Response of Costata Persimmon Trees to Different Rootstocks and NK Fertilization
2. Fruit quality at Harvest and Post-storage

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ABSTRACT

This investigation was carried out in 2000 and 2001 to study the effect of rootstock (seedling and Trabols), nitrogen (0, 600, 1200 and 1800 g ammonium nitrate per tree), potassium (0, 600 and 1200 g potassium sulphate per tree) and their interactions on fruit quality at harvest date and after storage at 1-2°C or at room temperature of Costata persimmon trees. The results are summarized as follow:

1. Regardless of potassium fertilization and rootstock, nitrogen fertilization increased fruit weight and total chlorophyll at harvest date and weight loss and total chlorophyll after 60 days from storage at 1-2°C. Whereas, it decreased fruit TSS and total sugars at harvest date and after storage at 1-2°C or at room temperature, fruit firmness, tannins and pectin at harvest date or after cold storage and reducing sugars at harvest date. The nitrogen fertilization did not affect fruit carotene at harvest date and after storage at 1-2°C or at room temperature, non-reducing sugars at harvest date, fruit acidity after storage at 1-2°C or at room temperature and fruit weight loss, fruit firmness, total chlorophyll, tannins and pectin after storage at room temperature.
2. Regardless of nitrogen fertilization and rootstock, potassium fertilization increased fruit weight and reducing sugars at harvest date only, fruit TSS, total sugars and carotene at harvest date and after storage at 1-2°C or at room temperature and fruit acidity at harvest date and after cold storage, but decreased fruit tannins and pectin at harvest date. Potassium fertilizer did not affect fruit firmness and total chlorophyll at harvest date and after storage at 1-2°C or at room temperature, fruit weight loss after storage at 1-2°C or at room temperature, non-reducing sugars at harvest date, fruit acidity after 30 days at room temperature and fruit tannins and pectin after 60 days at 1-2°C or after 30 days at room temperature.
3. Regardless of nitrogen and potassium fertilization, the Costata persimmon fruits on seedling rootstock had higher fruit weight and total chlorophyll at harvest date, and lower fruit TSS and total sugars at harvest date and after cold storage and firmness, fruit reducing sugars and fruit pectin at harvest date. Rootstocks did not affect fruit acidity and tannins at harvest and after 60 days at 1-2°C or after 30 days at room temperature, fruit weight loss, total sugars and TSS after 30 days from storage at room temperature, firmness, total chlorophyll, carotene and pectin after 60 days from storage at 1-2°C and 30 days from storage at room temperature.

INTRODUCTION

Costata persimmon cultivation is starting to expand numerously allover Egypt. Thus, it is going to play an important role in the Egyptian fruit industry. The Costata persimmon seems to be the most predominant persimmon variety grown in Egypt. However, the fruits have a relatively short storability period and, therefore, they are usually marketed without practicing any post-harvest cold storage treatments. Many factors may affect the quality and the storability of the fruits. In addition, the influence of rootstock on fruit quality and storage particularly for apple has been reported (Drake *et al.*, 1988 and 1991 and Kassem, 1996). These studies have indicated that rootstocks could influence fruit weight, firmness, colour, TSS, acidity, carbohydrate concentration and incidence of fruit disorders at harvest time and post-storage. On the other hand, nothing has been reported about the influence of rootstocks on fruit quality at harvest or post-storage of Costata persimmon fruits. Also, NK fertilizers had been reported as one of the factors affecting the quality of persimmon fruits (Suzuki *et al.*, 1989 and Abd El-Megeed, 1992). N fertilization increased fruit acidity and flesh firmness at harvest and after cold storage and it reduced weight loss during storage. The effect of K fertilization was less marked than that of N fertilization (Noe *et al.*, 1997). The present study was carried out to determine the fruit quality at harvest date and post-storage of Costata persimmon trees as affected by rootstocks, nitrogen, potassium fertilization and their interactions.

MATERIALS AND METHODS

The present study was carried out during 2000 and 2001 seasons. Fifteen years old Costata persimmon trees (*Diospyrus kaki*, L.) grown in a private orchard at El-Tarh region, El-Beheira Governorate and budded on seedling rootstock and Trabols rootstocks were used in the present study. The soil of the orchard was clay well drained with water table depth of 100-120 cm and pH of 7.8-7.9. The physical and chemical characteristics of the soil are presented in Table (1).

Trees were planted at 5 meters apart, were irrigated with Nile water every 15 days during each experimental season. The orchard was fertilized with organic manure at a rate of 25 m^3 per feddan in November every year. Calcium superphosphate was also added at a rate of 150 kg per feddan in mid February in both seasons. Forty-eight trees, as uniform as possible, were selected for each rootstock; i.e., 48 x 2 = 96 trees for the whole experiment.

