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Impact Of Pre-Harvest Bagging And Spraying Treatments On Yield, Fruit Sunburn, And Shelf Life Of Mango Keitt

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ABSTRACT

Sunburn is a major problem caused by high temperature and direct solar radiation, which leads to significant economic losses in mango Keitt yield. So, a field experiment was conducted during the 2019 and 2020 seasons to study the effect of pre-harvest fruit bagging or spraying treatments on Keitt fruit sunburn, and the shelf life of fruit. The research was conducted at a private orchard In Egypt on six-year-old Keitt mango trees planted at two-by-four meters. In order to reduce the incidence of sunburn, plants were sprayed with ammonium silicate (Kaolin) or bagged with several types of paper. The treatments were as follows non-sprayed (control), Aqueous Ammonium silicate (Kaolin) at 1%, 2%, and 3 in addition to bagging with a white paper bag (A4, 70 gm), Pergamene paper bag, Foam paper bag, and Muslin cloth bag. The white paper treatment had the lowest percentage of burned fruits, resulting in the highest number of fruits per tree at harvest and fruit retention percentage. The difference from control was notable, as control had the highest number of burnt fruits and the largest sunburned area of fruits in both seasons, and in some cases was on the same par with other treatments.

Keywords: Keitt mango, bagging, ammonium silicate (kaolin), sunburn, shelf life.

INTRODUCTION

Egyptian mangoes (Mangifera indica L.) are one of the most nutritionally rich fruits with a distinctive flavor, smell, and taste. Keitt cv. has a large fruit size and is distinguished by its maturity at the end of the season, as in Egypt it ripens from September to October (Olando et al., 2005). Being a late-season ripening cultivar, it is exposed to high solar radiation during the summer with increased light and heat convection that often causes sunburn in fruits. Burned fruits cause significant economic losses for a large number of fruits due to the interaction of high temperatures and light in different crops (Schrder et al., 2003). Sunburn injury is common on fruit due to high levels of solar radiation, air temperatures, low relative humidity, and high altitudes. Therefore, the inadequacy of resistance mechanisms and the high susceptibility of the fruit to sunburn would suggest the need for external intervention to suppress sunburn in the fruit.

The grower must follow best management practices to minimize sunburn and grow tolerant cultivars, efficient irrigation, appropriate canopy management, cover or intercropping, over tree sprinkler, shade netting, fruit bagging, suppressants (Kaolin or calcium carbonate), and chemical protectants (Narayan and Sahu, 2017). Bagging or spraying mango fruits before harvest is an outstanding alternative to avoid

adverse effects such as physical damage and their role in improving the commercial value of the fruit, i.e., improving fruit color, reducing splitting mechanical damage, sunburn on the skin, etc. Trees are subject to many diseases. Various outbreaks of mango diseases and attacks on insect pests reduce the target mango crop each year. The ammonium silicate (Kaolin) used in clay-based sunscreens has been purified and modified to produce table powder that can be mixed with water and sprinkled on foliage and fruit to create a white coating that reflects some sunlight. That can lower fruit surface temperatures by as much as 5 to 10 °C (Glenn and Buterka, 2005). The clay-based coating was not affected by photosynthesis or even increased due to reduced heat stress and better light distribution to the lower shaded parts of the tree canopy under light intensity. Clay-based products can be easily washed off the tree and should be reapplied after rain, spray irrigation over trees, and evaporative cooling (Glenn, 2009). These products can act as insect repellents in fruit crops. Kaolin is recommended to lower the temperature of the fruit, thus reducing sunburn and improving the red color of the fruit in cases where temperatures are above optimum (Heacox, 1999 and Glenn et al., 2001). By increasing the reflection of visible and ultraviolet light, Kaolin reduces fruit surface temperature (Glenn et al., 2001and Wünsche et al., 2002). The efficacy of kaolin in reducing sunburn in most cultivars and regions is more strongly attributed to a decrease in harmful radiation reaching the surface of the fruit than to a decrease in surface temperature (Gindaba and Wand, 2005).

