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SCREENING OF LITCHI (*LITCHI CHINENSIS* SONN.) GENOTYPES AGAINST SUN BURN

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Abstract

Thirty genotypes were evaluated for incidence of sun burn and fruit cracking. Fourteen genotypes were affected by sun burn with maximum in genotype IC-0615602 (54.48%). Sixteen genotypes were free from sun burn which possessed maximum cuticle thickness ranging from 1.99 mm in IC-0615585 to 1.95 mm in IC-0615595 whereas susceptible genotypes possessed least thickness of cuticle. Tolerant genotypes possessed maximum fruit skin strength, number of leaflet per shoot, densely spaced leaflet, minimum length of rachis and petioles. Fruit Surface Temperature (FST) of susceptible genotypes was higher than that of tolerant genotypes. Fruits located in the south direction were highly affected to sun burn to the tune of 62.45 % whereas north direction showed least (43.46 %). Positively correlation of sun burn was found with FST (0.83), leaflet interval (0.69), petiole length (0.49) and negatively correlation with cuticle thickness (-0.69), spongy layer thickness (-0.79), fruit skin strength (-0.68) and total leaflet (-0.65).

Introduction

Litchi (*Litchi chinensis* Sonn.), also known as Lychee, is an evergreen subtropical fruit tree of Sapindaceae which has strong mycorrhizal association (Lal and Nath 2020). It is highly specific to its climatic requirements (Lal *et al*. 2017a). India and China account for 91% of the world litchi production with the highest production recorded in Bihar, India. In this state, litchi is the livelihood for millions of people as it provides both on-farm and off-farm employments. The inflorescence is a panicle accelerated by high temperature while low temperature slows down the panicle emergence (Lal *et al.* 2019a). The induction of flowering depends on internal as well as external factors. Stress (due to water scarcity, human intervention like Human talks, noise, vehicle movement and other things which passes near to the plants) promotes flowering in litchi (Lal and Nath 2020). Higher phenol content promotes flowering (Lal *et al.* 2019b) and success of fruit set depends on the sources of pollen grains in litchi (Lal *et al.* 2019c, Lal *et al.* 2019d). Fruit retention, yield and fruit quality are highly affected by temperature (Lal *et al.* 2017b) as well as crop load. Least fruit load resulted in maximum fruit weight (Nagraj *et al.* 2019). Litchi fruit development and ripening commence at the period of high temperature which encourages sun burn and cracking. The incidence and severity of these maladies depends upon many factors (Schrader *et al.*2003). The damage caused due to sun burning has been reported upto the tune of 0.9 - 19.13% in different varieties (Singh *et al.* 2012).Cracking mainly occurs after the colour break stage, coinciding with the start of rapid aril growth (Wang *et al.* 2000). As such, sun burnt and cracked fruits lose the quality but no attention has been given on sun burn. Thus, an investigation was carried out to identify tolerant genotypes and understand the basis of incidence of sun burn and fruit cracking in litchi.

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Materials and Methods

An experiment was conducted to evaluate the incidence of sun burn and fruit cracking in 30 genotypes of litchi planted at ICAR-National Research Centre on Litchi, Muzaffarpur during the years 2017 and 2018. The experiment was laid out in RBD consisting three replications, 30 treatments with one plant in each treatment. Five shoots tagged in all directions (North, South, East and West) were selected for recording observations. Numbers of sun burn fruits were counted from each tagged shoots and sun burn fruits with cracking were also counted in the same shoots. Fruit surface temperature (FST) was measured by temperature probe device. Cuticle and spongy layer were measured using vernier calipers and expressed in millimetre. The number of tubercles was counted from one centimetre square of pericarp cut from four different portions of fruit. The fruit skin strength was measured by using penetrometer (FT 011, Italian equipped with 4 mm probe) and data were recorded in lb/inch^2. Number of leaflet per 30 cm shoot was counted on each tagged shoot and distance between two leaves, rachis length, petiole length, leaf blade length and leaf blade width were measured and expressed in centimetre. The statistical analysis of the data on the mean values of individual characters was made using OP State software.

