J. Plant Production, Mansoura Univ., Vol. 2 (12): 1805 - 1814, 2011

RESPONSE OF SOME EGYPTIANS SWEET MELON (*Cucumis melo* var. *Aegyptiacus* L.) CULTIVARS TO WATER STRESS CONDITIONS

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ABSTRACT

Drought is a wide-spread problem seriously influencing sweet melon (*Cucumis melo* var. *Aegyptiacus* L.) production and quality. Therefore, the identification or development of tolerant genotypes is of high importance for incorporating in sweet melon production. Hence, two field experiments were conducted in a clay loam soil at Baramoon Experimental Farm, Dakahlia Governorate, Egypt during the two summer seasons of 2009 and 2010, to evaluate five sweet melon cultivars (Shahd El-Dokki, Ananas El-Dokki, Ismaelawi, Kahera-6 improved, Albasosi) under regular irrigation and stress conditions using a split plot design with three replicates. Drought conditions were started after first irrigation and created by reducing the frequency of irrigation by one half compared with regularly irrigated plants, *i.e.*, missing alternate irrigation. Results indicated that exposing the sweet melon cultivars to water stress led to significant decreases in fruit weight, fruit length, fruit width, flesh fruit thickness, total yield per plant and Leaf relative water content in both seasons. Whereas, water deficit caused significant increases in total soluble solids in both seasons. The tested cultivars markedly varied among them in all estimated characters in both seasons. The interaction between irrigation levels and cultivars had significant effects on all traits under study. Cultivars with the highest yield and yield components under non-stress conditions had the highest yield and yield components under stress conditions, and this was true in both seasons. On the basis of the drought resistance indices (drought susceptibility index, relative yield reduction and relative yield values), Kahera-6 improved was relatively stress susceptible, whereas Albasosi was more tolerant and stable cultivar so; this cultivar could be further tested for their drought confirming characteristics.

Keywords: *Cucumis melo*, sweet melon, cultivars, water stress, drought resistance.

INTRODUCTION

Sweet melon (*Cucumis melo* var. *Aegyptiacus* L.) is considered one of the most important vegetable crops grown in Egypt. Fruits are consumed in the summer period and are popular because the pulp of the fruit is very refreshing, high nutritional and sweet with a pleasant aroma (Melo *et al*., 2000).

The shortage availability of water has become a worldwide problem; therefore, there has been an intense interest in studying plant water stress interactions in arid and semi-arid environments. In Egypt, under limited water supply conditions the farmer tends to increase the irrigation interval, which creates water stress. Water stress is one of the most important factors affecting every aspect of plant growth. Many irrigation experiments have shown that melon is sensitive to water stress (Faberio *et al.*, 2002; Sensoy *et al*., 2007).Fruit yield and its components were highly influenced by the total volume of irrigation water at different crop stages in a semi-arid climate (Faberio *et al*., 2002). Water deficit produces smaller fruits; Fabeiro *et al*., 2002; Long *et al.,* 2006) and lower yields (Kirnak *et al*., 2005; Sensoy *et al*., 2007 Dogan *et al.,* 2008; Cabello *et al.*, 2009; Zeng *et al.,* 2009). Fruit weight was more sensitive to water deficit than fruit number (Long *et al*., 2006; Dogan *et al.,* 2008; Cabello *et al.*, 2009).

Although considerable variation for drought resistance has been identified among muskmelon cultivars (El-Kassas and El-Sebsey, 1998) limited research has been done to study the effects of water stress on sweet melon cultivars in Egypt.

In future years, breeding programs must consider and select from improved water use efficiency in newly released varieties. In this regard, screening for more drought tolerant sweet melon varieties, which are able to produce an acceptable yield under water stress, has became a new strategy in breeding research programs. Thus, it is important to identify sweet melon genotypes with high yield potential and stability under drought stress.

Therefore, this study was an attempt to screen cultivars with high yield potential and stability under water stress conditions, in order to identify cultivars that can adapt themselves to conditions of water deficit.

MATERIALS AND METHODS

Two field experiments were performed at Baramoon Experimental Farm, Dakahlia Governorate, Egypt, where the soil is Clay-loam, during the two summer seasons of 2009 and 2010. Five sweet melon cultivars (Shahd El-Dokki, Ananas El-Dokki, Ismaelawi, Kahera-6 improved, Albasosi) were used for this study.

