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Effect of Some Horticultural Methods and Gibberellic Acid Spray on Yield, Fruit Quality and Storage Ability of "Costata" Persimmon Cultivar

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THIS INVESTIGATION was conducted during two successive seasons (2012 and 2013) on 22 years old "Costata" persimmon trees budded on "Lotus" rootstock grown on clay loam soil and irrigated with surface irrigation at Kalubeia Governorate, Egypt. The aim of this study was to evaluate the effect of some horticultural practices or GA_3 spray on fruit set, fruit drop percentage and yield (kg/tree). Also, N, P, K, Ca, carbohydrates leaf content and fruit quality parameters were determined. In addition fruit storability and fruit quality characters during cold storage for 6 weeks at 5^{o}C and RH 90-95% were studied. Results showed that girdling trees or GA_3 spray at full bloom was more effective in reducing fruit drop, increasing yield, leaf nutrient status, also, to prolong cold storage period and maintained the good quality of fruits.

Persimmon is one of the common deciduous fruit trees grown in warm regions. It is grown in some limited areas in Egypt. Recently, cultivation of oriental persimmon (*Diospyros kaki* L) is extended in Egypt especially "Costata" which is the leading cultivar. The persimmon area reached 811.6 ha (Ministry of Agriculture, Statistics, 2013). However, the blossom and young fruit drop are the main problems face this cultivar. In this respect Gould (1940) mentioned that "Costata" fruit setting is true parthenocarpically. Young parthenocarpy fruits tend to drop easily than young fertilized fruits (Chandler, 1957). Also, he stated that girdling trunks and branches tends to reduce the amount of fruit drop. Among horticultural practices which may improve carbohydrate balance and increase their availability is girdling, which increases fruit set and yield (Peng and Rabe, 1996). Moreover, girdling may enhance ethylene production (Autio and Greene, 1994) and results in a promotion of ripening (Hyodo, 1991). It has been found that cytokinin and gibberellin contents of the shoots are modified along with the C/N ratio, which increase (Li *et al.*, 2003). El-Shaikh *et al.* (1999) found that girdling at full bloom decreased fruit drop and consequently increased the yield of "Costata" persimmon trees. Girdling treatment gave the best fruit weight, volume, height, diameter and increased leaf area, dry weight and total carbohydrates. In addition, girdling on "Mit Ghamr" peach and "Costata" persimmon trees reduced the percentage of June drop, acidity and increased yield. Moreover, physical and chemical fruit characters (weight, volume, dimensions, firmness and TSS) were improved. Furthermore, leaf area, dry weight, total carbohydrates, N, P and K leaf contents were increased with girdling (Eliwa, 2003 and Eliwa *et al.*, 2003). Scoring or girdling increased the cumulative yield of "Triumph" persimmon

(Steyn *et al.,* 2008). Moreover, sucrose, glucose and fructose concentrations were the highest in fruits from girdled trees. Girdling had a distinctive and significant effect on most of fruit quality characteristics of "Nova" mandarin (Roussos and Tassis, 2011).

GA_3 applied after full bloom at 200 ppm increased persimmon fruit set in "Hiratanenashi" and "Saijo" persimmon cultivars (Hasegawa *et al.,* 1991). Also, Eliwa *et al.* (1998) reported that "Costata" trees sprayed with 100 ppm GA_3 in the first season and 200 ppm in the second one scored the highest increment in fruit weight, volume and dimensions as compared with control, also, GA_3 at 100 ppm recorded the highest increment in fruit firmness, while TSS, acidity and tannins of fruits did not clearly affected by GA_3. In addition, "Costata" persimmon trees sprayed with GA_3 at 50 and 100 ppm increased fruit set, yield and improved physical & chemical fruit quality (Kabeel, 1999). Also, Sweet cherry fruit responded to GA_3 treatment by delaying ripening date and increasing firmness at maturity (Choi *et al.,* 2004). Girdling and scoring treatments of "Anna" apple trees caused an increase in firmness, TSS and anthocyanin, meanwhile reduced acidity in fruits (Naiema *et al.,* 2006). The highest fruit set, yield and quality of "Canino" apricot trees were obtained by spraying 20 ppm GA_3 at full bloom compared with control (Abd El-Megeed *et al.,* 2007). Moreover, GA_3 sprayed at full bloom on "Le-Conte pear" trees significantly increased fruit set, yield, fruit weight, volume, firmness and TSS fruit content, while decreased fruit drop. In addition, these treatments also decreased fruit weight loss%, fruit decay% and acidity%, while increased fruit firmness and TSS during cold storage of pear (Nasr *et al.,* 2009).

The aim of this research is to study the effect of some horticultural methods (girdling, half girdling, scoring) and gibberellic acid spray at different concentrations on fruit set, fruit drop percentage and yield (kg/tree), also, physical and chemical fruit characteristics. In addition, fruit storability and fruit quality parameters during cold storage.

Materials and Methods

The present investigation was carried out during two successive seasons, 2012 and 2013 at Hort. Res. Sta., El-Kanater, Kalubeia Governorate, Egypt (30° 11' 35" N, 31° 8' 13" E) on 22-years old "Costata" persimmon trees (*Diospyros kaki* L.) budded on (*Diospyrous Lotus*) rootstock, planted at 4x5 meters apart. Trees were planted on clay loam soil and irrigated with surface irrigation. The 21 selected trees under study were similar in vigor, and received regularly similar cultural practices. The different treatments were arranged in a complete random block design. All treatments were carried out at full bloom during the two seasons. Girdling was carried out using a girdling knife by de-barking a complete ring of 5 mm around the main branches without wood layer injured, while de-barking half ring as half girdling. Also, using the same Knife to make a single cut through the bark to the xylem (scoring) during the two seasons.
The different treatments in this study were:

- Trees were sprayed with GA_3 at 25 ppm.

- Trees were sprayed with GA_3 at 20 ppm.
- Trees were sprayed with GA_3 at 15 ppm.
- Trees were girdled.
- Trees were half girdled.
- Trees were scored.
- Trees were left without spraying or girdling (control).

Each treatment consisted of three replicates, each replicate has one tree. Four main branches (one branch on each direction) were labeled and all the developed shoots on those branches, on August, were used for measuring preharvest parameters:

▪ Leaf area (cm^2): At growing season four main branches per tree in different directions were selected, four shoots (one shoot per branch) were labeled and all leaves for each shoot on mid-August were measured using Li-core 3100 area meter. Average number of leaves/shoot were counted to get area per leaf.

