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Improving yield and quality of Manfalouty pomegranate growing in newly reclaimed soils by using bagging and some foliar spray treatments

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Abstract

We looked into bagging and spraying as potential methods for increasing the yield and quality of Manfaloty pomegranate trees. During the 2020 and 2021 seasons, 7-year-old trees were used in the investigation. They were grown in sandy, calcareous soil with high temperatures. Six treatments were used to examine the effects on fruit yield and quality parameters at harvest time in the first week of September. These treatments included foliar spraying with kaolin and potassium silicate treatments, polypropylene bags and bagging with white and yellow paper. Results indicated that white paper bagging resulted in the lowest percentage of fruit cracking and sunburn compared to the control and other treatments. White paper bagging increased fruit yield, weight, length, and diameter. Additionally, compared to the other treatments, the application of kaolin spray increased the biochemical contents of the fruit (TSS, total sugars, vitamin C, anthocyanin, and juice) while lowering acidity and tannins. We concluded that using kaolin spray and white paper bags could enhance the yield and quality of Manfaloty pomegranate grown under challenging conditions.

Key words: Kaolin, bagging, Manfaloty, pomegranate, fruit quality, paper

Introduction

Pomegranate (*Punica granatum* L.) is an economically important fruit crop in tropical and subtropical regions of the world. Assiut Governorate is regarded as being one of Egypt's most crucial categories for pomegranate cultivation and production. Manfaloty is perhaps the most major fruit cultivar that has begun to grow and is exported from this region, where the temperature in summer could also attain 40^{o}C. Pomegranate plants are exposed to multiple biotic and abiotic challenges regarding a region's weather conditions, resulting in yield loss. Sunburn is the most common biotic stress (Meena *et al.,* 2016). Sunburn is considered a physiological disorder caused by the combined action of high temperatures, high solar radiations with low humidity, which leads to changes the colour of the peel from brown to black, depletes the moisture content of the fruit and creates drying, and lessens the market value of the fruit (Pareek *et al.,* 2015). Even though consumers choose fruits premised on peel colour, peel colour is the most important quality trait. Besides that, aril colour, juice colour, juice substance, antioxidants, or other quality metrics of pomegranate fruits are also essential. According to reports, sun exposure seriously affects all quality characteristics of fruits, leading to a loss of nutritional and market value (Melgarejo *et al.,* 2004; Meena *et al.,* 2016).

Because pomegranate is a terminal-bearing plant, its fruits are exposed to solar radiation. Besides this, fruits are more susceptible to sunburn than leaves because they lack a mechanism for using the radiation from the sun for photosynthesis. Sunburn damage in pomegranate can grade inflation to 30% of harvested fruit or more (Melgarejo *et al.,* 2004).

Many researchers have proposed different methods for reducing sunburn damage in pomegranate fruits and increasing the quality of fruits *e.g.,* bagging, spraying kaolin, and silicon to reduce the previous reasons. When sprayed on the plant, kaolin forms a uniform, thin protective layer. By reflecting some of the light reaching the canopy, kaolin lowers the temperature of the canopy by 2 to 6 ^{o}c. This drop in temperature will mitigate the negative impacts of drought stress and improve photosynthesis, carbohydrate transfer to the fruit, and anthocyanins in the fruit.

Bagging is a novel technique in practice; this is a simple and safe method (Sharma *et al.,* 2014b; Haldankar *et al.,* 2015). Also, bagging is a physical method that can decrease bird damage and cracking (Abbasi *et al.,* 2014; Chen *et al.,* 2012; Sharma and Sanikommu, 2018). Yuan *et al.* (2012) showed that bagging pomegranate effectively prevents fruit cracking.

Potassium silicate is a source of highly soluble potassium and silicon. Spraying K-silicate can potentially decrease the detrimental effects of drought stress on crops since it contains no volatile organic components. Epstein and Bloom (2003) stated that silicon is a semi-essential plant element because deprivation causes aberrant growth, development, and reproduction. Silicon enhances plant defence mechanisms against environmental and biological impacts, increasing crop yield and quality. Sarkomi *et al.* (2019) found that bagging significantly affected the percentage and severity of sunburned fruits in pomegranate. Bagged fruit with white bags had the lowest percentage of sunburned fruits (25%) compared to 90 percent in control (non-bagged fruit). Grinan *et al.* (2018) significantly reduced pomegranate peel burn.