A split plot design with three replicates was used. The main plots were assigned to two irrigation levels (regular irrigation and stress conditions). Drought conditions were started after first irrigation and created by reducing the frequency of irrigation watering by one half compared with regularly irrigated plants, *i.e.*, missing alternate irrigation. Sub plots were devoted to five sweet melon cultivars. Each experimental unit area was consisted of four ridges each of 5 m length and 1.5 m in width, and one plant per hill with 50 cm apart.

Seeds were sown on 8 and 7 April in both study seasons, respectively. The culture practices, except irrigation, were done according to the general program of sweet melon cultivation.

Leaf relative water content was determined according to Barrs and Weatherley (1962). At the end of ripening stage before 4 days for harvest, eight uppermost fully expanded leaves were cut per plot, with random sampling. Leaf samples were weighed and saturated in distilled water. After 24 h, samples were taken out of water, dried and immediately weighed to obtain fully turgid weight. The samples were then oven dried at 65°C for 48 h and their dry weights were recorded. Leaf relative water content (RWC) was calculated as:

RWC (%) = [(W-DW) ⁄ (TW-DW)] x 100, Where W= sample of fresh weight, TW= sample of turgid weight, DW= sample of dry weight.

At harvest, a random sample of 8 plants was taken from each experimental unit to study the total yield per plant (g), while fruit weight (g), fruit length (cm), fruit width (cm), flesh fruit thickness (cm), and total soluble solids (TSS) were recorded as the average data of 10 fruits/plot. Total soluble solids were determined using a hand refractometer.

The data were statistically analyzed as split plot design according to Snedecor and Cochran (1982). Comparisons among means of treatments were tested using LSD values at 5% level.

Evaluation of drought resistance: Based on average of two seasons, the results were used to evaluate the effect of drought stress. Drought resistance indices were defined by following formula:

1. Stress susceptibility index = (1-Ys/Yw)/D (Fisher and Maurer, 1978)
2. Relative yield reduction = 1-Ys/Yw (Hiller and Clark, 1971)

Where Ys is the mean of yield under drought, Yw is the mean of yield under well-watered conditions, and D is the environmental stress intensity = 1-(mean yield of all varieties under drought/mean yield of all varieties under well-watered conditions). The relative yield under drought was calculated as the yield of a specific genotype under drought divided by that of the highest yielding genotype in the population.

RESULTS AND DISCUSSION

Yield and its components:

Data illustrated in Table 1 reveal that drought stress significantly decreased the fruit weight, fruit length, fruit width, flesh fruit thickness and total yield per plant in both seasons. At water deficit, low crop yield obtained may be due to infrequent application of water resulting in a lack of moisture in active crop root zone, inadequate moisture conservation, and poor nutrient utilization, which affects net assimilation, thereby decreasing the production and allocation of carbohydrates to the epigeous plant parts, including the fruits (Frank and Viets, 1967; Huang et al., 2011). These results are supported by the research findings of Fabeiro *et al*. (2002), Long *et al.* (2006), Sensoy *et al.* (2007), Dogan *et al.* (2008), Cabello *et al.* (2009), Zeng *et al.* (2009), Tuna *et al.* (2010) and Simsek and Comlekcioglu (2011).

Table 1: Effect of irrigation levels on sweet melon yield and its components during summer 2009 and 2010 seasons

Irrigation levels	Fruit weight (g)	Fruit length (cm)	Fruit width (cm)	Flesh fruit thickness (cm)	Total yield / plant (g)
2009 season					
Normal	2429	23.08	15.02	3.88	5779
Stress	1896	20.68	13.30	3.45	4170
LSD 5%	61	0.39	0.64	0.19	204
2010 season					
Normal	2304	22.02	14.13	3.67	5642
Stress	1809	20.15	12.99	3.20	4091
LSD 5%	172	1.38	0.15	0.10	47

Data in Table 2 reveal that sweet melon cultivars exhibited significant differences for all tested characters in both seasons. Albasosi cultivar gave the highest means in fruit weight, fruit length, fruit width, flesh fruit thickness and total yield per plant than other cultivars in both seasons. While Shahd El-Dokki cultivar gave the lowest values of fruit weight, fruit width, and total yield per plant in both seasons. The lowest values of fruit length and flesh fruit thickness were recorded with plants of cv. Kahera-6 improved. These findings were similar in both experimental seasons. Some investigators concluded that the genotypic variation between cultivars of Egyptians sweet melon might result in variation in yield and its components (El-Dweny 1978; El- Shimi and Ghoneim, 2006; Khereba *et al*., 2010).

