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PANICLE AND FRUIT CHARACTERISTICS INFLUENCED BY PLANT AGE IN LITCHI CV. ROSE SCENTED

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Abstract

An experiment was conducted during the cropping season of 2018 and 2019 to determine how plant ages affect flowering, fruit quality and incidence of sunburn and fruit cracking in litchi cv. Rose Scented. In a lot consisting of litchi plants aged between 1 and 30 years, 25-30- years-older plants initiated panicle emergence earlier with larger-sized panicles (42.35 cm length and 28.65 cm spread) and thicker peduncle (>6 mm). Fruit retention per panicle was also more in number (15.68) in 25-30- yearsolder plants as compared to1-5 yearyounger plants(4.76). An important observation involved fruits being borne closer to leaf in25-30- years-older plants, which ultimately resulted in lesser incidence of sun burn and fruit cracking. Older plants (25-30-years) produced bigger fruit than1-5 year-younger ones and highest fruit weight (22.58 g) was recorded in 15–20-year-old plant. The time taken for fruit borne in older trees (25-30-years) to attain optimum fruit maturity was extended or delayed by 5 days as compared to younger plants (1-5-year). Total soluble solids was also higher in fruits borne on 25-30 yearsolder litchi plants, while titratable acidity and ascorbic acid contents was more in fruits borne on 1-5 yearyounger plants. Total phenolics and antioxidant activity of pulp were the highest in young plants and least in older plants. we conclude that heavy bunches and proximity of fruit to leaf are important traits in litchi for consideration in breeding programmes to identify clones or variants tolerant to sun burn and fruit cracking.

Introduction

Litchi (*Litchi chinensis* Sonn.), an important member of the Sapindaceae family, is an evergreen subtropical fruit tree. Popular among masses for its delectable taste and flavour with high nutritional value litchi is often referred to as 'Queen of fruits'. India is the second largest litchi-producing country in the world. Litchi is an important source of livelihood of millions of people in Bihar, West Bengal, Jharkhand, Assam, Orissa and *terai* region of Uttar Pradesh where on-farm as well as off-farm engagement in the fruit are involved (Anon 2015). The fruit yield and fruit quality of litchi are affected by several pre-harvest factors. These include cultivar, orchard soil management, irrigation, foliar application of nutrients, canopy management, fruit bagging, vegetative vigour of tree, position of fruit on tree, harvesting stage, use of growth regulators, girdling and insect pests of litchi. In the past, considerable researches have been focused on enhancing production and productivity of litchi crop (Nath *et al.* 2022). Now, consumers are aware and more conscious about healthy food. Quality food production with enhanced functionality has become a key challenge for researchers. Litchi fruit quality may be indicated by various external and internal attributes. It is generally observed that young litchi trees (cv. rose scented) produce fruit with high acidity, low sugars, and dull pericarp colour. Litchi cv. Rose Scented is also highly susceptible to sun burn and fruit cracking (Lal *et al.* 2023). There is considerable degree of variation in the quantum loss reported by several workers related to these attributes of fruit quality. Kumar *et al.* (2016) found losses up to 14% due to fruit cracking in

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litchi cv. shahi in Bihar and they also recorded losses of up to 44.5% and 27% due to sun burn in 2012 and 2013, respectively. About 5-70% losses is due to fruit cracking (Singh *et al.* 2012). There are few reports that tree age also affects the nutritive value of fruits. Old trees of guava showed decline in mineral absorption and accumulation which significantly affected the physicochemical properties and mineral content of guava fruits (Asrey *et al*. 2007). Young trees of orange produced poor quality fruits than the older trees. Tree age also affected fruit yield and physical characteristics of pummel (Nakorn and Chalumpak 2016) and apple (Arshad *et al*. 2014). It is, therefore, evident that tree age plays an important role in fruit quality, but studies to determine its effects are rare in litchi, and no work has been conducted to assess the effect of tree age on bioactive compounds content. Litchi cv. rose scented is the most popular and widely cultivated variety occupying maximum area of litchi in India. It is a regular and prolific bearer bearing fruit with pleasant aroma but highly susceptible to sun burn and fruit cracking. However, few works have been conducted to assess the effect of plant age sun burn and fruit cracking in litchi in general and Rose Scented cultivar in particular. Therefore, the present investigation was carried out to assess the effect of plant ages on panicle and fruit characteristics, and sun burn and fruit cracking in litchi cv. Rose Scented.

