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Performance evaluation of paddle type and push up type coconut climbing devices

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Coconut (*Cocos nucifera* L.) is a dominant tree crop in coastal and plain areas of southern India and is used as food and income source. At present, lack of skilled manpower to climb the coconut tree is a major problem faced by coconut growers across the country. Since 1970s, different coconut climbing devices have been developed (Davis, 1963). A tractor mounted hydraulically operated lifting device suitable for harvesting and other crown operations for medium tall coconut trees (maximum height of 12 m) was developed and evaluated at Dr. B.S. Konkan Krishi Vidhya Peeth, Dapoli (Kolhe, 2010). To reach a height of 10 m it requires 38 s and another 28 s to descend. However, it could work only in plain areas where the slope is less than 20.5 per cent (Kolhe and Jadhav, 2011). Similar device was tried in Saudi Arabia (Sial, 1984) and in Iraq (Shabana and Mohamad, 1993) for harvesting dates. The major problems with these devices are low elevation height (approx. 10 m), traction, maneuverability, plant geometry and difficulty in passing through irrigation channels and other obstructs. Cost is the other major concern.

Among the prototypes of coconut climbing machines developed, manually operated paddle type (Chemberi Joseph model) and push up type (TNAU model) are the two models available commercially. Chemberi Joseph model is a paddling type or standing type climbing device. It has got mainly two assemblies of similar construction. The steel rope wires of both top and bottom assembly has to be looped with the tree and needs to be locked. Then the user can stand by placing foot on both assemblies and has to hold on the handles provided. As the user lifts the assembly by foot and raises the assembly by hand the steel rope gets loosened around the trunk. When the climber push back with foot after reaching to a particular height it will get tightened. The user has to co-ordinate these two assemblies simultaneously by using hands and legs to climb on coconut tree easily. In this device the steel rope wire will get adjusted as per the diameter of the tree by the force applied by the user towards gravity. The TNAU model of the coconut climbing machine was developed by Tamil Nadu Agricultural University. This is a sitting type or push up type model. The device has two MS frames and one upper and lower; they are connected by a belt while the equipment is on the coconut tree. The user has to sit on the seat which is provided on the upper frame and has to insert his foot between the rubber rollers available in the lower frame. The upper frame can be lifted by hands and the lower frame has to be lifted by leg. The process is repeated for continuous climbing. In this type, the size can be adjusted as per the diameter of the coconut tree. As both frames are positioned in angle, due to the friction by rubber bush it will get gripped to the tree trunk and the process is repeated for further climbing. Safety belt can be adjusted for proper body posture. Distance between the top and bottom frames can be adjusted by the belt as per the convenience.

In this study, these two models were evaluated for their performance in terms of climbing efficiency and ergonomics. Study involved experienced male climbers in the respective models and traditional climbers who use neither of these devices. Evaluation was conducted at two places, at Tamil Nadu Agricultural University (TNAU), Coimbatore and Central Plantation Crop Research Institute (CPCRI), Kasaragod.

Climbing efficiency of the devices were computed on the basis of number of trees climbed per day. For this, experienced climbers were made to climb coconut trees using the respective device in which they were experienced to a certain height. Number of trees climbed by each climber was noted on hourly basis. The trial was conducted for one full day at Coimbatore where the average tree height was only 9m where as, it was done only for a duration of one hour at Kasaragod where the tree height was 15m.

While climbing a tree the weight of the device is a very important factor, since the machine is to be lifted by a person along with his body weight. The weight of TNAU model (15.25 kg) is almost double that of Chemberi Joseph model (7.87 kg).

In case of TNAU model, climber has to lift the lower part of the device with his/her toes. Lifting the device by toes is a daunting task. Further, it is proved that human body is designed to carry load by 'push' paddling and not for 'pull' paddling. Whenever the lower part of the device is struck with the trunk of the plant it becomes difficult to lift. On the other hand in Chemberi Joseph model, only affordable weight is lifted by the feet and rest is done by the hands.