Table 2: Effect of sweet melon cultivars on yield and its components during summer 2009 and 2010 seasons

Cultivars	Fruit weight (g)	Fruit length (cm)	Fruit width (cm)	Flesh fruit thickness (cm)	Total yield / plant (g)
2009 season					
Shahd El-Dokki	1354	19.21	11.66	3.30	3280
Ananas El-Dokki	1540	17.11	13.32	3.37	3867
Ismaelawi	2292	27.50	12.91	3.45	5135
Kahera-6 improved	1675	17.06	15.95	3.16	4292
Albasosi	3952	28.53	16.96	5.05	8298
LSD 5%	185	1.45	1.17	0.35	223
2010 season					
Shahd El-Dokki	1279	18.24	11.31	3.16	3219
Ananas El-Dokki	1435	16.46	12.77	3.26	3833
Ismaelawi	2167	26.53	12.40	3.32	5025
Kahera-6 improved	1571	16.55	15.10	3.05	4203
Albasosi	3831	27.65	16.20	4.88	8054
LSD 5%	155	1.07	1.00	0.19	139

The interaction between irrigation levels and cultivars had significant effects on all studied traits in both seasons (Table 3). The results clearly show that for all tested sweet melon cultivars the effect of drought stress resulted in reduction in all studied traits. The plants of cv. Albasosi watered regularly gave the highest values for fruit weight, fruit length, fruit width, flesh fruit thickness and total yield per plant, but it gave the lowest values for TSS in comparison with other interactions in both seasons (Table 3). While stressed plants of cv. Shahd El-Dokki exhibited commonly reduction in fruit weight, fruit width, and total yield per plant in both seasons. These results were in agreement with those found by El-Kassas and El-Sebsey (1998) on muskmelon.

Leaf relative water content and fruit TSS:

In both growing seasons, the relative water content of leaves decreased significantly with water deficit, whereas fruit TSS increased significantly under water stress conditions (Table 4). The results obtained by different researchers (Zeng *et al.,* 2009: Tuna *et al.,* 2010; Kusvuran *et al*., 2010; Huang *et al*., 2011) show that water stress has a wider role in reducing leaf relative water content. Moreover, a positive effect of drought on TSS was also observed by Fabeiro *et al*. (2002), Long *et al*., (2006), Sensoy *et al.* (2007) and Zeng *et al.* (2009).

Table 3: Effect of the interaction between irrigation levels and sweet melon cultivars on yield and its components during summer 2009 and 2010 seasons

Treatments		Fruit weight (g)	Fruit length (cm)	Fruit width (cm)	Flesh fruit thickness (cm)	Total yield / plant (g)
Irrigation levels	Cultivars					
2009 season						
Normal	Shahd El-Dokki	1519	20.39	12.50	3.48	3813
	Ananas El-Dokki	1712	18.01	14.13	3.56	4485
	Ismaelawi	2587	28.87	13.66	3.68	5995
	Kahera-6 improved	1875	18.04	16.87	3.31	5044
	Albasosi	4453	30.11	17.93	537	9558
Stress	Shahd El-Dokki	1189	18.03	10.82	3.12	2747
	Ananas El-Dokki	1368	16.20	12.51	3.19	3248
	Ismaelawi	1997	26.13	12.16	3.23	4274
	Kahera-6 improved	1474	16.08	15.03	3.00	3540
	Albasosi	3450	26.95	15.98	4.72	7038
LSD 5%		68	2.06	1.66	0.50	316
2010 season						
Normal	Shahd El-Dokki	1404	19.11	11.78	3.25	3701
	Ananas El-Dokki	1572	16.95	13.21	3.36	4367
	Ismaelawi	2451	27.53	12.86	3.47	5849
	Kahera-6 improved	1756	17.45	15.87	3.11	4907
	Albasosi	4337	29.07	16.93	5.14	9385
Stress	Shahd El-Dokki	1153	17.36	10.84	3.06	2737
	Ananas El-Dokki	1298	15.97	12.32	3.15	3298
	Ismaelawi	1883	25.54	11.95	3.17	4200
	Kahera-6 improved	1386	15.66	14.34	2.98	3498
	Albasosi	3324	26.24	15.47	4.62	6723
LSD 5%		219	1.51	1.41	0.27	197

Table 4: Effect of irrigation levels on leaf relative water content (RWC) and fruit TSS during summer 2008 and 2009 seasons

Irrigation levels	RWC (%)		TSS (%)	
	2009	2010	2009	2010
Normal	84.9	85.1	9.93	9.50
Stress	42.8	42.4	11.71	11.44
LSD 5%	2.8	2.7	0.26	1.23

In various sweet melon cultivars, Albasosi cultivar recorded the highest relative water content of leaves and the lowest values of TSS in fruits, while Kahera-6 improved cultivar recorded the lowest relative water content of leaves and the highest values of TSS in fruits in comparison with other cultivars in both seasons (Table 5). Other previous studies have focused upon variability among melon cultivars in relative water content of leaves (Kusvuran et al., 2010) and TSS in fruits (Khereba *et al*., 2010).

