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Impact of pre-harvest fruit bagging on pomegranate cv Mridula quality and cracking in southwestern Haryana

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ABSTRACT

This two-year study, conducted in Hisar, Haryana, evaluated how different types of pre-harvest bagging affect the quality of Mridula pomegranates. The goal was to identify the best bagging practices for semi-arid, irrigated regions in northern India. The experiment tested five treatments: polyethylene bags, selfing bags (butter paper), non-woven white bags, non-woven red bags and an unbagged control. The results showed that bagging is a highly effective practice. All bagging treatments completely prevented fruit cracking, which occurred in 18.2 per cent of the unbagged control fruits. Bagged fruits, particularly those in selfing, polyethylene and non-woven white bags, were significantly heavier than the control fruits. While non-woven bags enhanced aril percentage and juice content, selfing bags were the most effective at reducing disease incidence, specifically bacterial blight and black spot. All bagging treatments significantly reduced disease severity, with selfing bags recording the lowest infection rates. These findings confirm that pre-harvest bagging is an eco-friendly way to improve yield, fruit quality and disease resistance in pomegranates grown in northern India.

Keywords: Pomegranate; Mridula; fruit bagging; fruit cracking; disease resistance; fruit quality

INTRODUCTION

Pomegranate is one of the humanity's oldest and most prized fruits, valued for its juicy arils and commercial significance. As a member of the Punicaceae family, it has long been a staple, enjoyed both fresh and in processed forms. Despite its popularity, pomegranate cultivation is plagued by significant challenges that can severely impact yield and market value. A major concern for growers is fruit cracking and sunscald, which occur during the fruit's growth and development (Panwar et al 1994, Singh 1995). These issues can lead to substantial economic losses. Additionally, pomegranates are susceptible to damage from various pre- and post-harvest factors. These include diseases (Munhuweyi et al 2016), bruising (Hussein et al 2020) and a high rate of water loss after harvest, which reduces fruit weight and quality during storage (Fawole and Opara 2013, Lufu et al 2019, 2020). Another common physiological disorder is sunburn, caused by high temperatures and intense sunlight. This condition darkens the peel, dries out the fruit and decreases its overall market value (Pareek et al 2015). To combat these issues, farmers often rely on traditional practices such as spraying growth promoters and anti-transpirants or using drip irrigation and mulching (Waskar 2006).

Recently, fruit bagging has emerged as a promising alternative. Research has shown that this technique is an effective way to prevent fruit cracking (Yuan et al 2012) and protect against pests (Shlomo 2015). It is now a common practice in apple, pear and pomegranate cultivation in countries like China, Japan, the United States and India (Chen et al 2012, Griñán et al 2019, Wang et al 2022). Bagging has been shown to improve peel coloration, reduce russeting and minimize sunburn (Zhang et al 2021). However, the results on how different types of bagging affect key characteristics like fruit size, maturity and quality in the semi-arid, irrigated regions of northern India have been inconsistent. This highlights a need for more specific research to determine the best bagging practices for this particular environment. To address this gap, the current study was initiated. Its goal was to evaluate the effects of different types of bagging on the fruit quality and other important parameters of the pomegranate cv Mridula. The findings will help inform growers in northern India on how to best use this technique to improve crop performance and enhance their yields.

MATERIAL and METHODS

Study site and design: The experiment was conducted over two consecutive years, from 2020 to 2022, in the experimental orchard of the Department of Horticulture at CCS Haryana Agricultural University, Hisar, Haryana. The study utilized 12-year-old pomegranate plants of the Mridula cultivar. The climate in Hisar is hot and semi-arid, characterized by blistering summers where temperatures can soar to 45-48°C and cold winters that drop to 3-5°C. The region receives very low annual rainfall, typically under 400 mm, with the majority of it occurring during the southwest monsoon from July to September.

Experimental setup and treatments: The study was designed as a randomized block experiment within a one-acre orchard, where four plants were selected for each of the five treatments. All plants were maintained under uniform cultural practices according to the university's standard guidelines. The five treatments involved different types of fruit bagging viz T_1: polyethylene bags (low density), T_2: selfing bags (butter paper), T_3: non-woven white bags, T_4: non-woven red bags and T_5: control (no bagging). In mid-June, 20 fruits per plant were bagged, with each bag having small holes (4 mm diameter) at the bottom to ensure proper ventilation and fruit development.

