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Effect of Compost Tea and Some Antioxidant Applications on Leaf Chemical Constituents, Yield and Fruit Quality of Pomegranate

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Abstract: Seven years old Manfalouty pomegranate trees grown at Tanbol region, Wadi EL-Natroon district, Behira Governorate, Egypt were used in this study. Two applications of compost tea (Foliar and soil applications each at 5 liter/tree) beside control trees with or without three foliar antioxidant treatments (ascorbic acid, citric acid and ascorbic + citric acids). All leaf chemical constituents, yield and fruit quality were increased in the second season than in the first one. In addition, foliar application of compost tea gave the higher leaf mineral and pigments contents, yield and fruit parameters than soil application of compost tea. As well as, ascorbic + citric acids gave the highest results followed by ascorbic acid then citric acid in descending order. Concerning the interaction between seasons, application of compost tea and antioxidant treatments, foliar application of compost tea with double combined antioxidants treatment (ascorbic + citric acid) gave the highest leaf N, P, K, Ca, Mg, Fe, chlorophyll a and b contents, tree yield, fruit physical parameters (fruit weight, volume, length, diameter, juice and grain) and fruit chemical parameters (total sugars, vitamin C, total anthocyanin, TSS and TSS/acid ratio) in the second season in comparison with other studied treatments in both seasons. Also, the same treatment gave the lowest leaf proline content, fruit cracking and fruit acidity in both seasons.

Key words: Compost tea · Antioxidant · Ascorbic acid · Citric acid · Pomegranate

INTRODUCTION

Nutritionally, the pomegranate is a food medicine of a great importance. Every part of the tree, leaves, fruits (grain and peel) and roots has been considered as a tonic for the heart. Therefore, the demand has increased for pomegranate to face the need of local and foreign markets.

One third of the world irrigated soils are approximately affected by excess salinity [1]. In Egypt the problem is acute, where about 60% of the arable soils are classified as salt affected [2]. Organic fertilizers improve the physical, chemical and biological properties of nearly all soil types, adjusting soil pH, increasing nutrients solubility and production of plants [3]. Compost tea in modern terminology means compost extract brewed with microbial food source, humic, fulvic acids and catalyst amendments to promote the growth and multiplication of microbes in the tea [4]. This procedure can also improve nutrient utilization and lower environmental pollution through reducing the amounts of fertilizers added to soil [5].

Moreover, foliar feeding of a nutrient may actually promote root absorption of the same nutrient or other nutrients uptake [6]. Moreover, several researches revealed that foliar feeding is more efficient than soil fertilization; this fact is totally true in case of adding micronutrients under arid and semi-arid conditions [7, 8].

Antioxidants such as ascorbic acid and citric acid have auxinic action and synergistic effect on flowering and fruiting of fruit trees, recently antioxidants have been used instead of auxins and other chemicals for enhancing growth and fruiting of various fruit trees [9, 10]. Also, Maksoud *et al.* [11] found that spraying antioxidants (ascorbic acid or citric acid) each at 1000 and 2000 ppm alone or combined with the bioferilizer enhanced yield and fruit quality of olive trees.

The present investigation was outlined to study the beneficial effects of compost tea and antioxidants on leaf chemical constituents, yield and fruit quality of Manfalouty pomegranate trees planted in sandy soil.

MATERIALS AND METHODS

The present study was carried out during two successive seasons, 2005/2006 and 2006/2007. Manfalouty pomegranate trees aged 7 years old grown in

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Table 1: Physical and chemical analysis of the experimental soil

Physical character	Value	Chemical character	Value
Field capacity (cm^3/cm^3)	0.46	$CaCO_3$ (%)	13.24
Available water (cm^3/cm^3)	1.55	Organic matter (%)	0.11
Wilting point (%)	4.20	pH (1:25)	7.5
		EC (dS/m)	6.14
Particle- size distribution			
Sand (%)	80.8	Ca (mg/ 100g)	0.13
Silt (%)	16.1	Mg (mg/ 100g)	0.12
Clay (%)	3.1	Na (mg/ 100g)	0.33
Textural class	Sandy	K (mg/100g)	0.14
		HCO_3 (mg/100g)	0.17
		Cl (mg/100g)	0.31

Table 2: Analysis of well irrigation water used in the present study

			Soluble cations, meq/l				Soluble anions, meq/l			
			Ca^{+2}	Mg^{+2}	Na^+	K^+	CO_2^-	HCO_3^-	Cl^-	SO_4^{-2}
Value	7.52	2.43	1.73	1.65	3.85	0.17	0.07	1.96	3.71	2.13

Table 3: Some chemical characteristics of the used farm compost and compost tea prepared (compost extract)

	Value	
	Mature farm compost	Compost tea (extract)
Cubic meter weight (Kg)	550	_
Moisture%	27	_
Organic matter%	33.65	_
Organic carbon%	31.75	_
pH	8.5	7.52
EC (dS/m)	6.33	7.82
C/N ratio	19.12	-
Total N	1.73%	231 ppm
Total P	0.55%	29 ppm
Total K	1.18%	17 ppm
Total Ca	1.23%	14 ppm
Total Fe	331 ppm	135 ppm

sandy soil (Table 1) and spaced 4×5m apart in an orchard at Tanbol region, Wadi EL-Natroon district, Behira Governorate were used in this study. Orchard trees had received water requirements through drip irrigation system (Table 2).