Nitrogen fertilizer as ammonium nitrate (33.5% N) and potassium fertilizer as potassium sulphate (48% K_2O) were applied at different rates, either alone or in combination, to the selected trees. Nitrogen fertilizer was applied at four different rates; i.e., 0.0 (N_0), 600 g (N_1), 1200 g (N_2) and 1800 g (N_3) per tree. Potassium fertilizer was applied at three different rates; i.e., 0.0 (K_0), 600 g (K_1) and 1200 g (K_2) per tree. Nitrogen and potassium fertilizers were added at three equal doses; at early (for N fertilizer) and later (for K fertilizer) March, May and August of both seasons. Twenty-four fertilization treatments that represent all possible combinations of the two rootstocks, four levels of nitrogen fertilizer and three levels of potassium fertilizer were used in this study (4x3x2 = 24 treatments). Treatments were arranged in a randomized complete block design with four replicates for each treatment, using one tree as a single replicate (24x4 = 96 trees). Fertilizers were broadcasted on the soil surface 1.5-2.0 m apart from the tree trunk and trees were immediately irrigated after application. Each fertilization treatment was added for trees on each rootstock in the two successive seasons.

In addition, the effect of the different nitrogen and potassium fertilization treatments and different rootstocks on fruit quality at harvest date and post-storage was investigated.

Table 1. Physical and chemical properties of the experimental orchard soil samples at different soil depths.

Properties		Soil depth (cm)		
		0 - 30	30 - 60	60 - 90
Physical properties:				
$CaCO_3$	%	14.65	12.48	14.75
EC	mmhos/cm	0.9	1.1	2.6
Texture		clay	clay	clay
Chemical properties:				
Macro-elements				
N	%	0.17	0.10	0.11
P	ppm	55	26	42
K	ppm	0.1	0.6	1.1
Ca^{++}	meq/L	6.0	5.6	12.0
Mg^{++}	meq/L	2.8	2.6	5.8
Na^{+}	meq/L	2.4	2.8	7.2
Micro-elements				
Fe	ppm	22.7	19.6	20
Cu	ppm	14.3	8.9	10.6
Zn	ppm	13.2	7.3	12.8
Mn	ppm	54	31	47
Anions, meq/L				
CO_3^{--}		0.0	0.0	0.0
HCO_3^{-}		6	5.2	4.6
Cl^{-}		1.8	2.6	10.0
SO_4^{--}		3.6	3.9	11.8

Average fruit weight (g) was determined at normal commercial harvest date on October of each year. Fruit quality was determined on 7 fruits/replicate at harvest date of each year. Moreover, shelf life quality of 8 fruits/replicate was evaluated after 30 days storage at 20°C. Twelve fruits/replicate were evaluated after 60 days storage at 1-2°C and 85-90% relative humidity for post-cold storage fruit quality.

Fruit firmness was measured (lb/inch^2) using a 5/16" plunger. TSS (%) was determined by a hand refractometer. Acidity (%), as malic acid, was determined according to A.O.A.C (1985). Tannins (%) were determined by using the method of modified Lowenthal's permanganate oxidation procedure as described by Egan *et al.*(1981). Pectin was expressed as mg/100 g fresh weight. The reducing sugars were determined by Nelson method as illustrated by Malik and Singh (1980). The total soluble sugars were determined after hydrolysis with hydrochloric acid and the non-reducing sugars were calculated by the differences between total soluble sugars and reducing sugars. Total chlorophyll and carotene pigments in fruit skin tissues were determined according to the procedure outlined by Wensttein (1957). Colour degree was determined from 1 = green fruit to 5 = 100% of the surface covered with an orange colour.

All data obtained were statistically analyzed according to Little and Hills (1978).

RESULTS AND DISCUSSION

Average fruit weight

The effect of nitrogen fertilization on the average fruit weight at harvest date is presented in Tables (2 and 3). The data showed that, regardless of potassium fertilizer and rootstock, the average fruit weight was increased by N application, in both seasons. These results are in line with those reported by Abd El-Megeed (1992) on persimmon and Hipps (1997) on apple trees. Moreover, data in Tables (4 and 5) indicated that increasing nitrogen levels significantly increased the percentage of weight loss after the cold storage, in both seasons. On the other hand, weight loss was not affected by any of N levels after storage period of 30 days at room temperature, in both seasons. These results agreed with those found by Kassem (1991) on apple fruits. Abd El-Megeed (1992), working on persimmon fruits, found that the nitrogen fertilization did not affect fruit weight loss percentage after storage at 4°C or room temperature. On the contrary, Noe *et al.*(1997), working on apples, found that the nitrogen fertilization reduced weight loss during cold storage.

Regardless of nitrogen fertilizer and rootstock, fruit weight at harvest was increased by the application of 600 and 1200 g potassium sulphate per tree as compared with the control (Tables 2 and 3). These results are in agreement with those obtained by Kassem (1991), Abd El-Megeed (1992) and Neilsen *et al.*(1998). They all reported that potassium fertilization increased fruit weight and size and this might be due to the role of potassium on carbohydrate translocation. On the other hand, data in Tables (4 and 5) showed that fruit weight loss was not affected after 60 days storage at 1-2°C or after 30 days at room temperature, in both seasons. Similar results were also reported by Abd

Table 2. Effect of NK fertilization rates and rootstocks on fruit quality of Costata persimmon trees at harvest in 2000 seasons.

