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REDUCING CRACKING AND ENHANCING COLORATION AND QUALITY OF WONDERFUL POMEGRANATES CULTIVAR BY SAFE TREATMENTS

Karim M. Farag[1], Neven M.N. Nagy[1], M.H. ElSheikh[2] and H.S. Abada[2*]

1. Hort. Dept. (Pomol.), Fac. Agric., Damanhour Univ., P.O. Box 22516, Damamhour, Egypt

2. Pl. Prod. Dept., Arid Lands Cultivation Res. Inst., City of Sci. Res. and Technol. Applications, Alex, Egypt

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ABSTRACT: Pomegranates fruit cracking and poor coloration of peel and aril are the main problems facing the expansion of its cultivation especially under arid condition in the desert. This study was conducted during the two successive seasons 2014 and 2015 on "Wonderful" pomegranates (*Punica granatum* L.). The trees were grown under drip irrigation system in a private orchard at Nubaria region, Beheira Governorate, Egypt. The trees were treated twice at weekly interval by using a hand sprayer to the run off point at the marble size with some mineral nutrients to reduce fruit cracking. The treatments included: water spray (as the control), calcium borate at 100 ppm, calcium borate at 200 ppm, zinc chelated with EDTA at 100 ppm, zinc chelated with EDTA at 200 ppm and finally calcium nitrate at 1% (*W/V*). Moreover, to enhance coloration of pomegranates peel and aril, at maturity the trees were treated with the control (water spray), ProTone (ABA 1%) at 100 ppm, ProTone at 100 ppm plus glycerol at 1% (*V/V*), ProTone at 100 ppm plus potassium sulphate at 1% (*W/V*), ProTone at 100 ppm plus potassium sulphate at 1% and glycerol at 1% (*V/V*), glycerol at 1% (*V/V*) and finally potassium sulphate at 1% (*W/V*). The non-ionic surfactant Top film at 0.05% (*V/V*) was added to all treatments. The results proved that calcium borate at 200 ppm treatment was more effective on reducing cracking and sun scald of pomegranate fruits. In addition, the results revealed that the formulation containing ProTone plus potassium sulphate and glycerol had a consistent effect on increasing anthocyanin content in the peel, when compared with the control or with ProTone alone. Moreover, anthocyanin content of the arils was significantly increased by application ProTone along with glycerol or ProTone plus potassium sulphate and glycerol in both seasons. Meanwhile, electrolyte leakage of the aril was similar for most applications. There was also a significant increase in total sugars by various ProTone-containing formulations relative to the control in the juice. Thus, this study recommended applying ProTone in a formulation containing potassium sulphate and glycerol in order to enhance coloration and quality of "Wonderful" pomegranates in a consistent manner under field conditions.

Key words: Pomegranates, wonderful, cracking, coloration, anthocyanin, ProTone, glycerol, potassium sulphate, zinc, boron.

INTRODUCTION

Pomegranate is one of the most promising and demanded fruits for cultivation especially in the desert and under arid conditions. The tree possesses many desired properties such as high tolerance to salt stress, frost, soil alkalinity and even water stress. Thus, the tree can live, survive and be productive for a long time, may reach to 200 years old.

The pomegranate tree can grow in coastal areas as well as in internal and desert regions. It has the ability to flower over an extended period of time especially near the sea coast. Meanwhile, it yields about 6-8 tons of fruits/faddan, under

* **Corresponding author: Tel. :** +201004001993
E-mail address: heshamabada14@gmail.com

these coastal areas, the trees keep foliage for long time while in desert areas, the tree is deciduous. Moreover, the fruit can be stored well for a long duration and has long shelf life since it is a non-climacteric fruit. The self-compatibility is very high, thus one cultivar could be grown alone in one blot and even densely planted. The fruit weight and size are extra-ordinary especially under warm climate in upper Egypt. The pomegranate diseases are rare and blossoming occurs over three flushes. Thus, the diversity in the tree properties ensure the lasting productive life.

In spite of the large expansion in growing pomegranates in Egypt in the last two decades, the increase in production and cultivated areas from 2902 fad., in 2000 to 58319 fad., in 2015 **(CAPMAS, 2017)**. The tree still suffers from major physiological disorders in addition to the fruit problems. These could be summarized in the following points: - Fruit cracking and splitting, sun scald and sun burn damage to the fruit, excessive abscission of flowers and fruits, and poor coloration of the skin and arils.

