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SOME BIOMETRIC PROPERTIES OF TOMATO (*SOLANUM LYCOPERSICUM*) WHICH INFLUENCES MECHANICAL HARVESTING INSIDE POLYHOUSES

M. Ayisha*, K. P. Shivaji and P. Niyas

Kelappaji College of Agricultural Engineering and Technology, Kerala Agricultural University, Tavanur, Malappuram - 679 573 (Kerala), India.

Abstract

Harvesting has been identified as one of the critical and resource consuming operation because of several reasons especially inside polyhouse structures. The common method adopted for harvesting is manual picking of individual fruit, which is highly time consuming operation. The environmental conditions like temperature and humidity create some inconvenience in the work place for the workers and it is very difficult to remain inside the polyhouse for longer durations. Longer working hours in the polyhouses may cause suffocation, and hence farmers often need to take rest exiting from polyhouse. Frequent entry or opening and closing of doors of polyhouses enhance the chance of plant contamination. Also, as majority of fruits are at a height and hence mechanical aids like ladders for positioning is required for proper harvesting. These factors make harvesting as one of the most labour intensive and costlier operation and hence emphasize the requirement of an appropriate system for harvesting in polyhouses. Knowledge of physical properties of crops and fruits like tomato plays an important role in the design and optimization of its machinery. Evaluation of these properties like plant height, leaf numbers, leaf length, leaf width, fruit length and width were taken for observation. It was seen that, these properties had a direct impact on deciding the components of the harvester.

Key words : Tomato, polyhouse, biometric properties, leaf parameter, fruit parameter.

Introduction

Tomato (*Solanum lycopersicum*) is a commonly used agricultural product which is considered as a summer vegetable. It belongs to the family Solanaceae. Different varieties of tomato are widely grown across the world, with polyhouses allowing its production throughout the year and in cooler areas. Tomato plant has many special features like fleshy-fruit plant with compound leaf structure. The size of the fruit may vary depending upon the variety of seeds selected and various environmental factors. It is a nutritious product which mainly contains water as the main content and also contains minerals, vitamins and some organic acids.

Evaluations of the biometric properties of the crops help in making harvesting smooth to certain extend. Knowledge of physical properties of crops like tomato plays an important role in the design and optimization of its machinery. This help out to obtain quality products with reduced wastages (Mousavizadehi *et al*., 2010). Study of various biometric properties of plants and fruits which influence mechanical harvesting have been started since 1980s. Evaluation of physical properties of the crop and fruit may help in designing a harvester suitably. Despite these, it helps in grading, sorting and some processing operations. The main objective of this study is to measure some physical properties of tomato and to identify how it will affect the mechanical harvesting. The result can be used for designing a harvester or related equipment.

Author for correspondence : E mail: ayishamangat@gmail.com

Materials and Methods

Polyhouse cultivation is an alternative new method in agriculture for attaining foothold in farming sector. This practice provides controlled and favorable environment to crops by reducing the dependency on rainfall and makes maximum use of land resource. It is made of using GI pipes. The roofing and side covering is provided with a transparent UV stabilized low density polyethylene film of 200 micron thickness, which will create a micro climate inside the tent by regulating temperature, relative humidity and partially cutting Ultra Violet rays. Polyhouse are used

to produce sensitive crops such as tomatoes, cucumbers, cherries, capsicum etc., which are susceptible to cracking. The specifications of the polyhouse used for the study are as given in table 1. The polyhouse were built in east west direction.

Table 1 : Specifications of the polyhouse.

Particulars	Specifications
Polyhouse height (center)	4 m
Polyhouse height (side)	2.4m
Area inside	45.08 m^2
GI pipe posts	2 inch diameter
Roofing	200 micron thickness UV stabilized LDPE

Tomato (*Solanum lycopersicum*) variety *Anagha*, a hybrid variety from Maharashtra Hybrid Seeds Co. Pvt Ltd was used for the study. This variety is high yielding variety and is most suited for polyhouse cultivation. Tomato (*Solanum lycopersicum*) seeds were sown in a protray containing a mixture of coco peat, vermiculate and perlite in 1:1:1 ratio. These seedlings were transplanted to the field 12 days after sowing. The seedlings were transplanted to UV stabilized vegetable grow bags of size 20X20X35.Each grow bag was kept at a distance of 30cm apart.

For analyzing the growth pattern of the crop, five tomato plants were selected. The main crop growth parameters like height of the plant, number of leaflets, terminal leaf length, terminal leaf width, plant circumference, number of fruits, fruit length, and fruit circumference were measured. The readings were taken for about 70 days after transplanting, since the plants started to show yellowing of leaves, which indicates that the plants started to die and cannot be re-grown (FAO, 2015).

Plant height : Plant height was measured for tomato plant the soil surface to the tip of the topmost leaf (youngest leaf). Readings were taken once in a week using a measuring tape. The average was worked out for each plant.

