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Design and development of coconut ultra-low volume climbing sprayer

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Abstract
Harmful pests greatly affect the growth of coconut trees. These pests attack the outer layer of the coconut and pollute it from the inside. As a solution to this problem, tree-specific pest control devices have been developed. The coconut sprayer has been developed at Dept. of Agricultural Engineering, Kakinada Institute of Technology and Sciences. East Godavari. In the year 2022. A new technique has been developed to model the accumulation of spray on the leaves of coconut trees. Injecting the agent directly on the leaves from an optimal location dramatically reduces the amount of chemical pesticide needed. Due to the height of coconut trees, climbing injuries especially falls, are common in India. The sprayer can climb at an average speed of 3 m/min and carry a sprayer with a tank capacity of 2 Liters. The sprayer sprays at range of 45 cm with 4.5 k/g/cm^2 for a 16 m tree and 36 cm with 4.5 k/g/cm^2 for a 13.5 m tree when tested.

Keywords: Coconut trees, pests, pest control equipment, spraying, chemical pesticide, coconut climbing sprayer

Introduction
The coconut palm, known as the "Kalpavriksha" or "tree of heaven," is highly beneficial to humanity as every part of the tree has practical uses. It provides food, drink, fuel, and wood, making it a vital source of livelihood for millions of Indian families. Athulya, S. N. (2017) [3]. India ranks as the third-largest coconut producer globally in terms of both area and production, with the southern states of Kerala, Tamil Nadu, Karnataka, and Andhra Pradesh being the primary coconut-producing regions, accounting for over 90 percent of the total area and production. Adopting scientific farming techniques can enhance coconut productivity. Narmadha, N., Karunakaran, K. R., Anjugam, M., Palanisamy, N. V., & Vasanthi, R. (2022) [2]. The coconut tree can thrive in diverse climatic and soil conditions, predominantly in tropical regions between 20°N and 20°S. The optimal temperature for growth and harvesting ranges from 27 ± 5 °C, with humidity levels above 60 percent. De, L. C. (2020)

The quality and quantity of mature coconut yield have been greatly affected due to the disease that affects the coconut inflorescence is a disease of top rot and fruit drop caused by fungi. The rhinoceros beetle and coconut beetles destroy young shoots, resulting in fan-shaped cleavage, and the coconut die off and become a decapitated coconut shoot. It is difficult to spray chemicals to prevent diseases and pests due to the large and tall nature of the coconut tree. Daoden, K., Sornnen, T., Pankasemsuk, T., Phaphuangwittayakal, P., Sringam, S., & Nicrotha, S. (2021) [1].

Traditionally, climbing coconut trees for spraying has been a simple yet perilous process. To address this safety concern, the development of a climbing device is essential. we have successfully designed a coconut palm climbing device that meets ground handling requirements, is suitable for both men and women and can be repaired quickly, if not faster than existing devices.

Climbing injuries, especially falls, are common in India due to coconut trees height. Many climbing machineries was developed but only few can handle the trees' irregular surfaces and varying diameters. Some tree barks may not support conventional climbing devices, making them unsuitable for heights above 12 m. Hence, there is a need to develop a sprayer for coconut trees. which can be used for spraying pesticides.

Materials and Methods

The development and testing of Coconut climbing sprayer are carried out at Dept. of Agricultural Engineering, Kakinada Institute of Technology and Sciences. East Godavari. In the year 2022.

Theoretical, agronomic, functional, and technical aspects were considered in the design of a coconut climbing sprayer. The main functions of this mechanical device are to climb and spray pesticides on plants. Below are the main parts that are effectively used in designing and manufacturing a coconut tree climbing sprayer.

1. Main frame

A 1-inch square tube of mild steel material used for the frame, as shown in Figure 1. All parts are mounted on this frame in proper arrangement. and the frame is attachable and removable. Attaching and detaching are done using a spring that holds the frame firmly in the tree while climbing.

2. Battery

A 12-volt battery is used as a power source to operate the sprayer. All the electric components are connected to the battery. It is shown in Figure 7.

