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Study on Biometrics of Selected Coconut Varieties for the Development of a Drone Spraying and Harvesting System for Coconut Palms

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ABSTRACT

Background: Coconut palm (*Cocos nucifera*) is a significant cash crop in the humid tropics of India. The quality, variety and types of coconut palm vary from one place to other. Nowadays, the lack of skilled climbers for tree climbing is a serious problem experienced by coconut farmers. The adoption of drone technology in coconut cultivation is considered to enhance the productivity of coconut. The current study aimed to study the biometrics of different varieties of coconut trees to design and develop a drone-based spraying and harvesting system which suits all types of coconut palms.

Methods: The major parameters influencing drone spraying and harvesting design are crop, machine and meteorological parameters. The crop parameters for the palms were measured by using standard techniques. The prominent varieties include West coast tall, Coconut - ALR (CN) 1, Coconut - ALR (CN) 3, Chowghat orange dwarf, Chowghat green dwarf, Malaysian yellow dwarf, East coast tall and Chandra Kalpa were selected. The biometric data were observed from the randomly selected healthy coconut trees.

Result: The eight major coconut varieties were selected and their biometric data was observed. It was concluded that the observations aided in deciding the design of the drone components as well as the spraying and harvesting mechanism suitable for coconut palms.

Key words: Bunch, Coconut, Leaf, Peduncle, Petiole, Variety.

INTRODUCTION

Coconut palm (*Cocos nucifera*) is a significant cash crop in the humid tropics of India. The quality, variety and types of coconut palm vary from one place to other. It has an average height of 30 to 60 meters and has a long life of 60 to 100 years. The coconut trees usually grow in narrow dimensions and the time taken to harvest the nuts will be around 3 to 4 years. In India, Coconut is a crop of small and marginal farmers since 98% of about five million coconut holdings are less than two hectares (Anonymous, 2020). As for the Government of India, the total area was 2173.28 thousand hectares under coconut cultivation, 20308.70 million nuts produced and productivity nut per hectare was 9345 in 2019-2020 (Anonymous, 2020). Among the states in India, Kerala achieved first place in terms of cultivated area, which was 760.78 ha and the Tamil Nadu state obtained the third-highest area (37.57 ha.) during 2019-2020. The four southern states together account for more than 90% of the total production in the country (Kerala 36.88%, Tamil Nadu 34.11%, Karnataka 13.83% Andhra Pradesh 6.16% and other states 9.0%) Selvaraj *et al*. (2017). Coconut tree usually starts bearing after 5 to 6 years of the plantation. The growth of the coconut tree is affected by harmful insects, pests and diseases. If the spraying operation is done at the affected region of the tree, the efficiency will be better in controlling pests and diseases (Tamilselvi and Anantha Krishnan, 2016). The acute shortage of human coconut tree climbers results in the deterioration of coconut farming (Megalingam *et al.* 2017). The harvesting of coconuts also

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becomes a hectic issue for coconut farmers. The manual harvesting is the traditional method of coconut harvesting. To hold the trees, climbers use rope loops. Climbing with the front foot and the frog foot are two types of manual of manual climbing (Pawar *et al.* 2019). Due to the height and lack of branches, it is challenging to climb coconut trees. Climbing a coconut tree is only possible for a professional climber with proper training. Although this is dangerous, it is very commonly done to harvest coconuts. There are many coconut tree climbing devices available on the market, but that does not ensure the safety aspects of the climbers. Nowadays, most people are not interested in climbing coconut trees due to the risks involved (Edacheri *et al.* 2011). The drone sparying and harvesting system is very important for this era to overcome these issues. The system comprises a drone mounted with a camera and a spraying module with a telescopic lance. The telescopic lance attached to the nozzle helps to reach out to the site-specific, *i.e.*, disease-affected or pest-affected area to spray the chemicals.

