

Impact of pre-harvest fruit bagging technology on growth and quality traits in litchi cv. Rose Scented under Indian prospective

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Abstract: Litchi orchards of 15 year age in Pantnagar were subjected to different fruit bagging treatments in study entitled “Impact of pre-harvest fruit bagging technology on growth and quality traits in litchi cv. Rose Scented under Indian prospective”. The combination includes white and pink polypropylene bags practiced on three dates *i.e.* 15, 25 and 30 days after fruit set and a control. Hence, study comprised of 7 treatment combination in total. The data of year 2017 and 2018 as well as pooled data revealed that T₁ *i.e.* white polypropylene bags + bagging 15 days after fruit set was found to be promising in attributes such as fruit cracking (%) and Sun burn (%). T₃ White Polypropylene bags + bagging 30 days after fruit set was found best for fruit Weight (g) and Acidity (%), T₄ Pink Polypropylene bags + bagging 15 days after fruit set was found promising for TSS (⁰Brix), T₆-Polypropylene Pink + 10th May (30 days after fruit set) was observed to be best for most of the desired attributes viz. Fruit breadth (mm), Yield (Kg/tree), Acidity (%), Anthocyanin (mg/100g), Fruit colour (visual), borer infestation (%) and B:C Ratio. However, fruits without bagging *i.e.* control were found to have inferior appearance and have maximum fruit cracking (%) and sun burn (%). Thus the bagging of litchi fruits with white polypropylene bags 15 days after fruit set resulted in lesser cracking and sunburn incidence. For other attributes, polypropylene pink bagged 30 days after fruit set was found promising. In Litchi under Indian condition, the novel technique of fruit bagging significantly enhance the fruit appearance and quality.

Keywords: litchi; fruit bagging; bag colours; dates; quality

1. Introduction

Litchi (*Litchi chinensis* Sonn.) is important fruit crop belong to family sapindaceae. This non-climacteric fruit is grown for fleshy fruit. It is known for its well known aromatic pulp with sweet and acid taste adapted to the subtropical region of the world. India ranks 2nd in litchi production after China [1]. Area and production of litchi in India is 93,300 hectares and 568,200 metric tons respectively [2]. Bihar solely accounts for 40% of production. The litchi fruit is very rich nutritional values having good amount of sugar, T.S.S. (15.90- 20.100 Brix) and ascorbic acid (27.8 mg/100 g) and Vitamin C content which can fulfill recommended daily allowance (RDA) of these nutrients by eating 14-17 fruits [1]. The fruits are also offers source of minerals such as calcium (8.00-10.00 mg), phosphorus (30.00-42.00 mg), Iron (0.40 mg), sodium (3.00mg), and potassium (170.00 mg). The moisture content and acid of the fruits varies in between 77-83% and 0.2 % to 0. 64%. Under Indian conditions, the fruits remains in the market for a very shorter period *i.e.* first week of May to the first week of July, hence farmers tried to fetch out more cost in comparison to other fruits. The litchi fruit contains about 60% juice, 8% rag, 19% seed, and 13% skin depending upon variety and climatic condition [1]. Fruit quality is considered to be the aspect of utmost importance which affects the profit of litchi grower. In this regard, fruit bagging is an innovative technology and was first described in litchi by National Research Centre on Litchi, Muzaffarpur, Bihar and popularized by G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. The technique save the fruits from the insect and pest attacks including Litchi fruit borer, fruit sucking moth and fruit nut borer and also affecting various physiological disorders such as fruit cracking and sun burn [1,3]. Bagging has been widely used to improve the commercial value of fruit by retaining the vitamin and mineral contents of the fruits [4]. Bagging not only enhances fruit’s visual quality by promoting peel coloration and decreasing the incidence of fruit cracking, but can also alter the microenvironment for fruit [5]. Thus, based on above

background the study was carried out to explore the different bagging technologies to understand the fruitful effect on growth and quality traits of litchi cultivars at pre-harvest fruit conditions.