Several research attempts have been made to investigate the causes behind each problem and to recommend the applicable treatments. Regarding fruit cracking, **El-Khawaga (2007)** used foliar application with paclobutrazol and zinc sulphate to reduce cell division and to increase fruit skin thickness. Meanwhile, **Abd El-Rahman (2010)** tried the application of zinc sulphate in addition to spraying the reflective material called kaolin to reduce heat absorption by fruits and control the irrigation regime to manipulate the pressure on fruit skins. Reduction of skin and internal fruit temperatures leads to increasing anthocyanin formation **(Azuma *et al.,* 2012; Lin-Wang *et al.,* 2010; Iland, 1989; Yamane *et al.,* 2006)**, and reduces the incidence of sun scald and sun burn injury **(Yazici and Kaynak, 2009)**. It was reported that surface temperature of the fruit was greater than air temperature due to heat absorption especially with colored skins **(Weerakkody *et al.,* 2010)**. Furthermore, it was found that poor coloration of the skin and arils occurs in many production areas especially with new cultivations of pomegranates under arid conditions in the desert and in many regions of Upper Egypt. Pulp-bearing seeds (arils) do not develop their typical red color and are somewhat flattened rather than plump **(Ryall and Pentzer, 1974)**. Pomegranate fruits must be very rich in anthocyanin pigments **(Gil *et al.,* 1995)** to attract consumers.

One of the most important quality characteristics of the pomegranate is the red pigmentation of the arils and juice. The red color depends on anthocyanin concentration and on the chemical structure of the individual anthocyanin, since pelargonidin is responsible for red-orange colors **(Hernandez *et al.,* 1999)**. However, there is still a lack to more research efforts to overcome the problems facing the production of pomegranates in many regions around the world.

The objectives of these studies were to provide new treatments and approaches to reduce the incidence of fruit cracking and new formulations of ProTone that have greater efficacy in increasing anthocyanin biosynthesis in both the skin and the aril. Since ProTone is hydrophilic and has low diffusion rate across the pomegranates cuticle and skin, there has been used to provide the producers and farmers with an applicable production system and treatments that could be adopted under field condition.

MATERIALS AND METHODS

The present study was conducted during the two successive seasons 2014 and 2015 on Wonderful pomegranate cultivar (*Punica granatum* L.). The trees were 3-years-old spaced at 2.5×3 m and grown under drip irrigation system in a private orchard at Nubaria region, Beheira Governorate, Egypt. Sixty-five uniform trees, free from various physiological and visible pathological disorders were selected for investigation, Trees had been under the standard agricultural practices throughout the season. Soil texture was sandy and drip irrigation system was adopted. Treatments were arranged in a completely randomized block design. Five replications were used for each treatment and one pomegranate tree represented one replication, thus sixty five trees were employed to this study in each season. The study was divided into two experiments:

The First Experiment

Use of Some Mineral Nutrients to Reduce Cracking of "Wonderful" Pomegranates

Thirty standard "Wonderful" pomegranate trees were randomly assigned to receive one of six treatments and applied as spraying twice at weekly interval at marble size after fruit set. The treatments included; tap water spray (as the control), calcium borate at 100 and 200 ppm, zinc chelated with EDTA (Zn- EDTA) at 100 and 200 ppm, in addition to calcium nitrate at 1% (*W/V*). The non-ionic surfactant Top film at 0.05% (*V/V*) was added to all treatments to reduce the surface tension and to increase the contact angle of sprayed droplets.

Every month starting from July to September, number of fruits per tree in each treatment was counted to calculate the percentages of sun scald, sun burn and cracking.

This experiment included 18 treatments which were the combinations between 6 treatments and 3 spraying dates. These treatments were arranged in split plot in randomised complete plot desigen. The spraying date were randomly arranged in the main plots and treatments were randomly arranged in sub plots.

The Second Experiment

The Effect of ABA Acid Formulations on Improving "Wonderful" Pomegranates Coloration

Thirty five standard "Wonderful" pomegranate trees were randomly assigned to receive one of seven treatments and applied by spraying to the run off twice at weekly interval following maturation on 25 and 15 August, for the successive seasons. The treatments include; the control (tap water spray), ProTone (ABA 1 %) at 100 ppm, ProTone at 100 ppm plus glycerol at 1% (*V/V*), ProTone at 100 ppm plus potassium sulphate at 1% (*W/V*), ProTone at 100 ppm plus potassium sulphate at 1% and glycerol at 1% (*V/V*), glycerol at 1% in addition to potassium sulphate at 1% (*W/V*). The non-ionic surfactant Top film at 0.05% (*V/V*) was added to all treatments to reduce the surface tension and to increase the contact angle of sprayed droplets.