▪ Sample of twenty mature leaves of each replicate were taken from the tagged shoots on mid-August, dried and weighed to get leaf dry weight (g.). Total carbohydrate of leaves was measured by the method described by Dubois *et al.* (1956).

▪ Macro-elements leaf content: Twenty mature leaves on mid-August in both seasons were collected at random from the middle previously tagged shoots of each tree. Leaf samples were washed with tap water then distilled water and oven dried at 70°C to constant weight and prepared according to Evenhuis and Dewaard (1980) for determination leaf mineral content.

Nitrogen was estimated by micro-Kjeldahl method by Pregl (1945). Phosphorus was determined with a colorimetric method as described by Snell and Snell (1967). Potassium and Calcium were determined by using the Perkin Elmer Atomic Absorption Spectrophotometer Model 305B, according to Chapman and Pratt (1961) and expressed as percent on dry weight basis.

▪ Fruit set and yield: Percentage of initial fruit set (15 days after full bloom) was calculated as number of fruits per 100 flowers on four main branches for all treatments and control according to (Westwood, 1993).

▪ Yield, weight of fruits which harvested at maturity for each tree was recorded as Kg/tree.

▪ Total fruit drop: percentage of fruit drop was calculated by the following equation:

$$\text{Fruit drop (\%)} = \frac{\text{Number of fruitlets at fruit set - Number of harvested fruits}}{\text{Number of fruitlets at fruit set}} \times 100$$

▪ Physical fruit characteristics at harvest: Samples of 10 fruits for each replicate at harvest time were taken when the control trees reached maturity according to Abdel-Hafeez (2005) to determine, fruit weight (g), volume (cm^3), fruit length & fruit diameter (cm) and fruit firmness ($Ib/inch^2$) by using Magness and Taylor pressure tester with 5/16 inch plunger were determined.

▪ Chemical fruit characteristics at harvest: Total soluble solids% (TSS) was measured in fruit juice by hand refractometer. Total acidity % in juice as a malic acid was recorded according to (A.O.A.C., 1985). TSS/acid ratio was calculated. Total tannins (%) in fruit juice were estimated by the methods described by Winton and Winton (1958).

Fruit quality during storage

Mature uniform fruits were picked, washed with tap water and air dried. Treatments were arranged in a complete randomized design and each one replicated three times, however, every replicate was represented in two boxes (each one contained 20 fruits). Fruits were stored at 5^oC and RH 90-95% for 6 weeks. Samples of fruits were taken at random at 15 days intervals up to the end of storage.

The determination procedures were as follow:

Physical fruit characteristics

- Periodical loss in fresh fruit weight was estimated by:
  Weight loss (%) = Average loss in fruit weight/Average initial fruit weight x 100
- Fruit decay (%) = Number of decayed fruits/Number of stored fruits x 100. Decayed fruits from each treatment were periodically counted and expressed to percent of discarded fruits from the original number of stored fruits at each examining date according to McCornack and Brown (1973).
- Periodical changes in fruit firmness ($Ib/inch^2$) was measured as above mentioned.

Chemical fruit characteristics

Periodical changes in total soluble solids (%), acidity (%), TSS/acid ratio and total tannins (%) in fruit juice were determined as above mentioned.

Statistical analysis

The obtained data were subjected to analysis of variance according to Snedecor and Cochran (1982) and the means were compared using Duncan's multiple range test at 0.05% according (Duncan, 1955).

Results and Discussion

First: Preharvest studies

Fruit set and fruit drop%

Results in Table 1 and Fig. 1 showed effect of GA_3, girdling or scoring on the fruit set, fruit drop percentages of "Costata" persimmon trees through 2012 and 2013 seasons. All treatments had high fruit set% compared with control during the two seasons. The highest significant percentage of fruit set were in girdled trees (79.70&78.07 %) followed by GA_3 at 25 and 20ppm, while the lowest significant values were observed in control trees (41.30&38.05%) at 1st and 2nd seasons, respectively. All treatments significantly decreased fruit drop% as compared with control trees. Girdled trees recorded the lowest fruit drop % (20.20 &18.70%), while it was (68.60&73.45%) in control at both seasons, respectively.

Yield (kg) and fruit weight (g)

From data presented in Table 1 it is obvious that girdling and GA_3 spray on trees increased the yield and fruit weight than those of scoring or control trees. Thus, girdling produced the highest yield (32.14 & 34.84 kg/tree) and average fruit weight (114.2 & 127.5g) at both seasons, respectively as a result of high fruit set and low fruit drop percentages. Vice versa, scoring and control trees produced the lowest yield (20.02 & 21.06 kg/tree), (19.80 & 21.10 kg/tree) and fruit weight (96.63 & 105.4 g), (82.42.42 & 105.2g) as a result of low fruit set and more fruit drop during the two seasons, respectively.

TABLE 1. Effect of girdling, GA_3 and scoring on fruit set, fruit drop, yield and fruit weight of "Costata" persimmon cultivar at harvest during 2012 and 2013 seasons.

Treatments	F. set (%)		F. drop (%)		Yield (kg/tree)		F. weight (g)	
	2012	2013	2012	2013	2012	2013	2012	2013
GA3 25ppm	65.20b	56.45c	28.36f	29.70f	29.71b	32.09b	113.9a	126.9a
GA3 20ppm	62.33c	58.65c	36.07e	37.85e	27.78c	29.94c	112.2b	125.6bc
GA3 15ppm	58.60e	54.02e	50.10c	53.39c	25.78d	27.75d	110.2c	125.8b
Girdling	79.70a	78.07a	20.20g	18.70g	32.14a	34.84a	114.2a	127.5a
½ Girdling	60.33d	54.75d	43.00d	45.37d	26.22d	28.24d	111.5b	124.9c
Scoring	49.50f	43.45f	65.33b	69.73b	20.02e	21.06e	96.63d	105.4d
Control	41.30g	38.05g	68.60a	73.45a	19.80e	21.10e	82.42e	105.2d

Means having the same letters in each column are not significantly different at 0.05 level.

