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Assessment of Dwarf Genotypes in Litchi based on Trunk and Leaf Characteristics

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ABSTRACT

Studying the relationship between trunk quantitative parameters and tree growth and vigour in litchi is crucial for estlablishing the basis of dwarfing in different genotypes. Observation on plant height, trunk girth, bark area of trunk, xylem diameter, xylem area, xylem transversal area, bark transversal area, trunk transversal area, bark:wood ratio, rachis length, leaf blade length, dry weight of leaf were recorded on 30 litchi genotypes, having diverse growth habit. Data were subjected to correlation analysis. A positive correlation of plant height was found with trunk girth, rachis length, leaflet blade length and dry weight of leaf which was observed which also exhibited strong positive correlation with xylem diameter, xylem area and xylem transversal area. Similarly, bark area had a very strong positive correlation with bark:wood ratio but was negatively correlated with plant height, trunk girth, xylem diameter, xylem area and xylem transversal area. In litchi, dwarf genotypes have higher bark area and bark:wood ratio compared to vigorous ones. Using these parameters as criteria for screening the dwarfing genotypes would be useful to generate the information for differentiating between genotypes with varying growth and vigour.

KEYWORDS

India, Litchi chinensis, trunk characters, leaf characters, dwarf

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INTRODUCTION

Litchi (*Litchi chinensis* Sonn., Sapindaceae) is a subtropical evergreen fruit crop being cultivated in only few subtropical countries in the world. India is one of the major litchi growing countries and ranks 2nd in area and production. World production of litchi is more than 2,000,000 tonne, out which China and India account for more than 90% of the world litchi production. Over the years, India has recorded significant growth in area and production of litchi. There has been substantial increase in area and production of litchi in India during last 50 years. Area has increased from 9,400 hectares (1949-50) to over 86,000 ha (2016-17). The contribution of litchi to total area under fruit has increased from 0.75 to nearly 2.00%. Increase in area during 1991-92 and 2016-17 (25 years) has been over 80%, while production increase during the same period is to the tune of more than 150 percent. However, productivity of litchi in India is only 7 t ha^{-1} which is very much below the potential productivity of 15 t ha^{-1} as obtained in Punjab. Poor plant establishment, less fruiting span, low and irregular yields due to poor flowering and fruit set and traditional system of planting at wider spaces are the reason attributed to this. The present state of burgeoning population and shrinking land resources calls for the need to produce more from a given area of land. This emphasizes the role of high density planting, which has potential in doubling the crop from the unit area. High density planting integrates several component of which, use of dwarfing rootstock/cultivar has been gaining popularity in fruit crops like mango, citrus, apple and grapes. The role of rootstocks and its use in different fruit crops has significant impact on fruit crop production by influencing canopy architecture, nutritional uptake, flowering, yield and fruit quality. Vigour management plays an important role, especially for high density planting and orchard management in terms of canopy management, harvesting and plant protection measures. Thus identification and development of dwarfing rootstock in litchi will play a crucial role in revolutionizing the production scenario of litchi in our country, which is lacking till date. The mechanisms of dwarfness in rootstock are complex and poorly understood. Rootstock anatomical properties, mainly the characteristics of wood and xylem conduits are strongly believed to be major mechanisms controlling dwarfing and should be considered in establishing the biological basis of dwarfing. Several studies have been conducted concerning the anatomy of apple and peach dwarfing rootstocks (Beakbane and Thompson, 1947; Miller *et al*, 1961; Basile *et al*, 2003). Lower xylem-to-phloem ratio, smaller vessels, and lower hydraulic conductance were characteristics of apple dwarfing rootstocks. However, information on the anatomy of litchi rootstocks and their connection with dwarfing has not been reported till date.

In litchi, tree characteristics such as plant height, trunk girth, vigour directly correlates with trunk girth and trunk cross sec-

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tional area. Higher trunk girth implies a higher number of conducting vessels responsible for vigorousness. Therefore, defining trunk characteristics and determining relationship between them will help to researcher the basis of dwarfing in rootstock/cultivars. It has been reported that bark-xylem relationship, is associated with the tree vigour and dwarf trees have a higher proportion of bark than normal size trees (Mukherjee and Das (1980) and (Jaumien and Faust, 1984). Such knowledge may contribute in identifying dwarf rootstock/cultivars for high density planting in litchi. Moreover, as there are no such studies in litchi, this work could provide technical or practical information for researchers to explain some experimental results. In our study, open pollinated seedlings population of 12 years old litchi were screened with the aim of identifying dwarf genotypes.

