

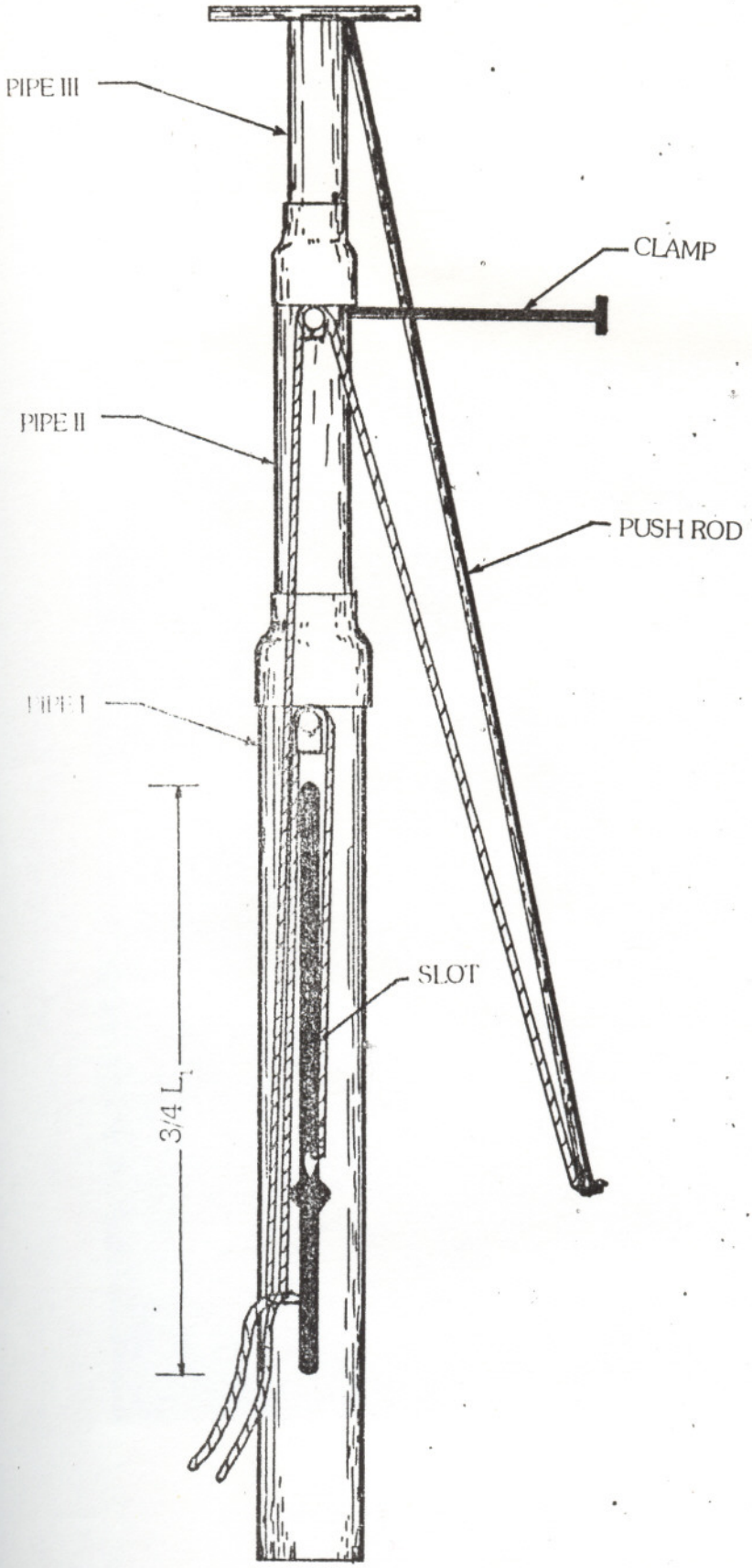


Fig. 3.1 EXTERNAL ROPE SYSTEM-MODEL I.

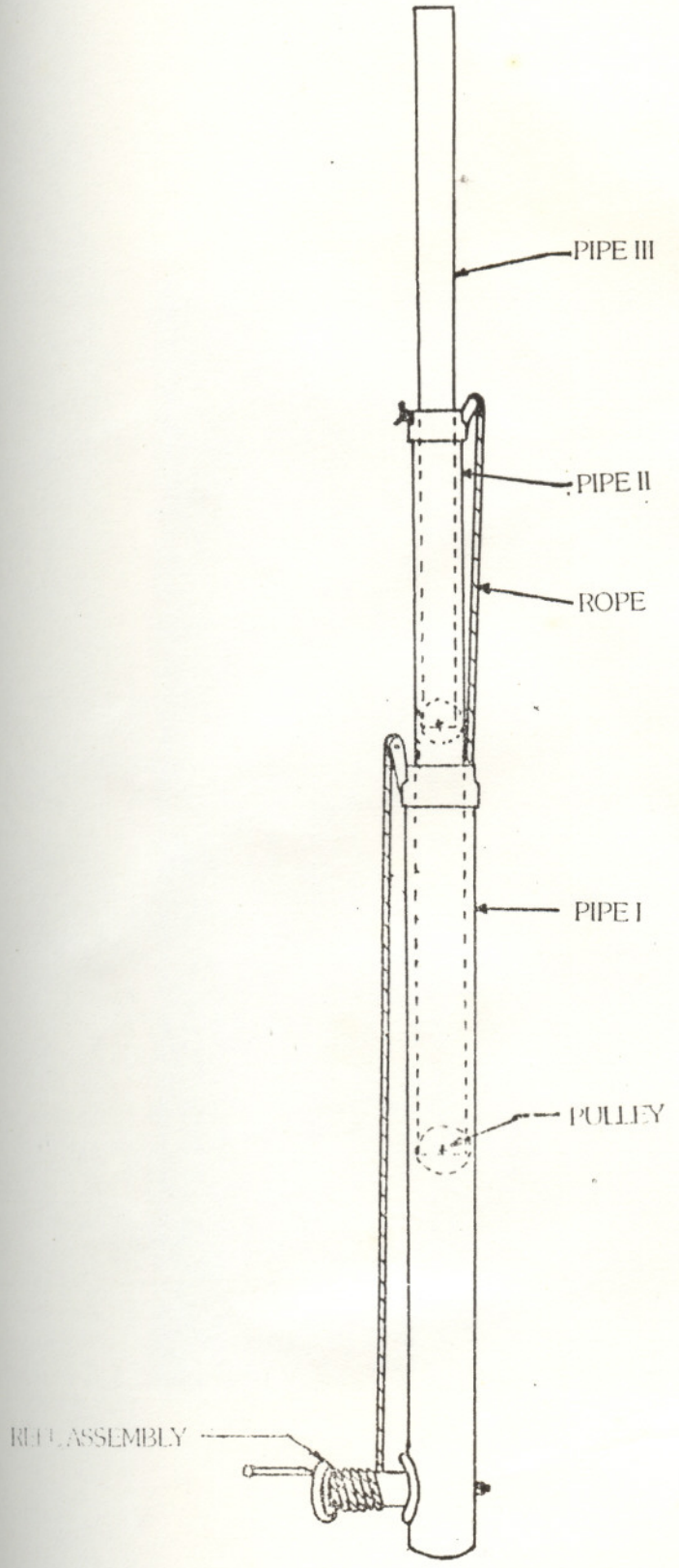


Fig. 3.2 INTERNAL ROPE SYSTEM-MODEL II.

The advantages of the system are its simplicity in construction, easiness in operation and less time consumption. Disadvantages are difficulty in repairing and high cost.

3.3 Arecanut Harvester - Prototype

Since the second model was found to be easier to operate, it was selected as the prototype of the lifting mechanism (**Fig 3.3**) of the arecanut harvester. The operation of the prototype is shown in (**Plate 3.3**).