Similarly, the harvesting system comprises a drone-mounted cutting tool with a camera. An operator can perform coconut harvesting by remotely assisting the drone from the ground station, which is performed by monitoring the camera output. For the development of the drone system, the specifications and design parameters should be taken based on the biometric data of the coconut tree. The drone design parameters involve the frame dimensions, propeller size, the number of propellers, spray tank capacity, spray lance, harvesting tool, camera specifications, ground control station and path programming (Huang *et al*. 2013), (Durham and Ryan 2015), (Dongyan *et al*. 2015), (Mhetre *et al*. 2020), (Nivas *et al*. 2020) and (Cuaran and Leon 2021). Therefore, in developing a drone top reaching mechanism, it is necessary to identify the biometrics of different varieties of coconut palms.

MATERIALS AND METHODS

The biometric study was conducted (2020-2021) at Coconut Research Station, Tamil Nadu Agricultural University, Aliyar Nagar India. The Research Station is located in the foothills of Western Ghats at the geographic coordinates of 10° N latitude and 77° E longitude, 20 km south of Pollachi at an elevation of 260 m above MSL with undulating topography. The station owns 22 hectares of land comprising A, B and C blocks, of which nearly 17.22 hectares are under coconut cultivation. The genetic diversity of coconut is exhibited in a wide array of phenotypic traits, mainly in the stature of a tree (John and Narayana 1949, Sugimura *et al*. 1997, Arunachalam and Rajesh 2008). The prominent varieties commonly grown in the Tamil Nadu region are West coast tall, Coconut-ALR (CN) 1, Coconut-ALR (CN) 3, Chowghat orange dwarf, Chowghat green dwarf, Malaysian yellow dwarf, East coast tall and Chandra Kalpa were selected for the investigation. East and West coast tall are the most widely grown tall varieties. The biometric data such as pedicel length, pedicel thickness, peduncle width, peduncle thickness, number of matured bunches, number of coconut in a bunch, number of leaves in a tree, number of leaflets in a leaf, length of the leaflet, length of the leaf, the width of the leaf, petiole length, petiole thickness, height of the tree, the girth of the tree bottom, the girth of the tree top, spathe length maximum, spathe length minimum, spathe width maximum and spathe width minimum were noted from the healthy palms which influence the development of a drone in various aspects of the design. The healthy trees of each variety were selected and tree climbers were used to climb the tree along with the measuring instruments to measure each biometric reading (Lal *et al*. 2017) and (Prakash *et al*. 2020). Most of the observations were taken from the freshly cut parts of the coconut tree. The measurements were recorded using graduated scale, tape

Fig 1: Biometric observations.

and digital vernier caliper having an accuracy of 0.02 mm. The biometric data collections were taken on randomly selected ten trees of each variety and it was replicated thrice to achieve better results as shown in Fig 1.

Spacing

In the square system, a spacing of 7.5 x 7.5 x 7.5 m is generally recommended for coconut (Figure.2.). This will accommodate 177 and 156 palms per ha, respectively. An additional 25 palms can be planted if the triangular system is adopted. A hedge system can also be adopted, giving a spacing of 6.5 m rows. To facilitate multiple cropping in coconut gardens, it is advisable to go for wider spacing of 10 m × 10 m to provide ample opportunity to accommodate a number of perennial and annual crops in the interspaces (Anonymous, 2020).

Formulate for calculating the number of plants per unit area in different layout systems.

$$\text{Square layout} = S/L$$

S = Unit surface.
L = Side of the Square pattern.

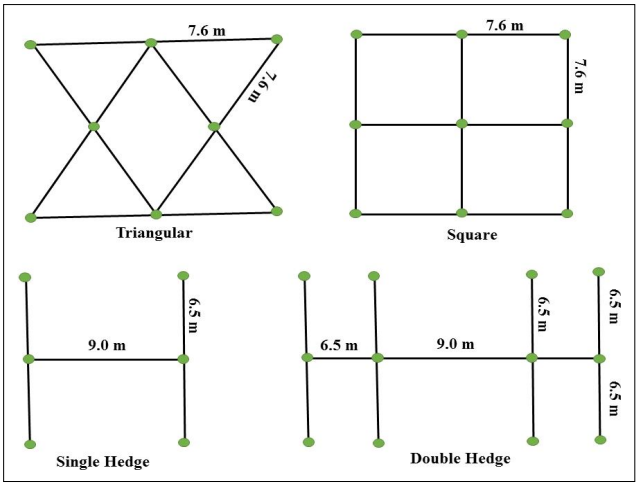

Fig 2: Coconut planting - spacing (layout).