Data collection and analysis: At the point of proper maturity in mid-September, five fruits were randomly selected from each treated plant to collect data on various quality parameters. Measurements included fruit circumference, average fruit weight, seed softness, aril content, juice content, total soluble solids (TSS) and acidity.

Aril percentage was determined by dividing the weight of arils per fruit by the total fruit weight and multiplying by 100 (Wetzstein et al 2011). Cracked fruit percentage was calculated by dividing the number of cracked fruits by the total number of fruits and multiplying by 100 (Singh et al 2014). Juice content was measured as a percentage of the total fruit weight and TSS were measured using a digital refractometer, while titratable acidity was measured using the AOAC method (Anon 2005). The maturity index was then calculated as the ratio of TSS to acidity.

Additionally, disease incidence and severity were assessed using various scale methods established in earlier studies (Kumar et al 2016, 2017, 2018).

Statistical analysis: The procedures described by Panse and Sukhatme (1985) were followed when examining the data. Applying the five per cent level of critical differences (CD) of importance, the overall importance of the variations among the treatments was investigated. The data were statistically evaluated using OPSTAT, a Windows-based computer application (Sheoran et al 1998).

RESULTS and DISCUSSION

Impact of bagging on fruit cracking and quality

The experiment's findings detailed in Table 1 demonstrate that pre-harvest bagging is remarkably effective at preventing fruit cracking. While the unbagged control fruits suffered from an 18.2 per cent cracking incidence, all of the bagged treatments, including polyethylene, butter paper (selfing) and both non-woven white and red bags had a perfect record of zero cracking. The results are confirmed by the findings of Sarkomi et al (2019) and Griñán et al (2019), who also found that bagging successfully prevents cracking in pomegranates. This is likely because the bags create a stable microclimate around the fruit, protecting it from the extreme thermal stress, harsh solar radiation and strong winds that typically cause cracking, a theory supported by Yilmaz and Özgüven (2006).

Beyond cracking, bagging also had a significant positive effect on fruit weight. Every bagging treatment, except for the non-woven red bag, produced fruits that were significantly heavier than the control fruits, which averaged only 201.14 g. The heaviest fruits were found in the selfing bags (266.20 g), polybags (252.46 g) and non-woven white bags (250.84 g). This suggests that the protected environment created by the bags is highly beneficial for overall fruit development and growth. These results align with research by Abd El-Rhman (2010) and Samra and Shalan (2013) on pomegranates and similar positive trends have been observed in other fruits like guava, apples and peaches.

Interestingly, the type of bag used appeared to influence the aril content. The non-woven red bag (74.04%) and non-woven white bag (72.24%) treatments were at par with control (70.49%) for aril content, control being at par with polybags and selfing bags. This suggests that non-woven bags may create conditions that enhance the development of the juicy arils. This enhancement could be due to altered gas exchange and microclimatic conditions that specifically favour aril expansion, as proposed by Wassel et al (2015) and Ehteshami et al (2015).

Statiscally, there was no effect of treatments on fruit circumference.

Impact of bagging on chemical fruit quality

The chemical quality of the pomegranates, as detailed in Table 2, varied significantly among the different bagging treatments. The juice content was highest in fruits bagged with NWB-red bags (55.79%) and NWB-white bags (53.20%) which were at par as compared to unbagged control (50.59%), selfing bags (47.17%) and polyethylene bags (44.50%).

In terms of TSS, the sweetest fruits were those from the NWB-white bags (13.9%), selfing bags (13.8%), NWB-red bags (13.7%) and unbagged control fruits (13.4%), all being at par, while polybagged fruits had the lowest TSS at 12.4 per cent. This aligns with findings by Bentley and Viveros (1992) on apples, who also noted that bagging could increase sugar levels.

The acidity of the fruit was lowest in the NWB-white bag (0.56%), NWB-red bag (0.58%) and control (0.58%) treatments, all of which were statistically similar. The highest acidity was found in the polybagged fruits (0.83%), followed by the selfing bags (0.70%).

