Development and Evaluation of Palmyrah Tree Climbing Device

by
K. Kathirvel, Professor
T. G. Kishore
D. Ananthakrishnan, Professor
C. Divaler Durairaj, Professor & Head

Department of Farm Machinery, Agricultural Engineering College & Research Institute,
Tamil Nadu Agricultural University, Coimbatore - 641003 INDIA

Abstract

Skilled workers are engaged in climbing palmyrah tree for harvesting nuts, crown cleaning and neera collection. Difficult in getting the services of skilled palmyrah climbers in time and their high wages, accident risk factors are perceived as important constraints in profitable palmyrah cultivation. For ensuring safety in tree climbing and to encourage even unskilled palm workers into climbing the tall tree, a palmyrah tree climber with safety features has been developed. The device has a set of upper and lower frames, which are alternately used to grip the tree for climbing up or down. The upper frame of tubular construction has a seat, side rails and a back support. The safety features viz., adjustable and pivotable seating arrangement, improved configuration of tree holding section, side support in any direction, safety rope and turn buckle mechanism enhance safety and comfort of the user. The performance of palmyrah tree climbing device was evaluated in terms of safety, comfort, output, saving in cost and time of operation and compared with conventional method. The use of palmyrah tree climbing device enhanced the comfort of the workers with 28-29, 36-43 and 36-37 percent reduction in energy expenditure, overall discomfort rating (ODR) and body part discomfort score (BPDS) respectively. Also it resulted in three and four fold increase in the safety and ease of operation respectively when compared with conventional method for neera tapping and fruit harvesting operations. Though the capacity of palmyrah tree climbing device with safety features for harvesting fruit bunches and tapping neera was lower than the conventional method, it resulted in alleviation of acute skilled labour constraints in palmyrah cultivation with enhanced safety and comfort. The cost of fruit bunch harvesting and neera tapping operation using palmyrah tree climbing device with safety features is comparable.

Introduction

Climbing techniques of palmyrah palm is similar to that of coconut palm. Two basic techniques used for climbing palm trees are front foot technique and frog technique. The front-foot technique used by the workers to climb palmyrah tree is very similar to rock climbing. The accessories employed by the worker viz., a ladder, a pair of gripping aids for upper and lower part of the body, a basket for holding the knife, a wooden tongs/stave and containers for the lime and for collecting the sap from the tree. Skilled workers are engaged in climbing palmyrah tree for harvesting nuts, crown cleaning and neera collection. Due to various socio-economic factors, the number of such traditional skilled palm climbers is steadily declining. It was a challenge to the technology developers to fabricate a simple, safe and easy to use device for climbing palmyrah tree, which could even be operated by an unskilled person.

Methods and Materials

The sequence of operations carried out by the worker after reaching the top of the tree for neera tapping as shown in **Fig. 1** is anchoring his body on the tree trunk with the help of the gripping aids, transferring the sap form the clay pot fitted with the inflorescence to a container carried on the back of his body, slicing the

male/female inflorescence using the knife, pressing and stroking the male/female inflorescence with the help of wooden tongs/stave for softening the tissue, applying lime inside the clay pot with a brush, fitting the clay pot back on the inflorescence stalk, moving around the tree and repeating the above sequence of operations for all the matured inflorescence and cleaning the crown of the tree.

The sequence of operations carried out by the worker after reaching the top of the tree for harvesting fruit bunch is tying a pair of adjacent bunches with the coir rope, cutting the stalk of the fruit bunch with knife, lowering the bunch to the ground level with the help of rope or tying the harvested bunches with hip, moving around the tree and repeating the above sequence of operations for all the matured fruit bunches and descending the tree with fruit bunches as shown in **Fig. 2**.

After completion of the operation at the top of the tree, the worker descends. For descending, he lowers his hands one by one behind the trunk with aid and just lets the sole of his feet with the aid drag against the tree. While descending, he carries the weight of neera or fruit bunches on his back.

