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Improving quality of seedless Rawa pomegranate fruits by using bagging and spraying with calcium

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Abstract
A study was conducted in the district of Rawa, which is located 224 km away from the city of Ramadi, on the pomegranate trees of the seedless Rawa cv. The study investigated the effect of fruit bagging and calcium spray in some qualitative characteristics of fruits. Two factors were studied during the research: the first factor involved using different types of bags to cover the fruits, including (uncovered control, double-layer muslin cloths, saran, and white paper bags). The second factor included calcium spraying at concentrations of 0, 1, and 2 g per liter. The results indicated that fruit bagging treatments had a significant effect on all studied characteristics. Saran bagging contributed to achieving the best results for characteristics (TSS, total sugars, reducing sugars and ascorbic acid) at 13.06%, 15.28%, 11.65% and 5.03 mg 100 ml^{-1}, respectively. Furthermore, the treatment (B0) resulted in the lowest percentage of total acidity at 0.76%. As for the calcium spray, it showed a significant effect on all studied characteristics except for the percentage of total acidity. The high concentration (2 g $liter^{-1}$) achieved the best values for TSS, total sugars, reducing sugars and ascorbic acid, at 13.05%, 14.94%, 11.83% and 5.10 mg 100 ml^{-1}) respectively. The interaction between the two study factors reached a significant level of influence on all studied characteristics except for the percentage of total acidity. The interaction treatment (B2C2) excelled in achieving the best values for most of the studied characteristics, while the control treatment (B0C0) showed the lowest values for the studied characteristics.

Keywords: Pomegranate, bagging type, calcium spraying, fruit traits

Introduction
Pomegranate (*Punica granatum* L.) is a temperate fruit belonging to the Punicaceae family. It holds a significant place in Islamic culture, being mentioned in the Quran in multiple verses. According to most sources, the pomegranate originated in Southwest Asia, including Iran, Iraq, Yemen, the southern Arabian Peninsula, and the Mediterranean Basin. It was later introduced to European countries such as Spain, Italy, and France, and eventually to the Americas [30, 22]. Iraq is home to a large pomegranate crop, with about 23 different types growing there [2]. There were 241,671 metric tons produced that year, or 28.16 percent of the nation's total fruit output. With rates of 54.94%, 38.28%, and 3.50%, respectively, Diyala, Salah al-Din, and Karbala governorates were the top three producers in Iraq. Out of the overall production, 3.28 percent came from the other governorates [6].

From the end of summer all the way into the middle of winter, you may find pomegranate fruits in stores. This is because their thick skin prevents the fruit from spoiling and allows it to keep more of its nutritious value for a longer period of time. Vitamin C is one of several nutrients found in pomegranates, which also include pigments, lipids, carbs, sugars, acids, fiber, proteins, and more [23, 13]. The medicinal and therapeutic uses of pomegranate are numerous. It is a heart tonic, astringent, and vermifuge. It is used to treat stomach diseases and indigestion because its juice contains compounds with therapeutic properties such as anthocyanins, phenolic and tannin substances, and some vitamins such as B1 and B2. These compounds have been proven effective against cancer and various pathogens. Pomegranate juice is one of the most important antioxidants [1, 12].

Bagging, or covering fruit with different materials, is a physical process that creates favorable conditions for successful pollination, improves fruit quality, and protects fruit from unfavorable conditions, especially in hot and dry areas. It also protects fruit from insects, birds, and mechanical damage that can negatively affect tree productivity and fruit quality [27, 28]. Several studies have shown the potential of using different types of covers, including paper, saran, polyethylene, and muslin cloth. Covers are also available in different colors, depending on the purpose of the cover [18].

Nutrition is a key factor in plant growth and development. One of the vital components that is crucial for the development of cell walls, particularly in the middle lamella, is calcium. During the development of the cell wall, pectic acid and calcium combine to generate insoluble calcium pectate, which then combines with magnesium pectate to hold cellulose strands together [33]. Consequently, calcium is necessary for quickly developing tissues like the cambium and the meristems of the stem and roots [10]. Additionally, it is crucial to the success of fertilization because it draws the pollen tube into the ovary [8, 25].