Materials and Methods

The experiment was conducted during 2018 and 2019 to assess the influence of plant ages on panicle characteristics, fruit quality and incidence of physiological disorder *viz.* sun burn and fruit cracking in litchi cv. rose scented. Litchi plants of different age groups *viz*. 1-5 years, 5-10 years,10-15 years, 15-20 years, 20-25 years, and 25-30 years, were randomly selected at the experimental farm of ICAR-National Research Centre on Litchi (1-15 years) as well as in farmer's field (15-30 years) located in Muzaffarpur, Bihar. Uniform cultural and orchard management practices were followed in all the selected plants. The experiment was laid out in randomized block design (RBD) consisting of six treatments (tree age groups) and three replicates.

Observations were recorded on panicle length and spread, thickness of panicle, number of fruits per panicle, distance of fruits from leaf in fruiting shoot, fruit weight, fruit length and diameter, days to maturity, sun burn, fruit cracking, TSS, sugar content, titratable acidity, ascorbic acid, anthocyanin in pericarp, total phenolics and total antioxidant activity in pulp. The panicle length and width measured with tape when panicle was fully developed and expressed in centimeter (cm). Thickness of peduncle was measured with vernier caliper when fruits fully developed. Number of fruits per panicle was counted at harvest. The Precision balance AND GH-252 (A&D Company Ltd. Oxford, United Kingdom) was used to determine the average weight (g) of the 20 sample fruits. A digital vernier caliper was used to measure the length and width of the 20 sample fruits and calculated in millimeter (mm).

The juice was extracted from 20 collected fruits. Ten ml of juice was taken and volume made up 100 ml with distilled water. Then 10 ml of this solution was taken for the purpose of titration with 0.1 N NaOH using phenolphthalein as indicator. TSS in the fruits was recorded at room temperature using digital refractometer (Hanna, HI 96801, 0 to 85 %, Hanna Instruments Inc., Woonsocket, USA) and was expressed in term of ^{0}Brix. Five fruits per replication were collected from each treatment and the average value was taken.

Ten gram peel sample of each genotype was grinded in 10 ml of Ethanolic:HCL (85:15) was transferred to 50 ml conical flask. The solution was stored overnight at 4 °C and then filtered. Washed the bottle and residue on filter paper repeatedly with Ethanolic:HCL. Finally, made up the final volume of the solution to 100 ml and stored in the dark for 2 hrs. The absorbance of the sample was taken at 535 nm and total anthocyanin concentration was calculated by the following formula (Ranganna 1997). The total phenolics contents in extracts were estimated using a modified colorimetric Folin-Ciocalteu method (Sethi *et al.* 2013). The measurement values were compared with standard curve of gallic acid solutions and expressed as milligrams of gallic acid equivalents (GAE) per gram fresh weight (FW). Total antioxidant capacity was determined following CUPRAC (Cupric reducing antioxidant capacity) assay of Apak *et al.* (2008). The results were expressed as molTrolox equivalent g^{-1}FW.The data were subjected to analysis of variance as described by Panse and Sukhatme (1967). Significance was tested by 'F' value at 5 per cent level of significance. Critical difference (CD) values were calculated wherever the F test was found to be significant.

Results and Discussion

Panicle is the fruiting body in litchi. The sizes of panicles were influenced by age of plants. The maximum length and spread of panicles (42.35 cm x 28.65 cm) were produced in25-30 yearsolder plants whereas young plants produced smaller-sized panicles (29.4 cm x 16.12 cm). Large panicles produced in 25-30 yearsolder plants may have been due to higher reserve food material used in boosting panicle emergence. Older plants also produced stronger panicles as indicated by thicker peduncle which was more than 6 mm. Fruit retention per panicle was also higher in older trees (15.68) as compared to younger plants (4.76) (Table 1) which may be attributed to larger panicle size in older trees. The older plants have better capacity to provide photosynthates to the growing fruits (Yang *et al.* 2014). It has been also observed that panicle initiation and emergence started first in older that were also found in our earlier study (Lal and Nath 2020).

Table 1.Panicle characteristics in litchi cv. Rose scented influenced by plant age.