The technique of gripping the tree with both hands and feet, using gripping aids and then pushing up the body to climb higher, results in intermittent pressure over the soles and palms leading to thickening of skin in palms,, legs and shoulder of the worker. In response to friction, there is steady rate of increase in epidermal turnover, and laying down of thickened vertically oriented collagen bundles in papillary dermis, resulting in lichenfication in fore arms as shown in **Fig. 3**. The other health hazards associated with palmyrah tree climbing include slip during rainy days and insect bite. Carrying the accessories viz., ladder (12 kg) and ascending the palmyrah tree with a basket for holding the knife (1.2 kg), a set of gripping aids (1.4 kg) and containers for collecting the sap (0.4 kg) from the tree and

Fig. 1 Unit operations involved in neera tapping

Transfering neera from clay pot to the container

Slicing the inflorescence

Pressing the inflorescence with wooden tongs

Applying lime inside the clay pot

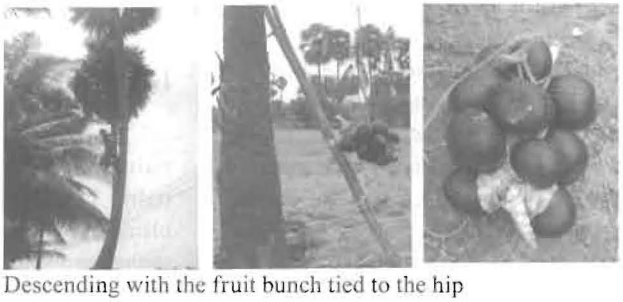
Fitting the clay pot

Cleaning the crown of tree

Fig. 2 Unit operations involved in fruit bunch harvesting

Tieing, harvesting and dropping the fruit bunch from tree top to the ground

Harvesting and tieling the fruit bunch with hip



Descending with the fruit bunch tied to the hip

for the lime (0.04 kg), descending with an additional weight of neera (5-10 kg minimum per tree) results in lower back pain and musculoskeletal disorders.

Hence for minimizing drudgery of the arecanut plantation workers with increased safety at reduced human energy expenditure level, a palmyrah tree climbing device with safety features has been developed. The developed device has a set of upper and lower frames, which are alternately used to grip the tree for climbing up or down (**Fig. 4**). The upper frame of tubular construction has a seat. It has an adjustable/detachable 'U' member between which and the main frame, the tree is gripped. The user sits comfortably on the seat facing the tree, the force of which grips the tree quite firmly. The lower frame is also constructed similarly, but lighter in weight and has a provision for the operator to hold it with his toes. The worker first sits on the upper frame and pulls the lower frame up with his legs. Then he puts his weight on the lower frame, stands on it and pulls up the upper frame. This action is alternated and the climbing is executed. The device can be adjusted to accommodate the small range of variations in the palm tree's girth with turn buckle mechanism. However the diameter of a typical palmyrah near the ground and up to a height of 3 m being quite huge, the developed device cannot be accommodated in this part of the tree. So, similar to the ladder/device that a traditional climber uses, an aluminium ladder of 3 m height has been provided along with the climbing device. This ladder has a hoop to lock itself to the tree as well as a foldable top, on which the climbing device can be positioned and clamped on the tree for the operator to climb on to it (**Fig. 4**). The specifications of Palmyrah tree climbing device with safety features are furnished in **Table 1**.

The performance evaluation of palmyrah tree climbing device with safety features is compared with conventional method for harvesting fruit bunches and tapping neera. The physiological stress imposed on the worker for ascending, neera tapping/fruit bunch harvesting and descending palmyrah tree operations viz., heart rate (beats per min^{-1}) and energy consumption of work (kJ min^{-1}). The heart rate and oxygen consumption rate was recorded using computerized ambulatory metabolic measurement system (K4b2). The discomfort experience by the worker was assessed interms over all discomfort rate (ODR) and

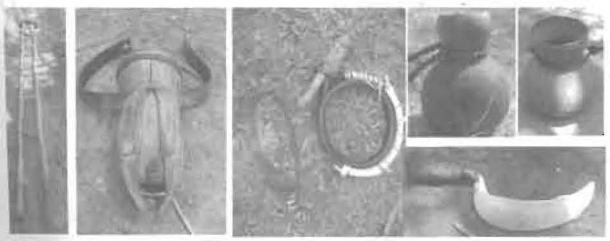
Fig. 3 Health hazards associated with palmyrah tree climbing

Thickening of skin in palms of palmyrah tree climber

Thickening of skin in legs of palmyrah tree climber

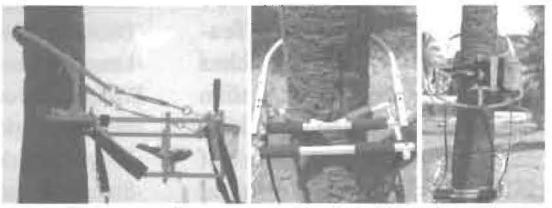
Thickening of shoulder of palmyrah tree climber

