

A cost-effective ground pollination system for hybridization in tall coconut palms

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Large-scale production of hybrid seed nuts of commercially cultivated palms such as coconut, arecanut, oil palm and date palm is of prime importance due to the high demand for hybrid nuts and their role in augmenting the production of these crops. However, commercial production of hybrid nuts in these crops is impeded by various factors such as height of the palms, cost and availability of labour, low percentage of fruit-setting, seasonal influences like monsoon rains, etc. We report here the development and use of a simple, viable, cost-effective and labour-saving device for pollinating tall palms from ground-level, which is ideal for large-scale commercial production of coconut hybrids, even by farmers. At least four climbs per coconut palm can be saved by this method during the hybridization process. This simple method can enhance the availability of hybrid seedlings at a cheaper rate to coconut farmers. This method of pollination developed for coconut, can easily be adapted to other commercially important palms depending on the bunch morphology.

Coconut is the most important tropical palm of India, occupying an area of 2.07 million ha producing 23.3 billion nuts/year¹. More than 10 million farm families are directly dependent on coconut cultivation for their subsistence. The average productivity of coconut in India is only 30 nuts/palm/year, which is among the lowest in the world. Coconut cultivars are generally identified as tall, dwarfs or hybrids. Amongst these, hybrids between tall and dwarfs are preferred for their medium height, early flowering habit, increased nut and copra yield (2.79–6.28 tonnes of copra/ha/year), high quality and quantity of oil, better drought-tolerance and disease-resistance capabilities when compared to their parents or other cultivars. On an average, a hybrid coconut tree yields 100 nuts more per palm per year which is a 200–300% increase in yield when compared to the local cultivars. So far, 19 hybrids have been released for cultivation in India. These include, eleven tall × dwarf hybrids and eight dwarf ×

tall hybrids². The parental tall and dwarf coconut palms can grow more than 30 and 12 m respectively, necessitating trained professional climbers to carry out the hybridization work. In India, 10 million coconut seedlings are produced annually by various agencies, and out of this, only 0.3 million are hybrids³. Government research institutions and various private seed agencies are unable to meet the increasing demand for hybrid coconut seedling as they are now being produced mainly by hand pollination technique that requires repeated climbing of the same palm, which is proving costly and cumbersome. Setting percentage of hybrid seed-nuts is also very low with only about 15–20% of female flowers converting into viable seed-nuts. Added to these woes is the non-hybrid, off-type rejects appearing in the nursery (to the tune of around 30%), due to certain uncontrollable extraneous factors operating during pollination. As a result of low fruit-set and high cost of seed-nut production due to repeated climbs, the

small and marginal coconut farmers are unable to afford the high cost of hybrid coconut seedlings which are now priced between Rs 200–600/seedling by various Government and private hybrid coconut seedling producers.

A MASs Controlled POLLination or MASCOPOL system was devised to obviate the need to bag individual inflorescences. However, it can be practised only in isolated seed gardens planted with compact blocks of parental palms⁴. Another method of pollination using a long tube attached to a squeeze wash-bottle was tried earlier; but this method is applicable only in dwarf palms and suffers from practical difficulties like steadily holding and correctly directing the tube to the tiny opening in the transparent plastic window of the isolation bag. Hence this method is not in practice anymore⁵.

We report here the development and use of a simple, viable, cost-effective (Table 1) and labour-saving device for pollinating tall palms from the ground-level.

Table 1. Details of the various parts of the pollination equipment and its cost-estimate

Component parts of the device	Cost (Rs)	Remarks
PVC tube – 8 mm diameter (length as per tree height)	200	Needed for individual palms
Pollen chamber	250	Can be used for pollinating multiple palms
12 V air pump	500	One time investment
12 V rechargeable battery	850	Rechargeable and a single charge can be used for pollinating 25 palms
SMPS battery charger	500	Can charge many batteries
Modification of the pollination bag and other miscellaneous items	100	Single-use pollination bags stitched with buckle straps
Total investment	2400	Fixed cost – Rs 2100 for 25 palms. Each palm, an one-time cost of Rs 300 for 30 mts of pollen delivery tube, nylon rope and belts.