The samples were collected on 9^{th} and 4^{th} October during 2014 and 2015, respectively and carefully placed in plastic bags and transferred from the orchard to the laboratory as quickly as possible for quality assessment.

Fruit Quality Parameters Assessment

Physical characteristics

Fruit weight (g) the average weight of five fruits of each replication was determined by a digital scale (RADWAG, wlc6/A2). Fruit length (cm) and fruit diameter (cm) were measured using a Vernier caliper. Fruit peel, Granules and septum weights (g) were recorded.

Chemical characteristics

The percentage of total soluble solids (TSS%) was determined in pomegranates fruit juice using a digital refractometer. The acidity was detected based on estimated tartaric acid **(AOAC, 1985)**. TSS (%) to acidity (%) was calculated from obtained data. Vitamin C was determined as mgs ascorbic acid per 100 ml juice using the method of **Egan *et al.* (1981)**. Total sugars were determined by using the phenol sulfuric acid method **(Smith, 1956)**, and the concentration was calculated from a standard curve of glucose (mg. per g) fresh weight of fruit tissue. Reducing sugars were determined according to Lane and Eynon colorimetric method as described by **Egan *et al.* (1981)**. Non- reducing sugars were also calculated. Anthocyanin was determined according to the method of **Fuleki and Francis (1968)** in peel or aril using spectrophotometer (ORION AquaMata 8000 UV-VIS spectrophotometer, Thermo Scientific). The percentage electrolytes leakage of granules was calculated according to the method of **Farag and Palta (1993)** by using the Conductivity meter (AD8000 EC Bench Meter, ADWA Instruments Kft).

Statistical Analysis

Data of the first experiment was analyzed as split plot in RCBD design. On the contrary, the data of the second experiment was analyzed as randomized completely blocks design (RCBD) with five replicates. The comparisons among means were made *via* the least significant difference (LSD) at 0.05 level according to **Snedecor and Cochran (1980)**. The data was analyzed using **SAS (2009)**.

RESULTS AND DISCUSSION

The First Study

Use of Some Mineral Nutrients to Reduce Cracking, Sun Scald and Sun Burn of "Wonderful" Pomegranates

The effect of some preharvest treatments on the susceptibility of "Wonderful" pomegranates to the incidence of sun scald, sun burn or cracking was reported in Table 1. The results revealed that sun scald occurred in low percentage ranged from 3.12 to 5.51%, where the control did not vary from the early application of calcium borate at 100 or 200 ppm, Zn- EDTA at either 100 or 200 ppm and calcium nitrate at 1% (*W/V*) in 2014 and 2015 seasons except with calcium borate at 200 ppm which significantly reduced sun scald damage in the second season only, when compared with the control. Moreover, sun burn damage was significantly reduced by the application of calcium borate at 100 ppm in the first season and 200 ppm in the second season, when compared with the control. None of the other treatments was superior to the others in terms of reducing the incidence of sun burn injury to "Wonderful" pomegranates in both seasons. Meanwhile, skin cracking that it mostly the consequence of sun burn damage was significantly reduced by all applications in a consistent manner in both seasons, when compared with the control. Again, none of the applied treatments resulted in a superior difference in skin cracking as compared with the others (Table 1) in both seasons.

Since three times of survey were used in both seasons on July, August and September, the results in Table 1 reported the influence of such time on the progress of sun scald, sun burn or skin cracking of "Wonderful" pomegranates under field condition. It was evident that the greatest sun scald was found in September followed by August survey. That was also the general trend with regard to the percentage of sun burn in the first season only. Moreover, cracking percentage was greater in September followed by August survey.

The results in Table 1 demonstrate the variations in the percentage of the incidence of sun scald in "Wonderful" pomegranates. It was clear that insignificant differences were found in the first season over the three months of the season except in the control that had a significant increase in sun scald from July to September. In the second season, however, the incidence of sun scald was faster since the percentage of sun scald had increased significantly from July to August in all treatments, but actually was lowered by calcium borate at 200ppm when compared with the control even in August assessment. Moreover, the increase in sun scald started to be significant late in September in case of applied calcium nitrate 1% (*W/V*), in the contrary to the control that had a significant increase in sun scald earlier in August. Changes in the percentage of sun burn of "Wonderful" pomegranates as influenced by the interaction between applied treatments and the time factor were reported in Table 1. The results revealed that there was a significant increase in sun burn from July until September in the first season in the control, calcium borate at 100ppm and Zn- EDTA at 100ppm while the increase in sun burn was mainly increasing relatively late from August to September in calcium borate (at 200 ppm), Zn- EDTA (at 200 ppm) and calcium nitrate.