Bagging mango fruits before harvest is an outstanding alternative to avoid adverse effects by causing physical damage and improving the commercial value of the fruit, i.e. improving fruit color and reducing mechanical cracking damage, sunburn on the skin, etc. (Islam et al., 2017). Fruit bagging is one of the best pre-harvest practices to protect fruits from insect pests especially fruit fly infestation and fungal diseases (Sharma et al., 2014), and avoid adverse effects by causing physical damage and improving the commercial value of the fruit, i.e. improving fruit color and reduce mechanical cracking damage, sunburn on the skin (Islam et al., 2017) in addition to enhancing the shelf life of mango (Islam et al., 2019). Bagging with a brown paper bag and white paper bag enhanced fruit retention, weight, diameter, pulp weight, TSS, ascorbic acid, citric acid %, reducing sugars and β-carotene at harvest and ripe stage over control. In all cases, good quality, cleaner, disease, and insect-free fruits were harvested. Sensory qualities in fruits of brown, white, and muslin cloth bags were improved more than control. Pre-harvest bagging also reduced the incidence of spongy tissue and the occurrence of mealy bugs (Islam et al., 2017). Furthermore, bagging fruits gave the highest shelf life up to 12.67 days with the lowest weight loss and good physical appearances as against 10.67days of control fruits (Zaky et al., 2018).

The objectives of the study are to determine the effects of different fruit bagging or spraying of ammonium silicate (Kaolin) on fruit sunburn, and the shelf life of mango cv. Keitt.

MATERIALS AND METHODS

The present study was undertaken to study the efficacy of different pre-harvest bagging or spraying treatments on mango (Mangifera indica L.) cv. Keitt quality and shelf life. This research was conducted, in two consecutive seasons 2019 and 2020 on a private farm of mango located on Alexandria desert road. Uniformly grown six -years old Keitt mango trees grafted on Sukarry rootstock spaced at 2x4m apart under drip irrigation system were selected. The experiment was established as a randomized block design with three replicates for each treatment each of one tree.

I. Experiment layout:

Twenty-Four uniformly grown trees were selected from the Keitt mango cultivar for this study. The selected trees were arranged in eight treatments with 3 trees for each treatment and each tree is considered a replicate. The treatments included foliar spray with aqueous ammonium silicate (Kaolin) at 1, 2, 3% were sprayed 15 days after fruit set (mid of May), then continued at 15-day intervals till harvesting. In comparison with bagging mango fruits 15 days after fruit set with different types of bags and left till fruit maturity. The particular bags were wrapped properly at the stalk of each fruit of respective treatments so that it would not befall down as well as there would not be open space. Besides the control plant which not sprayed or bagged its fruits. The treatments were as follows:

T1: Non-sprayed (control).
T2: Aqueous Ammonium silicate (Kaolin) 1%.
T3: Aqueous Ammonium silicate (Kaolin) 2%.
T4: Aqueous Ammonium silicate (Kaolin) 3%.
T5: White paper bag (A4, 70 gm).
T6: Pergamene paper bag.
T7: Foam paper bag.
T8: Muslin cloth bag.

II. The studied parameters:

Immediately pre-harvest, several fruits and the number of sunburned fruits per tree were counted. Then the percentage of fruit retention (%) was calculated as follows: Number of fruits at harvest/ Initial fruit set X 100.

In addition, the percentage of sunburned fruit was calculated as the total count of fruits per tree. Also, in Lab, the sunburned area was measured by considering the area of the sunburn injury took an ellipse shape so its area is equal to the smallest radius x the largest radius x π.

Then the samples of fruits from the different treatments under investigation were separately harvested at the optimum maturity stage by hand and then transported to the laboratory. Fruit good in quality were selected and washed with regular tap water and soap and then rinsed with water. All fruits were stored on the lab's tables in the room conditions (25±5 <C and 65-70% R.H.), to measure fruit weight loss percentage and shelf-life. The weight of fruit was done at zero storage days (harvesting time), then the weight loss was tracked for 20 days of storage. To determine the following parameters:

1- Physiological loss in weight (%): It was determined after 10 and 20 days of storage by periodical weighing of fruits at storage and expressed as a percentage of original weight according to Amayogi and Alloli (2007). Damaged fruits were not included with it.

Whereas physiological loss in weight % (PLW %) = $\frac{\mathrm{IW}-\mathrm{FW}}{\mathrm{IW}}\mathrm{X}\ 10$

Where PLW= Physiological loss in weight of mango.

IW= Initial weight of mango.

FW= Final weight of mango.

2- Shelf life (days): The shelf life of fruits was determined up to the time when weight loss of fruits reached 10% during the storage at room temperature, the shelf life of fruits was accounted for from the date of harvesting to the expiration date.

