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Role of Brassinolide in Fruit Growth, Development, Quality and Cracking of Litchi Cv. Bombai Grown in New Alluvial Zone of West Bengal

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ABSTRACT

'Bombai' is a popular litchi variety of West Bengal but susceptible to fruit cracking which reduces the market price. Till now numbers of research trial conducted in litchi with different chemicals but reports on impact of application of brassinolide in reduction of fruit cracking maintaining quality attributes are limited. Therefore, an experiment was conducted during January-May of 2019–20 at the Experimental Farm of Horticultural Research station, Mondouri, Bidhan Chandra Krishi Viswavidayala, Nadia, West Bengal, India to evaluate the effect of different dose of brassinolide on fruit yield, quality and reduction of cracking in litchi. The experiment was laid out in randomized block design comprising five treatments of brassinolide [T_1: Brassinolide (0.5 mg l^{-1}), T_2: Brassinolide (1.0 mg l^{-1}), T_3: Brassinolide (1.5 mg l^{-1}), T_4: Brassinolide (2.0 mg l^{-1}) and T_5: Control (water spray)] with four replication/treatment. The solutions were applied two times; first before anthesis and another at 15 days after anthesis. Result revealed that brassinolide increased the number of fruits per panicle and significantly increased individual fruit weight, length, diameter, and yield. Among different treatments, brassinolides at 1 mg l^{-1} (two-time application i.e., 15 days before and after anthesis) is identified to be superior considering all qualitative aspects i.e., maximum fruit weight (26.40 g), fruit length (5.15 cm) and yield (95.88 kg plant^{-1}). This treatment also exhibited maximum TSS (21.22°Brix), total sugar (14.11%), ascorbic acid (37.42 mg 100 g^{-1}) and anthocyanin (23.13 mg 100 g^{-1}) content with minimum (9.12%) fruit cracking. The control treatments registered minimum values for all parameters.

KEYWORDS: Anthocyanin, Brassinolide, fruit quality, fruit cracking, litchi, physiological disorder

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1. INTRODUCTION

Litchi (*Litchi chinensis* Sonn.) an evergreen, subtropical fruit tree belonging to the family Sapindaceae is called as 'Queen of Fruit' due to its taste, aroma and sweetness (Trong et al., 2021; Lal et al., 2020). According to NHB database 2019–20, in India litchi is cultivated on 97,000 hectare and total production is about 726 thousand MT mainly restrained to Bihar (74%). Though its commercial cultivation is predominantly found in the Indo-Gangetic plains of Uttar Pradesh, Bihar, Uttarakhand and West Bengal but successful cultivation in suitable climatic conditions of the sub-tropical states of Punjab, Himachal Pradesh, Assam, Tripura and Jammu and Kashmir has also been recorded (Lal et al., 2019). Despite of unique and desirable characteristics, litchi fruit is seriously affected by fruit cracking disorder that causes significant loss of yield and commercial value (Huang et al., 2005; Wang et al., 2021). Cracking occurs during the final stage of fruit growth when the aril develops and exerts pressure on the inactively growing pericarp (Marboh et al., 2017). In India, the development of litchi coincides with rising atmospheric temperature and low soil moisture and relative humidity that makes more congenial for skin to crack (Yadav et al., 2011; Mandal and Mitra, 2018) may be due to lack of tensile strength of skin tissue or developed spongy tissue etc. Whereas in China, severity of fruit cracking is mostly cultivar specific and it is worst in 'nuomici litchi (L. *chinensis* cv. Nuomici), which is one of the excellent varieties (Peng and Lin, 1999). Researchers over the world reported that several chemicals like $Ca(NO_3)_2$, boron, Zn, gibberellins etc sprayed on the litchi leaves reduced the fruit cracking rate (Marboh et al., 2017; Peng et al., 2004).