2. Materials and Methods

The study was carried out at Horticulture Research Centre, Patharchatta of G.B. Pant University of Agriculture and Technology, Pantnagar during 2017-18. The place is subtropical and found suitable for the quality litchi production. The study comprised of the seven treatments including control. The treatment include, T₁-Polypropylene white + 25th April (15 days after fruit set), T₂-Polypropylene white + 5th May (25 day after fruit set), T₃-Polypropylene white + 10th May (30 days after fruit set), T₄-Polypropylene pink + 25th April (15 days after fruit set), T₅-Polypropylene pink + 5th May (25 day after fruit set), T₆-Polypropylene pink + 10th May (30 days after fruit set) and, T₇- No bagging (control). The experiment was replicated 5 times in randomized block design (RBD). The data obtained was subjected to OPSTAT software for the analysis. The parameters such as fruit weight (g), fruit length(mm), fruit breadth (mm), fruit cracking (%), sun burn (%), yield (kg/tree), TSS (^oBrix), acidity (%), anthocyanin (mg/100g), fruit colour (visual), borer infestation (%), and B:C ratio were taken into consideration.

3. Results and Discussion

3.1. Fruit weight

The fruit weight is an important trait which decides the farmer's profit. In 2017 the years, It was effected significantly from bagging and found to be maximum in T₂ (30.70 g), whereas during 2018 season, T₃ (22.84 g) also gives significant effect comparative to the means of both seasons (26.69 g). The minimum fruit weight was recorded in T₇ i.e. 27.30 g at 2017 which was significantly better than the means of both seasons in treatment T₂ i.e.17.92 g and T₇ i.e. 23.39 g, respectively (Table 1). The result obtained from the study are in good harmony with [6] who reported that bagging with plastic bags increased fruit weight in carambola cultivar when bagging were practiced for 10 days after full bloom. Similarly, [7] revealed that mango cv. 'Nam Dok Mai' bagged with different wavelength of selective bags relatively increased fruit weight, size, and sphericity over un-bagged fruit. Earlier similar result was also reported by [8] who observed significant increment in finger and bunch weight with blue bags in datepalm cv. 'Succary' and 'Khalas'. On contrary, the opposite result was also reported by various groups in fruits like pomegranate [9], apple [10], pear cultivars including loquat cv. 'Baiyu' and 'Ninghaibai' [11,12]. Moreover, it was reported that upon bagging the pear fruits became unsuitable for marketing because of adverse effect on its fruit quality. However, no significant influence was observed on fruit weight with micro-perforated polyethylene bags in fruit like pear [13] and banana [14,15].

Table 1 Effect of various treatments on fruits weight (g), Fruit size (mm), Fruit cracking (%), Sun burn (%) in litchi cv. Rose Scented

| Treatments | Fruit Weight (g) | | | Fruit breadth (mm) | | | Fruit cracking (%) | | | Sun burn (%) | | | Yield (Kg/tree) | | |
|----------------------|------------------|-------------|--------|--------------------|-------------|--------|--------------------|-------------|--------|--------------|-------------|--------|-----------------|-------------|--------|
| | 2017 | 2018 | Pooled | 2017 | 2018 | Pooled | 2017 | 2018 | Pooled | 2017 | 2018 | Pooled | 2017 | 2018 | Pooled |
| T₁ | 29.58 | 21.66 | 25.62 | 30.20 | 31.90 | 31.05 | 4.00 | 2.54 | 3.27 | 5.34 | 7.09 | 6.22 | 70.99 | 44.00 | 57.50 |
| T₂ | 30.70 | 17.92 | 24.32 | 30.48 | 34.80 | 32.64 | 4.00 | 5.46 | 4.73 | 6.67 | 7.97 | 7.32 | 73.68 | 48.50 | 61.09 |
| T₃ | 30.54 | 22.84 | 26.69 | 30.96 | 36.30 | 33.63 | 2.67 | 6.36 | 4.52 | 5.33 | 9.63 | 7.48 | 73.30 | 56.40 | 64.85 |
| T₄ | 30.21 | 21.43 | 25.82 | 30.98 | 31.00 | 30.99 | 4.00 | 3.03 | 3.52 | 8.00 | 7.42 | 7.71 | 72.50 | 43.64 | 58.07 |
| T₅ | 30.20 | 19.98 | 25.09 | 30.34 | 34.50 | 32.42 | 4.00 | 5.54 | 4.77 | 6.67 | 8.39 | 7.53 | 72.48 | 46.28 | 59.38 |
| T₆ | 31.31 | 21.59 | 26.45 | 31.32 | 37.00 | 34.14 | 2.67 | 6.69 | 4.68 | 4.00 | 10.38 | 7.19 | 75.14 | 58.48 | 66.81 |
| T₇ | 27.30 | 19.47 | 23.39 | 29.12 | 32.40 | 30.76 | 12.00 | 12.07 | 12.04 | 13.60 | 12.00 | 12.80 | 65.52 | 40.36 | 52.94 |
| SE±m | 0.36 | 0.09 | | 0.75 | 0.01 | | 19.04 | 0.08 | | 37.04 | 0.04 | | 4.11 | 0.55 | |
| CD at 5 % | 1.06 | 0.39 | | 1.13 | 0.04 | | 5.69 | 0.37 | | NS | 0.24 | | 2.64 | 0.97 | |
| CV% | 0.68 | 1.43 | | 2.85 | 0.89 | | 29.80 | 4.70 | | 27.67 | 2.08 | | 2.82 | 1.54 | |