Statistical analysis

The current study followed a complete randomized block design, with three replicates for each treatment. Data obtained throughout the current study were tested for analysis of variance as indicated by Snedecor and Cochran (1972) and means were compared using the LSD test at 5% (Steel and Torrie, 1980).

RESULTS & DISCUSSIONS

I. Number of fruits and percentage of Retention fruit at harvest

Obtained data from both seasons of study proved that the use of white paper achieved the highest number of fruits, and it was significantly equal to spraying with ammonium silicate (kaolin) at a concentration of 2 or3% in the first season. Contrarily, untreated control fruits recorded significantly fewer numbers of fruits at harvest compared to the rest of the treatments in the first season, while it was significantly equal with the coverage by muslin cloth bag or with spraying ammonium silicate at 1% in the second season. Thus, the treatment of covering with white paper achieved an increase in the number of fruits in the tree compared to the control by 63.31% and 54.10% in both seasons, respectively (Table, 1). The data in Table (1) also shows that the highest percentage of retention fruits on the tree was achieved with the treatments of covering the fruit with white paper or with foam paper and without significant differences between them in both years of the study. While the lowest percentage of retention fruits was obtained with untreated trees (control treatment) in both seasons.

Our findings on the effect of spraying kaolin on yield were agreed upon by Kerns and Wright (2000), Colavita et al. (2011), and Alvarez et al. (2015). Where they showed that the application of Kaolin clay treatments has been successfully applied in different fruit species to minimize fruit sunburn and improve yield and fruit quality. Bagging, on the other hand, improved fruit retention and quality over control (Islam et al., 2017). Whereas Ammonium silicate (Kaolin) and bagging have been identified as promising short-term strategies for the long-term alleviation of adverse abiotic stress (Brito et al., 2019 and Rajan et al., 2020), which resulted in increased fruit retention, the final number of fruits per tree, and fruit quality.

Table 1. Fruits number and retention % of Keitt mango cultivar at harvest as influenced by preventing sunburn treatments during 2019 and 2020 seasons.

Preventing sunburn treatments	The final number of fruits		Retention fruit %	
	2019	2020	2019	2020
Control	17.33 ^{d}	12.33 ^{e}	32.59 ^{e}	30.59 ^{d}
Ammonium Si. 1%	25.33 ^{b}	13.00 ^{de}	33.94 ^{de}	31.24 ^{cd}
Ammonium Si. 2%	26.00 ^{ab}	16.67 ^{b}	36.77 ^{cd}	33.87 ^{cd}
Ammonium Si. 3%	26.67 ^{ab}	15.67 ^{bc}	41.45 ^{b}	36.23 ^{bc}
White Paper (70 g)	27.00 ^{a}	19.00 ^{a}	44.76 ^{a}	42.09 ^{a}
Pergamene Paper	18.67 ^{c}	14.67 ^{bcd}	37.36 ^{c}	34.39 ^{cd}
Muslin cloth bag	19.33 ^{c}	13.00 ^{de}	34.26 ^{de}	31.48 ^{cd}
Foam Paper	20.00 ^{c}	14.73 ^{cd}	43.17 ^{ab}	40.44 ^{ab}
LSD at 5%	1.638	2.053	2.855	5.224

II. Sunburned fruits

The control fruits as well as those were sprayed with ammonium silicate at 1% recorded a higher number of burned fruits in both seasons of study. While the rest of the plants in both seasons worked to reduce the number of burned fruits, the covering treatment with white paper or foam paper treatment achieved significantly the lowest number of burned fruits. Pergamene ranked second in terms of reducing the number of burnt fruits, with no significant difference between them (Table, 2).

Data revealed the highest percentage of burned fruit with the untreated control fruits followed by ammonium silicate treatments at 1% as well as the paper muslin treatment. Ammonium silicate 3% and bargemen paper came next with significant effect, although no significant difference among them was detected. The lowest percentage of burned fruits was recorded for white paper A4 70gm treatment and foam paper (Tabe, 2).

Bagging with foam paper, spraying with ammonium silicate (kaolin) 3% and muslin have recorded the smallest size of sunburned fruits respectively. Bargemen came next in lessening the size of the fruit burned area. On the other hand, the biggest area of burned fruits was recorded with the control fruits and those were sprayed with ammonium silicate 1&2% (Table, 3).

