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Development of manually operated sapota harvester

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■ **ABSTRACT :** The manually operated PVC made citrus harvester is usually used by the sapota growers in Konkan region for harvesting the sapota fruits. It is very light in weight and easy to fix with bamboo or pipe. Though the penetration of the harvester in the plant canopy is better, finding and plucking out the fruit through it is difficult due to its visibility issue. As the harvester is made up of opaque PVC material, the fruits can not be seen through it when used beyond some angle of inclination with the ground. The fruits may get popped up out of the harvester at particular inclination. Due to this restrictions of the inclinations, the picker (person) may develop some strains in neck and shoulder. Considering this, a sapota harvester made up of 6 mm circular MS rod was developed with better visibility through it and to have better angle of inclination with horizontal (0 to 90^{O}) for harvesting the fruits without letting it popped out of the harvester. A. The developed sapota harvester met the requirements and found comfortable for sapota harvesting. The picker (person) can operate the harvester at wide range of angle of inclination with the horizontal.

■ **KEY WORDS :** Sapota harvester, Bamboo, Metal pipes, MS rod

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Traditional manual methods of fruit harvesting include snatching or pulling of fruits with hand, hitting fruits/branches with a stick, shaking tree branches, snatching the fruits by manual fruit harvesters mounted on bamboo or metal pipes etc. The fruits at short height can be harvested by hand while those at more height have to be harvested with bamboo or stick or using ladder. Harvesting the fruit by hitting it is quite cumbersome and cause considerable damage to fruits and adversely affecting their quality. Shaking tree trunk and branch is effective only in the crops which shows uniform fruit maturity and where the fruit detaching force is minimum. There is a chance that the immature fruits may also get harvested and the over matured fruits may get damaged when falling on the ground due to shaking tree branch or limb. Hence, fruit snatching and collecting device fitted to the bamboo are mostly preferred in the developing countries. The harvesting rate *i.e.* number of fruits harvested per hour may vary depending upon the type of fruit, height of fruits, size and shape of fruit, fruit bearing structure of the tree and terrain and skill and stamina of the person harvesting the fruits. The fruit harvesting rate goes down if done continuously for longer time.

Sarig (1993) concluded that mechanization of the fruit harvesting and primarily of those that are destined for the fresh market, is still manual task and is highly desirable in many countries due to decrease in seasonal labor availability. Sanders (2005) reported that none of the currently available mechanical harvesting systems have been able to fully replace the flexibility and fruit selection abilities of manual pickers. All the mechanical

fruit harvestersare based on the once-over harvesting with no provision for selective harvesting which is the common requirement of the many fruit crops. Prussia (1985) mentioned that in many countries manual harvesting is preferred over the mechanical harvesting as human beings have the better sense of harvesting the suitable fruit than the mechanical harvesters. Mechanical harvesters are suitable only for the once mass harvesting. Penttinen, 1987 and Meyers, 1997 found that due to many hours' long physical strain as well as the monotypic character of movements performed by the picker (person), apple harvesting may contribute to the development of ailments in the musculoskeletal system. It is most often manifested by pain in upper limbs, lower limbs and the spine. The studies conducted by Pinzke *et. al.* (2001); Armstrong (1986) and Stal *et al.* (2000) have shown that in addition to the wrists, extreme loads are applied on the forearms and often the neck and the lumbar part of the spine. It is directly related to the angles at which the wrists and hands are positioned while performing the subsequent moves.

Satyagopal *et al.* (2015) mentioned that the average height of cultivated specimens, however, is usually between 9 and 15 m with a trunk diameter not exceeding 50 cm.A number of harvestings are required during the harvesting season as fruits of the sapota do not mature at a glance. As the plant canopy is very dense, harvesting the fruits is bit difficult. Sapota fruits can not be harvested by hitting it as it may get mechanically damaged. The damaged fruits can be used for processing only. As the sapota fruits don't have demand for processing in the Konkan region, the fruits should be harvested undamaged only for better fresh market value. In Konkan region, the mechanical fruit harvesters for sapota fruit are not available and also these can not be used considering the non uniform maturity of the fruits. Sapota growers use mango harvesters or PVC material citrus harvester. This harvester is used for harvesting of small fruits like lemon, sapota etc. It consists of main body of PVC having cylindrical shape. The upper end of the body is closed while bottom end is open to which nylon net for collecting the fruits is tied. A stretched string closes the other end of the net. A gate is made on the body for entry of the fruits to be harvested. On the lower surface of the body a metal holder is fixed to hold the bamboo of required length. Two fingers cut in V-shape and with small sharp blades are provided at the closed end of the body of the harvester. The fingers help to select and hold the fruit to be harvested from the bunch. By pulling the harvester, fruit is detached from the bunch, which falls in the body and rolls into the net. To unload the harvested fruits in the net a stretched string at the closed end of the net is loosened (Fig. A). It can be penetrated easily through the plant canopy. It is having one drawback that the fruit can not be seen through the harvester while harvesting. This makes it difficult to harvest the fruits. Considering this aa study was undertaken to develop a sapota harvester with the following objectives:

Objectives:

– To find the different types of sapota harvesters available in the Dapoli market.