MATERIALS AND METHODS

An experiment was carried out on 10-year old litchi at ICAR-NRC on Litchi, Muzaffarpur, during 2017-18. Thirty genotypes with diverse growth habit, each having 3 replicates were selected for recording observation on plant height, trunk girth, bark area of trunk, xylem diameter, xylem transversal area, bark transversal area, trunk transversal area, bark wood ratio, rachis length, leaf blade length, dry weight of leaf. From each tree, a fraction of bark was cut from five points around the trunk at a height of 20 centimeter from ground, for measuring bark thickness, using vernier caliper and expressed in millimeter (mm). The trunk girth was measured at the height of 20 cm before taking the bark fraction.The transversal total area was calculated based on trunk girth data while the transversal area of the bark was calculated using bark thickness data. The formulae used are presented in fig. 1 to compare different genotypes with varying bark transversal area in proportion to xylem transversal area (%). Data were subjected to statistical analysis to work out the relationship between trunk characters and tree height using SPSS software.

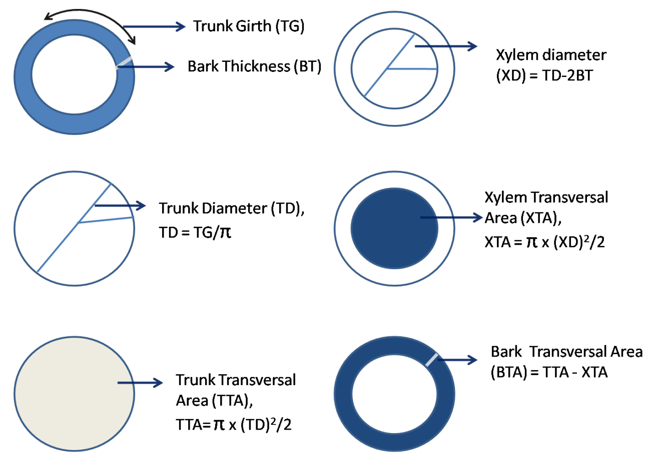

Fig. 1: Formula for computing different trunk parameters

RESULTS AND DISCUSSION

The correlation data on plant height and trunk characters are presented in Table 1 and Figure 1,Figure 2,Figure 3,Figure 4 , Figure 5, Figure 6,Figure 7 ,Figure 8 and Figure 9. Results revealed that plant height was negatively correlated with percentage of bark area (-0.44) (Figure 2). A positive linear relationship was also observed between plant height and trunk girth (0.70), trunk transversal area (0.67), xylem diameter (0.70), xylem transversal area (0.66), bark transversal area (0.39) and rachis length (0.57), leaf blade length (0.51), dry weight of leaf (0.39).There was a negative relationship between plant height and bark wood ratio (-0.42) while trunk girth was negatively correlated with bark area (-0.63) and bark wood ratio (-0.61).

The potential of rootstocks in fruit tree production has been realized worldwide (Tombesi *et al*, 2010). A great attention on selection of rootstock in fruit crops with growth controlling feature has been paid in the past as well as in recent year. Besides, contributing to higher productivity and more cost-effective orchard maintenance (Seleznyova *et al*, 2008), dwarfing rootstocks also minimize labor costs and pesticide usage without compromising precocity and fruit quality (Olmstead *et al*, 2004). Hence, knowledge of the biological properties of rootstocks is essential to unravel the mechanisms of growth control parameters of rootstock. In the present study, a very strong correlation was observed between xylem diameter, xylem area and xylem transverse area with plant height and trunk girth, which implies that these parameters can be used to indicate tree vigorousness. Bark area was directly proportional to bark:wood ratio. Both these parameters exert a highly negative correlation with xylem diameter, xylem area, xylem transverse area and trunk girth. The genotypes with the highest area of bark and bark:wood ratio had dwarf structure in comparison to genotypes with the lowest bark wood ratio. This finding was also supported by Jimenez and Priego (1987) who observed that circumference of the trunk was highly but negatively correlated with proportion of bark area in avocado. They also observed thattree height was negatively (-0.89) correlated with proportion of bark area. A higher proportion of bark in dwarf trees was also reported in mango (Mukherjee and Das, 1980) . Bark percentage and number of xylem has been used in classification of mango rootstocks as a good indicator of dwarfism (Majumdar *et al* (1972), (Hegazi *et al*, 2013). The size of the xylem determines the amount of water and solubles translocated through the plant and thereby it had a direct effect on plant growth and vigor. In mango, high xylem percentage indicates vigorous seedling (Majumdar *et al*, 1972). Rashedy *et al* (2014) also recorded the highest xylem percentage in dwarf mango cultivars compared to vigorous ones. The above findings clearly indicate that the percentage of bark area of trunk may be an important criterion influencing vigour of plants.