Our findings are confirmed by Glenn et al. (2001) and Wünsche et al. (2002). They explained the effects of spraying and bagging for lessening the incidence of burning, Kaolin reduces fruit surface temperature by increasing the reflection of visible and ultraviolet light, the efficacy of kaolin in reducing sunburn in most cultivars and regions may be more strongly attributed to a decrease in harmful radiation reaching the surface of the fruit than from a decrease in surface temperature (Gindaba and Wand, 2005). Also, Glenn and Buterka (2005) are also recommended that Kaolin is recommended to lower the temperature of the fruit, thus reducing sunburn.

Table 2. Total number and percentage of sunburned fruits Keitt mango cultivar as influenced by preventing sunburn treatments during 2019 and 2020 seasons.

Preventing sunburn treatments	Total number of sunburned fruits		Sunburn fruit%	
	2019	2020	2019	2020
Control	15.83 ^{a}	10.00 ^{a}	91.40 ^{a}	81.19 ^{a}
Ammonium Si. 1%	16.67 ^{a}	9.00 ^{ab}	65.74 ^{b}	69.44 ^{b}
Ammonium Si. 2%	12.67 ^{b}	6.67 ^{cd}	48.80 ^{c}	46.51 ^{c}
Ammonium Si. 3%	9.33 ^{cd}	5.00 ^{ef}	35.04 ^{d}	32.03^{de}
White Paper (70 g)	6.33 ^{ef}	3.67 ^{f}	23.43 ^{e}	19.24 ^{f}
Pergamene Paper	8.00 ^{de}	5.67 ^{de}	42.79 ^{c}	38.57^{cd}
Muslin cloth bag	12.22 ^{b}	7.67 ^{bc}	63.23 ^{b}	60.00 ^{b}
Foam Paper	5.67 ^{f}	4.33 ^{ef}	28.38 ^{de}	25.98 ^{ef}
LSD at 5%	1.735	1.371	7.687	11.439

Table 3: Size of sunburned fruit (cm of Keitt mango cultivar as influenced by preventing sunburn treatments during 2019 and 2020 seasons.

Preventing sunburn treatments	Size of sunburned fruit (cm^2)	
	2019	2020
Control	12.01 [a]	14.65 [a]
Ammonium Si. 1%	11.00 [b]	12.03 [ab]
Ammonium Si. 2%	10.51 [c]	11.51 [ab]
Ammonium Si. 3%	8.50 [f]	9.94 [bc]
White Paper (70 gm)	7.00 [g]	7.85 [c]
Pergamene Paper	10.12 [d]	11.51 [ab]
Muslin cloth bag	9.00 [e]	10.46 [bc]
Foam Paper	7.01 [g]	8.89 [bc]
LSD at 5%	2.70	2.04

III. Physiological loss in fruit weight and Shelf life

Physiological loss in fruit weight (%) after 10 and 20 days from harvest at room temperature presented in Table (4) prove the changes in fruit weight and its loss due to different spray and bagging treatments at ten days and twenty days from harvesting and under room temperature conditions. According to the data in Table (4), the percentage of weight loss after 10 days in both seasons of the study was significantly similar between the treatments and the control treatment, except for spraying with ammonium silicate (kaolin) at 3 %, which was significantly less in weight loss compared to the control treatment. In contrast, after 20 days of storage, all treatments had a significant and distinct effect on reducing the rate of weight loss when compared to the control treatment. In this case, spraying with 3 % ammonium silicate (kaolin) outperformed in terms of achieving the lowest percentage of weight loss, as it did not exceed 10.5% in both seasons. Significantly, the use of both white paper and foam paper achieved the same results achieved with spraying with 3 % ammonium silicate in the first season. This was followed by the use of pergamene paper.

Table 4: Physiological loss in fruit weight (%) after 10 and 20 days from the harvest of Keitt mango cultivar as influenced by preventing sunburn treatments during 2019 and 2020 seasons.

