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Arecanut and Cocoa

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3.1 INTRODUCTION

Farm mechanization aims for increasing land labour efficiency by improving the safety and comfort of agricultural labour and to protect the environment by allowing precision operations and increasing the overall income. The future of farm mechanization technology package has to be eco-friendly, user friendly, facilitating the strenuous and hazardous farming operations in a safe and comfortable manner, increasing the area and productivity and facilitating custom hiring/ contract farming. The principal advantage of mechanized agriculture is that it reduces the demand for labour and allows operations to be carried out faster. Mechanization is needed to get over some of the major constraints to enhance productivity and to make farming less arduous and attractive enough to enable educated youth taking willingly agriculture as vocation.

In the dynamic and fast changing agricultural scenario, particularly with diversification in the cropping pattern and commercialization of agriculture, more efficient and sophisticated equipment are required by the farmers. The demand for improved farm equipment in our country will continue to rise in the coming years. The present fast changing situation of migration of labour to various other avenues and thrust for higher agricultural production to meet the future demands; and the drudgery involved in the agricultural operations making them tiresome for human labor, necessiate the introduction of suitable mechanization equipment

The mechanization gadgets and equipment developed and adopted widely in India for arecanut and cocoa are described in this chapter

3.2 ARECANUT

Arecanut (*Areca catechu* L), popularly known as the betel nut or *supary,* is an important commercial crop of our country. Of the total production of 12.24 lakh metric tons of arecanut in the world, India alone produces more than

6 lakh metric tons. Indonesia, China, Myanmar and Bangladesh are the other major arecanut growing countries in the world. The cultivation of arecanut in our country is mainly concentrated in three states, namely Karnataka and Kerala in southern region and Assam in the north eastern region. They totally contribute nearly 87% of the total production in India. More than ten million people depend on this crop for their livelihood in our country.

The areca palm is a perennial monocot, growing very tall with single straight stem. It is generally planted at spacing of 2.7 × 2.7m with a pit size of 60 × 60 × 60 cms. Arecanut palm generally grows, depending on the variety, very tall up to 25m or even more. Except certain varieties, the arecanut palm starts yielding from the fifth year of planting. Starting from the preparation of soil and throughout its cultivation, every cultural operation of this crop demands involvement of manpower both in the form of skilled and unskilled workers. Ironically, the availability of such manpower is the limiting factor in improving its production and enhancing its productivity in our country. Mechanization in all fields of cultivation is the only answer to overcome this persistent problem.

The areca nut is commercially available in dried, cured and fresh forms. While fresh, the husk is green and the nut inside is so soft that it can easily be cut with an average knife. In the ripe fruit, the husk becomes yellow or orange and, as it dries, the fruit inside hardens to a wood-like consistency. At that stage, the areca nut can only be sliced using a special scissor-like cutter. Harvesting of nuts at correct stage is very important for obtaining the produce of better quality. In *chali* preparation, only ripe nuts are harvested. It should be ensured that fully ripe nuts alone are harvested for preparation of chali. The out-turn of *Patora* and *Koka* will be more if unripe or under-ripe nuts are harvested, which fetches only lower price in the market

3.2.1 Raising Nursery

3.2.1.1 Filling Poly Bags with Potting Mixture to Raise Seedlings

To raise quality seedlings in nursery, it is essential to fill nursery bags with potting mixture containing soil, sand and farm yard manure or other ingredients in required proportions. Generally, it is being done manually with human labour. The Central Institute of Agricultural Engineering, Regional Centre, Coimbatore has developed a machine to powder, sieve and mix different ingredients in the required proportion and fill the same in poly bags for raising seedlings in nursery (Fig 3.1).

The unit consists of 3 HP motor, a feed hopper, paddles, sieving tray and an electronic vending instrumentation which can fill the potting mixture at a set quantity (100 g, 250 g, 500 g, 1,000 g, etc) at a set time gap. In addition, a pedal has been provided for the operator to manually control the quantity of potting mixture. Any unskilled person, male or female, can operate the machine. Two workers are needed for its operation. It can fill 200 poly bags in one hour with 500 gm potting mixture (Annamalai *et al.*, 2015).

Fig. 3.1: Nursery pot media filling machine

3.2.2 Preparation of Land for Planting Seedlings

3.2.2.1 Digging Pits

Arecanut is generally planted in solitary pits of the size 60cm x 60cm x 60cm or 90cm x 90cm x 90cm depending on the soil condition. At the recommended spacing of 2.7m x 2.7m, there will be nearly 1300 pits in one hectare area. More than 200 man days are required to finish this work if farmers take up this work manually. Now-a-days this work can be done mechanically by employing digging machines. Several good machines are now available in the market for this work. These can be manually operated, power tiller operated or tractor operated (Fig.3.2).

Fig. 3.2: Power tiller operated and tractor operated auger digger

3.2.2.1.1 Power tiller operated auger digger

It consists of a spiral auger of 300 mm diameter and 100 mm pitch which impart an up and down motion by a rack and pinion arrangement. The drive for the circular motion of the auger is drawn through belt pulley and bevel gear transmission with a ratio of 10:1 from the engine directly. The entire assembly is mounted on a rectangular frame with necessary bearings and fixtures. The hand wheel provided at the side of the unit is used for introducing the auger into the soil, thus digging the pit. For varied size of holes, replaceable type larger diameter

auger bits of 200, 250 and 275 mm can be used. A balancing frame attached to the hitch bracket assembly in the rear and a support wheel fitted in the front portion of the unit counter the down suction offered by the auger while digging and ensure easy movement in the field.