– To develop a new sapota harvester.

– To study the performance of the newly developed sapota harvester.

■ METHODOLOGY

Study on the available sapota harvesters:

A survey was made to find out the available sapota harvester. The following two sapota harvesters were found in the market and used by the farmers.

The sapota harvester shown in the Fig. A (a) is made up of MS rod (4 mm dia) while the sapota harvester shown in the Fig. A (b) is made up from the scrap plastic bottle. The Indian Institute of Horticultural Research, Bengaluru has also recommended some sapota harvesters (Fig. B).

(a) Sapota harvester made up of MS rod, pipe and nylon net

(b) Sapota harvester made up of plastic bottle, MS plate and MS rod

Fig. A : The available sapota harvesters

(a) Sapota harvester 1 (b) Sapota harvester 2

Fig. B : Sapota harvesters recommended by Indian Institute of Horticultural Research, Bengaluru

The lime harvester as shown in the Fig. C can be used for the harvesting of the Sapota and the hence similar harvester of Dr. BSKKV, Dapoli named 'Atul' sapota harvester is used for the sapota harvesting. The features of the Atul sapota (Fig. D) harvester are

Fig. C : Lime harvester recommended by Indian Institute of Horticultural Research, Bengaluru

Fig. D : Atul sapota harvester

Features of 'Atul sapota' harvester:

– A hand tool to harvest sapota, kokum, ber, kagzi lime and similar fruits easily

– No injuries to fruits,

– Nylon net for collecting fruits

Requirement of wooden handle suitable to tree height, Capacity: 600 fruits/hr.

The MS rod made harvester [Fig A (a)] required more MS material and nylon net. The plastic bottle harvester is having the limitation that the fruit can not be harvested at any angle (horizontal position), as the fruits may fall down out of the bottle. While harvesting the fruit, if the jerk is given then the fruit may pop out of the bottle. The limitation of the Atul sapota harvester is having poor visibility of the fruit through it at particular inclinations. Hence, a new sapota harvester was developed (Fig. E and F) to have ease for harvesting the fruits and to have better visibility of the fruits.

The cost and weight of the harvesters were determined and found as below in Table A.

Table A : Weight and cost of sapota harvesters available in Dapoli

Sr. No.	Type or name of sapota harvester	Weight of harvester, g	Cost of harvester, Rs
1.	Atul Sapota harvester, Dr. BSKKV, Dpoli	338	250/-
2.	Bottle type harvester (Wada, Thane made)	144	70/-
3.	M.S. Rod harvester (Kolhapur made)	338	160 to 200
4.	Newly developed harvester	382	---

Considering the limitations of the existing sapota harvester, a new sapota harvester is developed. The details of the newly developed sapota harvester is as below.

Construction of the sapota harvester:

Main ring:

The harvester is made up elliptical ring made from 4 mm diameter MS rod. The elliptical ring is having 14 cm radius and 28 cm length. This ring is then bent to have the curve of 22 cm radius as shown in Fig. E and F.

Bamboo (handle) fixing arrangement:

One of the ends of the elliptical ring is welded with a nut inserted in it. The nut is the provided with a bush like ring having wing nut provided to it to lock bush with the nut welded on the ring. Exactly at the diametral end

on the wing nut, the 3 cm diamter and 12 cm length MS pipe is welded to fix bamboo of desired length in it. The pipe is provided with the bush arrangment so that the angle of the bamboo with respect to the elliptical ring could be changed easily. This can help to harvest the fruits at different heights by placing the bomboo at different confertable angles.

Hook:

The 'Y' shape hook having upper 'V' of 30°, 45° and 60° and length of 6.5 cm is made up of 4 mm diameter MS rod. The lower arm of the 'Y' is made up of 1.5 cm long bolt so that it coud be fixed with the bush provided on the ring. The 'Y' shaped hook is used to change the angle of the bamboo with respect to the ring and also for harvesting the fruits.

Nylon net:

The nylon net is tied to the ring to catch the harvested fruit in it.