Because the calcium salt of the fatty material lecithin is engaged in the composition of the cell membrane, calcium also plays a part in the production of cellular membranes. It is thought that calcium plays a crucial role in cell elongation and division, and that a calcium deficit decreases the permeability of cell membranes [21, 34]. Additionally, spindle formation and the stability and shape of chromosomes are influenced by calcium. Furthermore, a number of enzymes, including phospholipase, triphosphatase, arginine, adenosine, and kinase, are activated by calcium [4]. It seems that calcium is necessary for the absorption of nitrate nitrogen, as sugars and starches accumulate in plants growing in calcium-deficient environments, rendering them unable to absorb nitrate nitrogen, although this situation changes rapidly [17]. Nitrates appear quickly when fertilized with calcium, and most of the calcium accumulates in plant leaves. Plants absorb it in the form of calcium ions Ca^{++} and use it to neutralize the organic acids produced in plant cells, therefore avoiding harm brought on by an increase in these acids' concentration [9].

Pomegranate cultivation in Iraq has been neglected in recent times, with a decline in the number of trees due to prevailing circumstances. These include inefficient fertilizer use, lack of advanced techniques, and poor agricultural practices. These factors are crucial for the success of pomegranate cultivation and determine its productivity. Due to the scarcity of research in this area, this study was conducted to investigate the effect of using different types of fruit bagging and foliar calcium application on some traits of fruits and percentage of cracking of the seedless pomegranate fruits variety "Rawa."

Material and Methods

A study was conducted in the district of Rawa, located 224 km from the city of Ramadi, on seedless pomegranate trees of the "Rawa" variety. The study investigated the effect of fruit bagging and foliar calcium application on some traits of fruits.

Treatments Used in the Experiment

In the experiment, two factors were used as follows:

First

Fruit bagging type (M) includes the following four treatments:

Non-bagged (control treatment) (B0); Double-layer *Muslin* Cloths (B1); Saran (B2) and White paper bags (B3).

Second: Spraying with calcium (C) and includes the following treatments:

Spraying with distilled water only (C0); 1 g L^{-1} (C1) and 2 g L^{-1} (C2).

Calcium was sprayed three times (the first at the beginning of the flower buds opening, the second a month after the first spray, and the third a month after the second spray).

Experimental Design

Using two factors (3 x 4), a factorial experiment was conducted in accordance with the RCBD. There were 36 trees utilized in total for the experiment because there were 12 treatments, 3 replications, and one tree for each experimental unit. The Genstat statistical program was used to statistically analyze the data and compare the averages using (L.S.D.) test at a probability level of 5% [3].

Studied Traits

Total soluble Solids (%), Total sugars (%), Reducing sugars, Total acidity (%) and Ascorbic acid (mg 100 ml^{-1})

Results and Discussion

Total Soluble Solids (%)

The results in Figure (1) show that fruit bagging treatments had a significant effect on the total soluble solids (TSS) of seedless pomegranate fruits of the Rawa cultivar. This is evident as treatment (B2) provided the highest values of 13.06%, followed by treatments (B3 and B1) which gave percentage at 12.96 and 12.79%, respectively, while the uncovered fruit treatment (B0) recorded the lowest percentage of 12.01%. On the other hand, it was observed that calcium spraying significantly affected this characteristic, as treatment (C2) recorded the highest percentage of 13.05%, followed by treatment (C1) with 12.74%, while fruits reached their lowest percentage with the non-sprayed treatment (C0) at 12.32%. The results also indicated significant differences in TSS due to the interaction between the study factors, especially with treatment (B3C2), which yielded the highest percentage of 14.20%, while the lowest value was observed with the control treatment (B0C0) at 11.65% (Table 1).