3.2.2.1.2 Mini excavators

A mini excavator like 'U30-5' developed by *Kubota* is small earth moving equipment, the dimensions of which are as follows: Length: 4.485m; Height: 2.440m; Width: 1.550m; standard bucket width is 480/430mm and it can be used in plantation crop (Fig. 3.3). The width of the equipment is around 1500 mm and can operate between two rows of arecanut palms.

Fig. 3.3: Digging machine by 'Kubota'

3.2.2.2 Making Drainage Channels

In arecanut gardens, the drainage channels are a must and they should be at least 15-30 cm deeper than the depth at which the seedlings are planted. Tractor operated trenchers have been developed to make the channels.

3.2.2.2.1 Tractor drawn trencher

Tractor drawn trencher (Fig. 3.4) is used to form rectangular trench of 30cm width and 30 cm deep. The unit consists of two mould board bottoms placed in line one behind the other. The front and rear bottoms operate at a depth of 0-15 cm and 15-30 cm respectively. The two bottoms throw the removed soil in opposite directions and form vertical walls one on each side of the trench. The mould board shape is formed for easy lifting and throwing of soil away from the trench opened. A safety pin is provided to protect the unit from over loading. An adjustable bar point share is provided in addition to the trench bottom cutting share.

Fig. 3.4: Tractor drawn trencher

Similar equipments are available in smaller capacities, which can be attached to power tiller or self propelled with lower horsepower capacities.

3.2.2.3 Base Opening

Base opening is done by a power tiller attached with an opening tool which can till the basin and open up the basin around the palm. It can open up a basin of 60 cm width with 15 to 25 cm deep within 5-6 minutes. The machine consumes 1.5 liters of diesel per hour. The equipment has been developed by Agricultural Research Station of Kerala Agricultural University at Mannuthy, Thrissur, Kerala and Tamil Nadu Agricultural University (TNAU), Coimbatore.

3.2.2.3.1 Spading machine

In Tamil Nadu Agricultural University, a special equipment 'spading machine' is used to make base opening around the plantation crop like arecanut. Spading machines (Fig. 3.5) are basically tillage equipment largely appreciated in several working conditions and applications, such as:

a) to work without any problem in extremely wet soil.

b) to work up to a maximum working depth of 40 cm

c) to remove the bottom soil hardpan.

d) to partially lay underground crop residues without throwing the clods back completely.

e) Also it require low traction power

This can be very effectively used in the plantation crops .

Fig. 3.5: Spading machine

3.2.3 Weeding and Intercultural Operations

Weeding by power weed cutters is very common in areca gardens. Different types of weed cutters (Fig. 3.6) powered by petrol engine, are now available commercially.

Fig. 3.6: Weeding equipment

3.2.3.1 Rotary Power Weeders

Rotary power weeder developed at TNAU, Coimbatore under AICRP on Farm Implements

and Machinery (Fig. 3.7). The equipment consists of 8.3 hp light weight diesel engine mounted on a frame. Engine power is transmitted to the gear box and then to the ground wheels.

Fig. 3.7: Rotary power weeder- TNAU Model

There is a provision to adjust wheel settings according to row to row spacing of the crop. Two clutches are provided, one to engage or disengage ground wheel and other for engaging or disengaging power to rotary weeder. Rotary weeder has 3 rows of discs mounted with 6 nos of curved blades fitted in opposite directions alternatively in each disc. These rotating blades enable cutting of the weeds, which is chopped up into the soil. Width of coverage is 350 mm and depth can be adjusted. Rotary weeder unit can be detached from frame and its plate and sweep type blades, junior hoe cultivator or a ridger can be fitted. The field capacity of the unit is 3 ha/day.

3.2.3.2 Intercultivators/Rotavators

Forking the soil in arecanut gardens once in a year or two is the usual practice carried out by several farmers. This not only helps in loosening the soil but also mulching the weeds. It also increases aeration and water percolation. The process is very laborious and now-a-days most of the farmers forgo this operation due to non-availability of man power. Several machine operated intercultivators/ rotavators are now available commercially for this job (Fig. 3.8).

Fig. 3.8: Commercial intercultivators/ rotavators

3.2.4 Plant Protection Equipment

The usual method for spraying of pesticide to arecanut fruit bunches is done by manually climbing the palms by skilled persons. Due to shortage of manpower and heavy rains during monsoon, it is practically impossible to spray in time. There is an urgent need for a mechanical device to spray pesticides from ground without climbing palms. Several attempts have been made on this aspect, but have not been successful inside arecanut gardens where we have several

mixed crops with arecanut. Further, in most areca gardens, the palms are of uneven height.

3.2.4.1 Telescopic Spray Lances

Many attempts have been made to develop simple telescopic aluminum lances of different heights up to 6m length and of different diameters are fixed one into the other telescopically and extended to different heights by using ropes and pulleys. The sprayer nozzle can be rotated or moved to different directions from the ground itself using the rope fixed to it (Fig. 3.9).

A farmer from Hariharapura of Koppa Taluk of Karnataka has developed a simple device to spray pesticides. Advantage of this device is that it has no machinery. Three to four steel pipes, with two clamps on each pipe to hold the palm stem, are pulled up on the palm by using ropes. The spray nozzle with rotating device is fixed on the top portion of the topmost pipe. The sprayer pump is kept on the ground and the end of the hose is fixed to the nozzle at the top. Once the device is fixed, it can spray the adjacent palms also. This device can spray tall palms even up to a height of 20m. The same device, by fixing a sharp sickle, can also be used for harvesting areca bunches.

Another telescopic spray lance developed by an industries (*viz.*, Redbee Engineering, Chikmagaluru, Karnataka called as 'AL 10' Palm sprayer) is also found useful. The lance is of 5.5 m. It can spray up to 20m height from the ground (Fig. 3.10). A belt is provided at the base of the equipment to tie it to our body so that the hands are free to work.