Table 1. Effect of bagging on pomegranate cv Mridula fruit cracking and quality (pooled data for 2020-21 and 2021-22)

Treatment	Fruit cracking (%)	Average fruit weight (g)	Fruit circumference (cm)	Aril content (%)	Seed softness
T_1 (Control – unbagged)	18.2	201.14	24.28	70.49	Soft
T_2 (Polybags)	Nil	252.46	26.70	66.19	Hard
T_3 (Selfing bags)	Nil	266.20	26.47	65.56	Semi
T_4 (NWB-white)	Nil	250.84	26.05	72.24	Soft
T_5 (NWB-red)	Nil	226.20	25.22	74.04	Soft
CV		6.88	3.78	4.53	
$CD_{0.05}$		31.0	NS	6.04	

NWB: Non-woven bags

Table 2. Effect of bagging on chemical quality of pomegranate cv Mridula fruits (pooled data for 2020-21 and 2021-22)

Treatment	Juice content (%)	TSS (%)	Acidity (%)	TSS:acidity
T_1 (Control – unbagged)	50.59	13.4	0.58	23.05
T_2 (Polybags)	44.50	12.4	0.83	14.97
T_3 (Selfing bags)	47.17	13.8	0.70	19.67
T_4 (NWB-white)	53.20	13.9	0.56	24.77
T_5 (NWB-red)	55.79	13.7	0.58	23.67
CV	5.28	2.99	7.14	
$CD_{0.05}$	5.08	0.8	0.11	

NWB: Non-woven bags

This suggests that certain bagging materials can help maintain lower acidity levels.

Finally, the maturity index (TSS-acidity ratio), a key indicator of flavour quality, was highest in the NWB-white treatment (24.77), followed by the NWB-red (23.67) and the control (23.05). The polybagged fruits had the lowest maturity index (14.97) due to their combination of low TSS and high acidity. The high maturity index in the non-woven bags confirms that these materials create a modified microclimate that promotes superior ripening and flavour development, which is consistent with previous research on bagged pomegranates.

Bagging's impact on disease control

The results clearly show that all bagging treatments significantly reduced disease severity compared to the unbagged control fruits. As seen in Fig 1, the control fruits had the highest incidence of bacterial blight (24%) and black spot (30%).

Among the different treatments, selfing bags proved to be the most effective, recording the lowest infection rates for both bacterial blight (5.5%) and black spot (3.9%). Other bagged treatments also provided substantial protection, but not to the same degree as the selfing bags. This is supported by the findings of Sharma et al (2013) and Sarkomi et al (2019), who demonstrated that bagging acts as a simple yet effective physical barrier. By modifying the microclimate, specifically by influencing humidity and the fruit's surface microflora, the bags create an environment that is less hospitable for pathogens, thereby, preventing disease from taking hold.

Under the hot, semi-arid conditions of Hisar, bagging was highly effective in minimizing sunburn and peel damage, thereby, improving the fruit's appearance and marketability. This observation is consistent with the findings by Griñán et al (2019), who noted similar benefits in Mediterranean climates, highlighting the stability of yield and quality in bagged pomegranates under full irrigation.

A growing body of research supports these findings. Abd Al-Hayany and Hathal (2022) reported that bagging Salimi pomegranates with various coloured non-woven bags reduced cracking and sunburn, with white bags producing the highest fruit weight, aril percentage, TSS, sugars, anthocyanins and peel moisture. Similarly, Ahmed and Gaber (2022) found that white paper bagging effectively minimized fruit cracking and sunburn, while also enhancing the yield, size and weight of Manfaloty pomegranates. Singh et al (2021) observed that both fruit bagging and full plant covering improved the microclimate by increasing internal temperature and relative humidity, which in turn