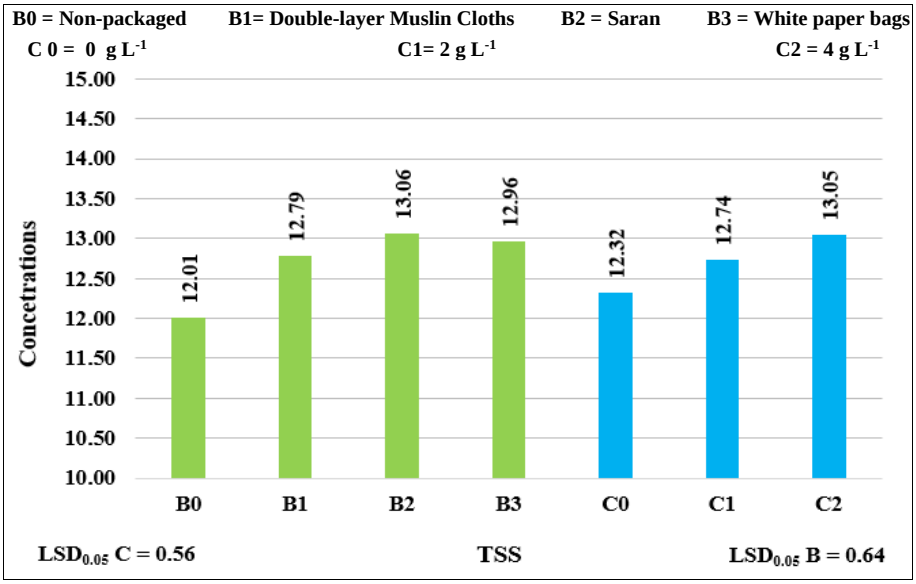

Fig 1: Effect of bagging type and calcium spraying on TSS (%) of seedless Pomegranate fruits variety Rawa

Total sugars: The statistical analysis results shown in Figure (2) indicate that fruit bagging treatments had a significant effect on total sugars. Treatments (B2 and B3) recorded the highest values of 15.28 and 15.01%, respectively, followed by treatments (B1) with value of 14.73%, while the lowest value was observed with treatment (B0) at 13.85%. On the other hand, calcium spraying treatments demonstrated a significant effect, with treatment (C2 and C1) recording the highest values of 14.94 and 14.81%, compared to treatments (C0), which resulted in decreased to the lowest percentage of 14.40%. Additionally, the results indicated significant differences in total sugars due to the interaction between the study factors, especially with treatment (B3C2), which yielded the highest mean of 16.23%, while treatment (B0C0) achieved the lowest value at 13.54% (Table 1).

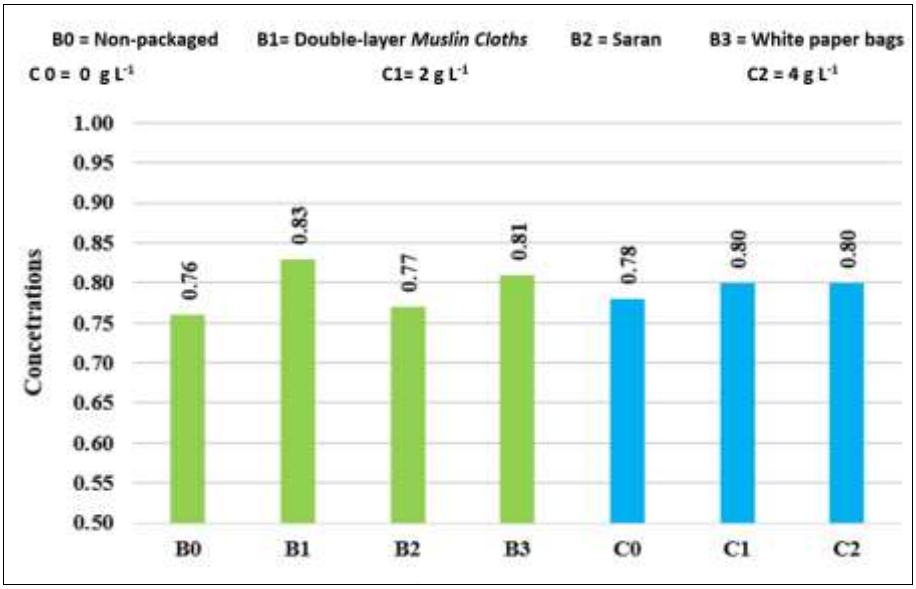

Fig 2: Effect of bagging type and calcium spraying on Total sugars (%) of seedless Pomegranate fruits variety Rawa.

Reducing sugars (%): The results in Figure (3) showed that fruit bagging treatments had a significant effect on the reducing sugars of seedless pomegranate fruits of the Rawa cultivar. This is evident as treatment (B2) provided the highest percentage of 11.65%, followed by treatments (B1 and B3) which gave percentage at 11.28 and 11.26%, respectively, while the uncovered fruit treatment (B0) recorded the lowest percentage of 10.81%. Additionally, it was observed that spraying fruits with calcium had a significant effect with treatment (C2) recording the highest percentage at 11.83%, followed by treatment (C1) at 11.26%, while the lowest percentage was for the untreated control (C0) at 10.67%. Furthermore, the results indicated significant differences in the calcium content of fruit peels due to the interaction between both study factors, especially in treatment (B2C2) which showed the highest percentages at 12.62%. The lowest percentage, at 10.34%, was observed in the control treatment (B0C0) (Table 1).

