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Performance Evaluation Of BARI-Developed Sitting-Type Coconut Tree Climber

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Abstract
In our country, coconuts are usually harvested using traditional manual techniques. That traditional harvesting technique involves climbing on a tree directly with hands and feet. This method is time-consuming and creates physical health hazards. So, to mitigate this problem, the Farm Machinery and Postharvest Process Engineering Division of the Bangladesh Agricultural Research Institute (BARI) has developed and fabricated two models of sitting-type coconut tree climbers during the period of 2019–20 and it was improved during the period of 2020–21.This study was undertaken to compare the performance of BARI's develop coconut three climbers. The total weights of the previous climber and the improved climber are 15.8kg and 10.8 kg, respectively. During the operation, the height of the trees was increased from 6.9 m to 9.7m. During operation, the highest speed of the sitting type climber during climbing up a tree was 10.54 m/min, and the highest speed of the climber during climbing down from a tree was 7.46 m/min when the height of the tree was 9.7m. The average speed of the climber during climbing up was 8.19 m/min, whereas it was 6.81m/min during climbing down from the tree. During the operation, blood pressure data varied from 10–20 mmHg of systolic and diastolic pressure. At the beginning, it is time-consuming, but with continuous use and practice, it will reduce the time required for climbing. Though there are some problems with the coconut climbing machine, it will be useful for both residential growers and commercial cultivators. The prices of the previous climber and the improved climber were calculated at about 6000 Taka and 12000 Taka, respectively. The weight of the climber can be reduced by the use of alloys or composite materials.

Key words: *Coconut tree climber, manual technique, BARI and Traditional harvesting*

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I. Introduction

Coconut is very popular and common fruits in Bangladesh. Bangladesh is the 12th highest coconut-producing country generating 442708 tons from 25334 hectares of land[1] (FAOSTAT, 2023). About 80% of total production comes from the southern part of the country[2] (BBS, 2002). Coconut harvesting is still done without proper safety measures which can lead to serious injuries. Because of the consistent cylindrical form and single stem, climbing a coconut tree manually is quite tough. Not only that, this traditional method of climbing a coconut tree is time-consuming, dangerous, and needs a great deal of skills[3] (Mohankumar *et al,* 2013a). A person who wishes to manually climb a coconut tree must place his hands close together on the rear of the trunk and pull one foot in front of the other while standing in front of the tree. Walk up while alternating moving your hands and feet, maintaining pressure on the trunk with the climbing person's feet and toes. Jepson[4]*et al*. reported that climbing seems to be the simplest to do technically, but it requires superb balance and arm power. Persons engaged in climbing coconut trees suffer from musculoskeletal disorders. Learning the skills required to climb coconut trees is very difficult. A professional climber with proper training is only able to climb coconut trees. The traditional method of collecting coconuts in Bangladesh is climbing the trees which are very risky. As coconut trees are very tall, climbing coconut trees, especially falling from coconut trees, is a common occurrence in Bangladesh[5] (Jahan, 2018).

Recently, different methods are using to harvest coconut in developing countries such as India, Malaysia and Sri Lanka. According to Edacheri et al.[6] there are primarily two types of coconut tree climbing device available in the Indian market at the moment which are sitting type and standing type climbing device. A tree climbing apparatus was invented by Mohankumar et al.[7] and evaluated based on financial factors and ergo improvements. As you climb closer to the peak of the tree, the upper frame of the climbing aid becomes more

inclined with regard to the horizontal. As a result, the user's center of gravity shifts away from the body, making them feel unsteady and unsafe. Morris[8] made a climbing tree stand that has a base frame, a first and second arm, a support arm, first and second illumination components, and a blade linked to an upper bracket of the base frame. The first and second arms are pivotally attached to the base frame and may be engaged with the support arm when released. A curved portion of the support arm was attached to an opposite distal end of the first arm of each platform, and a second lighting assembly was coupled to a distal end of the second arm of each platform. A foot support lifting bracket was added to the base frame of the second platform. The inflexible non-flexible structure of the foot support lifting bracket.