Results and Discussion

Based on the maturity, the studied were genotypes are categorized into two groups; early and late ripening genotypes (Table 1). High-light and high temperature have an adverse effect on fruit production especially in litchi (Ma and Cheng 2004). Result of present studies indicated that maximum sun burn (54.48%) was reported in genotype IC-0615602 (Table 2). Sixteen genotypes were absolutely free from sun burn. All the early ripening genotypes were susceptible to sun burn while late ripening genotypes were tolerant to sun burn which is limiting factors in production of early cultivars of litchi (Mandal and Mitra 2016). The incidence and severity of sunburn depends upon climatic factor, cultivars, hormonal, nutritional and soil moisture (Schrader *et al.* 2003). Pericarp of fruit affected by sun burn lose was found to extensibility and developed micro cracks. The incidence of sun burn also coincided with period of rapid pulp growth which exerted pressure on the surface of peel thereby causing fruit cracking. Sun burn in grape was characterized by loss of chlorophyll (Merzlyack *et al.* 2002) and brown lesions (Schrader *et al.* 2003).

Table 1. Category of Indian litchi genotypes based on maturity.

Early ripening genotypes	Late ripening genotypes
IC-0615586, IC-0615589, IC-0615594, IC-0615597, IC-0615600, IC-0615601, IC-0615602, IC-0615603, IC-0615605, IC-0615606, IC-0615608, IC-0615610, Coll. 35, Coll. 39	IC-0615585, IC-0615587, IC-0615588, IC-0615590, IC-0615591, IC-0615592, IC-0615593, IC-0615595, IC-0615596, IC-0615599, IC-0615604, IC-0615611, IC-0615613, Coll. 36, Coll. 37, Coll. 38

Fruit cracking in litchi is unique and entirely different from other crops because sun burn incidence predisposes fruits to pericarp cracking. In the present study, maximum sun burning was noted in genotype IC-0615602 in which 65.25% fruits turned into cracking (Fig. 1) and genotypes free from sun burn were also free from fruit cracking. Fruit surface temperature (FST) of sun burn affected fruit was more as compared to healthy fruit (Table 2). It is apparent that higher temperature of fruit surface was closely related with burning of fruits. Sunlight can cause damage to the sun-exposed surface of the fruit when air temperatures rise above 30 to 35 $^{\circ}$C during the day time (Lal and Sahu 2017). Sun burn in litchi varied with directional position of fruits on plants.

Maximum sun burn was observed in the South direction due to higher duration of exposure to direct sun which favour sun burn and fruit cracking in litchi. In grapes, sunscald formation was affected by wind direction and speed (Tarara *et al.* 2005). The surface temperature on the sunlit side of the fruit can be as much as 18 ºC higher (Meheriuk *et al.* 1994). The higher burning of litchi fruits on south side of the tree canopy was due to high temperature (Kumar *et al.* 2001). UVB radiation plays a bigger role than visible light (Schrader *et al.* 2003). The rise on fruit temperature dramatically increased the pressure exerted by the pulp on the skin and decreased skin stiffness and strength, increasing the incidence of splitting (Lang and During 1990).

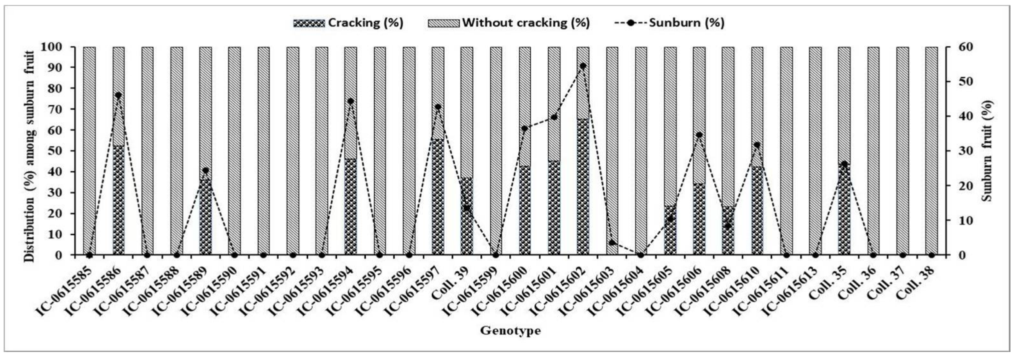

Fig. 1. Distribution of cracking and non-cracking among sunburnt fruit.