3.3.1 Pipe

Three aluminium pipes of 50.8mm, 38.1mm, and 25.4mm diameters and 3.6 m length were used to make the mainframe of the unit. Aluminium pipe was preferred because of its low weight and high strength. 12.7mm diameter aluminium pipe was discarded because of its less wall thickness was not sufficient to meet the requirement of threading.

3.3.2 Reel assembly

The self weight of the aluminium pipe was not enough to lower it. Hence a rope and reel arrangement was provided on the same shaft of the raising reel (**Plate 3.4**). As the lengths of raising and lowering ropes were different relative motion was provided for both the reels. Raising reel was riveted to the shaft, so that both could rotate as a single unit. The selection of diameter of reel is shown in **Appendix III.** In order to prevent the lowering of the pipe a ratchet and pawl was provided along with the raising reel. For locking the the system at an intermediate position, a locking arrangement was incorporated with the lowering reel. A detachable handle was provided on the reel assembly to facilitate its proper working. While raising the pipes, the handle was attached to the raising reel. Where as at the time of lowering as the raising reel experienced higher rpm, hand braking was provided. In order to accomplish proper braking the handle was detached. The same handle was used for the lowering the reel also.

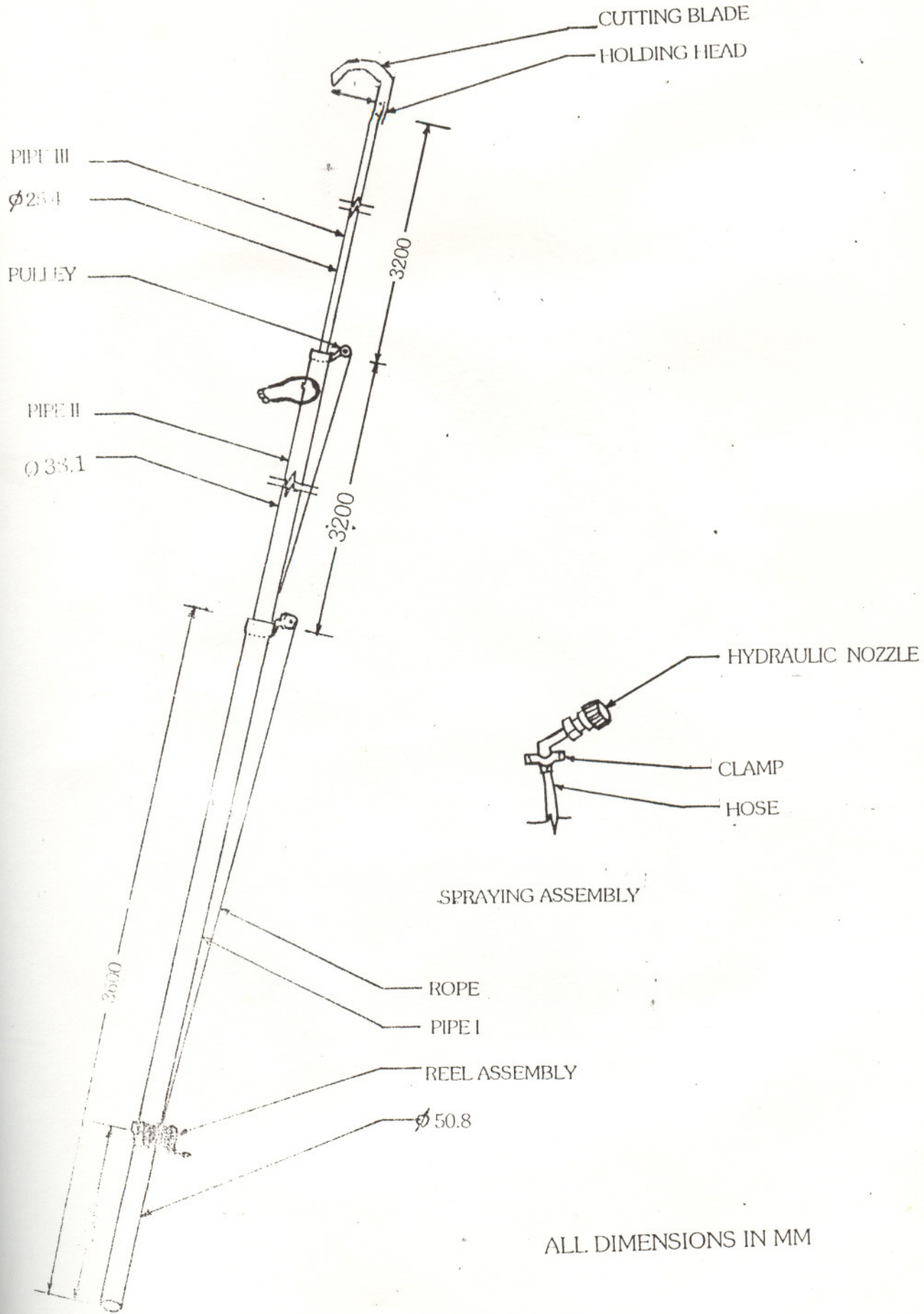


Fig.3.3 ARECANUT HARVESTER CUM SPRAYER - PROTOTYPE

According to L.P. Gile and B.G. Yadav, the oleranon height is in the range 99-104.1 cm. So the reel assembly was fixed at a height of 100 cm for easy operation.

3.3.3 Pulley

Pulleys having 3mm rope way were fabricated as two external and two internal pulleys. An external pulley of outer diameter 25.4mm and one internal pulley of diameter 50.8 mm were attached at the bottom of second pipe. Similarly the second internal pulley was attached at the end of first pipe with diameter as that of inner diameter of second pipe. The view of pulleys used in fabrication are shown in **Fig 3.4.**and **Fig. 3.5.**

3.3.4 Metal rope

Metal rope of diameter 2 mm was selected to obtain the required flexibility.

3.3.5 Socket

Couplings were provided by sockets (**Fig. 3.6.**) to connect the consecutive pipes, as shown in figure **Fig 3.7.**

3.3.6 Fork shaped clamp

To act as a guide during lifting and for holding the device during resting period, the mechanism was raised through the entire length of its lift taking a support from the areca tree. This support is drawn by means of a fork shaped arm of internal diameter 16 cm which slides along the trunk of areca tree, when the mechanism was lifted.

3.3.7 Holding head

A detachable holding head was provided at the top to which the knife or the nozzle can be bolted as the case may be (**Fig 3.8.**)

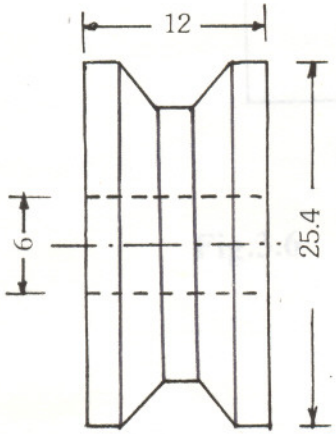
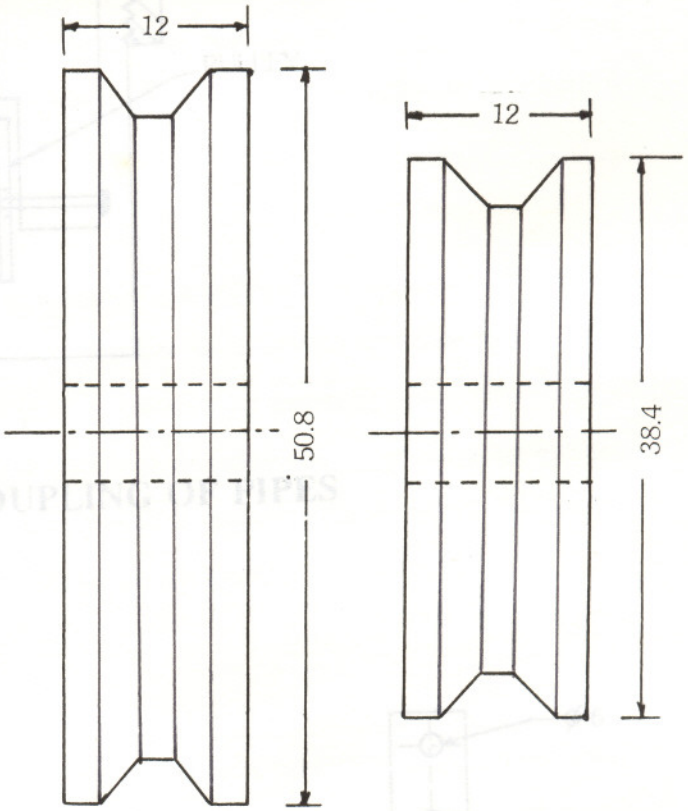