Lichenfication (Occupational dermatosis) in forearms of palmyrah tree climber



Additonal weight carried by the worker Ladder, Knife holder, Gripping aids, Neera container and knife

Fig. 4 Palmyrah tree climbing device with safety feratures



Upper and lower frame assembly fitted in palmyrah tree

Alternate sitting and standing action of worker for ascending/descending

Ladder used for fitting the device at 3 m height form ground level

Tapping neera and Harvesting of fruit bunches

body part discomfort score (BPDS). The Corlett and Bishop (1976) technique of 10: point psychophysical rating scale (0: No discomfort, 10: Extreme discomfort) for the assessment of (ODR and the localized discomfort for BPDS. For the assessment of safety rating, a 10: point psychophysical rating scale (0: Completely secure and no fear, 10: Totally insecure and extreme fear) and for the assessment of ease of operation, a 10: point psychophysical rating scale (0: Very easy, 10: Extremely difficult) was used which are an adoption of Corlett and Bishop (1976) technique.

Results and Discussion

Performance Evaluation

The results of performance evaluation of palmyrah tree climbing device with safety features and conventional method for harvesting fruit bunches and tapping neera are furnished in **Table 2**.

The capacity of palmyrah tree climbing device with safety features for harvesting fruit bunches and tapping neera was lower than the conventional method. The may be due to the proficiency level of the skilled workers in traditional method. However the use of ergo refined palmyrah tree climbing device by unskilled labour with enhanced safety, comfort and stability will alleviate the acute skilled labour constraints in palmyrah cultivation. The cost of fruit bunch harvesting and neera tapping operation using palmyrah tree climbing device with safety features was almost same as that of conventional method. Both the operations of harvesting fruit bunches and tapping neera are performed by a handful of skilled workers only on contract basis, the cost of operation is comparable. The cost of the ergo refined palmyrah tree climbing device with the ladder is Rs. 7,000.

Ergonomic Benefits

To ascertain the improved comfort, safety and ease of operation of the palmyrah tree climbing device for harvesting fruit bunches and tapping neera, the ergonomic parameters are measured compared with conventional method and the

Table 1 Specifications of Palmyrah tree climbing device with safety features

Particulars	Values
Over all dimensions of upper frame (L × B × H), mm	1,125 × 545 × 730
Size of the lower frame (L × B), mm	600 × 515
Size of the rigid base section in upper frame (L × B), mm	575 × 514
Size of tree gripping section in upper frame (L × B), mm	465 × 525
Number of cross rail in upper frame	3
Number of cross rail in lower frame	4
Length of gripping aid (rubber bush) in "U " shaped adjustable frame, mm	215
Length of gripping aid (rubber bush) in cross rail of tree gripping section, mm	100
Diameter of rubber gripping bush, mm	50
Gripping diameter of tree trunk in extendable 'U" frame, mm	200-400 mm adjustable in 5 steps
Mechanism for adjusting the gripping diameter while ascending or descending the tree	Turnbuckle mechanism
Number of gripping aids (rubber bush) in upper frame	3
Number of gripping aid (rubber bush) in lower frame	3
Total weight of the climbing device, kg	16.7
Weight of the lower frame, kg	5.5
Weight of the upper frame, kg	11.2
Seating arrangement	Rigid type (adjustable and pivotable)
Diameter of lime container holding ring, mm	80
Diameter of wooden tongs holding ring, mm	60
Length of wooden tongs, mm	920
Weight of wooden tongs, kg	1.2
Height of ladder, mm	3,000
Weight of ladder, kg	14.9
Size of platform on ladder top (L × B × H), mm	385 × 300 × 20

Table 2 Results of field performance evaluation of palmyrah tree climbing

DETAILS	Palmyrah tree climbing practices	
	Conventional method	Palmyrah tree climbing device
Total time consumed (for ascending, performing operations and descending) per tree, s	240	514
Number of trees climbed per hour	15	7
Number of fruit bunches harvested per hour	80	20
Quantity of fruit bunches harvested per hour	720	180
Quantity of neera collected, lit per hour	120	78
Cost of ascending, fruit bunches harvesting and descending palmyrah tree, Rs. per tree (Operation performed only on contract basis only)	15.00	-
Cost of operation of palmyrah tree climbing device, Rs. per hour	-	52.70
Cost of fruit bunch harvesting, Rs per kg	0.32	0.29
Cost of ascending, tapping neera and descending palmyrah tree, Rs. per tree (Operation performed only on contract basis only)	5.00	-
Cost of tapping neera, Rs./lit	0.63	0.68

