

TESTING AND ERGONOMICALLY EVALUATION OF TRACTOR MOUNTED AND SELF MOUNTED COCONUT CLIMBER

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Abstract

The coconut is known as *Kalpa Vriksha* to the world for being its multi faceted uses, which provide livelihood security to millions of people, every part of it useful to humans in one of the other ways. The coconut palm is grown in more than 93 countries of the tropics. Its botanical name is *cocos-nucifera* L. and belongs to the *aracaceae* (Palm) family. The climbing methods of coconuts like manual, mechanical and climbing by Tractor Mounted Hydraulic Elevator (THME) were studied. The stability, safety, harvesting efficiency, drudgery of coconut harvesting is reduced by Tractor Mounted and Self Propelled Coconut Climber (TMSPCC) developed by considering the drawbacks of the above methods. The testing of developed TMSPCC was carried out at a Coconut Research Station, Bhyte Ratnagiri, India. To assess the physiological cost and the drudgery involved in the traditional method of tree climbing operation. The digital polar heart rate meter RS400TM having infrared connectivity sensor was used for recording the heart rates. The technical assessments included the use of biomechanical models, ODR, BPDS. The ergonomical evaluation of TMSPCC was carried out for testing feasibility, ease of operation; workers jeopardize safety health and efficiency for coconut harvesting. Ergonomically operational safe and controlled heart rates are recorded. The fourteen to seventeen number of coconut orchards were harvested in one hour by using TMSPCC. The tractor mounted and self propelled coconut climber founds suitable for harvesting 100 to 120 coconut trees in a day. The net coconut harvesting by using TMSPCC are 4000 coconuts/day. Also TMSPCC is safe, less hazardous and economical as compared to manual climbing coconut harvesting and climbing by the existing tractor mounted hydraulic elevator

Keywords: TMSPCC, Coconut, Ergonomics, Heartbeat, Harvesting platform

1. INTRODUCTION

The coconut palm is essentially a tropical crop, does not tolerate extremes of temperature and fails to come up well in places where long dry spell and severe cold condition prevail. Coconut grows at different altitudes from saline seacoast to an elevation of 1000 m. Normally and altitude of 600m appears to be limited for commercial cultivation. The palms tolerate a wide range of in the distribution and intensity of rainfall, ranging from 1000-3000mm/yr. warm and humid climate with 60% or more relative humidity is good for growth. The coast, palm gets benefited from a humid climate throughout the year, with less temperature fluctuation. Coconut is particularly grown in sandy soil of the coastal belt of the tropics, where highly permeable soil with shallow deep subsoil water is available. Highly organic matter containing rock free laterite soils are suitable for coconut cultivation. The coconut palm is essentially a tropical crop, does not tolerate extremes of temperature and fails to come up well in places where long dry spell and severe cold condition prevail. Coconut grows at different altitudes from saline seacoast to an elevation of 1000 m. Normally and altitude of 600 m appears to be limited for commercial cultivation. The coconut production and plantation was increasing consistently for last 40 years. But the increased rate of coconut yield noted very slow due to the unavailability of suitable mechanized machineries and is implemented in India. Hence to increase the yield rate/ha the automatic machineries are required. Traditional areas of

coconut cultivation in India are the states of Kerala, Tamil Nadu, Karnataka, Goa Andhra Pradesh, Orissa, West Bengal, Pondicherry, Maharashtra and the islands of Lakshadweep and Andaman and Nicobar. Four southern states put together account for almost 92% of the total production in the country: Kerala (45.22%), Tamil Nadu (26.56%), Karnataka (10.85%) and Andhra Pradesh (8.93%). Other states like Goa, Maharashtra, Orissa, West Bengal and those in the northeast like Tripura and Assam account for the remaining 8.44 per cent. Maharashtra which is 720 km long strip, contributes 8338 nuts/hectare. Maharashtra ranks seventh in area and seventh in production of coconuts in India. The harvesting of coconut marked as a major problem due to unavailability suitable harvesting tools, machineries and trained coconut climbing labours in India. The tractor mounted hydraulic lifter for harvesting pruning and spraying of horticultural crops upto 12 m by applying the product development cycle. Nevertheless, the trees taller than 6 m are difficult and not economical for harvesting, pruning and spraying, by considering the labor cost and time. These problems were eliminated by the tractor mounted hydraulic elevator. The machine was very much suitable for harvesting and other allied operations of horticultural crops. The testing of the machine was carried out for harvesting and pruning operations for Mango and Coconuts orchards. (Kolhe, 2009a; 2009b) the stability and the ergonomic design considerations of the tractor mounted hydraulic elevator were studied for the future development of the machine. The better stability results