In the second season, however, all treatments and the control started earlier to increase in sun burn from July to August, then remained without any significant changes between August to September. Thus, some treatments were able to delay the symptoms in the first season such as calcium borate (at 200 ppm), Zn- EDTA (at 200 ppm) or calcium nitrate at 1% (*W/V*). Furthermore, the results in Table 1 show the effect of the interaction between treatments and the time factor on fruit cracking of "Wonderful" pomegranates. It was found that as the season progressed, there was a significant increase in skin cracking reaching to the maximum in September in the control, which had greater cracking percentage than all other treatments especially by the end of the second season in September. Meanwhile, Bo or Zn containing treatments had an increase in cracking relative to the control or to the beginning of the season in July assessments but remained lower in the percentage of fruit cracking when compared with the control, especially in September, while

Table 1. Effect of some preharvest treatments and date of spraying on sun scald, sun burn and cracking of "Wonderful" pomegranate cultivar fruits during 2014, 2015

Treatment	No. of sun scald fruits/tree				No. of sun burned fruits/tree				No. of cracked fruits/tree			
	July	August	Sept.	Av.	July	August	Sept.	Av.	July	August	Sept.	Av.
						First season (2014)						
Control	2.71 b	3.14 ab	5.55 a	3.80 a	1.06 ef	3.59 d	6.01 bc	3.55 ab	0.00 c	0.60 c	5.23 a	1.94 a
Ca Bo (100ppm)	2.61 b	3.45 ab	3.80 ab	3.29 a	0.87 f	2.34 def	5.06 c	2.76 b	0.00 c	0.49 c	2.70 b	1.06 b
Ca Bo (200ppm)	2.31 b	3.17 ab	3.86 ab	3.12 a	1.79 def	3.52 d	5.76 bc	3.69 ab	0.21 c	0.22 c	2.49 b	0.97 b
Zn-EDTA (100ppm)	3.67 ab	3.98 ab	5.31 a	4.32 a	2.95 d	5.37 c	8.37 a	5.56 a	0.00 c	0.84 c	2.77 b	1.20 b
Zn-EDTA (200ppm)	3.02 ab	2.58 b	4.81 ab	3.47 a	1.94 def	3.27 d	6.62 bc	3.94 ab	0.00 c	0.41 c	2.48 b	0.96 b
$CaNO_3$ (1%)	3.43 ab	3.80 ab	4.44 ab	3.89 a	2.65 de	3.59 d	7.22 ab	4.49 ab	0.00 c	0.43 c	3.06 b	1.16 b
Av.	2.96 b	3.35 b	4.63 a		1.88 c	3.61 b	6.51 a		0.03 c	0.49 b	3.12 a	
						Second season (2015)						
Control	3.52 efg	5.71bcd	7.02abc	5.42 a	2.83 cd	7.15 ab	6.26abc	5.41 a	0.56 d	6.60 b	10.26 a	5.81 a
Ca Bo (100ppm)	3.35 fg	5.21bcd	7.98 a	5.51 a	1.46 d	4.94abc	5.94abc	4.11ab	0.00 d	3.85 c	7.80 b	3.88 b
Ca Bo (200ppm)	2.55 g	3.57efg	5.47bcd	3.87 b	1.08 d	6.16abc	4.09bcd	3.78 b	0.00 d	2.68 c	5.77 b	2.82 b
Zn-EDTA (100ppm)	3.24 fg	5.54bcd	7.28 ab	5.35 a	1.45 d	7.91 a	5.53abc	4.97ab	0.00 d	2.37 c	6.45 b	2.94 b
Zn-EDTA (200ppm)	3.19 fg	4.74def	8.31 a	5.41 a	1.81 d	6.90 ab	6.92 ab	5.21ab	0.40 d	4.05 c	6.86 b	3.77 b
$CaNO_3$ (1%)	3.52 efg	5.25cde	7.27 ab	5.35 a	1.34 d	5.42abc	5.18bcd	3.98ab	0.24 d	3.51 c	7.37 b	3.71 b
Av.	3.23 c	5.00 b	7.22 a		1.66 b	6.42 a	5.65 a		0.20 c	3.84 b	7.42 a	

* Values, within a season, of similar letters are not significantly different according to the least significant difference (LSD) at 0.05 level.

there was similar cracking to that obtained with chelated zinc or calcium borate at either 100 or 200 ppm. Furthermore, Ca nitrate treated fruits maintained lower cracking than the control.