Fig.3.4 **EXTERNAL PULLEY**



All dimensions in mm

Fig.3.5 **INTERNAL PULLEYS**

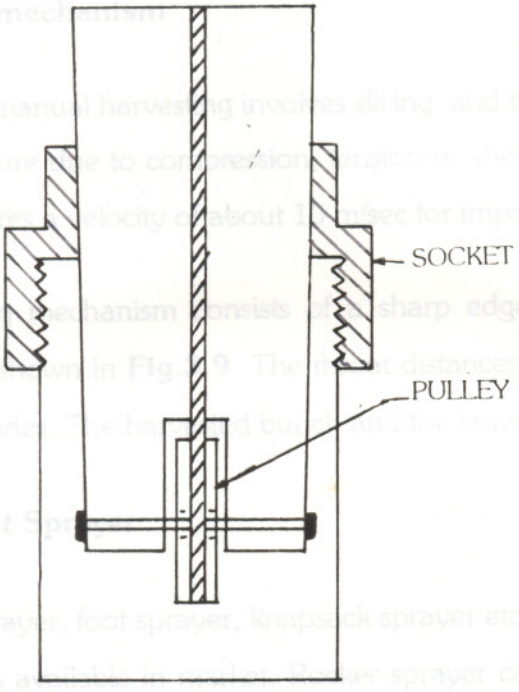


Fig.3.6 COUPLING OF PIPES

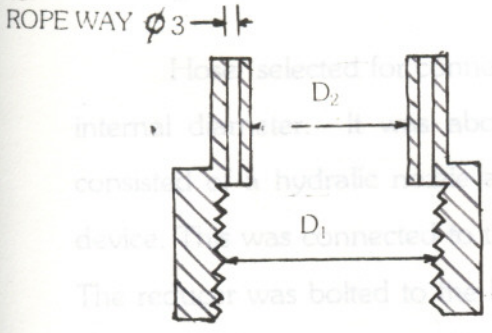
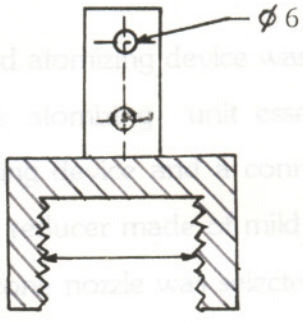


Fig.3.7 SOCKET



All dimensions in mm

Fig.3.8 HOLDING HEAD

3.3.8 Cutting mechanism

Generally manual harvesting involves slicing and tearing actions that result in plant structure failure due to compression, tension or shear. A single element, sharp edged blade requires a velocity of about 10 m/sec for impact cutting.

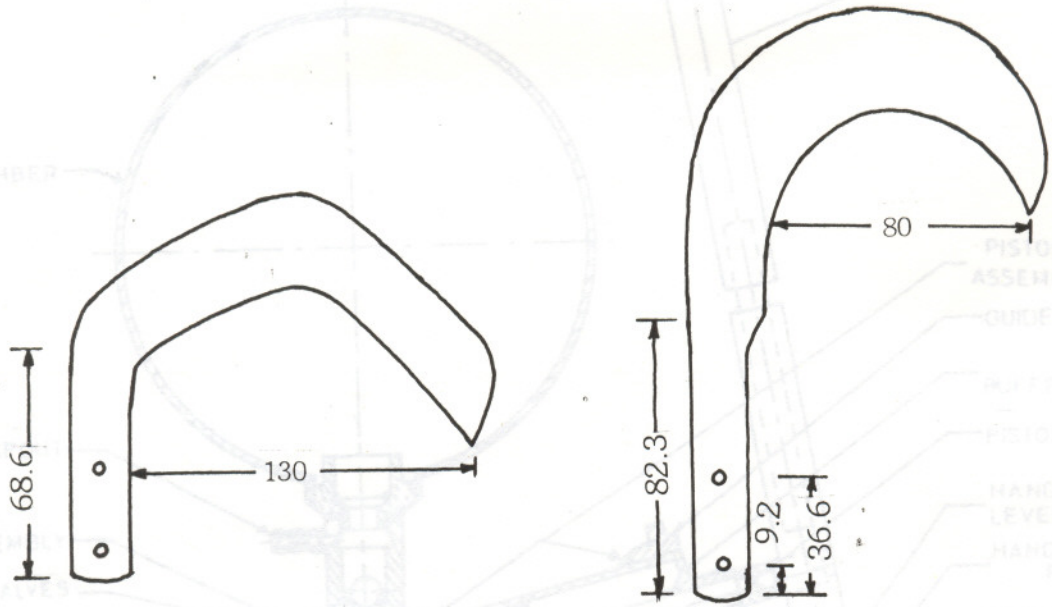
The cutting mechanism consists of a sharp edged blade of cast iron, the shape and size is shown in **Fig.3.9** The throat distances were 13 cm and 8 cm for the two cutting blades. The harvested bunch and the knives are shown in **Plate 3.5**.

3.4 Areacanut Sprayer

Rocker sprayer, foot sprayer, knapsack sprayer etc. are some of the manually operated sprayers available in market. Rocker sprayer can develop higher pressure compared to foot sprayer. Rocker sprayer develops a pressure ranging from 14 to 18 kg/cm^2, which was greater than the required pressure for areca farm spraying. Also its compact size and long rocker arm made it ergonomically sound. Hence rocker sprayer is selected(**Fig. 3.10.**) for this particular study.

3.4.1 Atomizing unit and hose

Hose selected for connecting rocker sprayer and atomizing device was 1 cm internal diameter. It was about 20 m length. The atomizing unit essentially consisted of a hydralic nozzle as atomizing unit tomizing device and a connecting device. This was connected to the hose by means of a reducer made of mild steel. The reducer was bolted to the holding head. A solid cone nozzle was selected as it give complete coverage on the inflore secure of the areca during flowering. The nozzle was kept at an angle of 70 degrees with the horizontal so that spraying of fruit bunches was conveniently done. Hand control from the ground was achieved by boom and trigger mechanism attached to the outlet of the rocker sprayer. Hose & atomizing unit during work is shown in **Plate 3.6**.