with the controlled vibrations and frequency of the lifting platform and welded joints were recorded by keeping constrained boundary conditions. Ergonomically operational safe and 3 controlled heart rate was recorded. Consequently, the labors can continuously do the coconut harvesting work by using the tractor mounted hydraulic elevator. The minimum PTO power was recorded for the coconut harvesting by using tractor mounted hydraulic elevator. (Kolhe *et al.*, 2011; Kolhe and Jadhav, 2011). The problems of machine stability, operating mechanism, human safety and harvesting reach in the tractor mounted hydraulic elevator were noted. By considering the problems of the existing prototype tractor mounted hydraulic elevator it was decided to develop the tractor mounted and self propelled coconut climber. The machine was designed and developed with the financial support of Coconut Development Board, Ministry of Agriculture and Government of India (Fig. 1). Ergonomics is the tailoring of products, so that the human user involved is as comfortable as possible with minimized stress and fatigue. Health, safety and productivity benefits often result from this worker friendly approach. Most designer of agricultural equipment concentrated to improve efficiency and durability, but none seem to give importance to the operator comfort. Generally, the operator is only a part of the machine system. The fit between a person and a farm implement is not typically an issue for short-term users, but becomes more critical for long term users. Long term users historically report a great deal of discomfort or pain (Corlett and Clarke, 1976). The farm tools used in agriculture were estimated about 800 millions. Though there were a good number of agricultural hand tools developed in the State Agricultural Universities and other institutes for better output, they were rare in use except in very few cases and the farmers were still using age old traditional hand tools and methods because of its versatility and adoptability.

The observed field capacity of the above TMSPCC is 500 coconuts h. There were some limitations of the TMSPCC; these limitations are rectified in the present development. Keeping in view of above facts, present

study on “Ergonomical evaluation of climbing practices of labor manually and by machine for assessing their suitability for coconut harvesting” was undertaken specific objectives like, assess the physiological cost and the drudgery involved in traditional method of tree climbing operation.

2. MATERIALS AND METHODS

The Design and Development of the proposed TMSPCC was undertaken by studying the available climbing coconut harvesting practices mechanism as shown in Fig. 1. The climbing methods from manual climbing to climbing by various mechanical climbers and tractor mounted hydraulic elevator were studied to observe the ergonomic performance of individual machine. The hazardous of conventional harvesting methods are presented in Fig. 2. Further the ergonomic study of the developed tractor mounted and self propelled coconut climber was compared with the manual climbing operation as shown in Fig. 3.

The Physiological coat and drudgery involved in conventional method and by tractor operated hydraulic platform of the labors used for coconut harvesting in this study are presented in Table 3 and 4. Ergonomic evaluations of selected coconut tree harvesting were conducted for assessing the suitability of the user with respect to comfort, safety and ease of operation. The evaluation was carried out with the four selected subjects in terms of Heart Rate (HR), Oxygen Consumption Rate (OCR), Limit of Continuous Performance (LCP), Overall Discomfort Rating (ODR) and Body Part Discomfort Score (BPDS). The age, weight and height of the selected male subjects were 34.5 years, 47.5 kg and 159.0 cm respectively (Alexander 2001). The ergonomical study of the tractor mounted and self propelled coconut climber was carried out by using the guidelines and standard of ergonomics. The steps of ergonomic evaluation of tractor mounted and self propelled coconut climber are presented in Fig. 4.



Fig. 1 Tractor mounted and self propelled coconut climber for coconut harvesting



Fig.2. (a-g) Conventional method of Coconut tree climbing

The experiments were carried at coconut research plot, Dr Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dis, Ratnagiri (Maharashtra, India), for three different labors for manual climbing method and by using tractor mounted and self propelled coconut climber for coconut harvesting. The labors work in continuation of one and half hours was taken for the above study for getting the precious results the same group of workers were used for manual and machine coconut harvesting. The working hart rates by both the methods were compared to deciding the feasibility, operational safety and efficiency

of the machine for coconut harvesting. Attachment of heart beat recording belt on the operator chest Fig. 3 (g-f)

3. RESULTS AND DISCUSSION

Figure 2(a-e) presents the conventional methods of coconut harvesting, however these methods are very jeopardy, operational drudgery, totally anxious to the human being. The effects of these methods on human dynamism are presented in **Fig. 3 (a-f)**. There is always the likelihood of serious accidents by the above methods to the climbing labor of coconut orchards.