$$\text{Rectangular layout} = S/L_1 \times L_2$$

S = Unit surface.
L_1= Shorter side of the rectangle.
L_2= Longer side of the rectangle.

$$\text{Triangular Layout} = S/D \times 0.866$$

S = Unit surface.
D = length of the triangle side.

$$\text{Hedge system} = N \times 100{,}000{,}000/Y\ (x + z)$$

N = Number of lines in a hedge (double hedge = 2).
Y = Distance between plants in a line.
X = Distance between hedges.
Z = Distance between lines.

RESULTS AND DISCUSSION

Coconut leaf

Pinnate leaves, which are sometimes described as being feather-like, have leaflets entirely separated from each other that is attached perpendicularly to the rachis. The rachis is an extension of the petiole, which extends into the leaf blade. The leaves are crowded together at the top of the trunk in the form of a crown. The crown has an average of 12- 15 open leaves and 15 young leaves in different stages of development. The leaf consists of many leaflets arranged obliquely on the mid-rib or rachis. From the Fig 3, 4 and 5 it is observed that east coast tall and Coconut - ALR (CN) 1 variety was recorded with more leaves ranging from 26 to 28, which shows that higher the numbers of leaves give the densified canopy it covers the coconut bunch.

Similarly, the number of leaflets in the leaf decides the length and width of the entire leaf. East coast tall and Coconut - ALR (CN) 1 has a mean number of 217 and 213 leaflets and all other varieties exist in the range from 200 to 210. The Malaysian yellow dwarf variety has a mean of 180 leaflets. Therefore, the length of the leaf was recorded higher in coconut - ALR (CN) 3 and coconut - ALR (CN) 1 variety ranging from 6 m to 5.3 m. Similarly, the width of the leaf was recorded higher in coconut - ALR (CN) 3, Chowghat green dwarf, coconut - ALR (CN) 1 ranging from 2.1 m to 2.0 m.

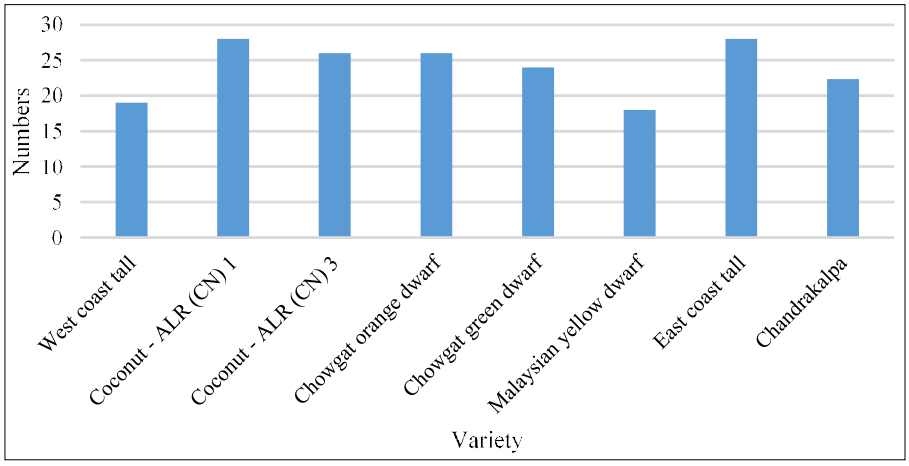

Fig 3: Number of leafs in a tree.

Leaf area

Usually, the coconuts are spread around the top of the coconut trees unpredictably and its stacks are very hard. In 2005, Sousa proposed a model for the viability of estimating the coconut tree leaf area using a simple measure of the leaf rachis length.

$$LA = 0.8282\ [LR]^{1.5662}$$

Where,
LA = Leaf area.
LR = Leaf rachis length.