This study aimed to investigate the effect of bagging and some foliar spray treatments on sunburn, fruit cracking, yield and fruit quality of Manfalouty pomegranate grown in sandy calcareous soil.

Materials and methods

Experimental site: The experimental site was located in a hot and semi-arid region in sandy calcareous soil at the experimental Farm of Arab El-Awammer Research Station, Agric. Res. Center (ARC)., Assiut Governorate, Egypt (which lies between latitude 27°, 11′ N, longitude 31°, 06′ E and 71 m above sea level) during two successive seasons (2020 and 2021). The trees received the same practices usually applied in the orchard, including irrigation and pest control.

Treatments and experimental design: 7-year-old Manfaloty pomegranate (*Punica granatum* L.) trees. The trees were planted at 3x3 m and supplied water via a drip irrigation. Thirty-six trees were selected as uniform as possible in growth and vigour and were subjected to six treatments as follows: T1- control, T2- kaolin, T3- potassium silicate, T4- bagging (white paper), T5- bagging (yellow paper), T6- bagging (polypropylene). The bagging and spraying treatments were applied when the fruits reached 3 cm in diameter. Fruit bagging (20 x 30 cm) were applied from the second week of May until the second week of August and bags were removed two weeks before the expected harvesting date.

Fruit was sprayed with 4% kaolin (a soluble powder of aluminium silicate ($Al_2Si_2O_7$) mineral clay formulated for conventional spray and 4 % potassium silicate four times at monthly intervals from the second week of May to the second week of August.

A sample of fruits (n=15) of each treatment was randomly selected at the harvest date in the first week of September to determine the physical and chemical properties as follows:

Physical characteristics: Yield (kg) was calculated and fruit cracking %, sunburn % and the marketable fruits per tree were calculated according to the following equations:

Cracking %= (Number of cracked fruits/ Total number of fruits) x 100
Sunburn %= (Number of sunburned fruits/ Total number of fruits) x 100
Marketable fruits %= [Total number of fruits – (cracking fruits + sunburned fruits)] x 100.

Fruit weight was calculated, selected fruits were peeled by hand, and then their rind and capillary membranes (seed) were separately weighted. The difference between total fruit weight and seed weight calculated is the arils weight/fruit. The volume of juice was expressed in mL per 100 g of seed.

Chemical characteristics: A hand refractometer was used to determine the total soluble solids percentage (TSS %). Total acidity (%) was determined according to AOAC (1995). Total soluble tannins % was determined according to (Balbaa, 1981). Total sugars (%) were determined according to the methods described by Dubois *et al.* (1956). Vitamin C as (mg) ascorbic acid /100 ml. juice was determined according to AOAC (1995). Total anthocyanins (mg/100mL) content was determined according to Ranganna (1979**).**

Statistical analysis: This study was designed as a randomized complete block design (RCBD) with three replicates/treatments and one tree per each. Data were analyzed using Statistix version 8.1 software (Analytical Software, 2005). Differences between means were determined using the least significant difference test at $P \leq 0.05$.

Results and discussion

Physical properties of fruits

Fruit cracking: Results illustrated in Table 1 indicate that bagging and spraying treatments decreased the cracking of fruits than the control, with the least fruit cracking (2.77 and 2.72%) obtained with T4 (bagging with white paper), followed by T5 (bagging with yellow paper) (3.12 and 3.07 %) while the control gave the highest fruit cracking value(6.94 and 6.65 %) in both seasons respectively. These results agree with those of Abou El–Wafa (2014), who reported a considerable reduction in cracked and sunburned fruits in bagged pomegranate, with the lowest cracking (1%) in the Prgmen bag compared to 24% in control. Sarkomi *et al.* (2019) found that bagging with different bagging materials reduced cracking significantly as compared to non-bagged fruit, with the highest percentage of cracking (65%) in control and the lowest (5%) in white-bagged fruits in pomegranate. Rathore and Pal (2016) showed that bagging treatments reduced mango fruit cracking significantly compared to unbagged fruit and that the blue paper bag was the most effective in preventing fruit cracking. Maintaining moisture around bagged fruit and avoiding direct contact with strong and hot winds on the fruit's skin would have been helpful in decreasing pomegranate cracking (Yilmaz & Ozguven, 2006).