Table 1: Correlation between plant height, trunk and leaf characters

Traits	PH	TG	TTA	XD	XTA	BTA	BA	XA	BW	RL	LBL	DWL
PH	1	.70**	.67**	.70**	.66**	.39*	-.44*	.44*	-.42*	.44*	.51**	.38*
TG		1	.99**	.99**	.99**	.55**	-.63**	.63**	-.61**	.36*	.31	.18
TTA			1	.99**	.99**	.53**	-.63**	.63**	-.62**	.35	.27	.16
XD				1	.99**	.49**	-.68**	.68**	-.66**	.39*	.34	.20
XTA					1	.46*	-.69**	.69**	-.67**	.39*	.29	.18
BTA						1	.28	-.28	.29	-.20	-.09	-.14
BA							1	-1.00**	.99**	-.62**	-.49**	-.34
XA								1	-.99**	.62**	.49**	.34
BW									1	-.62**	-.51**	-.32
RL										1	.61**	.40*
LBL											1	.48**
DWL												1

PH= Plant height, TG= Trunk Girth, TTA=Trunk Transversal Area, XD= Xylem diameter, XTA= Xylem Transversal Area, BTA= Bark Transversal Area, BA= Bark area, XA= Xylem area, RL= Rachis length, LBL= Leaf blade length, DWL= Dry weight of leaf