3. Motor

This machine uses two 12-volt, 90-watt, 60-rpm D.C. motors one at the bottom and one at the top of the frame. These motors are connected to the wheels through a transmission mechanism. The wheels are shown in Figure 2

4. Gears

Spur gears are used for this device. Gears will only engage only when mounted on parallel shafts. This machine uses two gear mechanisms connected with the lower D.C. motor.

5. Wheels

In this machine, the wheels are essential for tree climbing. The plastic wheels on this machine are lightweight and 4 inches in diameter. There are four wheels on the four corners of the machine, and on the inside of the frame, we use four extra wheels with a diameter of 2 inches to increase traction when climbing trees. It is shown in Figure 3.

6. Universal joint

The universal joint connects rigid rods whose axes are inclined to each other. It is often used on shafts that transmit a rotary motion. It consists of a pair of hinges located close to each other, oriented at 90° to each other, and connected by a cross-axis. The universal joint is not a permanent quick joint. Two universal joints connect the wheels on the four sides.

7. Sprayer tank

The sprayer tank is used for storing the pesticide solution, as shown in Figure 7. The tank has a capacity of 2 Liters and is connected by a hose to a vacuum pump. It is shown in Figure 7.

8. Rotary vacuum pump

A rotary vacuum pump is a water displacement pump consisting of vanes mounted on a rotor rotating in a cavity. It increases the pressure of solution passing through the nozzle. In some cases, these vanes can be of different lengths and can be stretched to maintain contact with the walls when the pump rotates. A pump can be seen in Figure 4.

9. Nozzles

The nozzle atomizes the liquid solution, 4 misting nozzles are used for the spraying. The Nozzle is shown in Figure 5

10. Arduino microcontroller

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital I/O pins (6 of which can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB interface, a power connector, an ICSP header, and a reset button. All the operations (Climbing, and spraying) are controlled by the Arduino. The device is shown in Figure 6.

Lab evaluation for the coconut climbing sprayer.

The sprayer was tested based on the test code IS:11429 - 1985 Indian Standard METHODS FOR CALIBRATION OF SPRAYERS

Spray droplet size is highly important for efficient and effective utilization of pesticides with minimum contamination of environment. Misting nozzles are used for this sprayer as it has droplet volume mean diameter(µm) 51-100. The pressure of nozzle is controlled by the Arduino controller from the ground. Sahay, Jagdishwar. (2008) [5].

Results and discussions

Calibration of the coconut sprayer

This process involves dividing the chemical solution into small droplets of optimal size, ensuring their effective distribution across all the leaves. Applying sufficient pressure is essential to ensure the chemicals reach the leaves positively. Careful regulation of pesticide solution sprayed on the leaves of coconut tree is so crucial to avoid excessive application and ensure precise and controlled usage. this method aims to enhance the effectiveness of chemical treatments while minimizing waste and potential harm to the environment.

The sprayer's calibration is configured to spray at a 30-degree angle, and pressure is adjusted based on the swath width of the tree. The climbing speed is fixed at 1.5 km/h. at a pressure of 4.5 km/cm^2, the sprayer achieves a maximum swath width of 45 cm.

Nozzle discharge rate

This experiment involves testing various nozzle flow rates, ranging from low to high, at different pressures while maintaining a constant climbing speed of 0.2 km/h. the sprayer's angle is set to be 30^0 throughout the experiments to observe its effect on spray distribution.

The findings indicate a clear relationship between nozzle discharge rates and the sprayer's performances. At higher flow rates, the spray swath width increases, leading to improved coverage over larger area. Data measurements founds that when pressure increases from $3Kg/cm^2$, $3.5Kg/cm^2$, $4.0Kg/cm^2$, and $4.5Kg/cm^2$discharge of nozzle increases from 450,940,1330 and 1880.

Field Evaluation of coconut climbing sprayer

The wholly assembled sprayer was tested on coconut trees and recorded the time required to climb from the ground to the top of the tree. The time to require reaching ground from the top of a tree are tabulated in Table 2.