This technique is ideal for large-scale commercial production of coconut hybrids, even by farmers. This device can also be extended for hybrid seed-nut production in other commercially valuable palms such as oil palm, date palm, arecanut and palmyrah.

Pollination equipment

This equipment consists of the following components:

Pollen chamber: A hollow closed chamber with a screwable lid, that houses the air inlet and outlet that are positioned at right angles to each other (Figure 1).

Pollen tray: A removable small tray/cup with a 0.01 mm fine wire-mesh below and an open top, that can be snugly fitted to the mouth of the pollen chamber's inner inlet. The pollen meant for pollination is filled in this pollen-tray. The fine wire-mesh prevents the pollen from falling into the pollen chamber so that the pollen can be forcibly blown away through the air outlet into the attached tube that is directed upwards to the pollination bag fixed atop the palm-crown. The fan fitting acts as an exhaust and blows out pollen steadily from the pollen tray (Figure 1).

Pollen delivery tube: An 8 mm internal diameter, clear, flexible, PVC tube, whose length is suited to the height of the coconut palm to be pollinated (Figure 2). The length of the pollen delivery tube can be increased by simple coupling as the tree grows year after year.

A 12 V electrical air-blower: A switch-operated 12 V air pump (Figure 2).

A 12 V rechargeable storage battery: This is the power source for the 12 V electrical air-pump (Figure 2).

Battery charger: It is used to recharge the 12 V battery.

A modified pollination bag: The standard rectangular pollination bag was suitably modified with four stiff belt attachments (four short belts of 10–15 cm length at a distance of 20 cm from the top-edge and a long belt of 30 cm stitched onto the top-edge of the bag. The ends of short belts are fitted with durable plastic buckles (Figure 3).

Hose guide: This is a metal bracket with four arms that tightly holds onto the pollen delivery tube. This metal bracket is fitted at a distance of 10–15 cm from the tube end that delivers the pollen into

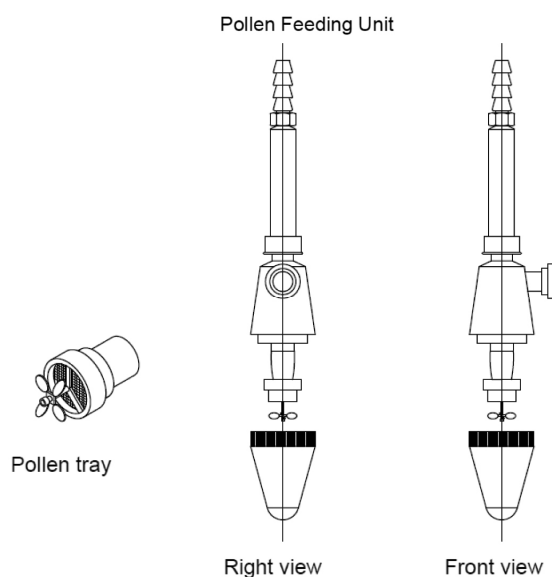


Figure 1. Pollen chamber and the pollen tray.