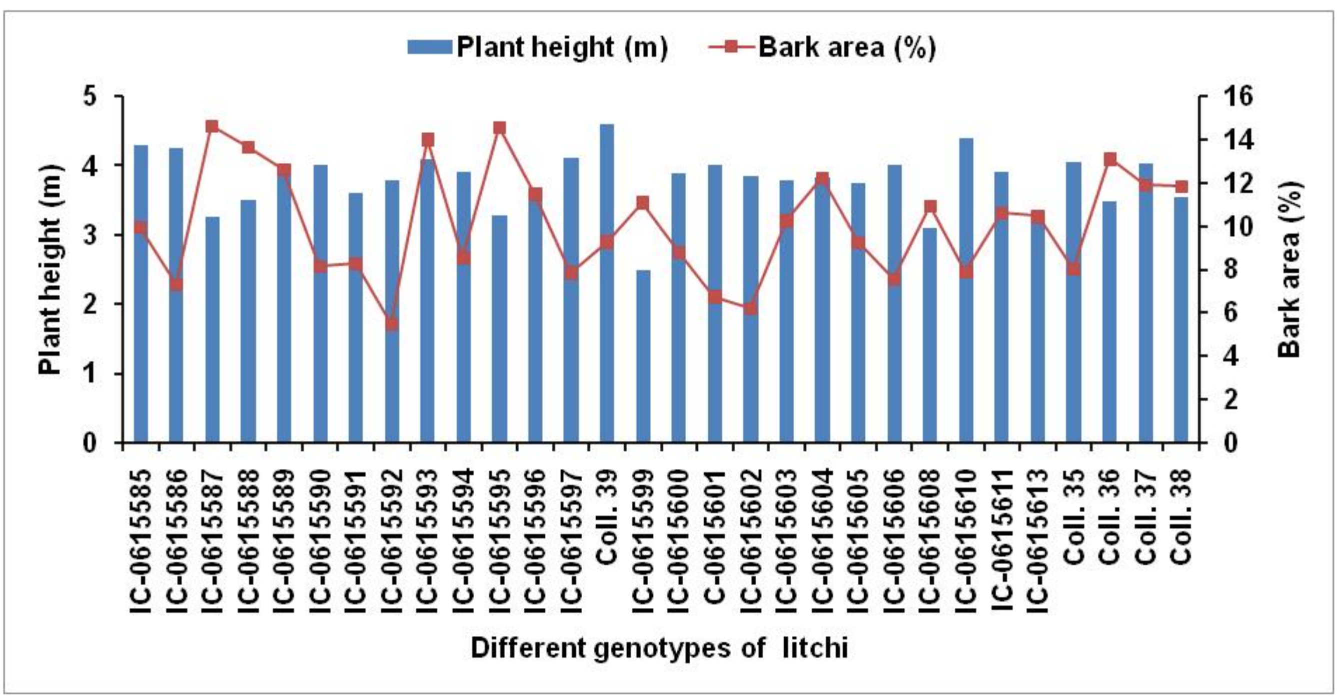

Fig. 2: Correlation between plant height and bark area of trunk (R^2=-0.44) in litchi