3.2. Fruit breadth

Likewise, fruit breadth was also influenced significantly with bagging and breadth was found higher in T₆ with the breadth of 31.32mm, 37.0mm and 34.14mm in year 2017 and 2018, respectively. However least fruit breadth was found to be 29.12mm in T₇ in 2017 and 31.0 in T₄ in 2018 and the pooled breadth was reported upto 30.76 mm in T₇ (Table 1.). [16] in longan observed that bagging put forward fruit development, out-turn in larger-sized fruit. Similarly, [7] in mango cv 'Nam Dok Mai #4' studied the effects of pre-harvest bagging and noticed that bagging improved size, and sphericity of fruits in comparison to un-bagged fruit. Individual fruit size in 'Xiangtian' olive was found to be enhanced by Shengda™ bags in China [17]. On contrary to this the bagging has also been reported to reduce fruit size of pomegranate [9] and apple [10].

3.3. Fruit cracking

Fruit cracking in terms of fruit crops determine the market acceptability and the rate of the produce. In this regard, fruit cracking was found least (2.67 %) in T₃ and T₆ at 2017 season while during 2018 it was found least in T₁ (2.54 %). Following the same trend, mean cracking of two year was also observed in T₁ (3.27 %). However, in 2017, 2018 and pooled value of two years, the maximum cracking was observed in the order, 12.07 %, 12.00 % and 12.04 % in control with reference to T₇ (Table 1.). It was reported that the bagging produced cracking free fruits in litchi [18], pomegranate [19] whereas reduction in fruit cracking was also reported with red bags [20]. Much earlier it was also revealed that in nectarines, bagging reduced cracking and enhanced overall appearance [21].

3.4. Sun burn

Sun burn reduces the palatability of litchi and for getting the desired quality fruits, sun burn needed to be as lesser as possible. Thus, in this prospect bagging of fruits can be considered as an innovative technology for improvement of quality of fruits especially for litchi. The incidence of sun burn was observed minimum in T₆ (4.68 %) in 2017 and T₁ (7.09 %) in 2018. Following same sequence, mean sun burn during both 2017 and 2018 was observed least in T₁ (6.22 %) treatment. In the year 2017, data for sunburn was non-significant (Table 1.). However, maximum sunburn in 2018 and the pooled were noted as 12.00 % and 12.80 % in the treatment (T₇). Furthermore, [18] observed increase in the percentages of extra class and class I fruit, and the decreased number of sunburned fruit was recorded because of bagging with plastics. Similarly, bagged litchi fruit were found free from blemishes due to a low incidence of sunburn. [20] also resulted significant reduction in sun burn by using white bags.

3.5. Yield

Yield being the main attributes which is an ultimate requirement from grower point of view. Fruit yield in present study was recorded maximum in T₆ viz. 75.14, 58.48 and 66.81 in 2017, 2018 and the mean of both the years. [22] observed significant increase in fruit yield in pomegranate coupled with reduced pest attack as because of fruit bagging. As revealed in the study, T₇ showed the least yield viz. 40.36, 52.94 and 65.52 kg/tree for the year 2017, 2018 and pooled data of both years (Table 1.). The results of our experiment were in well agreement with [23] who also noticed increment in yield by using polypropylene bags.