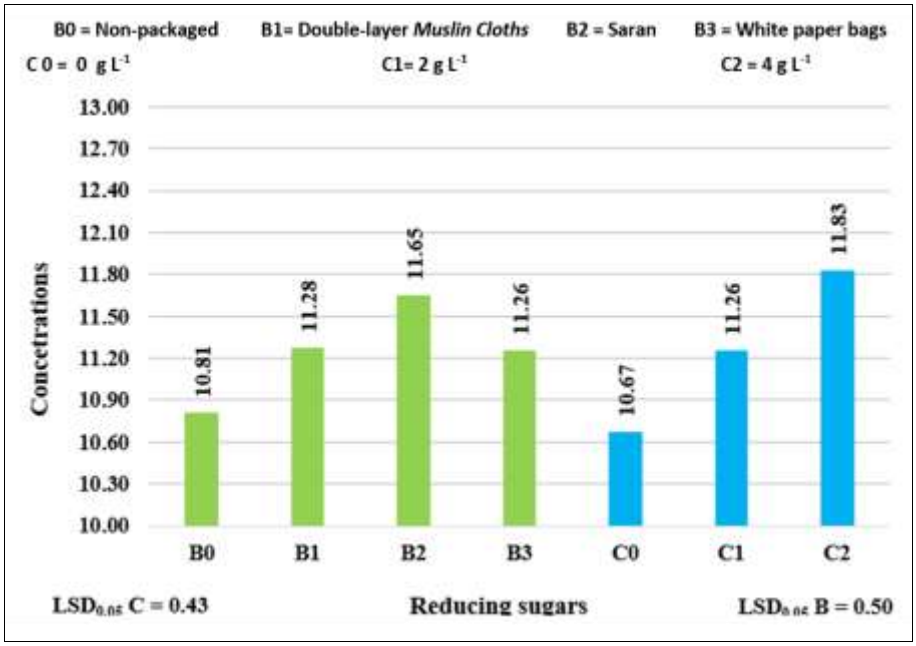

Fig 3: Effect of bagging type and calcium spraying on reducing sugars (%) of seedless Pomegranate fruits variety Rawa

Total acidity (%): The results from Figure (4) indicate significant differences in the percentage of total acidity, particularly concerning fruit bagging treatments. Treatment (B0 and B2) had the lowest percentage at 0.76 and o.77%, respectively, followed by treatments (B3 and B1) at 0.81 and 0.83%, respectively. On the other hand, the highest percentage was showed with treatment (B0) at 23.48%. While calcium spraying treatments showed had no significant effect on the percentage of total acidity. Additionally, the results indicated no significant differences in the percentage of total acidity due to the interaction between the study factors (Table 1).

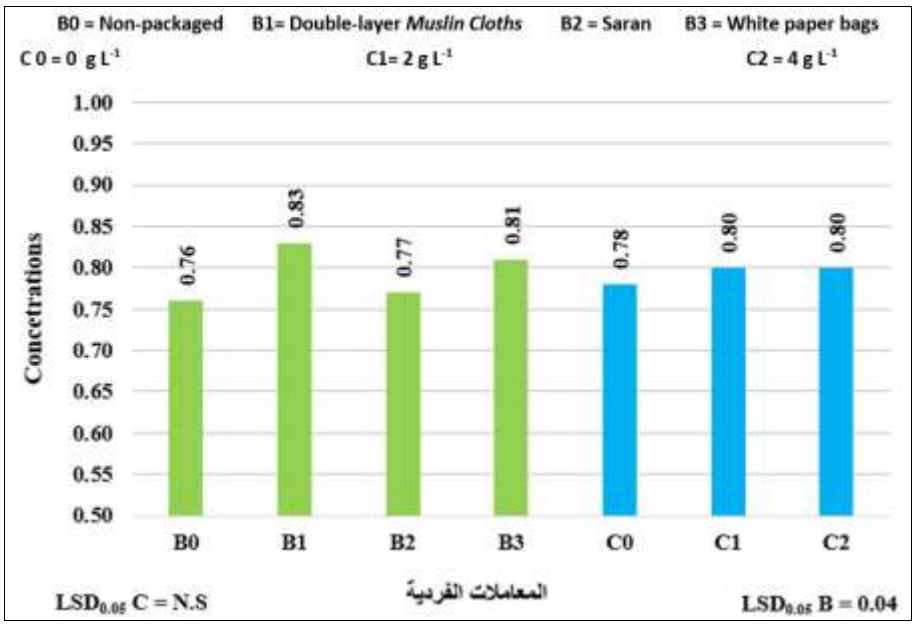

Fig 4: Effect of bagging type and calcium spraying on total acidity (%) of seedless Pomegranate fruits variety Rawa.