In general, these results are in agreement with those obtained by **El-Khawaga (2007), Khorsandi *et al.* (2009), Sheikh and Manjula (2012), Kuldeep *et al.* (2001), Abd El-Aziz *et al.* (2001), Hasaballa (2002)** and **Abd Elaal (2007)** who mentioned that using Ca, Zn and B was very effective in reducing fruit cracking (%) in various pomegranate cvs.

Such results may be due to the importance of calcium in reducing fruit cracking percentage lies in its role in the cohesion of cell walls due to its connection with pectic acid link by crossing link chains (**Sheikh and Manjula, 2012**). **Lane *et al.* (2000)** explained the role of the skin in the resistance to cracking as a function of the calcium content of the epidermis cells that induce integrity of these cells. The beneficial effects of zinc on controlling water absorption and nutrient uptake as well as enhancing the biosynthesis of the natural hormone namely IAA surely reflected on reducing fruit cracking (%) **(Yagoden, 1990)**. In addition, zinc is responsible for strengthening cell wall and reducing the formation of the abscission zone (**Mengel *et al.*, 2001**). Also, zinc plays many important regulatory roles in plant development through activating different enzymes, the biosynthesis of organic foods, cell division and cell enlargement **(Yagoden, 1990)**. The reducing effect on fruit cracking (%) in response to application of boron was mainly attributed to its important role in the extension of plant cell walls through building of pectins as well as enhancing IAA and water uptake (**Yagoden, 1990**). In addition, using boron achieved many merits such as building and translocation of carbohydrates and promoting photosynthesis and pollen germination and cell division (**Kaneko *et al.,* 1997**). The decline in cracking of fruits due to boron treatments may be attributed to its physiological role in synthesis of pectin substances in cells. Boron is responsible for increasing the elasticity of cell membranes and prevents the breakdown of vegetative tissues. Boron also improved the translocation of sugar and synthesis of cell wall material. Thus, this decrease in fruit cracking might be the result of borate bridging with cell wall constituents, thus giving elastic response to it as advocated by **Singh *et al.* (2005)**.

The Second Study

The Effect of ABA Acid Formulations on "Wonderful" Pomegranates Coloration

Physical characteristics

The effect of preharvest treatments with ProTone alone or in some formulations on fruit weight of "Wonderful" pomegranates was reported in Table 2. The results revealed that the application of ProTone alone did not have a consistent influence on fruit weight when compared with the control, since it was considerably effective in the first season. Moreover, the application of ProTone plus potassium sulphate resulted in a similar fruit weight to that of the control without significant differences between them in both seasons. Even the formulations containing ProTone and glycerol and potassium sulphate did not have a significant influence on fruit weight as compared with the control. The only consistent influence on fruit weight was found with the application of glycerol relative to the control in both seasons.

Pomegranate fruits grow in a sigmoid pattern where the growth rate slows down near maturity (**Gozlekci and Kaynak, 1996 ; Saad *et al*., 1988**), which might explain the slight response of fruit weight to most treatments, when applied relatively late due to the need to enhance fruit coloration. Thus, to exert an effective influence on fruit weight, the application time must precede maturity by several weeks. The general trend of results reported in this study, in general, agreed with the findings of (**Khayyat *et al.,* 2012**).

The response of pomegranate fruit length to various applied treatments before harvest was shown in Table 2. It was obvious that "Wonderful" fruit did not have a significant alteration in fruit length in the second season only by any applied treatment. Such obtained results were in line with those reported by **Khayyat *et al.* (2012)**.

While regard to the changes in fruit diameter in response to applied treatments, the results showed that ProTone and ProTone plus potassium sulphate and glycerol treated fruits did not change especially in the second season. However, the individual application of either glycerol or potassium did not show a consistent increase in fruit diameter in the second season as compared with the control, since their positive influence on fruit diameter was shown only in the first season.

These results could be explained on the basis that ProTone has no direct- reported influence on increasing fruit dimensions but rather maintains cell turgor pressure which increases available water that could be utilized to enhance the photosynthetic capacity and carbohydrates partitioning into the fruit.