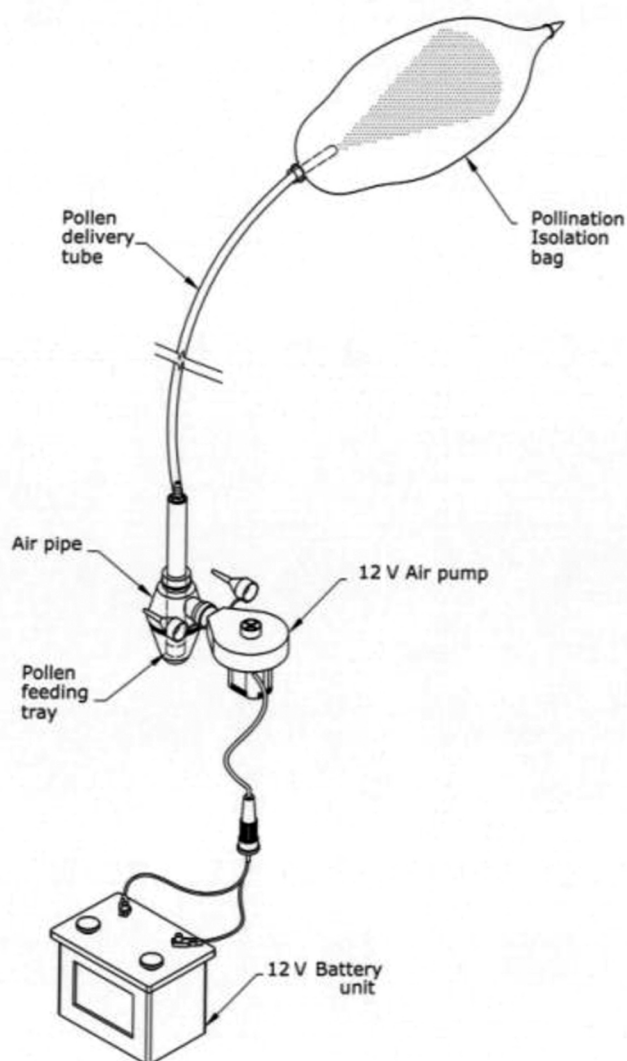


Figure 2. Pollen-delivery tube, pollen chamber/feeding unit and 12 V air pump.

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the pollination bag. A set of four belts with adjustable buckles is tightly fitted with screws to the four arms. These buckles can be locked to those of the short belts of the modified pollination bag (Figure 4).

Nylon rope: This is a long nylon rope (5 mm diameter) of length equal to that of the pollen delivery tube. One end of the nylon rope is attached to the long belt of the pollination bag, which is tightly

tied to the inflorescence stalk. It runs along the pollen delivery tube which is attached to a double hinge at equal intervals.

Operational details

In conventional hand-pollination, once the mother-palm to be pollinated is identified, the climber carries the pollination

bag and a small machete to the crown of the palm, emasculates the male flowers just prior to anthesis, and covers the inflorescence securely with the pollination bag. Over the next few days, the climber climbs again to check the maturity/receptivity of the female flowers. Once the day of maturity is ascertained, he then climbs the palm for four successive days to spray the pollen-talc mixture (1 : 9 ratio), so that all the successively maturing female flowers are pollinated. Three days after the last pollen spray, the climber climbs the palm again to remove the pollination bag so that the dampness inside the pollination bag does not affect the further development of nuts. Thus, seven climbs are normally required for a climber to complete the pollination of a single inflorescence.

Using the available simple device, the climber initially ties the pollen delivery tube tightly to the top end of the pollination bag. He then buckles the belts of the hose guide with the short belts of the pollination bag. He then ties the pollination bag along with the pollen delivery tube around his waist and climbs initially to the crown of the palm, with the pollen delivery tube drooping down. After reaching the crown of the palm, he removes all male flowers and covers the inflorescence with the pollination bag with the pollen tube suspended to the ground. He then climbs down and securely ties the drooping pollen delivery tube to the basal trunk of the palm (Figure 5 a). The end of the tube is secured with a cap for preventing passage of insects.

After a few days, the climber climbs again to ascertain the maturity of female flowers. Thereafter, there is no need to climb the palm for dusting the pollen four successive times and for final bag removal. Skilled climbers are not required after this stage. Anybody can use the device to perform the pollen pumping/dusting from ground-level itself. The pollinator carries the pollen chamber containing pollen-talc mixture and the 12 V electric air-pump with the charged battery, near the pollinating palm. The lid of the pollen chamber is removed and the pollen tray is then detached. Around 500 mg of the pollen-talc mixture (1 : 9) is filled in the pollen tray which is then fitted near the outlet of the pollen chamber. The outer lid of this chamber is then closed tightly. The drooping end of the pollen delivery tube is fitted to the outlet