Fig. 3 (a-f) Hazard of Conventional harvesting methods on human being for coconut

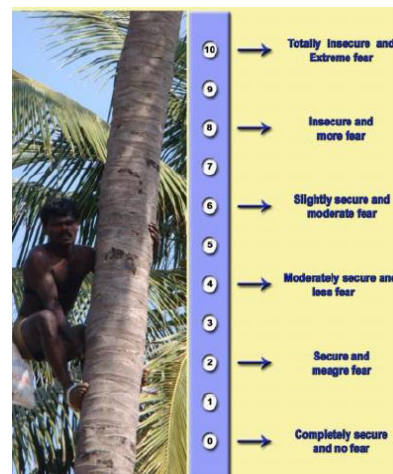


Fig.3 Showing the ergonomic evaluation of a climber by manual climbing and by TMSPCC

These techniques are economical to the marginal coconut growers, but totally insecure. Nevertheless, these techniques are very much expensive, hazardous and less productive for the medium and large coconut growers. The mechanical climbers were developed as presented Fig. 2 (c-f) is economical and safe for marginal coconut growers. But these are not suitable for the medium and large coconut growers, having many limitations i.e., trained operator requirement, very less harvesting capacity, laborious. However, the mechanized tractor mounted hydraulic elevator was right solution for the marginal and medium coconut growers. But its use was restricted upto 12 m tree height using an available harvesting pole. Hence the tractor mounted and self propelled coconut climber is developed

and recommended for coconut harvesting up to 16 m tree height using an available harvesting pole. The test results of tractor mounted and self propelled coconut climber for coconut harvesting are presented in Table 1 and 2.

The test results of the developed tractor mounted and self propelled coconut climber are presented in Table 1 and 2. The ergonomic testing results of the developed TMSPCC are presented in Table 3-5. From Table 1 and it is observed that the 15 to 17 coconut trees may be harvested in one hour by using tractor mounted and self propelled coconut climber for coconut harvesting. The average time of 79 sec was recorded for lifting and 59 seconds were recorded for lowering the lifting platform.



(a)



(b)



Fig.4 Ergonomical evaluation of Tractor mounted and self propelled coconut climber

Table 1 Test results of tractor mounted and self propelled coconut climber coconut harvesting up 15 m

Group of coconut orchards	Lifting time, sec	Harvesting time, sec	Lowering time, sec	Coconut Palm harvested/hr	Nut harvested
A	775	1790	1030	15	400
B	841	1728	1016	16	502
C	632	1634	1312	15	430
D	843	1885	902	16	388
E	907	1823	989	15	377
F	935	1902	988	17	520
G	1012	1832	1100	16	412
H	822	1900	930	15	395

Table 2. Test results of tractor mounted and self propelled coconut climber for coconut harvesting upto 14 m. Variety: T/D

Group of coconut orchards	Lifting time, sec	Harvesting time, sec	Lowering time, sec	Coconut Palm harvested/hr	Nut harvested
A	1398	3655	1133	17	412
B	636	1651	1142	15	488
C	849	1732	1257	15	450
D	1000	2199	1177	16	396
E	810	1623	989	15	387
F	1035	1902	1108	17	420
G	1012	1832	1100	16	389
H	1010	1800	1200	15	368

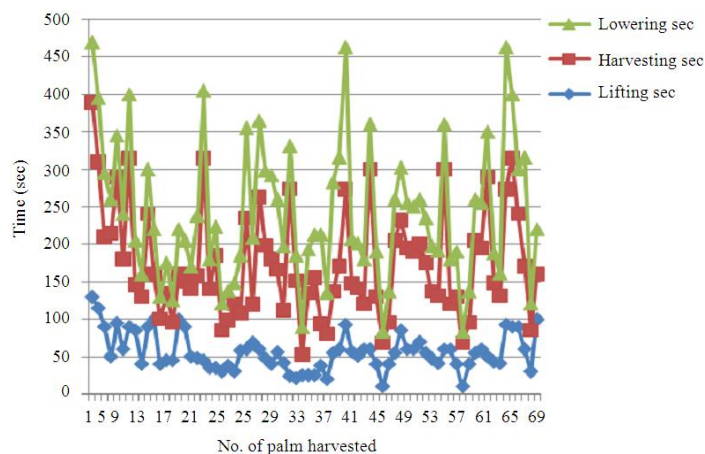


Fig. 5. Influence of time (sec) on number of coconut palm harvested for Banavali variety

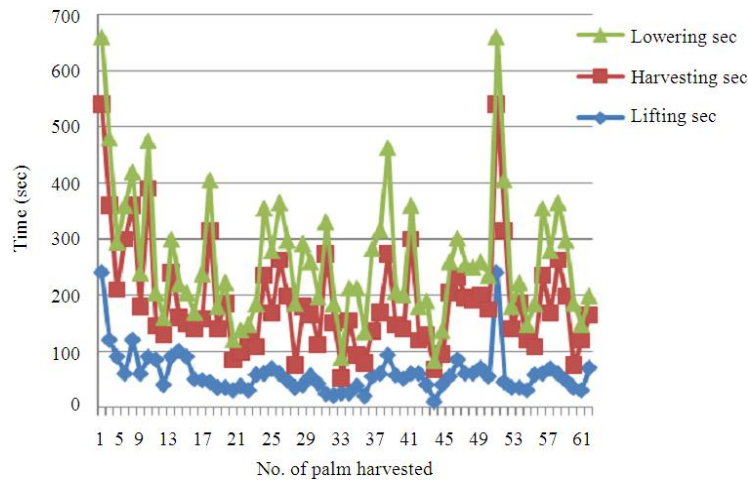


Fig. 6. Influence of time (sec) on the number of coconut palm harvested for T/D variety