Data presented in Table 2 showed that maximum cuticle thickness was recorded in genotype IC-0615595 (2.01 mm) which was free from sun burn while minimum cuticle thickness of genotypes showed maximum sun burn. Similarly, thickness of spongy layer has shown the same results. Fruits which were tolerant to sun burn absorbed more moisture from adjacent tissue and imparted tolerance to other cell against desiccation. Hence, thickness of cuticle and spongy layer can be considered as marker for tolerance/resistance to sun burn and cracking in litchi. The number of tubercles per unit area of fruit surface may play a role in imparting development of thicker peel. It is interesting to note that sun burn tolerant genotypes had large size of tubercles in term of length and low spacer between two tubercles. Genotypes tolerant to sun burn possessed higher fruit skin strength because of more thickness of cuticles which was directly related with tolerant to sun burn. Leaf characteristics had shown significance role in imparting tolerance in genotypes (Table 2). The genotypes which were tolerant to sun burn possessed maximum number of leaflet which did not allow raising the temperature under micro climate around the fruit bunches. Similarly, leaflet interval had great role on tolerant to sun burn. Tolerant genotypes possessed densely spaced leaflet while in susceptible genotypes, leaflet was sparsely arranged which could not induce cooling effect as densely arranged leaflet did. The tolerant genotypes also possessed lowest length and width of leaflet blades, lowest length of rachis and petiole which imparted dense foliage to the plants resulting in cooling effect. The correlation study revealed that sun burn was positively correlated with fruit surface temperature (0.837), leaflet interval (0.694), rachis length (0.391) and negatively correlated with thickness of cuticle (-0.698) and spongy layer (-0.795) and fruit skin strength (-0.684) (Table 3).

Since llitchi is highly susceptible to sun burn and fruit cracking, it is needed to develop/ identify sun burn tolerant cultivars; correlation of different traits needs to be identified so that tolerant genotypes could be identified at early stage. Therefore, knowledge about the morphological attributes of the genotypes with response to sun burn is of great importance. The

Table 2. Characteristics of litchi genotypes governing sun burn.

