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Effect of Different Irrigation Regimes on Quality and Storability of Mango Fruits *(Mangifera indica* L.)

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Abstract: The present work aims to study the effect of different irrigation regimes (100%, 85% and 70% of Etc) on quality and storability of two mango cultivars namely Ewais and Tomy Atkins. Fruit samples were collected at maturity stage and stored at 14° C RH 85% ± 2 for four weeks (analyzed weekly). The results indicated that irrigation trees with 70% of Etc decreased pulp moisture content and weight loss % increased pulp firmness, decay %, TSS %, total acidity in fruit juice, TSS/acid ratio of mature fruit when compared with those irrigated with 100% Etc under cold storage, fruit moisture content, weight loss %, firmness, fruit decay % and total acidity were decreased with increasing number of storage days, while TSS% and TSS/ acid ratio were increased.

Key words: Mango · Water regimes · Cold storage · Ripening stage

INTRODUCTION

Mango (*Mangifera indica* L.) is widely cropped in tropical, subtropical regions and can be also successfully cultivated in the irrigated semi arid regions all over the world. Egypt is one of semi arid countries that successfully cultivate and produce lot of mango cultivars. However, deficit of irrigation water is a serious problem that faces mango cultivars in all semi arid countries. Many efforts have been worldwide done to improve the efficiency of irrigation water use in lot of various fruit crop species [1, 2]. Moreover, other studies, De Azevedo *et al*. [3] are performed to determine the optimal water regime for some mango cultivars However, little research regarding the response of mango fruit yield either the quantity or quality to the reduction of irrigation water is reviewed. The impact of water deficit on fruit quality has been investigated for several fruit species. Pickering *et al.* [4] found a positive influence of water deficit on mango fruit quality. Kader [5] in the view that time period between harvest and fruit consumption should be too short in order to get the optimum fruit flavor. Johnson and Hofman [6] reported that rapid cooling of fruits is needed to minimize the respiration rate of fruits and to provide the best possible eating quality. Therefore, the aim of the present study is to determine the fruit quality and storability after subjecting the tree in the field to different regimes of irrigation water.

MATERIALS AND METHODS

The study was conducted in a commercial orchard located in El-Molak Valley-Ismailia Governorate, Egypt during the two seasons of 2010 and 2011. Mango tress of Tomy Atkins and Ewais cultivars were 10 years old, grafted on seed rootstocks, a parted 4x6 m and drip irrigated were devoted for the study. The experiment was done on three trees nearly similar in growth per each studied cultivar since one tree was considered a replicate. The two mango cultivars were subjected to three irrigation regimes. The three water irrigation regimes were equivalent to 100%, 85% and 70% of crop evaporation respiration (Etc) were determined by using the Penman-Monteith according to Allen *et al.* [7] equation:

$$\text{Crop evapotranspiration (Etc) mm /day} = Et_o \times Kc$$

Fruits of the two mango cultivars were collected at maturity stage as recommended by Khalifa [8]. A sample of 5 fruits replicated three times (5x3 = 15 fruits) were collected from each treatment in each mango cultivar at harvest and devoted for determining the physical and chemical fruit characteristics. The same number of fruits (5x3) was sampled at harvest to determine the weight loss and decay percentage of fruits during storage. Fruits were washed with tap water, let to dry and weighed after harvesting and during storage. Pulp moisture content,

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TSS % in fruit juice, total acidity in fruit juice and fruit firmness was determined. The second fruit samples that were devoted for storage were washed, dried, weighed and put in boxes then stored in refrigerator at 14°C and relative humidity 85% ± 2 according to Sobieh *et al.* [9]. The loss in fruit weight during storage and also decayed fruit as well as physical and chemical properties of sound fruits under storage were biweekly recorded.

Physical Properties of Fruit: Moisture fruit content %, weight loss %, fruit firmness and fruit decay % were determined. Fruit firmness was measured in Lb/inch^2 using pressure tester (digital force-Gouge model FGV-0.5 A to FGV-100 A. Shimpo Instruments).

$$\text{Fruit decay \%} = \frac{\text{No. of decayed fruits at sampling date}}{\text{Initial number of stored mature fruit}} \times 100$$

Chemical Properties of Fruit: TSS % and total acidity % in fruit juice were determined. TSS/acid ratio was estimated.