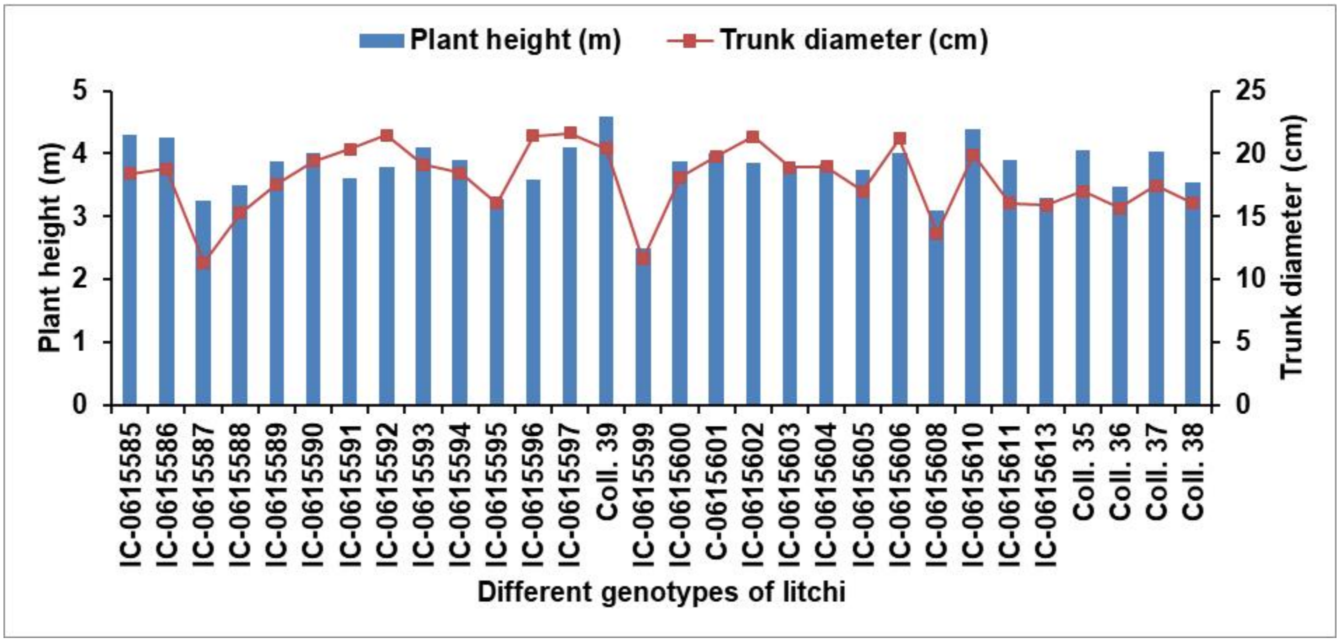

Fig. 3: Correlation between plant height and trunk girth (R^2=0.70) in litchi

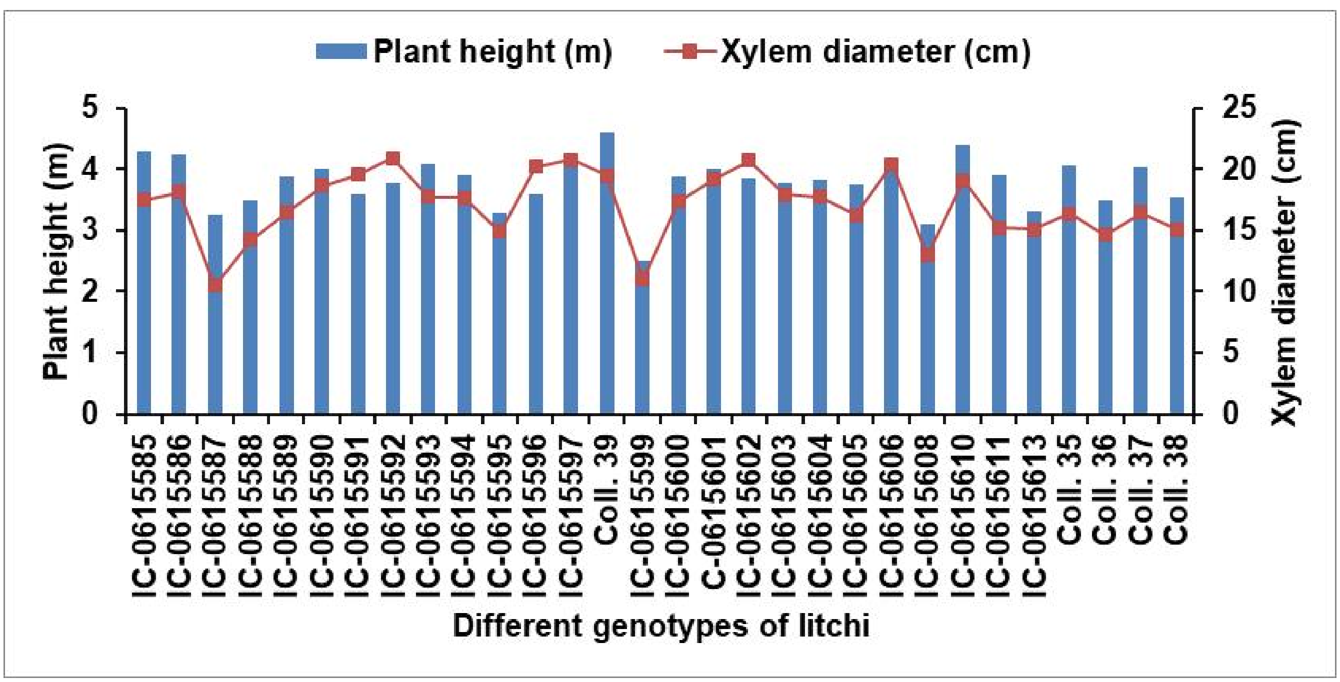

Fig. 4: Correlation between plant height andxylem diameter (R^2=0.70) in litchi