ALL DIMENSIONS IN MM

Fig.3.9 CUTTING MECHANISM

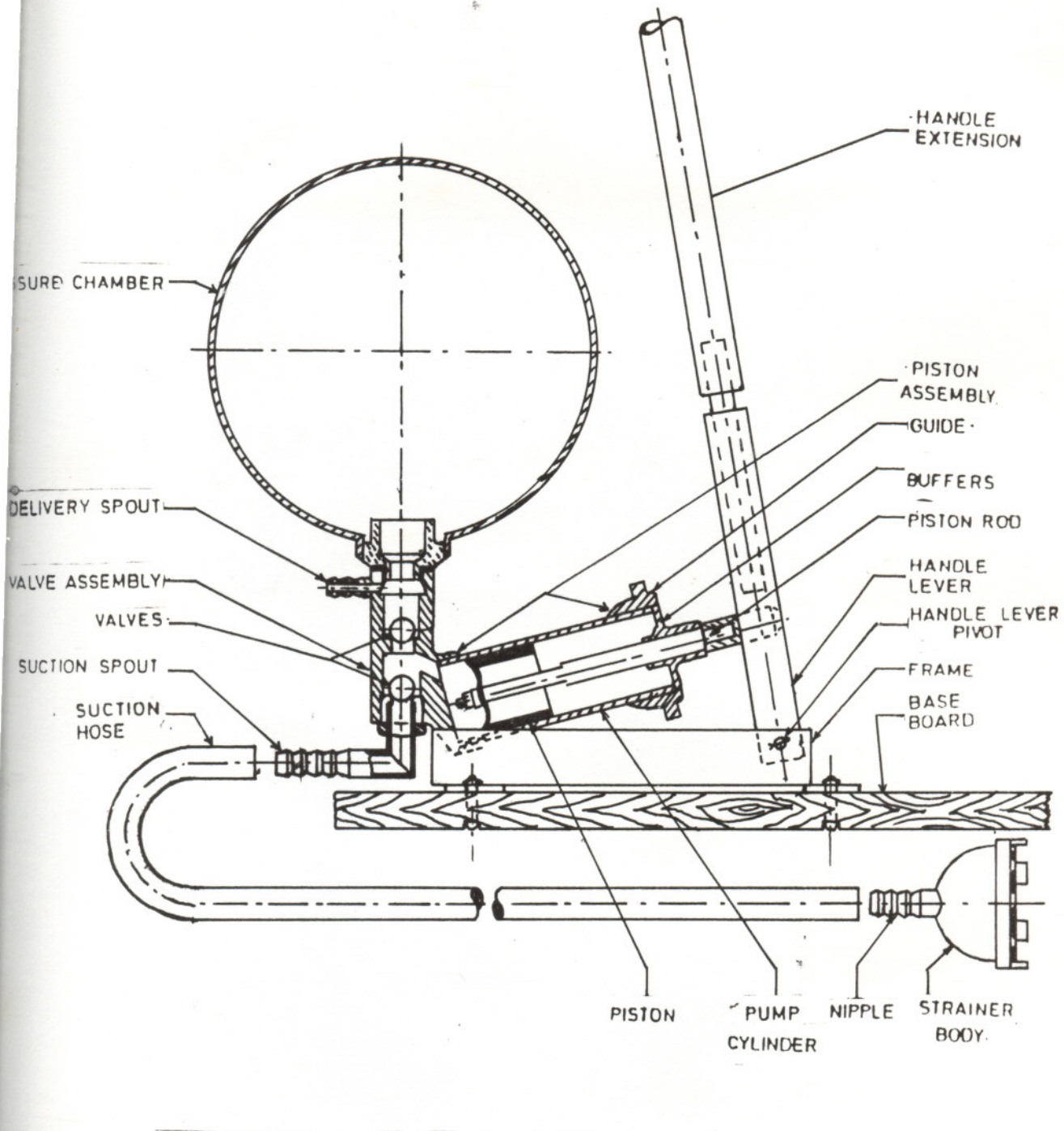


Fig.3.10 ROCKER SPRAYER

3.4.2 Selection of pump

The criteria for pump selection depends on the pressure it can develop, ergonomic aspects and economic feasibility. There are many power operated sprayers, which could develop very high pressure. But the main constraint in adopting such sprayers are its high initial cost. The total pressure required to be developed is shown in **Appendix III**

3.4.3 Operation procedure of the sprayer.

The hose of the sprayer was bolted to the holding head. The section hose of the rocker sprayer was dipped in a bucket. The preparation procedure of bordeaux mixture is shown in **Appendix IV.** The holding head with nozzle was lifted manually until required hight was covered. Thus with this mechanism, the delivery hose with nozzle at its tip was raised to the top. The working of the system is shown in **Plate 3.7.**

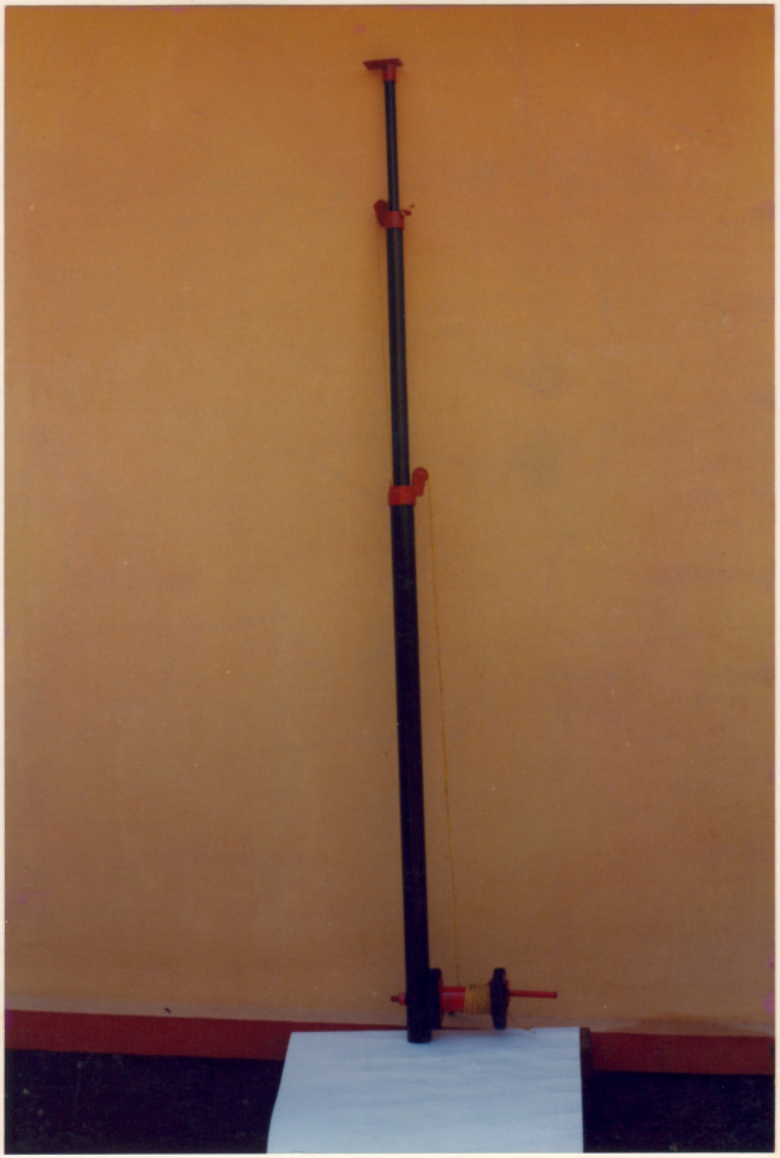
By the rocking motion of the rocker arm, sufficient pressure to atomize the spray fluid developed inside the rocker sprayer and hence spraying was done at the top of areca tree.

3.5 Field testing and performance evaluation

The performance of the arecanut harvester cum sprayer was tested for various field conditions in an arecanut farm of a local farmer in Tavanur. Major parameters considered were lifting capacity of the lifting mechanism, maximum height at which it can cover, performance efficiency during harvesting, selection of suitable knife among the two types tested, performance efficiency during spraying, and cost of operation.