Brassinosteroids(BRs) is a group of naturally occurring polyhydroxy steroids (Rao et al., 2002). These are considered as the 6th important group of phytohormones in plants, which are considered essential for normal growth and several developmental processes in plants (Ali, 2017; Hayat and Ahmad, 2011). These steroidal compounds are also involved in inducing defence mechanism against various biotic and abiotic stresses, such as water-stress, temperature-stress, oxidative stress and high salinity stress (Sharma, 2021; Nolan et al., 2020). Further, BRs are natural, non-toxic, non-genotoxic, biosafe, and eco-friendly phytohormone which can be used in agri-horti plants to improve the growth, yield, fruit quality (Coll et al., 2015). Owing to multiple effects, BRs are considered as the sixth group of plants hormones having pleiotropic effects (Luan et al., 2016). This group has also been conferred as hormones of the twenty-first century, owing to active contribution of BRs in a large number of physiological processes (Khripach et al., 2000). From the recent studies, it has been proved that BRs act together with other phytohormones such as auxins, cytokinins, ethylene, GAs, jasmonic acid, ABA, salicylic acid and polyamines for regulating various physiological and developmental activities in plants (Saini et al., 2015). As of now, more than 70 BRs have been isolated from different plant species, out of which, only three i.e., BL, 24-epibrassinolide and 28-homobrassinolide are the biologically most active forms and are extensively used in physiological studies in different horticultural plants (Aghdam et al., 2016; Nawaz et al., 2017). In response to seed treatment and foliar application with different concentrations of brassinolide (BR) (0.05, 0.1 and 0.2 ppm) as significant increase in vegetative growth was obtained. However, the foliar application treatment was more promising in this respect (Baghel et al., 2019).

As a whole, litchi fruit cracking the major physiological disorder (Martinez Bolanos et al., 2017), is closely related to imbalance of mineral nutrition and water metabolism (Xiao and Lu, 2002). However, the data on relations among the fruit pericarp development, the application of brassinolide to litchi fruit and fruit cracking are limited. The present work was conducted to investigate the effects of spraying brassinolide on litchi cv. Bombai trees on fruit growth, development, quality and incidence of fruit cracking at agro-climatic situation of new alluvial soil of West Bengal, India.

2. MATERIALS AND METHODS

2.1. Experimental site and details of spray solutions

An experiment was conducted at the Experimental Farm of Horticultural Research station (22.43° N latitude and 88.34° E longitudes, with an altitude of 9.75 m above mean sea level), Bidhan Chandra Krishi Viswavidayala, Mondouri, Nadia, West Bengal, India during January–May of 2019–20. The experiment soil was sandy loam having pH 6.6, 0.69% organic carbon, 240 kg ha^{-1} available nitrogen, 95 kg ha^{-1} available phosphorus and 280 kg ha^{-1} potassium. The plant was 35 years old spaced at 10×10 m^2. The climatic condition of this region is subtropical humid in nature with average annual rainfall ranges from 1200–1400 mm and the minimum and maximum temperature varies between 17°C to 32°C.

The spray solutions of brassinolide (produced by Sigma-Aldrich) of different strength were prepared by dissolving directly the requisite quantities of their commercial formulations in water. For all treatments, 15 litres of spray solution was made adding 10 ml sticker (market name-Sandovit) and applied on the trees with the help of foot sprayer to wet the developing fruits and foliages completely without causing runoff which are influenced by brassinolide comprising; T_1: Brassinolide (0.5 mg l^{-1}), T_2: Brassinolide (1.0 mg l^{-1}), T_3: Brassinolide (1.5 mg l^{-1}), T_4: Brassinolide (2.0 mg l^{-1}) and T_5: Control (water spray). The solutions were applied two times; first before anthesis and another at 15 days after anthesis. The experiment was laid out in randomized block design (RBD) with four replications.

2.2. Observations recorded and statistical analysis

Fruit set was determined as per the procedure suggested by Banyal et al. (2013) and the number of fruit panicle^{-1} were counted at harvest time. Data on yield (kg plant^{-1}) and fruit weight (g) were recorded by top pan balance, while pulp weight (g) was recorded by using electronic balance. Fruit length (cm) and breadth (cm) were measured by vernier calliper. Total soluble solids (TSS) was calculated by hand refractometer (0-32°B). Total sugar, titratable acidity, and anthocyanin content were estimated according to Ranganna (2002). Ascorbic acid was determined by colorimetric method based on the reduction of 2, 6 - dichlorophenol indophenols by ascorbic acid and was expressed in milligram of ascorbic acid per 100 g of sample (Anonymous, 2000). Fruit cracking was recorded by counting the number of total fruits set initially and cracked fruits on the tagged branches and converting the differential into percentage. Statistical analysis was done as per method suggested by Panse and Sukhatme (1985).