Statistical Analysis: Analysis of variance (ANOVA) was performed using two way ANOVA from SAS software [10].

RESULTS AND DISCUSSION

Physical Properties of Fruit

Fruit Moisture Content %: Data presented in Tables 1 and 2 showed that fruit pulp moisture% was gradually and proportionally decreased with decreasing either the irrigation water % of Etc from 100% to 70% or with increasing number of days being under cold storage in both studied mango cultivars in both 2010 and 2011 seasons. The reduction in moisture content may be due to fruit skin transpiration and to some extent to fruit respiration as reported by Rathore *et al.* [11]. The present results are also similar with the finding of Proietti and Antognozzi [12], who reported that with increasing irrigation regime, pulp water content of olive was increased.

Weight Loss %: As shown in Tables 1 and 2, fruits of both mango cultivars showed a decrease in weight loss percentages by a reduction under irrigation water from 100% to 70%, while the loss values (percentages) were increased in general with increasing number of days being under cold storage in both studied cultivars. Fruit of Ewais mango cv. showed clearly more loss in weight up to 4 weeks being under cold storage than that of Tomy Atkins cultivar. The present results are in agreement with those obtained by Rathore *et al.* [11], who found that weight losses of cold stored mango fruits proportionally increased with increasing number of days being under cold storage condition. The authors reported that the increase in fruit weight loss under cold storage may be due to respiration and transpiration of water through fruit peel tissue and to some biological changes occurred in fruits. However, weight loss was lower in fruits treated with 70% Etc as compared to that of control (100% Etc).

Fruit Firmness (Lb/inch^2): Data presented in Tables 1 and 2 clearly showed that pulp firmness gradually decreased with increasing number of days being under cold storage in all irrigation water treatments. Hosakote *et al*. [13] observed that softening in fruit texture from unripe to ripe stage of mango was a result of a decrease in starch content, pectin, cellulose and hemicelluloses. Data also in Tables 1 and 2 showed a sharp decrease in fruit firmness occurred after being the fruit three weeks under cold storage condition and that indicated the occurrence of fruit ripening of both cvs. Ewais and Tomy Atkins. Fruit firmness could also be an index for determining the optimum stage of fruit maturity as reported by Proietti and Antognozzi [12] on olive, that increasing irrigation water decreased the fruit firmness. The results in Tables 1and 2 also showed that the reduction in irrigation water regime to be 70% increased the fruit firmness compared with those irrigated with 100% Etc under cold storage condition. In other words, the reduction in irrigation water should slow the converting to fruit ripening stage under cold storage.

Fruit Decay %: The results in Tables 1and 2 clearly showed that decayed fruits could not be detected for seven days being under cold storage in both studied mango cultivars. Data indicated that the reduction irrigation water from 100% to 70% Etc decreased the decayed fruit percentage under cold storage. The increase in number of days being under cold storage increased the decayed fruit percentage. It seemed that ripening stage occurred after being the fruits under cold storage, therefore the percentage of decayed fruits drastically increased. Therefore, it's better to end the cold storage after three weeks. The present results are in agreement with those obtained by Abdrabboh and Abdel-Razik [14], they reported that decay percentage of cold stored grapes was increased with advancing storage period.

Table 1: Effect of different irrigation water regimes on physical properties of Ewais mango cultivar under cold storage during 2010 and 2011 seasons