Fig. 3.9: The telescopic spray lances in operation

Fig. 3.10: Telescopic spray lance developed by the Redbee Engineering

3.2.4.2 Telescopic Sprayers

3.2.4.2.1 Telescopic sprayer developed by TNAU, Coimbatore

A telescopic type of sprayer was developed by the TNAU, Coimbatore to spray pesticides to arecanut palms from the ground level without climbing palms (Fig. 3.11). It is a manually operated machine with a dimension of 600 x 600 x 1500 mm. The sprayer has a telescopic aluminum boom which can be extended from 8m to 16m height by winding a cable. The boom is mounted on a supporting frame. The entire boom can be rotated to spray in all directions around the boom. The nozzle can be angled up or down by a remotely actuated pneumatic actuator. The spray fluid is supplied from a rocker arm sprayer. A team of three persons will be required for spraying operation. It is suitable for spraying palms up to a height of 18 m. The equipment weighs around 22kg.

Fig. 3.11: Telescopic sprayer – TNAU Model

3.2.4.2.2 Telescopic sprayer developed by CPCRI, Kasaragod

Almost similar type of telescopic sprayer was also developed by ICAR-CPCRI, Kasaragod, Kerala (Fig. 3.12). It consists of two light weight pipes, one in the top and another in the bottom. The top pipe can be extended or lowered with a special mechanism. The bottom pipe is fitted on a rotating bearing for rotating the pipe (at 360 degrees) for spraying in all the directions. A steel wire is also provided for lifting and lowering these pipes. A ratchet mechanism helps to fix the pipes firmly at required heights. The spray boom is pivoted at the top of the pipe with a spring and a rope to control the spraying direction from the ground. The pipe height can be locked at any desired level above 6 m height. The pipes has been specially treated by a process called alloying which gives the poles extra durability to stand wear and tear and can be ideally used for a long time without getting damaged. However the equipment is useful in plantations where the palms are of uniform height.

Fig. 3.12: Telescopic sprayer – ICAR-CPCRI model

3.2.4.3 Spraying After Reaching Near the Canopy

3.2.4.3.1 Wonder climber cum sprayer

The 'wonder climber' developed by Sri Prakasan Thattary of Kozhikode, Kerala to harvest arecanut bunches can also be used to spray pesticides without climbing areca palms (Fig. 3.13). For spraying, the knife is removed and a rotatable clamp is fitted at that point. The nozzle is fitted at the end of this clamp and the hose pipe connected to the nozzle is extended to the ground and connected to the trigger valve near the compressor. A long rope is tied to the clamp near the nozzle. By pulling and controlling this rope from the ground the position of the nozzle can be adjusted to the required directions while spraying. Pumping machine to pump the spray liquid is to be provided by the farmer.

Fig. 3.13: Wonder climber cum sprayer

3.2.4.3.2 Robotic sprayer

Attempts have also been made to develop small robot like equipment to climb areca palm and spray pesticide (Fig. 3.14). The machine has two parts, one climbing machine and another spraying robot. The spraying robot is fixed to the top of the climbing machine. Both are controlled by separate motors. A control panel is in the ground from which cables are connected to both the machines to operate them. Spray liquid goes to the spraying robot through a pipe fixed to the pumping machine kept on the ground. The climbing machine has two detachable frames fixed to the palm by coupler and bolts. The height of the machine is 0.75m and weight is 20 kg. The machine climbs the palm even up to 18m, sprays all around the palm and comes down after spraying the palm on which it was fixed. Equipment is yet to be commercialized

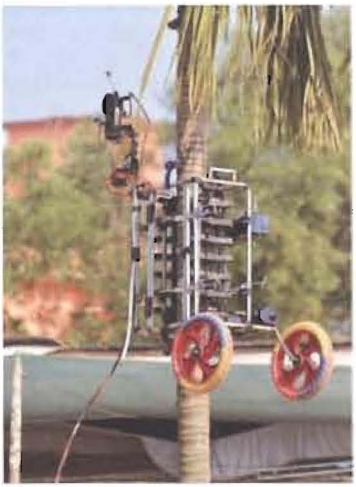

Fig.3.14: Robotic sprayer

3.2.4.4 Use of Spray Guns

Many commercial models of spray guns which can reach up to 10-11m from the ground itself (Fig. 3.15) are available.

Fig. 3.15: A model of Spray gun

3.2.5 Harvesting

Arecanut harvest is seasonal and during that period, the farmer has to harvest the crop 4 to 5 times a year. In young palms, say up to 7.5 to 9.0 m, the farmer generally harvest the nuts by using long bamboo poles or metal pipes with hooks or sickle at one end (Fig. 3.16).

Fig. 3.16: Harvesting pole – bamboo and metallic

3.2.5.1 Mechanical Gadgets for Harvesting

The traditional way of climbing arecanut tree is quite tedious, risky and requires lot of skill. It requires competent labour who is specialists in tree climbing. Difficulty to get the service of skilled arecanut climbers in time and their high wage are thus perceived as important constraints. The professional climber has the risk of accidental fall from top of tree, which can result in fatal injury. Agricultural workers employed for climbing arecanut tree suffer musculoskeletal disorders. Many lives could be saved if the workers/ farmers use a climbing device with safety features.