Sunburn: Data presented in Table 1 reveal that the bagging and spraying treatments significantly decreased the percentage of fruit sunburn compared to the control, which gave higher percentage fruit sunburn (35.50 and 42.75). In addition, bagging with white paper recorded the lowest percentage of sunburn (1.45 and 2.10 %) during the two study seasons, followed by kaolin, which gave (9.45 and 10.82 %). Reducing sunburn damage caused by bagging and kaolin may be due to their role in reflecting radiation, sun rays, especially UV wavelengths.

These results are in line with those obtained by Hamedi *et al.* (2019), who found that the highest (90%) sunburn was observed with control (non-bagged) while the lowest Sunburn percentage (25%) With white-bagged fruits in August Ghorbani *et al.* (2015), Hegazi *et al.* (2014) and El-Rhman (2010) found that bagging decreased the fruit cracking and percentage of sunburn on pomegranate. Melgarejo *et al.* (2004) stated that kaolin significantly reduced the percentage of sunburn damage of fruit pomegranate from 21.9% in control to 9.4% in the treated fruits. Sarkomi *et al.* (2019) found that bagging significantly affected the percentage and severity of sunburned fruits in pomegranate. Bagged fruit with white bags had the lowest percentage of sunburned fruits (25%) compared to 90 percent in control (non-bagged fruit). Grinan *et al.* (2018) showed a significant reduction in pomegranate peel burn as a result of bagging.

Marketable yield: Marketable yield significantly increased with bagging and spraying treatments compared with control, which gave the least marketable yield (57.56 and 50.60%) in both seasons (Table 1) . The highest marketable yield (95.78% and 95.18%) was recorded under T4 bagging with white paper. The marketable yield increased by 66.40% and 88.10% more with T4 bagging with white paper than with control, respectively.

Fruit length and diameter: Regarding fruit length and fruit diameter, there was no significant differences between treatments and control in both seasons (Table 2). Meanwhile, T4 (bagging with white paper) gave the highest fruit length and diameter

Table 1. Effect of bagging and foliar spray treatments on fruit cracking, sunburn and marketable yield of Manfaluty pomegranate during 2020 and 2021 seasons

Treatments	Cracking (%)		Sunburn (%)		Marketable yield	
	2020	2021	2020	2021	2020	2021
T1 Control	6.94^{a}	6.65^{a}	35.50^{a}	42.75^{a}	57.56^{d}	50.60^{d}
T2 Kaolin	4.18^{b}	4.05^{b}	9.45^{cd}	10.82^{c}	86.37^{b}	85.13^{b}
T3 Potassium silicate	4.23^{b}	4.13^{b}	16.90^{b}	18.15^{b}	78.87^{c}	77.72^{c}
T4 Bagging (white paper)	2.77^{e}	2.72^{e}	1.45^{e}	2.10^{d}	95.78^{a}	95.18^{a}
T5 Bagging (yellow paper)	3.12^{d}	3.07^{d}	10.75^{c}	11.77^{c}	86.13^{b}	85.16^{b}
T6 Bagging (polypropylene)	3.74^{c}	3.70^{c}	11.55^{c}	12.23^{c}	84.71^{b}	84.07^{b}

Values followed by the same letters within a column are not significantly different ($P < 0.05$) according to the least significant difference test.