3. RESULTS AND DISCUSSION

Different treatments of Brassinolide enhanced the nutraceutical value and post-harvest quality of litchi fruits in compare to the control ones. The significant increases in the different treatments of Brassinolide were more pronounced in physical properties and the trend followed by biochemical constituents also.

Data presented in Table 1 revealed that different treatments of Brassinolide significantly increased the fruit weight. Among different treatments, brassinolide 1.0 mg l^{-1} (T_1) showed maximum fruit weight (26.40 g) followed by brassinolide 2.0 mg l^{-1} (26.10 g) while control recorded minimum (24.25 g). Like fruit weight, fruit length and diameter also increased by different treatments of brassinolides. Brassinolide at 1.0 mg l^{-1} showed maximum pulp weight (13.71 g) followed by brassinolide at 2.0 mg l^{-1} (13.10 g) while control recorded least (12.11 g). Maximum yield (95.92 kg plant^{-1}) was recorded in brassinolides 1.0 mg l^{-1} treated fruits while minimum (92.11 kg plant^{-1}) was recorded in controlled plant. Similar results were obtained by Gomes et al. (2006) in yellow passion fruit. They observed increased in fruit weight and yield with application of brassinolide analogous. Data presented in Table 1 revealed that number of the fruits per panicle varied between 18.22 to 24.75 due to different treatments of brassinolides. Maximum (24.75 number panicle^{-1}) fruits of harvest recovered from brassinolide 1.0 mg l^{-1} (T_2) treated fruits followed by T_4 (Brassinolides 2.0 mg l^{-1}) while minimum (18.22 number) was recorded from controlled plant. In grape trees, brassinolide sprayed at flowering and 25 days after increased the production but no modification in the internal fruit quality. In vines the application of epibrasssinolide at flowering also increased the numbers of grapes per panicle and yield compared to the non-treated plants by 66.7 and 29.9% when using dose of 0.01 and 0.1 ppm respectively (Pozo et al., 1994). Besides, that similar types of yield increment observed in guava by Lal et al. (2013) and in sugar apple by Mostafa and Kotb (2018).

The brassinolide increased the number of fruits per panicle at harvest. This is might be due to delay in leaf and fruit abscissions as observed by Sugiyamas and Kuraishi (1989) and for higher assimilation of photosynthetic carbon along with better supply of nutrients and metabolites from source to sink (Sridhara et al., 2021). Furthermore, they play a key role in the regulation of flower-to-fruit transformation and thus optimize fruit set by conferring resistance to biotic and abiotic stress (Tang et al., 2016).

Like physical characters, bio-chemical constituent was also affected by exogenous application of brassinolides in litchi trees. Total soluble solid was also influenced by Brassinolide treatments. Data presented in Table 1 revealed that TSS content of fruits varied from 18.40 to 21.20°Brix due to different treatments of brassinolides. Maximum 21.20°Brix was recorded in T_2 (Brassinolides 1.0 mg l^{-1} of water) followed by T_4 (Brassinolide 2.0 mg l^{-1} of water) while minimum was measured in control fruit. Maximum total sugar (14.11%) of fruits was noted in brassinolide treated fruit while control recorded minimum (13.27%). However, fruits treated with brassinolide 1.0 mg l^{-1} of water showed minimum acidity (0.54%) while maximum (0.79%) was measured in control fruits. Brassinolide helpful in maintaining peel colour and reducing its titrable acidity degradation (Champa et al., 2015). The present result of fruit quality was also corroborating the findings of Roghabati and Pakkish (2014) who observed that exogenous application of brassinolide increased the peel colour of fruits by increasing anthocyanin content, organic acid, ascorbic acid and phenol content. Brassinolide 1.0 mg l^{-1} showed that maximum (37.42 mg 100 g^{-1}) ascorbic acid content of fruits while minimum (33.14 mg 100 g^{-1}) recorded in control fruits. It is evident from the data presented in Table 1 anthocyanin content of fruits varied due to exogenous application of brassinolide. Maximum (23.11 mg 100 g^{-1}) was recorded in T_2 while minimum (20.79 mg 100 g^{-1}) was recorded in T_5 i.e., untreated control. Pre-harvest treatments of fruits as a foliar spray with brassinolide have been reported to maintain the quality and enhances the shelf life of fruits as observed by Beghel et al. (2019). The application of brassinolide also increased the internal fruit quality like total soluble solids (TSS), ascorbic acid and

