CRITICAL STAGES OF SWEET SORGHUM IN RELATION TO IRRIGATION REGIME AT NORTH NILE DELTA

By

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ABSTRACT

Two field experiments were conducted during the summer seasons of 2002 and 2003 at Sakha Agricultural Research Station, Middle North Nile Delta region to identify irrigation effect of two sweet sorghum varieties at different growth stages on water parameters and their yield. The growing sorghum crop was subjected to nine irrigation regimes. Irrigation treatments were as follows: no stress (trt. A). stress at vegetative growth stage(trt. B), flowering (trt. C), beginning of yield formation (trt. D), end of yield formation (trt. E), ripening (trt. F), vegetative and beginning of yield formation (trt. G), at both flowering and end of yield formation (trt. H) and at beginning of yield formation and ripening (trt. I). Obtained results showed that:

- Regarding to varieties of sweet sorghum, the higher yield of stripped stalk 17.45 ton/fed., juice and syrup (10.33 and 2.58 ton/fed.) and its extraction percentage (59.20 and 14.79%) resulted form variety Williams. While the lower yield of 14.34, 7.87 and 1.97 ton/fed., 54.88 and 13.74% obtained from variety Deal, respectively. Whereas, the higher percentage of sucrose and T.S.S. of 8.12 and 10.67% was resulted from variety Deal, compared with variety Williams of the lower percentage 7.43 and 10.58%, respectively.
- Concerning to yield which resulted from different irrigation treatments, they could be arranged in descending order as A > C > E > B > H > F > D = G > I. The corresponding values were: 20.48, 18.45, 17.27, 16.54, 16.01, 14.44, 14.22, 14.18 and 11.48 ton/fed. For juice and syrup yield, the highest values 12.09 and 3.02 were resulted from trt. A while the least values 6.70 and 1.67 ton/fed. were obtained from trt. I.
- The extraction percentage of juice and syrup which resulted form different irrigation treatments could be arranged in descending order as: F > G > A > I > H > C > D > E > B. The corresponding values were: 61.15, 60.65, 59.03, 58.36, 57.21,

56.91, 56.26, 52.40 and 48.31% and 15.31, 15.16, 14.75, 14.55, 14.30, 14.20, 14.07, 13.09 and 12.09% for juice and syrup, respectively.

- Sucrose and T.S.S. percentage for different irrigation treatments could also be arranged in the descending order as D > A > I > C > E > H > G > B > F and A > D > B > F = I > H > G > E > C, respectively.
- The average of seasonal water applied for sweet sorghum under no stress condition of trt. A was 2648.12 m^3/fed. (63.05 cm), while under the moderate stress condition of trt. B, C, D, E and F (missing one irrigation) was 2242.90 m^3/fed. (53.40 cm),whereas under severe stress condition of trt. G, H and I (missing two irrigations) was 2103.60 m^3/fed. (50.09 cm) for the two varieties.
- Average water consumptive use under no stress condition of sweet sorghum (trt. A) was 60.64 cm while under moderate stress condition of trt. B, C, D, E and F (escaping one watering) was 51.03 cm whereas, under severe condition of trt. G, H and I (escaping two waterings) was 47.72 cm for the two varieties. The corresponding rates were 4.5, 3.8 and 3.5 mm/day under no stress, moderate and severe condition for the two varieties.
- Water utilization efficiency (W.UT.E) expressed as stripped stalk yield was the highest of about 9.60 kg/m^3 and 7.76 kg/m^3 which was accompanied with drought stress at flowering (trt. C) for both varieties Williams and Deal, respectively. On the other hand, the lowest values of about 6.51 and 4.65 kg/m^3 resulted form trt. I for the two varieties, respectively. The corresponding highest values of syrup yield were 1.37 and 1.09 kg/m^3, while the lowest values were 0.93 and 0.70 kg/m^3 obtained from the same mentioned treatments for the two varieties, respectively.
- No specific trend was found regarding to the effect of stress on the water use efficiency (W.U.E) for both stalk or/and syrup yields. The overall average value of W.U.E. is about 7.44 and 1.05 kg/m^3, respectively.

INTRODUCTION

Sweet sorghum is one of the sugar crops that recently cultivated in Egypt. It is considered as the third sugar crop following to sugar cane and sugar beet. It is sown as summer sugar crop and its growing season is only 3-4 months. Irrigation plays a vital role in

maximizing the obtained yield of both stalk and sugar of the sorghum crop. Physiological stages in relation to crop-water functions are among the most important factors that affecting the production.

The effect of physiological growth stages on some water parameters of sweet sorghum was studied intensively by Doorenbos and Pruitt (1975) who described the physiological stages of sweet sorghum as: establishment (15-20 days) from sowing to head initiation, vegetative (20-30 days) from head initiation to head emergence, flowering (15-20 days) from head emergence to head set, yield formation (35-40 days) from seed set to physiological maturity and ripening (10-15 days) from physiological maturity to harvest. Chielle and Chielle (1986) stated that water uptake was greatest between emergence and 50% flowering (290-360 mm). Between 50% flowering and physiological maturity, water uptake was 100-150 mm. It was concluded that 390-500 mm. water was required for production of highest seed yield. Also, Olalla *et al.* (1983) reported that there was no significant difference in yield when irrigation ceased one month early, but average total DM yield were 17.5 and 23.5 ton/ha. in stands given 70 and 100% water requirement respectively. Also, Choudhari (1990) found that the reading of yield quality increased up to 20 days after physiological maturity and also increased up to 30 days after flowering but decreased between 30 and 40 days after flowering which coincided with the period of maximum DM accumulation in seed.

So, the main objective of the present work was to find out the most critical sorghum physiological stages in relation to irrigation. Specific goals were:

1. Determination of sweet sorghum water requirement irrigated according to different stages and its role on effective water management.
2. Consequently, the actual consumed water of sorghum under such status of study was computed.
3. Role of such irrigation regime on obtained crop yield per each unit of water either applied or consumed.