Factors		Fruit weight (g)	TSS (%)	Acidity (%)	Firmness (lb/in^2)	Total chlorophyll (mg/100 g)	Carotene (mg/100 g)	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)	Tannins (%)	Pectin (mg/100 g)
Nitrogen levels (N)	0	163.92	26.30	0.21	24.63	15.32	3.46	14.01	2.05	16.05	2.50	54
	1	165.89	24.52	0.22	22.82	16.85	3.24	14.45	2.60	17.05	2.13	51
	2	176.83	22.62	0.18	20.66	17.62	3.18	13.02	2.03	15.05	2.26	52
	3	172.61	23.28	0.14	20.20	18.58	3.68	12.30	2.42	14.72	1.98	44
L.S.D$_{0.05}$		6.26	2.07	0.030	2.86	2.16	NS	0.85	NS	0.92	0.41	6
Potassium levels (K)	0	164.85	22.54	0.17	21.86	17.26	2.21	12.68	2.32	15.00	2.50	52
	1	171.29	24.43	0.18	22.26	16.58	3.76	13.06	2.44	15.50	2.38	50
	2	173.34	25.54	0.21	22.11	17.46	4.22	14.60	2.09	16.69	1.79	49
L.S.D$_{0.05}$		5.46	1.80	0.028	NS	NS	0.59	0.74	NS	0.80	0.37	NS
Rootstocks (RT)	S	176.61	23.23	0.19	20.62	18.87	3.12	12.70	2.35	15.05	2.23	47
	T	162.57	25.11	0.18	23.54	15.31	3.66	14.19	2.21	16.40	2.26	54
L.S.D$_{0.05}$		4.48	1.48	NS	2.04	1.54	0.49	0.60	NS	0.66	NS	4
N x K		*	*	*	NS	NS	*	*	NS	*	*	NS
N x RT		*	*	*	*	*	NS	*	NS	*	NS	*
K x RT		*	*	NS	NS	NS	*	*	NS	*	*	NS
N x K x RT		*	*	*	*	*	*	*	*	*	NS	*

S = Seedling rootstock. T = Trabols rootstock.
* = Significant. NS = Not significant.

Table 3. Effect of NK fertilization rates and rootstocks on fruit quality of Costata persimmon trees at harvest in 2001 seasons.

Factors		Fruit weight (g)	TSS (%)	Acidity (%)	Firmness (lb/in^2)	Total chlorophyll (mg/100 g)	Carotene (mg/100 g)	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)	Tannins (%)	Pectin (mg/100 g)
Nitrogen levels (N)	0	136.67	25.83	0.19	25.86	16.46	4.16	12.64	3.23	15.87	2.22	52
	1	164.94	24.95	0.17	25.90	18.47	3.82	13.88	3.30	17.18	2.30	50
	2	172.35	24.50	0.16	22.60	20.08	4.22	12.08	3.72	15.80	2.06	48
	3	171.24	22.46	0.11	21.42	19.12	4.08	11.05	3.08	14.12	1.89	47
$L.S.D_{0.05}$		18.64	1.02	0.05	3.06	1.89	NS	1.10	NS	0.96	0.22	3
Potassium levels (K)	0	144.70	21.86	0.13	23.62	18.35	3.18	11.60	3.22	14.82	2.57	53
	1	171.90	24.24	0.17	24.18	18.72	4.21	12.66	3.43	16.10	2.21	51
	2	170.49	27.22	0.17	24.04	18.53	4.82	13.00	3.31	16.31	1.58	44
$L.S.D_{0.05}$		16.23	0.89	0.04	NS	NS	0.62	0.96	NS	0.84	0.19	2.6
Rootstocks (RT)	S	171.39	23.62	0.17	22.66	18.86	3.69	12.01	3.05	15.06	2.10	47
	T	153.37	25.26	0.16	25.25	18.20	4.46	12.82	3.59	16.41	2.14	52
$L.S.D_{0.05}$		13.30	0.73	NS	2.18	1.35	0.51	0.79	0.45	0.69	NS	2
N x K		*	*	*	NS	NS	*	*	NS	*	*	*
N x RT		*	*	*	*	*	NS	*	NS	*	NS	*
K x RT		*	*	NS	NS	NS	*	*	*	*	*	*
N x K x RT		*	*	*	*	*	*	*	*	*	NS	*

S = Seedling rootstock. T = Trabols rootstock

* = Significant. NS = Not significant

Table 4. Effect of NK fertilization rates and rootstocks on fruit quality of Costata persimmon trees after 60 days storage at 1-2°C in 2000 and 2001 seasons.