Table 1: Effect of Brassinolide on physical character, bio-chemical constituent and physiological constituent of litchi fruit cv. Bombai

Treatments	Fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)	Pulp weight (g)	No. of fruits panicle^{-1} at harvest	Yield (kg plant^{-1})	TSS (°Brix)	Total sugar (%)	Acidity (%)	Ascorbic acid (mg 100 g^{-1})	Anthocyanin content (mg 100 g^{-1})	Fruit cracking (%)
T_1	25.13	4.91	3.14	12.43	23.02	94.72	20.02	13.91	0.62	36.11	21.41	10.12
T_2	26.42	5.15	3.86	13.74	24.75	95.88	21.22	14.11	0.54	37.42	23.13	9.12
T_3	25.32	5.04	3.39	12.97	23.94	94.62	20.80	13.96	0.61	37.11	22.71	9.42
T_4	26.15	4.98	3.77	13.13	24.11	94.82	20.90	13.99	0.61	37.36	22.17	9.99
T_5	24.27	4.70	3.65	12.11	18.22	92.11	18.43	13.29	0.82	33.13	20.82	17.25
SEm±	0.031	0.03	0.019	0.115	0.016	0.018	0.009	0.012	0.015	0.008	0.019	1.13
CD (p =0.05)	0.103	0.100	0.063	0.379	0.054	0.058	0.031	0.039	0.049	0.028	0.062	3.62

Where- T_1: Brassinolide (0.5 mg l^{-1}), T_2: Brassinolide (1.0 mg l^{-1}), T_3: Brassinolide (1.5 mg l^{-1}), T_4: Brassinolide (2.0 mg l^{-1}) and T_5: Control (water spray)

anthocyanin content of litchi fruits. The results are in close with findings of Vardhini and Rao (1998). They reported that brassinolides treatments increased all carbohydrate fractions, reducing sugar, non-reducing sugars and increased DNA and RNA and protein concentration. Luan et al. (2016) noticed that brassinolide at a concentration of 0.4 mg l^{-1} enhanced the total anthocyanin content grapes over controlled fruits. Similar observation was also obtained by Manava and Wang (2016) in sweet cherry.

The reasons behind improved quality parameters of litchi with pre harvest application of brassinolide might be due to its stimulating role in various physiological and biological processes such as cell division, hyperpolarization of membranes, ATPase activity, orientation of cortical microtubules, antioxidant enzyme activities, photosynthetic and chlorophyll contents that impart tolerance to many biotic and abiotic stresses (Anwar et al., 2018).

Fruit cracking was also influenced by the application of brassinolide (Table 1). The present study revealed that foliar brassinolide reduced the fruit cracking. Minimum (9.12%) cracking of fruit was recorded in T_2 followed by T_3 while maximum (17.25%) was recorded in control fruits. The results are in close conformity with the findings of Peng et al. (2004) in litchi. They obtained that foliar brassinolide spray significantly affected the enzyme's activity, the calcium content of fruits pericarp and reduced the fruit cracking.

4. CONCLUSION

Exogenous application of brassinolide was effective in influencing all physico-chemical properties of litchi fruits. Among the treatments of brassinolide studied, brassinolide at 1 mg l^{-1} (two-time application i.e., 15 days before and after anthesis) was identified to be superior based on suitable morphological characteristics, biochemical compositions which can be selected for further improvement with minimum fruit cracking and can be promoted for cultivation.

6. REFERENCE

Anonymous, 2000. Official methods of analysis. 17th edn., Association of Official Analytical Chemist Benjamin Franklin Station, Washington D.C., USA

Aghdam, M.S., Babalar, M., Sarcheshmeh, M.A.A., 2016. Impact of brassinosteroids on postharvest physiology of fruits and vegetables. In: Siddiqui, M.W. (Ed.), Eco-friendly technology for post-harvest produce quality, Academic Press, 203–218.

Ali, B., 2017. Practical applications of brassinosteroids in horticulture-some field perspectives. Scientia Horticulturae 225, 15–21.

Anwar, A., Liu, Y, Dong, R, Bai, L., Yu, X., Li, Y., 2018. The physiological and molecular mechanism of brassinosteroid in response to stress: a review. Biological Research 51(46), 10.1186/s40659-018-0195-2

Baghel, M., Nagaraja, A., Srivstan, M., Meena, M.K., Kumar, M.S., Kumar, A.W., Sharma, R.R., 2019. Pleiotropic influences of brassinolides on fruit crops: a review. Plant Growth Regulation 87, 375–388.