Number of leaves : Tomato has a compound leaf structure. A compound leaf was selected randomly and the number of leaflets on that leaf was counted. Readings were taken once in a week.

Leaf length and leaf width : The length of the compound leaf was measured from petiole to the terminal leaf tip using a ruler for tomato plant. Also, the terminal leaflet length was measured. It was measured at weekly intervals. The width of the terminal leaflet on the compound leaf was taken. Reading was taken once in a week, using a ruler.

Plant circumference : The plant circumference of tomato plant was measured at the axil where the leaflet parameters were measured. Reading was taken using a measuring tape. Measurements were taken at weekly intervals.

Number of fruits : Number of fruits per plant was counted at weekly intervals.

Fruit length : The fruit length was measured longitudinally from top to the bottom. Length of the fruits was measured using a measuring tape and it was taken once in a week.

Fruit circumference : The equatorial circumference of the fruit was measured using a measuring tape. The dimensions of the all fruits in each plant were taken once in a week.

Results and Discussion

The biometric properties of the crops that affect the mechanical harvesting are discussed below.

Plant height : Plant height influences the harvesting operation of the harvester. Gay *et al*. (2008) reported that the size of the harvester should be foreseen while designing the harvester, depending upon the height of the crop.

From fig. 1, the mean height observed on the 7th day after transplanting was 244 mm and 70th day after transplanting was 1100 mm.

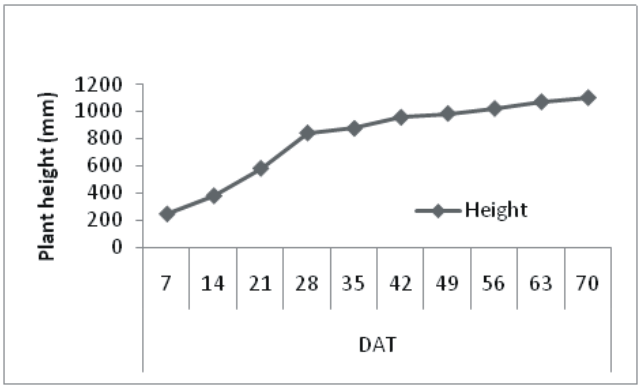

Fig. 1 : Height of tomato plant on different DAT.

Number of leaves : The number of leaves affects the performance of the harvester. Leaf density in the working area of the machine decides the presence of obstacles in the operation. In this case, since there is no artificial vision system used for identifying the objects, this parameter has a role in identifying and locating the fruit position. A modest change was observed in the

number of leaflets on a compound leaf of tomato plant from fig. 2. The number of leaflets came in a range of 9 and 11.

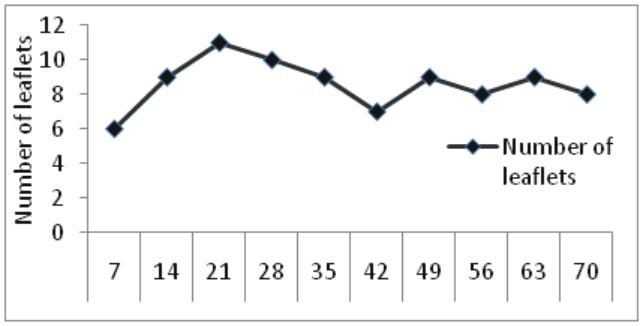

Fig. 2 : Number of leaflets on a compound leaf of tomato plant on different DAT.

Leaf length and leaf width : Length of leaf and width of leaf affects the leaf canopy of a plant. This in turn affects the performance of the harvester. Burks *et al.* (2005) suggest a thin leaf canopy for better result of the performance of the harvester. They find it difficult to harvest a fruit located in the interior of the leaf canopy. From fig. 3, the mean value on first observation was 26 mm and 82.6 mm on last observation of terminal leaflet length of tomato plant on 7th and 70th day after transplanting. Terminal leaflet width of the tomato plant was recorded as 22.8 mm (mean) in the first observation on 7th day after transplanting. The final observation was reported with a mean leaflet width of 40.6 mm.

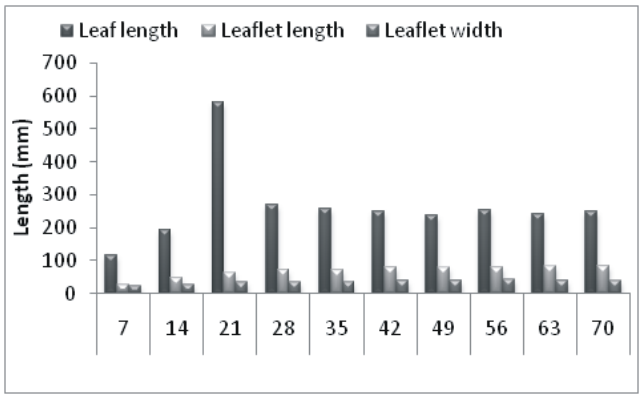

Fig. 3 : Average length of compound leaf, terminal leaf and width of terminal leaves of tomato on different DAT.