MATERIALS AND METHODS

The present study was carried out during the two growing seasons of 2002 and 2003 at the Crops Water Requirement Research Field, Sakha Agricultural Research Station, Kafr El-Sheikh

Governorate. This site is located at 31°-07' N latitude and 30°-57' E longitude with an elevation of about 6 metres above mean sea level. The location represents the conditions and circumstances of north Nile Delta region. Soil of the experimental field is clayey in texture (Table 1).

Table (1): Soil particle distribution and soil water constants for the experimental field.

Soil depth (cm)	Soil particle distribution			Textural class	F.C. %	D_b kg/m³	W.P %	A.W. %	EC mmhos clc at 25°C	pH
	Sand %	Silt %	Clay %							
0-15	13.75	33.05	53.20	Clay	47.91	1.05	26.12	21.79	3.00	7.80
15-30	20.75	34.50	44.75	Clay	42.65	1.38	21.85	20.80	2.10	7.96
30-45	20.30	40.74	38.96	Clay loam	40.36	1.40	21.03	19.33	2.89	7.91
45-60	21.90	41.13	36.97	Clay loam	38.08	1.43	20.10	17.98	3.00	7.92

F.C. = Field capacity D_b = Bulk density
W.P = Wilting point A.W. = Available water.

Two sweet sorghum varieties Williams and Deal were sown on June 11 and 16, 2002 and 2003, respectively. all cultural practices such as fertilization and weed control were as the same as implemented in the area except for irrigation at different physiological sorghum growth stages which related to the crop water needs. The studied treatments were arranged in a split-plot design with four replications as:

- The main-plot: two varieties, Williams and Deal.
- The sub-plot: wateing based on physiological stages, the crop subjected to nine irrigation regime viz., : no stress (A), no irrigation only at vegetative (b), (N.I.) only at flowering (C), (N.I.) only at beginning of yield formation "milk stage" (D), only at end of yield formation "dough stage" (E), (N.I.) only at complete ripening (F), (N.I.) at vegetative and beginning of yield formation (G), (N.I.) at flowering and end of yield formation (H) and (N.I.) at beginning of yield formation and ripening (I).

These stages of plant growth (establishment, vegetative, flowering, yield formation and ripening were considered, respectively at 20, 50, 70, 110 and 125 days after sowing (DAS).

Irrigation level was implemented as watering till irrigation water reaches 5.0 cm above soil surface. While, the timing of

irrigation was based upon different physiological stages of sweet sorghum as shown in the following table:

Stages / Treat.	20 days Establishment Sowing 0	1 15 days	30 days Vegetative 2 30 days	3 50 days	20 days Flowering 4 66 days	40 days Yield formation 5 80 days	6 94 days	15 days Ripening 7 115 days	Number of irrigations
A	+	+	+	+	+	+	+	+	(8) irrigation
B	+	+	+	-	+	+	+	+	(7) irrigation
C	+	+	+	+	-	+	+	+	(7) irrigation
D	+	+	+	+	+	-	+	+	(7) irrigation
E	+	+	+	+	+	+	-	+	(7) irrigation
F	+	+	+	+	+	+	+	-	(7) irrigation
G	+	+	+	-	+	-	+	+	(6) irrigation
H	+	+	+	+	-	+	-	+	(6) irrigation
I	+	+	+	+	+	-	+	-	(6) irrigation

(+) refers to irrigation at this stage. (-) refers to no irrigation at this stage.

It should be noticed that the stated treatments were applied after the first common three irrigations; namely: Sowing, first (El-Mohaia) and the second one at which fertilizer doses were applied.

The experimental basic unit included 11 ridges, 60 cm apart and 7.5 m long occupying an area of 52.5 m^2 i.e. 1/80 fed. Irrigation intervals were the same as the traditional farmers commonly irrigate their fields.

Data collections:

a. Irrigation control:

Application of irrigation water was controlled and measured by an upstream fixed measuring weir with a discharge of 0.01654 m^3/sec at 10 cm as an effective head.

b. Crop consumptive use (ETc):

To compute the crop evapotranspiration (ETc) or so called crop consumptive use (C.U) depending upon soil moisture depletion in root zone i.e. direct method of C.V. was calculated according to Doorenbos *et al.* (1979) as follows:

$$C.U. = \frac{F.C. - \theta}{100} * D_b * D$$

Where:

C.U. = Consumptive use (cm).
F.C. = Field capacity for each layer (%).
0 = Soil moisture content on the weight basis before irrigation (%).
D_b = Bulk density of the specified soil layer (kg/m^3).
D = Depth of each soil layer = 15 cm.

c. **Crop-water efficiencies:**

- **Water utilization efficiency (W.UT.E):**

It was calculated according to Doorenbos and Pruitt (1975) as:

$$W.UT.E. = \frac{Yield}{Water\ applied}$$

For both stalk and sugar yields.

- **Water use efficiency (W.U.E):**

Water use efficiency was calculated according to Doorenbos and Pruitt (1975) as:

$$W.U.E. = \frac{Yield}{Crop\ evapotranspiration}$$

For both stalk and sugar yields.

- **Consumptive use efficiency (Ecu):**

It was calculated by Doorenbos and Pruitt (1975):

$$Ecu = \frac{ETc}{Wa} * 100$$

Where:

Ecu = Consumptive use efficiency
ETc = Crop evapotranspiration ~ consumptive use
Wa = Water applied to the field.

2. **Yield and its quality:**

Two inner furrows of each strip were harvested, collected together and cleaned. Stalks were separately weighed in kg, then it was converted to estimate:

- Stripped stalk yield ton/fed.
- Juice yield ton/fed.
- Juice extraction % = Juice yield ton/fed. x 100/stripped stalk yield ton/fed.
- Syrup yield ton/fed.
- Determined by using flame to juice boiling point and indirect using a hot plate (to T.S.S. about 73% after cooling reached ~ 75%).
- Syrup extraction % = Syrup yield ton/fed./stripped stalk yield ton/fed.

- Total soluble solids % was determined using Abb refractometer standardized at 25°C as described in Plews (1970).
- Sucrose content in juice % was determined according to A.O.A.C. (1990).

All data were subjected to statistical analysis according to the procedures outlined by Snedecor and Cochran (1967) and treatment means were compared by Duncan's multiple range test (Duncan, 1955). Combined analysis for the obtained data were statistically analysed using the procedures outlined of SAS Computer Package Programme (1992).