3.6 Cost of Operation

Cost of operation for the harvesting and spraying in both modern and traditional method is seperately shown in **Appendix V**



3.4.2 Selection of pump

The criteria for pump selection depends on the pressure it can develop, ergonomic aspects and economic feasibility. There are many power operated sprayers, which could develop very high pressure. But the main constraint in adopting such sprayers are its high initial cost. The total pressure required to be developed is shown in **Appendix III**

3.4.3 Operation procedure of the sprayer.

The hose of the sprayer was bolted to the holding head. The section hose of the rocker sprayer was dipped in a bucket. The preparation procedure of bordeaux mixture is shown in **Appendix IV.** The holding head with nozzle was lifted manually until required hight was covered. Thus with this mechanism, the delivery hose with nozzle at its tip was raised to the top. The working of the system is shown in **Plate 3.7.**

By the rocking motion of the rocker arm, sufficient pressure to atomize the spray fluid developed inside the rocker sprayer and hence spraying was done at the top of areca tree.

3.5 Field testing and performance evaluation

The performance of the arecanut harvester cum sprayer was tested for various field conditions in an arecanut farm of a local farmer in Tavanur. Major parameters considered were lifting capacity of the lifting mechanism, maximum height at which it can cover, performance efficiency during harvesting, selection of suitable knife among the two types tested, performance efficiency during spraying, and cost of operation.

3.6 Cost of Operation

Cost of operation for the harvesting and spraying in both modern and traditional method is seperately shown in **Appendix V**

RESULTS AND DISCUSSION

The non availabilty of the skilled labourers being a serious constraint for the arecanut cultivators, an arecanut harvester cum sprayer was fabricated and tested. This equipment was evaluated to find whether it accomplish the cultivators goal.

In this chapter, results obtained while testing the performance of newly developed equipment for areca harvesting and spraying is provided. Various parameters, which were under study while testing were maximum height attained by the lifting mechanism, deflection of the lifting mechanism, ease of operation, selection of suitable knife for harvesting, spraying efficiency and economic aspects.

4.1 Maximum height

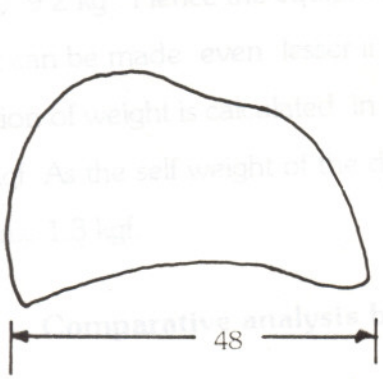
The maximum height refers to the fetch of the equipment upto which it can be operated . It was found to be 10 m . The compacted height was about 4 m . Hence it could be uesd for trees up to a height of 10 m. If necessary, more numbers of concentric pipes can be used to increase the height.

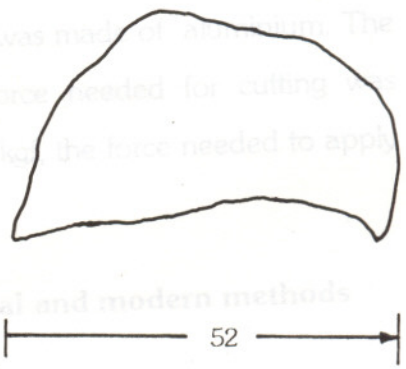
4.2 Selection of Suitable Knife.

From the **Fig 3.9** it is clear that knife of throat clearance of 13 cm was easy to cut . The size and shape of cross section of the arecanut penducle is shown in **Fig 4.1**. The cross section of peduncle almost resemble the knife A. Hence knife (A) was selected.

4.3 Deflection

The equipment in compacted position has no deflection at all. Since lifting was done by supporting against areca tree using a clamp, there was no deflection during the operation.





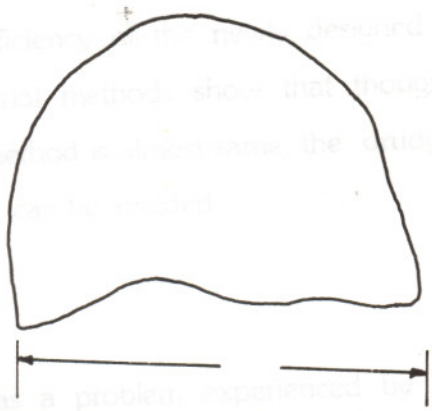


Fig. 4.1 PEDUNCLE CROSS-SECTION.

ALL DIMENSIONS IN MM

4.4 Ease of operation

To study the ease of operation, the time taken for raising, locking, harvesting/ spraying , lowering and transport were noted and shown in **Table 4.1** and **Table 4.2.**

Average time for harvesting was found to be 131 sec and for spraying was 170 sec. From **Fig. 4.2 and Fig. 4.3** it was found that the time taken for harvesting and spraying increased linearly with the number of trees.

During raising and lowering, whole equipment was supported by ground . It was done by raising /lowering each pipe one after another using a reel assembly. Since the material used for pipe being aluminium the entire system was very light ie, only 9.2 kg . Hence the equipment could be eaily carried by a single man. The weight can be made even lesser if the reel assembly was made of aluminium. The reduction of weight is calculated in **Appendix VI**. Force needed for cutting was 10.5 kgf. As the self weight of the device supplied 9.2 kgf, the force needed to apply was only 1.3 kgf.

4.5 Comparative analysis between traditional and modern methods

The efficiency of operation of the newly designed arecanut harvester cum sprayer and traditional method is compared in **Appendix VII**. Comparative analysis of harvesting/spraying efficiency of the newly designed arecanut harvestor cum sprayer and the traditional methods show that though the time required for traditional and modern method is almost same, the drudgery of climbing as well as the need for skilled labour can be avoided.

4.6 Safety aspects

Pesticide drift was a problem experienced by spraying which could be detrimental to operators health. This could be prevented by providing a hood to the frame.

Table 4.1 TIME TAKEN FOR HARVESTING

o. of Trees	No. of Bunches	Time for Raising (Sec)	Time for Locking(Sec)	Time for harvesting(Sec)	Time for Lowering(Sec)	Time for Transport(Sec)	Total Time(Sec)
1	2	40	3	3	35	50	131
2	3	78	6	6	70	100	260
3	5	118	8	8	105	150	389
4	7	157	11	10	143	200	521
5	8	196	13	13	182	250	654

Table 4.2 TIME TAKEN FOR SPRAYING

No. of Trees	Time for Raising(Sec)	Time for Locking(Sec)	Time for Spraying(Sec)	Time for Lowering(Sec)	Time for Transport(Sec)	Tot Time
1	46	3	40	35	50	168
2	78	6	82	70	100	336
3	118	8	120	105	150	501
4	157	11	160	143	200	671
5	196	13	210	182	250	851