Plant circumference : Cargill (1983) pointed out that the uniform shape and size of the plant in a nursery or orchard will help to improve the efficiency of the harvester. Similar findings were explained by Burks *et al.* (2005). The fruit detaching mechanism will interact directly with the fruit and plant parts. The cutting tool can be designed by considering the circumferential area of the stem in order to reduce the damages occurring while harvesting. The plant circumference had a significant increase from mean value of 16.4 mm to 40.6 mm for tomato plant from fig. 4.

Number of fruits : A study conducted by Burks *et al.* (2005) reports that the number of uniform sets of fruits on a particular area helps to locate the fruit easily and also, the harvester can work with maximum productivity when the number of fruits in a specified work space is more. The number of tomato fruit on individual plant was recorded with a maximum value of 28 after 63 days of transplanting and a minimum value of 5 after 28 days of transplanting from table 2.

Table 2 : Number of fruits tomato plant at different days after planting.

Number of fruits	Days after transplanting						
	28	**35**	**42**	**49**	**56**	**63**	**70**
Tomato	5	11	14	18	23	28	26

Fruit length and fruit width : The length and circumference indicates the size of the fruit which will directly affect the harvesting operations. The weight holding capacity of the cutting unit is directly influenced by the size of the fruit. The volume of the fruit collector is also determined by the fruit size. Coppock *et al.* (1969) mentioned the relevance of fruit size while harvesting using mechanical harvester. Since, tomato has an oblate shape, the equatorial circumference of the fruit was greater than the fruit length. Fruit length and fruit width

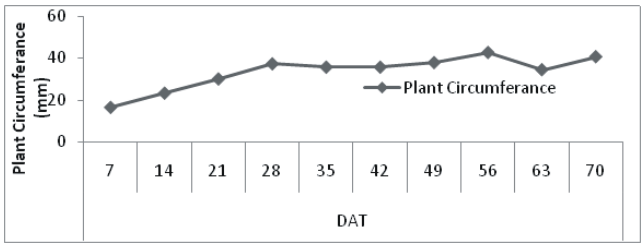

Fig. 4 : Average circumference of tomato stem on different DAT.

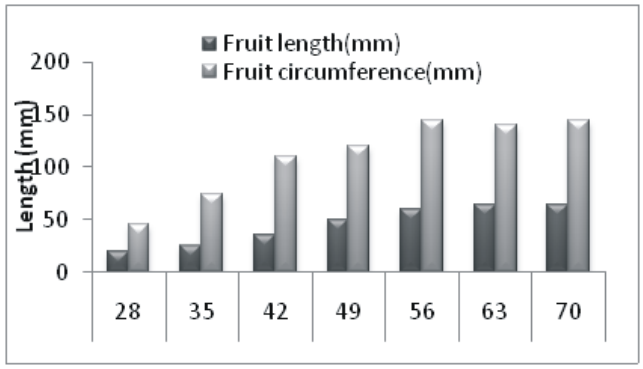

Fig. 5 : Fruit characteristics of tomato on different DAT.

was seen least in the initial observations and it was shown the maximum value in the final observations.

Summary and Conclusion

For analyzing the growth pattern of crop five tomato plants were selected. The main crop growth parameters like height of the plant, number of leaves, leaf length, leaf width, and plant circumference, number of fruits, fruit length, and fruit circumference were measured. Readings were taken once in a week.

It was observed that, certain parameters affected the design of harvester directly and certain other parameters affected indirectly. Depending upon the height of the plant, the position at which fruits appeared also changes. So, the height of the harvester was decided based on the height of the plant. Similarly, leaf parameters like number of leaves, leaf length and leaf width affects the performance of the harvester. These parameters have an impact on formation of leaf canopy and leaf density. And this in turn contributes to the presence of obstacles in the working area of the machine while in the operation. Another parameter that influences the harvesting performance is the plant circumference. The chance of occurrence of damages to the plants and fruits while harvesting depends on this factor. The fruit detaching mechanism will interact directly with the fruit and plant parts. The cutting tool can be designed by considering the circumferential area of the stem in order to reduce the damages occurring while harvesting. Despite of all the plant parameters, fruit parameters also influence the harvesting operation. The number of uniform sets of fruits on a particular area helps to locate the fruit easily. Along with this, the harvester can work with maximum productivity when the number of fruits in a specified work space is more. The operation of gathering fruits will be less difficult for harvesting equipment that concentrates on individual plant than collective plant operation. This was because, individual plants bear the fruits in a limited area, which makes the number of fruits per working area more.

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