RESULTS AND DISCUSSION

1. Crop water relations:

a. Seasonal water applied (Wa):

The highest water applied of sweet sorghum for the non-stress treatment A in the range of 62.32 cm or 2617.44 m^3/fed. and 63.78 cm or 2678.79 m^3/fed. of the variety Williams and Deal, respectively, the overall average of the two varieties was 63.1 cm or 2648.1 m^3/fed. Irrigation water was applied through 6 waterings plus the sowing one (399 m^3/fed. = 9.5 cm) based on plant needs to water as the traditional farmers irrigate their fields in the area.

Regarding to variety Williams, the non-stress treatment A which irrigated at all growth stages received the maximum average of water applied of 2617.44 m^3/fed., i.e. 62.32 cm (Table 2). Comparing the growth stages for the other irrigation treatments on one side with treatment A on the other side, the following remarks could be noticed:

The average irrigation water reduction in the two growing seasons (Table 3) were: 250.96 m^3/fed. (9.59%) at vegetative stage, 475.34 m^3/fed. (18.16%) at flowering, 453.16 m^3/fed. (17.31%)at beginning of yield formation, 330.31 m^3/fed. (12.61%) at end of yield formation, 363.15 m^3/fed. (13.87%) at ripening. 481.70 m^3/fed. (18.40%) at vegetative + beginning of yield formation, 525.26 m^3/fed. (20.07%) at flowering + end of yield formation and 544.82 m^3/fed. (20.82%) at beginning of yield formation + ripening. They have drought stress at 51, 66, 80, 94, 115 (51 + 80), (66 + 94) and (80 + 115) DAS for treatments B, C, D, E, F, G, H and I, respectively.

Concerning to variety Deal, the maximum average of water applied of non-stressed treatment A was 2678.79 m^3/fed. 63.78 cm. Comparing the other irrigation treatments in relation to treatment A, we find that:

- In the two growing seasons, the average irrigation water differences were: 275.73, 554.83, 512.52, 424.01, 412.15, 489.00, 609.59 and 616.81 m^3/fed. The corresponding percentages of reduction are 10.29, 20.71, 19.13, 15.83, 15.39, 18.26, 22.75 and 23.04%. They have drought stress at the same stages which mentioned before for treatments B, C, D, E, F, G, H and I, respectively.

Comparing the stress treatments from one side and the non stress treatment A from the other side. The mean difference of the two varieties as computed from Table (3) are: 263.35, 515.09, 482.84, 377.16, 387.65, 485.35, 567.43 and 580.82 m^3/fed. The corresponding percentage are: 9.94, 19.44, 18.22, 14.22, 14.63, 18.33, 21.41 and 21.93%, respectively. Chielle and Chielle (1986) reached to almost similar results.

b. Crop consumptive use (Etc):

Seasonal water consumptive use for sweet sorghum in cm was calculated for all treatments and listed in Table (2).

From the obtained data of variety Williams, it is cleared that the consumptive use was the highest under the non-stress treatment A of the maximum value 60.24 cm. On the other hand, the lowest value 47.34 cm was resulted from treatment I (stress at the beginning of yield formation + ripening). While the other values are in between. Similar results were obtained regarding to variety Deal, where the highest value 61.04 cm was resulted under treatment A and the lowest value 46.44 cm was recorded from treatment I.

The average values of consumptive use rate for different treatments are in the same direction of C.U.

This finding showed that the consumptive use declined at the stages where the drought stress occurred as a result of the change in the habitat of the root system in comparison with that grown under a relatively enough soil moisture content of non stress.

The mean rate of C.U for the non stress treatment A of the two varieties was 4.5 mm/day. On the other hand, the lowest mean value of 3.5 mm/day was resulted under treatment I of stress at

beginning of yield formation and ripening. While other values in between.

Table (2): Seasonal water applied (Wa, m^3/fed) consumptive use (C.U., cm) and its rate (C.U rate, mm/day), as affected by irrigation regime in 2002 and 2003.

Treatments		Water parameters								
		Wa m^3/fed.			ETc cm.			ETc rate mm/day		
Main	Sub.	1st	2nd	Av.	1st	2nd	Av.	1st	2nd	Av.
Var. Williams	A	2533.50	2701.37	2617.44	58.18	62.30	60.24	4.3	4.6	4.5
	B	2282.54	2450.41	2366.48	52.23	56.35	54.29	3.9	4.2	4.0
	C	2058.16	2226.03	2142.10	46.88	51.00	48.94	3.5	3.8	3.6
	D	2080.34	2248.21	2164.28	47.38	51.50	49.44	3.5	3.8	3.7
	E	2203.19	2371.06	2287.13	50.28	54.40	52.34	3.7	4.0	3.9
	F	2170.35	2338.22	2254.29	49.58	53.70	51.64	3.7	4.0	3.8
	G	2051.80	2219.67	2135.74	46.78	50.90	48.84	3.5	3.8	3.6
	H	2008.24	2176.11	2092.18	45.68	49.80	47.74	3.4	3.7	3.5
	I	1988.68	2156.55	2072.62	45.28	49.40	47.34	3.4	3.7	3.5
Var.Deal	A	2585.75	2771.83	2678.79	58.99	63.09	61.04	4.4	4.7	4.5
	B	2310.02	2496.10	2403.06	52.49	56.59	54.54	3.9	4.2	4.0
	C	2030.92	2217.00	2123.96	45.78	49.88	47.83	3.4	3.7	3.6
	D	2073.23	2259.31	2166.27	46.89	50.99	48.94	3.5	3.8	3.6
	E	2161.74	2347.82	2254.78	48.99	53.10	51.05	3.6	3.9	3.8
	F	2173.60	2359.68	2266.64	49.19	53.29	51.24	3.6	4.0	3.8
	G	2096.75	2282.83	2189.79	47.39	51.49	49.44	3.5	3.8	3.7
	H	1976.21	2162.29	2069.25	44.49	48.59	46.54	3.3	3.6	3.5
	I	1968.94	2155.02	2061.98	44.39	48.49	46.44	3.3	3.6	3.4

Table (3): Reduction of water applied (m^3/fed.) and their percentages in the different stages of the two varieties.