(8.63 and 8.82 cm) (9.62 and 9.71 cm) during both seasons, respectively, followed by T2 (kaolin) (8.50 and 8.66 cm) (9.49 and 9.51 cm), while the control gave the lowest values (7.97 and 8.13 cm) (9.13 and 9.25) in both seasons, respectively. Similar to Hegazi *et al.* (2014), these results reported that fruit length and diameter were not affected by bagging or kaolin spray of "Manfaloty" pomegranate. El-Wafa.(2015) stated that spraying kaolin at 2% gave the highest fruit diameter (cm) compared to other treatments. On the other hand, Tran *et al.* (2014) reported that bagging fruit with paper improved the length and diameter of 'Manfalouty' pomegranate. Also (Abd El-Rhman, 2010; Ehteshami *et al.,* 2012; Samra and Shalan, 2013). They indicated that kaolin spray treatments significantly increased the fruit length and diameter of pomegranate.

Table 2. Effect of bagging and foliar spray treatments on fruit length, diameter and yield of Manfaluty pomegranate during 2020 and 2021seasons

Treatments	Fruit length (cm)		Fruit diameter (cm)		Yield (kg)	
	2020	2021	2020	2021	2020	2021
T1 Control	7.97^{a}	8.13^{a}	9.13^{a}	9.25^{a}	15.45^{d}	15.98^{c}
T2 Kaolin	8.50^{a}	8.66^{a}	9.49^{a}	9.51^{a}	17.68^{a}	17.82^{a}
T3 Potassium silicate	8.16^{a}	8.32^{a}	9.37^{a}	9.42^{a}	16.75^{cd}	17.11^{b}
T4 Bagging (white paper)	8.63^{a}	8.82^{a}	9.62^{a}	9.71^{a}	17.86^{a}	18.10^{a}
T5 Bagging (yellow paper)	8.25^{a}	8.41^{a}	9.39^{a}	9.40^{a}	17.16^{b}	17.22^{b}
T6 Bagging (polypropylene)	7.99^{a}	8.11^{a}	9.32^{a}	9.43^{a}	16.93^{bc}	17.23^{b}

Values followed by the same letters within a column are not significantly different ($P < 0.05$) according to the least significant difference test.

Total yield: Concerning yield (kg), the result in Table 2 indicated that all treatments significantly increased as relative to the control. The higher yield (17.86 and 18.10 kg) was obtained with T4 bagging (white paper) during two seasons, followed by T2 (17.68 and 17.82 kg) while the control recorded the least yield (15.45 and 15.98 kg) in both seasons respectively. In addition, the difference between T4 and T2 was not significant. These results are in agreement with those obtained by Abd El-Rhman (2010) and Samra and Shalan (2013), who found that bagging fruit increased the yield (kg/ tree) of pomegranate. According to Abou El-Wafa (2015), spraying 2% kaolin produced the highest yield/tree. Abdel Gawad Nehad *et al.* (2017) in mango recorded increased production (kg plant^{-1}) could be attributable to increased fruit weight due to bagging.

Fruit weight (g): Data presented in Table 3 shows that treatments of bagging and spraying kaolin or potassium silicate increased fruit weight compared with control. In addition, the best fruit weight (415.51 and 424.45 g) was recorded under T4 in both seasons, respectively, followed by T2 kaolin (399.37 and 412 g), while the control gave the lowest values (360.53 and 356.11 g) during both seasons, respectively. Meanwhile, the difference between T4 and T2 was not significant. These results were nearly in line with Saad *et al.* (2017), who found that bagging with white colour with a diameter of 4.5 cm gave the highest average fruit weight than control and other treatments. Abou El-Wafa (2015) observed the highest fruit weight (g) with 2% of kaolin treatment.

Arils and seed weight: There were no significant differences between the treatments and the control for arils and seed weight (Table 3) These results are similar to Saad *et al.* (2017) on Wonderful pomegranate. Harhash and Al–Obeed (2010) on date palm and Kumar *et al.* (2015) on red banana reported that bagging fruit increased the arils and seed weight.

Chemical characteristics

Acidity: Data illustrated in Table 4 revealed that all treatments decreased the percentage of acidity than the control, which gave the highest values (1.05 and 1.00 %), and the treatment T2 gave the lowest values (0.90 and 0.88 %) in two seasons of study, respectively. Meanwhile, the difference between treatments was not significant. These results are similar to those obtained by Samra and Shalan (2013); Abdel-Sattar *et al.* (2017) reported that fruit acidity was not affected by bagging or kaolin sprays of the pomegranate fruit.

