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Research Paper

Effect of rainfall and temperature on sun burn and fruit cracking in litchi

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ABSTRACT

The sun burn and fruit cracking in litchi were high in 2019 (10.5% and 10.1%) when temperature was high with low rainfall during fruit growth while low in 2017 (1.9% and 3.7%) when temperature was low. Lack of soil moisture and high temperature reduced the fruit weight in Kasba cultivar by (26.2%) and rainfall induced cracking in the cultivars Bedana and Early Bedana. The cultivars having higher relative water content and cuticle thickness reflected in low fruit cracking and vice-versa. These results may be helpful to identify suitable cultivars for preventive measures to reduce sun burn and fruit cracking in litchi.

Key words **:** Sun burn, Fruit cracking, FST, RWC, Temperature

Farmers get additional income from litchi as it is grown on bunds and their homesteads in Bihar. Flowering starts during February-March and fruit growth and ripening commence in May. The elevated temperature increases the growth rate of fruit (Ramteke *et al*., 2021). Temperature rise across eastern India during the ripening phase of litchi causes sun burn and fruit cracking. Sun burn and fruit cracking may be specific to cultivars and these are becoming most vulnerable with the climate change scenario and detrimental to cultivation of litchi. The magnitude of sunburn and fruit cracking are governed by climatic factors, genetic, nutritional and soil moisture status. Temperature and rainfall appear to be the major atmospheric parameters which influence the physico-chemical and physiological parameters of the fruits. Therefore, a study was conducted to determine the relationship between sun burn, fruit cracking and physiological as well as environmental stresses in litchi.

MATERIALS AND METHODS

The present investigation was carried out at National Active Germplasm Site, ICAR-National Research Centre on Litchi, Muzaffarpur in 2017, 2018 and 2019. The experimental site is located at an elevation of 210 m above mean sea level and lies between 26°5'64"N latitude and 85°26'64"E longitude. The region is characterized by humid subtropical climate with temperature varying from 30°C-43°C in summer and 5°C-10°C in winter. The region is characterized by dry and hot summer and cold winter with heavy rainfall during rainy season. The monsoon starts in the second or third week of June and continues in appreciable amount up to mid of September. Three plants of each cultivar of uniform size and vigour of twelve cultivars (Early cultivars: Late Large Red and Shahi; Late cultivars: Kasba, Bedana, Mandaraji, Purbi, Calcuttia, Longia, China, Early Bedana, CHL-4 and CHL-5) planted at 8 m x 8 m apart were maintained under uniform cultural practices. The ten uniform fruits of each cultivar of litchi were harvested as and when they attained optimum ripening and these fruits were then analyzed considering all aspects of tree growth during each picking. Fruit weight was taken using digital balance. Five shoots were tagged in each direction (North, South, East and West) and numbers of sun burnt and cracked fruits were counted from each tagged shoots and calculated on per cent basis. Fruit surface temperature (FST) was measured with temperature probe device. Cuticle thickness was measured from vernier caliper and expressed in millimetre (mm). The fruit skin strength was measured by using penetrometer (FT 011, Italian equipped with 4 mm probe) and data recorded in Ib/inch^2. Relative leaf water content (RWC) was estimated following the method, in triplicate on each sampling from the branch which was nearest to the fruit and calculated with the formula:

$$RWC = [(\text{Fresh weight} - \text{dry weight}) / (\text{turgid weight} - \text{dry weight})] \times 100$$

Fresh leaves were weighed in the electronic balance. The leaves were then immersed in water for two hrs, blotted to dry surface and then weighed to get the turgid weight. Next, the leaves were dried overnight in an oven at 70°C and weighed to obtain the dry weight. Analysis of variance and correlation were carried out

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using the statistical packages of SPSS software.

RESULTS AND DISCUSSION

Fruit weight of twelve cultivars of litchi has been shown in Table 1. The bigger size fruit and maximum fruit weight was found in Kasba (27.7g) followed by CHL-5 (21.5g), whereas small fruits were found in Bedana (16.5g). However, aril content was higher in Bedana. The variations in fruit weight and pulp content among the cultivars are genetic characters of each cultivar (Singh and Nath, 2012) but fruit weight and pulp content was highly influenced by rainfall and temperature. The maximum sun burn and fruit cracking was recorded in Late Large Red (32.30% and 32.38%) followed by Shahi (22.89% and 23.57%), whereas, Kasba, Longia and CHL-5 were totally free from these problem at the end of harvesting (Table 1). Cracking mainly occurred after the fruit development approaches colour breaking stage, coinciding with the start of rapid aril growth but in some cultivars, cracking have been observed when fruits were green. The fruit surface temperature differences (FSTD) was 0.30 to 2.20°C higher than air temperature. FSTD was recorded maximum in Late Large Red followed by Shahi. Direct exposure to the sun increases fruit surface temperature (FST) by as much as 12–15°C above air temperature on the berry's sun-exposed side (Spayd *et al*., 2002). FST may vary widely according to fruit bunch location in the canopy and level of solar exposure. Excessive temperature differences can lead to the accumulation of carbohydrates, reducing the plants osmotic potential and allowing them to absorb more water, grow faster, and crack more easily. The different cultivars showed difference in FST under the same climatic condition which may be due to difference in their leaf size, leaflet interval, rachis length, petiole length and canopy volume as well as physico-chemical characteristics of fruits across the cultivars.