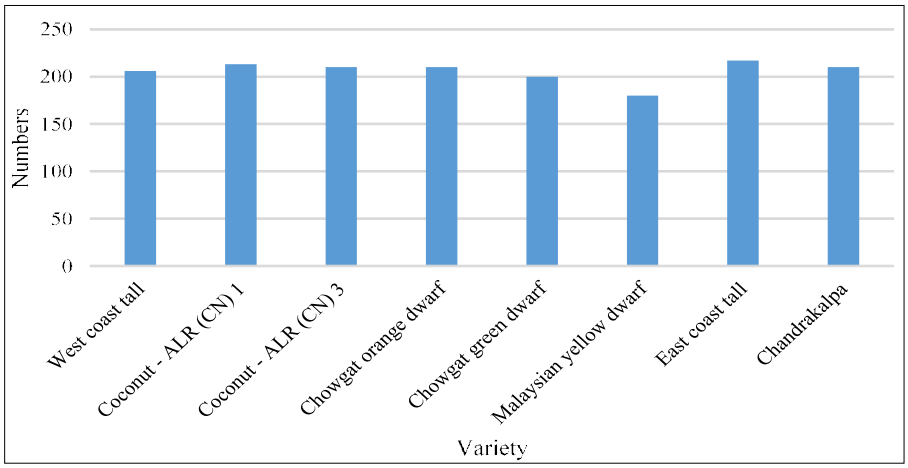

Fig 4: Number of leaflets in a leaf.

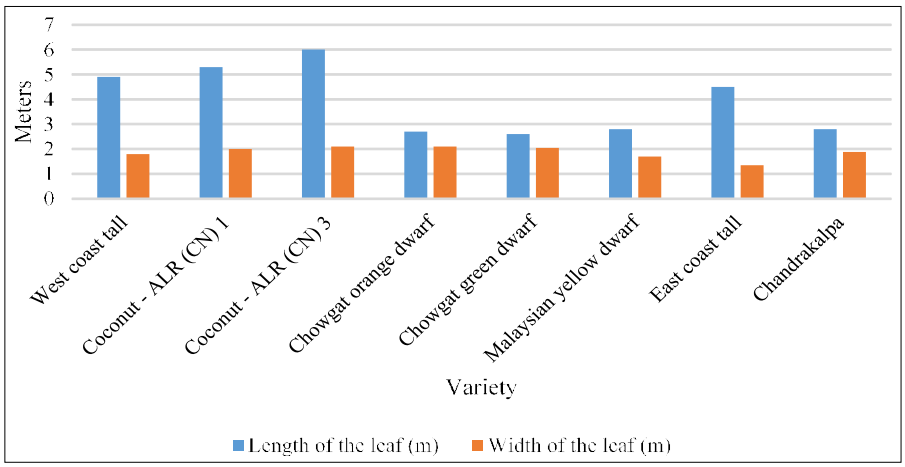

Fig 5: Length and width of the leaf (m).

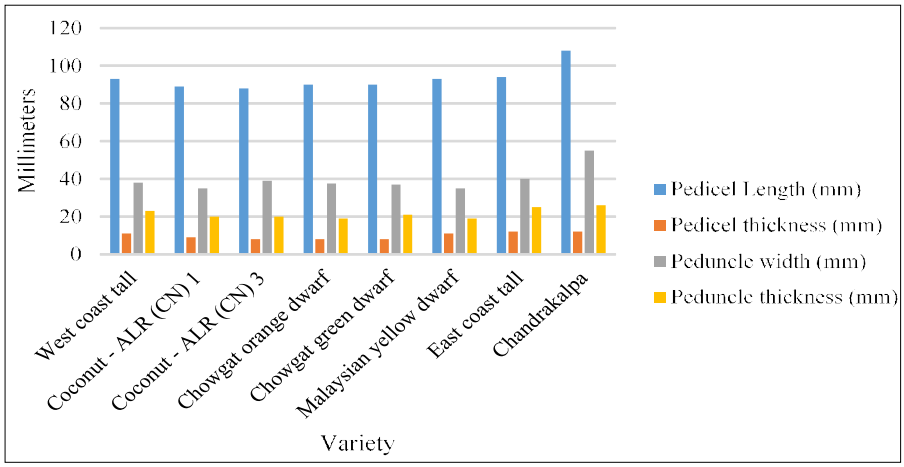

Fig 6: Pedicel and peduncle dimensions (mm).