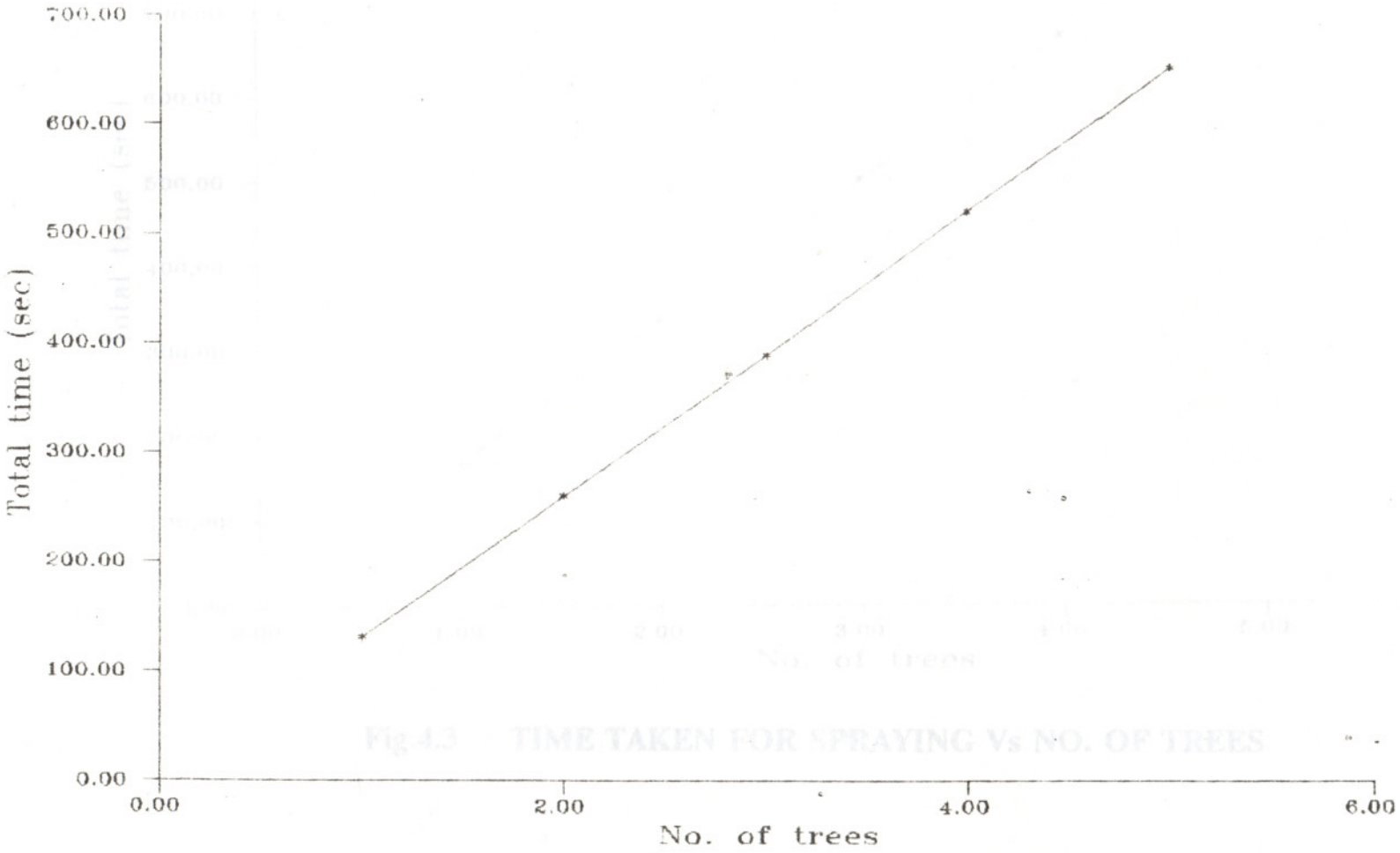


Fig.4.2 TIME TAKEN FOR HARVESTING Vs NO. OF TREES

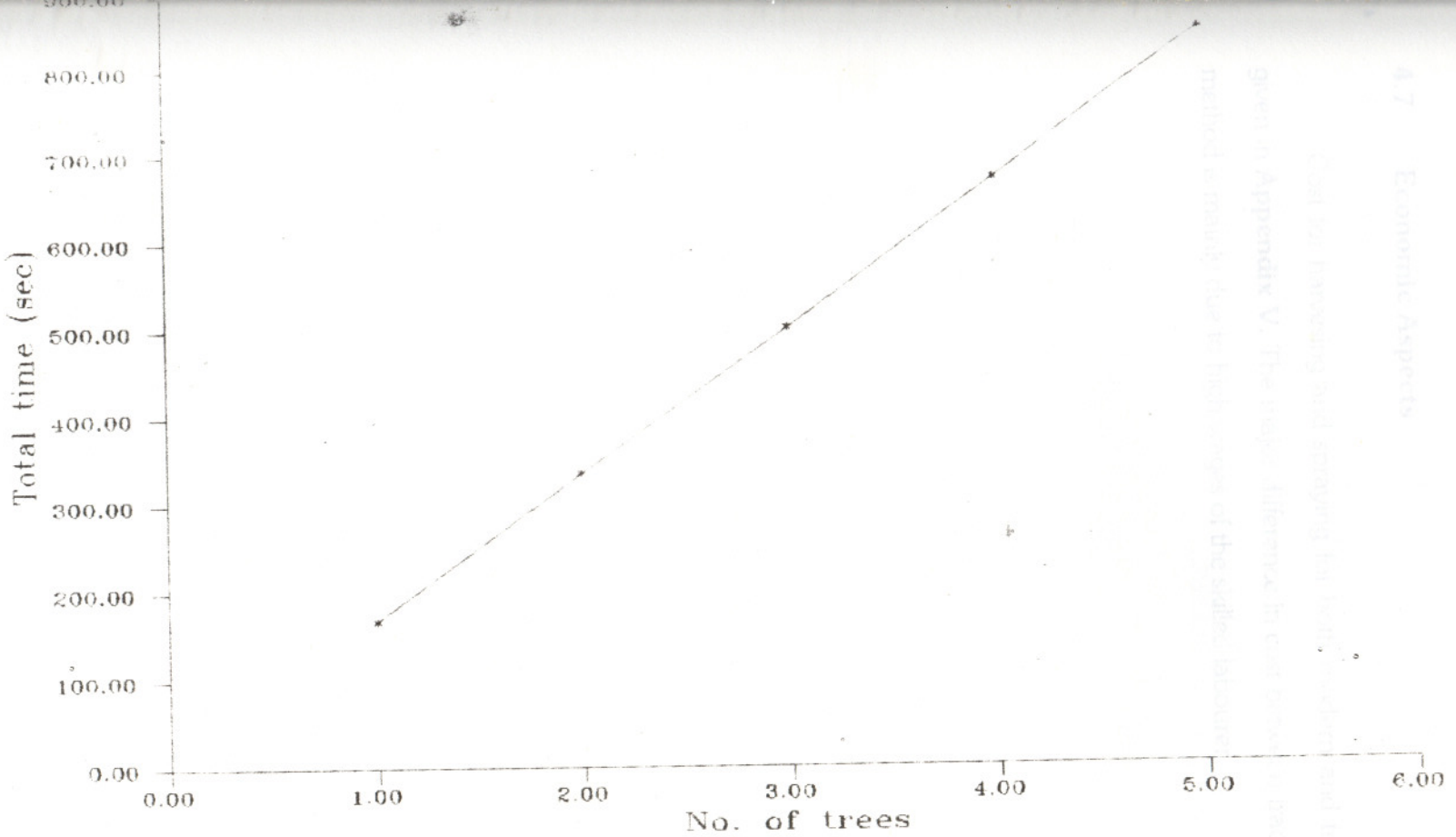


Fig.4.3 TIME TAKEN FOR SPRAYING Vs NO. OF TREES

4.7 Economic Aspects

Cost for harvesing and spraying for both modern and traditional method is given in **Appendix V.** The major difference in cost between traditional and modern method is mainly due to high wages of the skilled labourer.

SUMMARY AND CONCLUSION

Need of an efficient arecanut harvester cum sprayer was aggrevated by the lack of efficient labours in time. This prompted the scientists to develop many models of arecanut harvester cum sprayer of which none could be that much effective to meet allthe requirements of the farmers. Hence to overcome the limitation of existing models a new device was developed. An estimate shows that Kerala produces about 17466 million nuts from an area of 71676 ha (**Table 2.1 and Table 2.2**) in the year '94 -'95

The device developed basically consist of three concentric aluminium pipes attached by sockets. Raising and lowering of the pipes is facilitated by rope and pulley mechanism, which is driven manually through a reel assembly. Cutting blades was bolted to the holding head for harvesting and hydraulic nozzle connected to a hose was bolted to the holding head for spraying. A rocker sprayer has been selected for spraying pesticide.