According to the data collected in the coconut field, it takes around 5.0 minutes to climb a16.5m tall coconut tree from the ground to the top and about 3.8 minutes to reach the ground surface again due to gravitational force.
The time taken to spray a chemical solution on a coconut tree 360 degrees around and the time taken to attach and detach the unit from one coconut tree were also noted, and the values were tabulated in Table 3.

Testing of developed of Coconut sprayer
The swath width of the sprayer increases with the increase in pressure without affecting the tree height. Shortest tree with the height of 13.5 m required $3Kg/cm^2$ pressure to reach swath width of 35.64 cm. Similarly, longest tree with the height of 16.5 m required $4.5Kg/cm^2$ pressure to reach swath width of 35.64 cm. the effect of operating pressure on the swath width of the sprayer was presented in table 4 and from the fig.10 and fig.11, it was shown that with increasing height the operating pressure was increased to improve the swath width.

Table 1: Nozzle discharge rate

Details	T_1	T_2	T_3	T_4
Pressure Kg/cm^2	3	3.5	4.0	4.5
Period of testing(min)	1	2.5	4	5
Capacity (l)	2	2	2	2
Discharge rate (ml/min)	450	940	1330	1880

Table 2: Time taken to climb coconut trees and reach the ground.

S. No	Height of tree (m)	Time taken to climb (min)	Time taken to reach ground (min)
1	13.5	4	2.50
2	14.0	4.3	3.00
3	14.3	4.1	2.09
4	14.5	4.0	2.06
5	15.0	4.2	2.05
6	15.2	4.9	3.40
7	15.5	4.6	3.20
8	15.7	5.0	3.50
9	16.0	4.4	3.20
10	16.5	4.5	3.40
Mean	15.2	4.4	2.17

Table 3: Time is taken to spray, attach, and detach the unit to a tree.

S. No	Height of the tree (m)	Time taken to spray a tree (min)	Time taken to attach and detach to coconut tree (min)
1	13.5	3.0	10.0
2	14.0	3.2	10.5
3	14.3	3.1	11.0
4	14.5	3.2	10.3
5	15.0	3.3	10.5
6	15.2	3.0	10.8
7	15.5	3.0	10.6
8	15.7	3.2	10.2
9	16.0	3.1	10.5
10	16.5	3.1	10.2
Mean	15.2	2.84	10.46

Table 4: Effect of operating pressure and on swath width

S. No	Tree Height(m)	Pressure (Kg/cm^2)	Swath width(cm)
1	13.5	3.0	35.64
2	14.0	3.0	36.96
3	14.3	3.2	38.00
4	14.5	3.5	38.80
5	15.0	3.7	39.20
6	15.2	3.7	39.60
7	15.5	4.1	40.92
8	15.7	4.1	41.20
9	16.0	4.3	42.24
10	16.5	4.5	43.56
Mean	15.02	3.7	39.612

Table 5: Analysis of variance (climb up and reach down)

Source	Dependent Variable	Type III Sum of Squares	d. f	Mean Square	F
Corrected Model	Climb up	1.105[a]	6	.184	36.833
	Reach down	1.565[b]	6	.261	6.521
Intercept	Climb up	175.291	1	175.291	35058.273
	Reach down	83.265	1	83.265	2081.636
Height	Climb up	1.105	6	.184	36.833
	Reach down	1.565	6	.261	6.521
Error	Climb up	.015	3	.005	
	Reach down	.120	3	.040	
Total	Climb up	194.720	10		
	Reach down	94.710	10		
Corrected Total	Climb up	1.120	9		
	Reach down	1.685	9		
Squared = .987 (Adjusted R Squared = .960)					
R Squared = .929 (Adjusted R Squared = .786)					