TSS: From the results presented in Table 4, it is clear that all treatments significantly increased TSS% compared with the control, which gave the least TSS values (15.60 and 15.83%). In addition, T2 gave the highest values (17.33 and 17.67%), followed by T4 recorded (17.16 and 17.50%) during both seasons, respectively. Furthermore, the differences between T2 and T4 were not significant. These results align with those obtained by Abd El-Rhman (2010), who mentioned that spraying GA_3 and kaolin significantly increased total soluble solids (TSS) in pomegranate. Also, Samra and Shalan (2013) found that bagging fruit increased TSS. Saavedra *et al.* (2006) found that higher TSS in fruits treated with kaolin could be due to its reflective effect that may decrease leaf temperature and reduce respiration, resulting in better accumulation of sugars.

Total sugar: Concerning the results, it's evident that kaolin spray significantly increased total sugar content compared to the control and the other treatments in both seasons (Table 4), followed by T4, while the lowest values were obtained under control. Similar results were registered by Saad *et al.* (2017), who reported that bagging with a white bag gave the best results for total sugar (%) compared with other bagging treatments in both seasons. Also Abd El-Rhman (2010) on pomegranate, Harhash and Al-obeed (2010) on date palm, and Haldankar *et al.* (2015) on mango cv. "Alphonso" reported that bagging fruit increased total sugar (%).

Anthocyanin: Data presented in Table 5 indicate that all treatments significantly increased anthocyanins compared with the control. The treatment of kaolin spray recorded the highest anthocyanin values, followed by treatment bagging with white paper (T4) while the control gave the least values. Similar results were previously reported by Samra and Shalan (2013) on pomegranate. Ghorbani *et al.* (2015) and Saad *et al.* (2017) recorded that bagging increased the

Table 5. Effect of bagging and some foliar spray treatments on Anthocianin, Tannins, VC and Juice% of Manfaluty pomegranate during 2020 and 2021seasons

Treatments	Anthocyanin mg/L		Tannins %		VC mg/100ml		Juice volume (mL /100g seeds)	
	2020	2021	2020	2021	2020	2021	2020	2021
T1 Control	56.56^{e}	57.82	0.39^{a}	0.38^{a}	23.68^{d}	23.61^{e}	37.24^{d}	37.77^{d}
T2 Kaolin	61.63^{a}	63.16^{a}	0.32^{c}	0.33^{cd}	26.89^{a}	27.79^{a}	41.44^{a}	41.50^{a}
T3 Potassium silicate	58.80^{d}	58.97^{d}	0.37^{b}	0.36^{b}	25.31^{c}	25.73^{d}	39.75^{b}	39.90^{c}
T4 Bagging (white paper)	60.50^{b}	62.71^{b}	0.32^{c}	0.34^{c}	26.10^{b}	27.15^{b}	40.05^{b}	40.24^{b}
T5 Bagging (yellow paper)	58.63^{d}	59.20^{d}	0.37^{b}	0.35^{bc}	25.17^{c}	26.10^{c}	38.51^{c}	38.76^{d}
T6 Bagging (polypropylene)	59.97^{c}	60.80^{c}	0.37^{b}	0.36^{b}	25.35^{c}	26.45^{c}	39.58^{b}	39.78^{c}

Values followed by the same letters within a column are not significantly different ($P < 0.05$) according to the least significant difference test.