From the field trials, it was revealed that the lifting mechanism properly functioned upto a height of 10 m without any problem of deflection. As it was made of aluminium pipes, it was light in weight, simple in construction, easy to operate and required only one operator for harvesting and two operators for spraying. The device can harvest 1 bunch in 131 Sec and spraying of 1 tree can be done in a time period of 170 Sec. The cost of operation for harvesting is Rs. 1835.55/ ha and for spraying is Rs. 6120/ ha.

Some suggestions that may help future research work in modifying arecanut harvester cum sprayer are listed below :

1. Higher heights can be easily achieved by inserting more pipes.
2. If the lowering and raising reels are provided on separate shafts at both sides, there will be proper balancing and there will not be any interlock with the ropes.

3. Instead of providing manual breaking to raising reel while lowering, a mechanical breaking unit can be provided.

4. A hood can be provided to the frame to protect operators below from pesticide drift and to minimise chemical loss by collecting the pesticide dripping from the target.

REFERENCES

Anil V., Bindu. J., Babu, M.S.S. (1996) Development of Areca sprayer, *B. Tech project report*, Department of Farm Power Machinery & Energy, K.C.A.E.T, Tavanur.

Annamalai, S.J.K. (1982). *Proceedings of V annual symporium on plantation corps.* M/s Sarada press, Madras Pp. 335-342.

Aziz.H, David T.A.,(1980) Macaque monkey, a master Harvester of palms, *Indian coconut Journal* 11(8)

Bindra, O.S. and Singh, H. (1980). *Pesticide application equipments.* Oxford and IBH publishing Co. India. Pp.5-118,198,205-297.

Bopaiah M.G., (1996) *Arecanut Research & development* , CPCRI, Kasargod.

Clinton, O.J. and William, R.H. (1983). *Agricultural power and machinery.* Mc-Graw Hill book Company. Pp.355-376.

Chattopdhyay, S.M. (1985*). Principles and procedures of plant protection.* Oxford and IBH publishing Co. New Delhi. Pp.6-8.

Culpin, C. (1981). *Farm machinery.* The english language Society and Granada, London. Pp. 135-141.

Davis, T.A.(1977) *Journal of plantation crops 5(1)* Attempts at mechanical climbing of palms with special reference to coconut palm Pp 31-34.

Dwivedi. R.S., (1977) Palm Climbing Device, *Invention Intelligence.*

Kepner, R.A., Bainer, R. and Barger, E.L. 91987). *Principles of farm machinery.* C.B.S. publishers and distributers. India. Pp.282-307.

Kirk, J.W., Bouse, L.F. and Bode, L.E. (1990). Effect of spray mixture on droplet size. *Transactions of ASAE.*33(3):783-788.

Ozkani, H.E., Reichard, D.L., Fox, R.D. and Braze, R.D. (1994). Simulation of drift of discrete sizes of water droplets from field sprayer. *Transactions of ASAE.* 37(5):1401-1407.

Ozkani, H.E. and Reichard, D.L. (1992). Droplet size distribution across fan pattern. *Transactions of ASAE.* 35(4) : 1097-1102.

Pillai, G.R. (1970). *Crop-Husbandry.* State institute of languages. Trivandrum. Pp. 185-187.

Purseglove, J.W. (1983). *Tropical crops-monocotyledons.* The english language book society and long man pp. 434-439.

Rangaswamy, G. (1984). Diseases of crop plants in India. Prentice hall of India. Pvt. Ltd. New Delhi. Pp. 337-339,463-465.

Richey, B. (1961). *Agricultural engineers Hand book.* Mc-Graw hill book Company. Pp.187-200.

Sasidhar, V.K. (1997) Pakage of Practices recommendations 'Crops'. KAU Publication. Pp 141-146.

Singh, R.S. (1983). *Plant diseases.* Oxford and IBH publishing Co., New Delhi. Pp.165-166.

Soon A.K., Salokhe, V.M. Gajendra Singh, Hydraulic cutter for harvesting tree fruits (1992), *proceedings of international Agrl. Engineering conference(I)* pp 395-401.

Srivashava A.C. (1990) *Elements of Farm Machinery*, Oxford IBH publishing Co. India pp. 175-176.

Tata, S.N. (1992). *Hand book of Agriculture.* Indian Council of Agricultural Research, New Delhi. Pp.525-530.

APPENDIX - I

Common Diseases and Pests affecting areca tree

Diseases and Pests	Symptoms	Remedy
Mahali (Koleroga)	Fallen nuts discoloured and with a whitish felt	Spraying of 1% Bordeaux mixture two times, before and after monsoon
Stem Bleeding	A reddish brown ooze from the stem cracks. Large cavities are formed inside stem	Scooping out the diseased tissues; sterilizing the open wound with burning torch
Foot rot	Stem cracks giving out dark brown ooze	Sulphur is deposited on ground around the tree
Leaf rot	Burnt appearance of leaves	1% Bordaux mixture is used
Scale insects and mealy bugs	It will affect the vitality of plant adversly	Spray 0.4% Diazinon of DDVF
Aphid	-do-	-do-
Arecanut beetle	Feed on the leaves and ripening fruits	Spray 0.2% BHC
Mites	Devitalize the tender plant parts	Dust Sulphur
Spindle bug	Dark brown patches appear on the leaves	50 % BHC is applied
Tirathalia Mundella (Pukkula puzhu)	Flowers are destroyed	Malathayon is applied
Leukofilis Lepedphora (Vella puzhu)	Tender roots are destroyed	Aldrin or clorden are added to ground

(Source : Hand Book of Agriculture)

APPENDIX II

DIAMETER OF THE REEL ASSEMBLY

Diameter of the reel assembly is calculated as follows,

$$\pi D N = Length\ traversed$$

Where, D is the diameter

N is the revolutions per minute

$$xDx54 = 100\{(2.6 + 2.6 + 3.6 + 3.6 + 3.6) - (2.6 + 3.6 + 0.8)\} = 880$$

(Refer Fig. 3.3)

therefore D=50.8 mm ~ 2"

APPENDIX III

PRESSURE CALCULATIONS

Pressure required at nozzle for proper atomization = 2.812 kg/cm^2.

Atmospheric pressure = 1kgf/cm^2

Pressure required to reach cropheight upto 10 m = 1kgf/cm^2

(Assuming density of spary fluid is same as water)

$$Friction\ loss\ in\ hose = \frac{4flv^2}{2gd} = \frac{4x.02x20x(.0955)^2}{2x9.81x.01}$$

$$= .07x10^{-4}\ kgf/cm^2$$

Total pressure required to be developed = 2.812+1+1+.000007

= 4.812 kgf/cm^2

The sprayer must be capable of developing a pressure equal to or greater than 4.812 kgf/cm^2

APPENDIX - IV

PREPARATION OF BORDEAUX MIXTURE (1 PERCENT)

1 kg of copper sulphate ($CuSO_4$) is dissolved in 50 l of water and in another 50 l, milk of lime, is prepared with 1 kg of quicklime. $CuSO_4$ solution is poured in milk of lime, slowly, with stirring. The vessel used must not be wooden, earthern or copper vessel. Test it before apply by dipping a polished knife in it. If it show reddish colour add more lime till blade is not stained on dipping.

APPENDIX V

COST ANALYSIS

MODERN METHOD

For Harvesting

Initial cost of lifting mechanism	=	Rs. 1250/-
Initial cost of cutting blade	=	Rs. 50/-
Initial cost of arecanut harvester (C)	=	Rs. 1300/-
Useful life period (L)	=	10 yrs
Annual working hours (H)	=	750 hr
Salvage value (S)	=	10% of initial cost
Interest on initial cost, (I)	=	15% annually
Repairs and maintenance	=	3% of initial cost.
Labour wage	=	Rs. 150/- per person per day of 8 hr.
Lubrication charge	=	1% of initial cost.