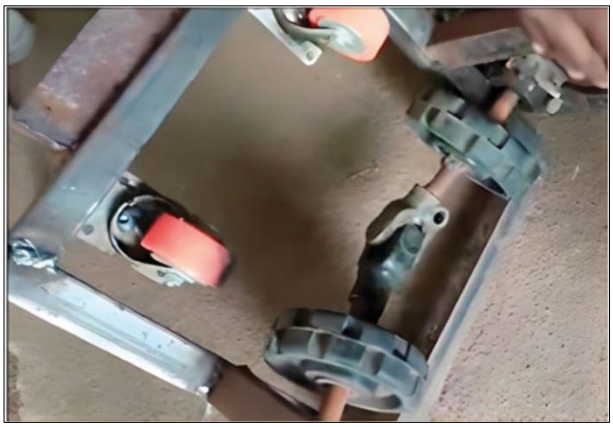

Fig 1: Main frame

Fig 2: 12 V DC Motor

Fig 3: Rubber Wheels

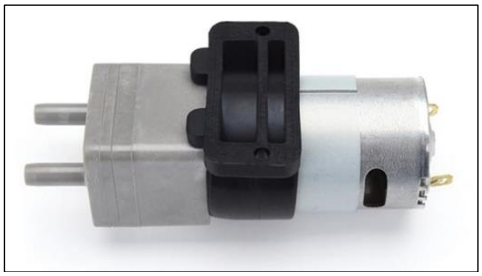

Fig 4: Rotatory Vacuum pump

Fig 5: Nozzles

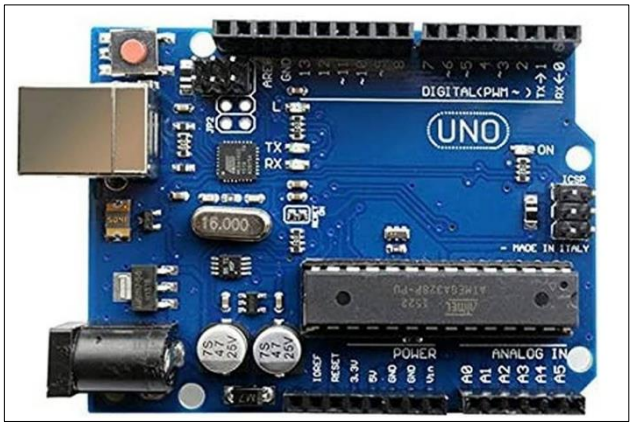

Fig 6: Aduino microcontroller board

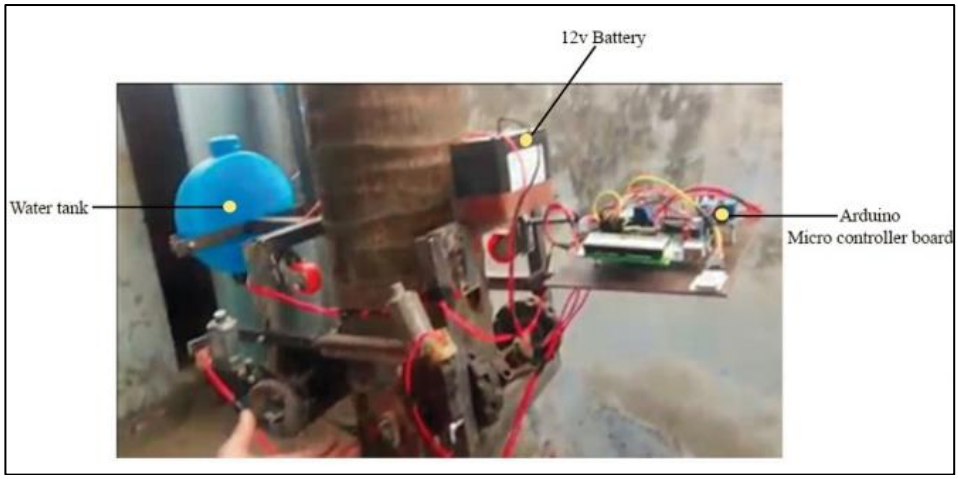

Fig 7: Assembled coconut sprayer