Table 5: Effect of sweet melon cultivars on leaf relative water content (RWC) and fruit TSS during summer 2009 and 2010 seasons

Cultivars	RWC (%)		TSS (%)	
	2009	2010	2009	2010
Shahd El-Dokki	63.1	62.7	10.48	10.10
Ananas El-Dokki	65.8	66.5	11.48	11.32
Ismaelawi	62.4	62.0	9.95	9.58
Kahera-6 improved	60.6	60.2	12.95	12.40
Albasosi	67.3	67.3	9.23	8.94
LSD 5%	3.3	3.1	0.82	0.49

Data in Table 6 show that drought stress and cultivars interaction had significant effects on the relative water content of leaves and fruit TSS in both seasons. Relative water content of leaves in drought stress decreased in all tested cultivars, Albasosi plants had the highest values in comparison with other cultivars. Differences in relative water content among cultivars that are under drought stress may be due to differences in plant ability for more absorption of water from soil or differences in ability of stomata to reduce the loss of water. The cultivars that are resistant to drought have more leaf relative water content, Kusvuran *et al.* (2010) reported similar results. Accordingly, leaf relative water content under stress could be used as a measure of tolerance to water stress and could be used in screening programs.

Concerning the fruit TSS, data in Table 6 indicate that TSS increased under drought stress as compare with those of non-stress condition. The plants of cv. Albasosi watered regularly gave the lowest values for TSS. Whereas, highest values of TSS resulted from stressed plants of cv. Kahera-6 improved. Those results are aliened with those obtained by El-Kassas and El-Sebsey (1998) on muskmelon.

Table 6: Effect of the interaction between irrigation levels and sweet melon cultivars on leaf relative water content (RWC) and fruit TSS during summer 2009 and 2010 seasons

Treatments		RWC (%)		TSS (%)	
Irrigation levels	Cultivars	2009	2010	2009	2010
Normal	Shahd El-Dokki	82.7	82.7	9.53	9.22
	Ananas El-Dokki	87.3	88.5	10.71	10.19
	Ismaelawi	83.4	82.8	9.15	8.68
	Kahera-6 improved	84.1	83.6	12.01	11.25
	Albasosi	86.8	87.7	8.25	8.14
Stress	Shahd El-Dokki	43.5	42.6	11.43	10.98
	Ananas El-Dokki	44.2	44.5	12.24	12.46
	Ismaelawi	41.4	41.2	10.75	10.48
	Kahera-6 improved	37.1	36.7	13.89	13.56
	Albasosi	47.7	46.8	10.22	9.74
LSD 5%		4.0	3.6	1.16	0.69

Evaluation of drought resistance:

Yield losses from the normal level due to water stress are useful in assessing drought resistance. A larger value of relative yield reduction may be show more sensitivity to stress, thus a smaller value of relative yield reduction is favored. Results in Table 7 implied that Ananas El-Dokki had the smallest relative yield reduction value (26 %), so it was the best cultivar based on this index. As shown in Table 6 and Table 7, Ismaelawi had greater the relative yield reduction value (28%) than Ananas El-Dokki, and it had less relative water content of leaves than Ananas El-Dokki under stress condition. So, a selection based on minimum yield reduction under stress with respect to favorable conditions (relative yield reduction) failed to identify the best genotypes.

The stress susceptibility index (SSI) appeared to be a suitable selection index to distinguish resistant cultivars. Genotypes with low SSI values (less than 1) can be considered to be drought resistant (Fisher and Maurer, 1978), because they exhibited smaller yield reductions under water stress compared with well-watered conditions.