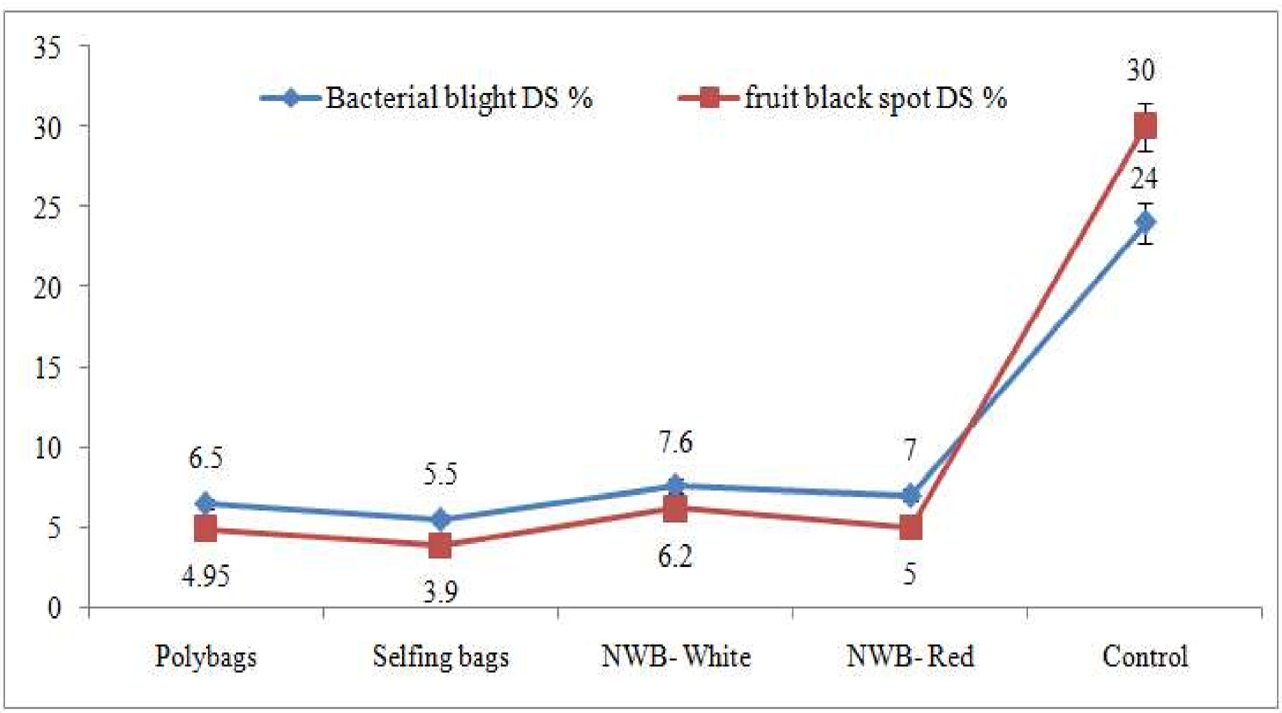

Fig 1. Effect of bagging on severity of pomegranate bacterial blight and fruit black spot

improved fruit development in arid conditions. Furthermore, Wang et al (2024) demonstrated that bagging significantly reduced pomegranate fruit cracking by enhancing calcium signaling and cell-wall metabolism pathways.

The use of pre-harvest bagging is also recognized as an effective and eco-friendly horticultural practice. Malini et al (2025) highlighted that it improves external traits like peel colour and texture while reducing pest and disease damage, thus minimizing the need for chemical treatments. Chowdhury et al (2020) found that pre-harvest bagging, particularly with water-resistant butter paper bags, substantially enhanced the physico-chemical quality and shelf life of dragon fruit, resulting in firmer, juicier and more nutrient-rich fruits with fewer defects.

Pre-harvest bagging of pomegranates is a highly effective and beneficial practice. It was found to completely prevent fruit cracking, a major issue for growers and significantly increase the fruit's overall weight. The technique also improved key quality parameters like juice content and sweetness and proved to be an excellent method for disease control, specifically for bacterial blight and black spot. Additionally, bagging successfully minimized sunburn and other peel damage, resulting in fruits with a better appearance and higher market value.

CONCLUSION

For pomegranate growers, challenges like fruit cracking, sunburn and diseases can be a real headache, causing big losses. This study aimed to find a simple, effective solution by testing different types of pre-harvest bagging in the hot, semi-arid climate of northern India. Over two years, pomegranates were wrapped in different materials: polyethylene, butter paper and non-woven bags and compared them to fruits left uncovered. It was found that bagging was a huge success.

First, and most importantly, bagging completely stopped fruit cracking. While nearly 20 per cent of the unprotected fruits cracked, not a single bagged fruit did. This is a game-changer for growers. Second, bagging made the fruit heavier. The pomegranates in butter paper and polybags, in particular, grew to be much bigger and heavier than the unbagged ones, which is great for market value. Third, the bags acted as a fantastic shield against diseases. All the bagged fruits had significantly lower rates of bacterial blight and black spot, with the butter paper bags providing the best protection. Finally, the bags helped improve the fruit's overall quality. The non-woven bags, for instance, resulted in juicier fruits, proving that the microclimate created inside the bags helps the fruit develop better.

In short, this study shows that pre-harvest bagging is a simple, eco-friendly and powerful tool for pomegranate growers in northern India. It not only protects the fruit from major damage but also makes them bigger, better and more marketable.

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