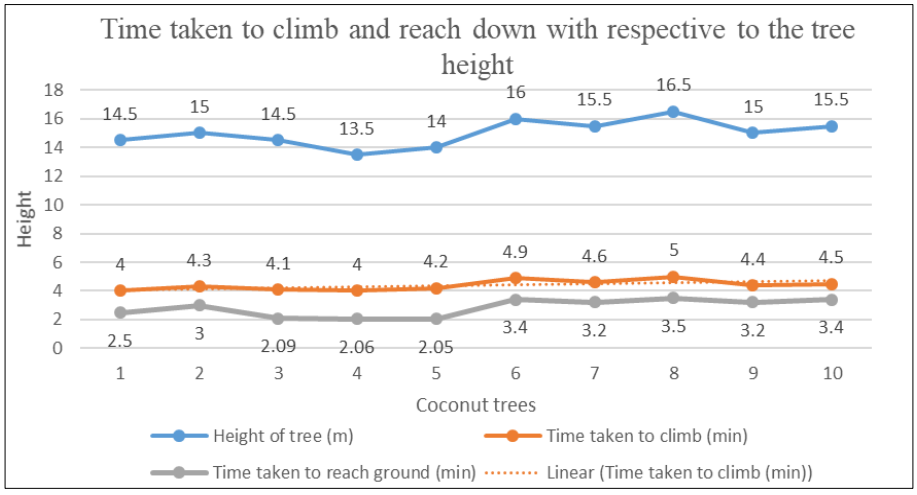

Fig 8: Graph showing time taken for climbing up and reaching down the tree with reference to the tree height.

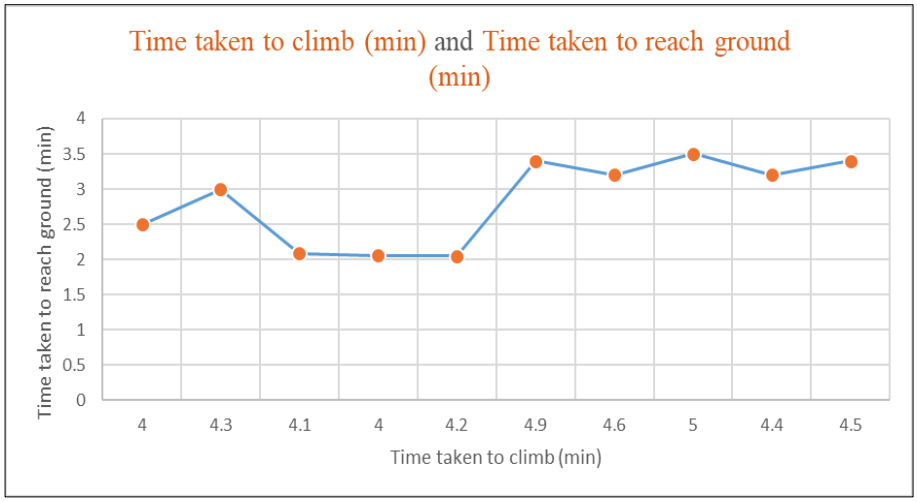

Fig 9: Graph showing time taken for climbing up and reaching down the tree with reference to the tree height are highly corelated.