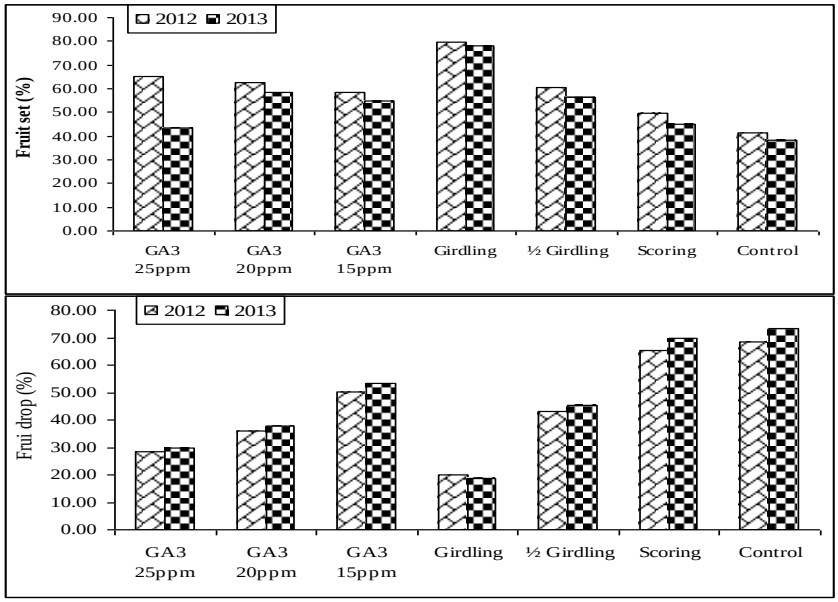

Fig. 1. Effect of girdling, GA_3 and scoring on fruit set and drop of "Costata" persimmon cultivar during 2012 and 2013 seasons.

These results are in agreement with those reported by Monselise *et al.* (1972) who indicated that girdling increases endogenous gibberellins activity in the aerial parts, the dual effect of gibberellin on flower formation and fruit setting may explain these influences of girdling (causing on abortion of late flowers which are in the first stages of differentiation and increasing setting of ovaries of earlier flowers). Blumenfeld (1986) reported that girdling prevented some fruit drop. Rabe and Van Rensburg (1996) mentioned that girdling increased final yield of citrus.

Similar trend was obtained also by El-Shaikh *et al.* (1999), Eliwa *et al.* (2003), Eliwa (2003) and Naiema *et al.* (2006), they reported that girdling increased yield, fruit weight, volume and dimensions. Moreover, GA_3 results are in accordance with Hasegawa, *et al.* (1991), EL-Sese (2005), Steyn *et al.* (2008) and Guirguis *et al.* (2009) on persimmon, In addition, Nasr *et al.* (2009) on pear and Tuan and Ruey (2013) on "Wax" apple.

Fruit volume (cm^3), dimensions (cm) and firmness (Ib/in^2)

Effect of GA_3, girdling or scoring treatments on the physical characteristics of "Costata" persimmon fruits during 2012 and 2013 seasons shown in Table 2. The achieved results of both seasons confirmed that fruits resulted from girdled trees or sprayed with 25 ppm GA_3 were the biggest in volume. Also, there was an increase in fruit length and diameter with all GA_3 levels or girdling as compared with either scoring or control trees which had the smallest values during the two seasons. In addition, all treatments recorded higher significant fruit firmness compared to control

trees. Moreover, GA_3 sprayed trees gave the highest firmness values at 25 ppm (20.50, 21.43) and 20 ppm (20.15, 21.05 Ib/inch^2) during the two seasons, respectively.

These results are in harmony with those obtained by El-Shaikh *et al.* (1999), Mostafa (2002), Eliwa *et al.* (2003), Eliwa (2003). They found that girdling after fruit set increased both length and diameter of fruits, also, Roussos and Tassis (2011) cleared that "Satsuma" girdling treatment had a distinctive and significant effect on fruit quality.

Furthermore, Clayton *et al.* (2006), Steyn *et al.* (2008), Guirguis *et al.* (2009), on persimmon, Nasr *et al.* (2009) on pear and Tuan & Ruey (2013) on apple stated that GA_3 was effective in this respect.

TABLE 2. Effect of girdling, GA_3 and scoring on fruit volume, length, diameter and fruit firmness of "Costata" persimmon cultivar at harvest during 2012 and 2013 seasons.

Treatments	F. volume (cm^3)		F. length (cm)		F. diameter (cm)		F. firmness (Ib/in^2)	
	2012	2013	2012	2013	2012	2013	2012	2013
GA3 25ppm	116.6a	128.5ab	6.80a	6.32a	6.46ab	6.25b	20.50 a	21.43 a
GA3 20ppm	114.1bc	127.3bc	6.69a	6.20ab	6.38a-c	6.15b	20.15 a	21.05 ab
GA3 15ppm	111.7d	127.8a-c	6.65a	6.13b	6.30bc	6.05bc	19.81 ab	20.72 bc
Girdling	115.4ab	129.5a	6.75a	6.24ab	6.50a	6.38a	19.60 abc	2o.51 cd
½ Girdling	113.0cd	126.4c	6.63a	6.18ab	6.25c	5.90c	19.47 abc	20.13 de
Scoring	98.62e	108.3d	6.11b	5.79c	5.93d	5.44d	19.01 bc	19.90 ef
Control	97.50e	108.0d	6.12b	5.62d	5.97d	5.46d	18.75 c	19.66 f

Means having the same letters in each column are not significantly different at 0.05 level.

There are three important apparent mode of actions of GA_3, the first action that GA_3 intensifies an organ ability to function as a nutrient sink. The second one is the ability of GA_3 to increase the synthesis of IAA in plant tissues. The third action involves accelerated synthesis of hydrolytic enzymes (Addicott and Addicott, 1982). Thus, GA_3 has been recommended to produce better firmness and large fruits (Early, 1988).

In the same line, Eliwa *et al.* (2003) on peach Naiema *et al*. (2006) on apple, they reported that girdling treatment significantly increased fruit firmness.

On contrary, Mostafa (2002) indicated that girdling of "Dorsett Golden" apple trees reduced fruit firmness than that of control. Moreover, GA_3 increased fruit firmness of cherry and pear (Clayton *et al.*, 2006 and Nasr *et al.*, 2009).

However, GA_3 may increase flesh firmness because it cause less methylation of pectin which would leave more sites for Ca binding (Facteau, 1982).