All tested trees were healthy, nearly uniform in vigor. All trees received the recommended regular organic fertilization, farm compost was added to the soil at the first week of December (15 m^3/feddan at 15 cm soil depth). Two treatments of compost tea were applied in this study: the first one was soil application and the second one was foliar application. The dose of both treatments was 5 liter/tree for each one. The control trees received water only (compost tea free). In addition, soil; foliar and control treatments were applied with or without three foliar antioxidant treatments at 1000 ppm of each, i.e. ascorbic acid, citric acid and ascorbic + citric acids. Compost tea was prepared from composted farm refuse [12]. Mature compost was suspended in a barrel of water for 7 days to produce compost extract (1 kg/10 liters water), compost extract was added to fill tank (50 liters capacity, attached to air pump and the aerator provides continuous flow of air bubblers), the chemical properties of mature compost and compost tea are shown in Table 3.

All tested application treatments were applied in March and repeated with the same dose in April, June and July in both seasons of study. The 12 treatments (compost tea soil, foliar and control that interacted with spraying antioxidants ascorbic, citric, ascorbic+ citric and water "control") were replicated three times; each replicate was represented by one tree during the two seasons of the study. During the two seasons, the following parameters were recorded:

Leaf Mineral Composition: Some macro and micro elements were determined in the oven dried leaf samples (15 leaves from the middle part of shoots) collected in the second week of July. Leaves were dried at 70°C for 48 hours and used for the chemical analysis. N% was determined by modified micro-Kjeldahl methods as mentioned by Pregel [13]; P% was determined by wet digestion of plant materials by using sulphuric and perchloric acid as recommended by Piper [14]. K% was determined in the digested materials using Zeiss flame photometer according to method described by Brown and Lilleland [15]. Ca%, Mg% and Fe (ppm) were determined using an atomic absorption spectrophotometer model 305 B [16].

Leaf Pigments and Proline: Representative fresh leaf samples at middle part of shoots were taken in the second week of July and used for analysis of chlorophylls a and b were colorimetrically according to Mackinney [17]. Proline (mg/g DW) was determined according to AOAC [18] in other dried leaf samples.

Yield (Kg/tree) and Fruit Parameters: Yield (Kg) and fruit cracking (%) per tree were estimated during the second week of August. Six fruits were taken at harvest form each treatment for determination of the following physical and chemical properties: fruit weight (g), fruit volume (cm^3), fruit length (cm), fruit diameter (cm), fruit juice (%), fruit grain (%) and fruit peel (%). Also, TSS (%) of fruit juice was determined using a hand refractometer: Acidity (%), TSS/acid ratio, total sugars (%), vitamin C (ascorbic acid/100 ml juice) were determined according to AOAC [18] and anthocyanin content in fruit juice was determined as described by Hsia *et al.* [19].

Statistical Analysis: All the obtained data were tabulated and statistically analyzed according to the split plot design [20]. The value means were compared using LSD method at 5% level. The percentages were transformed to arcsine to find the binomial percentages according to Steel and Torrie [21].

RESULTS AND DISCUSSION

Leaf Mineral Composition: Data presented in Tables 4 and 5 indicated that all leaf mineral contents (N, P, K, Ca, Mg and Fe) were significantly affected by compost tea applications with antioxidant treatments in the two seasons of the study. In addition, all leaf mineral contents, except P and Mg, were significantly increased in the second season than the first one. Concerning the effect of compost tea applications, foliar application of compost tea gave the higher leaf minerals content (N, P, K, Ca, Mg and Fe) than soil application of compost tea. In addition, antioxidant treatments by double antioxidants (ascorbic acid + citric acid) gave the highest leaf mineral contents followed by single application of ascorbic acid or citric acid treatment in a descending order.

Moreover, the interaction between compost tea applications, antioxidants and seasons, foliar application of compost tea with ascorbic acid + citric acid in the second season gave the highest leaf mineral contents compared to other interactions under study in both seasons.

These results go in line with Mohammed *et al.* [22] who showed that application of compost tea gave the higher leaf N, P, K, Ca, Mg and Fe contents in the second seasons than the first one on pear trees. As well as Mostafa *et al.* [23] on orange trees found that compost tea gave the highest value in leaf contents of N, P and K in both seasons of the study compared with control. Moreover, foliar feeding of a nutrient may actually promote root absorption of the same nutrient or other nutrients uptake [6].

Also, several researches revealed that foliar feeding is more efficient than soil fertilization; this fact is totally true in case of micronutrients under arid and semi-arid conditions [7, 8]. El-Sayed *et al.* [9] suggested that antioxidants, such as ascorbic acid and citric acid, have auxinic action and synergistic effect on fruit trees. Recently, antioxidants had been used instead of auxins and other chemicals for enhancing growth of various fruit trees [10]. In addition, Maksoud *et al.* [11] found that application of ascorbic acid or citric acid each at 1000 or 2000 ppm alone or combined with biofertilizer enhanced leaf N, P and Ca contents of olive trees.