Factors		2000 season									2001 season								
		Weight loss (%)	TSS (%)	Acidity (%)	Firmness (lb/in²)	[illegible] (mg/100 g)	carotene (mg/100 g)	Total sugars (%)	Tannins (%)	Pectin (mg/100 g)	Weight loss (%)	TSS (%)	Acidity (%)	Firmness (lb/in²)	[illegible] (mg/100 g)	carotene (mg/100 g)	Total sugars (%)	Tannins (%)	Pectin (mg/100 g)
Nitrogen levels (N)	0	7.32	28.62	0.05	3.12	1.32	18.23	18.97	1.86	141	7.65	27.58	0.05	4.00	1.21	19.51	19.26	1.30	150
	1	7.48	28.72	0.05	3.00	1.45	18.62	18.26	1.08	148	7.86	27.18	0.04	4.16	1.65	19.72	[illegible]	1.42	145
	2	7.82	25.96	0.04	3.26	1.82	17.85	17.42	1.02	140	8.32	27.02	0.03	3.21	1.52	21.00	18.86	1.06	146
	3	8.32	25.01	0.04	2.12	2.00	19.05	16.08	0.81	122	8.86	25.46	0.03	2.18	1.83	20.22	16.27	0.68	142
$L.S.D_{0.05}$		0.36	3.38	NS	0.86	0.58	NS	2.72	0.92	12	0.27	1.86	NS	1.08	0.49	NS	1.86	0.51	6
Potassium levels (K)	0	7.76	25.36	0.03	3.02	1.60	17.43	16.13	1.31	140	8.11	24.30	0.02	3.28	1.60	19.16	16.32	1.08	145
	1	7.83	27.23	0.05	2.86	1.61	18.05	17.86	1.10	140	8.21	27.18	0.04	3.32	1.45	20.30	18.86	1.28	148
	2	7.62	28.62	0.06	2.75	1.70	19.83	19.06	1.17	133	8.20	28.99	0.06	3.56	1.63	20.88	19.65	1.01	144
$L.S.D_{0.05}$		NS	2.93	0.02	NS	NS	1.10	2.37	NS	NS	NS	1.62	0.03	NS	NS	1.40	1.62	NS	NS
Rootstocks (RT)	S	7.95	25.55	0.05	3.10	1.76	18.73	16.45	1.31	140	8.38	25.79	0.04	3.59	1.42	20.32	17.41	1.26	144
	T	7.52	28.60	0.04	2.68	1.50	18.18	18.96	1.11	137	7.97	27.86	0.04	3.21	1.68	19.89	19.16	0.98	147
$L.S.D_{0.05}$		0.26	2.40	NS	NS	NS	NS	1.94	NS	NS	0.19	1.33	NS	NS	NS	NS	1.33	NS	NS
N x K		*	*	*	*	*	*	*	NS	NS	*	*	*	*	*	*	*	NS	NS
N x RT		*	*	NS	NS	NS	NS	*	*	*	*	*	NS	NS	NS	NS	*	*	*
K x RT		NS	*	NS	NS	NS	*	*	NS	NS	NS	*	NS	NS	NS	*	*	NS	NS
N x K x RT		*	*	*	*	*	NS	*	NS	*	*	*	*	*	*	NS	*	NS	*

S = Seedling rootstock. T = Trabols rootstock.

* = Significant. NS = Not significant.

Table 5. Effect of NK fertilization rates and rootstocks on fruit quality of Costata persimmon trees after 30 days storage at room temperature in 2000 and 2001 seasons.

Factors		2000 season									2001 season								
		Weight loss (%)	TSS (%)	Acidity (%)	Firmness (lb/in²)	[illegible] (mg/100 g)	carotene (mg/100 g)	Total sugars (%)	Tannins (%)	Pectin (mg/100 g)	Weight loss (%)	TSS (%)	Acidity (%)	Firmness (lb/in²)	[illegible] (mg/100 g)	carotene (mg/100 g)	Total sugars (%)	Tannins (%)	Pectin (mg/100 g)
Nitrogen levels (N)	0	16.12	30.12	0.07	3.00	2.90	18.36	18.68	1.60	88	17.76	28.36	0.09	2.81	2.88	19.86	19.12	1.40	107
	1	16.36	30.26	0.07	2.70	2.80	18.76	19.10	1.66	94	17.68	28.21	0.08	2.40	2.22	19.08	18.86	1.18	110
	2	16.86	27.18	0.06	2.08	3.00	19.00	17.16	1.20	110	17.83	25.46	0.07	2.04	3.30	20.36	17.26	1.03	124
	3	17.22	27.26	0.07	2.12	3.20	18.68	16.26	1.06	108	18.60	24.86	0.08	2.08	3.20	20.18	17.46	1.10	122
$L.S.D_{0.05}$		NS	1.18	NS	NS	NS	NS	1.42	NS	NS	NS	1.34	NS	NS	NS	NS	1.62	NS	NS
Potassium levels (K)	0	16.92	27.82	0.07	2.24	2.96	17.83	16.08	1.42	96	18.06	25.86	0.08	2.26	2.82	19.16	16.78	1.20	118
	1	16.08	29.08	0.06	2.60	3.15	19.43	17.72	1.36	104	17.82	26.78	0.07	2.15	2.86	19.98	18.52	1.15	110
	2	16.95	29.22	0.06	2.57	2.82	18.89	19.60	1.37	101	18.02	27.55	0.09	2.53	3.02	20.39	19.21	1.18	121
$L.S.D_{0.05}$		NS	1.03	NS	NS	NS	0.69	1.24	NS	NS	NS	1.17	NS	NS	NS	1.10	1.41	NS	NS
Rootstocks (RT)	S	16.96	28.86	0.06	2.30	3.00	18.78	17.60	1.40	108	18.16	26.46	0.07	2.46	2.96	20.00	17.95	1.23	120
	T	16.34	28.55	0.07	2.64	2.92	18.65	18.01	1.36	93	17.78	27.00	0.08	2.18	2.85	19.75	18.38	1.12	112
$L.S.D_{0.05}$		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.02	NS	NS	NS	NS	NS	NS
N x K		NS	*	NS	NS	NS	NS	*	NS	NS	NS	*	NS	NS	NS	NS	*	NS	NS
N x RT		NS	NS	NS	NS	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	*	NS	NS
K x RT		NS	NS	NS	NS	NS	*	NS	NS	NS	NS	*	*	NS	NS	*	NS	NS	NS
N x K x RT		NS	*	NS	NS	NS	*	*	NS	NS	NS	*	*	NS	NS	*	*	NS	NS

S = Seedling rootstock. T = Trabols rootstock.