Chemical Fruit Characteristics

It could be noticed from Table 3 that girdling treatment significantly improved TSS % in fruits which had the highest values (22.00, 22.60 %) compared to other treatments and control. While GA_3 spray at 25 ppm had the lowest values of TSS% (18.61, 19.30) in fruits at both seasons, respectively.

The best known effect of girdling are presumably the accumulation of assimilates above girdle, due to the blocking the downward translocation of soluble sugars, altering thus the carbohydrate partitioning (Li *et al.*, 2003 and Rivas *et al.*, 2006 & 2007) and increasing the availability of carbohydrates to the fruit inducing higher sugar concentrations (Agusti *et al.*, 2002).

TABLE 3. Effect of girdling, GA_3 and scoring on TSS, acidity, TSS/acid ratio and tannins fruit content of "Costata" persimmon cultivar at harvest during 2012 and 2013 seasons.

Treatments	TSS (%)		Acidity (%)		TSS/acidity		Tannins (%)	
	2012	2013	2012	2013	2012	2013	2012	2013
GA3 25ppm	18.61 c	19.30 d	0.422 a	0.390 a	44.15 d	49.50 f	1.38 a	1.36 a
GA3 20ppm	18.90 c	19.50 d	0.402 ab	0.370 b	47.22 d	52.72 f	1.30 ab	1.24 b
GA3 15ppm	19.22 c	19.78 d	0.385 ab	0.340 c	49.94 d	58.24 e	1.25 b	1.23b
Girdling	22.00 a	22.60 a	0.312 d	0.280 c	71.89 a	80.92 a	0.98 e	1.03 f
½ Girdling	21.40 ab	22.00 b	0.323 cd	0.293 de	66.48 ab	75.13 b	1.08 de	1.06 e
Scoring	19.53 c	21.55 b	0.340 cd	0.308 d	61.48 bc	70.03 c	1.14 cd	1.12 d
Control	19.22 c	20.78 c	0.363 bc	0.331 c	54.14 cd	62.78 d	1.20 bc	1.15 c

Means having the same letters in each column are not significantly different at 0.05 level

Moreover, girdling treatment gave the lowest values of acidity (0.312, 0.280) in fruits, while GA_3 sprays at 25 ppm gave the highest acidity values (0.422,0.390 %) compared to control at 1st and 2nd seasons, respectively.

As for maturity index, girdling of trees had the highest TSS/acid ratio in fruits (71.89, 80.92 %), but GA_3 spray at 25 ppm gave the least ratio (44.15,49.50) at both seasons, respectively.

These results are in line with El-Fakharani *et al.* (1995), Peng & Rabe (1996), El-Shaikh *et al.* (1999), Kabeel (1999), Eliwa *et al.* (2003), Eliwa (2003), Guirguis *et al.* (2009), Nasr *et al.* (2009) and Tuan & Ruey (2013).

With regard to tannins content in "Costata" persimmon fruit, GA_3 spray at all levels gave the highest values comparing with control and other treatments especially at 25 ppm (1.38, 1.36 %), on the contrary, the lowest tannins fruit content than control and the other treatments was related to girdling treatment (0.98,1.03 %) at both seasons, respectively.

Table 4 showed the effect of GA_3, girdling or scoring on leaf area, dry weight and total carbohydrates in "Costata" persimmon leaf through 2012 and 2013 seasons. GA_3 sprays and girdling significantly increased leaf area and its dry weight during the two seasons compared with scoring and control. GA_3 at 25ppm recorded the highest values (81.86, 84.42 cm^2 of leaf area) and (0.88, 0.96 g of leaf dry weight) at both seasons, respectively.

Moreover, leaves of girdled trees had the highest significant values of total carbohydrate (8.87, 8.36 mg/g f.w.) followed by 25 ppm GA_3 (8.42, 7.95) at the two seasons, respectively. On contrast, leaves of control trees had the lowest values (6.77, 6.62), while the other treatments had in between values in this respect.

TABLE 4. Effect of girdling, GA_3 and scoring on leaf area, leaf dry weight and carbohydrates of "Costata" persimmon cultivar during growing seasons 2012 and 2013.

Treatments	Leaf area (cm^2)		Leaf dry weight (g.)		Carbohydrates (mg/g .f.w.)	
	2012	2013	2012	2013	2012	2013
GA3 25ppm	81.86a	84.42a	0.88a	0.96a	8.42ab	7.95ab
GA3 20ppm	77.54b	80.81b	0.83ab	0.90ab	8.08bc	7.60bc
GA3 15ppm	75.12c	76.73d	0.79bc	0.78cd	7.76bc	7.20c-e
Girdling	73.74d	77.80c	0.75c	0.83bc	8.87a	8.36a
½ Girdling	69.43e	71.68e	0.66d	0.70de	7.91bc	7.39b-d
Scoring	62.44f	65.15f	0.61de	0.66e	7.35cd	6.80de
Control	62.33f	65.14f	0.58e	0.62e	6.77d	6.62e

Means having the same letters in each column are not significantly different at 0.05 level

The obtained results agree with those of El-Shaikh *et al.* (1999), Kabeel (1999), Eliwa *et al.* (2003) and Roussos & Tassis (2011). Generally, El-Shaikh *et al*. (1999) found that fruit weight and size were correlated with leaf area.

However, Girdling results could be attributed to the effect of girdling on increasing the accumulation of carbohydrate in the parts above wounds (Beruter and Feusi, 1997) and changes in hormones concentration such as gibberellins (Wallerstein *et al.,* 1993).

Table 5 presented the effect of GA_3, girdling or scoring on N, P, K, Ca percentages in "Costata" persimmon leaf through 2012 and 2013 seasons. Leaves from girdling trees contained the highest values of N (2.47, 2.74 %). In addition, all treatments significantly increased P and K leaf content comparing with control during the two seasons, respectively. Also, the differences between all treatments of P leaf content were no significant. Furthermore, 25ppm GA_3 at both seasons followed by 20 ppm GA_3 in the 1st season recorded the highest significant values of Ca leaf content (2.84, 2.87 and 2.74 %) compared to control and other treatments. On the other hand, the lowest values of Ca were noticed with girdling treatment (1.95, 1.88).

In this respect, Eliwa *et al.* (2003) and Eliwa (2003) found that leaf N, P and K contents were significantly increased by girdling treatments.