Table 3 Comparison of ergonomic parameters of palmyrah tree climbing practices

Parameters	Conventional method	Palmyrah tree climbing practice
A. Neera tapping		
Heart rate, beats min^{-1}	160	130
Energy expenditure, kJ min^{-1}	34.4	24.9
ODR	8.0	4.6
Over all safety rating (OSR)	2.0	8.2
Ease of operation rating (OER)	2.7	7.9
Body Part discomfort score (BPDS)	51	32
B. Fruit bunch harvesting		
Heart rate, beats min^{-1}	168	136
Energy expenditure, kJ min^{-1}	36.8	26.2
ODR	8.3	5.1
Over all safety rating (OSR)	1.9	8.9
Ease of operation rating (OER)	2.5	8.2
Body Part discomfort score (BPDS)	55	35

values are furnished in **Table 3**.

The use of palmyrah tree climbing device enhanced the comfort of the workers with 28, 43 and 37 percent reduction in energy expenditure, overall discomfort rating (ODR) and body part discomfort score (BPDS) respectively. The safety and ease of neera tapping operation was increased by four and three times respectively when compared with conventional method.

The use of palmyrah tree climbing device enhanced the comfort of the subjects with 29, 36 and 36 percent reduction in energy expenditure, overall discomfort rating (ODR) and body part discomfort score (BPDS) respectively. The safety and ease of neera tapping operation was increased by four and three times respectively when compared with conventional method.

Conclusions

For enhanced safety and comfort of the user, a palmyrah tree climbing device with safety features viz., adjustable and pivotable seating arrangement, improved configuration of tree holding section, side support in any direction, safety rope and turn buckle mechanism has been developed out. The performance of palmyrah tree climbing device was evaluated in terms of safety, comfort, output, saving in cost and time of operation and compared with conventional method. The use of palmyrah tree climbing device enhanced the comfort of the subjects with 28-29, 36-43 and 36-37 percent reduction in energy expenditure, overall discomfort rating (ODR) and body part discomfort score (BPDS) respectively and increased the safety and ease of operation by four and three folds respectively for neera tapping and fruit harvesting operations when compared with conventional method. Though the capacity of palmyrah tree climbing device with safety features for harvesting fruit bunches and tapping neera was lower than the conventional method, It resulted in alleviation of acute skilled labour constraints in palmyrah cultivation. The cost of fruit bunch harvesting and neera tapping operation using palmyrah tree climbing device with safety features is comaparable. The cost of the ergo refined palmyrah tree climbing device with the ladder is Rs.7,000.

REFERENCES

Amacker. 1992. A Universal compact and versatile trees stand with a seating section. US Patent-5090504.

Astrand, I. 1960. Aerobic work capacity in men and women. Acta Physiologica Scandinavica. Vol.4, Supplement 169.

Brundke, J. 1984. Langzeitmessungen der Pulsfrequenz und Moglichkeiten der Aussage uber die Arbeitsbeansprunchung. In Pulsfrequenz und Arbeitsunchungen, Schriftenreihe Arbeitswissenschaft und Praxis, Band 28. Berlin: Beuth- Vertrieb.

Corlett, E. N. and R. P. Bishop. 1976. A technique for assessing postural discomfort. Ergonomics, 19: 175-182.

Cotton, C. W. 1976. Tree climbing device, US Patent –3960340.

Craft, A. Roger. 2005. Slope compensating tree stand. US Patent – 0178618 A1.

Grandjean, E. 1988. Fitting the task to the man, A text book of Occupational Ergonomics, Taylor & Francis.

Horace. 1985. Tree climbing apparatus. Patent storm. US Patent -4549633.

Louk John M., Alex Brewer, and Ronnie J. Fuller. 1999. Convertible tree stand for rifle/bow use, US Patent -5921348.

Saha, P. N., S. R. Datta, P. K. Banerjee, and G. Narayane. 1979. An acceptable workload from a modified scale of perceived exertion, Ergonomics, 37, 485-491.

Williams. 1989. Combined climbing and hang-on tree stand with optional climbing aid, US Patent -4802552.

Wolford, D. 2005. Tree stand with adjustable leveling mechanism. US Patent -6942064B2.

Woller, R. Ronald and Woller, A. John. 1999. Climbing tree stand with cable attachment. US Patent -5975242.

Yerger, W. Joseph. 2000. Safety belt climbing tree stand. US Patent -6082492.

■■