* = Significant. NS = Not significant.

El-Megeed (1992) on persimmon. He reported that potassium fertilization had no significant effect on the fruit weight percentage during storage at 4°C or room temperature.

With regard to the rootstock effect alone, however, fruit weight of trees budded on seedling rootstock was significantly higher than those on Trabols rootstock (Tables 2 and 3), in both seasons at harvest date. These results are, generally, in line with those reported by Omarov and Erokhina (1989), Autio (1991) and Kassem (1996). They concluded that the average weight values of the fruit varied with rootstock. In addition, fruit weight loss percentage of trees on seedling rootstock after cold storage was significantly higher than those of trees on Trabols rootstock (Tables 3 and 4).

Total soluble solids (TSS)

Regardless of rootstock and potassium fertilization, the data presented in Tables (2 and 3) indicated that, in both seasons, nitrogen fertilization tended to decrease the total soluble solids at harvest time. The addition of 1200 and 1800 g ammonium nitrate per tree decreased the fruit TSS as compared with the control. Similarly, Suzuki *et al.*(1989) on persimmon, Kassem (1991) on apples and Jia *et al.*(1999) on peaches, found that nitrogen fertilizer decreased fruit TSS. Moreover, the data in Tables (4 and 5) showed that after storage at either 1-2°C or room temperature the TSS content was significantly decreased by increasing nitrogen fertilizer rate. Moreover, application of 1800 g ammonium nitrate per tree and 1200 or 1800 g per tree in both seasons, decreased fruit TSS after 60 days at 1-2°C and after 30 days at room temperature storage, respectively. Suzuki *et al.*(1989) on persimmon, Kassem (1991) on apples and Jia *et al.*(1999) on peaches reported that nitrogen fertilization decreased fruit TSS content at harvest date and/or during storage. Whereas, Abd El-Megeed (1992) on persimmon reported that nitrogen fertilizer increased fruit TSS after cold storage and after shelf life.

Data also revealed that, in both seasons, the fruit TSS at harvest was significantly increased by the addition of 600 or 1200 g potassium sulphate per tree, regardless of nitrogen fertilizer and rootstock. These results are in line with those obtained by Ahlawat and Yamdagni (1988) on grapes, Abd El-Megeed (1992) on persimmon trees and Attala (1997) and El-Morshedy (1997) on apples. They all found that potassium fertilizer increased fruit TSS. Also, the data in Tables (4 and 5) revealed that the TSS was increased by potassium fertilizer after storage at 1-2°C or at room temperature, in both seasons. These results are in line with those obtained by Abd El-Megeed (1992) on persimmon and Attala (1997) on apples. They found that potassium fertilizer increased fruit TSS after storage at 4°C or at room temperature.

As for the effect of rootstock alone on fruit TSS, the data in Tables (2 and 3) showed that the fruit TSS content of trees on Trabols rootstock was higher than that on seedling rootstock, in both seasons. The incidence of such varietal differences was also reported by several investigators. Drake *et al.*(1988 and 1991), Autio (1991), Barden and Marini (1992) and Kassem (1996) found a great variation in fruit TSS between different rootstocks. In addition, fruit TSS content was higher in trees budded on Trabols than those on seedling rootstock after 60 days storage at 1-2°C, in both seasons. However, after 30 days storage at room temperature, fruit TSS was not affected by any rootstock (Tables 4 and 5). The incidence of such differences was also reported by Drake *et al.*(1988 and 1991), Barden and Marini (1992) and Kassem (1996). They found that the different apple rootstocks showed differences in their TSS at harvest or after storage.

Acidity

Regardless of potassium fertilizer and rootstock, data in Tables (2 and 3) indicated that the application of 1200 or 1800 g ammonium nitrate per tree, in the first season, and 1800 g, in the second season, significantly decreased fruit acidity at harvest time as compared with the control. Similar results were reported by Kassem (1991), Abd El-Megeed (1992) and El-Morshedy (1997). On the other hand, fruit acidity was not significantly affected by nitrogen application after 60 days cold storage and 30 days storage at room temperature, in both seasons (Tables 4 and 5). These results disagreed with those of Kassem (1991), Abd El-Megeed (1992) and El-Morshedy (1997), who found that the application of nitrogen fertilizers decreased fruit acidity at harvest date or after storage.

Data in Tables (2 and 3) showed that, regardless of nitrogen fertilizer and rootstock, fruit acidity at harvest was significantly increased by the addition of 1200 g, in the first season, and either 600 or 1200 g potassium sulphate per tree, in the second season, as compared with the control. Similar results were found by Cummings and Reeves (1971), Kassem (1991), Attala (1997), El-Morshedy (1997) and Neilsen *et al.*(1998). They all found that potassium fertilizer increased fruit acidity. Cummings and Reeves (1971), working on peaches, reported that potassium was positively related to acidity. They added that the lower hydrogen ion concentration with the concomitant positive correlation between potassium supply and total organic acids as potassium was increased. The data presented in Tables (4 and 5) also showed that fruit acidity after cold storage was increased, in both seasons, as the rate of potassium sulphate increased from 0.0 to 1200 g/tree. On the other hand, after storage at room temperature, the fruit acidity was not affected by any of the potassium treatments. Kassem (1991), Attala (1997) and Neilsen *et al.*(1998) reported that the potassium fertilizer increased fruit acidity at harvest or during storage.