Noticeably, girdled trees leaf scored a decrease in Ca content than control at both seasons. This trend is in agreement with Eliwa *et al.* (2003) on persimmon. In this concern, Priestly (1976) mentioned that calcium concentrations in girdling limbs of apple trees were very low because calcium depended on phloem transport.

TABLE 5. Effect of girdling, GA_3 and scoring on nitrogen, phosphorus, potassium and calcium leaf content of "Costata" persimmon cultivar during growing seasons 2012 and 2013.

Treatments	N%		P%		K%		Ca%	
	2012	2013	2012	2013	2012	2013	2012	2013
GA3 25ppm	2.16c	2.30c	0.26a	0.27a	1.70a	1.63a	2.84a	2.87a
GA3 20ppm	2.14d	2.23d	0.25a	0.27a	1.63ab	1.55ab	2.74a	2.72b
GA3 15ppm	2.09e	2.18e	0.25ab	0.27ab	1.60ab	1.53ab	2.61b	2.60b
Girdling	2.47a	2.74a	0.27a	0.28a	1.56bc	1.48b	1.95e	1.88f
½ Girdling	2.21b	2.37b	0.26a	0.28a	1.55bc	1.46bc	2.06e	2.03e
Scoring	2.06f	2.14f	0.25ab	0.26ab	1.45cd	1.36c	2.35c	2.38c
Control	1.92g	2.02g	0.23b	0.25b	1.34d	1.25d	2.17d	2.25d

Means having the same letters in each column are not significantly different at 0.05 level

Second: Storage studies

Physical fruit characteristics

Fruit decay and weight loss percentage

Data in Table 6 and Fig. 2, 3 cleared that both fruit decay % and weight loss % gradually increased with the advance of the storage period and reached their maximum after 6 weeks at the end of storage period (25.10 & 22.43 % decay) and (17.96 & 16.05 % weight loss) during the two seasons, respectively. There were no decayed fruits or weight loss % of fruits after 2 weeks of storage period with GA_3 or girdling. Concerning the effect of treatments, the lowest values of fruit decay and weight loss % were related to GA_3 spraying than other treatments especially at 25 ppm. They reached (5.92 & 5.01 % decay) and (9.29 & 7.89 % weight loss) at the two seasons, respectively.

As for the interaction, all treatments significantly reduced the fruit decay % and weight loss % compared to control. The lowest discarded fruits % and weight loss % were related to GA_3 25 ppm treatment after 4 or 6 weeks of cold storage at 5^oC**.** They reached (16.04, 14.02 %) and (16.32, 14.61 %) after 6 weeks at both seasons, respectively.

Those results are in agreement with those achieved by Turk (1993), Kamal and Rabeh (1989), Abdel-Hafeez (2005) on persimmon and Nasr *et al.* (2009) on pear.

However, Zhiguo *et al.* (1999) reported that GA_3 applied on the tree delayed fruit maturation and harvest, also, reduced flesh browning after cold storage. Moreover, cold temperature storage is required to reduce the generation of heat, however, low temperature as a beneficial effect on delaying the rapid fruit softening and reduce fruit decay by reducing the respiratory rate of fruits (Fawaz and Sabek, 2006).

TABLE 6. Effect of girdling, GA_3 and scoring on decay% and weight loss% of "Costata" persimmon fruits during cold storage 2012 and 2013 seasons.

Treatments	Decay (%)					Weight loss (%)				
	0	2	4	6	Means	0	2	4	6	Means
1st season										
GA3 25ppm	0.0	0.0	7. 62m	16.04i	5..92G	0.0	7..40 m	13.45 h	16.32 de	9.29E
GA3 20ppm	0.0	0.0	9..30l	17.50h	6.70F	0.0	7..82lm	14.02gh	16.74 de	9.65D
GA3 15ppm	0.0	0.0	10.40k	18.80g	7..30E	0.0	8.42kl	13.90 gh	17.01 cd	9.83D
Girdling	0.0	0.0	21.86f	30.89c	13.19B	0.0	9. 05jk	14.50 fg	17.60 bc	10.29C
½ Girdling	0.0	0.0	17.42 h	26.88d	11.07C	0.0	9..30 j	15.20 f	18. 03 b	10.63BC
Scoring	0.0	0.0	14.70j	23.16e	9.47D	0.0	9..52 j	16.03 e	18.35 b	10.98B
Control	0.0	0.0	33.80b	42.44a	19.06A	0.0	10.70 i	17.90 b	21.65 a	12.56A
Mean	0.0C	0.0C	16.44B	25.10A		0.0D	8.89C	15.00B	17.96A	
2nd season										
GA3 25ppm	0.0	0.0	6.02l	14.02h	5.01G	0.0	5.30 n	11.66 i	14.61ef	7.89 E
GA3 20ppm	0.0	0.0	7.24k	15.80g	5.76F	0.0	6.01m	12.20hi	15.00 de	8.30D
GA3 15ppm	0.0	0.0	8.36j	17.18f	6.39E	0.0	6.51lm	12.23hi	15.02 de	8.44D
Girdling	0.0	0.0	13.60h	22.20d	8.95C	0.0	6.97kl	12.80gh	15.55 cd	8.83 C
½ Girdling	0.0	0.0	14.05h	25.55c	9.90B	0.0	7.22 k	13.30 g	15.90 bc	9.11 C
Scoring	0.0	0.0	11.55i	21.25e	8.20D	0.0	7.39 k	14.10 f	16.24 b	9.43 B
Control	0.0	13.80h	31.00b	41.00a	21.45A	0.0	8.05 j	16.02bc	20.00 a	11.02A
Mean	0.0D	1.97C	13.12B	22.43A		0.0D	6.78C	13.19B	16.05A	

Means having the same letters in each column, line or interaction are not significantly different at 0.05 level

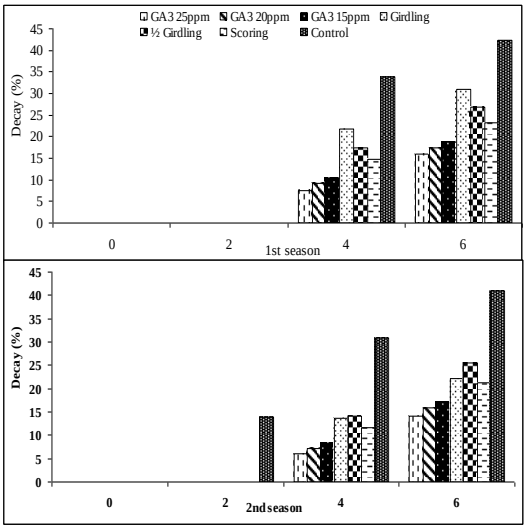

Fig. 2. Effect of girdling, GA_3 and scoring on fruit decay% of "Costata" persimmon fruits during cold storage 2012 and 2013 seasons.