Banyal, A.K., Raina, R., Kaler, R.K., 2013. Improvement in fruit set, retention, weight and yield of apple cv. Royal delicious through foliar application of plant growth regulators. Journal of Krishi Vigyan 2, 30–32.

Champa, W.H., Gill, M.I.S., Mahajan, B.V.C., Arora, N.K., Bedi, S., 2015. Brassinosteroids improve quality of table grapes (*Vitis vinifera* L.) cv. flame Seedless. Tropical Agricultural Research 26, 368–379.

Coll, Y., Coll, F., Amoros, A., Pujol, M., 2015. Brassinosteroids roles and applications: an up-date. Biologia 70, 726–732.

Gomes, M.D.M.A., Campostrini, E., Leal, N.R., Viana, A., Ferraz, T.M., Nascimento-Siqueira, L., Rosa, R.C.C., Netto, A.T., Nunez-Vazquez, M., Zullo, M.A.T., 2006. Brassinosteroid analogue effects on the yield of yellow passion fruit plants (*Passiflora edulis* f. *fiavicarpa*). Scientia Horticulturae 110, 235–240.

Hayat, S., Ali, B., Hassan, S.A., Ahmad, A., 2007. Brassinosteroid enhance the level of antioxidants under cadmium stress in Brassica juncea. Environmental and Experimental Botany 60, 33–41.

Huang, X., Wang, H.C., Li, J., Yuan, W., Lu, J., Huang, H.B., Yin, J., 2005. An overview of calcium's role in lychee fruit cracking. Acta Horticulturae 665, 231–40.

Khripach, V.A., Zhabinskii, V.N., de-Groot, A., 2000. Twenty years of brassinosteroids: steroidal plant hormones warrant better crops for the XXI century. Annals of Botany 86, 441–447.

Lal, N., Das, R.P., Verma, L.R., 2013. Effect of plant growth regulators on flowering and fruit growth of guava (*Psidium guajava* L.) cv. Allahabad safeda. Asian Journal of Agriculture and Horticultural Research 8(1), 54–56.

Lal, N., Gupta, A.K., Marboh, E.S., Kumar, A., Nath, V., 2019. Effect of pollen grain sources on success of hybrids in 'Bedana'Litchi. International Journal of Bio-resource and Stress Management 10(3), 241–245.

Lal, N., Kumar, A., Nath, V., 2020. Quantitative analysis of relationships between panicle size and fruit traits in litchi (*Litchi chinensis* Sonn.). International Journal of Bio-resource and Stress Management 11(4), 381–386.

Luan, L.Y., Zhang, Z.W., Xi, Z.M., Huo, S.S., Ma, L.N., 2016. Brassinosteroids regulate anthocyanin biosynthesis in the ripening of grape berries. South African Journal of Enology and Viticulture 34, 196–203.

Mandal, D., Mitra, S., 2018. Cracking of lychee fruits: responsible factors and control. In V International Symposium on Lychee, Longan and Other Sapindaceae Fruits 1211 (pp. 35-44). DOI htpp//10.17660/ActaHortic.2018.1211.6

Mandava, B., Wang, Y., 2016. Effect of brassinosteroids on cherry maturation firmness and fruit quality. Acta Horticultuare 1139, 451–458.

Marboh, E.S., Singh, S.K., Pandey, S., Nath, V., Gupta, A.K., Pongener, A., 2017. Fruit cracking in litchi (*Litchi chinensis*): An overview. Indian Journal of Agricultural Sciences 87(1), 03–11.

Martinez Bolanos, M., Martinez Bolanos, L., Guzman Deheza, A., Gomez Jaimes, R., Reyes Reyes, A.L., 2017. Calcium and gibberellic acid in litchi fruits cracking (*Litchi chinensis* Soon.) cultivar Mauritius. Revista Mexicana de Ciencias Agricolas 8(4), 837–848.

Mostafa, L.Y., Kotb, H.R.M., 2018. Effect of Brassinosteroids and Gibberellic acid on parthenocarpic fruit formation and fruit quality of Sugar Apple (*Annona squamosa* L.). Middle East Journal of Agricultural Research 7(4), 1341–1351.