However, Noe *et al.*(1997) found that the potassium fertilization did not affect fruit acidity at harvest date and after storage.

With regard to the effect of rootstock alone on fruit acidity, the data in Tables (2 and 3) showed that the acidity was not affected by the different rootstocks at harvest time, in both seasons. These results disagreed with those of Drake *et al.*(1988 and 1991) and Kassem (1996). They reported a great variation in fruit acidity between different rootstocks at harvest date. However, the data in Tables (4 and 5) showed that fruit acidity was not affected by both rootstocks after storage at 1-2°C or at room temperature, in both seasons. These results disagreed with those of Drake *et al.*(1988 and 1991) and Kassem (1996) on apples.

Firmness

With regard to nitrogen fertilizer only, fruit firmness at harvest time was significantly decreased by the addition of 1200 or 1800 g ammonium nitrate per tree, in both seasons (Tables 2 and 3). The results obtained by Kassem (1991) and Fallahi *et al.*(1997) completely coincided with the present data of this study. They reported that larger fruits were usually softer than smaller ones. Under the prevailing conditions of this study, nitrogen application tended to produce larger persimmon fruits (Tables 2 and 3). Moreover, application of 1800 g ammonium nitrate per tree decreased fruit firmness after 60 days storage at 1-2°C, while after 30 days at room temperature fruit firmness was not affected by any of the N levels (Tables 4 and 5). Kassem (1991) and Fallahi *et al.*(1997) reported that the nitrogen fertilizers decreased fruit firmness at harvest or during storage.

In addition, fruit firmness was not affected in both seasons by any of the potassium treatments alone (Tables 2 and 3). These findings agreed with those found by Kassem (1991) and El-Morshedy (1997). Also, fruit firmness was not affected at either 1-2°C or room temperature, in both seasons (Tables 4 and 5). These findings completely agreed with those reported by Kassem (1991) and El-Morshedy (1997).

The effect of rootstock only on fruit firmness is presented in Tables (2 and 3). Fruits of trees on Trabols rootstock were firmer than those on seedling rootstock at harvest date, in both seasons. These results are, generally, in agreement with those reported by Drake *et al.*(1988 and 1991) and Kassem (1996). They found a great variation in fruit firmness among different apple rootstocks. However, the fruit firmness after storage at 1-2°C or at room temperature was not affected by any of the rootstocks used in this study (Tables 4 and 5). These results disagreed with those of Drake *et al.*(1991) and Kassem (1996).

Total chlorophyll

With regard to nitrogen fertilizer only, the addition of 1200 or 1800 g ammonium nitrate per tree, in the first season, and 600, 1200 and 1800 g per tree, in the second season, significantly increased the fruit total chlorophyll concentration as compared with the unfertilized trees (N_0) at harvest time(Tables 2 and 3). These results are in agreement with those obtained by Kassem (1991) on apples, Abd El-Megeed (1992) on persimmon and Jia *et al.*(1999) on peaches. Moreover, fruit total chlorophyll after storage at 1-2°C tended to increase by the highest level of nitrogen fertilization (N_3), in both seasons (Tables 4 and 5). After 30 days at room temperature, however, this increase was not big enough to be significant. These results are, generally, in line with those reported by Kassem (1991) on apples and Jia *et al.*(1999) on peaches. On the other hand, Abd El-Megeed (1992), working on persimmons, found that nitrogen fertilizer decreased fruit chlorophyll content after storage at 4°C or at room temperature.

However, fruit total chlorophyll at harvest was not significantly affected by any of the potassium levels, in both seasons, as compared with the unfertilized trees (K_0) (Tables 2 and 3). Similarly, Kassem (1991) reported that the fruit total chlorophyll was not correlated to potassium. On the other hand, Abd El-Megeed (1992) found that the potassium fertilization decreased fruit total chlorophyll in persimmon trees at harvest. In addition, the data in Tables (4 and 5) indicated that, after storage at 1-2°C or at room temperature, potassium fertilization had no significant effect on chlorophyll content, in both seasons, as compared with the control. Kassem (1991) reported that potassium fertilizer seemed not to be related to fruit total chlorophyll content. On the contrary, Abd El-Megeed (1992), working on persimmon, found that the potassium fertilization decreased fruit chlorophyll after storage at 4°C or at room temperature.

The data also showed that fruits from trees on seedling rootstock had higher total chlorophyll than those on Trabols rootstock, in the first season only (Table 2). The incidence of such varietal differences was also reported by Drake *et al.*(1988) and Kassem (1996). However, neither of the two rootstocks affected chlorophyll content after either cold storage or shelf life (Tables 4 and 5).

Carotene content

The effect of nitrogen fertilization on the fruit carotene content at harvest is presented in Tables (2 and 3). The fruit carotene content was not significantly affected by nitrogen fertilizer as compared with the control (N_0). Similarly, Abd El-Megeed (1992), working on persimmon trees, found no correlation between carotene content and nitrogen fertilization. Moreover, the carotene content after storage at 1-2°C or at room temperature was not significantly affected by nitrogen fertilization, in both seasons (Tables 4 and 5). Abd El-Megeed (1992) reported that nitrogen fertilization increased fruit carotene after cold storage, whereas after 15 days at room temperature the increase in carotene content was not big enough to be significant.