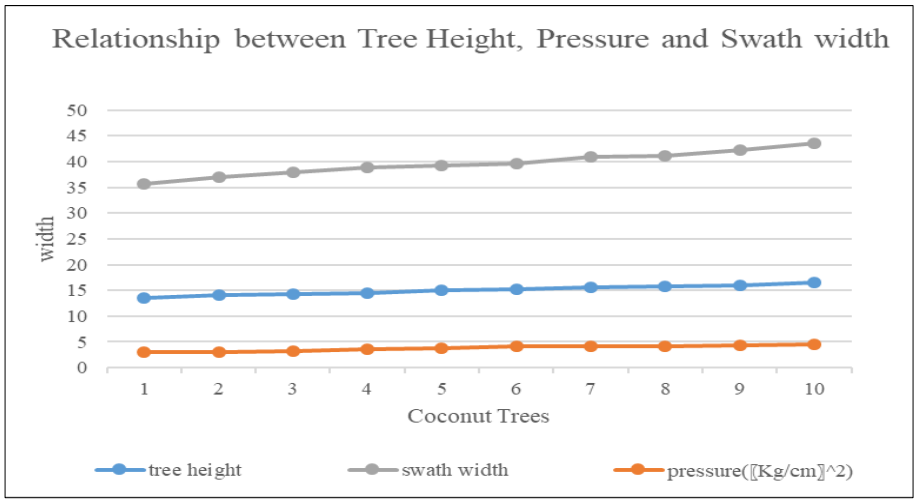

Fig 10: Graph showing Swath width with reference to the tree height

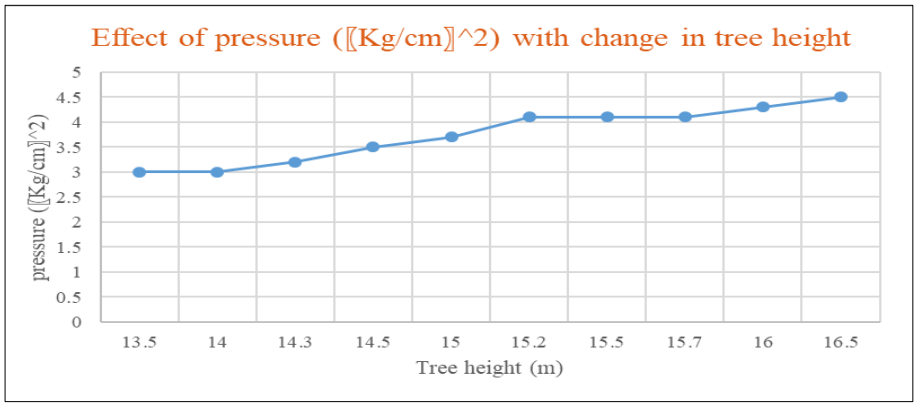

Fig 11: Graph showing Pressure with reference to the tree height is highly coreleated.

Conclusion

The climber can cover one tree in 22 minutes, giving the expected results. This sprayer can cover a tree with a chemical solution on both sides entirely in 4 minutes. The machine takes 5 minutes to climb a 16.5m tall tree and 3.8 minutes to reach the ground surface from the top after spraying is completed. Approximately 10 minutes is needed to attach and detach the machine from a tree, and this can vary from person to person. The swath width of the sprayer increases with the increase in pressure without affecting the tree height. Shortest tree with the height of 13.5 m required $3Kg/cm^2$ pressure to reach swath width of 35.64 cm. Similarly, longest tree with the height of 16.5 m required $4.5Kg/cm^2$ pressure to reach swath width of 35.64 cm. The efficiency of sprayer is 97% when compared with lab evaluation and field evaluation. The nozzle discharge rate plays a pivotal role in determining the success of spray applications in agriculture. By understanding the relation nozzle discharge rates, pressure adjustments, and spray swath width one can make informed decisions to achieve superior crop protection while minimizing environmental impact. This research contributes valuable insights to optimize spraying techniques and promoting sustainable practices.

References

1. Daoden K, Sornnen T, Pankasemsuk T, Phaphuangwittayakal P, Sringam S, Nicrotha S. Development of agricultural spraying drones' prototype for coconut beetle weevil control. NVEO Nat Volat Essent Oils J. 2021:8322-8332.
2. Narmadha N, Karunakaran KR, Anjugam M, Palanisamy NV, Vasanthi R. An economic analysis on Indian scenario of coconut production: Trends and prospects. Econ Aff. 2022;67(3):263-269.
3. Athulya SN. Characterisation of boron deficient coconut palms (*Cocos nucifera* L.) [doctoral dissertation]. Department of Plantation Crops and Spices, College of Agriculture, Vellayani, 2017.
4. De LC. Good agricultural practices of commercial orchids, 2020.
5. Sahay J. Textbook of elements of agricultural engineering. Plant Protection Equipment. Delhi: Standard Publishers Distributosrs; 2008. p. 333-337.
6. Bureau of Indian Standards. IS 11429:1985 Indian standard – Methods for calibration of sprayers. New Delhi: BIS, 1985.