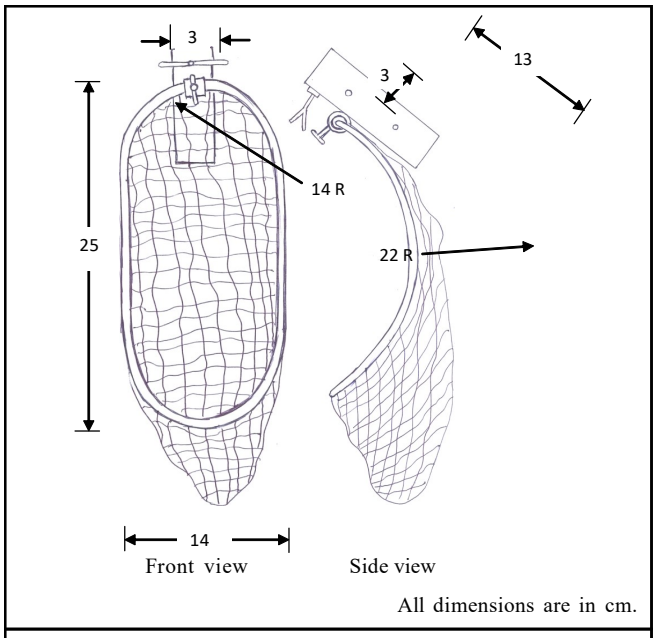

Fig. E : Details of newly developed sapota harvester

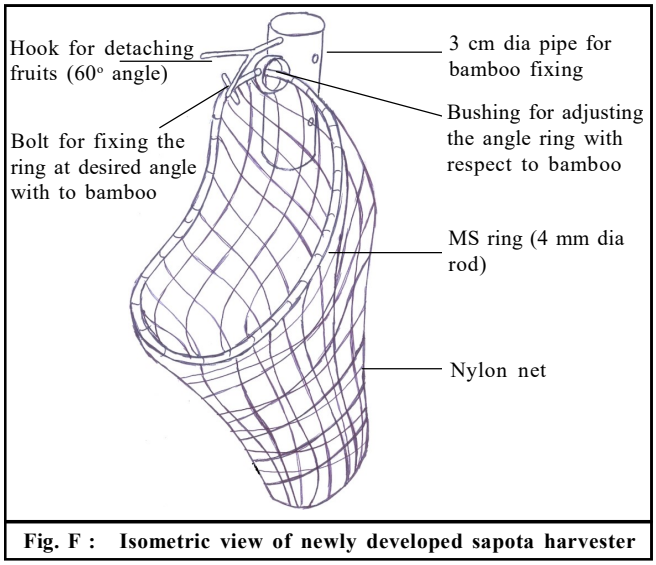

Fig. F : Isometric view of newly developed sapota harvester

■ RESULTS AND DISCUSSION

The developed sapota harvester was tested (on 28/02/2017 and 21/03/2017) for its performance for harvesting of sapota at Pangari Block, Dr. B.S. KKV, Dapoli during the sapota harvesting season (March 2017) depending upon the availability of the matured fruits. The sapota fruits of variety 'Kalipatti' were harvested using the developed harvester. The height of the crop was about 7 m while the canopy was about 6 m in diameter. The plantation was on the flat land. Two male labours for fruit harvesting and two female labours for fruit collecting were employed on 28/02/2017 and two male labours were employed for fruit harvesting and collecting on 21/03/2017. Two different bamboos of lengths 2 m and 3.3 m, respectively were used for the harvesting.

Total harvesting time and productivity:

The performance of the harvester was evaluated based on the total harvesting time and labor productivity. The harvesting was done for 120 min in first trial and for 40 min duration in second trial. The labours were not intimated about the duration for which the trial was to be conducted to estimate the average labor productivity (kg/h). The total harvesting time includes selecting, detecting and detaching fruit to be harvested, collecting or gathering detached fruits in the basket. In addition to this, the time required for moving harvester between trees inside the field was also considered. The total harvesting time is divided in productive and non-productive time. The productive time means the time required to actually harvesting the fruits while the non-productive time means the time utilized for harvester adjustment, detecting and selecting the fruits from the tree and moving from one tree to another. It also included the labourers personal time *i.e.* taking rest and drinking water. The number of trees from which the fruits were harvested was also

measured. The data is presented in Table 1.