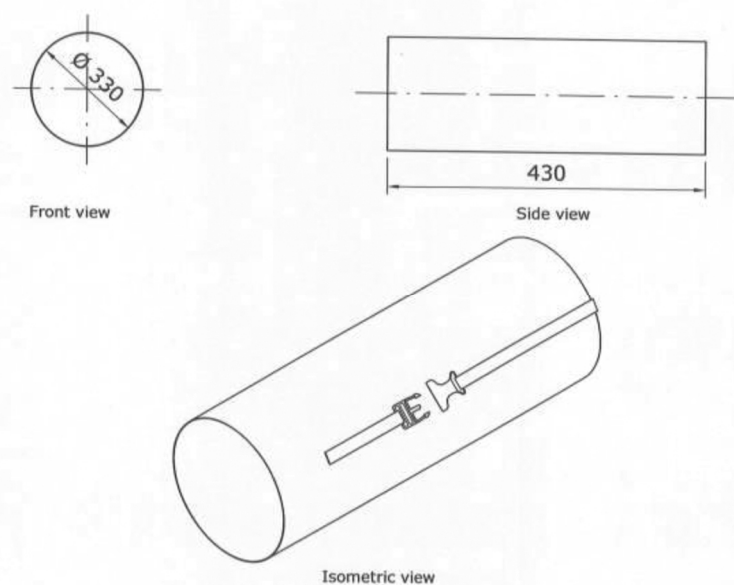


Figure 3. Modified pollination bag.

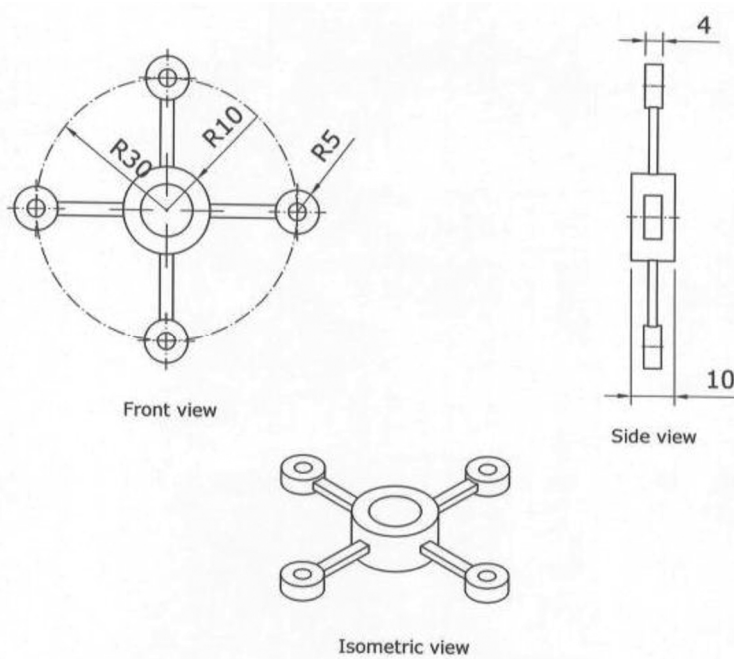


Figure 4. Details of hose guide.