However, with regard to potassium fertilizer only, the data in Tables (2 and 3) showed a significant increase in carotene content at harvest when 600 or 1200 g potassium sulphate per tree were applied, in both seasons. Abd El-Megeed (1992), working on Costata persimmon trees, reported that the potassium fertilizer increased fruit carotene content. Bussi and Amiot (1998) stated that the colouring of apricot fruit was stimulated by potassium fertilization. Fruit carotene content was significantly increased after storage at 1-2°C or at room temperature as compared with the control. These results could be supported by the work done by Abd El-Megeed (1992) on persimmon.

As for the effect of rootstock only, the data in Tables (2 and 3) indicated that the fruits from trees on Trabols rootstock had higher carotene content than fruit from trees on seedling rootstock. These results are in agreement with those of Drake *et al.*(1988) and Kassem (1996). They found a great variation in fruit colour according to different apple rootstocks. However, the rootstocks did not affect fruit carotene content after storage at 1-2°C or at room temperature in both seasons.

Fruit sugars

With regard to nitrogen fertilization only, it was found that non-reducing sugars were not significantly affected at harvest date, in both seasons (Tables 2 and 3). However, reducing sugars and total sugars seemed to behave distinctively according to the amount of nitrogen applied to the trees. The addition of 600 g ammonium nitrate per tree tended to increase the concentration of both total and reducing sugars, in the second season only. On the contrary, the addition of 1200 or 1800 g ammonium nitrate per tree in the first season and 1800 g per tree in the second season significantly decreased the concentration of these two carbohydrate fractions at harvest time.

The inverse relationship between nitrogen fertilizer and fruit sugars could be supported by Suzuki *et al.*(1989) on persimmons, Kassem (1991) on apples, Saayman and Lambrechts (1998) on grapes and Jia *et al.*(1999) on peaches. They pointed out that when trees were grown under high nitrogen conditions greater amounts of carbohydrates would be directed and utilized in maintaining vigorous vegetative growth, and little proportions would be left to supply the growing fruits with sufficient carbohydrates. Meanwhile, Abd El-Megeed (1992), working on persimmons, reported that increasing nitrogen nutrition, generally, resulted in increasing fruit sugars content.

In addition, total sugars after storage at 1-2°C or at room temperature were significantly decreased with increasing nitrogen rate. The application of

1200 or 1800 g ammonium nitrate per tree decreased total sugars content after 60 days storage at 1-2°C and after 30 days at room temperature, in both seasons. Similarly, Suzuki *et al.*(1989), working on persimmon, found that nitrogen fertilizer decreased fruit total sugars content during storage.

As for the effect of potassium fertilization only, data in Tables (2 and 3) indicated that fruit non-reducing sugars were not affected in both seasons. However, fruit reducing sugars as well as total sugars at harvest date were significantly increased by the addition of 1200 g potassium sulphate per tree, in the first season, and 600 or 1200 g per tree, in the second season. Similar results were also reported by Abd El-Megeed (1992) on persimmon fruit trees and Attala (1997) and El-Morshedy (1997) on apple trees. They all reported that the potassium fertilizer increased fruit sugars content. Moreover, total sugars after storage at 1-2°C or at room temperature was increased by potassium fertilization, in both seasons (Tables 4 and 5).

Costata persimmon fruits at harvest date taken from trees on Trabols rootstock contained more total and reducing sugars, in both seasons, and non-reducing sugars, in the second season, than that from trees on seedling rootstock. The incidence of such differences was also reported by Autio (1991), Barden and Marini (1992) and Kassem (1996). They found that different apple rootstocks showed differences in their total, reducing and non-reducing sugars content at harvest date. Similar results were found after 60 days storage at 1-2°C, in both seasons, whereas after 30 days storage at room temperature total sugars were not affected.

Tannins

The data presented in Tables (2 and 3) indicated that, in both seasons, the nitrogen fertilization at the rate of 1800 g ammonium nitrate per tree significantly decreased the percentage of tannins in fruits at harvest date as compared with the unfertilized trees (N_0). The same trend of results was found by Abd El-Megeed (1992) on Costata persimmon trees. In addition, tannins contents were decreased, in both seasons, after 60 days storage at 1-2°C according to the application of 1800 g ammonium nitrate. However, no significant differences in tannins content after 30 days storage at room temperature were found (Tables 4 and 5). These results agreed with those reported by Abd El-Megeed (1992).

With regard to potassium fertilization only, fruit tannins were decreased at harvest date by the addition of 1200 g potassium sulphate, in the first season, and 600 or 1200 g potassium sulphate, in the second season. These results are in agreement with those reported by Abd El-Megeed (1992) on Costata persimmon trees. In contrast, potassium fertilization did not significantly affect fruit tannins after storage either at 1-2°C or at room temperature, in both seasons (Tables 4 and 5). These results disagreed with those reported by Abd El-Megeed (1992).

As for the effect of rootstock on the fruit tannins content at harvest, data in Tables (2 and 3) indicated that the rootstock had no significant effect on tannins content. The same results were found after storage at 1-2°C or at room temperature, in both seasons (Tables 4 and 5).