Irrigation water %	2010															
	Fruit moisture %				Fruit firmness L / in^2				Fruit weight loss %				No. of decayed fruit %			
Storage period (week)	100%	85 %	70%	Mean	100%	85 %	70%	Mean	100%	85 %	70%	Mean	100%	85 %	70%	Mean
0	75.73	73.73	72.00	73.82	24.40	28.13	31.84	28.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	74.47	73.00	71.07	72.85	20.33	21.45	26.55	22.78	7.52	6.88	4.89	6.43	0.00	0.00	0.00	0.00
2	73.00	72.17	70.17	71.78	16.20	18.34	20.81	18.45	8.92	8.00	6.15	7.69	13.08	5.26	3.33	7.22
3	72.04	72.00	69.93	71.32	14.41	14.70	16.48	15.20	11.02	8.78	8.03	9.28	15.50	19.59	12.22	15.77
4	71.00	70.60	69.60	70.40	2.50	3.20	3.43	3.04	13.69	11.02	10.48	11.73	49.33	50.00	39.33	46.22
Mean	73.25	72.30	70.55	--	15.57	17.16	19.82	--	8.23	6.94	5.91	--	15.58	14..97	10..98	--
LSD 0.05:																
Treatments		0.94				2.03				1.72				3.99		
Storage period		1.21				2.62				2.27				5.15		
T x S		2.11				4.54				4.54				8.93		

Table 1: Continue

Irrigation water %	2011															
	Fruit moisture %				Fruit firmness L / in^2				Fruit weight loss %				No. of decayed fruit %			
Storage period (week)	100%	85 %	70%	Mean	100%	85 %	70%	Mean	100%	85 %	70%	Mean	100%	85 %	70%	Mean
0	74.87	73.23	72.40	73.50	22.95	25.73	28.23	25.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	75.20	72.73	71.53	73.15	20.47	21.24	24.83	22.18	6.49	2.89	3.34	4.24	0.00	0.00	0.00	0.00
2	74.00	72.17	71.33	72.50	16.99	17.13	19.61	17.91	8.65	4.70	4.01	5.79	8.09	4.76	3.33	5.39
3	73.47	72.00	71.00	72.16	13.51	15.06	16.67	15.08	10.94	8.82	5.44	8.40	14.28	9.52	10.83	11.54
4	74.87	73.23	72.40	71.32	2.80	3.04	3.79	3.21	14.96	10.21	8.32	11.16	50.33	40.0	40.00	43.44
Mean	73.97	72.27	71.33	--	15.34	16.44	18.63	--	8.21	5.32	4.22	--	14.54	10.86	10.83	--
LSD 0.05:																
Treatments		1.93				0.74				1.17				6.35		
Storage period		2.49				0.96				1.51				8.20		
T x S		4.32				1.67				2.62				14.21		

Table 2: Effect of different irrigation water regims on physical properties of Tomy mango cultivar under cold storage during 2010 and 2011 seasons

Irrigation water %	2010															
	Fruit moisture %				Fruit firmness L / in^2				Fruit weight loss %				No. of decayed fruit %			
Storage period (week)	100%	85 %	70%	Mean	100%	85 %	70%	Mean	100%	85 %	70%	Mean	100%	85 %	70%	Mean
0	78.83	75.53	74.80	76.39	21.32	23.63	28.08	24.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	76.80	74.37	74.27	75.15	20.27	20.68	23.90	21.62	3.35	3.04	1.91	2.77	0.00	0.00	0.00	0.00
2	75.77	74.00	73.20	74.32	17.20	18.76	20.67	18.88	4.12	3.46	2.56	3.38	2.56	5.13	9.52	5.74
3	74.70	73.17	72.90	73.59	14.50	15.76	16.62	15.63	5.36	4.02	3.23	4.20	19.56	13.33	10.44	14.44
4	72.77	71.73	71.63	72.04	5.77	5.79	5.96	5.84	13.73	8.33	7.93	10.00	33.33	24.00	13.33	23.55
Mean	75.31	73.76	73.36	--	15.81	16.92	19.04	--	5.31	3.77	3.12	--	11.09	8.49	6.65	--
LSD 0.05:																
Treatments		3.82				2.09				0.96				6.10		
Storage period		4.94				2.70				1.24				7.88		
T x S		8.55				4.69				2.16				13.65		