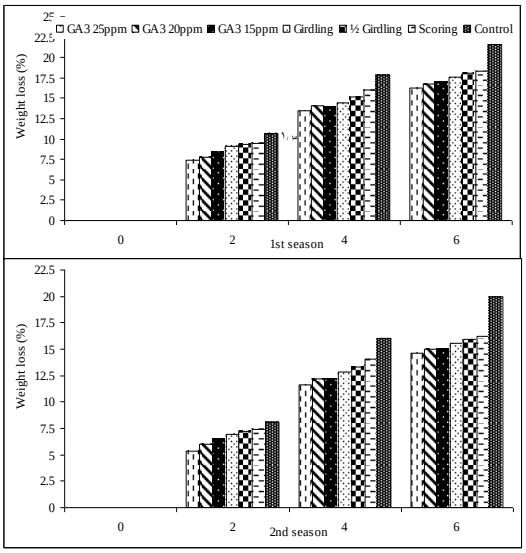

Fig. 3. Effect of girdling, GA_3 and scoring on fruit weight loss% of "Costata" persimmon fruits during cold storage2012 and 2013 seasons.

Fruit firmness

Concerning the fruit firmness, Data presented in Table 7 indicated that, a gradual decrease in fruit firmness was observed towards the end of the storage period (13.34, 14.20 Ib/inch^2). Moreover, there were a significant differences detected between all treatments compared to control. Control fruits recorded the less firmness of fruits (15.32, 16.23 Ib/inch^2), while fruit treated with all GA_3 levels gave the highest firmness than control specially at 25 ppm GA_3 (17.78 & 18.70 Ib/inch^2) during cold storage at both seasons under study. As for interaction, the highest fruit firmness values were scored after 6 weeks when treated with GA_3 at 25 ppm (14.50, 15.40 Ib/inch^2) at both seasons, respectively. This decrease in firmness may be due to the polygalacturonase activity on the pectic substances.

However, fruit firmness decreased as the degradation rate of insoluble proto-pectins to more simple pectins increased with the advanced of storage period (Fawaz and Sabek, 2006). Similar results were obtained in this concern by Ben-Arie *et al*. (1991), Turk (1993), Abdel-Hafeez (2005) and Nasr *et al*. (2009).

However, GA_3 might increase flesh firmness because it cause less methylation of pectin which would leave more sites for Ca binding (Facteau, 1982).

TABLE 7. Effect of girdling, GA_3 and scoring on firmness and TSS of "Costata" persimmon fruits during cold storage 2012 and 2013 seasons.

Treatments	Firmness (Ib/inch^2)					TSS (%)				
	0	2	4	6	Mean	0	2	4	6	Means
	1st season									
GA3 25ppm	20.50 a	19.10 de	17.02 h	14.50k	17.78 A	18.61q	19.12 nop	19.90l-o	20.52j-m	19.54 F
GA3 20ppm	20.15 ab	19.01 de	16.82 hi	14.10l	17.52 A	18.90 pq	19.50m-p	20.61i-l	22.40d-h	20.35 E
GA3 15ppm	19.81 bc	18.31 fg	16.30hi	13.45mn	16.96 B	19.22 o-q	20.15lmn	21.60g-i	22.30d-h	20.82 DE
Girdling	19.60 bcd	18,04 g	15.85j	12.89n	16.59 C	22.00 e-h	22.80de	24.10bc	25.52a	23.60 A
½ Girdling	19.47 cd	18.06 g	16.10j	13.52l-n	16.79 BC	21.40hij	22.05e-h	23.25cd	24.70b	22.85 B
Scoring	19.01 de	17.87 g	16.05j	13.66lm	16.65 BC	19.53m-p	21.30h-k	22.00f-h	22.60d-g	21.70 C
Control	18.75 ef	16.80 hi	14.45k	11.30 o	15.32 D	19.22o-q	20.32klm	21.63f-i	22.72d-f	21.05 D
Means	19.61 A	18.17 B	16.08 C	13.34 D		20.08D	20.75C	21.87B	22.96A	
	2nd season									
GA3 25ppm	21.43 a	20.00 cd	17.97 h	15.40 l	18.70 A	19.30r	19.82pq	20.28 no	21.20kl	20.15G
GA3 20ppm	21.05 ab	20.12 cd	17.55h-j	15.00lm	18.43 B	19.50qr	20.10op	21.20kl	22.04hi	20.71F
GA3 15ppm	20.72 b	19.22 fg	17.21i-k	14.33no	17.87 C	19.78pq	20.72m	22.40gh	23.10ef	21.50E
Girdling	20.51 bc	18.95 g	16.76 k	13.78o	17.50 D	22.60g	23.42e	24.70c	26.08a	24.20 A
½ Girdling	20.13 cd	19.40 e-g	17.04 jk	14.20no	17.69 CD	22.00 hi	22.63g	23.86d	25.27b	23.44 B
Scoring	19.90 de	18.82 g	17.00 jk	14.52m	17.56 D	21.55jk	21.85ij	22.70fg	23.10ef	23.30C
Control	19.66 d-f	17.71 hi	15.35l	12.20p	16.23 E	20.78lm	20.60mn	22.10hi	23.40e	21. 72 D
Means	20..49 A	19.17 B	16.98 C	14.20 D		20.79D	21.31 C	22.46 B	23.46A	

Means having the same letters in each column, line or interaction are not significantly different at 0.05 level

Chemical fruit characteristics

Total Soluble Solids

As for TSS, data in Table 7 indicated that there was a continuous increase in the TSS fruit content during all storage period and they reached maximum values (22.96, 23.46 %) at the end of storage period at 1st and 2nd seasons. In addition, the highest TSS values (23.60 & 24.20 %) were recorded by girdling followed by half girdling, while the least TSS values (19.54 & 20.15 %) were recorded by 25 ppm GA_3 at both seasons, respectively. The interaction, it was noticed that, the highest significant values of TSS were scored with girdling treatment at all storage period and reached maximum values (25.52, 26.08 %) after 6 weeks of cold storage at 5°C and RH 90-95% at both seasons, respectively.