Pectin

The effect of nitrogen fertilization at harvest on the fruit pectin content is presented in Tables (2 and 3). The data indicated that, regardless of potassium fertilizer and rootstock, the nitrogen fertilization tended to decrease the pectin content of the fruits. The addition of 1800 g of ammonium nitrate per tree, in the first season, and 1200 or 1800 g per tree, in the second season, decreased the pectin content as compared with the unfertilized trees (control). Also, after storage at 1-2°C, pectin content was significantly decreased, in both seasons (Tables 4 and 5), whereas storage at room temperature did not significantly affect pectin content.

As for the effect of potassium fertilizer only, the data in Tables (2 and 3) indicated that potassium fertilizer significantly decreased fruit pectin, in the second season only. However, fruit pectin content after cold storage or after shelf life was not affected by any of the potassium fertilization treatments (Tables 4 and 5).

Regardless of nitrogen and potassium fertilization, fruit pectin of trees on Trabols rootstock was higher than that of trees on seedling rootstock at harvest date (Tables 2 and 3). On the other hand, the rootstock had no effect on fruit pectin content after storage at 1-2°C or at room temperature (Tables 4 and 5).

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الملخص العربى

استجابة أشجار الكاكى صنف كوستاتا لنوع الأصل المستخدم والتسميد بالنتروجين والبوتاسيوم

٢- جودة الثمار عند القطف وبعد التخزين.

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أجريت هذه الدراسة خلال عامى ٢٠٠٠، ٢٠٠١ على أشجار كاكى صنف كوستاتا بغرض دراسة تأثير نوع الأصل المستخدم (أصل بذرى وطرابلس) كذلك تأثير التسميد بمعدلات مختلفة من النتروجين والبوتاسيوم والتداخلات الممكنة بينهم على كل من جودة ثمار الكاكى عند القطف وبعد ٦٠ يوم من التخزين المبرد (١-٢°م) أو بعد ٣٠ يوم من التخزين على درجة حرارة الغرفة. وقد أوضحت النتائج المتحصل عليها الآتى :

١- أدى التسميد النتروجينى إلى زيادة متوسط وزن الثمرة ومحتوى الثمار من الكلورفيل عند الجمع وكذلك زيادة فى فقد الوزن ومحتوى الثمار من الكلورفيل بعد ٦٠ يوما من التخزين المبرد بينما قلل التسميد بالنتروجين محتوى الثمار من المواد الصلبة الذائبة الكلية والسكريات الكلية عند الجمع وبعد التخزين على درجة ١-٢°م أو درجة الغرفة وأيضا قلل من صلابة الثمار ومحتوى الثمار من التانين والبكتين عند الجمع أو بعد التخزين المبرد وقلل السكريات المختزلة عند الجمع. ولم يؤثر التسميد بالنتروجين على محتوى الثمار من الكاروتين عند الجمع أو بعد التخزين على ١-٢°م ودرجة الغرفة كذلك لم يؤثر على السكريات

الغير مختزلة عند الجمع وحموضة الثمار بعد التخزين المبرد أو على درجة الغرفة وكذلك لم يؤثر على فقد الوزن والصلابة والكلوروفيل والتانين والبكتين بعد التخزين على درجة حرارة الغرفة.

٢- أدى التسميد بالبوتاسيوم إلى زيادة فى متوسط وزن الثمرة والسكريات المختزلة عند الجمع وزيادة فى المواد الصلبة الذائبة الكلية والسكريات الكلية والكاروتين عند الجمع أو بعد التخزين على ١-٢°م وعلى درجة الغرفة وزيادة حموضة الثمار عند الجمع أو بعد التخزين المبرد. بينما أدى التسميد بالبوتاسيوم إلى نقص فى محتوى الثمار من التانين والبكتين عند الجمع ولم يؤثر على صلابة الثمار والكلوروفيل عند الجمع وبعد التخزين سواء المبرد أو على درجة الغرفة كذلك لم يؤثر على فقد الوزن بعد التخزين المبرد أو على درجة الغرفة والسكريات الغير مختزلة عند الجمع والتانين والبكتين بعد ٦٠ يوم من التخزين المبرد أو بعد ٣٠ يوم من التخزين على درجة حرارة الغرفة.

٣- إحتوت أشجار الكاكى صنف كوستاتا المطعم على الشتلات البذرية على أعلى قيم فى متوسط وزن الثمار ومحتوى الثمار من الكلوروفيل عند الجمع وعلى أقل قيم فى المواد الصلبة الذائبة الكلية والسكريات الكلية عند الجمع أو بعد التخزين المبرد كذلك على أقل قيم للصلابة والسكريات المختزلة والبكتين للثمار عند الجمع بالمقارنة بالأصل الطرابلس. ولم يكن هناك تأثير لنوع الأصل المستخدم على حموضة الثمار والتانين عند الجمع وبعد التخزين سواء المبرد أو على درجة حرارة الغرفة. كذلك على فقد الوزن والسكريات الكلية والمواد الصلبة الذائبة الكلية بعد ٣٠ يوم من التخزين على درجة حرارة الغرفة. أيضا لم يكن هناك تأثير لنوع الأصل على الصلابة والكلوروفيل والكاروتين والبكتين بعد ٦٠يوم من التخزين المبرد وبعد ٣٠ يوم من التخزين على درجة حرارة الغرفة.