Fixed cost

$$Depreciation = \frac{C-S}{L} = \frac{1300-130}{10} = Rs.117/-$$

$$Interest = \frac{C+S}{2} x\, I = \left(\frac{1300+130}{2}\right)\frac{15}{100} = Rs.107.25/-$$

$$Total\ fixed\ cost = Rs.224.25/yr$$

Variable Cost

$$\text{Repairs and Maintenance} = 1300 \times \frac{3}{100} = Rs.39/-$$

$$\text{Lubrication Charges} = 1300 \times \frac{1}{100} = Rs.13/-$$

$$\text{Labour Charges} = \frac{150 \times 750}{8} = Rs.14062.5/yr$$

$$\text{Total Variable cost} = Rs.14114.5/yr$$

$$\text{Total Cost per hour} = \frac{14338.75}{750} = Rs.19.12/hr$$

$$\text{Total Cost per day} = 19.12 \times 8 = Rs.152.96/day$$

$$\text{Total Cost per hectare} = 152.96 \times 12 = Rs.1835.52/ha$$

For Spraying

Initial cost of lifting mechanism	=	Rs. 1250/-
Initial cost of spraying mechanism	=	Rs. 1700/-
Initial cost of arecanut sprayer (C)	=	Rs. 2950/-
Useful life period (L)	=	10 yrs
Annual working hours (H)	=	750 hr
Salvage value (S)	=	10% of initial cost
Interest on initial cost (I)	=	15% annually
Repairs and maintenance rate	=	3% of initial cost
Labour charges	=	Rs. 150/- per person per day of 8hr.
Lubrication charges	=	1% of initial cost

Fixed cost

Depreciation	=	$\frac{C-S}{L} = \frac{2950-295}{10}$ = Rs. 265.5/-
Interest	=	$\frac{C+S}{2} I = \left[\frac{2950+295}{2}\right]\frac{15}{100}$
	=	Rs. 243.38/-
Total fixed cost	=	Rs. 508.88/ yr

Variable cost

Spray cost :

Cost of 1Kg $CaCO_3$ = Rs. 3/-

Cost of 1Kg $CuSO_4$ = Rs. 75/-

Volume of 1% bordeaux mixture = 100 l

Volume required by one plant = $\frac{3}{4}$ l

Number of plants which can be sprayed = $\frac{100}{0.75} \approx 133$

Cost of spray for one plant = $\frac{78}{133} = 0.59 \approx 60$ *paise*

Cost of spray per year = $\frac{750 \times 3600 \times 0.6}{170}$

= Rs. 9529.4/ yr

Labour charge = $\frac{150 \times 750 \times 2}{8}$

= Rs. 28125/ yr

Repair and maintenance = $\frac{2950 \times 3}{100}$

= Rs. 88.5/-

Total variable cost per year = Rs. 37742.9/ yr

Total cost per year = Rs. 38251.78/ yr

Total cost per hour = $\frac{38251.78}{750}$

= Rs. 51/ hr

Total cost per day = 51 x 8 = Rs. 408 /day

Total cost per hectare = 408 x 15 = Rs. 6120/ha

TRADITIONAL METHOD

For Harvesting

Prevailing rate for harvesting = Rs. 1/Bunch

From experience we know that,

No. of plants harvested per day = 250/day

No. of bunches harvested per day = 350/day

(Assumption 100 plants have 2 bunches each)

Total cost per day = Rs. 350/Day

Total cost per hectare = 350 x 12 = Rs. 4200/Ha

For Spraying

Initial cost of spraying mechanism (C) = Rs. 1700/-

Useful life period (L) = 10 yrs

Annual working hours (H) = 750 hr

Salvage value (S) = 10% of initial cost

Interest on initial cost (I) = 15% annually

Repairs and maintenance rate = 3% of initial cost

Fixed cost

Depreciation = $\frac{C-S}{L} = \frac{1700-170}{10}$

= Rs. 153/-

Interest = $\frac{C+S}{2}\Big]I = \Big[\frac{1700+170}{2}\Big]\frac{15}{100}$

= Rs. 140.25/-

Total fixed cost = Rs. 293.25/-

Variable cost

Cost of spray per year = Rs. 19058.8/ yr

Labour charge : by practice it is proved that two skilled labourers are required for spraying and one unskilled labourer (preferably women) for operating the rocker arm

Skilled labour charge	=	Rs. 200/day
Unskilled labour charge	=	Rs. 100/day
(Assumption : women is employed)		
Total labour cost per day	=	Rs. 500/day
Total labour cost per year	=	500 x 92
	=	Rs. 46000/yr
Repair and maintenance	=	$\frac{1700 \times 3}{100}$
	=	Rs. 51/ yr
Total variable cost per year	=	Rs. 65109.8/yr
Total cost per year	=	Rs. 65403.05/yr
Total cost per hour	=	$\frac{65403.05}{750}$
	=	Rs. 87.2/Hr
Total cost per day	=	87.2 x 8
	=	697.6/day
Total cost per hectare	=	697.6 x 15
	=	Rs. 10464/ha

APPENDIX VI

PROPOSED WEIGHT REDUCTION OF ALUMINIUM REEL

Density of Al. (ρ_{Al}) = 2.7×10^3

Density of Galvanized iron (ρ_{GI}) = 7.6×10^3

Weight of reel assembly = 3 kg

Density = mass/vol

$$\frac{\rho_{Al}}{\rho_{GI}} = \frac{2.7 \times 10^3}{7.6 \times 10^3} = 0.355$$

$$\frac{W_{Al}}{W_{GI}} = 0.355$$

W_{Al} = 1.07 kg.

Therefore reduction in weight = 3-1.07 = 1.93 kg

APPENDIX VII

COMPARITIVE ANALYSIS BETWEEN TRADITIONAL AND MODERN METHOD

Harvesting

1 ha		=	10,000 m^2
area per plant	= 2 x 2	=	$4m^2$
no. of trees per ha		=	2500
average time per plant for harvesting		=	131 sec
time for harvesting 1 ha		=	90.97 hr
		=	$\frac{90.97}{8} = 11.3 \approx 12\, days$

From experience for harvesting 1 acre time required is 4 to 5 days. (In one day, work is done for 4 hours)

2.5 acre	=	1 ha
Time for 1 ha	=	10 to 12.5 days

Spraying

Average time for spraying	=	170 Sec
Time for 1 ha	=	118.06 hr ≈ 15 days

For traditional spraying of 1 acre we require 6 days (In one day, work is done for 4 hours).

Time required for 1 ha	=	15 days

DEVELOPMENT AND TESTING OF AN ARECANUT HARVESTER CUM SPRAYER

By

NIMMI RACHEL GEORGE

PREETHA. T. J.

ABSTRACT OF THE PROJECT REPORT

Submitted in partial fulfilment of the
requirement for the degree

Bachelor of Technology
in
Agricultural Engineering

Faculty of Agricultural Engineering and Technology
Kerala Agricultural University

Department of Farm Power Machinery and Energy

KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY

TAVANUR - 679 573, MALAPPURAM

KERALA

1998

ABSTRACT

Harvesting and spraying of areca trees have been identified as a highly labour intensive and difficult task to be performed in farm. The existing method of harvesting and pesticide application is done by manual climbing. It is laborious, time consuming, hazardous and can't ensure the timeliness of operation. An equipment was developed after considering the priorities and demands of farmers. A telescopic pipe arrangement was fabricated; to lift the cutting tool and spraying unit. The harvesting time for one bunch was 131 Sec and spraying time for one tree was 170 Sec. The maximum time for harvesting 1 ha was 12 days and that for spraying was 15 days. Even women can operate it easily. With few modifications, the machine could be made available for commercial production. The cost of operation for harvesting with this device is about Rs. 1835.55/ ha and that of spraying is about Rs. 6120/ ha.