The sun burn and cracking susceptible cultivar Late Large Red, Shahi and CHL-4 exhibited lowest cuticle thickness (1.16 mm, 1.20 mm and 1.21 mm, respectively) whereas rest cultivars have shown higher thickness of cuticle (1.76-2.04 mm) which were tolerant to cracking. The tolerant cultivars had more cuticle thickness which restricted gas exchange, water losses and did not allow rise in skin temperature. The thicker cuticle imparts cracking-resistance by providing more pericarp extensibility. The thickness and hardness of fruit peel are important indicators to measure fruit strength and they are directly related with fruit cracking. The lowest fruit pressure strength was recorded in Shahi (2.07 Ib/inch^2) followed by Late Large Red (2.39 Ib/inch^2) whereas rest cultivars have shown higher fruit pressure strength. Skin strength is very important and desirable traits as cell turgidity of cell and extensibility lead to fruit cracking. The more tensile strength of skin was an important mechanical property to resist the pressure by the aril and hence, greater skin strength was indicative of cracking tolerant cultivars. The relative water content (RWC) had impacted on fruit cracking and it has been found that RWC was high in Mandaraji (91.57%) amongst cultivars, associated with lowest sun burn and fruit cracking (2.86% and 3.27%). However, lowest RWC was recorded in Late Large Red (57.29 %) followed by Shahi (61.43%) which exhibited highest sun burn and fruit cracking. It is a type of direct heat injury where tissues exposed to direct light gets sun burnt while fruits located in shade suffers less injury. Sunburn disorder is more severe in early cultivars of litchi.

Monitoring the occurrence of fruit weight and physiological disorders in different years

Mean T_{max} in the above studied period were higher in 2019, followed by 2017 and 2018 (mean T_{max}, 39°C, 34.2°C, and 34°C, respectively). The average % RH was higher in 2017 and 2018, compared with 2019. The rainfall occurrences were higher in 2017 (119.2 mm) and lowest was in the year 2019 (14.4 mm) whereas it was 94.4 mm in 2018. Irrespective of the cultivars, average fruit weight was recorded highest 23.81g in 2017 when rainfall was highest (119.2 mm) and temperature was lowest (34°C), and lowest fruit weight 19.90g was recorded in 2019 when rainfall was least (14.4 mm) and temperature was highest (39°C) whereas intermediate fruit weight 21.47g was recorded when rainfall and temperature were in between. However, variation in fruit weight is genetic character of the cultivar but in the same cultivar (Kasba), fruit weight varied from 24.12-32.68g in different years (Table 1). The average fruit weight of Kasba was 27.71g. The highest weight of this cultivar was recorded 32.68 g in 2017, 26.34g in 2018 and 24.12g in 2019. Thus, fruit weight was reduced by 26.19% in 2019 (24.12g) as compared to 2017 due to lack of soil moisture and higher temperature as rainfall was lowest and temperature was highest during this period.

The maximum sun burn and fruit cracking were recorded in 2019 (Table 1) when temperature was highest (39°C) and rainfall was least (14.4mm) as compared to 2017 (34.2°C, 119.2 mm) and 2018 (34°C, 94.4 mm). In 2017, Mandarji, Purbi, Calcuttia, China, Bedana and Early Bedana were free from sun burn but affected with fruit cracking as rainfall was highest in this year. This indicated that rainfall is highly vulnerable during fruit growth for these cultivars. In 2019, Mandarji, Purbi, Calcuttia and China were affected with sun burn (8.57%, 9.86%, 7.48% and 6.57%, respectively) as temperature was highest in 2019 (39°C) and fruit cracking (6.57%, 6.28%, 5.56% and 8.67%, respectively). Fruit cracking is highly influenced by environmental factors. Sun burn and fruit cracking were almost five times more in 2019 as compared to 2017. Heavy rainfall during 2017, promoted only fruit cracking disorder due to more accumulation of water in the pulp. The increase in aril pressure stresses the pericarp and makes it susceptible to rupture. The fruit cracking rate of most popular litchi cultivar 'Shahi' ranged from 5.28 in 2017 and 38.54% in 2019.