Preventing sunburn treatments	Physiological loss in fruit weight (%)			
	10 days from harvest		20 days from harvest	
	2019	2020	2019	2020
Control	5.95 [ab]	6.10 [a]	18.51 [a]	19.74 [a]
Ammonium Si. 1%	5.04 [abc]	5.41 [a]	15.36 [b]	16.22 [bc]
Ammonium Si. 2%	4.41 [abc]	5.43 [a]	13.24 [c]	15.48 [c]
Ammonium Si. 3%	3.44 [c]	3.49 [b]	10.49 [e]	10.05 [e]
White Paper (70 g)	4.32 [abc]	4.56 [ab]	12.97 [de]	13.42 [d]
Pergamene Paper	5.45 [ab]	5.84 [a]	14.30 [bc]	15.74 [c]
Muslin cloth bag	4.63 [abc]	5.58 [a]	15.66 [b]	17.64 [b]
Foam Paper	3.79 [bc]	4.34 [ab]	11.36 [de]	12.48 [d]
LSD at 5%	1.86	1.83	1.687	1.813

Shelf life of the Mango cv. Keitt was affected by both spray and bagging treatments which prolonged the ability to keep the quality under the ambient conditions (Table, 5). The best treatment in this regard was for ammonium silicate 3% and foam paper treatment could stay at room temperature in good condition for up to 16 and 19 days in both seasons. On the other hand, the shortest shelf-life period was recorded for the control fruits as they couldn't resist and survive in a good shape to be accepted in the market for more than 11 days and 13 days in the two-season respectively.

Recorded results are supported by Islam et al. (2019) who mentioned that fruit bagging can enhance fruit quality in addition to enhancing the shelf life of mango. Furthermore, bagging fruits gave the highest shelf life up to 12.67 days with the lowest weight loss and good physical appearances as against 10.67days of control fruits (Zaky et al., 2018).

Table 5: Shelf life of Keitt mango cultivar as influenced by preventing sunburn treatments during 2019 and 2020 seasons.

Preventing sunburn treatments	Shelf life (days)	
	2019	2020
Control	11.33 ^{e}	13.33 ^{e}
Ammonium Si. 1%	13.33 ^{d}	15.67 ^{cd}
Ammonium Si. 2%	14.33 ^{cd}	16.67 ^{bcd}
Ammonium Si. 3%	16.67 ^{a}	19.33 ^{a}
White Paper (70 gm)	15.33 ^{abc}	17.33 ^{bc}
Pergamene Paper	13.67 ^{cd}	15.33 ^{d}
Muslin cloth bag	14.67 ^{bcd}	15.67 ^{cd}
Foam Paper	16.33 ^{ab}	18.33 ^{ab}
LSD at 5%	1.67	1.68

Conclusion

Sunburn damage on fruit is common due to high levels of solar radiation, air temperature, low relative humidity, and high elevations. Farmers use pre-harvest fruit bagging and spraying as a preventative strategy to avoid sunburn injury. Even so, the effect of the two strategies (bagging and spraying) is not clearly distinguishable. Subsequently, the purpose of this research is to examine the effects of various fruit bagging and spraying of ammonium silicate (Kaolin) on mango cv. Keitt fruit sunburn and shelf life in Egypt. The Keitt mango trees used in this experiment are six years old trees grafted on Succory seedlings and planted at 2×4 meters in sandy soil under irrigation. The orchard where the study was conducted is located in the El-Behara governorate, Alexandria Desert Road. The obtained results revealed that the highest number of fruits per tree at harvest was recorded with the use of white paper or with spraying with 2 or 3% ammonium silicate. The highest retention fruits % was achieved by covering the fruit with white paper or with foam paper. The control fruits recorded the highest number of burned fruits biggest sun burnet area of fruits in both seasons. The lowest percentage of burned fruits was recorded for white paper A4 70gm treatment and foam paper. However, pre-harvest spray and bagging treatments prolonged mango shelf life compared to the untreated control fruits. Ammonium silicate 3% and foam

paper proved to be the most effective treatment; treated mango could stay at room temperature in good condition up to 16 and 19 days in both seasons compared to 11 and 13 days for the control treatment.

REFERENCES

Alvarez, H.L., C.M. Di Bella, G.M. Colavita, P.Oricchio , J. Strachnoy. (2015): Comparative effects of kaolin and calcium carbonate on apple fruit surface temperature and leaf net CO2assimilation. Journal of Applied Horticulture, 17(3): 176-180.

Amayogi, R. K., Alloli, T. B. (2007): Studies on integrated nutrient and postharvest management of fig (Ficus carica L.) (Doctoral dissertation, Ph. D. Thesis. Department of Horticulture. College of Agriculture, Dharwad University of Agricultural Sciences Dharwad–580 005.143 p.