The palms generally grow very tall and it is difficult to harvest nuts without climbing which can be done only by skilled workers. After climbing one palm

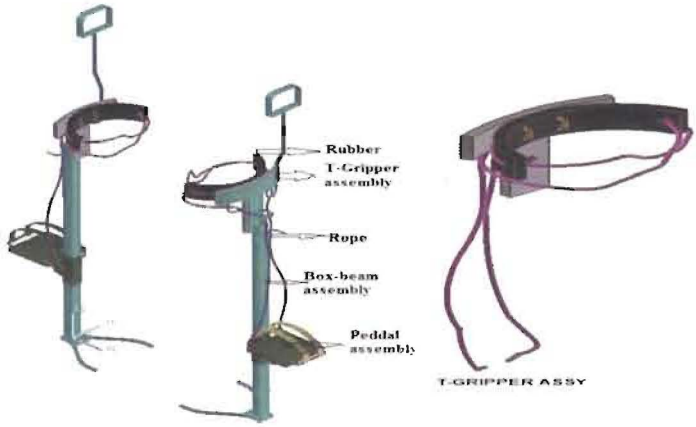

Fig. 3.17: Arecanut tree climber

the climber harvests the bunches from the adjoining 5 to 6 palms with the help of long bamboo poles having hook or sickle at the proximal end. However, due to acute shortage of manpower for this sort of skilled work, the farmers find it very difficult to harvest the crop in time. Hence, there was an urgent need for an effective and efficient mechanical device to harvest arecanuts from such tall palms without depending much on manpower.

Attempts have been made to develop mechanical gadgets for harvesting to reach the arecanut bunch (Fig. 3.17). In order to make the harvest of arecanut easier, several gadgets have been developed in recent years.

3.2.5.1.1 Climbing areca palms with the help of mechanical devices

Several mechanical devices are now available in the market to climb areca palms. The person need not be a skilled, but with some training he or she can climb the palm with ease and harvest the nuts.

3.2.5.1.1.1 Climbing device developed by entrepreneurs

A simple palm climbing device has been developed by Sri M.J. Joseph of Kannur, Kerala, for both arecanut and coconut in early 1980s (Fig. 3.18). It consists of two metal loops of 10 mm MS rod having sub-loops, one loop is intended for the right leg and the other for the left leg. The left loop is the main loop and is slightly bigger than the right loop. The top of the main loop is bent forward to form handle, and just below this part, two metal plates are attached with holes with a long rubber belt. On the rubber belt, a wire rope having rings on each end is fixed. The bottom most part is a plate and a clamp is provided above it. A long holed plate is fixed on the main loop, which is used as parking brake. The loops are put around the tree trunk on the opposite sides to fasten the tree trunk. The ropes pass around the tree and through hooks provided in the machine. It has a handle at the top for hand grip and a pedal base at the bottom

Fig. 3.18: Climbing device (*Courtesy*: Sri MJ Joseph)

for resting the foot. The device is 116 x 34 x 13 cm in size and 7.9 kg in weight. It can be used to palms having 15 to 32 cm diameter.

The operation is simple. First, raise the right side pedal a little upward so that the grip of the right hand part of the climber become loose facilitating upward movements by using the right hand and the right leg. Once the right part is moved up, the weight of the body rests on the right hand part of the machine. The whole process is repeated for the left hand side. By such alternate motion, one can easily climb a palm with ease. Slight training is required to work faster.

A few more models of climbing devices are by R Tech Industries, Coimbatore (Fig. 3.19) and CAMPCO Ltd. (Fig. 3.20).

Fig. 3.19: Demonstration of the climbing device-R Tech Agri-Equipment

A folding type '*skylift*' fitted on the top of a tempo was developed by an entrepreneur. The equipment can go up to 12m height by the motor attached to it. Since the ladder is fitted on the top of the tempo, the only disadvantage is that the tempo cannot move freely inside areca gardens (Fig. 3.21)

Fig. 3.20: Climbing device developed by CAMPCO Ltd and its demonstration

3.2.5.1.2 Ergo friendly model of climbing device

For ensured safety and comfort with minimum drudgery for the workers, an arecanut harvester with safety features has been developed under All India Coordinated Research Project on Ergonomics and safety in Agriculture functioning in the Department of Farm Machinery, Agricultural Engineering College and Research Institute, Tamil Nadu Agricultural University, Coimbatore (Fig. 3.22).

The salient features of arecanut harvester are:

- Light weight aluminium pole with improved configuration of cutting edge of the knife facilitates easy harvesting of arecanut bunches.
- The user feels completely secure and stable, since the upper frame is always horizontal and parallel to the ground

Fig. 3.21: Skylift platform mounted on tempo

Fig. 3.22: Arecanut tree climber

throughout the ascent and/or descent with variation in diameter of tree trunk.

- The device offers the user the side support in any direction, thus eliminating the danger of falling down when the user ascends or descends the tree.
- The worker can conveniently sit/stand and harvest bunches from the surrounding trees.
- Increased feeling of stability, comfort and safety to the user.
- The proficiency level required for the worker in the traditional method of climbing tree is not needed.
- Seating arrangement (adjustable and pivotable) with back rest makes the worker feel safe and secured when the user ascends or descends the tree. It also enables the worker to exercise firm grip in lifting the unit easily.
- The worker can rotate the unit and move around the tree trunk to facilitate harvesting of bunches form the surrounding trees.
- Eliminates the high work stress, severe neck and back pain disorders caused in traditional method of harvesting.

3.2.5.1.3 Areca bunch harvesting device

One successful arecanut bunch harvesting device was developed by Sri Prakasan Thattari of Kozhikode, Kerala and is now readily available in the market as wonder climber (Fig. 3.23). The added advantage of this device is that it can climb the palm by itself, harvest the bunch and get down. The person need not go up on the palm, as conventionally done, to harvest the bunch. It weighs about 6.5 kg and easy to carry from place to place.