The total leaf area of one tree to be easily determined from the length average of the last three leaf rachis and the leaf numbers in the crop canopy.

$$TLA = 0.8282 \{ -0.3125 + 1.3207 [LR_3] - 0.2078 [LR_3]^2 + 0.05407 [NL]\}^{1.5662}$$

Where,

Table 1: Single leaf area of the selected coconut varieties.

Variety	Leaf length (m)	Leaf area (m^2)
West coast tall	4.9	9.97
Coconut-ALR (CN) 1	5.3	11.28
Coconut-ALR (CN) 3	6	13.7
Chowgat orange dwarf	2.7	3.92
Chowgat green dwarf	2.6	3.69
Malaysian yellow dwarf	2.8	4.15
East coast tall	4.5	8.73
Chandrakalpa	3	4.62

NL = Number of leaves in the tree.
LR = Average rachis lengths of the last three leaves.

The calculated leaf area of the different coconut varieties is shown in Table 1.

Peduncle and pedicel

The stem or branch from the main stem of the inflorescence that holds a group of pedicels is called a peduncle. The pedicel attaches each coconut to an inflorescence. The pedicel of coconut at the early stage was deep green in colour. The colour of the pedicel turned green and pale yellow in the harvesting stage. The thickness and length of the pedicel have a significant role in the selection of the harvesting mechanism as the blade or knife has to be strong enough to cut the pedicel. It is observed that the chandrakalpa variety has a higher peduncle length of 55 mm and 26 mm thickness from the Fig 6. The chandrakalpa and east coast tall were recorded with a higher pedicle length of 108 mm and 12 mm thickness.

The number of matured bunches in coconut palms was observed and Coconut - ALR (CN) 1 was recorded at a

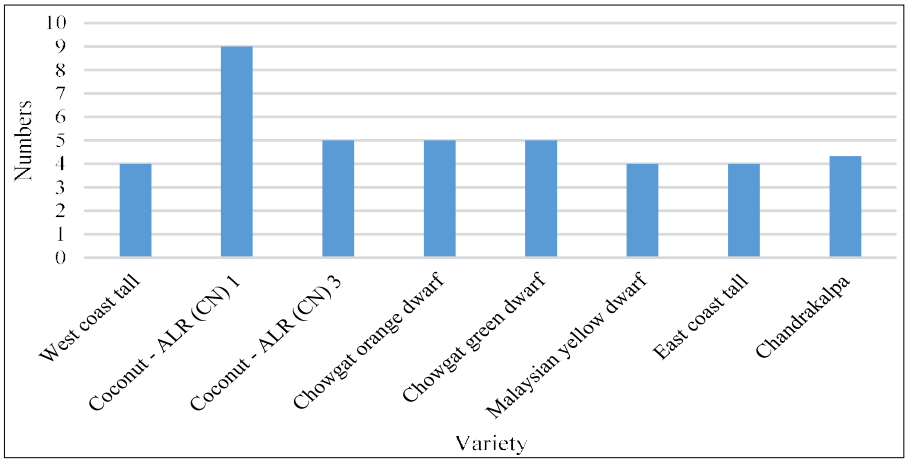

Fig 7: Number of matured bunches.