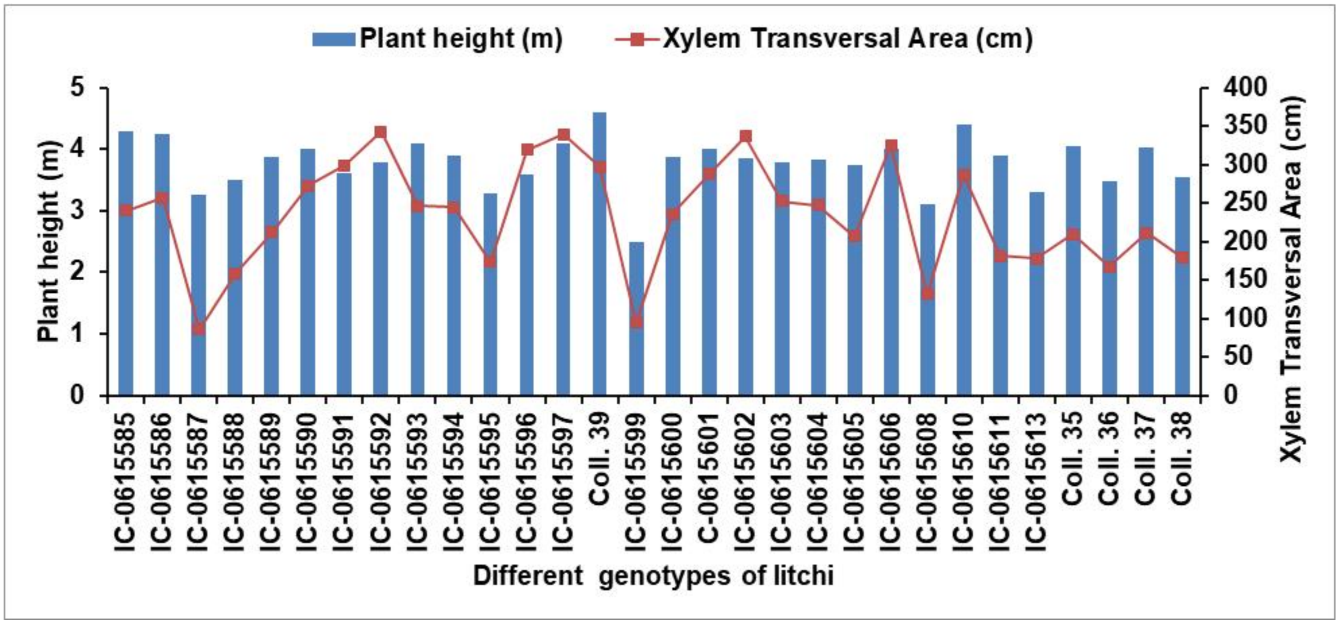

Fig. 5: Correlation between plant height and xylem transversal area (R^2=0.66) in litchi

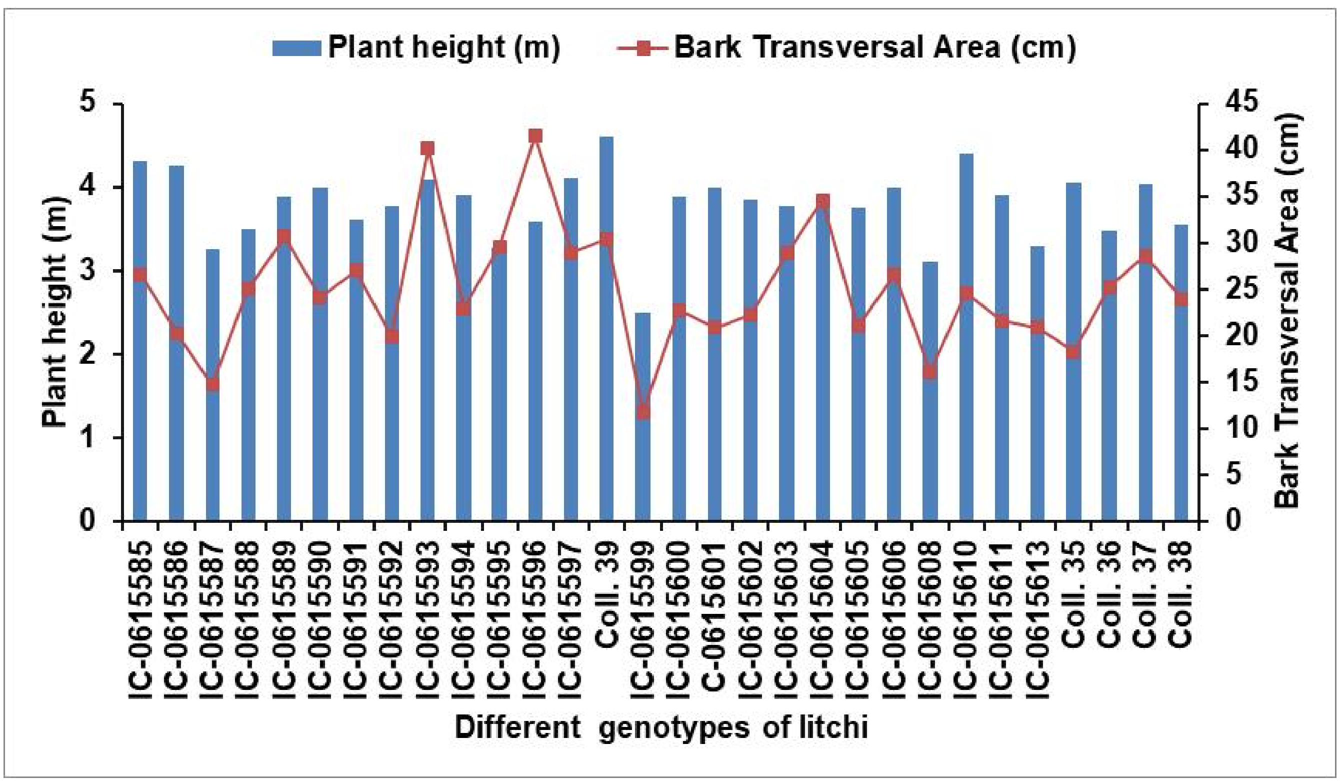

Fig. 6: Correlation between plant height and bark transversal area(R^2=0.39) in litchi