Correlation matrix of different physiological parameters, meteorological parameters and fruit cracking is presented in Table 2. Both sun burn and fruit cracking have been found positively correlated with FSTD (r = 0.928 and 0.927, respectively) and negatively correlated with RWC (r = -0.731 and -0.736, respectively), cuticle thickness (r = -0.959 and -0.968, respectively) and fruit pressure strength (r = -0.746 and -0.745, respectively). It indicates that increase in temperature has led to low leaf water content which reduced the latent heat and thus decreased the evaporative cooling of plant canopy. Fruit surface temperature has always been found higher than ambient temperature, and more was the difference, less was the RWC (r = - 0.767). This might be due to maximum demand of water during growth and development of fruit, which was driven from leaf (Hepaksoy *et al.,* 2000). From the correlation matrix, it has been observed that fruit cracking was significantly correlated with leaf water content (r = -0.736). The losses of water from fruit may be due evapo-transpiration (Gelly *et al.,* 2004) or due to water moving out of the fruit back through the pedicel. Leaf water potential gradient induces the process of water loss from plant either

Table 1: Fruit weight, sun burn and fruit cracking during the study period

Cultivars	Fruit weight (g)				Sun burn (%)				Fruit cracking (%)			
	2017	2018	2019	Mean	2017	2018	2019	Mean	2017	2018	2019	Mean
Kasba	32.68	26.34	24.12	27.71	0	0	0	0	0	0	0	0
Late Large Red	20.16	18.00	17.35	18.5	10.65	37.58	48.67	32.3	9.45	39.48	49.56	32.83
Bedana	17.85	16.58	15.35	16.59	0	0	0	0	4.65	0	0	1.55
Mandaraji	22.4	20.5	19.27	20.72	0	0	8.57	2.86	3.24	0	6.57	3.27
Purbi	22.28	20.65	19.18	20.7	0	0	9.68	3.23	4.58	0	6.28	3.62
Calcuttia	23.15	21.95	19.38	21.49	0	0	7.48	2.49	4.56	0	5.56	3.37
Longia	22.34	20.00	19.38	20.57	0	0	0	0	0	0	0	0
Shahi	23.65	22.14	20.12	21.97	4.26	25.86	38.54	22.89	5.28	26.45	38.97	23.57
China	23.76	22.86	19.86	22.16	0	0	6.57	2.19	2.35	0	8.67	3.67
Early Bedana	26.12	22.35	21.35	23.27	0	0	0	0	8.65	0	0	2.88
CHL-4	28.23	24.56	23.65	25.48	0	0	0	0	0	0	0	0
CHL-5	23.12	21.65	19.76	21.51	0	0	6.75	2.25	1.65	0	6.38	2.68
Mean	23.81	21.47	19.9	21.72	1.24	5.28	10.52	5.68	3.70	5.49	10.17	6.45
CD (0.05)	0.799	0.831	0.951	0.832	0.172	0.59	1.166	0.610	0.185	0.932	0.736	0.402

Table 2: Correlation between fruit cracking with meteorological and physiological parameters

	FSTD	RWC	Cuticle thickness	Fruit pressure strength	Sun burn	Fruit cracking
FSTD	1	-.767**	-.897**	-.757**	.928**	.927**
RWC		1	.680*	.667*	-.731**	-.736**
Cuticle thickness			1	.801**	-.959**	-.968**
Fruit pressure strength				1	-.746**	-.745**
Sun burn					1	.999**
Fruit cracking						1

through fruit surface or canopy surface to atmosphere in soil plant atmosphere continuum and thus significantly affects water relations which lead to cracking in fruits (Singh *et al*., 2014).

CONCLUSIONS

The studies revealed that temperature and rainfall play very important role in induction of sun burn and fruit cracking in litchi. Lack of soil moisture and high temperature reduced the fruit weight in Kasba cultivar by (26.2%) whereas rainfall induced cracking in the cultivars Bedana and Early Bedana. Correlation between fruit cracking and leaf water content may help in future to identify suitable cultivars for a specific agro-ecological region after evaluating the prevailing temperature and water status situation. This is likely to also suggest traits to be targeted for suitable preventive measures to reduce sun burn and fruit cracking in litchi.

Conflict of Interest Statement: The author (s) declares (s) that there is no conflict of interest.

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