Fig. 3.23: Wonder climber

The device is very simple with assembly of frame, pulleys, levers, two ropes, a special-purpose harvesting blade at the top and a v-shaped areca bunch holder. To start with, the machine is fixed vertically on the base of the areca palm. While pulling and releasing rope 1 (the climbing rope), the machine moves upward to the desired height due to the mechanical energy stored in the compression springs fixed on the main frame of the machine. The harvesting blade fixed on the top of the machine reaches the areca bunch and cuts its base. The bunch is then carried to the ground by the arecanut holder fixed below the knife. The machine can be moved in all directions with the help of rope 1 and rope 2 (control rope). The machine can be made to descend by pulling rope 2. The only disadvantage of this machine is that it should be fixed to each and every palm from where the arecanut is to be harvested.

3.2.6 Transportation

Transport cart with rubber tyres available commercially can be used for on farm transportation of harvested bunches, manures etc. Some of them are given in Table 3.1. Details of some of the transport cart used in arecanut field.

Table 3.1: Details of some of the transport cart used in arecanut field.

Firm	*Brief specification*
Farm Cart from 'Redlands'	Small, three wheeler farm carts with sitting arrangements for the operator are available with 'Red lands', Thrissur, Kerala. The Carts have 3.0 HP to 5.0 HP single cylinder diesel/ gasoline engine with a loading capacity of 250 to 500 kg. It is fitted with a hydraulic dumping tray which can be tilted easily, an ideal machine to go inside areca gardens. The fuel efficiency is around 2.00 hours per litre for 3.0 HP model. The width of the tray is 3.0 feet, very convenient to move inside areca gardens.
Moto carts	These are machine operated carts with 1.6 to 3.5 HP petrol engines without sitting arrangements, but with four tyres. Like power tillers these moto carts have two handles to operate and the operator has to walk while operating the machine. The loading capacity of the cart varies from 125 to 350 kg depending on the capacity of the engine. Here also the tray can be easily tilted to unload the material. The fuel efficiency is about 1.5 h per litre, very ideal for transporting goods inside areca gardens.

Firm	*Brief specification*
Agro Carts	It is a small moto cart without tyre but with rubber chain almost similar to that of *Hitachi*. Because of this arrangement in the wheel, the machine can easily cross small obstacles such as fallen areca stem, drainage channels, small ditches, etc. It can even climb small terraces and move freely in uneven surfaces generally encountered in arecanut gardens. The width of the tray is only 0.65m, very ideal for its movement inside areca gardens. There is also a facility to tilt the tray to unload the material. Two handles are also there to operate the machine. The fuel efficiency is around 1.5 hours per litre.

3.2.7 Arecanut Separator/Stripper

After the harvest of ripe arecanuts, the nuts are separated from the bunch by beating the bunch on a solid surface several times. When the green areca/ areca fruit bunches are harvested from the trees, removing arecanuts from the harvested bunches is a difficult aspect of areca-nut cultivation. One of the serious health hazards associated with arecanut stripping is the insect bite. To alleviate the acute labour scarcity with reduction in drudgery for the workers, the need for mechanized arecanut stripper is keenly felt. Traditional arecanut stripping demands enormous effort and energy from arecanut plantation workers as the arecanuts are separated from bunches by impact force.

The two most commonly used methods for stripping arecanut from bunches are lifting and beating bunches on a wooden pole tied between two arecanut trees or striking bunches at the bottom of the arecanut tree trunk. Some entrepreneurs have developed machines ranging from 0.5 HP to 3.0 HP to separate arecanuts from its bunch without employing much manpower (Fig. 3.24). The arecanut separator unit consists of a feed tray, a peg tooth cylinder, a stripping mechanism and oscillating

Fig. 3.24 : Arecanut separator/stripper

sieve. The stripping mechanism is a hollow peg tooth cylinder with pegs equally spaced at 42 mm distance from one another. The arecanuts are separated from bunches due to the impact force of the pegs of the rotating cylinder and the stripped arecanuts fell on the oscillating sieve. The oscillating motion of the sieve separates the arecanut from the chaff and other impurities. The entire unit can be mounted on wheels for easy transportation inside the areca plantation. The stripper is suitable for stripping both green and ripe arecanuts. The stripping capacity varied from 100 bunches to 1000 bunches per hour depending on the motor.

Fig. 3.25: Hold on type arecanut stripper

The hold-on type arecanut stripper (Kathirvel *et al.*, 2012) consisted of a feed tray, a peg tooth cylinder, a stripping mechanism and an oscillating sieve. The prime mover is a 2.2 kw, 3,600 rpm petrol start kerosene run engine mounted on one side of the unit with a supporting frame. The arecanut bunch is lifted and rested on the platform during feeding. The arecanuts are separated from bunches due to the impact force of pegs of the rotating cylinder and the stripped arecanuts fell on the oscillating sieve. The oscillating motion of the sieve separated the arecanut from the chaff and other impurities. A stripping efficiency of 99.5 percent was achieved, resulting in 66 and 77 percent savings in cost and time when compared to conventional arecanut stripping (Fig. 3.25 and Fig. 3.26).