Table 3 Physiological coat and drudgery involved in conventional method of coconut harvesting

Subjects	Age (years)	Weight (kg)	Stature (cm)	Resting HR	Working HR	Work Pulse (ΔHR)	ODR	BPDS
S1	40.0	45.0	144.7	113.69	142.50	28.81	5.00	26
S2	49.0	48.0	165.1	71.20	113.71	42.51	5.00	22
S3	26.0	45.0	152.0	68.59	132.34	63.75	4.00	22
S4	23.0	52.0	174.0	116.15	149.41	33.26	9.00	22
Average	34.5	47.5	159.0	92.40	134.49	42.09	5.75	23

Table 4 Physiological coat and drudgery involved in coconut harvesting by tractor operated hydraulic platform

Subjects	Age (years)	Weight (kg)	Stature (cm)	Resting HR	Working HR	Work Pulse (ΔHR)	ODR	BPDS
S1	40.0	45.0	144.7	111.03	147.72	36.69	3.00	14.00
S2	49.0	48.0	165.1	70.08	100.51	30.43	2.00	14.00
S3	26.0	45.0	150.0	85.45	101.31	15.86	3.00	12.00
S4	23.0	52.0	174.0	116.15	142.23	26.08	5.00	13.00
Average	34.5	47.5	159.0	95.67	122.94	27.26	3.25	13.25

Nevertheless, the 137 seconds time was recorded for the actual coconut harvesting. Thus the most of the time recorded here is for the actual coconut harvesting, however the actual time for harvesting based on the actual number of matured coconuts available with the individual tree. Thus the capacity of the machine is restricted to the actual number of matured coconuts available with the individual tree. However in most of the coconuts plot more lowering time is recorded as compared to lifting time.

Figure 5 Influence of Time (Seconds) on Number of coconut palm harvested for T/D Variety. From Fig. 5 and 6, it is observed that the TMSPPC requires more lowering time as compared with the lifting time of TMSPPC. Therefore it is suggested to keep the TMSPPC lower arm open partially to reduce the excess lowering time. The tractor mounted and self propelled coconut climber was persistently tested for harvesting of coconut to observe the field capacity of tractor mounted and self propelled coconut climber for coconut harvesting. The field testing was carried out on the various coconut varieties like Banawali and T/D, during Jan-2011 to May 2011 at a coconut research station, Bhyte. From Table 1 and 2.1 the following observations were recorded. For

harvesting of coconut upto 14 m height the total lifting time required by using tractor mounted and self propelled coconut climber for harvesting of 13 coconut trees is 775 sec. Whereas, the recorded lowering time for harvesting of 13 coconut Palm trees was 1030 seconds. However maximum time expensed for the actual harvesting of coconuts. Thus it is observed that total 13 coconut trees can be comfortably harvested by using tractor mounted and self propelled coconut climber within one hour.

Table 3 presents the ergonomically test results of conventional climbing practices of coconut trees. The average resting heart rate was 92.40 beats min⁻¹ and that of working heart rate was 134.49 beats min⁻¹. The average work pulse was found to be 42.09 beats min⁻¹. The ODR and BPDS values were 5.75 and 23 respectively. Speed of climbing up on coconut tree and coming down below coconut tree were 0.21 m s⁻¹ and 0.23 m s⁻¹. The average capacity (Coconuts harvested/h) was found to be 50.

However Table 4 presents the test results of ergonomically tested TMSPPC Coconut climbing practices for coconut harvesting. The average resting heart rate was 95.67 beats min and that of working heart

rate was 122.94 beats min^{-1} . The average work pulse was found to be 27.26 beats min^{-1} . The average numbers of trees harvested per hour were 14. The average capacity (Coconuts harvested/h) was found to be 500. Speed of rising up and lowering down the platform were 0.30 m s^{-1} and 0.45 m s^{-1} . The ODR and BPDS values were 3.25 and 13.25 respectively.

4. CONCLUSION

The following conclusions were made from the above study. The TMSPPC found suitable for harvesting of coconut up to 45 ft. height of coconut tree, 450 to 500 coconuts including 18 to 20 coconut trees were harvested in one hour by using tractor mounted and self propelled coconut climber.

The safety and less hazardous results are noted for the tractor mounted and self propelled coconut climber as compared to manual climbing methods for coconut harvesting.

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BIOGRAPHIES



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