Table 2: Continue

Irrigation water %	2011															
	Fruit moisture %				Fruit firmness L / in^2				Fruit weight loss %				No. of decayed fruit %			
Storage period (week)	100%	85 %	70%	Mean	100%	85 %	70%	Mean	100%	85 %	70%	Mean	100%	85 %	70%	Mean
0	79.53	75.67	74.97	76.72	20.20	22.72	27.33	23.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	77.43	74.07	73.67	75.06	19.60	19.93	23.29	20.94	3.89	2.22	1.76	2.62	0.00	0.00	0.00	0.00
2	76.20	73.14	73.00	74.11	16.20	17.03	21.05	18.09	4.88	3.88	2.68	3.81	4.76	8.09	0.00	4.28
3	75.00	72.83	72.67	73.50	14.06	14.80	15.98	14.95	6.14	5.10	3.81	5.02	14.76	9.52	13.09	12.46
4	73.95	71.27	71.03	72.08	4.83	5.37	6.04	5.41	14.33	9.37	7.67	10.46	35.00	25.00	20.00	26.67
Mean	76.42	73.40	73.07	--	14.98	15.97	18.74	--	5.85	4.11	3.18	--	10.90	8.52	6.62	--
LSD 0.05:																
Treatments		0.84				0.67				1.13				5.56		
Storage period		1.09				0.87				1.46				7.18		
T x S		1.89				1.51				2.53				12.45		

Table 3: Effect of different irrigation water regims on chemical properties of Ewais mango cultivar under cold storage during 2010 and 2011 seasons

Irrigation water %	2010											
	TSS %				Total acidity %				TSS/ Acidity			
Storage period (week)	100%	85 %	70%	Mean	100%	85 %	70%	Mean	100%	85 %	70%	Mean
0	10.67	13.00	15.00	12.89	1.50	1.42	1.67	1.53	7.44	9.99	9.10	8.84
1	13.33	14.00	16.67	14.67	1.28	1.34	1.40	1.34	11.71	10.75	12.14	11.53
2	17.00	19.00	21.00	19.00	1.10	1.22	1.32	1.21	16.07	15.86	16.17	16.03
3	22.33	24.33	24.33	23.66	0.77	0.84	1.04	0.88	28.91	28.26	24.29	27.15
4	26.00	25.00	29.67	26.89	0.14	0.23	0.25	0.21	186.90	116.36	118.81	140.69
Mean	17.87	19.7	21.33	--	0.96	1.01	1.14	--	50.21	36.24	36.10	--
LSD 0.05:												
Treatments		1.85				0.19				10.06		
Storage period		2.39				0.25				11.85		
T x S		4.15				0.44				19.94		

Table 3: Continue

Irrigation water %	2011											
	TSS %				Total acidity %				TSS/ Acidity			
Storage period (week)	100%	85 %	70%	Mean	100%	85 %	70%	Mean	100%	85 %	70%	Mean
0	11.33	13.33	15.34	13.33	1.49	1.65	1.79	1.64	7.62	8.03	8.63	8.09
1	13.00	15.00	17.33	15.11	1.35	1.43	1.63	1.47	9.67	10.86	10.67	10.40
2	16.00	19.00	22.00	19.00	1.13	1.19	1.53	1.28	14.17	16.54	14.44	15.05
3	22.67	24.00	26.00	24.22	0.78	0.84	1.06	0.89	29.27	28.50	24.90	27.56
4	25.67	27.00	29.33	27.33	0.24	0.28	0.29	0.27	107.25	96.43	101.07	101.58
Mean	17.73	19.67	22.00	--	1.00	1.08	1.26	--	33.60	32.07	31.94	--
LSD 0.05:												
Treatments		1.23				0.15				2.21		
Storage period		1.59				0.19				2.85		
T x S		2.47				0.34				2.94		

Table 4: Effect of different irrigation water regims on chemical properties of Tomy mango cultivar under cold storage during 2010 and 2011 seasons