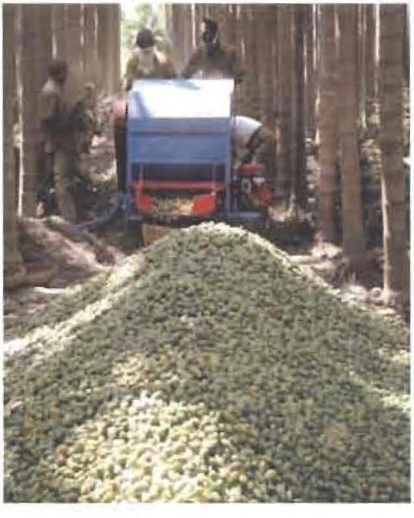

Fig. 3.26: Hold on type arecanut stripper- in operation

3.2.8 Dehusking/Peeling

In arecanut, there are mainly two types of processed nuts, one is white chali where ripe arecanuts are dried and then dehusked and another is the red variety where the unripe arecanuts are dehusked first and processed afterwards. In

both the cases, dehusking is a must which is being done conventionally by hand using sickles. These are labour intensive operation and one skilled person can dehusk on an average 60 kg chali per day. Several entrepreneurs and manufacturers have developed arecanut dehuskers to do this work mechanically. Some of them are described below:

3.2.8.1 Dehusking Dried (chali) Arecanut

3.2.8.1.1 Women friendly arecanut dehusking tool

The traditional method of dehusking arecanut is primitive and laborious. Cut on the fingers and fissures on the hand, skin allergy are common health hazards observed with the workers.The farm women felt more inconvenience because they were doing the operation in sitting posture at ground level. The major body part discomfort experienced by them was numbness of legs, abdomen, elbow, leg and low back pain (LBP). For enhanced safety and comfort of the worker, a women friendly ergo refined arecanut dehusking tool has been developed.

The hand-operated ergo refined green arecanut dehusking tool consists of a slightly curvilinear knife with pointed edge, a seat and rest similar to the configuration of the arecanut, a handle with grip and a frame to hold all the important movable parts. The tool can be easily operated by women. The hand-operated ergo refined dry arecanut dehusking tool consists of a rasp type blade, seat for arecanut, a handle with grip, a spring loaded holding device with a handle and a frame to hold all the important movable parts. The tool can be easily operated by women. Savings in cost and time of operation are 10.7 and 14.5 per cent, respectively for dehusking green nuts and 9.9 and 12.4 per cent, respectively for dehusking dry arecanut.

3.2.8.1.2 Pedal-operated arecanut dehusker

ICAR-CPCRI Kasaragod, Kerala and UAS Bangalore, Karnataka have developed pedal operated arecanut dehusker which can dehusk both green and dry nuts (Fig. 3.27).

ICAR - CPCRI Model UAS Bangalore model

Fig. 3.27: Pedal operated arecanut dehuskers

3.2.8.1.3 Power-operated arecanut dehusker

There are many models of power operated arecanut dehusker. It mainly consists of a mainframe on which a rotary shelling drum having 8 numbers of solid rubbers on its periphery is mounted (like rasp bar threshing cylinder). Below this, a concave is placed to aid shelling and to pass the dehusked material down. After dehusking kernels and husk flow to the duct and reach the air stream, produced by a blower. The husk is thrown out and the kernels/ nuts are collected at the bottom. Depending upon the size of fruits, the concave has to be changed for higher efficiency and minimum breakage. Grading the dried fruits before dehusking will also help to increase the dehusking efficiency and reduce the breakage.

Bundit Jarimopas *et al.*, 2009 developed prototype of a dry arecanut nut fruit husking machine (Fig. 3.28). (1 Frame; 2 First tyre; 3 Second tyre;4 220 V 50 Hz 1 Phase 2.2 kW Electric motor; 5 Driving pulley; 6 Following pulley; 7 V-belt; 8 25.4 mm Axial shaft; 9 Steel concave sieve; 10 Hopper).

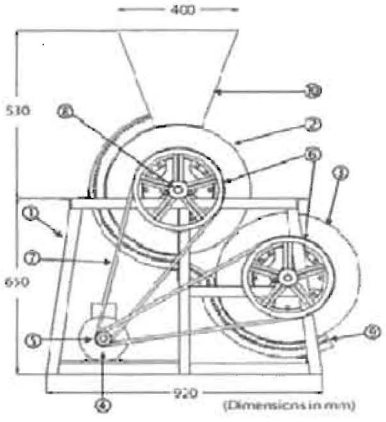

Fig. 3.28: Schematic diagram of arecanut husking machine.

Dehusking is usually found incomplete after the first tyre stage; the partially husked fruit was fed into a second tyre stage, which had the same design and operating conditions as the first. Repeating husking of the partially husked fruit by the second tyre separated the nut from the husk, resulting in complete nut removal. Many commercial manufacturers and entrepreneurs have developed several models for dehusking dry/ chali arecanut. Some of them are listed in Table 2.

Table 3.2: Details of some of the firms manufacturing dehusking machine for chali arecanut

Firm	*Brief specification*	
M/s Aparna Steel Industries, Sullia, Dhashin Kannada, Karnataka	There are four different models of areca dehusking machines with firm. The smallest machine, 'Adithya Mini' which weighs 95 kg and runs in 1 HP single phase motor can dehusk up to 40 Kg of chali; Whereas the slightly bigger one, 'Adithya', which weighs 1,500 kg and runs in 2 HP single phase can dehusk up to 100 kg chali. In the third model 'Adithya Jumbo' which weighs 3,000 kg and runs	