Ascorbic acid (mg 100 ml^{-1}): The statistical analysis results shown in Figure (5) indicate that fruit bagging treatments had a significant effect on the ascorbic acid of the seedless pomegranate fruits, Rawa variety. Treatments (B2) outperformed with the highest value at 5.03 mg 100 ml^{-1}, followed by treatments (B1 and B3) which gave values at 4.87 and 4.73 mg 100 ml^{-1}, respectively, while the lowest value were observed with treatment (B0) at 4.56 mg 100 ml^{-1}. Conversely, calcium spraying treatments demonstrated a significant effect, with treatment (C2) recording the highest value at 5.10 mg 100 ml^{-1}, followed by treatment (C1) at 4.96 mg 100 ml^{-1}, whereas the lowest value was observed with the non-sprayed treatment (C0) at 4.31 mg 100 ml^{-1}. Additionally, the results indicated significant differences in the ascorbic acid owing to the way the research components interact, particularly with therapy (B2C2), which yielded the ascorbic acid percentage at 5.74%. On the other hand, at 4.20%, the comparison treatment (B0C0) produced the lowest value (Table 1).

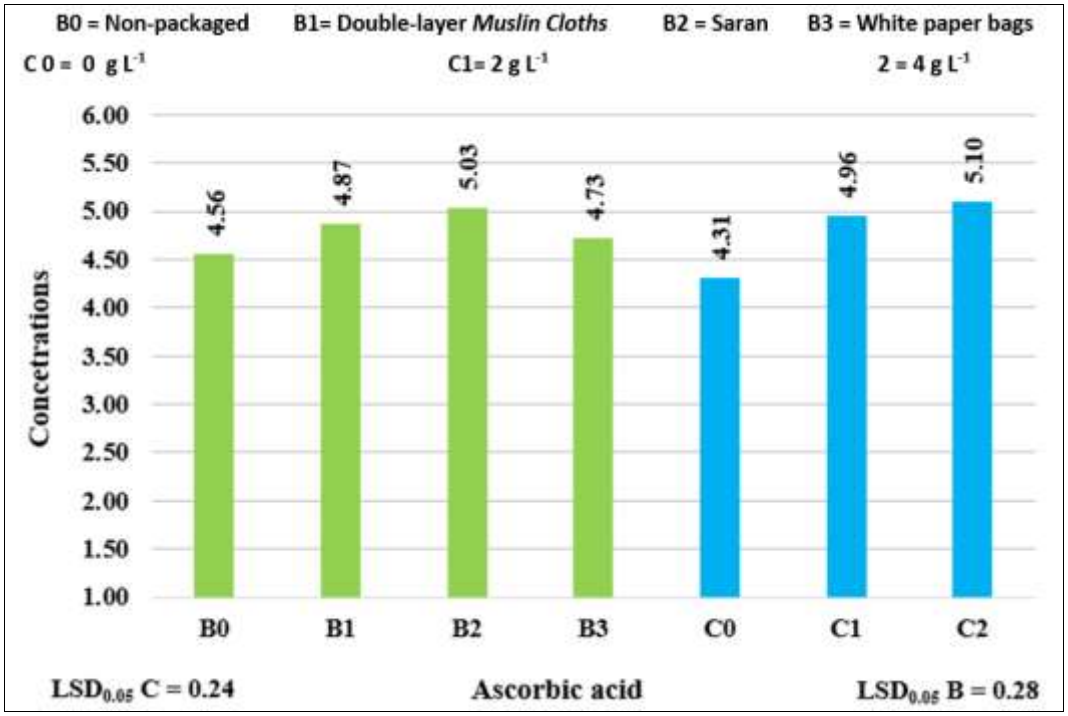

Fig 5: Effect of bagging type and calcium spraying on Ascorbic acid (mg 100 ml^{-1}) of seedless Pomegranate fruits variety Rawa.