Age of plant (Years)	Panicle length (cm)	Panicle spread (cm)	Thickness of peduncle(mm)	Total number of fruits/panicles	Distance of fruits from leaf (cm)
25-30	42.35a	28.65a	6.35b	15.68a	7.25d
20-25	36.65b	23.57b	6.28b	14.75b	7.43d
15-20	36.85b	21.44c	6.94a	13.65c	8.38c
10-15	34.25c	19.24d	6.26b	11.38d	9.74b
5-10	31.65d	15.62e	4.36c	6.52e	13.72a
1-5	29.42e	16.12e	4.19c	4.76f	13.48a

Different letters in the same row indicate significant differences between treatments ($p < 0.05$).

Maximum fruit weight (22.58g) was obtained from 15–20-year-old plants with moderate number of fruits per panicle (Tables 1 and 2).This may be a direct case of younger trees having smaller canopy, lesser number of leaves and ultimately lesser photosynthates in comparison to older trees. Leaves are the main source of photosynthesis in plants (Nakorn and Chalumpak 2016). Photosynthetic rates are generally low in young unexpanded leaves, and increase up to full leaf expansion or soon after the leaves become fully expanded. The time taken to attain fruit maturity was prolonged in older plants (25-30-years) as compared to young plant (1-5-year). Higher crop load in older plants may have resulted in reducing growth rate of fruit and, therefore, the delay in attaining fruit maturity.

Highest incidences of sun burn and fruit cracking were recorded in younger plants where numbers of fruits per panicle were least. The panicles that possessed more number of fruits were free from sun burn and fruit cracking. In older plants heavier bunches or crowding of fruits may have obstructed direct sunlight in shaded region thereby resulting in less to no sun burn. Fruits were close to leaf in older plants which might have imparted shading and cooling effect near fruit zone thereby resulting in least or no sun burn and fruit cracking. The distance of fruit from leaf is therefore an important trait to select tolerant cultivars against sun burn and fruit cracking in breeding programmes. Older plants also have a wider and deeper root system as compared to younger plants. This leads to a more efficient water absorption and uptake to the fruit in older plants thereby resulting in lesser incidence of fruit cracking. Least sun burn and fruit cracking were recorded in older plants (Table 2) compared to young plants. Thus, sun burn and cracking are highly influenced by age of plants. The variation in losses due to sun burn and fruit cracking might be due to variation in environmental conditions and variable age of plants.

Table 2.Fruit characteristics and physiological disorder of litchi cv. rose scented influenced by plant age.

Age of plant (Years)	Fruit length (mm)	Fruit diameter (mm)	Fruit weight (g)	Sun burn (%)	Fruit cracking (%)
25-30	32.85b	30.14b	20.46b	6.57e	5.26e
20-25	34.53a	31.28ab	21.49ab	15.62d	14.25d
15-20	35.42a	32.32a	22.58a	17.58c	16.57c
10-15	34.88a	30.62b	21.78a	20.35b	16.35cd
5-10	31.68b	28.46c	18.57c	52.56a	48.65a
1-5	31.52b	28.56c	18.61c	53.68a	42.68b

Different letters in the same row indicate significant differences between treatments ($p < 0.05$).

The total soluble solids (TSS) and total sugars were higher in older tree fruits (Table 3). The titratable acidity and ascorbic acid was more in least crop load of younger plants. High TSS has been reported in older tree than younger in mango (Meena and Asrey 2018a). Higher TSS in aged tree fruits could be attributed to a comparatively higher respiration and ethylene evolution rate, which could have increased enzymatic activities in fruits and lead to rapid conversion of starch to soluble solids.Acidity was highest in younger tree than older. The younger trees have higher levels of anti-senescence hormones (auxins and gibberellins) in their fruits, which might have retarded organic acids utilization during the ripening process. Anthony *et al*. (2019) found that titratable acidity was highest in apple when fruit load was least (2.1).Younger tree produced fruit with higher ascorbic acid content than older. Higher ascorbic acid in younger tree age fruits might be due to presence of high titratable acidity, which makes ascorbic acid more stable. Early fruit maturity was observed in fruits harvested from older aged trees and thereby it was presumed that hydrolysis of carbohydrate and organic acid substrates were bit faster in fruits harvested from old aged trees. Compared to the high-cropping trees, fruit of lighter cropping trees were significantly more mature at harvest (Jens and John 2000).The trees with heavy crop were source-limiting (high fruit competition) and could not provide enough photosynthates to ensure the appropriate growth required to obtain good fruit size. Thus, the trees with increasing crop load were source-limiting, which led to a reduction in fruit growth.