The cultivars Kahera-6 improved and Ismaelawi were relatively drought susceptible (SSI > 1), while the cultivars Shahd El-Dokki, Ananas El-Dokki and Albasosi were relatively drought resistant (SSI values < 1). However, the low SSI values may not necessarily give a good indication of drought resistance of a genotype. Low SSI values of a variety could be due to lack of yield production under well-watered conditions rather than an indication of its ability to tolerate water stress. Therefore, a stress tolerant genotype as defined by SSI is not necessarily to have a high yield potential. So, SSI values are not enough to determine the drought tolerant cultivar, this could be done with the help of relative yield under water stress estimate. The mean relative yields values under imposed water stress was 0.60 (Table 7). Cultivar Albasosi was relatively high yielding under water stress (RY > mean RY), while Shahd El-Dokki and Ananas El-Dokki were relatively low yielding (RY < mean RY) in this treatment.

Therefore, Albasosi is a more tolerant variety among the studied varieties, and can be further tested for their other drought conferring characteristics. Results in Table 7 also implied that Kahera-6 improved with the highest SSI, relative yield reduction and low relative yield under water stress condition was identified as sensitive cultivar.

Table 7: Average yields of five sweet melon cultivars (based on average of two seasons) under normal (Yw) and stress (Ys) conditions, stress susceptibility index (SSI), Relative yield reduction and relative yield under water stress (RY_S)

Cultivars	Total yield / Plant (g)		Relative yield Reduction (%)	Stress susceptibility index	RY_S
	Yw	Ys			
Shahd El-Dokki	3757	2742	27	0.98	0.40
Ananas El-Dokki	4426	3273	26	0.95	0.47
Ismaelawi	5922	4237	28	1.03	0.61
Kahera-6 improved	4976	3519	29	1.06	0.51
Albasosi	9472	6931	27	0.99	1.00
Mean	5711	4140	-	-	0.60

Conclusion

Due to the current climate changes exemplified by longer drought periods and higher temperatures during the growing season, a description of the principles and processes of plant adaptation to unfavorable conditions is essential. According to the results obtained in this study, exposing the sweet melon cultivars to water stress led to significant decreases in fruit weight, fruit length, fruit width, flesh fruit thickness, total yield per plant and leaf relative water content, whereas, total soluble solids was increased. Also, in drought stress conditions the cultivars that have more relative water content and low fruit TSS are more resistant to drought stress and their yield is stable. Albasosi was more drought tolerant and stable cultivar compared with other cultivars. So; this cultivar can be further tested for their drought confirming characteristics.

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استجابة بعض أصناف الشمام المصري لظروف الاجهاد المائي

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يعتبر الجفاف من أكثر المشاكل التي تؤثر على انتاجية وجودة الشمام؛ لذلك يعتبر تحديد الطرز الوراثية المقاومة للجفاف والعمل على تحسينها ذو أهمية كبيرة في إنتاج الشمام. لذلك أجريت تجربتان حقليتان في تربة طينية طميية بالمزرعة البحثية بالبرامون، محافظة الدقهلية، خلال الموسمين ٢٠٠٩ و٢٠١٠م؛ لتقييم خمسة أصناف من الشمام وهي: شهد الدقي، أناناس الدقي، الاسماعيلاوي، القاهرة ٦ محسن، الباسوسي، وذلك تحت ظروف الري العادي أوتعريض النباتات للاجهاد المائي بأن يكون الري بنصف عدد الريات (أي بمنع رية من كل ريتين في الري العادي) وعلى أن يتم ذلك بعد الرية الأولى من الزراعة. واستخدم تصميم القطع المنشقة في ثلاث مكررات. كما استخدمت مقايس دليل الحساسية للجفاف والانخفاض النسبي في المحصول والمحصول النسبي لتوضيح مدى اجهاد وثبات المحصول. أوضحت النتائج أن تعريض أصناف الشمام إلى الاجهاد المائي أدى إلى حدوث إنخفاض معنوي في وزن وطول وعرض الثمرة وسمك اللحم والمحصول الكلي للنبات ومحتوى الماء النسبي في الأوراق، وفي نفس الوقت أدى إلى حدوث زيادة معنوية في نسبة المادة الذائبة الكلية في الثمار، وذلك في كلا الموسمين. ومن ناحية أخرى كان هناك إختلافات معنوية بين الأصناف في كل الصفات المدروسة في كلا الموسمين. كذلك أثر التفاعل بين عاملي الدراسة معنويا على جميع الصفات المدروسة في كلا الموسمين. وبناءاً على مقايس تحمل الجفاف، كان الصنف " القاهرة ٦ محسن" أكثر الأصناف حساسية للجفاف، بينما كان الصنف " الباسوسي" أكثر الأصناف تحملاً لظروف الإجهاد المائي، ومن ثم يمكن استخدامه في الدراسات المستقبلية في هذا الشأن.

قام بتحكيم البحث

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