Treatments	Stages	Var. Williams		Var. Deal	
		Reduction (m^3/fed.)	Reduction (%)	Reduction (m^3/fed.)	Reduction (%)
A	Control	0.00	0.00	0.00	0.00
B	Vegetative	250.96	9.59	275.73	10.29
C	Flowering	475.34	18.16	554.83	20.71
D	Beginning of yield formation	453.16	17.31	512.52	19.13
E	End of yield formation	330.31	12.61	424.01	15.83
F	Ripening	363.15	13.87	412.15	15.39
G	Veget. + begin. of yield formation	481.70	18.40	489.00	18.26
H	Flower. + end of yield formation	525.26	20.07	609.59	22.75
I	Begin. of yield form. + ripening	544.82	20.82	616.81	23.04

2. Water efficiencies:

a. Water utilization efficiency (W.UT.E., kg/m^3):

This parameters is an indicator to find out the yield per unit water applied (Wa).

Both stalk and syrup yields of sweet sorghum variety Williams were computed in Tables 4 & 5. From the obtained data, it

is revealed that by increasing the value of applied water, both yields of stalk and syrup were decreased. For example, the average of W.UT.E. in the two seasons could be arranged in descending order as: 9.60, 8.64, 8.51, 8.31, 7.87, 7.08, 7.01, 6.82 and 6.51 kg stalk/m^3 for treatments, C, H, E, A, B, D, F, G and I, respectively. This finding could be explained that this trait of W.UT.E. is affected by both the yield as nominator and the water applied as dominator. So, by increasing the nominator, the resulted efficiency increased and vise versa. In other words, treatment C (stress at flowering stage) was accompanied with the highest average of W.UT.E. for 9.60 kg/m^3. While the lowest value 6.51 kg/m^3 as W.UT.E. resulted from treatment I (stress at beginning of yield formation + ripening).

Similar trend was obtained regarding to variety Deal. (For example, the average of W.UT.E. in the two seasons could be arranged in descending order as: 7.76, 7.22, 6.81, 6.75, 6.36, 6.11, 6.07, 5.82 and 4.65 kg stalk/m^3 for treatments C, A, H, E, G, D, B, F and I, respectively). Therefore, in the same meaning, treatment C of stress at flowering stage was accompanied with the highest average of W.UT.E. of 776 kg/m^3. While the lowest value 4.65 kg/m^3 as W.UT.E. was resulted form the same treatment I (drought stress at the beginning of yield formation + ripening stages).

The same finding were obtained regarding to syrup yield (Tables 4 & 5). In other words, the maximum values of 1.37 and 1.09 kg syrup/m^3 resulted from treatment C for the two varieties Williams and Deal, respectively. While the lowest values 0.93 and 0.70 kg/m^3 were found with treatment I for the two mentioned varieties, respectively. These results indicated that, under the sufficient water supply i.e. no stress (trt. A) sweet sorghum required about 0.13 and 0.87 m^3 of water to produce 1 kg from stalk and syrup yield, respectively. While, under the moderate water supply conditions of treatments B, C, D, E and F (e.g. missing 1 irrigation), to produce 1 kg from stalk and syrup required about 0.14 and 1.00 m^3, respectively. Whereas, under the severe condition of water supply i.e. treatments G, H and I (escaping 2 irrigations) which associated with the minimum yield reducting, to produce 1 kg from stalk and syrup an amount of 0.15 and 1.03 m^3 is needed, respectively. Shin (1989) came to similar results.

b. Water use efficiency (W.U.E kg/m^3):

Water use efficiency (W.U.E) is considered as the evaluation parameter of the obtained yield per each unit of consumed water by

a specific crop. From data tabulated in Tables 4 & 5, it can be stated that:

An adverse effect for the consumed water by plants on values of W.U.E. Average values of the two seasons for Williams variety are; 8.59, 8.17, 10.01, 7.39, 8.85, 7.29, 7.11, 9.02 and 6.79 kg stalk/m^3 for treatments A through I, respectively. While the corresponding values for Deal variety are: 7.55, 6.37, 8.21, 6.44, 7.10, 6.12, 6.70, 7.21 and 4.92 kg/m^3, respectively These results could be explained that, these parameters of W.U.E are affected by both the yield as nominator and the water consumed as dominator. So, by increasing the nominator, the resulted efficiency increased and vise versa.

The same findings were obtained in relation to syrup yield. Average values of the two seasons for Williams variety are; 1.26. 0.98, 1.43, 1.06, 1.12, 1.13, 1.14, 1.28 and 0.96 kg/m^3 for treatments A through I, respectively. While the corresponding values for Deal variety are; 1.12, 0.78, 1.16, 0.89, 0.97, 0.92, 0.95, 1.04 and 0.73 kg/m^3 in the same manner. These results indicated that under the sufficient water supply i.e. no stress (trt. A) to produce 1 kg from stalk and syrup yield sweet sorghum is required about 0.12 and 0.84 m^3, respectively.While under the moderate conditions of treatments B, C, D, E and F (i.e. missing 1 irrigation), to produce 1 kg from stalk and syrup yield, it required about 0.13 and 0.96 m^3, respectively. Whereas, under the severe conditions of water supply i.e. treatments G, H and I (escaping 2 irrigation), to produce 1 kg from stalk and syrup, it requires about 0.14 and 0.98 m^3, respectively.

C. Consumptive use efficiency (Ecu %):

Consumptive use efficiency (Ecu) reflects the capability of plants to utilize the soil moisture stored in the effective root zone.

From data obtained in Tables 4 & 5, it could be noticed that, no clear direction was found under the two varieties of sweet sorghum. Williams and Deal. The overall average of Ecu is about 96.0 and 95.0%, respectively. Meaningful that, about only 4% from the applied water was not used by the growing plants. Doorenbos *et al.* (1979) stated that, the consumptive use efficiency increased with the increase of consumptive use and with the decrease in water applied.

Table (4): Water utilization (kg/m^3), water use (kg/m^3) and consumptive use (%) efficiencies as affected by irrigation regime in the two seasons 2002 and 2003.