Leaf Pigments and Proline: Data concerning leaf pigments (mg/g FW) are presented in Table 6. It appeared that leaf pigments (chlorophyll a and b) in pomegranate trees under compost tea application with antioxidant treatments were higher in the second season than the first one. Moreover, foliar application of compost tea gave the highest significant leaf pigments content, followed in a descending order by soil application of compost tea and control treatment. Also, antioxidant treatments appeared that double combined treatments (ascorbic acid + citric acid) gave higher leaf pigments content than single antioxidant treatments.

Table 4: Leaf N, P & K contents of Manfalouty pomegranate trees as affected by compost tea applications and some antioxidants during 2005/06 & 2006/07 seasons

			N (%)			P (%)			K (%)		
			Seasons			Seasons			Seasons		
Compost tea application	Treatments	Antioxidants	2005/06	2006/07	Average	2005/06	2006/07	Average	2005/06	2006/07	Average
Foliar application		Ascorbic	1.79	1.96	1.88	0.25	0.28	0.27	0.68	0.75	0.72
		Citric	1.76	1.76	1.76	0.24	0.27	0.26	0.59	0.72	0.66
		Ascorbic+citric	1.88	2.03	1.96	0.26	0.29	0.28	0.71	0.86	0.79
		Without	1.71	1.86	1.79	0.23	0.24	0.24	0.49	0.61	0.55
	Average		1.79	1.90	1.84	0.25	0.27	0.26	0.62	0.74	0.68
Soil application		Ascorbic	1.73	1.83	1.78	0.24	0.26	0.25	0.62	0.71	0.67
		Citric	1.65	1.71	1.68	0.23	0.26	0.25	0.54	0.69	0.62
		Ascorbic+citric	1.75	1.92	1.84	0.25	0.27	0.26	0.69	0.82	0.76
		Without	1.63	1.76	1.70	0.23	0.23	0.23	0.46	0.52	0.49
	Average		1.69	1.81	1.75	0.24	0.26	0.25	0.58	0.69	0.63
Control		Ascorbic	1.64	1.75	1.70	0.24	0.26	0.25	0.53	0.66	0.60
		Citric	1.61	1.66	1.64	0.23	0.25	0.24	0.46	0.64	0.55
		Ascorbic+citric	1.76	1.83	1.80	0.24	0.26	0.25	0.57	0.73	0.65
		Without	1.58	1.55	1.57	0.22	0.22	0.22	0.43	0.44	0.44
	Average		1.65	1.70	1.67	0.23	0.25	0.24	0.50	0.62	0.56
General Average			1.71	1.80	1.75	0.24	0.26	0.25	0.56	0.68	0.62
Average of antioxidants		Ascorbic acid	1.72	1.85	1.78	0.24	0.27	0.26	0.61	0.71	0.66
		Citric acid	1.67	1.71	1.69	0.23	0.26	0.25	0.53	0.68	0.61
		Ascorbic+citric	1.80	1.93	1.86	0.25	0.27	0.26	0.66	0.80	0.73
		Without	1.64	1.72	1.68	0.23	0.23	0.23	0.46	0.52	0.49
LSD at 5%											
Compost tea application				0.04			0.01			0.02	
Antioxidants				0.05			0.02			0.04	
Seasons				0.05			N.S.			0.06	
Compost x Antioxidant				0.06			0.03			0.12	
Compost x Seasons				0.06			0.03			0.12	
Antioxidant x Seasons				0.09			N.S.			0.22	
Compost x Antioxidant x Seasons				1.13			0.04			0.33	

Table 5: Leaf Ca, Mg & Fe contents of Manfalouty pomegranate trees as affected by compost tea applications and some antioxidants during 2005/06&2006/seasons

			Ca (%)			Mg (%)			Fe (ppm)		
			Seasons			Seasons			Seasons		
Compost tea application	Treatments	Antioxidants	2005/06	2006/07	Average	2005/06	2006/07	Average	2005/06	2006/07	Average
Foliar application		Ascorbic	1.50	1.67	1.59	0.38	0.42	0.40	145.66	166.66	156.16
		Citric	1.44	1.58	1.51	0.34	0.40	0.37	140.00	154.33	147.17
		Ascorbic+citric	1.58	1.74	1.66	0.40	0.44	0.42	152.33	172.33	162.33
		Without	1.21	1.35	1.28	0.33	0.39	0.36	134.00	146.66	140.33
	Average		1.43	1.59	1.51	0.36	0.41	0.39	143.00	160.00	151.50
Soil application		Ascorbic	1.46	1.61	1.54	0.36	0.40	0.38	137.33	161.33	149.33
		Citric	1.41	1.56	1.49	0.34	0.39	0.37	133.33	151.00	142.17
		Ascorbic+citric	1.54	1.66	1.60	0.37	0.42	0.40	140.00	165.66	152.83
		Without	1.18	1.22	1.20	0.33	0.38	0.36	125.66	133.66	129.66
	Average		1.40	1.51	1.46	0.35	0.40	0.37	134.08	152.91	143.50
Control		Ascorbic	1.38	1.50	1.44	0.33	0.41	0.37	116.66	143.66	130.16
		Citric	1.25	1.44	1.35	0.32	0.36	0.34	114.33	135.00	124.67
		Ascorbic+citric	1.40	1.57	1.49	0.36	0.41	0.39	118.00	152.33	135.17
		Without	1.13	1.16	1.15	0.31	0.31	0.31	110.00	111.66	110.83
	Average		1.29	1.42	1.35	0.33	0.37	0.35	114.75	135.66	125.21
General Average			1.37	1.51	1.44	0.35	0.39	0.37	130.61	149.52	140.07
Average of antioxidants		Ascorbic acid	1.45	1.59	1.52	0.36	0.41	0.38	133.22	157.22	145.22
		Citric acid	1.37	1.53	1.45	0.33	0.38	0.36	129.22	146.78	138.00
		Ascorbic+citric	1.51	1.66	1.58	0.38	0.42	0.40	136.78	163.44	150.11
		Without	1.17	1.24	1.21	0.32	0.36	0.34	123.22	130.66	126.94
LSD at 5%											
Compost tea application				0.03			0.02			2.66	
Antioxidants				0.04			0.03			3.22	
Seasons				0.05			N.S.			4.58	
Compost x Antioxidant				0.11			0.05			5.55	
Compost x Seasons				0.11			0.05			5.55	
Antioxidant x Seasons				0.14			N.S.			6.43	
Compost x Antioxidant x Seasons				0.15			0.07			7.91	