Graham *et al.*[9] developed an adjustable tree stand comprising of a seating section and a standing section, each having inclined attachment bars adjacent the section sides, and seating and standing section cables, each having first and second ends with handles at each of the ends. Each attachment bar had outer and inner faces with a plurality of spaced, aligned attachment holes extending between the faces, and a plurality of spaced, aligned latch holes alternating with the attachment holes. Each of the handles had a pair of flanged projections insert able into adjacent attachment holes in an attachment bar and a latch pin insert able into a latch hole between the adjacent holes. Each projection was moveable from an insertion position to a locked position within a hole when the cable was tensioned, and was prevented by the latch pin from moving back to the insertion position when the cable was relaxed. Joseph[10] developed a coconut-climbing device having two frames (left and right), each frame was having flexible adjustable encircling iron rope mounted around a tree and tree gripping rubber pad. The two main frames were fitted on the tree side by side enabling the operator to lift the frames conveniently using the sliding member.

Laborde[11] designed a climbing tree stand gadget with upper and lower platforms that could be independently pushed up the tree while seated or standing on one or the other. There isn't a device on the market that allows for safe climbing up coconut trees. The flimsy equipment, which included a safe and easy way to climb coconut palms that could even be utilized by a non-skilled individual, was made with the aforementioned factors in mind. Coconut trees can be climbed with little human effort thanks to equipment. Robotic climbers have developed in India.

According to Hariskrishna*et al.*[12] most of these climbing robots can climb standard structures such as poles, walls, domes, and so on. However, just a handful is capable of climbing trees, owing to the uneven surface and fluctuation in diameter with length. It also necessitates higher agility and dexterity when employed as a product. Furthermore, the bark of some trees may be too weak to support the weight of the climbing device, so typical climbing robots cannot be employed for tree climbing applications. BARI developed a standing type coconut tree climber at the Workshop of FMPE Division during the period of 2019-20 and itwas improved during 2020-21.So, it needs to know the performance of coconut tree climbers to determine which is better.Therefore, the main purpose of this study was to compare the performance between traditional and improved sitting-type coconut tree climbers.

II. Materials and Methods

A sitting-type coconut tree climber was designed and fabricated at the workshop of the Farm Machinery and Postharvest Process Engineering Division of the Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, during the period of 2019–20. It was improved during 2020–21.

Description of the fabricated sitting type coconut tree climbers

The materials used for the fabrication of different parts of the previous climber were MS square pipe, nut-bolts, rubber, belts, fabrics, etc. Improved climber consists of SS square pipe, nut-bolts, rubber, belts, fabrics, a movable cross-rail lock, etc. Rubber grips were provided for the operator's comfort. At the time of working, the center of gravity of the user shifts outside of the body, and the user feels insecure and unstable. In the case of the developed device, any portion of the trunk makes 90° with the trunk so that the operator feels safe. The total weights of the previous climber and the improved climber are 15.8kg and 10.8 kg, respectively. The photographic views of the sitting-type coconut tree climbers are shown in the figures below. The left-side figures are the parts of previous climbers, and the right-side figures are the parts of improved climbers.