Treatments		Water parameters														
		W.UT.E. kg/m³						W.U.E. kg/m³						Ecu %		
		Stripped st. yield ton/fed.			Syrup yield ton/fed.			Stripped st. yield ton/fed.			Syrup yield ton/fed.					
Main	Sub.	1st	2nd	Av.	1st	2nd	Av.	1st	2nd	Av.	1st	2nd	Av.	1st	2nd	Av.
Var. Williams	A	8.91	7.70	8.31	1.27	1.16	1.22	9.23	7.95	8.59	1.32	1.19	1.26	96.45	96.86	96.66
	B	8.50	7.23	7.87	1.01	0.88	0.95	8.85	7.48	8.17	1.05	0.91	0.98	96.11	96.58	96.35
	C	10.38	8.81	9.60	1.47	1.27	1.37	10.85	9.16	10.01	1.53	1.32	1.43	95.67	96.23	95.95
	D	7.76	6.40	7.08	1.08	0.95	1.02	8.11	6.65	7.38	1.13	0.99	1.06	95.66	96.21	95.94
	E	9.20	7.81	8.51	1.14	1.01	1.08	9.59	8.10	8.85	1.19	1.05	1.12	95.85	96.36	96.11
	F	7.66	6.36	7.01	1.16	1.01	1.09	7.98	6.59	7.29	1.21	1.05	1.13	95.95	96.46	96.21
	G	7.50	6.14	6.82	1.17	1.02	1.10	7.83	6.38	7.11	1.22	1.06	1.14	95.76	96.31	96.04
	H	9.40	7.87	8.64	1.31	1.13	1.22	9.84	8.19	9.02	1.37	1.18	1.28	95.53	96.12	95.83
	I	7.19	5.82	6.51	1.00	0.85	0.93	7.52	6.05	6.79	1.04	0.88	0.96	95.63	96.21	95.92

Table (5): Water utilization (kg/m^3), water use (kg/m^3) and consumptive use (%) efficiencies as affected by irrigation regime in the two seasons 2002 and 2003.

Treatments		Water parameters														
		W.UT.E. kg/m³						W.U.E. kg/m³						Ecu %		
		Stripped st. yield ton/fed.			Syrup yield ton/fed.			Stripped st. yield ton/fed.			Syrup yield ton/fed.					
Main	Sub.	1st	2nd	Av.	1st	2nd	Av.	1st	2nd	Av.	1st	2nd	Av.	1st	2nd	Av.
Var. Deal	A	7.79	6.65	7.22	1.09	1.05	1.07	8.13	6.96	7.55	1.13	1.10	1.12	95.82	95.60	95.71
	B	6.66	5.48	6.07	0.74	0.74	0.74	6.98	5.76	6.37	0.77	0.78	0.78	92.44	95.22	95.33
	C	8.50	7.02	7.76	1.09	1.09	1.09	8.98	7.43	8.21	1.16	1.16	1.16	94.67	94.50	94.59
	D	6.78	5.44	6.11	0.84	0.83	0.84	7.14	5.74	6.44	0.89	0.88	0.89	95.04	94.79	94.92
	E	7.40	6.09	6.75	0.93	0.91	0.92	7.78	6.41	7.10	0.97	0.96	0.97	95.18	93.91	94.55
	F	6.43	5.20	5.82	0.87	0.87	0.87	6.76	5.48	6.12	0.92	0.92	0.92	95.05	94.85	94.95
	G	7.01	5.70	6.36	0.91	0.89	0.90	7.38	6.01	6.70	0.96	0.94	0.95	94.93	94.73	94.83
	H	7.53	6.09	6.81	0.99	0.98	0.99	7.96	6.45	7.21	1.04	1.04	1.04	94.55	94.38	94.47
	I	5.27	4.03	4.65	0.69	0.70	0.70	5.57	4.27	4.92	0.72	0.74	0..73	94.69	94.50	94.60

Yield (ton/fed.):

1. Stripped stalk yield (ton/fed.):

Varieties of sweet sorghum have highly significant effect on stripped stalk yield in the two seasons as shown in Table (6).

Variety Williams resulted in the highest yield 17.45 ton/fed. i.e. 41.88 ton/ha (1 fed. = 0.42 ha) compared with variety Deal which gives the lower yield 14.34 ton/fed. i.e. difference of 3.11 ton/fed.

Regarding the irrigation treatments, it has highly significant effect on stripped stalk yield in the average of the two seasons as tabulated in Table (6).

Treatment A resulted in the highest stripped stalk yield because it did not suffer from drought stress at any stage of plant growth throughout the growing season.

In other words, the available soil water was sufficient for sorghum plants. The average of stripped stalk yield in the two growing seasons for treatments A, B, C, D, E, F, G, H and I are 20.48, 16.54, 18.45, 14.22, 17.27, 14.44, 14.18, 16.01 and 11.48 ton/fed., respectively. Comparison between treatment A and other treatments. The stated reduction which equals 3.94, 2.03, 6.26, 3.21, 6.04, 6.30, 4.47 and 9.00 ton/fed. and 19.24, 9.91, 30.57, 15.67, 29.49, 30.76, 21.83 and 43.95%, respectively. The listed reduction was occurred due to missing irrigation at; vegetative (51 DAS), flowering (66 DAS), beginning of yield formation (80 DAS), end of yield formation (94 DAS), ripening (115 DAS), vegetative + beginning of yield formation (51 and 80 DAS), flowering + end of yield formation (66 and 94 DAS) and beginning of yield formation + ripening (80 and 115 DAS).

Generally, stripped stalk yield could be arranged in the descending percentage as A > C > E > B > H > F > D = G > I. The relative yield was 100, 90.09, 84.33, 80.76, 78.17, 70.51, 69.43, 69.24 and 56.05%, respectively. Similar results were obtained by Olalla *et al.* (1983).

All interaction effect between the two factors had no significant effect on stripped stalk yield in any of the two seasons under the local conditions of the present investigation.

2. Juice and syrup yield (ton/fed.):

Varieties of sweet sorghum have highly significant effect on juice and syrup yields over both seasons of study as shown in Table (6).