Table 6: Leaf Pigments and proline contents of Manfalouty pomegranate trees as affected by compost tea applications and some antioxidants during 2005/06 & 2006 seasons

			Chlorophyll A (mg/g FW)			Chlorophyll B (mg/g FW)			Proline (mg/g DW)		
			Seasons			Seasons			Seasons		
Compost tea application	Treatments	Antioxidants	2005/06	2006/07	Average	2005/06	2006/07	Average	2005/06	2006/07	Average
Foliar application		Ascorbic	0.6357	0.8764	0.7561	0.4355	0.5425	0.4890	43.33	35.28	39.31
		Citric	0.5587	0.7754	0.6671	0.4046	0.4681	0.4364	45.82	38.55	42.19
		Ascorbic+citric	0.7258	0.8819	0.8039	0.4953	0.5591	0.5272	40.35	33.28	36.82
		Without	0.5788	0.6873	0.6331	0.4133	0.4687	0.4410	46.67	42.54	44.61
	Average		0.6248	0.8053	0.7150	0.4372	0.5096	0.4734	44.04	37.41	40.73
Soil application		Ascorbic	0.5479	0.7863	0.6671	0.4148	0.5364	0.4756	44.54	36.47	40.51
		Citric	0.5021	0.7452	0.6237	0.3826	0.4213	0.4020	47.51	40.35	43.93
		Ascorbic+citric	0.6145	0.8703	0.7424	0.4627	0.5421	0.5024	43.87	34.56	39.22
		Without	0.5371	0.5438	0.5405	0.3514	0.3578	0.3546	49.42	47.45	48.44
	Average		0.5504	0.7364	0.6434	0.4029	0.4644	0.4336	46.34	39.71	43.02
Control		Ascorbic	0.5329	0.7641	0.6485	0.3982	0.5312	0.4647	46.95	40.21	43.58
		Citric	0.4686	0.6782	0.5734	0.3647	0.4065	0.3856	47.66	44.91	46.29
		Ascorbic+citric	0.5521	0.7852	0.6687	0.4254	0.4538	0.4396	45.63	38.45	42.04
		Without	0.4321	0.4472	0.4397	0.3421	0.3486	0.3454	48.53	49.52	49.03
	Average		0.4964	0.6687	0.5826	0.3826	0.4350	0.4088	47.19	43.27	45.23
General Average			0.5572	0.7368	0.6470	0.4076	0.4697	0.4386	45.86	40.13	42.99
Average of antioxidants		Ascorbic acid	0.5722	0.8089	0.6906	0.4162	0.5367	0.4764	44.94	37.32	41.13
		Citric acid	0.5098	0.7329	0.6214	0.3840	0.4320	0.4080	47.00	41.27	44.13
		Ascorbic+citric	0.6308	0.8458	0.7383	0.4611	0.5183	0.4897	43.28	35.43	39.36
		Without	0.5160	0.5594	0.5377	0.3689	0.3917	0.3803	48.21	46.50	47.36
LSD at 5%											
Compost tea application				0.0239			0.0133			0.66	
Antioxidants				0.0321			0.0226			1.25	
Seasons				0.0521			0.0421			2.65	
Compost x Antioxidant				0.0478			0.0552			2.71	
Compost x Seasons				0.0478			0.0552			2.71	
Antioxidant x Seasons				0.1361			0.1124			2.95	
Compost x Antioxidant x Seasons				0.1482			0.1332			3.69	

Concerning the interaction between compost tea, antioxidants and seasons. Foliar application of compost tea with ascorbic acid + citric acid in the second season gave the higher leaf chlorophylls a and b contents than other studied interactions in both seasons. On the other hand, proline was significantly increased by control treatment in both seasons compared with other studied application treatments. Also, soil application of compost tea gave higher leaf proline content than foliar application of compost tea. Single application of antioxidant (citric acid) treatment gave the highest proline value followed by ascorbic acid and the application of ascorbic acid plus citric acid. Also, higher proline content was noticed in the first season than in the second season. As well as, Foliar application of compost tea with ascorbic acid + citric acid in the second season gave less leaf proline value compared to other applications under study in both seasons.