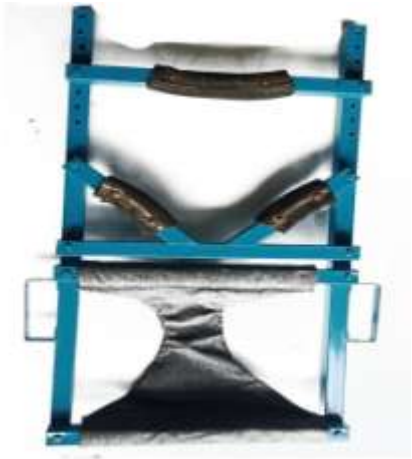

Fig. 1 Upper frame of the previous climber

Fig. 2 Upper frame of the improved climber

Fig. 3 Lower frame of the previous climber

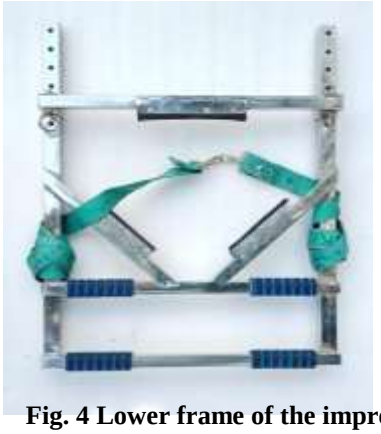

Fig. 4 Lower frame of the improved climber

Working Principles of the sitting type coconut tree climber

The climber has two frames upper one for sitting purposes and another lower one for leg use. They are connected by a belt, while the equipment is on the coconut tree. The user has to sit on the fabric seat that is provided on the upper frame and insert his foot into the foot holder in the lower frame. The upper frame can be lifted by hands, and the lower frame has to be lifted by a leg. The process has to be repeated for continuous climbing. In this type, there are two girth control provisions by the movable cross rail in both of the frames of the climber that help to adjust the machine as per the coconut tree diameter. Safety belts can be adjusted for the safety of the operator. The distance between the upper and lower frames can be adjusted by the connecting belt as per convenience.

Performance Evaluation of the climber:

Both of the coconut tree climbers were tested for climbing on coconut trees beside the land and construction section of the BARI campus. Before and after the climbing operation on trees using the fabricated climbers, the operators' blood pressures were taken. The blood pressure data were recorded using a sphygmomanometer and stethoscope. The speed of the operators for climbing on trees by the fabricated climbers was calculated using the following equation:

$$S = \frac{D}{T} \quad \ldots\ldots (1)$$

Where

S = Speed

D = Distance covered

T = Time required

Fig. 5. The operational view of the previous climber.

Fig. 6. The operational view of the improved climber.

III. Results and Discussion

The performance of the operator for climbing on trees depends mainly on the capability of the person, the slippage condition of the trees, the curving length of the tree trunk, the weight of the climber, the physical and mental condition of the operator, the height of the tree, etc. The blood pressure of the operators for climbing on trees by the previous climber and the improved climber is shown in Table 1. It was observed that in most cases, before climbing on a tree and after climbing down from a tree, the operator's blood pressure data varied from 10 to 20 mmHg of systolic and diastolic pressures. It is quite normal for every person because their blood pressure literally increases after hard physical work. Sometimes blood pressure data may show a little bit of a high value due to the fear of heights and the use of a new machine for the first time. During the operation of the previous climber, the heights of the trees ranged from 6.9m to 9.7m.

Table no 1: Performance of the operator for climbing on trees based on blood pressure

Height of the tree (m)		Blood pressure of the operator(mmHg)			
		previous climber		improved climber	
improved climber	previous climber	Before climbing up	After climbing down	Before climbing up	After climbing down
7.9	6.9	110/70	120/80	110/60	130/80
7.6	8.3	120/80	130/90	130/80	140/90
8.7	9.7	130/80	130/80	140/90	140/80
Average		120/77	127/83	127/77	137/83

The highest speed of the operator during previous climbing on a tree was 10.54 m/min, and the highest speed of the operator during climbing down from a tree was 7.46 m/min when the height of the tree was 9.7 m. During the operation of the previous climber, some problems were observed. The weight of the climber was a little bit more. So the operator felt it was sometimes inconvenient to climb on a tree. This problem was solved by reducing the weight of the improved climber.

