

Effect of Foliar Application of Nutrients on Fruit Firmness, Cracking and Shelf Life in Litchi (*Litchi chinensis* Sonn.) Cultivar Early Large Red

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Abstract An experiment was conducted during 2014-15 on 23 year old trees of litchi cultivar Early Large Red to study the effect of foliar application of different nutrients (calcium, zinc and boron) on fruit firmness, fruit cracking and shelf life. The maximum firmness was recorded with calcium chloride at 1.00% (2.57 kg/cm²) while minimum firmness under control (1.63 kg/cm²). Calcium chloride at 2.00% concentration significantly increased the shelf life of litchi fruits. It was observed that borax at 0.80% concentration resulted consistently reduction in the fruit cracking followed by zinc sulfate at 1.50% concentration which was at par with foliar spray of nutrient borax at 0.60%. Borax at 0.80% concentra-

tion reduced the fruit cracking about 77.12% with minimum cracked fruits (196.4 kg/acre) over control.

Keywords Litchi, Firmness, Shelf life, Cracking, Nutrients.

Introduction

Litchi (*Litchi chinensis* Sonn.) is a delicious fruit of Sapindaceae family [1]. The litchi fruit is having unique taste and aroma. The fruit is rich in sugar and also contains several minerals and vitamins. Therefore, this fruit is having more demand in market and fetching more prices. Litchi production and its potential yield is affected by many physiological disorders like fruit cracking, sunburn, flower and fruit drop, poor fruit development, black spot and irregular bearing. Fruit cracking is a major problem which causes loss as high as 5-70% in litchi resulting in deterioration of fruit quality. The various factors associated with fruit cracking in litchi are boron deficiency, increased irrigation interval and hot winds, higher levels of gibberellins and abscisic acid in the skin, aril and seed. Alternate spells of humid condition and dry heat in summer month cause cracking and dropping of fruits. The cracked fruit rot quickly

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and is not worth marketing. Early Large Red is an early ripening variety and is more susceptible to cracking than late ripening varieties. Litchi cultivars showed similar pericarp development, however, differences in cuticle thickness and spongy layers were found between different cultivars. However, the findings of Huang et al. [2] found that cultivar Huaizhi, which had a thicker spongy layer, showed less desiccation than other cultivars. Differences in relative proportions of reducing and non-reducing sugars could be important in fruit cracking [3].

An optimum nutritional management is important for optimum growth and development of the plants. Calcium is a structural component of the cell walls, during early fruit development it is required to build up cracking resistance [4]. The structural calcium levels in litchi pericarp generally decline during 22-52 days after anthesis due to dilution of structural calcium [2]. The increase in calcium during early stages of fruit development provides a basis of fruit pericarp development and the final increase in protopectin content in the pericarp ensures good fruit pericarp quality [5]. Boron is required for calcium uptake and movement and calcium deficiency is significantly reduced by boron application. Boron plays a similar role to calcium in stabilization of cell wall which strengthens the fruit skin, fruit firmness and storage life of litchi. So, when tree is lacking in nutrients mainly calcium, magnesium, boron, zinc resulted in physiological disorder like fruit cracking, poor shelf life. The status of these nutrient elements responsible for firmness of fruit and ultimately the post harvest life of fruits. Tree requires an optimum amount of nutrient at particular stage to mitigate these problems. Hence present study was conducted to explore the possibility of using foliar application of zinc sulfate, calcium chloride and borax to enhance fruit quality of cultivar Early Large Red especially by decreasing fruit cracking and increasing fruit firmness and shelf life.

Materials and Methods

An experiment on 23 year old trees of litchi cv Early Large Red was carried out at Regional Research Station of the Department of Horticulture, Chaudhary Charan Singh Haryana Agricultural University, Hisar

(Buria Yamuna Nagar). Forty two bearing trees with uniform vigor and size, planted at a spacing of 8 m × 8 m to study the effect of different nutrient sprays on quality of litchi especially in respect of fruit cracking and shelf life. The foliar application of the nutrient at different concentrations was done on 15th April and 5th May, 2014. The experiment was laid out in randomized block design. The data were analyzed as per method suggested by Panse and Sukhatme [6]. The following fourteen treatments with three replications : T₁ : ZnSO₄ at 0.5%; T₂ : ZnSO₄ at 1.0%; T₃ : ZnSO₄ at 1.5%; T₄ : ZnSO₄ at 2.0%; T₅ : CaCl₂ at 1.0%; T₆ : CaCl₂ at 2.0%; T₇ : CaCl₂ at 3%; T₈ : CaCl₂ at 4%; T₉ : Borax at 0.4%; T₁₀ : Borax at 0.60%; T₁₁ : Borax at 0.80%; T₁₂ : Borax at 1.0% T₁₃ = Water spray ; T₁₄ : No spray (control) ; sprays were tested. The treatments were applied at two times. The firmness of the fruit skin was measured using a Penetrometer (FT 011, Italian equipped with 4 mm probe) from the selected tagged fruits and data recorded in kg cm. The care was taken to use the smooth and uniform pressure applications throughout the data recording. Each reading consisted of 10 fruits and the data recorded on the two opposite sides of the equatorial area of the fruit. The shelf life of the litchi fruits was calculated by taking three bunches per branch under study of the different treatments and putting these at the room temperature (25°C) and observing the bunches showing the signs of blackness over the skin. Any bunch showing blackness over skin was rejected and the retention time was measured in days. Fruit cracking was recorded from 20 May to 27 May, and 14 June 2014 at the interval of 7 days. Total number of fruits having cracking was counted in each marked panicle and per cent fruit cracking was worked out by following relation.