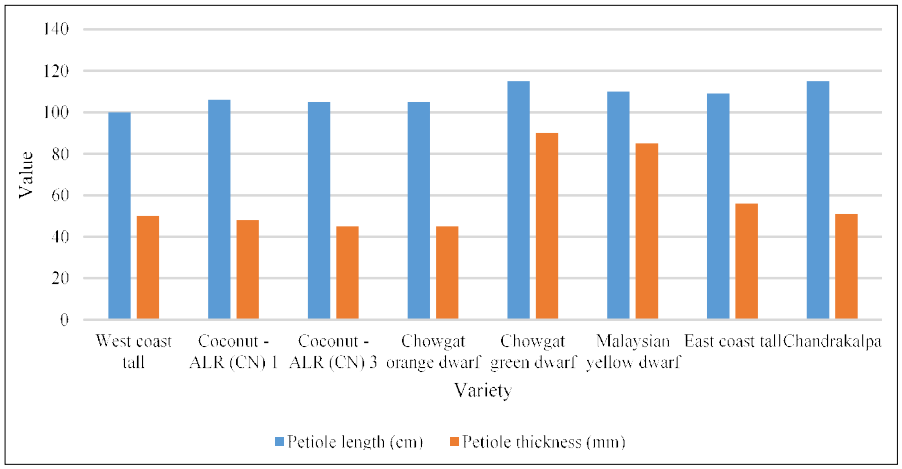

Fig: 8 Petiole Dimensions

maximum of 9 bunches per tree is shown in Fig 7. Each bunch holds on an average of 20-25 coconuts. These bunches are located all around the tree at different stages of the spathe.

Petiole

The stalk which attaches the leaf to the stem is called a petiole. This gives a characteristic foliage arrangement to the tree. The chandrakalpa and chowgat green dwarf have recorded a higher petiole length of 115 cm. The chowgat green dwarf and Malaysian yellow dwarf were recorded with a higher petiole thickness of 90 mm and 85 mm is shown in Fig 8.

Spathe

The spathe is the portion of the bunch that gets attached to the tree's stem. The maximum and minimum spathe length for all the selected varieties as shown in Fig 9. The west coast tall variety has a maximum spathe length of 165 cm and the minimum spathe length was found as 45 cm. Similarly, the chandrakalpa has a maximum spathe width of 131 cm and the east coast tall recorded a minimum spathe width of 43 cm.

Girth of the coconut tree

The girth remains uniform for several years and finally tapers in growth when the tree grows very old. The east coast tall and chandrakalpa were recorded higher girth at the bottom of 47 cm and 40 cm. The chowgat orange dwarf and Malaysian yellow dwarf were recorded higher girth at the top 20 cm is shown in Fig 10.

The results observed from the biometric study inferred that the maximum values of the parameters should be considered along with adding the factor of safety in the design and development of the drone for spraying and harvesting in coconut palms to ensure the stability, endurance and maneuverability of the flight. Also, it should be tested under laboratory and open field conditions. The multicopter normally lasts approximately 20 minutes and should be stabilized during the flight mechanism. The sprayer design consists of a sprayer frame, motors, a power system, a chemical tank, a pump and a nozzle with a remote

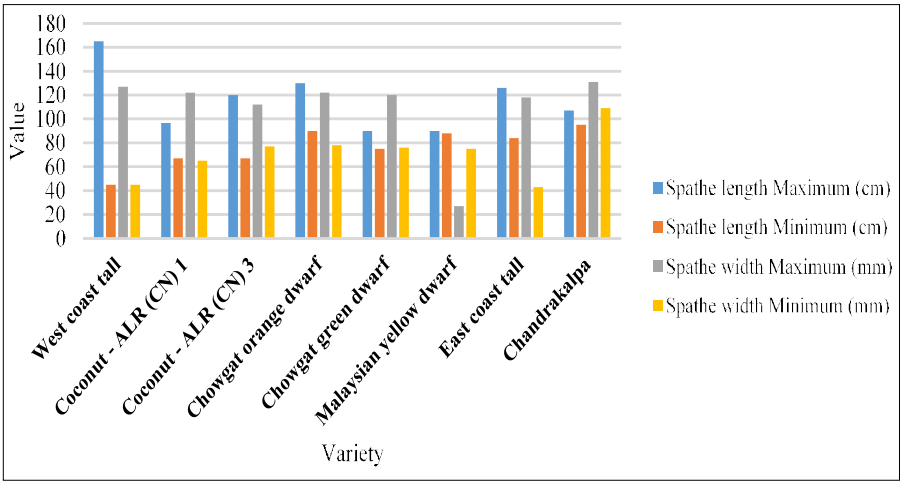

Fig: 9 Spathe Dimensions.