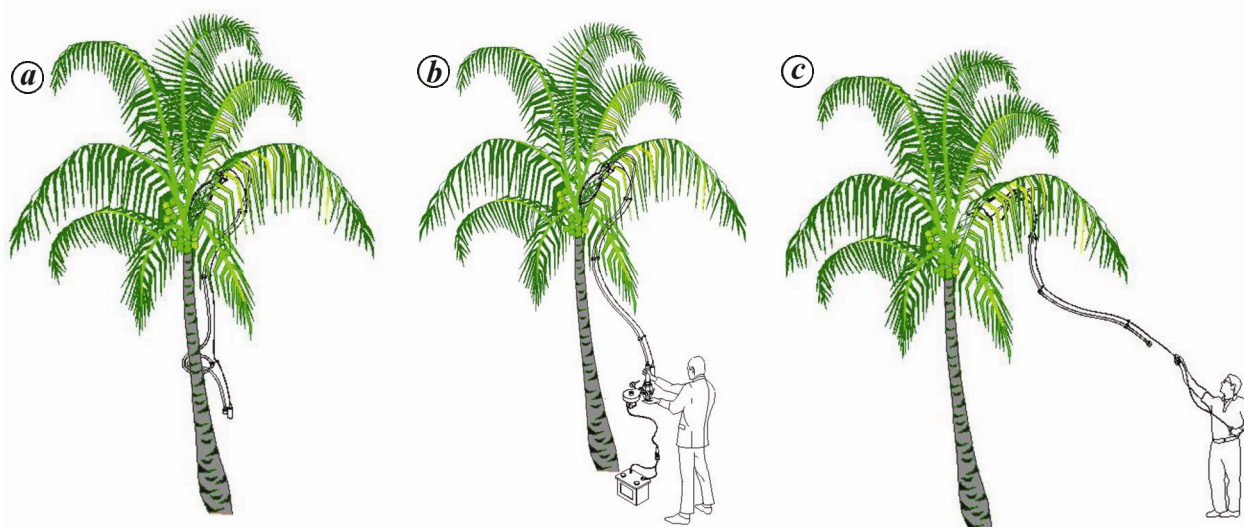


Figure 5. Illustration of the various activities involved during the use of the ground pollination device. **a**, Resting position; **b**, Operating position; **c**, Removal position.

Table 2. Comparison of the new improved pollination procedure with the existing one in terms of the number of climbs saved

Pollination activity	Whether climbing required?	
	Manual pollination method	With ground pollination device
Emasculation and bagging	Yes	Yes. Along with bagging, to fix and suspend the pollen delivery tube from the emasculated inflorescence
Inspection for stigma receptivity and for pollen-spray	Yes, once	Yes, once
Dusting pollen 1st time	Yes	No
Dusting pollen 2nd time	Yes	No
Dusting pollen 3rd time	Yes	No
Dusting pollen 4th time (If required)	Yes	No
Pollination bag removal	Yes	No

of the pollen chamber and the air is pumped through the inlet valve of the pollen chamber using the 12 V electric air pump (Figures 5 b and 6 b). In less than 15 sec, the entire pollen-talc mixture travels through the pollen delivery tube and is uniformly sprayed inside the pollination bag. This simple process is repeated for another three days so that all successively maturing female flowers are pollinated. Three days after the last pollen-spray, the bag is removed by pulling the rope which unties the knot from the bunch and loosens the bag. By pulling the pollen delivery tube, the entire bag is pulled down from the bunch effortlessly without any damage to the flowers (Figure 5 c). The hose guide and the four attached straps facilitate the smooth and effortless detachment of the pollination bag from the bunch. Thus, this method obviates the need for five repeated

climbs of the palm for hybridizing a single inflorescence (Table 2). After successfully pollinating one tree, the pollen chamber is unscrewed and detached from the pollen delivery tube and the pollination unit can be taken to the neighbouring tree for pollination. The device set-up and operational procedures are outlined in the flow chart 1.

Comparison between manual and ground pollination device

Both the ground pollination device and manual pollination require the pollination bag to prevent the extraneous pollen from other sources. In the ground pollination device, an 8 mm tube is suspended to the ground which acts as a conduit to pump the pollen from the ground. Because of ground level opera-

tion, anyone with basic knowledge of connecting the pump to the battery terminals can easily operate the instrument. While it takes 15–20 min for the climber to reach the crown of the palm and manually spray the pollen inside the bag, it takes less than two minutes to connect and pump the pollen to the top. The ground pollination device also avoids inadvertent shedding of the buttons/immature fruit of the inflorescence bunches as against manually climbing which requires clearing the way to reach the crown of the palm. For effectively comparing the ground pollination device and the manual pollination method, the pollination was carried out in two successive bunches during the October and November months respectively, to minimize the seasonal variations in fruit setting. Of the three palms tested at three different locations, the setting percentage

Flow chart 1. Setting up and operation of the ground pollination device

(a) Setting up of the ground pollination device

Insert 15 cm length of one end of the pollen delivery tube inside the central ring of the hose guide and fix it. Fix the islets of the flour nylon belts in each of the arms of the hose guide using a nut and screw.