Fruit acidity percentage and TSS/acid ratio

Data presented in Table 8 achieved that the stored fruits exhibited a trend of acidity decrease as the storage period advance, the least acidity value was obtained after 6 weeks (0.265 & 0.218 %) at 1st and 2nd seasons, respectively. All treatments significantly decreased acid fruit content comparing with control fruits. The lowest value was accompanied with girdling treatment (0.254 & 0.205 %). Moreover, the interaction revealed that, the lowest significant acid fruit content values (0.184, 0.138) were noticed after 6 weeks of storage with fruits from girdled trees, while the biggest acidity percentage (0.344 & 0.313 %) was recorded by 25 ppm GA_3 after 6 weeks of cold storage during both seasons, respectively.

These results are in harmony with those reported by Kamal and Rabeh (1989), Mostafa (2002), Abdel-Hafeez (2005), Chitu *et al*. (2007) and Nasr *et al*. (2009). Acidity changes may be related to changes in the mechanisms of the respiratory process (Abdel-Hafeez, 2005).

Concerning TSS/acid ratio Fig.4 it is gradually increased as the storage period prolonged till reached the maximum value (91.91&117.7 %) at both seasons, respectively. As for treatments, girdling treatments significantly increased TSS/acid ratio (98.35, 128.1%) than control and other treatments. While GA_3 at all levels significantly decreased the ratio compared with control at both seasons. Furthermore, the interaction appeared that, the highest values of TSS/acid ratio were recorded by girdling treatment at the end of storage period (139.21,189.0 %) at both seasons, respectively.

Effect of girdling on TSS % and TSS/acid ratio based on changes in translocation and accumulation of carbohydrates (Fisher *et al.,* 1983). However, hydrolysis of insoluble solids to soluble ones occurred in a slow manner in fruits held at 5°C. In this respect, Autio and Greene (1994) reported that girdling may enhance ethylene production.

TABLE 8. Effect of girdling, GA_3 and scoring on acidity and TSS/acid ratio of "Costata" persimmon fruits during cold storage 2012 and 2013 seasons.

Treatments	Acidity (%)					TSS/acid ratio				
	0	2	4	6	Means	0	2	4	6	Means
	1st season									
GA_3 25ppm	0.422a	0.400ab	0..370cd	0.344d-g	0.384 A	44.15 l	48.10kl	53.88j-l	59.85h-k	51.50 F
GA_3 20ppm	0.402ab	0.372cd	0.344d-g	0.318g-j	0.359B	47.22 kl	52.44j-l	60.10h-k	70.71f-h	57.62 EF
GA_3 15ppm	0.385bc	0.350d-f	0.325 f-i	0.295jk	0.339C	49.94 kl	57.62 h-l	66.58 g-j	75.85e-g	62.50 DE
Girdling	0.312h-j	0.280jk	0.240no	0.184 p	0.254G	71.89 f-h	81.55d-f	100.78 c	139.21 a	98.35 A
½ Girdling	0.323 f-j	0.298jk	0.250mn	0.213 o	0.271F	66.48g-j	71.26f-h	92.96cd	116.05 b	86.69 B
Scoring	0.340e-h	0.310ij	0.276k-n	0.238no	0.291E	61.48g-k	69.05f-i	58.98h-l	95.17 cd	71.17 C
Control	0.363c-e	0.338e-i	0.304 jk	0.263l-n	0.317D	54.14 i-l	60.14h-k	71.23f-h	86.55 de	68.02 CD
Means	0.364 A	0.335B	0.301C	0.265D		56.47 D	62.88 C	72.07B	91.91A	
	2nd season									
GA_3 25ppm	0.390 a	0.353c	0.345 cd	0.313 e	0.350A	49.50 p	56.19 no	58.79mn	67.78j-l	58.07 G
GA_3 20ppm	0.370 b	0.340cd	0.306ef	0.272hi	0.322B	52.72op	59.15 mn	69.35i-k	81.09 h	65.58 F
GA_3 15ppm	0.34 0cd	0.312e	0.254 j	0.234 k	0.285C	58.24m-o	66.45 kl	88.29 g	98.80 f	77.95 E
Girdling	0.280 gh	0.220k	0.182m	0.138 o	0.205G	80.92 h	106.75e	135.8 c	189.0 a	128.1 A
½ Girdling	0.293 fg	0.261ij	0.216 l	0.166n	0.234F	75.13 i	86.93 g	110.5 e	152.3 b	106.2 B
Scoring	0.308 ef	0.270h-j	0.224 k	0.190m	0.248E	70.03i-k	81.04h	101.3 f	121.8 d	93.56 C
Control	0.331 D	0.285gh	0.252 j	0.216 l	0.271D	62.78 lm	72.46 jk	87.93g	108.6 e	82.93 D
Means	0.330 A	0.291B	0.254C	0.218D		64.19 D	75.57C	93.14B	117.7 A	

Means having the same letters in each column, line or interaction are not significantly different at 0.05 level.

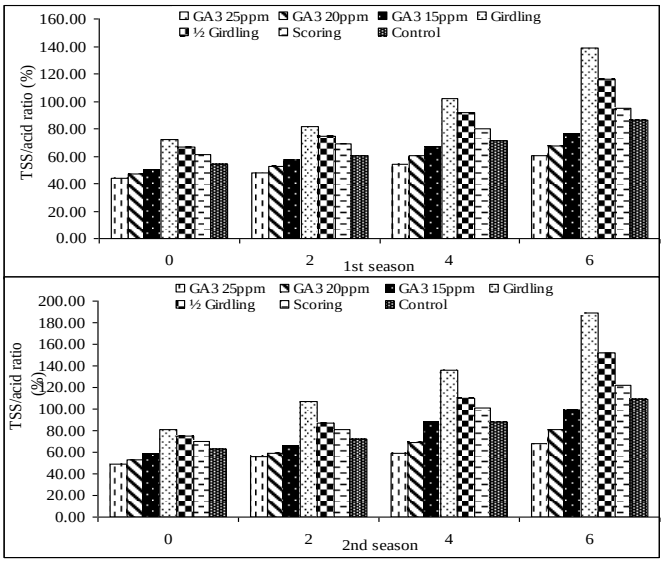

Fig. 4. Effect of girdling, GA_3 and scoring on TSS/acid ratio of "Costata" persimmon fruits during cold storage 2012 and 2013 seasons.