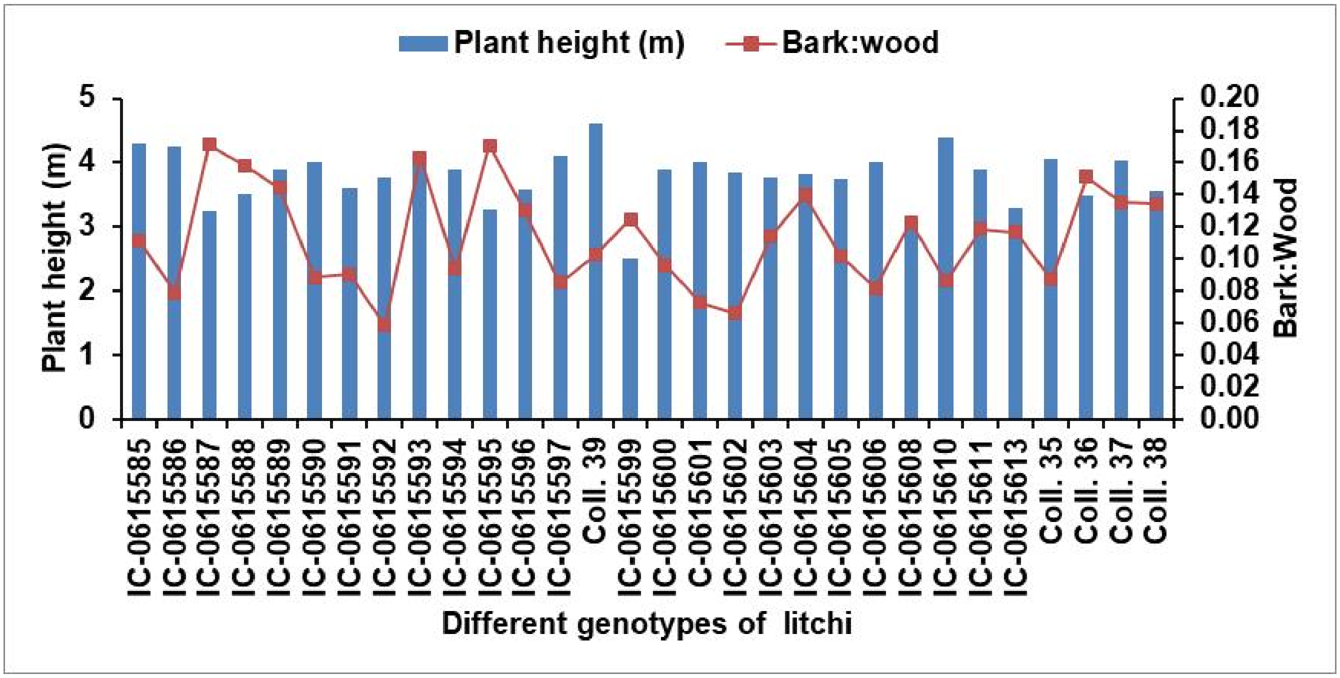

Fig. 7: Correlation between plant height and bark wood ratio (R^2=-0.42) in litchi