Genotypes	Sunburn (%)	FST (^{0}C)	Cuticle thickness (mm)	Spongy layer thickness (mm)	No.of tubercles /cm^{2}	Fruit skin strength (lb/inch^{2})	Total leaflet	Leaflet interval (cm)	Rachis length (cm)	Petiole length (cm)	Leaf blade length (cm)	Leaf blade width (cm)	Leaf area (cm^{2})
IC-0615585	0.00^{m}	34.10^{cdef}	1.99^{a}	0.29^{a}	14.50^{a}	2.57^{ab}	128.10^{k}	2.31^{j}	8.56^{hi}	4.13^{efg}	12.20^{hij}	3.91^{bcdefg}	22.90^{r}
IC-0615586	46.00^{b}	35.20^{abc}	1.15^{m}	0.08^{l}	11.40^{fg}	2.39^{gh}	125.46^{l}	3.12^{b}	10.09^{cdef}	3.99^{fgh}	13.42^{cdef}	3.46^{hij}	33.56^{hi}
IC-0615587	0.00^{m}	34.30^{cdef}	1.79^{gh}	0.21^{de}	5.46^{j}	2.59^{a}	99.32^{v}	1.96^{op}	6.52^{m}	3.06^{qr}	8.67^{nop}	3.56^{fghij}	24.82^{n}
IC-0615588	0.00^{m}	34.00^{def}	1.76^{h}	0.20^{def}	5.86^{ij}	2.57^{ab}	146.74^{e}	1.68^{u}	6.45^{m}	3.40^{mnop}	11.36^{kl}	3.79^{bcdefghij}	31.2^{k}
IC-0615589	24.40^{i}	35.80^{ab}	1.42^{j}	0.13^{ij}	12.15^{def}	2.38^{h}	98.40^{v}	2.62^{h}	9.88^{ef}	4.26^{de}	12.92^{efgh}	3.51^{ghij}	23.97^{op}
IC-0615590	0.00^{m}	33.90^{def}	1.83^{defg}	0.29^{a}	13.50^{abc}	2.54^{abc}	155.89^{c}	2.07^{n}	9.54^{fg}	3.80^{ij}	14.03^{bc}	3.83^{bcdefghi}	33.76^{h}
IC-0615591	0.00^{m}	33.80^{def}	1.82^{efgh}	0.24^{bc}	14.00^{ab}	2.53^{bc}	151.58^{d}	2.71^{g}	9.42^{fgh}	4.02^{fgh}	11.18^{l}	3.18^{bcdefg}	32.74^{ij}
IC-0615592	0.00^{m}	33.80^{def}	1.81^{efgh}	0.22^{cd}	13.46^{bc}	2.53^{bc}	140.76^{gh}	2.13^{m}	10.03^{def}	3.54^{lmn}	12.08^{ijk}	4.03^{bcd}	40.46^{c}
IC-0615593	0.00^{m}	34.00^{def}	1.86^{cdef}	0.21^{de}	6.30^{ij}	2.58^{ab}	185.09^{a}	1.86^{r}	7.72^{jkl}	2.86st	11.38^{kl}	3.96^{bcdef}	23.71^{q}
IC-0615594	44.47^{bc}	35.90^{ab}	1.63^{j}	0.14^{hi}	12.00^{defg}	2.06^{i}	104.70^{tu}	2.85^{d}	8.50^{ijk}	4.00^{fgh}	14.34^{b}	3.95^{bcdef}	31.34^{k}
IC-0615595	0.00^{m}	34.80^{bcd}	1.95^{ab}	0.31^{a}	5.50^{ij}	2.57^{ab}	132.48^{j}	2.24^{k}	6.51^{m}	2.54^{u}	8.10^{op}	3.75^{j}	20.09^{s}
IC-0615596	0.00^{m}	34.00^{def}	1.82^{efgh}	0.20^{def}	6.00^{ij}	2.58^{ab}	157.30^{c}	1.81^{s}	7.60^{kl}	2.88^{rs}	9.40^{mn}	3.85^{bcdefgh}	20.85^{s}
IC-0615597	42.61^{c}	35.70^{ab}	1.18^{m}	0.14^{hi}	13.00^{bcd}	2.46^{def}	113.50^{op}	2.79^{ef}	11.20^{b}	4.83^{a}	12.2^{hij}	3.88^{bcdefg}	46.51^{a}
Coll. 39	13.60^{j}	33.90^{def}	1.21^{m}	0.14^{hi}	11.50^{efg}	2.40^{gh}	120.78^{n}	2.28^{jk}	10.10^{cdef}	3.71^{jkl}	10.90^{l}	3.57^{efghij}	33.87^{h}
IC-0615599	0.00^{m}	33.20^{f}	2.01^{a}	0.31^{a}	7.50^{h}	2.59^{a}	128.85^{k}	2.24^{k}	7.78^{jkl}	3.24^{opq}	9.85^{m}	2.99^{k}	18.43^{t}
IC-0615600	36.53^{e}	36.00^{a}	1.61^{j}	0.15^{hi}	13.50^{abc}	2.47^{de}	99.29^{v}	2.77^{f}	9.74^{ef}	3.73^{jk}	13.15^{def}	4.16^{b}	26.29^{m}
IC-0615601	39.62^{d}	35.70^{ab}	1.28^{l}	0.09^{kl}	12.00^{defg}	2.44^{efg}	105.50st	2.66^{h}	9.98^{def}	3.77^{j}	14.05^{bc}	4.05^{bcd}	29.39^{l}
IC-0615602	54.48^{a}	35.80^{ab}	1.64^{j}	0.12^{hi}	11.64^{efg}	2.41^{fgh}	91.28^{w}	3.02^{c}	11.25^{b}	4.57^{bc}	12.25^{ghij}	4.11^{bc}	31.09^{k}
IC-0615603	3.64^{l}	33.60^{ef}	1.77^{gh}	0.16^{gh}	13.00^{bcd}	2.42^{efgh}	133.76^{ij}	2.83^{de}	9.59^{efg}	4.16^{ef}	13.67^{bcde}	5.05^{a}	31.60^{k}
IC-0615604	0.00^{m}	33.80^{def}	1.81^{fegh}	0.20^{def}	6.14^{ij}	2.58^{ab}	142.60^{f}	1.76^{t}	7.00^{lm}	2.68^{tu}	13.03^{def}	4.17^{b}	38.40^{e}
IC-0615605	10.34^{k}	34.00^{def}	1.42^{j}	0.18^{fg}	11.56^{feg}	2.50^{cd}	112.71^{q}	2.71^{g}	8.71^{ghi}	3.36^{nop}	14.05^{bc}	3.65^{defghij}	35.68^{g}
IC-0615606	34.60^{f}	35.90^{ab}	1.64^{i}	0.15^{hi}	12.50^{cde}	2.43^{efgh}	103.68^{u}	3.58^{a}	10.13^{cdef}	3.85^{hij}	12.80^{fghi}	3.46^{hij}	41.45^{b}
IC-0615608	8.55^{k}	33.70^{def}	1.35^{k}	0.19^{ef}	12.00^{defg}	2.44^{efg}	106.41^{s}	2.79^{ef}	15.40^{a}	4.60^{b}	15.98^{a}	4.15^{bc}	37.26^{f}
IC-0615610	31.84^{g}	35.90^{ab}	1.17^{m}	0.11^{jk}	11.50^{efg}	2.04^{i}	134.96^{i}	3.08^{b}	10.97^{bc}	3.99^{fgh}	13.33^{cdef}	4.10^{bc}	32.68^{j}
IC-0615611	0.00^{m}	34.20^{cdef}	1.87^{cde}	0.25^{b}	13.50^{abc}	2.56^{ab}	141.52^{fg}	3.00^{c}	10.61^{bcde}	4.05^{fg}	13.78^{bcd}	4.00^{bcd}	37.77^{ef}
IC-0615613	0.00^{m}	33.20^{f}	1.80^{fgh}	0.19^{ef}	6.50^{hi}	2.58^{ab}	123.42^{m}	1.95^{q}	7.48^{l}	2.81st	9.04^{n}	3.42^{ij}	24.82^{n}
Coll. 35	26.38^{h}	34.50^{cde}	1.21^{m}	0.11^{jk}	11.00^{g}	2.42^{efgh}	111.78^{r}	2.98^{c}	11.37^{b}	3.86^{hij}	12.30^{ghij}	3.65^{defghij}	29.44^{l}
Coll. 36	0.00^{m}	33.90^{def}	1.92^{bc}	0.30^{a}	14.00^{ab}	2.58^{ab}	160.32^{b}	2.56^{i}	10.05^{def}	3.97^{ghi}	11.54^{jkl}	3.74^{cdefghij}	37.25^{f}
Coll. 37	0.00^{m}	33.50^{ef}	1.91^{bc}	0.25^{b}	13.20^{bc}	2.58^{ab}	139.23^{h}	2.32^{j}	10.87^{bcd}	3.56^{klm}	13.35^{cdef}	3.83^{bcdefghi}	39.37^{d}
Coll. 38	0.00^{m}	33.30^{f}	1.89^{bcd}	0.24^{bc}	13.00^{bcd}	2.58^{ab}	150.48^{d}	2.18^{l}	9.50^{fg}	4.41^{cd}	12.76^{fghi}	3.98^{bcde}	33.97^{h}
SE (d)	0.94	0.59	0.03	0.01	0.51	0.02	0.83	0.02	0.45	0.09	0.40	0.20	0.41
CD (0.05)		1.18	0.06	0.02	1.02	0.05	1.68	0.04	0.92	0.18	0.811	0.41	0.82