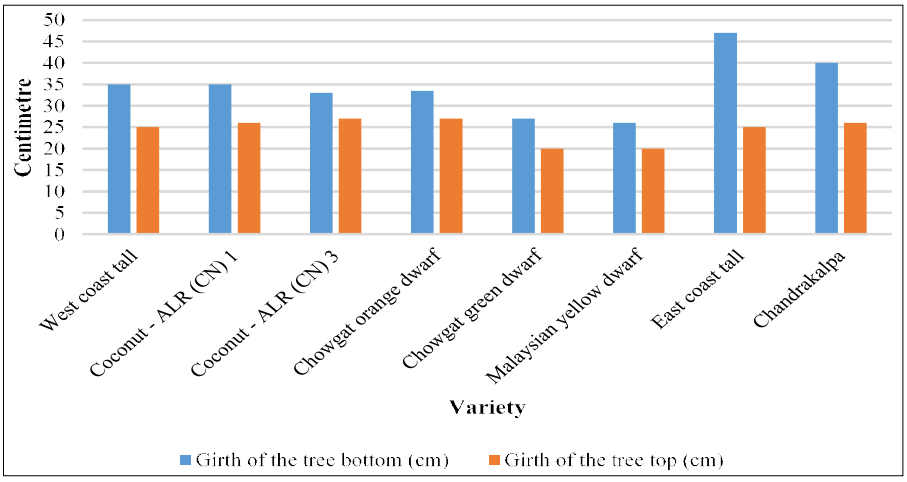

Fig 10: Girth of the tree (cm).

Table 2: Factors that influence the design of drone system.

Parameters	Observations	Design aspects considered for drone	Purpose
Number of leaves Leaflets Length of the leaf Width of the leaf	Leaf area	i. Size and number of axis of the frame, length of the telescopic spray lance and cutting tool. ii. Camera visibility	Ensures the propeller blades will not meet any crash
Height of the tree	Flying height	Number of propellers	Payload selection and battery endurance
Peduncle and pedicel	Thickness and length	Selection of the cutting mechanism	Proper selection of cutting tool saves time and ease of operation
Girth of the tree	Circumference	Safety gripper holder of the drone	Prevent crash or fall during the flight failure
Spacing of the tree	Distance	i. Path planning and flight duration ii. Camera visibility	Easy maneuvering through remote from the ground
Petiole Spathe	Thickness and length	Size of the telescopic tool	Maneuvering spray lance and harvesting tool near the bunch and centre of the tree
Matured bunches	Numbers	Degrees of freedom and flight duration	For harvesting bunches

actuating system. The drone is attached to the spray tanks, which can store the pesticide and spray it over the tree. These drones fly at a proper height, helping the pesticide penetrate perfectly into the canopy. The factors that influence the design of the drone system and its purpose is given in Table 2.

CONCLUSION

The lack of availability of labor became a severe problem for coconut tree farmers. There is a serious problem in the harvesting of crop nuts from the top of the tree, as there will be lots of crop nuts over the top of the tree at the bottom of the branches. The present biometric study of various coconut palm varieties associated with drone design could achieve effective spraying and harvesting by overcoming flight performance problems and changing load distribution. The major drone design parameters involve the frame dimensions, propeller size, the number of propellers, spray tank capacity, spray lance, harvesting tool, camera specifications, ground control station and path programming. It was concluded that the biometric observations aided in deciding the design and assembly of the drone components as well as the spraying and harvesting mechanism suitable for all coconut palms. The drone-based solution will create a revolution in the field of tree climbing which benefits lots of farmers to come up from their bad times to good times.

Conflict of interest: None.

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