Furthermore, the peel weight response of "Wonderful" pomegranates was found to increase in a consistent manner only by glycerol treatment (Table 2) as well as ProTone. Moreover, many treatments caused a significant increase in peel weight in both seasons such as ProTone plus glycerol or plus potassium sulphate.

The influence of various applied treatments on septum weight in "Wonderful" pomegranates shown in Table 2 clearly indicated that there was a consistent reduction in that weight as a result of applying ProTone alone or when combined with either glycerol or with potassium sulphate. Meanwhile, the sole use of either glycerol or potassium resulted in inconsistent trend of effect on septum weight in the second season when compared with the control.

Table 2. Physical characteristics of "Wonderful" pomegranate fruits as influenced by some preharvest treatments during the two seasons 2014 and 2015

Treatment	Fruit weight (g)		Fruit length (cm)		Fruit diameter (cm)		Peel weight (g)		Septum weight (g)		Granules weight (g)	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Control	470.20b*	439.82bc	8.54b	9.18a	9.78b	9.52ab	225.20b	206.70c	12.92a	14.52b	232.00d	218.64ab
ProTone	523.08a	453.31bc	8.98a	9.38a	10.27a	9.54ab	264.36a	234.57ab	9.28c	10.38d	249.44ab	208.39c
ProTone plus glycerol	475.72b	480.66a	8.6b	9.21a	9.84b	9.77a	234.20b	246.89a	6.72de	10.25d	234.80cd	223.52a
ProTone plus K_2SO_4	484.02b	460.32b	8.70ab	9.12a	9.93b	9.33b	236.48b	230.19b	7.64d	11.87cd	239.96bcd	218.26ab
ProTone plus glycerol and K_2SO_4	484.28b	456.43b	8.59b	9.30a	9.80b	9.46ab	235.28b	222.24bc	6.08e	13.45bc	242.88abc	220.66ab
Glycerol	517.96a	480.07a	8.86ab	9.25a	10.32a	9.70a	264.8a	246.49a	8.92c	17.98a	244.28abc	215.68abc
K_2SO_4	517.4a	447.94bc	8.83ab	9.18a	10.30a	9.33b	254.12a	220.64bc	10.73b	14.57b	252.52a	212.90bc

* Values, within a column, of similar letters are not significantly different according to the least significant difference (LSD) at 0.05 level.

Meanwhile, that was the case with granules weight (seed + aril) as shown in Table 2. It was found that there was an increase in granule weight in the first season only by ProTone, glycerol, potassium sulphate or their combined treatment.

Chemical characteristics

The results in Table 3 indicate that there was significant increase in TSS by all application treatments as compared with the control in both seasons. The highest TSS was recorded from treatments K_2So_4 (18.24 and 13.84%), K_2So_4 plus ProTone (18.66 and 13.88%) and treatment ProTone plus K_2So_4 and glycerol (18.86 and 14.38%) without differences among them in both seasons. The lowest TSS was showed with control treatment (15.72 and 12.92%) in the tow season respectively.

Acidity of Juice, was not influenced by various applied treatments since consistent trend was not found over the two seasons even with the formulation of ProTone plus potassium sulphate and glycerol. The reduction of acidity level by most treatments was in the second season only relative to the control, while in the first one, Juice acidity was increased compared with control.

Even with the formulation of ProTone plus K sulphate and glycerol, the considerable increase in TSS/acidity ratio was obtained only in the second season. The effect of treatments ProTone, ProTone plus potassium sulphate, ProTone plus glycerol and treatment glycerol alone was insignificant on TSS/acidity ratio in both seasons between them.

Results of vitamin C as influenced by various treatments were reported in Table 3. Meanwhile, the juice content of vitamin C was significantly increased in a consistent manner by application of the formulation containing ProTone plus potassium sulphate and glycerol when compared with the control and other treatments in both seasons.

With regard to the effect of various applied treatments on the leakage of electrolytes from granules (Table 3), the results indicated that there were in significant changes by the application of ProTone alone or when used in a formulation containing either glycerol, or potassium sulphate, when compared with the control in the second season only. The upper most electrolytes leakage was obtained with glycerol application when compared with the control in both seasons.