The higher number of fruits per panicle reduced the anthocyanin content in pericarp whereas medium fruit load (11) resulted in good anthocyanin content. The highest anthocyanin content was recorded in fruits harvested from 10-15- years-old tree than younger and older tree (Table 4). The total phenolic content (0.54mg GAEg^{-1}) was recorded in fruit harvested from 1-5-year-old trees, and the lowest (0.47mg GAEg^{-1}) in 25-30-year-old tree fruits. There are reports that a higher concentration of ascorbic acid stabilizes the phenolic content of the food matrix. Therefore, higher vitamin C content in younger tree fruits was attributed to higher total phenol content. Moreover, lower respiration rate in younger tree fruits may also have contributed to higher retention of total phenols (Khalid *et al.* 2016). The lower activities of cell wall-degrading enzymes (PME and PG) may be another reason for higher retention of total phenols in younger tree fruits. The antioxidant capacity of fruits was significantly affected by tree age (Table 4). Fruits obtained from 1-5-year-old trees maintained highest antioxidant capacity whereas the lowest value was observed in fruits from older trees. However, ascorbic acid and phenolics are two major antioxidant contributoryorganic chemicals in the majority of fruits (Khalid *et al.* 2012).

Table 3.Fruit quality of litchi cv. rose scented influenced by plant age.

Age of plant (Years)	TSS (Brix)	Total sugar (%)	Titratable acidity (%)	Ascorbic acid (mg/100g)	Maturity (Days)
25-30	21.56ab	13.85b	0.46d	24.35bc	65.72a
20-25	21.73ab	13.63b	0.47d	23.48c	65.88a
15-20	20.72b	14.88a	0.47d	24.76b	64.59a
10-15	21.81a	13.61b	0.49c	24.68b	63.62ab
5-10	18.36c	10.32c	0.52b	27.68a	60.41b
1-5	18.62c	9.90c	0.55a	27.80a	60.38b

Different letters in the same row indicate significant differences between treatments ($p < 0.05$).

Table 4.Bioactive compounds of litchi cv. rose scented influenced by plant age.

Age of plant (Years)	Anthocyanin in pericarp (mg/100g)	Total phenolic in pulp (mg GAE/g)	Total antioxidant activity in pulp (mol TE/g FW)
25-30	94.68b	0.47c	4.38d
20-25	95.82b	0.48c	4.36d
15-20	95.69b	0.50bc	4.67c
10-15	99.68a	0.52ab	5.68b
5-10	94.57b	0.53a	5.97a
1-5	93.68b	0.54a	5.99a

Different letters in the same row indicate significant differences between treatments ($p < 0.05$).

In our study, higher levels of ascorbic acid and total phenolics were recorded in younger tree fruits and these probably contributed to higher antioxidant capacity in younger tree fruits (Barman *et al.* 2011). The higher level of phenols in fruits harvested from younger trees may be linked to lower activities of pectin methylesterase and polygalacturonase enzymes. These enzymes are responsible for the breakdown of phenolic compounds which further oxidized into the simpler compound and polymerized into tannins (Meena and Asrey 2018b). The enhanced total phenols were also reported to be higher in the early phase of heavily pruned mango trees during first bearing after pruning (Asrey *et al.* 2013).

From this study, it can be concluded that older plants produced large panicles (42.35 cm x 28.65 cm) and retained maximum number of comparatively heavy fruits per panicle (15.68) as compared to young plant (4.76). Incidence of sun burn and fruit cracking was also lower in older plants. Fruits were closer to leaf in older plants resulted in lesser sun burn and cracking. The distance of fruit from leaf is, therefore, an important trait that can be considered in crop improvement programmes to select new variants/clones with tolerance to sun burn and fruit cracking. Similarly, heavy fruit load per panicle in older plants resulted in least or no sun burn and fruit cracking. Thus, heavy bunches or more number of fruits per panicle can also be considered as an important trait for breeders to select tolerant clones. TSS and sugar was highest in fruits harvested from older trees whereas acidity and bioactive compounds were highest in fruits borne on younger trees.

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