Nawaz, F., Naeem, M., Zulfiqar, B., Akram, A., Ashraf, M.Y., Raheel, M., Aurangzaib, M., 2017. Understanding brassinosteroid-regulated mechanisms to improve stress tolerance in plants: A critical review. Environmental Science and Pollution Research 24, 15959–15975.

Nolan, T.M., Vukasinovic, Liu, D., Russinova, E., Yin, Y., 2020. Brassinosteroids: Multidimensional regulators of plant growth, development, and stress responses. The Plant Cell 32, 295–318.

Panse, V.G., Sukhatme, P.V., 1985. Statistical methods for agricultural workers. Indian Council of Agricultural Research Publication, New Delhi, 87–89.

Peng, J., Tang, X.D., Feng, H.Y., 2004. Effects of brassinolide on the physiological properties of litchi pericarp (*Litchi chinensis* cv. nuomoci). Scientia Horticulturae 101, 407–416.

Peng, Y.H., Lin, G.H., 1999. Observation on litchi pericarp ultrastructure by scan electron microscope. I. Fruit Science 16(1), 18–23 (in Chinese with English abstract).

Pozo, L., Rivera, T., Noriega, C., Iglesias, M., Coll, F., Robainu, C., Velazquez, B., Rodriguez, O.L., Rodriguez, M.E., 1994. Algunos resultadosenel cultivo de los frutales mediante la utilizacion de brassieres.

Ranganna, S., 2002. Handbook of analysis of quality control for fruit and vegetables products. 2nd ed. Tata Mcgraw Hill Publication Company. New Delhi, 182–189.

Rao, S.S.R., Vardhini, B.V., Sujatha, E., Anuradha, S., 2002. Brassinosteroids - a new class of phytohormones. Current Science 82, 1239–1245.

Roghabadi, M.A., Pakkish, Z., 2014. Role of brassino steroids on yield, fruit quality and postharvest storage of "TakDanche Mashhadsweet" cherry (*Prunus avium* L.). Agriculture Communication 2, 49–56.

Saini, S., Sharma, I., Patil, P.K., 2015. Versatile roles of brassinosteroid in plants in the context of its homoeostasis, signaling and cross talks. Frontiers in Plant Sciences 6, 1–17.

Sharma, S.K., 2021. Brassinosteroids application responses in fruit crops-a review. International Journal of Agriculture, Environment and Biotechnology 14(2), 123–140.

Sridhara, S., Ramesh, N., Gopakkali, P., Paramesh, V., Tamam, N., Abdelbacki, A.M., Abdelmohsen, S.A., 2021. Application of homobrassinolide enhances growth, yield and quality of tomato. Saudi Journal of Biological Sciences 28(8), 4800–4806. https://doi.org/10.1016/j.sjbs.2021.05.008

Sugiyama, K., Kuraishi, S., 1989. Stimulation of fruit set of Morita' Navel orange with brassinolide. Acta Horticulturae 239, 345–348.

Tang, J., Han, Z., Chai, J., 2016. Q&A: what are brassinosteroids and howdo they act in plants? BMC Biology 14, 113–118.

Trong, L.V., Khanh, N.N., Huyen, L.T., Phuong, H.T., Hien, V.T.T., 2021. Physiological changes during the growth and development of litchi fruit (*Litchi chinensis* Sonn.) grown in Vietnam. Revista Brasileira de Fruticultura 43. DOI: http://dx.doi.org/10.1590/0100-29452021658

Vardhini, B.V., Rao, S.S.R., 2002. Acceleration of ripening of tomato pericarp dics by brassinosteroids. Phytochemistry 61, 843–8847.

Wang, J., Wu, X.F., Tang, Y., Li, J.G., Zhao, M.L., 2021. RNA-Seq Provides new insights into the molecular events involved in "Ball-Skin versus Bladder Effect" on fruit cracking in litchi. International Journal of Molecular Sciences 22(1), 454.

Xiao, H., Lu, L., 2002. A review of progress in stress physiology in litchi. Subtropical Plant Science 31(2), 70–74 (Chinese with English abstract).

Yadav, P., Lal, R.L., Pandey, C., 2011. Effect of different levels of fertigation on yield, quality and leaf nutrient status of litchi (*Litchi chinensis* Sonn.) cv. Rose Scented. Progressive Horticulture 43(2), 276–80.