$$\text{Fruit cracking (\%)} = \frac{\text{Total number of fruit cracked on fruiting panicle}}{\text{Total number of fruit retained on panicle}} \times 100$$

Results and Discussion

Fruit cracking (%) and yield of cracked fruits (kg/acre)

As seen from the Table 1, from 20th May, 2014 to

Table 1. Effect of foliar application of zinc sulfate, calcium chloride and borax on fruit cracking (%) of litchi cultivar Early Large Red.

Treat- ments	20 th	27 th	3 rd	10 th
	May 2014	May 2014	June 2014	June 2014
T ₁ : Zinc sulfate (0.50%)	5.91	7.12	9.45	13.03
T ₂ : Zinc sulfate (1.00%)	6.33	7.62	9.95	15.11
T ₃ : Zinc sulfate (1.50%)	5.12	6.12	7.94	10.64
T ₄ : Zinc sulfate (2.00%)	6.50	7.90	10.77	15.90
T ₅ : Calcium chloride (1.00%)	7.04	8.63	11.86	17.56
T ₆ : Calcium chloride (2.00%)	7.53	9.29	12.83	19.26
T ₇ : Calcium chloride (3.00%)	7.72	9.57	13.21	20.00
T ₈ : Calcium chloride (4.00%)	8.68	10.79	15.10	22.93
T ₉ : Borax (0.40%)	4.82	5.69	7.22	9.40
T ₁₀ : Borax (0.60%)	5.39	6.36	8.05	10.36
T ₁₁ : Borax (0.80%)	3.57	4.18	5.20	6.66
T ₁₂ : Borax (1.00%)	5.65	6.70	8.56	11.23
T ₁₃ : Water spray	9.71	12.16	17.05	26.10
T ₁₄ : No spray (control)	10.39	13.09	18.41	26.06
CD at %%	0.75	0.58	0.29	0.74

10th 2014, observations recorded at seven days interval. It was observed that borax at 0.80% concentration resulted consistently reduction in the fruit cracking in litchi cultivar Early Large Red as compared to all other treatments (Table 1). Overall borax at 0.80% resulted in maximum reduction in fruit cracking per cent over control i.e. no spray. The reason for the higher fruit cracking control by borax at 0.80% concentration was the foliar application of boron to the fruit which helped the fruits to meet their boron requirements and enhancing the water uptake by roots and translocation to the targeted fruits. The other cause of reduction in fruit cracking on application of boron may have been also due to physiological role of boron in synthesis of pectic substances in cell wall which prevented fruit cracking and splitting. Boron also has the role in synthesis of pectin substances in cells. It also increased the elasticity of cell membranes and prevents the breakdown of vegetative tissues. Sheikh and Manjula [7] recorded that pre-harvest spray of 0.2% boric acid resulted in the lowest percentage of cracked fruits (3.33%) against 28.44% in control in pomegranate var Ganesh. Boron plays a similar role to calcium in

cell wall stabilization which makes it essential for quality factors such as skin strength, fruit firmness and storage life of litchi. Similar result was observed Singh et al. [8] in pomegranate, Sharma and Belsare [9] in pomegranate var G-137.

The data pertaining to the fruit cracking per cent is depicted in Table 2 which clearly indicated that borax at 0.80% concentration significantly resulted in the least cracking in litchi. It reduced the fruit cracking about 77.12% over no spray (control). Among the different zinc sulfate nutrient concentrations, zinc sulfate at 1.50% resulted into a reduction of 63.40% of fruit cracking over no spray (control) which was estimated least among the different zinc sulfate concentrations. Calcium chloride at 1.00% resulted 17.55% of fruit cracking and it reduced the fruit cracking about 39.56% over control.

The lowest yield of cracked fruits of litchi was estimated with the foliar spray of borax at 0.80% with the 196.4 kg of cracked fruits per acre which was lowest among all the concentrations of borax. No spray resulted in highest cracked fruit yield of 680.4 kg/acre. The lower the fruit cracking the lesser will be the yield of cracked fruit and consequently the higher quality fruit yield till final harvest of the litchi crop. Borax helped the fruits to meet their boron requirements and enhancing the water uptake by roots and translocation to the targeted fruits.