Table no 2: Performance of the operator for climbing on trees based on speed

Height of the tree (m)		Speed (m/min)			
		previous climber		improved climber	
improved climber	previous climber	Climbing up	Climbing down	Climbing up	Climbing down
7.9	6.9	5.11	5.75	3.03	3.13
7.6	8.3	8.92	7.22	7.60	5.42
8.7	9.7	10.54	7.46	7.91	6.69
Average		8.19	6.81	6.85	5.08

It was also observed that by practicing more, the speed of the operator climbing on the tree increased. During the operation of the improved climber, the heights of the trees ranged from 7.6to 8.7m. The highest

speed of animproved climber during climbing on a tree was 7.91 m/min, and the highest speed of a climber during climbing down from a tree was 6.69 m/min for the same. Jahan[5] *et al*. found the average speeds of operator climbing up and down were 5.291 and 5.95 m/min respectively when the average height of the tree was 9.64 m. Their finding was slightly lower than the present study. In another research work, Jaikuman[10] et al. found the average speed of a climber during climbing up a tree was 3.79 m/min which too much lower than present study. The performance of the operator for climbing trees based on the time required is shown in Table 2. For both climbers, while operators moved towards the top of the tree, they felt insecure and unstable. To solve this problem, a safety belt was provided to avoid the possibility of a fall, which will increase the operator's confidence to work without fear at any height of the trees.

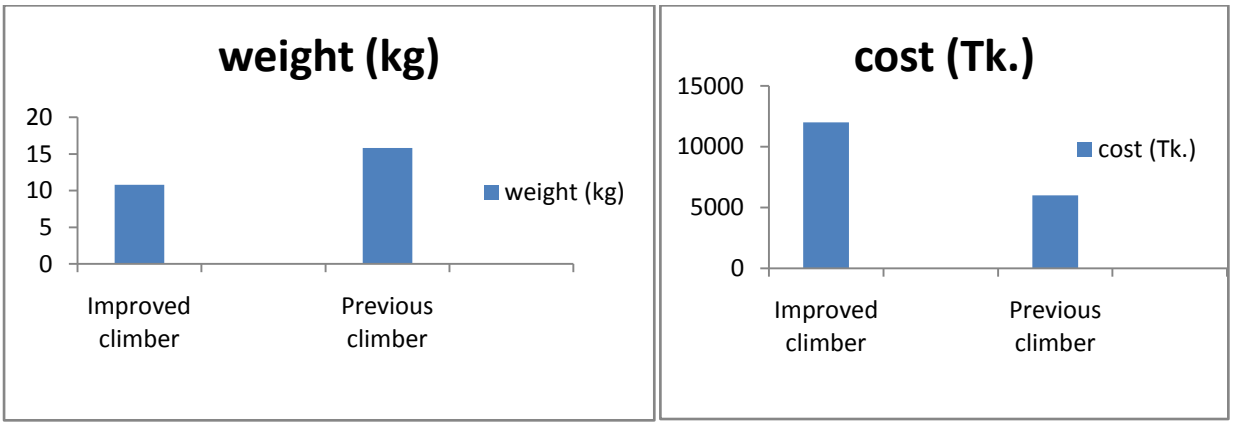

Fig. 1 Weight and cost of improved and previous climber

Fig 1 shows that weight of improved climber was lower than previous climber though the material cost of improved climber was higher than previous climber. But improved climber gave more safety than previous one.

IV. Conclusion

The average speeds of the operator during climbing on a tree by the previous climber were 8.19 and 6.81 m/min, respectively, during climbing up and down from a 9.7m tree. Where the average speeds of the improved climber during climbing up and down on a tree were 6.85 and 5.08 m/min, respectively, when the height of the tree was 8.7m. So, time requirements are slightly lower for the operator during climbing. The total weights of the previous climber and the improved climber are 15.8kg and 10.8 kg, respectively. The weight of the climber can be reduced by the use of alloys or composite materials. The prices of the previous climber and the improved climber were calculated at about 6000 taka and 12000 taka, respectively. Though the cost of the improved coconut tree climber is higher than previous one, it has better safety accessories.

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