Table 3. Correlation coefficient between sun burn and various characters.

Traits	Sunburn	FST	Cuticle thickness	Spongy layer thickness	Number of tubercles	Fruit skin strength	Total leaflet	Leaflet interval	Rachis length	Petiole length	Leaf blade length	Leaf blade width	Leaf area
Sunburn	1	.873**	-.698**	-.795**	0.293	-.684**	-.658**	.694**	.391*	.493**	.369*	0.038	0.19
FST		1	-.540**	-.636**	0.21	-.650**	-.583**	.611**	0.204	0.343	0.249	0.067	0.067
Cuticle thickness			1	.837**	-0.208	.620**	.504**	-.519**	-.523**	-.413*	-.394*	-0.002	-0.296
Spongy layer thickness				1	-0.099	.645**	.553**	-.497**	-0.335	-0.318	-0.358	-0.183	-0.188
Number of tubercles					1	-0.28	-0.158	.610**	.676**	.791**	.652**	0.139	.524**
Fruit skin strength						1	.408*	-.587**	-0.351	-.406*	-.438*	-0.17	-0.138
Total leaflet							1	-.517**	-0.299	-0.337	-0.192	0.078	-0.016
Leaflet interval								1	.638**	.643**	.513**	-0.001	.367*
Rachis length									1	.763**	.665**	0.163	.530**
Petiole length										1	.612**	0.205	.470**
Leaf blade length											1	.433*	.554**
Leaf blade width												1	0.214
Leaf Area													1

* Significant at $p < 0.05$; ** Significant at $p < 0.01$.

correlation study might help breeder to select tolerant genotypes at the seedling stages. It may be concluded that tolerant genotypes found in the diverse germplasm of litchi can be promoted and used as a male parent in hybridization programme. Sun burn was positively correlated with leaflet interval, rachis length, petiole length and leaf blade length. These leaf traits can be used as markers to select tolerant cultivars in the seedling stages.

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