Firm	*Brief specification*
	in 3 HP, 3 phase motor, we can get up to 225 kg chali: and in the last model 'Adithya Areca JCB' which weighs 3,750 kg and runs in 5 HP, 3 phase motor we can dehusk up to 275 kg chali per hour
M/s Basaweshwara Engineers, Kasthurba Nagara, Bengaluru, Karnataka	1HP single phase arecanut (Chali) dehusking machine with 0.25 HP blower which can dehusk up to 80 kg chali per hour. The total weight of the machine is about 250 kg 
CAMPCO Ltd, Mangaluru, Karnataka	It is named as 'Betal-50'. The machine is operated by1.5 HP, single phase motor. The dimensions of the equipment is 950mm x 850mm x 1500mm and total weight is 225kg. It can dehusk about 110kg chali per hour. The electricity consumption is 0.3 kWh 
M/s Mathana Home Industries, Bandagadde of Sagar Tq, Karnataka	Developed two models of arecanut dehusking machines. In the first model, which weighs around 200 kg and runs in 2 HP single phase motor, and can dehusk up to 40 kg chali per hour. In the second model, which weighs around 380 kg and runs in 2HP 3phase motor, and dehusk up to 80kg chali per hour
M/s SRS Agro Service, Nilesara, Sirasi, Karnataka	Weight the arecanut dehusking machine is about 140kg and dimension is 120 x 90 cm. There are two motors fixed to it, one 1.5 HP motor to dehusk and another 0.5 HP motor for blower unit. The machine is operated in single phase electricity and operated by single person. It can dehusk up to 50 kg of chali per hour 
M/s JEC Engineers, Kodicamp, Tarikere, Karnataka	Three different models of arcanut (chali) dehusking machines are available with the firrm. The first model, J-2, weighs 400 kg and runs in 1.5 HP motor and can dehusk up to 150 kg chali per hour. In the second model, J-4, which weighs 550 kg and runs in 2.0 HP motor and can dehusk 270 kg chali per hour. Third model, 

Firm	Brief specification
	J-6, which weighs 650 kg and can dehusk up to 375 Kg chali per hour. All the three machines runs in single phase electricity
M/s Star Associated Industries Belagavi, Karnataka	Have developed five models of chali areca dehusking machines. The smallest model is called as Mini domestic arecanut dehusker. The machine weighs around 170 kg and dehusk about 50 kg of chali (without husk) per hour. The biggest version is the Star brand improved automated double chamber model weighing around 450 kg. It can dehusk up to 200 kg chali per hour. It has a 5.0 HP three phase motor to dehusk the arecanut and another 2 HP motor for the blower. They also have machines run by diesel/ kerosene engines
M/s Shree Matha Industries, Sirsi, Karnataka	Developed an arecanut dehusking machine which can be used to dehusk both tender as well as chali variety. The weight of the machine is about 250 kg and dimension of Length 120 cm; Width 80cm and Height 140cm. The machine can be operated both by single phase or three phase electricity with 3 HP motor. It can dehusk up to 80 kg of tender arecanut (without husk) and 100 kg of chali per hour
M/s Shri Industry, Kolhapur, Maharastra	Developed a small machine weighing around 100 kg (Size: Length 100cm, Width100 cm and Height 150 cm) to dehusk chali variety of arecanut. It operates in single phase electricity. There are two motors fixed to it, one 1 HP motor to dehusk and another 0.5 HP motor for suction unit. The capacity is about 30 kg finished nuts per hour

3.2.8.2 Dehusking Tender Arecanuts

3.2.8.2.1 Dehusking machine developed by UAS, GKVK, Bengaluru

One manual pedal operated small dehusking machine to dehusk mature green arecanuts has been developed by the Post Harvest Technology Scheme, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka (Fig. 3.29). The dehusking assembly consists of two sharp edged flaps, one being stationary and the other movable, operated by a pedal through linkage mechanism. The unit has a hopper to hold about 20 kg raw nuts. The outer shell of the just harvested nuts is pierced on to the upper edge of flaps and is split open by the pedal mechanism. As this is a manually operated one, it is not suitable for large scale operation. Some of the commercial models are detailed in Table 3.3.

Fig. 3.29: Tender arecanut dehusking machine developed by UAS, GKVK, Bengaluru

Table 3.3: Details of some firms manufacturing dehusking machine for tender arecanut

Firm	*Brief specification*
M/s IWAC Pvt Ltd, Chandapura, Bengaluru, Karnataka	 Has developed two different models of machines to dehusk tender arecanut. In the first model (No ADH 02) with two conveyers, which is running in 1.0 HP motor, one can dehusk up to 500 kg of tender nuts (with husk). In the second type, Model No ADM 04, with four conveyers, which is running in 2 HP motor, we can dehusk up to 1,000 kg of tender nuts (with husk). Both the machines run in single phase electricity. The total weights of these machines range from 400 to 500 kg
M/s Maruthi Engineering Works Channagiri , Davanagere , Karnataka	 Has developed three models of tender arecanut dehusking machines. In the first model which weighs around 300 kg and runs in 1 HP motor one can dehusk up to 350 kg of tender nuts (with husk). In the second model which weighs around 400 kg and runs in 2 HP motor we can dehusk up to 700 kg of tender nuts and in the third model which weighs around 550 kg and runs in 2 HP motor, we can dehusk up to 1,000 kg of tender nuts. All these machines work in single phase electricity
M/s SGM Technologies, GSKM Road, Shivamogga, Karnataka	Has developed altogether seven models of tender areca peeling machines, four in belt system and three in gear system. The gear system models work well during voltage fluctuations. The smallest model in the belt system weighs 125 kg and runs in 1 HP motor with single chain. The output is up to 60 kg tender arecanut (without husk) per hour. In the biggest model in the belt system which weighs 325 kg and works with six chains and runs in 2 HP motor one can dehusk up to 270 kg tender nuts per hour. In the gear system, the smallest model weighs 200 kg and runs in 1 HP motor with double chain. The output is up to 120 kg tender arecanut (without husk) per hour. In the biggest model in the gear system which weighs 350 kg and works with six chains and runs in 2 HP motor one can dehusk up to 360 kg tender nuts per hour

3.2.9 Machinery to Polish and Clean Ulligedde/Gorabalu

In the conventional method of dehusking dried arecanuts, about 11% of nuts are not completely dehusked. They generally have thin whitish cover attached to the nuts, This is called as Ulligedde/ Gorabalu and valued as third quality of arecanut. The farmers generally peel the outer skin from such nuts by hand using knives. It generally involves much human labour. Now-a-days, there are machines available in the market to polish such Ulligedde and get good nuts from them in a very short time. Some of them are detailed in Table 3.4.