Brito, C., Dinis, L. T., Moutinho-Pereira, J., Correia, C. (2019): Kaolin, an emerging tool to alleviate the effects of abiotic stresses on crop performance. Scientia Horticulturae, 250, 310-316.

Colavita, G.M., V. Blackhall and S. Valdez. (2011): Effect of kaolin particle films on the temperature and solar injury of pear fruits. Acta Hort., 909: 609-615.

Gindaba, J., Wand, S.J. (2005): Comparative effects of evaporative cooling, kaolin particle film and shade net on sunburn and fruit quality in apples. HortSci., 40(3): 592-596.

Glenn, D.M. (2009): Particle film mechanisms of action that reduce the effect of environmental stress in “Empire” apple. J. Amer. Soc. Hort. Sci., 134(3): 314-321.

Glenn, D.M., Puterka, G.J. (2005): Particle Films: A New Technology for Agriculture. In Horticultural Reviews, Volume 31. Edited by Jules Janick. John Wiley & Sons, Inc.

Glenn, D.M., Puterka, G.J., Drake, S.R. and Boughs, T.R. (2001): Particle film application influences apple leaf physiology fruit yield and fruit quality. J. American Soc. Horticultural Sci., 126: 175-181.

Heacox, L. 1999. Powerful particles. Amer. Fruit Gower, 16-17.

Islam MT, Zoha MS, Bari MA, Rahman MS, Akter MM, Rahman MA. (2019): Effect of bagging time on fruit quality and shelf life of mango (Mangifera indica L.) cv. Langra in Bangladesh. International Journal of Agriculture, Environmental and Bioresearch.;4 (4):279-289.

Islam, M. T., Rahman, M. S., Shamsuzzoha, M., & Alom, R. (2017): Influence of pre-harvest bagging on fruit quality of Mango (Mangifera indica L.) cv. Mishribhog. International Journal of Biosciences, 11(3), 59-68.

Kerns, D. L., Wright, G. C. (2000): Protective and yield enhancement qualities of kaolin on lemons. 2000 Citrus and Deciduous Fruit and Nut Research Report. az1178. College of Agriculture and Life Sciences, The University of Arizona, Tucson, AZ.

Narayan, L., N. Sahu. (2017): Management strategies of sun burn in fruit crops-A Review. Int.J. Curr. Microbiol. App. Sci 6(6): 1126-1138

Olando, C.T., R.J. Schnell, W.E. Quintanilia., R.J. Campbell. (2005): Pedigree analysis of Florida mango cultivars. Proc. Fla. State Hort. Soc., 118: 192-197.

Rajan, R., Ahmad, M. F., Pandey, K., Solankey, S. S. (2020): Bagging of fruit crops: a low-cost sustainable technology for quality fruit production. Singh, HK; Solankey, SS; Roy, MK Farmers’ prosperity through improved agricultural technologies. Delhi: Jaya Publishing House, 121-140.

Schrader, L., J. Zhang and J. Sun, (2003): Environmental stress that caused sunburn of apple. Acta Hort., 618: 397- 405.

Sharma, R.R., Reddy, S.V.R., Jhalegar, M.J. (2014): 'Pre-harvest fruit bagging: a useful approach for plant protection and improved post-harvest fruit quality', The J. of Hort. Sci. and Biotechnology, Vol., 89, No. 2, pp.101–113.

Snedecor, G.W. and W.G. Cochran, (1980): Statistical Methods. 7th Edn. Iowa State Univ. Press Ames. Low USA.

Steel, R. G. D., J. H. Torrie. (1962): Principles and Procedures of Statistics. (With special Reference to the Biological Sciences.). In Biometrische Zeitschrift (Issue 3). McGraw-Hill Book.

Wünsche, J. N., Lombardini, L., & Greer, D. H. (2002): 'Surround' Particle Film Applications-Effects on Whole Canopy Physiology of Apple. In XXVI International Horticultural Congress: Key Processes in the Growth and Cropping of Deciduous Fruit and Nut Trees 636 (pp. 565-571).

Zaky, M. A., A. A. El-Baowab., S. A. Mohamed. (2018): Impact of spraying some chemical substances on controlling sunburn of Balady mandarin fruits. Egypt. J. Hort., 45(2):1-8.