Variety Williams recorded the highest yields of 10.33 and 2.58 ton/fed. of juice and syrup, respectively compared with variety Deal which gives 7.87 and 1.97 ton/fed. with the difference of 2.46 and 0.61 ton/fed. in juice and syrup, respectively.

Concerning to the irrigation treatments, it has highly significant effect on juice and syrup yields over both seasons of study as presented in Table (6). Treatment A (no stress) resulted the highest yields of 12.09 and 3.02 ton/fed. This increase in juice and syrup yields was obtained from the increase of both sugar percentage and stalk yield. The highest juice and syrup yields of trt. A was noticed as a result of the sufficient available water for sorghum plants at all stages of growth. As presented in Table (6), the average juice and syrup yields in the two growing seasons for treatments A, B, C, D, E, F, G, H and I were 12.09, 7.99, 10.50, 8.00, 9.05, 8.83, 8.60, 9.16 and 6.70 ton/fed. and 3.02, 2.00, 2.62, 2.00, 2.26, 2.21, 2.15, 2.29 and 1.67 ton/fed., respectively. Comparison between treatment A and treatments B through I shows that the average differences reached 4.10, 1.59, 4.09, 3.04, 3.26, 3.49, 2.93 and 5.39 ton/fed. and 1.02, 0.40, 1.02, 0.76, 0.81, 0.87, 0.73 and 1.35 ton/fed. for juice and syrup yields, respectively.

The stated reduction in juice and syrup yields in percentage was occurred at drought stress at; vegetative (51 DAS, 33.9 and 33.8%), flowering stage (66 DAS, 13.2 and 13.3%), beginning of yield formation stage (80 DAS, 33.8 and 33.8%), end of yield formation (94 DAS, 25.2 and 25.2%), vegetative and beginning of yield formation stages (51 and 80 DAS, 28.9 and 28.8%), flowering and end of yield formation stages (66 and 94 DAS, 24.3 and 24.2%) and beginning of yield formation and ripening (80 and 115 DAS, 44.6 and 44.7%) for juice and syrup, respectively.

Juice and syrup yields could be arranged in the descending order as A > C > H > E > F > G > D = B > I, respectively. The relative yield was 100.00, 86.85, 75.76, 74.85, 73.04, 71.13, 66.17, 66.09 and 55.42% for juice, respectively. While they were 100.00, 86.75, 75.83, 74.83, 73.18, 71.19, 66.22, 66.22 and 55.30% for syrup yield respectively.

All interaction between the two factors had no significant effect on juice and syrup yield in any of the two seasons under the local conditions of the present research.

Table (6): Stripped stalk, juice and syrup yield (ton/fed.) as affected by irrigation regime in the two seasons 2002 and 2003.

Treatments	Characters								
	Stripped stalk yield			Juice yield			Syrup yield		
	Ton/fed.								
	1st	2nd	Comb.	1st	2nd	Comb.	1st	2nd	Comb.
1. Main plot:									
Var. Williams	18.32	16.58	17.45	9.75	10.90	10.33	2.11	3.05	2.58
Var. Deal	15.19	13.49	14.34	6.91	8.83	7.87	1.48	2.45	1.97
F. test			**			**			**
L.S.D. 5%			1.00			0.57			0.18
L.S.D. 1%			1.34			0.77			0.26
2. Sub-plot:									
A	21.34	19.62	20.48	11.44	12.74	12.09	2.81	3.22	3.02
B	17.40	15.70	16.54	6.89	9.09	7.99	1.70	2.30	2.00
C	19.31	17.59	18.45	9.71	11.29	10.50	2.22	3.02	2.62
D	15.10	13.34	14.22	7.58	8.42	8.00	1.75	2.25	2.00
E	18.13	16.41	17.27	8.75	9.35	9.05	2.00	2.52	2.26
F	15.30	13.57	14.44	7.91	9.75	8.83	1.89	2.52	2.21
G	15.04	13.31	14.18	7.77	9.43	8.60	1.91	2.39	2.15
H	16.88	15.15	16.01	8.75	9.57	9.16	1.95	2.63	2.29
I	12.34	10.62	11.48	5.99	7.40	6.70	1.35	1.98	1.67
F. test			**			**			**
L.S.D. 5%			1.00			0.57			0.18
L.S.D. 1%			1.34			0.77			0.26
Interaction									
1 x 2			n.s			n.s			n.s

3. Juice and syrup extraction percentage:

Highly significant effect of varieties on juice and syrup extraction percentage in the average of the two seasons as shown in Table (7).

The highest extraction percentage of 59.20 and 14.79% was resulted form variety Williams. While the lower extraction of 54.88 and 13.74% came with variety Deal for juice and syrup, respectively.

Irrigation regime treatments has highly significant effect on juice and syrup extraction percentage in the two seasons as presented in Table (7). The highest juice and syrup extraction percentage 61.13 and 15.31% F was resulted form no watering at ripening growth stage e.g. drought stress at 115 DAS (trt. F). On the

other hand, the lowest values 48.31 and 12.09% was recorded from escaping irrigation at vegetative growth stage i.e. drought stress at 51 DAS (trt. B). The values of most other irrigation treatments were in between. These results indicated that juice and syrup extraction percentage were adversely affected by water deficit. Similar findings was recorded by Choudhari (1990).

4. Sucrose percentage:

As shown in Table (7), varieties of sweet sorghum have highly significant effect on sucrose percentage over both seasons of study. The higher sucrose percentage 8.12% was recorded from variety Deal, while variety Williams gives 7.43%.

Regarding irrigation treatments, it has highly significant effect on sucrose percentage as shown in Table (7). The highest value 9.67% was resulted from escaping irrigation at beginning of yield formation stage (trt. D) i.e. drought stress at 80 DAS, whereas, the lowest sucrose percentage 5.84% was obtained from water deficit at ripening growth stage (trt. F) i. drought stress at 115 DAS. These results indicted that, water stress not usually improve sucrose percentage. Choudhari (1990) came to nearly similar direction.

5. Total soluble solids percentage (T.S.S.%):

As shown in Table (7), a highly significant effect of sweet sorghum varieties on total soluble solids percentage over both seasons of research.

The higher T.S.S. 10.67% was resulted from variety Deal, while variety Williams gave a value of 10.58%.