Table 3.4: Details of some firms manufacturing machines for polishing dehusked arecanuts

Firm	*Brief specification*
M/s Maruthi Engineering Works, Channagiri, Karnataka	Two types of machines are available , one with 2 HP motor having 25 kg capacity and another with 3 HP motor having 35 kg capacity per hour. 
M/s Star Associated Industries, Belagavi, Karnataka	Separate machines are available to polish red Gorabalu and white Gorabalu arecanuts. In the former type, they have one without motor and another with 2 HP single phase motor. In the later type, they have a machine with 3 HP single / three phase motors. The capacity of these machines is about 200 kg per hour. 
M/s Mathana Home industries, Bandagadde, Karnataka	The machine is powered with 1.5 HP single phase motor with a capacity to polish 60 kg Ulligedde per hour.

3.2.10 Arecanut Sheath Shredder

Arecanut sheath is a good alternative use as a fodder for cattle. Its sheath length and breadth ranges between 50-120 cm and 20-35 cm respectively. A compact and energy efficient arecanut shredder developed can be utilized for dry as well as moist arecanut sheaths. It consists of a drum that rotates at a speed of 800 rpm and has four blades, and a counter- shear to shear- cut in both directions. The shredder (Fig. 3.30) operates by a 2.2- kW electric motor, and has a capacity of 100 kg/h, and shreds sheaths into particles of 5-8 mm (Anon, 2014.).

Alternatively the sheath can be used as composting material by using shredder. There are many model of shredder. One of them is depicted in Fig. 3.31.

Fig. 3.30: Arecanut sheath size reduction equipment - ICAR CIAE model

Fig. 3.31: Arecanut sheath shredder

3.3 COCOA

Cocoa (*Theobroma cacao* L) a native of Amazon in South America was introduced to our country during 1960's. It is the primary raw material for confectioneries, beverages, chocolates and other edible products. Majority of the processed cocoa products are consumed within India. The tropical diversified congenial climate available in India provides immense scope for its cultivation. It is a tropical crop, mainly grown in our country under irrigated condition in the four southern states, Kerala, Karnataka, Tamil Nadu and Andhra Pradesh. Being a shade loving crop, cocoa comes up very well as an inter/ mixed crop with palms such as arecanut, coconut, oil palm, etc. Total production of this commodity in our country is about 10,000 metric tons in the form of dry beans.

Cocoa is hardly grown as a mono crop. Its imminent capacity to share the alley spaces of tall growing coconut and arecanut palms and its combining ability with the microclimatic conditions available in such perennial gardens helps its cultivation in utilizing such areas without exacting for an independent growing climate of its own. In any groves of tall growing palms, where 40-50% sunlight penetration is possible, cocoa stands first to absorb such solar energy, remaining symbiotic to the main crop and generating additional income as well, besides helping the amelioration of the soil conditions making beneficial not only for its own growth but also for the benefit of the main crop under which it takes its shelter. When compared to arecanut, the cultivation of cocoa is less labour intensive. It requires lesser manpower for its cultivation and post harvest operations.

3.3.1 Raising Nursery

Nursery bag filling with compost is being done manually employing human labour. The Central Institute of Agricultural Engineering, Regional Centre, Coimbatore has developed a machine to mix potting mixture and fill the poly bags.

3.3.2 Collecting Scions for Grafting

Cocoa is generally propagated by raising seedlings. However, to get quality and high yielding trees, one has to go for grafting. Soft wood grafting is common in cocoa for which tender scions are to be collected from the growing tip of healthy branches. There are many telescopic seizer type cutter at one end to cut the scions from different heights for grafting up to 7-8m (Fig. 3.32). Branch cutters with telescopic handles are also available which can be used for grafting.

Fig. 3.32: Cocoa scion cutter device

3.3.3 Pruning in Cocoa

The branches of Cocoa need to be pruned every year. In smaller trees, it can be done by skilled labourers standing on the ground using sickles, but in bigger trees, one has to climb the tree to prune the branches. Now- a-days special branch cutters are available with long handles to prune the branches without climbing the tree. Such branch cutters with telescopic handle (5m length) and teflon coated high carbon blade to prune the branches of bigger trees are commercially available (Fig. 3.33).

Fig. 3.33: Commercial model of cocoa branch cutters

3.3.4 Harvesting Cocoa Pods

Long aluminium/ steel lances with double edged 7-8 m length to harvest cocoa pods have been developed. The harvesting lances of both fixed and telescopic types are available (Fig. 3.34).

Fig. 3.34: Cocoa pod harvester

3.3.5 Breaking Cocoa Pods and Extracting Beans

After the harvest of cocoa pods, they are generally broken by beating on a hard surface and the beans are extracted by hand. Manual cocoa breaking equipment has been developed by Tamil Nadu Agricultural University, Coimbatore. On a large scale, it involves much manpower. Some entrepreneurs have attempted to develop the machine to cut open and extract beans from fruits (Fig. 3.35).

Fig. 3.35: Cocoa pod breaker- Hand operated and motorized

3.4 CONCLUSION

Though there are several equipment/gadgets available commercially to arecanut–cocoa farmers, a large number of them are not reaching the small and marginal farmers due to their financial constraints to purchase and utilize them. If more and more entrepreneurs and establishments come up and establish custom hiring centres to hire such machinery with operators to the needy farmers, it will definitely be a boon to the arecanut-cocoa farming community and would greatly help in mechanising arecanut and cocoa gardens.

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