These results are coincided with Mohammed *et al.* [22] on pear trees and Mostafa *et al.* [23] on orange trees, they found that compost treatment gave the higher leaf pigments content than control under study. Also, leaf chlorophylls a and b were higher in the second season than the first one. Also, Maksoud *et al.* [11] on olive trees, found that spraying ascorbic or citric acid at 1000 ppm enhanced leaf pigments. On the function and metabolism effects, it was reported by Smirnoff [24] and Blokhina *et al.* [25] that using ascorbic acid has a wide range of important functions such as antioxidant defensing, photo protection and regulation of photosynthesis and growth, while the chlorophylls content of leaves is obtained due to N, Fe and Mg. The absorption of iron ions is involved in the chloroplast formation via protein synthesis or the depression of chlorophyll as a result of N accumulation in plant leaves through the breakdown of plastids [26].

Application of compost tea with ascorbic acid + citric acid gave the highest leaves N, Fe and Mg. These elements improve leaf pigments (chlorophylls a and b) content. Concerning the proline, it is increased proportionally in plants under salinity stress faster than other amino acids; thus it has been suggested as an evaluation parameter for selecting resistant varieties [27]. Bhaskaran *et al.* [28] found that there is no correlation between proline level and stress tolerance in cultured sorghum cells. They concluded that proline increases was an incidental consequence rather than an adaptive response to stress. Also, Mohammed *et al.* [22] on pear

Table 7: Yield and some fruit physical characteristics of Manfalouty pomegranate trees as affected by compost tea applications and some antioxidants during 2005/06 & 2006/07 seasons

			Yield (kg/tree)			Fruit weight (g)			Fruit volume (cm^3)		
			Seasons			Seasons			Seasons		
Compost tea application	Treatments	Antioxidants	2005/06	2006/07	Average	2005/06	2006/07	Average	2005/06	2006/07	Average
Foliar application		Ascorbic	25.90	30.76	28.33	261.33	312.82	287.08	292.68	353.48	323.08
		Citric	23.81	28.31	26.06	240.24	287.91	264.08	269.06	325.33	297.20
		Ascorbic+citric	26.62	33.93	30.28	268.59	345.18	306.89	300.82	392.67	346.75
		Without	20.57	22.14	21.36	222.29	225.16	223.73	248.96	254.43	251.70
	Average		24.23	28.79	26.51	248.11	292.77	270.44	277.88	331.48	304.68
Soil application		Ascorbic	21.82	27.92	24.87	253.11	283.66	268.39	286.01	323.37	304.69
		Citric	21.05	26.55	23.80	232.81	269.74	251.28	263.07	307.50	285.29
		Ascorbic+citric	23.46	29.49	26.48	248.67	299.61	274.14	280.99	341.55	311.27
		Without	19.25	20.63	19.94	215.56	219.60	217.58	244.03	269.66	256.85
	Average		21.40	26.15	23.77	237.54	268.15	252.85	268.53	310.52	289.52
Control		Ascorbic	17.31	18.57	17.94	215.84	217.26	216.55	246.05	249.84	247.95
		Citric	15.53	17.50	16.52	211.53	206.75	209.14	241.14	237.76	239.45
		Ascorbic+citric	18.63	20.89	19.76	219.44	223.41	221.43	249.66	256.92	253.29
		Without	15.33	15.42	15.38	200.62	204.50	202.56	224.69	231.08	227.89
	Average		16.70	18.10	17.40	211.86	212.98	212.42	240.39	243.90	323.08
General Average			20.77	24.34	22.56	232.50	257.97	245.23	262.26	295.30	278.78
Average of antioxidants		Ascorbic acid	21.68	25.75	23.71	243.43	271.25	257.34	274.91	308.90	291.91
		Citric acid	20.13	24.12	22.13	228.19	254.80	241.50	257.76	290.20	273.98
		Ascorbic+citric	22.90	28.10	25.50	245.57	289.40	267.48	277.16	330.38	303.77
		Without	18.38	19.40	18.89	212.82	216.42	214.62	239.23	251.72	245.48
LSD at 5%											
Compost tea application				1.03			6.44			8.43	
Antioxidants				1.09			8.51			9.73	
Seasons				1.12			9.42			11.42	
Compost x Antioxidant				1.23			10.55			13.07	
Compost x Seasons				1.23			10.55			13.07	
Antioxidant x Seasons				1.25			11.33			14.67	
Compost x Antioxidant x Seasons				1.48			12.52			16.21	

Table 8: Some fruit physical characteristics of Manfalouty pomegranate trees as affected by compost tea applications and some antioxidants during 2005/06&2006/07 seasons