Irrigation treatments has also highly significant effect on T.S.S. % over both seasons (Table 7). The highest value 12.50% was obtained from no stress treatment A, whereas the lowest value of 8.50% resulted form treatment C of drought stress at flowering growth stage i.e. at 66 DAS. Obtained results provide an evidence that moisture stress reduced T.S.S.% In other words, irrigation significantly increased total soluble solids percentage. Similar trend was found by El-Koliey *et al.* (1999).

Table (7): Juice extraction, syrup extrication, sucrose and T.S.S. (%) as affected by irrigation regime in the two seasons 2002 and 2003.

Treatments	Characters											
	Juice extraction			Syrup extraction			Sucrose			T.S.S		
	(%)											
	1st	2nd	Comb.	1st	2nd	Comb.	1st	2nd	Comb.	1st	2nd	Comb.
1. Main plot:												
Var. Williams	55.45	62.95	59.20	13.70	15.88	14.79	7.60	7.29	7.43	9.79	11.37	10.58
Var. Deal	49.90	59.85	54.88	12.51	14.96	13.74	8.28	7.96	8.12	9.35	11.98	40.67
F. test			**			**			**			**
L.S.D. 5%			2.80			0.70			0.38			0.52
L.S.D. 1%			3.91			0.98			0.53			0.73
2. Sub-plot:												
A	54.63	63.42	59.03	13.75	15.75	14.75	9.66	8.91	9.28	11.81	13.18	12.5
B	44.28	52.34	48.31	11.20	12.98	12.09	6.27	6.24	6.26	10.79	12.20	11.5
C	50.80	63.02	56.91	13.00	15.40	14.20	8.02	7.64	7.83	7.77	9.22	8.5
D	50.71	61.80	56.26	13.21	14.92	14.07	9.93	9.46	9.67	10.91	12.28	11.6
E	47.49	57.30	52.40	12.11	14.07	13.09	7.99	7.53	7.76	8.83	9.17	9.0
F	56.78	65.40	61.15	14.22	14.40	15.31	5.88	5.79	5.84	10.04	11.96	11.0
G	57.00	64.30	60.65	14.09	16.20	15.16	7.17	6.94	7.05	9.90	10.10	10.0
H	52.85	61.60	57.21	12.18	16.42	14.30	7.48	7.41	7.45	9.85	11.14	10.5
I	55.03	61.70	58.36	12.33	16.77	14.55	9.06	8.69	8.86	10.00	12.00	11.0
F. test			**			**			**			**
L.S.D. 5%			2.80			0.70			0.38			0.52
L.S.D. 1%			3.91			0.98			0.53			0.73
Interaction												
1 x 2			n.s			n.s			n.s			

CONCLUSION

The most critical stages of sweet sorghum in relation to water deficit are the beginning of yield formation (80 DAS) and ripening (115 DAS). The corresponding crop reduction were 43.95 and 44.70% for stalk and syrup yield, respectively.

With regard to irrigation, in case of abundance of irrigation water, it could be advisable to follow the irrigation regime that implemented with the non stress trt. A. Otherwise, in case of shortage of irrigation water it might be suggested to follow the regime of trt. C (missing one irrigation at flowering stage i.e. at about 66 DAS) followed by trt. E (missing one irrigation at end of yield formation i.e. at about 94 DAS). In case of severe shortage irrigation water, it is advisable to follow the regime of trt. H followed by trt. G i.e. missing two irrigation at flowering + end of yield formation (66 and 94 DAS) and vegetative + beginning of yield formation (51 and 80 DAS), respectively

Meaningful, the water regime of sweet sorghum in the north Nile Delta could be planed according to the obtained results depending upon the availability of irrigation and its relation on crop production.

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الملخص العربى

مراحل النمو الحرجة فى الذرة السكرية وعلاقتها بالحرمان من الرى فى شمال دلتا النيل

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أقيمت تجربة حقلية خلال موسمى صيف ٢٠٠٢م ، ٢٠٠٣م بمحطة البحوث الزراعية بسخا ، منتصف شمال دلتا النيل لمعرفة تأثري رى صنفين من الذرة السكرية بمختلف مراحل النمو على المحصول والتقديرات المائية المختلفة ، وقد تعرض المحصول إلى الحرمان من الرى بمراحل نموه خلال فترة تسع ريات. وقد كانت معاملات الرى كالآتى:

أ- بدون حرمان (وتعتبر معاملة المقارنة).
ب- حرمان رية واحدة خلال مرحلة النمو الخضرى.
جـ-حرمان رية واحدة خلال مرحلة التزهير.
د- حرمان رية واحدة فى بداية تكوين المحصول (طور النضج اللبنى).
هـ-حرمان رية واحدة فى نهاية تكوين المحصول (طور النضج العجينى).
و- حرمان رية واحدة خلال مرحلة النضج التام.
ز- حرمان ريتين خلال مرحلتى النمو الخضرى + بداية تكوين المحصول.
ح- حرمان ريتين خلال مرحلتى التزهير + نهاية تكوين المحصول.
ط-حرمان ريتين خلال مرحلتى تكوين المحصول + النضج.

وقد أوضحت النتائج الآتى

- بالنسبه لأصناف الذرة السكرية: أعطى الصنف Williams أعلى محصول لكل السيقان النظيفة (١٧,٤٥٠ طن/فدان) ومحصولى العصير والعسل (١٠,٣٣٠ ، ٢,٥٨٠ طن/فدان) والنسبة المئوية للاستخلاص لكل منهما والتى بلغت ٥٩,٢٠ ، ١٤,٩٧% بينما سجل الصنف Deal أقل القيم ١٤,٣٤٠ ، ٧,٨٧٠ ، ١,٩٧٠ طن/فدان ، ٥٤,٨٨ ، ١٣,٧٤% لكل من محصول السيقان النظيفة والعصير والعسل والنسبة المئوية للأستخلاص لكل منهما على التوالى فى حين

كانت أعلى القيم للنسب المئوية للسكروز والمواد الصلبة الذائبة (٨,١٢ ، ١٠,٦٧%) سجلت من الصنف Deal بالمقارنة بالصنف Williams الذى أعطى أقل القيم ٧,٤٣ ، ١٠,٥٨% على التوالى.