3.6. Total soluble solid

Total soluble solid in fruits was recorded significantly higher by bagging and was reported to be highest in treatment T₆ (18.48⁰B) in 2017 and T₄ (19.23⁰B) and (18.64⁰B) for the year 2018 and mean of both year respectively. On the other hand, T₇ (17.68⁰B), T₆ (16.8⁰B) and T₇ (17.5⁰B) produced minimum yield for the year 2017, 2018 and pooled of two years respectively (Table 2.). Enhancement of TSS with preharvest bagging was noted in loquat [24,11], grape [25], guava [26], peach [27], litchi [18], mango [28,29], pear [30] and apple [31]. On the other hand, reduction in TSS as a result of fruit bagging was reported in plum [32], pear [33,12], apple [34], and mandarin [35]. In contrary to this the opposite result was also reported in fruits like in pear [36], Nashi pear [37], peach [38], apple [39], longan [16] and banana [14], reported that the bagging does not change overall TSS content of the fruit.

Table 2 Effect of different treatments on TSS (^oBrix), acidity (%), and anthocyanin content (mg/100g flesh) in litchi cv. Rose Scented

| Treatments | TSS (^o Brix) | | | Acidity (%) | | | Anthocyanin (mg/100g) | | | Fruit colour (visual) | | Borer infestation (%) | | B:C Ratio | | |
|----------------------|--------------------------|-------------|--------|-------------|---------------|--------|-----------------------|-------------|--------|-----------------------|----------------|-----------------------|-------|-----------|------|--------|
| | 2017 | 2018 | Pooled | 2017 | 2018 | Pooled | 2017 | 2018 | Pooled | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 | Pooled |
| T₁ | 17.88 | 18.10 | 17.99 | 0.29 | 0.30 | 0.30 | 26.06 | 19.44 | 22.75 | Pink | Green brown | 4.00 | - | 3.29 | 3.32 | 3.31 |
| T₂ | 18.00 | 18.50 | 18.25 | 0.27 | 0.26 | 0.27 | 26.28 | 22.94 | 24.61 | Dark Pink | Light pink red | 4.00 | - | 3.41 | 3.38 | 3.40 |
| T₃ | 18.14 | 17.97 | 18.06 | 0.27 | 0.21 | 0.24 | 26.30 | 25.94 | 26.12 | Red | Bright red | 2.67 | - | 3.39 | 3.82 | 3.61 |
| T₄ | 18.06 | 19.23 | 18.64 | 0.28 | 0.30 | 0.29 | 26.00 | 21.02 | 23.51 | Light Pink | Yellowish red | 4.00 | - | 3.36 | 3.28 | 3.32 |
| T₅ | 18.04 | 18.15 | 18.10 | 0.27 | 0.26 | 0.27 | 26.14 | 23.12 | 24.63 | Red | Pink red | 4.00 | - | 3.36 | 3.36 | 3.36 |
| T₆ | 18.48 | 17.68 | 18.08 | 0.26 | 0.21 | 0.24 | 26.60 | 26.18 | 26.39 | Bright Red | Dark pink red | 2.67 | - | 3.48 | 3.84 | 3.66 |
| T₇ | 16.80 | 18.20 | 17.50 | 0.30 | 0.32 | 0.31 | 25.58 | 21.82 | 23.70 | Light Pink | pink | 10.66 | 10.59 | 3.03 | 3.01 | 3.02 |
| SE±m | 0.69 | 0.03 | | 0.67 | 0.0002 | | 0.11 | 0.24 | | - | - | 16.93 | | - | - | |
| CD at 5 % | 0.34 | 0.23 | | 0.11 | 0.012 | | 0.44 | 0.64 | | - | - | 5.37 | | - | - | |
| CV% | 1.47 | 0.96 | | 1.24 | 4.67 | | 1.31 | 2.12 | | - | - | 24.57 | | - | - | |

3.7. Titratable acidity

With reference to the titratable acidity, the acidity of fruits was observed minimum i.e. 0.26 in T₆ in the year 2017 and 0.21 in the year 2018 and the means of both years. The minimum acidity was recorded in T₇ 0.30, 0.32 and 0.31 for 2017, 2018 and mean of both years (Table 2.). Similar results were obtained in litchi [23] and pear [33], as a result of bagging. On contrary of this, in fruit crops like peach [38], apple [39], longan [16], banana [14] fruit bagging did not influenced the titratable acidity.