			Fruit length (cm)			Fruit diameter (cm)			Fruit cracking (%)		
			Seasons			Seasons			Seasons		
Compost tea application	Treatments	Antioxidants	2005/06	2006/07	Average	2005/06	2006/07	Average	2005/06	2006/07	Average
Foliar application		Ascorbic	8.51	8.97	8.74	7.35	7.44	7.40	5.33	4.02	4.68
		Citric	7.69	8.73	8.21	7.3	7.34	7.32	5.41	4.58	5.00
		Ascorbic+citric	8.88	9.81	9.35	7.49	8.23	7.86	4.83	3.88	4.36
		Without	7.41	7.55	7.48	7.18	7.26	7.22	6.22	6.45	6.34
	Average		8.12	8.77	8.44	7.33	7.57	7.45	5.45	4.73	5.09
Soil application		Ascorbic	7.45	8.64	8.05	7.3	7.35	7.33	5.57	4.82	5.20
		Citric	7.52	7.88	7.70	7.22	7.29	7.26	6.08	5.63	5.86
		Ascorbic+citric	8.55	9.66	9.11	7.41	8.09	7.75	5.11	4.51	4.81
		Without	7.36	7.46	7.41	7.16	7.18	7.17	7.55	7.32	7.44
	Average		7.72	8.41	8.07	7.27	7.48	7.38	6.08	5.57	5.82
Control		Ascorbic	7.44	7.49	7.47	7.19	7.25	7.22	7.61	6.22	6.92
		Citric	7.41	7.45	7.43	7.15	7.23	7.19	7.75	7.06	7.41
		Ascorbic+citric	7.92	8.65	8.29	7.20	7.92	7.56	7.54	6.15	6.85
		Without	7.33	7.35	7.34	7.11	7.15	7.13	8.66	8.52	8.59
	Average		7.53	7.74	7.63	7.16	7.39	7.28	7.89	6.99	7.44
General Average			7.79	8.30	8.05	7.26	7.48	7.37	6.47	5.76	6.12
Average of antioxidants		Ascorbic acid	7.80	8.37	8.08	7.28	7.35	7.31	6.17	5.02	5.60
		Citric acid	7.54	8.02	7.78	7.22	7.29	7.26	6.41	5.76	6.09
		Ascorbic+citric	8.45	9.37	8.91	7.37	8.08	7.72	5.83	4.85	5.34
		Without	7.37	7.45	7.41	7.15	7.20	7.17	7.48	7.43	7.45
LSD at 5%											
Compost tea application				0.22			0.02			0.31	
Antioxidants				0.31			0.12			0.54	
Seasons				0.42			0.17			0.62	
Compost x Antioxidant				0.53			0.19			0.66	
Compost x Seasons				0.61			0.19			0.66	
Antioxidant x Seasons				0.61			N.S.			0.71	
Compost x Antioxidant x Seasons				0.93			0.33			0.82	

Table 9: Some fruit physical characteristics of Manfalouty pomegranate trees as affected by compost tea applications and some antioxidants during 2005/06&2006/07 seasons

			Fruit juice (%)			Fruit grain (%)			Fruit peel (%)		
			Seasons			Seasons			Seasons		
Compost tea application	Treatments	Antioxidants	2005/06	2006/07	Average	2005/06	2006/07	Average	2005/06	2006/07	Average
Foliar application		Ascorbic	41.22	43.52	42.37	52.12	63.25	57.69	47.88	36.75	42.32
		Citric	37.82	40.55	39.19	51.33	60.49	55.91	48.67	39.51	44.09
		Ascorbic+citric	43.56	45.16	44.36	55.41	65.76	60.59	44.59	34.24	39.42
		Without	37.17	38.26	37.72	50.29	52.15	51.22	49.71	47.85	48.78
	Average		39.94	41.87	40.91	52.29	60.41	56.35	47.71	39.59	43.65
Soil application		Ascorbic	40.25	42.82	41.54	51.55	53.12	52.34	48.45	46.88	47.67
		Citric	34.61	37.23	35.92	50.36	50.91	50.64	49.64	49.09	49.37
		Ascorbic+citric	39.52	43.53	41.53	53.56	55.27	54.42	46.44	44.73	45.59
		Without	35.81	36.44	36.13	49.65	50.33	49.99	50.35	49.67	50.01
	Average		37.55	40.01	38.78	51.28	52.41	51.84	48.72	47.59	48.16
Control		Ascorbic	35.85	36.31	36.08	49.56	50.42	49.99	50.44	49.58	50.01
		Citric	35.79	35.99	35.89	49.53	49.88	49.71	50.47	50.12	50.30
		Ascorbic+citric	36.45	37.75	37.10	50.31	51.66	50.99	49.69	48.34	49.02
	Without		35.77	35.93	35.85	49.28	49.52	49.40	50.72	50.48	50.60
	Average		35.97	36.50	36.23	49.67	50.37	50.02	50.33	49.63	49.98
General Average			37.82	39.46	38.64	51.08	54.40	52.74	48.92	45.60	47.26
Average of antioxidants		Ascorbic acid	39.11	40.88	40.00	51.08	55.60	53.34	48.92	44.40	46.66
		Citric acid	36.07	37.92	37.00	50.41	53.76	52.08	49.59	46.24	47.92
		Ascorbic+citric	39.84	42.15	41.00	53.09	57.56	55.33	46.91	42.44	44.67
		Without	36.25	36.88	36.56	49.74	50.67	50.20	50.26	49.33	49.80
LSD at 5%											
Compost tea application				0.51			0.33			1.03	
Antioxidants				0.66			0.52			1.12	
Seasons				0.93			0.64			N.S.	
Compost x Antioxidant				0.95			0.96			1.16	
Compost x Seasons				0.95			0.96			1.16	
Antioxidant x Seasons				1.11			1.06			1.22	
Compost x Antioxidant x Seasons				1.15			1.15			1.36	

trees, found that application of compost tea gave the lowest proline value compared to using chemical fertilizers.

Compost tea with ascorbic acid + citric acid decreased proline content; this may be due to enhancing the vitamins and endogenous level of various growth factors such as cytokinens and gibberellins [29].