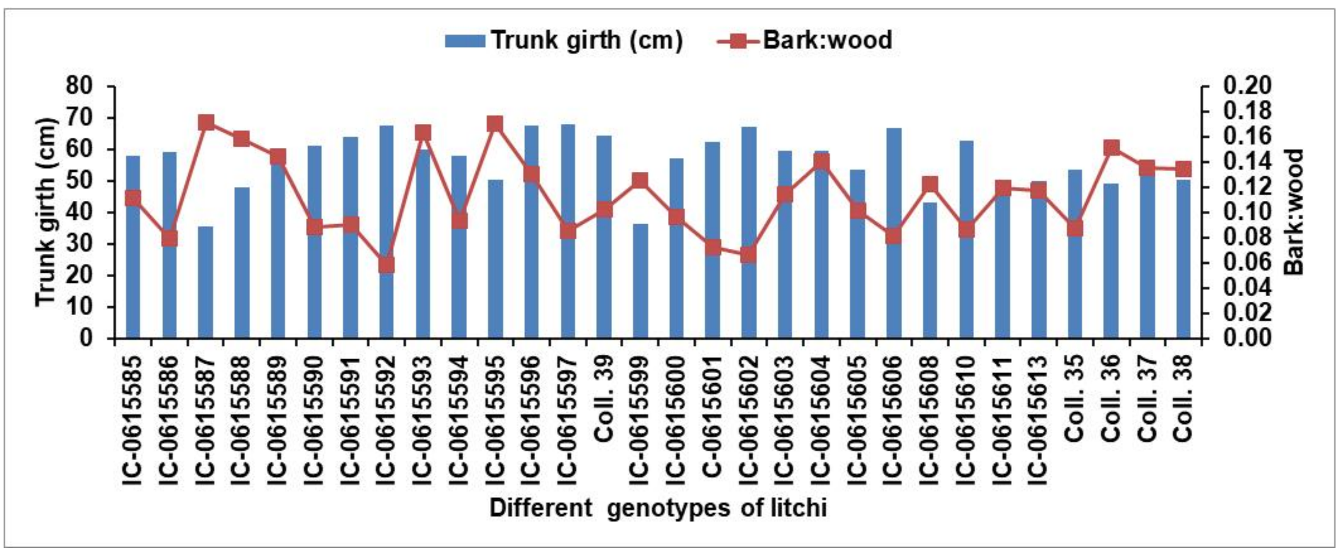

Fig. 8: Correlation between trunk girth and bark wood ratio(R^2=-0.61) in litchi

CONCLUSION

A significant relationship between trunk and leaf characters in the 30 studied genotypes of litchi was observed. The findings revealed that it is possible to screen the dwarfing genotypes in litchi by examining the trunk quantitative characters. Bark and xylem area and the ratio of bark:wood in different range classes gives a good indication of dwarfing potential of different genotypes. High R^2 values were noted in dwarf genotypes. Conclusively, using these criteria in evaluation program as the basis of dwarfing traits can provide the basic information to differentiate between dwarf and vigourous cultivars which can be useful in identifying dwarfing rootstocks or cultivars in litchi.

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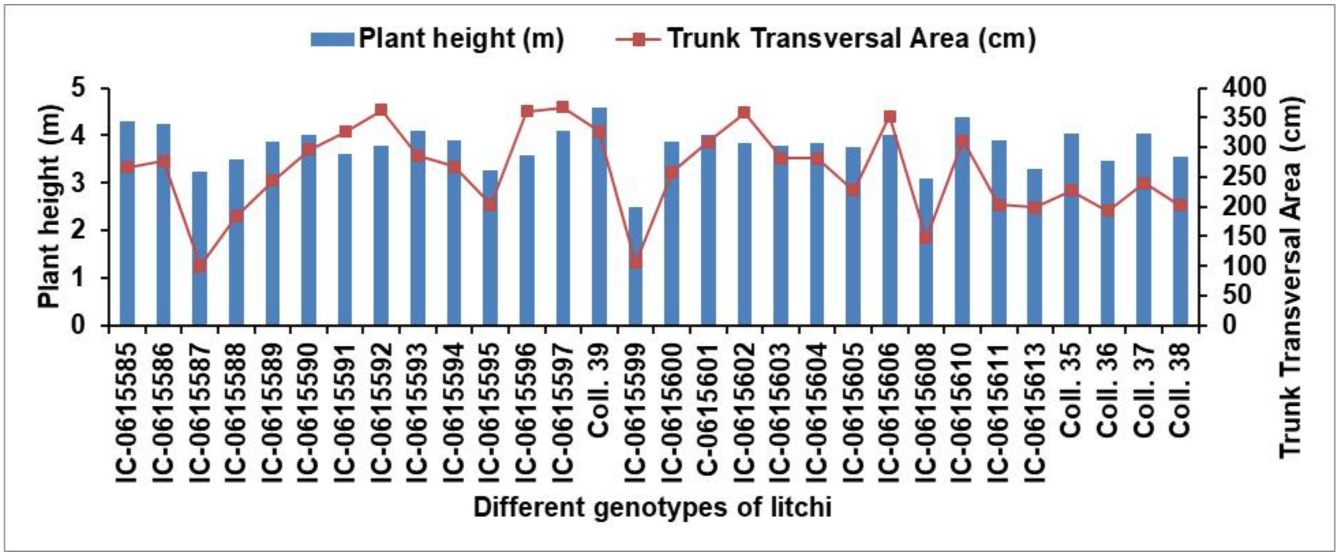

Fig. 9: Correlation between plant height and trunk transversal area(R^2=0.67) in litchi

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