Tannins percentage

Data shown in Table 9 and Fig. 5 cleared that, stored fruits exhibited gradually decrease in their total tannins content with the progress of the storage period to reach the minimum values at the end of storage period (0.142 & 0.585 %). As for treatments, girdling and half girdling treatments were the best significant treatments in decreasing tannins fruit content (0.512, 0.735%) and (0.591, 0.797%) at both seasons, respectively compared with control. Concerning the interaction, fruits from girdled treatment exhibited the lowest total tannins content at all storage period than other treatments and reached less content at the end of storage period (0.059 & 0.342 %) during the 1^{st} and 2^{nd} seasons, respectively.

These results are in conveyable with Kamal and Rabeh (1989), Ben-Arie *et al.* (1991) and Abdel-Hafeez (2005) on persimmon. They found that tannins fruit content were decreased as cold storage period prolonged.

TABLE 9. Effect of girdling, GA_3 and scoring on total tannins% of "Costata" persimmon fruits during cold storage 2012 and 2013 seasons.

Treatments	Total tannins (%)				
	0	2	4	6	Means
	1st season				
GA3 25ppm	1.380 a	1.033 fg	0.607 i	0.216 m	0.809 A
GA3 20ppm	1.300 b	1.030 fg	0.583 i	0.195 m	0.777B
GA3 15ppm	1.250 bc	0.846 h	0.483 j	0.157 mn	0.684 C
Girdling	0.980 g	0.642 i	0.370 l	0.059 o	0.512 F
½ Girdling	1.080 ef	0.800 h	0.392 kl	0.092 no	0.591 E
Scoring	1.140 de	0.814 h	0.440 jk	0.126 n	0.630 D
Control	1.200 cd	0.830 g	0.466 j	0.148 mn	0.661 CD
Mean	1.190 A	0.856 B	0.477 C	0.142 D	
	1st season				
GA3 25ppm	1.365 a	1.195 c	1.044 jk	0.780 o	1.086 A
GA3 20ppm	1.250 b	1.080 f	0.930 m	0.730 q	0.997 B
GA3 15ppm	1.235b	1.025 hi	0.820 n	0.656 t	0.934 C
Girdling	1.032 h	0.932 m	0.634 u	0.342 y	0.735 G
½ Girdling	1.065 g	0.974 l	0.673 s	0.476 x	0.797F
Scoring	1.116 e	0.993 k	0.690 r	0.513 w	0.828E
Control	1.154 d	1.014 ij	0.760 p	0.600 v	0.882 D
Mean	1.174 A	1.030 B	0.787 C	0.585 D	

Means having the same letters in each column are not significantly different at 0.05 level

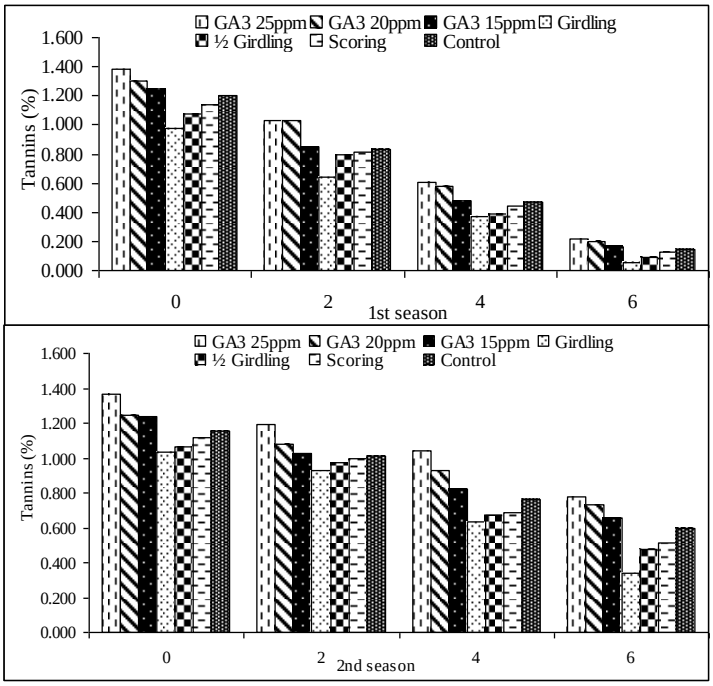

Fig. 5. Effect of girdling, GA_3 and scoring on total tannins% of "Costata" persimmon fruits during cold storage 2012 and 2013 seasons.

Conclusion

It could be concluded that complete girdling at full bloom of "Costata" persimmon trees was more effective in reducing fruit drop, increasing fruit set, yield, leaf nutrient status and improving fruit quality, as well as GA_3 spray has significant effect in this respect. In addition, girdling or GA_3 spray at full bloom helped "Costata" persimmon to prolong cold storage period and maintained the good quality of fruits.

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تأثير بعض المعاملات البستانية ورش حمض الجبرلين على المحصول وجودة الثمار والقدرة التخزينية لصنف الكاكى "كوستاتا".

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أجريت هذه الدراسة خلال موسمين متتاليين ٢٠١٢ ، ٢٠١٣ على أشجار الكاكى صنف "كوستاتا" عمر ٢٢ عاما المطعومة على أصل "اللوتس" والنامية فى تربة طينية طميية و مروية بالغمر بمحافظة القليوبية- مصر. الهدف من هذه الدراسة تقييم تأثير بعض العمليات البستانية أو رش حمض الجبريللك على النسبة المئوية للعقد ، تساقط الثمار والمحصول (كجم/شجرة). كذلك محتوى الأوراق من الكربوهيدرات والعناصر الكبرى نيتروجين ، فوسفور ، بوتاسيوم و كالسيوم وكذلك تم تقدير صفات جودة الثمار. إضافة إلى دراسة القدرة التخزينية للثمار وصفات جودتها خلال التخزين المبرد على درجة ٥ درجة مئوى ورطوبة نسبية ٩٠-٩٥٪ ، أوضحت نتائج الدراسة أن إجراء التحليق للأشجار أو رشها بحمض الجبر لين أثناء تمام التزهير كان الأكثر فاعلية فى تقليل نسبة التساقط للثمار و زيادة المحصول و المحتوى المعدنى للأوراق، بالإضافة إلى إطالة فترة التخزين المبرد للثمار مع إحتفاظها بصفات الجودة.