Yield (Kg/tree) and Fruit Physical Parameters: Data in Tables 7, 8 and 9 cleared that yield (kg/tree), fruit weight (g), fruit volume (cm^3), fruit length (cm), fruit diameter (cm), fruit juice (%) and fruit grain (%) were significantly affected by compost tea applications with antioxidant treatments in the two seasons of the study. Moreover, yield and all fruit physical parameters except fruit cracking and fruit peel were significantly increased in the second season than the first one. Concerning the effect of compost tea applications, foliar application of compost tea gave higher yield per tree and all fruit physical parameters except fruit cracking% and fruit peel (%) than soil application of compost tea. In addition, application of ascorbic acid + citric acid gave the best results followed by ascorbic acid then citric acid treatments. Concerning the interaction between compost tea applications, antioxidant treatments and seasons, foliar application of compost tea with ascorbic acid + citric acid in the second season gave higher yield per tree and all physical fruit parameters, except fruit cracking and fruit peel, than other applications under study in both seasons.

On the other hand, foliar application of compost tea with ascorbic acid + citric acid gave the less fruit cracking (%) and fruit peel compared to other applications under study in the two seasons. Nevertheless, control trees gave higher fruit cracking and fruit peel than other studied application in both seasons. Several research workers revealed that, foliar feeding is more efficient than soil fertilization; this fact is true in case of micronutrients under arid and semi-arid conditions [6-8]. Moreover,these observations are in according with those obtained by Mohammed *et al.* [22] who observed that application of compost tea resulted in higher yield than other organic application treatments without compost tea. In addition, Mostafa *et al.* [23] reported that 20-liter compost tea at five equal doses at mid of each applying month (February, March, April, June and August) gave the highest significant fruit number and yield/tree. As well as, Abdou [30] showed that application of compost in winter with compost tea at four equal doses (in summer) improved fruit physical parameters on Le Conte pear trees.

Table 10: Some fruit chemical characteristics of Manfalouty pomegranate trees as affected by compost tea applications and some antioxidants during 2005/06&2006/seasons

			T.S.S.(%)			Acidity (%)			T.S.S./acid ratio		
			Seasons			Seasons			Seasons		
Compost tea application	Treatments	Antioxidants	2005/06	2006/07	Average	2005/06	2006/07	Average	2005/06	2006/07	Average
Foliar application		Ascorbic	16.62	16.82	16.72	1.92	1.52	1.72	8.65	11.06	9.86
		Citric	16.55	16.71	16.63	1.98	1.61	1.80	8.35	10.37	9.36
		Ascorbic+citric	16.64	16.85	16.75	1.90	1.45	1.68	8.75	11.62	10.19
		Without	16.25	16.33	16.29	2.05	1.99	2.02	7.92	8.20	8.06
	Average		16.52	16.68	16.60	1.96	1.64	1.80	8.42	10.31	9.37
Soil application		Ascorbic	16.51	16.70	16.61	2.11	1.60	1.86	7.82	10.43	9.13
		Citric	16.49	16.65	16.57	2.25	1.67	1.96	7.32	9.97	8.65
		Ascorbic+citric	16.53	16.77	16.65	1.95	1.55	1.75	8.47	10.81	9.64
		Without	16.21	16.25	16.23	2.33	2.11	2.22	6.95	7.70	7.33
	Average		16.44	16.59	16.51	2.16	1.73	1.95	7.64	9.73	8.68
Control		Ascorbic	16.25	16.61	16.43	2.83	2.63	2.73	5.74	6.31	6.03
		Citric	16.21	16.53	16.37	2.90	2.75	2.83	5.58	6.01	5.80
		Ascorbic+citric	16.33	16.64	16.49	2.65	2.41	2.53	6.16	6.90	6.53
		Without	16.13	16.15	16.14	2.90	2.93	2.92	5.56	5.51	5.54
	Average		16.23	16.48	16.36	2.82	2.68	2.75	5.76	6.18	5.97
General Average			16.39	16.58	16.49	2.31	2.02	2.17	7.27	8.74	8.01
Average of antioxidants		Ascorbic acid	16.46	16.71	16.59	2.29	1.92	2.10	7.40	9.27	8.34
		Citric acid	16.42	16.63	16.52	2.38	2.01	2.19	7.08	8.78	7.93
		Ascorbic+citric	16.50	16.75	16.63	2.17	1.80	1.99	7.79	9.78	8.79
		Without	16.20	16.24	16.22	2.43	2.34	2.39	6.81	7.14	6.97
LSD at 5%											
Compost tea application				0.03			0.04			0.66	
Antioxidants				0.05			0.06			0.72	
Seasons				0.13			0.11			0.93	
Compost x Antioxidant				0.15			0.16			1.12	
Compost x Seasons				0.15			0.16			1.12	
Antioxidant x Seasons				0.22			0.18			1.15	
Compost x Antioxidant x Seasons				0.52			0.23			1.24	

Table 11: Some fruit chemical characteristics of Manfalouty pomegranate trees as affected by compost tea applications and some antioxidants during 2005/06&2006/seasons