- بالنسبه لمعاملات الرى: فقد أمكن ترتيب قيم المحصول الناتج من مختلف المعاملات تنازليا كالآتى: أ > جـ > هـ > ب > ح > و > د = ز > طـ ، وقد بلغت القيم ٢٠,٤٨ ، ١٨,٤٥ ، ١٧,٢٧ ، ١٦,٥٤ ، ١٦,٠١ ، ١٤,٤٤ ، ١٤,٢٢ ، ١٤,١٨ ، ١١,٤٨ طن سيقان نظيفة/فدان. كما أمكن ترتيب قيم محصولى العصير والعسل تنازليا كالآتى: أ > جـ > ح > هـ > و > ز > د = ب > ط ، وقد كانت القيم ١٢.٠٩ ، ١٠,٥٠ ، ٩,١٦ ، ٩,٠٥ ، ٨,٨٣ ، ٨,٦٠ ، ٨,٠ ، ٧,٩٩ ، ٦,٧٠ طن/فدان لمحصول العصير ، وكذلك ٣,٠٢ ، ٢,٦٢ ، ٢,٢٩ ، ٢,٢٦ ، ٢,٢١ ، ٢,١٥ ، ٢,٠ ، ٢,٠ ، ١,٦٧ طن/فدان لمحصول العسل على التوالى.
- أما النسبة المئوية للأستخلاص لكل من محصولى العصير والعسل الناتجة من مختلف معاملات الرى فقد أمكن ترتيبها تنازليا كالآتى: و > ز > أ > طـ > ح > جـ > د > هـ > ب ، وقد بلغت القيم ٦١,١٥ ، ٦٠,٦٥ ، ٥٩,٠٣ ، ٥٨,٣٦ ، ٥٧,٢١ ، ٥٦,٩١ ، ٥٦,٢٦ ، ٥٢,٤٠ ، ٤٨,٣١% ، وكذلك ١٥,٣١ ، ١٥,١٦ ، ١٤,٧٥ ، ١٤,٥٥ ، ١٤,٣٠ ، ١٤,٢٠ ، ١٤,٠٧ ، ١٣,٠٩ ، ١٢,٠٩% لمحصولى العصير والعسل على التوالى.
- كذلك أمكن ترتيب قيم النسبة المئوية للسكروز والمواد الصلبة الذائبة لمختلف معاملات الرى تنازليا: د > أ > طـ > جـ > هـ > ح > ز > ب > و ، وأيضا أ > د > ب > و = طـ > ح > ز > هـ > جـ على التوالى.
- بلغ المتوسط الموسمى للماء المضاف فى الذرة السكرية تحت ظروف عدم الإجهاد فى المعاملة "أ" ٢٦٤٨,١٢ م^3/ف (٦٣,٠٥سم). بينما بلغ تحت ظروف الإجهاد المعتدل للمعاملات ب ، جـ ، د ، هـ ، و (حرمان رية واحدة) ٢٢٤٢,٩٠ م^3/ف فى حين بلغ تحت ظروف الاجهاد الشديد للمعاملات ز ، ح ، ط (حرمان ريتين) ، ٢١٠٣,٦٠ م^3/ف (٥٠,٠٩سم) لكلا الصنفين على التوالى.
- بلغ المتوسط الموسمى للاستهلاك المائى للذرة السكرية تحت ظروف عدم الإجهاد (معاملة أ) ٦٠,٦٤سم ، بينا بلغ تحت ظروف الإجهاد المعتدل (حرمان رية واحدة) ٥١,٠٣سم ، أما تحت ظروف الإجهاد الشديد (حرمان ريتين) فقد بلغ ٤٧,٧٢سم لكلا الصنفين على التوالى.

أما معدل الاستهلاك المائي فقد بلغ ٤,٥ ، ٣,٨ ، ٣,٥ مم/يوم تحت ظروف عدم الإجهاد ، الأجهاد المعتدل ، الإجهاد الشديد لكلا الصنفين Williams ، Deal على التوالى.

- جاءت أعلى القيم لكفاءة استخدام المياه (W. UT. E.) والتى بلغت ٩,٦٠كجم/م^3 ، ٧,٧٦كجم/م^3 لمحصول السيقان النظيفة مصاحبة للإجهاد المائى فى مرحلة التزهير (معاملة جـ) لكلا الصنفين على التوالى. على الجانب الأخر نتجت أقل القيم ٦,٥١ ، ٤,٦٥كجم/م^3 من المعاملة طـ لكلا الصنفين على التوالى. وبالمثل فقد بلغت قيم كفاءة استخدام المياه لمحصول العسل ١,٣٧ ، ١,٠٩كجم/م^3 ، بينما كانت أقل القيم ٠,٩٣ ، ٠,٧٠كجم/م^3 والتى نتجت من نفس المعاملات السابقة الذكر لكلا الصنفين على التالى.

لم يكن هناك اتجاه واضح لتأثير الإجهاد على كفاءة استهلاك المياه (W.U.E.) لكل من محصول السيقان أو العسل ، وقد بلغ المتوسط العام للقيم ٧,٤٤ ، ١,٠٥كجم/م^3 لكفاءة الاستهلاك المائى بالترتيب.

وعليه توصى الدراسة بأنه:

- فى حالة توفر مياه الرى يتم اعطاء الريات بدون حرمان فى اى مرحلة من مراحل نمو النبات وفى حالة نقص مياه الرى فيمكن الحرمان فى مرحلة التزهير (٦٦ يوم من الزراعة) يتبعها كذلك فى نهاية مرحلة تكوين المحصول (٩٤ يوم من الزراعة) حيث لا يؤثر ذلك بشدة على المحصول وجودته.

- وفى حالة النقص الشديد فى مياه الرى يمكن النصح بالحرمان فى مرحلتى التزهير ونهاية تكوين المحصول (٦٦ ، ٩٤ يوم من الزراعة) وكذلك خلال مرحلتى النمو الخضرى وبداية تكوين المحصول (٥١ ، ٨٠ يوم من الزراعة) حيث تعتبر اقل المراحل الحرجة تأثيرا على انتاج المحصول وجودته.