Results presented in Table 4 show that the tested treatments had a significant effect on anthocyanin content in both seasons. The highest anthocyanin content in the peel recorded from the treatment ProTone plus potassium sulphate and glycerol in both seasons, while the differences between the other treatments were insignificantly in the second season. The application of potassium sulphate or ProTone plus potassium sulphate or ProTone plus potassium sulphate and glycerol recorded highest anthocyanin content in the aril in the two seasons without differences between them.

The results in Table 4 also indicate that total sugars of the juice were significantly affected by various applied treatments in both seasons. However, the greatest significant increase in total sugars was obtained with the formulation containing ProTone plus potassium sulphate and glycerol together relative to the control and to all other ProTone containing combinations or to ProTone alone. Meanwhile, the application of either potassium sulphate or ProTone caused a significant increase in total sugars as compared with the control. The only treatment that was not effective on total sugars content was glycerol in both seasons.

Similar trend of results was found with reducing sugars content in the juice since the control juice had the least content relative to all other applied treatments in both seasons. except, glycerol in the first season. Furthermore, the greatest content of reducing sugar among all other used treatments was found with the application of ProTone in the same above formulation that included potassium sulphate and glycerol simultaneously.

On the other hand, non-reducing sugars were not significantly affected by various used treatments since they all resulted, generally, in similar non-reducing sugars to each other and to the control in both seasons.

The above findings regrading, the trend of anthocyanin and various sugars were in agreement with the studies of **Sutthiwal Setha (2012) and Reynolds *et al.* (2013)**.

Table 3. Chemical characteristics of "Wonderful" pomegranate fruits as influenced by various applied preharvest treatments during the two seasons 2014 and 2015

Treatment	TSS (%)		Acidity (%)		TSS/Acidity (Ratio)		Vitamin C (mg/ 100 ml)		Granules electrolytes leakage (%)	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Control	15.72c*	12.92c	0.94d	1.35a	16.14bc	10.04c	11.56e	12.45bc	19.55b	15.69ab
ProTone	18.06ab	13.40bc	1.17a	1.31ab	17.08abc	10.54bc	12.48cd	13.84b	21.99a	13.34b
ProTone plus glycerol	17.74b	13.70b	1.08b	1.22cd	16.63abc	11.05b	12.68c	12.78bc	22.63a	18.27ab
ProTone plus K_2SO_4	18.66a	13.88ab	1.19a	1.19de	17.58ab	10.79bc	14.12b	12.54bc	22.86a	15.88ab
ProTone plus glycerol and K_2SO_4	18.86a	14.38a	1.21a	1.15e	15.39c	12.53a	15.68a	15.78a	19.90b	13.81b
Glycerol	17.6b	13.42bc	1.05bc	1.28bc	17.76ab	10.69bc	11.80de	12.78bc	23.04a	20.80a
K_2SO_4	18.24ab	13.84ab	0.99cd	1.28bc	18.26a	10.54bc	12.00cde	12.3c	21.91a	15.14ab

* Values, within a column, of similar letters are not significantly different according to the least significant difference (LSD) at 0.05 level.

Table 4. Chemical characteristics of "Wonderful" pomegranate fruits as influenced by various applied preharvest treatments during the two seasons 2014 and 2015

Treatment	Anthocyanin of peel (mg/100g)		Anthocyanin of aril (mg/100g)		Total sugars (%)		Reducing sugars (%)		Non- reducing sugars (%)	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Control	21.53c*	21.25b	24.45d	20.12d	11.71c	10.67d	10.63d	9.39e	1.10b	1.29a
ProTone	25.60a	21.77b	25.99cd	24.05c	13.24b	12.20bc	12.12bc	10.64cd	1.14b	1.56a
ProTone plus glycerol	22.26c	21.41b	29.45a	26.15bc	13.67b	12.89b	12.52b	11.58bc	1.19b	1.32a
ProTone plus K_2SO_4	25.09ab	21.98b	29.26a	27.97ab	13.33b	13.05b	12.16bc	11.73ab	1.17b	1.32a
ProTone plus glycerol and K_2SO_4	26.46a	24.61a	28.59ab	29.65a	15.07a	14.17a	13.92a	12.64a	1.15b	1.53a
Glycerol	23.08bc	20.94b	27.17bc	27.17b	12.49bc	11.47cd	11.25cd	10.33d	1.24b	1.14a
K_2SO_4	25.08ab	21.03b	27.94ab	27.84ab	13.73b	12.10bc	12.18bc	10.72cd	1.55a	1.37a

* Values, within a column, of similar letters are not significantly different according to the least significant difference (LSD) at 0.05 level.