			Total Sugars (%)			Vitamine C (mg /100 ml juice)			Total anthocyanin (%)		
			Seasons			Seasons			Seasons		
Compost tea application	Treatments	Antioxidants	2005/06	2006/07	Average	2005/06	2006/07	Average	2005/06	2006/07	Average
Foliar application		Ascorbic	14.32	14.85	14.59	15.52	16.95	16.24	5.25	5.94	5.60
		Citric	14.25	14.72	14.49	14.93	15.41	15.17	4.52	5.33	4.93
		Ascorbic+citric	14.55	14.96	14.76	15.88	17.52	16.70	5.66	6.82	6.24
		Without	13.77	13.85	13.81	14.33	14.52	14.43	4.18	4.95	4.57
	Average		14.22	14.60	14.41	15.17	16.10	15.63	4.90	5.76	5.33
Soil application		Ascorbic	14.41	14.67	14.54	15.11	16.33	15.72	5.18	5.44	5.31
		Citric	13.33	14.53	13.93	14.32	14.95	14.64	4.33	5.21	4.77
		Ascorbic+citric	14.62	14.82	14.72	15.65	17.21	16.43	5.42	6.55	5.99
		Without	13.63	13.81	13.72	14.25	14.63	14.44	3.99	4.86	4.43
	Average		14.00	14.46	14.23	14.83	15.78	15.31	4.73	5.52	5.12
Control		Ascorbic	13.44	13.73	13.59	14.93	16.09	15.51	5.09	5.31	5.20
		Citric	13.25	13.66	13.46	14.18	14.22	14.20	4.11	4.98	4.55
		Ascorbic+citric	13.74	13.85	13.80	15.12	16.17	15.65	5.21	5.91	5.56
		Without	13.00	13.05	13.03	14.11	14.13	14.12	3.85	3.96	3.91
	Average		13.36	13.57	13.47	14.59	15.15	14.87	4.57	5.04	4.80
General Average			13.86	14.21	14.03	14.86	15.68	15.27	4.73	5.44	5.09
Average of antioxidants		Ascorbic acid	14.06	14.42	14.24	15.19	16.46	15.82	5.17	5.56	5.37
		Citric acid	13.61	14.30	13.96	14.48	14.86	14.67	4.32	5.17	4.75
		Ascorbic+citric	14.30	14.54	14.42	15.55	16.97	16.26	5.43	6.43	5.93
		Without	13.47	13.57	13.52	14.23	14.43	14.33	4.01	4.59	4.30
LSD at 5%											
Compost tea application				0.03			0.06			0.03	
Antioxidants				0.04			0.13			0.06	
Seasons				0.12			0.16			0.14	
Compost x Antioxidant				0.14			0.21			0.18	
Compost x Seasons				0.14			0.21			0.18	
Antioxidant x Seasons				0.15			0.25			0.23	
Compost x Antioxidant x Seasons				0.23			0.55			0.33	

Concerning application of antioxidant treatments, ascorbic or citric acid have auxinic action and also synergistic effect on flowering and fruit of fruit trees, recently antioxidants are used instead of auxins and other chemicals for enhancing fruiting of various fruit trees [9, 10].

Spraying a mix of ascorbic and citric acids, each at 1000 ppm, enhanced yield and fruit quality of pomegranate trees. The fundamental role of antioxidants in regulation of cell division and elongation, protection against oxidative stress, act as a co-factor for many enzymes and play a role in signal transduction system and thereby regulation of growth and defense responses [24, 31, 32]. The results of fruit peel and cracking are in line with the results reported by many researchers [33-35].

Fruit Chemical Parameters: As shown in Tables 10 and 11, all fruit chemical parameters (TSS%, TSS/acid ratio, total sugars%, vitamin C mg/100 ml juice and Total anthocyanin%), except juice acidity%, were significantly affected by compost tea application with antioxidant treatments in the two seasons. Also, all fruit chemical parameters except acidity% were significantly increased in the second season than the first one.

Concerning the effect of compost tea application, foliar application of compost tea gave higher values of all fruit chemical content than soil application of compost tea in both seasons. Moreover, combined antioxidant treatments (ascorbic acid + citric acid) gave the best total sugars, vitamin C and total anthocyanin, as well as, ascorbic acid alone or combined plus citric acid gave the best TSS and TSS/acid ratio in both seasons.

Concerning the interaction between compost tea applications; antioxidant treatments and seasons, foliar application of compost tea with ascorbic acid + citric acid in the second season gave the highest fruit chemical values, except acidity, compared to other interactions under study. On the other hand, foliar application of compost tea with ascorbic acid + citric acid gave the lowest acidity in both seasons compared to other studied applications.

The present results are in agreement with those obtained by Mostafa *et al*. [23] who reported that 20 litres compost tea at five equal doses gave the higher significant fruit chemical parameters (TSS, total sugars, vitamin C and TSS/acid ratio) than control of orange trees. Also, Abdou [30] showed that the application of compost tea gave the superior fruit chemical quality compared with the control of pear trees.

The ameliorative effects of the applied treatment of ascorbic acid + citric acid could be explained by their antioxidant functions against the reactive oxygen species that forms in corresponding with exposing to stress [25]. Also, the enhancement effect of these treatments may be due to their essential roles in signal transduction system, membrane stability and functions, activating transporter enzymes, metabolism and translocation of carbohydrates [24, 28].

Finally, the recommendation is the using of foliar application of compost tea with ascorbic acid + citric acid to improve the leaf chemical constituents, yield and fruit quality of Manfalouty pomegranate trees.

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