Table 3. Effect of bagging and some foliar spray treatments on fruit weight, arial and seed weight (g) of Manfaluty pomegranate during 2020and 2021seasons

Treatments	Fruit weight (g)		Arial weight (g)		Seed weight (g)	
	2020	2021	2020	2021	2020	2021
T1 Control	360.53^{c}	360.11^{bc}	167.22^{a}	169.56a	193.31^{a}	190.55^{a}
T2 Kaolin	399.37^{ab}	401.27^{ab}	193.16^{a}	204.77^{a}	206.21^{a}	196.50^{a}
T3 Potassium silicate	365.78^{bc}	380.77^{abc}	168.56^{a}	176.88^{a}	197.22^{a}	203.89^{a}
T4 Bagging (white paper)	406.51^{a}	413.45^{a}	199.17^{a}	206.90^{a}	207.34^{a}	206.55^{a}
T5 Bagging (yellow paper)	387.78^{ab}	377.70^{bc}	197.78^{a}	178.33^{a}	190.00^{a}	199.37^{a}
T6 Bagging (polypropylene)	378.74^{bc}	382.77^{ab}	181.08^{a}	187.37^{a}	196.66^{a}	195.40^{a}

Values followed by the same letters within a column are not significantly different ($P < 0.05$) according to the least significant difference test

Table 4. Effect of bagging and some foliar spray treatments on Acidity, TSS, and total sugar % of Manfaluty pomegranate during 2020and 2021seasons

Treatments	Acidity		TSS (%)		Total sugar (%)	
	2020	2021	2020	2021	2020	2021
T1 Control	1.05^{a}	1.00^{a}	15.60^{c}	15.83^{d}	10.81^{f}	10.92^{f}
T2 Kaolin	0.90^{a}	0.88^{a}	17.33^{a}	17.67^{a}	13.44^{a}	13.71^{a}
T3 Potassium silicate	0.95^{a}	0.93^{a}	16.67^{b}	16.65^{bc}	12.23^{d}	12.48^{d}
T4 Bagging (white paper)	0.93^{a}	0.90^{a}	17.16^{a}	17.50^{a}	13.22^{b}	13.52^{b}
T5 Bagging (yellow paper)	0.91^{a}	0.92^{a}	16.66^{b}	17.17^{ab}	11.64^{e}	11.94^{e}
T6 Bagging (polypropylene)	0.92^{a}	0.92^{a}	16.50^{b}	16.83^{bc}	12.37^{c}	13.01^{c}

Values followed by the same letters within a column are not significantly different ($P < 0.05$) according to the least significant difference test

level of anthocianin (mg/100g) in fruit. It also increased levels of anthocyanin contents by using bagging fruit and kaolin spray due to their effect on decreased fruit heat. Meanwhile, Tora *et al.* (2008) mentioned that light temperature is the important environmental reason that improve anthocyanin synthesis.Anthocyanin biosynthesis is favored at a temperature of 25°C, but at 35°C, it leads to the inhibition of anthocyanin accumulation.

Tannins: The data presented in Table 5 revealed a consistent reduction in tannin levels across all treatments compared to the control. Particularly noteworthy are the outcomes of T2 (kaolin) and T4 (bagging with white paper), which exhibited the most favourable influence in contrast to the other treatments.

Vitamin C content: Regarding the vitamin C results (Table 5), using kaolin spray yielded the highest levels of vitamin C when compared to the alternative treatments. Conversely, the control group exhibited the lowest vitamin C content. These findings closely align with the findings of Abou El-Wafa (2015), who observed an increase in vitamin C content following foliar application of 4% kaolin. Similarly, Abdel-Sattar (2017) reported increased vitamin C content across all treatments (fruit bagging, kaolin, ascorbic acid, lime milk) compared to the control (water spray).

Juice: A significant increase in juice percentage was recorded across all treatments relative to the control (Table 5). Remarkably, the treatment involving kaolin spray (T2) registered the highest juice percentage values amongst all treatments, and the control group exhibited the lowest juice percentage values. This outcome mirrors the findings of Abd El-Rhman (2010), who observed that both kaolin and controlled irrigation with bagging and applying Zn SO_4 resulted in the highest juice percentage values during both seasons.

The findings of this study underscore the effectiveness of employing white paper bagging and kaolin spray treatments in mitigating sunburn occurrences and reducing fruit cracking. These interventions resulted in a substantial boost in marketable fruit yield, enhancing overall fruit quality—notably, marketable yield escalated by 66.40 and 88.10% for the two treatments. Furthermore, the most favourable outcomes regarding fruit yield and quality were consistently attributed to the employment of white paper bagging and kaolin spray strategies.

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