Fix the protruding end of the pollen delivery tube (about 15 cm in length) inside the modified pollination bag such that the hose guide is outside and tie it tightly. Now buckle the one end of the four plastic buckles in the belt to the corresponding buckles stitched on the pollination bag.



The other end of the pollination bag contains a half metre long stitched rope. At the end of the rope a removable hook is provided. The hook contains a long nylon rope which runs along the length of the pollen delivery tube.



Now the pollination tube along with the pollen bag is tied around the waist of the climber and the climber climbs the palm. As the climber climbs the palm the pollen delivery tube hangs from his waist.



The climber reaches the top of the crown and emasculates the male flowers leaving behind only the female flowers in the inflorescence. He then removes the pollination bag from his waist and covers (tie) the inflorescence with it, with the pollen delivery tube suspended from the other end.



The suspended pollen delivery tube touches the ground level and the end of the tube is fitted with a screwable cap. The pollen delivery tube is tied at the base of the palm and left undisturbed for a few days till the female flower maturity is ascertained.

(b) Operational details of the ground pollination device

Once the maturity of the female flower is ascertained, pollination starts with spraying of the pollen talc mixture. The screwable cap from the suspended pollen tube is accessed from the ground, opened and the pollen chamber is attached to the pollen tube.



The lid of the pollen chamber is removed and pollen tray is filled with the pollen talc mixture and the lid is closed. The 12 V electric pump is connected to the battery and the nozzle is fitted to the entry point of the pollen chamber and the air is pumped. The pollen talc mixture reaches the pollination bag in few seconds. The delivery of the pollen is judged by inspecting the pollen tray for the remaining pollen talc mixture.



The spraying of the pollen talc mixture is continued for the next 4–5 days from the ground itself.



Three days after the final pollen spray, the nylon rope is pulled to untangle the knot and the pollination bag is removed by the pulling the pollen delivery tube. The pollination bag falls to the ground.

Table 3. Comparison of the test results of the ground pollination device at three different locations with the manual setting percentage

Location	Year of testing	Height of the palm (m)	No. of female flowers		No. of nuts set (after 3 months)		% Setting	
			Device	Manual	Device	Manual	Device	Manual
CPCRI Farm, Kasaragod	2014	18	39	42	9	8	23	19
CPCRI Seed Farm, Kidu, Nettana, Karnataka	2015	15	29	28	11	12	38	43
CPCRI Regional Station, Kayangulam	2016	26*	68	50	25	18	37	36

*Root (wilt) disease resistant mother palm.

varies between 23 and 38 and is comparable to manual pollination of around 19–43 (Table 3). Due to individual palm-to-palm variations and alternative

bearing, a reliable comparison requires an average data of large number of palms spread over 3–4 years and over different seasons. This ground pollination device

saves at least 4–5 climbs to the crown of the palm/bunch of pollination, while maintaining the same/better efficiency of nut setting. The coconut pollination can

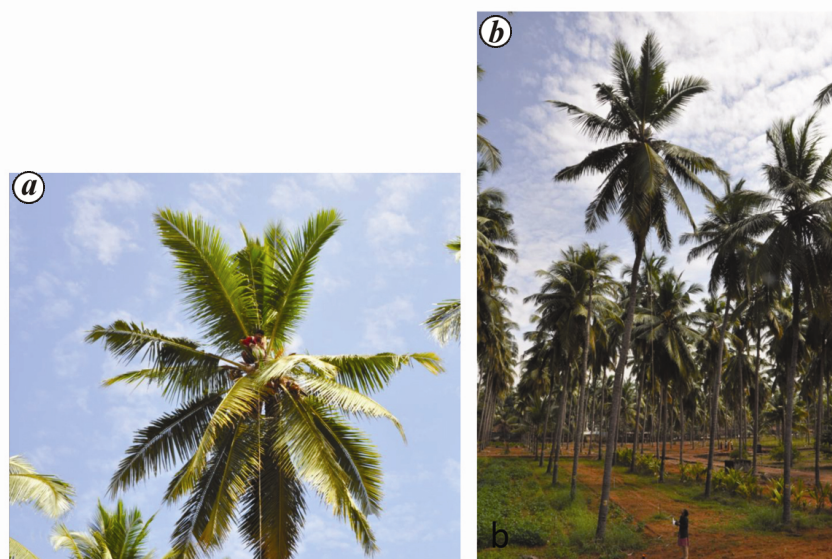


Figure 6. *a*, Pollinator emasculates and ties the pollination bag on the inflorescence with the 8 mm diameter pollen delivery tube suspended to the ground. *b*, A woman carries out pollen dusting on a 26 metres tall coconut palm from ground which is usually carried out once daily by climbing the tree for 4–5 consecutive days per inflorescence.