Fruit firmness (kg/cm²)

The effect of different treatments on fruit firmness of litchi is presented in Table 3. The maximum firmness was recorded with calcium chloride at 1.00% (2.57 kg/cm²) followed by CaCl₂ at 2% (2.47 kg/cm²). However, the minimum firmness was under control (1.63 kg/cm²). There was increase in shelf life as foliar application of calcium chloride delayed the ripening process by reducing respiration rate as well as ethylene production, also the significant increase in ascorbic acid and antioxidant compounds like phenol as cited by Koutinas et al. [10] and vangdal et al. [11]. The results are supported by Moor et al. [12], Haq et al. [13] and Denis Eroglu [14]. In addition to directly reinforcing the cell wall structure, calcium may also improve firmness retention

Table 2. Effect of foliar application of zinc sulfate, calcium chloride and borax on fruit cracking per cent and cracked fruit yield of litchi cultivar Early Large Red.

Treatments	plant (kg)	per acre (kg)	crack- ing (%)	fruit (kg/ acre)
T ₁ : Zinc sulfate (0.50%)	61.4	2580.10	13.04	336.4
T ₂ : Zinc sulfate (1.00%)	64.5	2709.00	15.12	409.6
T ₃ : Zinc sulfate (1.50%)	66.3	2785.90	10.64	296.4
T ₄ : Zinc sulfate (2.00%)	65.0	2730.00	15.87	433.3
T ₅ : Calcium chloride (1.00%)	65.4	2748.10	17.55	482.3
T ₆ : Calcium chloride (2.00%)	61.5	2581.70	19.29	498.0
T ₇ : Calcium chloride (3.00%)	60.5	2541.00	20.02	508.7
T ₈ : Calcium chloride (4.00%)	60.2	2528.40	22.95	580.3
T ₉ : Borax (0.40%)	66.4	2790.10	9.42	262.8
T ₁₀ : Borax (0.60%)	68.3	2868.60	10.36	297.2
T ₁₁ : Borax (0.80%)	70.3	2953.90	6.65	196.4
T ₁₂ : Borax (1.00%)	66.4	2788.80	11.25	313.7
T ₁₃ : Water spray	57.7	2423.40	26.06	631.5
T ₁₄ : No spray (control)	55.7	2340.70	29.07	680.4
CD at 5%			0.753	18.561

through the modulation of some cell wall modifying enzyme activities, as treated apple and peach fruits have been found to display lower levels of PME, PL, PG, β -Gal, A Fase or β -Xyl activity [15]. The fruit firmness of litchi fruit is a desirable characteristic because an imbalance in extensibility [16] and cell turgidity [17] could lead to fruit splitting.

Shelf life

Calcium chloride at 2.00% concentration significantly increased the shelf life of litchi fruits in cultivar Early Large Red as compared to all other treatments. Likewise, calcium chloride at 1% concentration was also significantly increased the shelf life of the fruits up to 7.0 days. Further, borax at 0.80 and 0.60% were at par with each other but significantly differ from other treatments but lower shelf life than calcium chloride 2.0 and 1.0%. Water spray and no spray resulted in poor shelf life of the litchi fruits with 3.9 and 3.8 days (Table 3). The reason for shelf life was due to the fact that foliar spray of nutrient calcium chloride on litchi fruits resulted in higher fruit peel strength or fruit firmness which leads to increase in shelf life of fruit after harvest. Pre-harvest application of 0.5% CaCl₂ proved to be efficacious in minimizing weight loss and increas-

Table 3. Effect of foliar application of zinc sulfate, calcium chloride and borax on firmness and shelf life of litchi cultivar Early Large Red.

Treatments	Fruit firmness (kg/cm ²)	Shelf life (days)
T ₁ : Zinc sulfate (0.50%)	1.77	4.7
T ₂ : Zinc sulfate (1.00%)	1.80	4.8
T ₃ : Zinc sulfate (1.50%)	1.73	5.5
T ₄ : Zinc sulfate (2.00%)	1.83	5.7
T ₅ : Calcium chloride (1.00%)	2.57	7.0
T ₆ : Calcium chloride (2.00%)	2.47	7.7
T ₇ : Calcium chloride (3.00%)	2.37	4.1
T ₈ : Calcium chloride (4.00%)	2.27	4.0
T ₉ : Boerax (0.40%)	1.83	5.3
T ₁₀ : Borax (0.60%)	1.93	6.0
T ₁₁ : Borax (0.80%)	2.13	6.2
T ₁₂ : Borax (1.00%)	2.07	4.7
T ₁₃ : Water spray	1.67	3.9
T ₁₄ : No spray (control)	1.63	3.8
CD at 5%	0.097	0.400

ing shelf life of plum cultivar Santa Rosa [18]. Calcium acts as an anti-senescent agent as it provides cellular disintegration by maintaining protein and nucleic acid synthesis. It is also effective in decreasing the respiration rates of produce. The poor shelf life in untreated fruits could be due to higher respiration rate which could lead to higher storage breakdown.

Conclusion

From going through above findings, it can be concluded that calcium chloride at 1.00 % resulted in highest firmness (2.57kg/cm²) but this nutrient was performed better to enhance the shelf life (7.7 days) at 2.00%. Borax at 0.80% resulted in lowest cracked fruit yield (196.4 kg per ace) which was reduced about 77.12% . No spray (control) resulted in highest cracked fruit yield of 680.4 kg /acre. So, application of calcium and boron enhanced the fruit firmness and shelf life and reduced the fruit cracking in litchi cv Early Large Red.

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