Capacity of newly developed harvester:

The newly developed harvester can harvest about 100 trees per hour with the help of two labours depending upon the number of matured fruits available per tree. It was observed that the capacity of the harvesting depends upon the skill of the operator and his way of selecting the fruits to harvest. In the second trial on 21/03/2017, the operators have selected the fruits based on maturity only while the size of the fruits was not taken into consideration. Hence, the selection time was reduced in the second trial compared to the first. In the first trial, the operators were more concerned about the size of the fruits, hence the time required per tree to harvest is more. The first trial was conducted for longer time as female labours were available to transport the fruit collection basket from one tree to another. In case of second trial, a shoulder bag of plastic material was used to carry the harvested fruits. Hence, the trial was conducted until the first break for rest. The harvesting capacity was 12.8 kg/h (111.5 fruits/h) in the first trial while in the second trial the harvesting capacity was 12.8 kg/h (243 fruits/h). The data is presented in Table 2.

Performance of harvester with different lengths of bamboo, ring inclination and shape of hook:

The two different lengths of bamboo *i.e.* 2 m and 3.3 m were used for the harvesting of the fruits with the harvester. Both the harvesters were used at a time on the same tree so that the fruits from the different heights could be harvested easily. The 2 m bamboo could harvest fruits up to the height of 5 m while the 3.3 m bamboo could harvest the fruits up to the height of 6.3 m.

Initially the fruits were harvested by setting the ring at different inclinations with respect to the bamboo. But, with the experience it was observed that the angle of about 45° with the bamboo was most convenient to harvest the fruits at different angles. The combination of inclination of the ring with the bamboo (45°) and the curvature of the ring made it easy to harvest the fruits at any height and at any inclination angle (vertical to horizontal position) of the bamboo. Even the fruits could be harvested at vertical line also .

To evaluate the effect of the angle of upper portion of the 'Y' shaped hook *i.e.* angle of 'V', three different hook were made with the angles 30°, 45° and 60°. It was observed that the 60° angle hook is more convenient to use to detach the fruit. Hence, it was used for the further trials.

Visibility through the harvester:

The harvester is having the better visibility through it than that of the 'Atul sapota harvester'. This makes it convenient for detaching the fruit from tree. The operators found it easy to use it than the Atul sapota

Table 1 : Actual capacity of manually operated newly developed sapota harvester

Sr. No.	Date of trial	No. of labours employed	No. of trees harvested	No. of fruits harvested	Quantity of fruits harvested, kg	Duration of trial, min	Productive time, min	Non productive time, min
1.	28/02/2017	Total – 4 Male – 2 Female – 2	25	223	25.6	120	85	35
2.	21/03/2017	Total – 2 Male – 2 Female – 0	12	166	14.2	40	30	10

Table 2 : Performance of harvester

Sr. No.	Parameters	28/02/2017	21/03/2017
1.	Time required to harvest one tree, min	4.8	3.33
2.	No. of tree harvested per hour	12.5	100
3.	Harvesting capacity, kg/h	12.8	21.3
4.	Man-h required per kg	0.31	0.09
5.	Fruits damaged by harvester	0	0
6.	Fruits dropped out of harvester	13	21
7.	Visibility through harvester	Clear	Clear
8.	Selection of fruits	Only bigger size fruits	Matured fruits of any size

Fig. 1 : Sapota harvesting different elevatios

Fig. 2 : Harvesting of sapota at different angles

Fig. 3 : Sapota harvester penetrated in plant canopy

harvester.

Penetration in the tree canopy:

It was observed that the harvester could not penetrate well in the dense canopy due to its width at the front end. In operator's opinion, the Atul sapota harvester could penetrate better than this newly developed harvester. This may be due to fact that the front end of the newly developed harvester is wide and having net fitted to it, while in case of Atul sapota harvester, the front end is narrow and plane.

Fig. 4 : Collection of harvested sapota fruits

Weight of the harvester:

The weight of the developed harvester is 382 g while that of Atul sapota harvester is 338 g. Lighter the the harvester, more is the capacity to collect the fruits in it. Hence, both these harvesters can meet this requirement. The newly developed harvester can collect 10 to 12 fruits at a time. It depends upon the size of the fruit and the height from which the fruits are harvested. The 3.3 m long harvester was needed to be brought down frequently due to the weight of collected fruits in it compared to shorter (2 m) harvester.

Fruits injured:

No one fruit was injured due to the harvester. But some fruits were fall down on the ground out of the harvester and got damaged. More number of fruits got fall out of harvester in second trial as the operators were doing operation speedily. This may also be due to the skill of the operator.

Conclusion:

The developed the harvester was suitable for harvesting the sapota fruits. The harvester is very easy to handle and to carry from one place to another.

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