be carried out 12–13 times in a year (an average emergence of 1 inflorescence bunch/month), saving 48 climbs per tree in a year. Suppose pollination is carried out for 100 mother palms, 4800 climbs can be saved in a year. This roughly translates to a saving of Rs 96,000/year (Rs 20 as climbing charge/palm). The cost of hybrid coconut seed nut is around Rs 200–600, and this simple device can significantly bring down the cost of hybrid seed nut production by about 20%. The main impediment to large scale production of hybrid seed nuts is the non-availability of climbers who are becoming rare and scarce with every passing year. This simple device can help overcome scarcity of climbers since anyone irrespective of gender and age, can operate it easily.

Cost analysis

The fixed cost of ground pollination equipment unit is Rs 2100 and covers the cost of a 12 V rechargeable battery, battery charger, 12 V electric pump and the pollen chamber. It can be used for 20–25 palms located in a single locality. A single charge of battery can be used to pollinate 25 palms at a time. Each palm requires a modified pollination bag, a nylon rope, four nylon belts and a pollen

delivery tube. The nylon rope, belts and the pollen delivery tube which can be used multiple times cost Rs 200, which is also a fixed cost. A recurring cost of Rs 100 is needed for stitching the single use pollination bag with four buckle straps which is required for pollinating each bunch.

The cultivated coconut palms worldwide are aging and becoming senile. They need to be replaced with high-yielding and disease-resistant/tolerant planting material. The hybrid coconut seed-nut/seedling requirement in India alone is 1 million seed nuts/seedlings per year. At present less than 0.3 million hybrid seed-nuts are being produced by all agencies put together. This simple method has the potential to generate 5- to 10-fold increase in production of hybrid nuts at a cheaper rate. Moreover, pollination in palms has never been easy work. But now using this simple device, farmers can produce hybrid nuts themselves. Availability of coconut climbers is of serious concern for the mass-pollination work. This simple method reduces the drudgery of repeated climbs and our complete dependence on climbers to carry out the pollination work in palms. In root (wilt)-disease-ravaged tracts of Southern Kerala, India, the *inter-se* derived seed-nuts of resistant palms were found to be performing better when com-

pared to open-pollinated nuts collected from resistant/tolerant palms. There is a huge demand for disease-resistant/tolerant planting material and research institutions and Government agencies are unable to cater to the ever-increasing demand for planting materials. The resistant palms are located at far-off distances and pollen from the male parent has to be transported to the site of the female palm and pollinated. This requires the climber to travel 30–40 km daily for the pollen spray which is done in few minutes. Using the ground pollination method, the pollen can be made available at far off places, for four consecutive days of pollination, either through post/by local delivery/by cool storage in fridges. Local farmers and youth (both male and female) can be trained to pollinate with this simple method. This saves labour, travel, time, money and significantly increases the availability of seed-nuts/seedlings and reduces the cost of production (from the present Rs 500/nut, due to long distance travel in scooters to reach the site of the palm) of disease-resistant/tolerant planting material. The equipment is fabricated with locally available materials and can be used several times. The farmers themselves can assemble the system with locally available components. The cost of equipment can be recovered from pollinating just 10 bunches, and the

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rest of its uses comes free. Hence, it qualifies as a low cost or no cost device, suited for small and marginal farmers. The adoption of this simple technique can lead to increased availability of hybrid and disease resistant coconut seedlings. The widespread availability of quality planting material and the concomitant increase in yield due to planting these hybrid seedlings by the farming community can bring prosperity to rural areas.

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