Climbing efficiency

Climbing efficiency of the devices on the basis of number of trees climbed per day was recorded and is given in Table 1. The climbers felt uncomfortable on their toes while lifting the TNAU model mainly because of its weight. The climbing efficiency of the model was also quite low mainly due to this reason and other restrictions while operating it. Further, climbing with TNAU model was not easy in those trees which are slippery due to rain or trees which are bent and becomes tapering towards apex. It was seen that after climbing certain height when there was slight variation in the trunk diameter the device required adjustment, which was not possible in TNAU model. The old/dry/broken leaves hanging from the crown obstruct the back seat of the upper part of the device and restrict the free climb of the operator. After three hours the traditional climbers at Coimbatore climbed 72 trees. During the same period climbers with Chemberi Joseph Model could climb 59 trees and with TNAU model only 13 trees. Climbers refused to climb with TNAU model after one hour as it was tiresome. At Kasaragod where the trees were tall, the traditional climber could climb 18 trees in one hour. During the same period the experienced climbers could climb 15 and four trees respectively in Chemberi Joseph Model and TNAU model.

Table 1. Coverage of trees by experienced climbers

Location	Climbing aid	Tree height (m)	No. of trees climbed
Coimbatore			
(Period-one day)	Traditional method	09	72
	Chemberi Joseph Model	09	59
	TNAU model	09	13
Kasaragod			
(Period-one hour)	Traditional method	15	18
	Chemberi Joseph Model	15	15
	TNAU model	15	04

Heartbeat measurement is the basic method to estimating the effort required to climb a tree. Average increase in the heartbeat of the climbers was noted before and after climbing a tree of 15m height. This was 104-138 beats/min for TNAU model while the corresponding increase in Chemberi Joseph Model was only 103-115 beats/min before and after climbing respectively for the trial conducted at Coimbatore. It shows that the average heart beat in case of TNAU model was higher than Chemberi Joseph model. In most of the cases the climber with TNAU model was unable to reach the crown due to sticking of dry hanging leaf and the machine slips due to less diameter of trunk at the top. After completing each tree, the climbers with TNAU model required considerable rest whereas other climbers did not require it.

Time required for various operations

Time required for engaging (setting) the climbing device to the tree trunk and disengaging (removing from the palm after completing the operation) was noted for evaluating the field performance of the climbing devices. Table 2 indicates that the engaging and disengaging time for the devices was very high in case of TNAU model compared to that of Chemberi Joseph model. This also clearly indicates that the TNAU model is useful only for domestic applications. Persons having 10-15 trees of medium height may use it for harvesting

Table 2. Time taken in various operations of tree climbing

Name of device	Time taken for operation (seconds)				
	Engagement	Ascending	Descending	Disengagement	Total time
Chemberi Joseph model	24	43	40	20	127
TNAU model	183	193	139	45	560

coconut for domestic use with this device. On the other hand, Chemberi Joseph model is quite suitable for regular users, adopts climbing for earning their livelihood. It was also seen during the evaluation that engagement of TNAU model is quite difficult and tedious compared to Chemberi Joseph model and some times more than one person is required for engaging and disengaging the device. As discussed earlier and shown in Table 2, this device also required much more time in climbing up and down because the lower part of the device sticks to the trunk very often and sometimes much effort is required to disengage it by the climbers and if the trunk is slippery, during monsoon, the field efficiency of the device reduces very much.

Conclusion

From the study it is clear that amongst the commercially available two climbing devices, Chemberi Joseph model is the best alternative to the traditional climbing method. It has better climbing efficiency, easy to use and ergonomically more suitable. On the other hand, TNAU model is very easy to learn but commercial exploitation of this device in the present form is not possible as its operation is time consuming. Weight of the device is another hindrance. The climbers who have some experience of traditional climbing did not feel the necessity of any safety measures but new comers in this area felt the need for a safety attachment to the Chemberi Joseph model for the safety and comfort of climbers.

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