Table 1: Effect of bagging type and calcium spraying interaction on some traits of fruits of seedless Pomegranate variety Rawa.

(C) Spraying with calcium (g L^{-1})	(B) Bagging type	TSS (%)	Total sugars (%)	Reducing sugars (%)	Total acidity (%)	Ascorbic acid (mg 100 ml^{-1})
C0 (0 g L^{-1})	B0 Control (Non-bagged)	11.65	13.54	10.34	0.78	4.20
	B1 (Double-layer *Muslin Cloths)*	12.87	14.72	10.71	0.77	4.32
	B2 (Saran)	13.06	15.34	10.45	0.75	4.36
	B3 (White paper bags)	11.71	13.98	11.18	0.80	4.38
C1 (1 g L^{-1})	B0 Control (Non-bagged)	12.35	14.19	10.46	0.75	4.63
	B1 (Double-layer *Muslin Cloths)*	12.89	14.96	11.26	0.84	5.06
	B2 (Saran)	12.74	15.30	11.89	0.78	4.97
	B3 (White paper bags)	12.97	14.82	11.43	0.81	5.19
C2 (2 g L^{-1})	B0 Control (Non-bagged)	12.02	13.84	11.64	0.76	4.85
	B1 (Double-layer *Muslin Cloths)*	12.61	14.51	11.87	0.87	5.22
	B2 (Saran)	13.38	15.19	12.62	0.79	5.74
	B3 (White paper bags)	14.20	16.23	11.17	0.80	4.61
LSD 5%		1.11	0.87	0.83	N.S	0.48

The positive impact of covering pomegranate fruits on improving their qualitative traits can be attributed to the role that covering plays in shielding the fruits significantly from external environmental influences, leading to a reduction in water loss from the fruits [15, 29, 14]. demonstrated that fruit bagging is an effective technique for modifying climatic conditions around the fruits, contributing to reducing fruit drop and preventing photooxidation, thus increasing the concentration of internal hormones that accelerate growth. Additionally [25], highlighted the positive role of covering pomegranate fruits in protecting their peel from cracking.

As for the role of calcium in improving the studied fruit characteristics, it may be attributed to its status as one of the major nutrients with numerous important physiological functions for plant growth and development. Calcium plays a fundamental role in cell structure as it is the main component of the middle lamella, where it is present in the form of calcium pectate. It is essential for cell division, chromosome stability, mitochondria production, cell hydration, and expansion [24, 5]. Additionally, Calcium is an essential biological component that facilitates numerous metabolic activities, In addition to triggering a variety of enzyme systems, supporting healthy plant development [32]. Additionally, it plays a fundamental role in stabilizing the membrane and cell integrity. An increase in the leakage of low molecular weight solutes from plant tissue cells suffering from severe calcium deficiency has been observed, contributing to the collapse of cell membrane structures and loss of cell activity in division [19]. Moreover, calcium treatment has been shown to inhibit chlorophyll loss and increase leaf content of it [20]. Calcium is also essential in improving the nutritional status of trees by increasing chlorophyll quantity, leaf area, water absorption, and thus enhancing the fruit content of major and minor nutrients [7]. This consequently enhances the efficiency of the photosynthetic process, positively impacting the improvement of vegetative growth and yield characteristics.

Many studies have shown that calcium contributes to regulating plant responses to various environmental stresses, including heat [10]. External calcium treatment has been proven to improve heat tolerance in many plants, which may be associated with increased activities of antioxidant enzymes and reduced lipid peroxidation in cell membranes [26]. Additionally, calcium contributes to reducing water

stress damage through its role in forming calcium pectate in cell walls and regulating cell wall permeability, as well as assisting in carbohydrate transport processes [31].

Conclusion

Bagging fruit during its growth and development on trees emerges as an important technique to effectively enhance the visual appearance and quality of the fruits. Additionally, this method plays a fundamental role in controlling the surrounding environment of the fruits, including light intensity, temperature, and humidity, thereby contributing to both biotic and abiotic resistance and consequently improving both the fruits' quantitative and fruits' qualitative. Moreover, spraying pomegranate trees with calcium has shown improvement in fruit characteristics and yield, especially at high calcium concentrations (2 grams liter-1). This underscores the importance of using calcium as an additive to enhance fruit growth and improve its overall quality.

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