3.8. Anthocyanin pigment

Fruit bagging is being practiced on commercial scale for uniform development of skin colour. In this regard, the highest anthocyanin pigment was produced by the plants in T₆ viz 26.60 mg/100g, 26.18 mg/100g, 26.39 mg/100g for the year 2017, 2018, and the mean of both the years respectively. The minimum anthocyanin content was found in T₇ (19.44) for year 2017 and T₁ (22.75) and (25.58) for both 2018 and pooled of both year, respectively as mentioned in Table 2. The anthocyanin pigment is significantly influenced as a result of bagging. It is because of that the bagging enhances light sensitivity of fruits and thus stimulating synthesis of anthocyanin pigment when the fruits are re-exposed to light. Similar results were obtained by [23] litchi crop itself. In other crops like pear [33], black grape [40], mango [28] and apple [41,42], anthocyanin content of fruit pulp was increased compared to unbagged fruits. Further, The differential effects of bag colour on fruits anthocyanin content was observed because of differences in the light reflectance, absorbance, or transmission patterns of each bag in the visible, far-red, and/or infra-red regions of the light spectra [7].

3.9. Fruit colour (visual)

When compared to fruit colorations in terms of visual appearance of the polypropylene bag, the dark pinkish colour is considered to be the characteristics colour through which orchardist gets many folds more profits. Fruit colour was varied in several treatments under consideration. In 2017, dark pinkish colour was observed in T₂. However, in 2018, this characteristics colour was obtained in T₆. In 2018, green fruits were produced in T₁ (Table 2.). [38] noted that peach cv. Hakuho covered with orange bags appeared bright red, which led to high visual quality. Similarly, [43] in litchi cv. Feizixiao noted enhanced colour content in fruits which was related with the higher metabolism of phenolics and flavonoids, and the activities of PAL and polyphenol oxidase (PPO). Earlier, [44] reported that if bags were removed before 3-7 days of harvesting, fruits may develop a more attractive colour compared to unbagged fruits. Later on, [45] recommended transparent polypropylene package for fruit bagging.

3.10. Borer infestation (%)

Borer incidence in litchi fruits is one of major constraints in the marketing. From Table 2. It is evident that, In 2017, infestation was observed minimum (2.67%) in both T₃ and T₇ whereas, maximum was recorded in T₇ 10.59, which was taken as control. In 2018, it was found that 10.66% borer incidence was found in control while other treatments were unaffected with borer incidence. It may be because that bagging reduced the incidence of fruit borer in litchi [18].

3.11. Benefit:Cost Ratio

Finally, the benefit cost ratio is the major factor that ultimately determines the farmer's profit after mathematical calculation of gross and net profit. Herein, B:C ratio was computed to be maximum of 3.48, 3.84 and 3.66 in T₆ for the year 2017, 2018 and the mean of both the years. Minimum value of benefit cost ratio was recorded in T₇ i.e. 3.03, 3.01 and 3.02 for year 2017, 2018 and pooled of both year (Table2.). the benefit cost ratio was higher in T₇ might be due to the protection of fruit against insect, pest and disease incidence hence producing fruits of higher quality. The study confirmed that bagging of the fruits influences the overall benefit cost ratio. Thus, the results obtained in present study were in good agreement with the results of [23].

4. Conclusions

On the perusal of the above data it can be concluded that the litchi bunch bagged with polypropylene pink on 30 days after fruit set responded significantly for improvement of quality traits of litchi fruits.

Author Contributions: SC and RS jointly designed the experiment based on concept. and assisted in manuscript preparation, RS* collected the data and wrote manuscript produced figures, tables, RS helped in manuscript preparation, designing experiment, AKC assisted in data analysis and manuscripts preparation. All the authors are have read and agreed to the published version of the manuscript.

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Figure1. Bagging of fruits with white polypropylene bags 15 days after fruit set and resulted mature fruits



Figure2. Bagging of fruits with pink polypropylene bags 15 days after fruit set and resulted mature fruits