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تقليــل التشــقـق وتحســين التلــوين وجــودة ثمــار الرمان صنف واندرفول باستخدام معاملات آمنة

كريم محمد فرج[1] - نيفين محمد نبيه ناجى[1] - محمد حامد الشيخ[2] - هشام شوقى عبادة[2]

1- قسم البساتين - كلية الزراعة - جامعه دمنهور - مصر

2- قسم الإنتاج النباتى - معهد بحوث زراعة الأراضى القاحلة - مدينة الأبحاث العلمية والتطبيقات التكنولوجية- مصر

إن سوء تلوين الرمان فى القشرة الخارجية و اللب الداخلى بالإضافة إلى تشقق الثمار من أهم المشكلات الرئيسية التى تواجه التوسع فى زراعة الرمان خاصة في ظل الظروف القاحلة في الصحراء، لذلك تم إجراء هذه الدراسة خلال موسمى 2014 و 2015 باستخدام شجيرات الرمان صنف واندرفول، تلك الأشجار تنمو باستخدام نظام الرى بالتنقيط فى مزرعة خاصة فى منطقة النوبارية بمحافظة البحيرة. تم معاملة الأشجار لتقليل التشقق بالرش ببعض العناصر الغذائية مرتين بينهم أسبوع عندما تكون الثمار فى حجم الخرزة باستخدام رشاشة يدوية حتى نقطة الجريان السطحى، واشتملت المعاملات على: الرش بالماء (كنترول)، بورات الكالسيوم بتركيز 100 جزء فى المليون، بورات الكالسيوم بتركيز 200 جزء فى المليون، زنك مخلبى بتركيز 100 جزء فى المليون، زنك مخلبى بتركيز 200 جزء فى المليون ونترات الكالسيوم بتركيز 1% (وزن/حجم)، وجد من النتائج أن الرش ببورات الكالسيوم 100 أو 200 جزء فى المليون أدى إلى تقليل تشقق الثمار وكانت اقل نسبة عند رش بورات الكالسيوم فى سبتمبر، علاوة على ذلك تم معاملة الأشجار لتحسين التلوين بالرش مرتين بينهم أسبوع عند اكتمال النمو بمعاملات تشتمل على: الرش بالماء (كنترول)، بروتون (حامض الابسيسيك 1%) بتركيز 100 جزء في المليون، بروتون بتركيز 100 جزء فى المليون مع الجليسرول بتركيز 1% (حجم/حجم)، بروتون بتركيز 100 جزء في المليون مضافا له سلفات البوتاسيوم بتركيز 1% (وزن/حجم)، كذلك بروتون بتركيز 100 جزء في المليون مضافا له سلفات البوتاسيوم بتركيز 1% (وزن/حجم) والجليسرول بتركيز 1% (حجم/حجم)، أيضًا الجليسرول بمفرده بتركيز 1% (حجم/ ئحجم)، والمعاملة الفردية بسلفات البوتاسيوم بتركيز 1% (وزن/حجم)، وتم إضافة المادة الناشرة غير الأيونية توب فيلم بتركيز 0.05% (حجم/حجم) لكل المعاملات، أظهرت النتائج أن التركيبة المحتوية على البروتون مع سلفات البوتاسيوم و الجليسرول أدت إلى زيادة الانثوسيانين في القشرة بالمقارنة مع الكنترول أو مع البروتون وحده، أيضًا محتوى الانثوسيانين فى اللب الداخلى حدث به زيادة معنوية عند المعاملة بالبروتون مع الجليسرول أو البروتون مع سلفات البوتاسيوم والجليسرول فى كلا الموسمين، بينما التسرب الإلكتروليتى كان متشابه فى معظم المعاملات، أيضًا كان هناك زيادة معنوية فى محتوى السكريات الكلية عند المعاملة بمختلف التركيبات المحتوية على البروتون مقارنة بالكنترول في العصير، لذلك توصى هذه الدراسة باستخدام التركيبة المحتوية على البروتون في وجود سلفات البوتاسيوم و الجليسرول لتحسين تلوين وجودة ثمار الرمان صنف واندرفول بطريقة ثابتة تحت الظروف الحقلية.

المحكمـــــون :

1- أ.د. أحمد محمد عبده عيسى أستاذ الفاكهة – كلية الزراعة – جامعة الإسكندرية.

2- أ.د. صفـــاء عبدالغني أحمد أستاذ الفاكهة المتفرغ – كلية الزراعة – جامعة الزقازيق.