Irrigation water %	2010											
	TSS %				Total acidity %				TSS/ Acidity			
Storage period (week)	100%	85 %	70%	Mean	100%	85 %	70%	Mean	100%	85 %	70%	Mean
0	9.00	11.00	12.00	10.67	1.08	1.21	1.62	1.30	8.45	9.29	7.39	8.38
1	12.00	11.33	17.00	13.44	0.93	0.95	1.59	1.16	14.32	12.21	10.67	12.40
2	14.00	12.00	18.00	14.67	0.89	0.91	1.20	1.00	16.27	13.54	15.56	15.12
3	15.33	16.00	19.00	16.78	0.64	0.67	0.96	0.76	20.89	23.93	20.06	21.62
4	21.00	22.33	27.00	23.44	0.23	0.24	0.64	0.37	94.16	106.65	46.64	82.48
Mean	14.27	14.53	18.60	--	0.75	0.80	1.20	--	30.82	33.12	20.06	--
LSD 0.05:												
Treatments		2.11				0.14				11.93		
Storage period		2.72				0.19				15.41		
T x S		4.72				0.33				26.69		

Table 4: Continue

Irrigation water %	2011											
	TSS %				Total acidity %				TSS/ Acidity			
Storage period (week)	100%	85 %	70%	Mean	100%	85 %	70%	Mean	100%	85 %	70%	Mean
0	9.67	10.67	11.33	10.56	1.03	1.04	1.60	1.22	9.39	10.43	7.14	8.99
1	12.67	11.67	17.33	13.89	0.91	0.97	1.46	1.11	14.59	11.94	11.82	12.78
2	13.33	13.00	18.33	14.89	0.84	0.90	1.24	0.99	15.89	14.39	14.74	15.00
3	15.00	16.33	19.67	17.00	0.69	0.68	0.91	0.76	21.62	24.19	21.54	22.45
4	20.00	20.67	26.00	22.22	0.21	0.25	0.52	0.32	95.22	83.03	50.03	76.09
Mean	14.13	14.47	18.53	--	0.73	0.77	1.15	--	31.34	28.80	21.05	--
LSD 0.05:												
Treatments		1.30				0.08				7.99		
Storage period		1.67				0.10				10.32		
T x S		2.90				0.18				17.87		

Chemical Properties of Fruit

Total Soluble Solids (TSS %): Data in Tables 3 and 4 indicated that TSS% in the juice of the two mango varieties gradually increased with the prolonging of cold storage period in both seasons. Thus the maximum values of TSS% were recorded at the end of storage period (4weeks) in both seasons. The results are corresponding with those obtained by Zheng *et al.* [15], who reported that TSS% was increased in the juice of mango fruit during cold storage. The increase in TSS% might be due to the breakdown of the complex form of carbohydrates into simple sugars during cold storage. According to Rathore *et al.* [11] the increase in TSS% are directly correlated with hydrolytic changes in starch and conversion of starch to sugar being an important index of ripening process in mango. The present results showed that TSS% was increased with the reduction of irrigation water that given to the orchard and the maximum increase was recorded at 70% of Etc.

Total Acidity %: Data presented in Tables 3 and 4 also showed that total acidity % of two mango cultivars was significantly decreased with prolonging cold storage periods; hence the minimum fruit acidity percentage was recorded at the end of storage period, during the two seasons of study. Similar changes were reported by Rathore *et al.* [11] on mango that titratable acidity showed a decreasing trend during 15 days of storage period. They added that the decrease in acidity may be attributed to the increase in activity of citric acid glyoxylase during ripening; the reduction in acidity also may be due to their conversion into sugars and their further utilization in metabolic process in the fruit. The highest value of acidity was found at 70% of Etc, while the lowest at 100% of Etc.

TSS /Acid Ratio: Results in Tables 3 and 4 showed that, TSS/acid ratio was gradually increased under cold storage for all treatments and attained the highest value at the fourth week in both mango varieties. The increase in TSS/acid ratio may be due to the increase of TSS and decrease of total acidity% by prolonging the cold storage period. As for the effect of water treatments on TSS/acid ratio, the results indicated that the reduction of irrigation water led to as increase in ratio of TSS/acid compared with 100% or 70% Et_c. The results are in agreement with those obtained by Nasir and Haq Main [16], who reported that, excessive moisture, has a depressing effect on TSS/acid ratio. On the other hand, Abdrabboh and Abdel-Razik [14] found that TSS/acid ratio was increased during the cold storage.

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