EFFECT OF SOIL MOISTURE DEPLETION ON YIELD OF TWO FORAGE SORGHUM CULTIVARS AND SOME WATER RELATIONS

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ABSTRACT

Two field experiments were conducted at Sakha Agricultural Research Station during 2004 and 2005 growing seasons to study the effect of soil moisture depletion on yield of two forage sorghum cultivars and some water relations. A split plot design with four replicates was used. The main plots were devoted to irrigation treatments while the sub-plots were assigned to forage sorghum cultivars.

Irrigation was given at 40, 60 and 80% depletion of available soil moisture content (ASMD) while forage sorghum cultivars were sorghum hybrid 102 and sorghum sudangrass.

Results showed that irrigation at 40% depletion of available soil water content significantly increased plant height, fresh and dry forage yields in the three cuts and their total.

Water requirements values were 3750 m^3/fed. (89.29 cm), 3285.10 m^3/fed. (78.22 cm), and 2710 m^3/fed. (64.52 cm) for the treatments irrigated at 40, 60 and 80% ASMD, respectively.

Mean values of seasonal water consumptive use were 61.1, 51.5 and 39.9 cm for irrigation at 40, 60 and 80% depletion in available water, respectively. On the other hand, water use efficiencies increased as soil moisture depletion increased.

Irrigation at 40% ASMD resulted in higher soil moisture extraction from the upper 30 cm of soil layer to be 82.2% compared to irrigation at 60% and 80% ASMD which were 76.6 and 66.9%, respectively.

As for sorghum cultivars, sorghum hybrid 102 was taller and produced higher fresh, and dry yields in the three cuts as well as seasonal forage yield. Sorghum hybrid 102 increased crop water use efficiency by 5.5% compared to sorghum sudangrass. Field water use efficiency was not affected significantly by sorghum cultivars.

A linear regression slope between water consumptive use and seasonal fresh and dry yields as well as crop water use efficiency were 0.54, 0.05 and -0.93, respectively.

INTRODUCTION

Forage sorghum genotypes are important summer forage in Egypt. In dry area, the forage sorghum crop can respond very favourable to supplemental irrigation. However, considerable differences exist amongst varieties in their response to irrigation and those that are considered very drought-resistant respond slightly. There are others forage sorghum produced high yields under well irrigation but they are poor yielding when water is limiting. Therefore, great efforts have been done to increase forage crops productivity using high yielding varieties and optimizing the agronomic practices.

Best fodder yields were obtained with irrigation regime which maintained a field capacity of 75-80% in the top 60 cm of soil (Grigorov *et al.* (2004), Grigorov and Borovoi (2002), Kruzhilin and Dronova (2003). The highest fresh and dry feed yields and plant height were obtained from 8 days irrigation intervals (Kazemi *et al.*, 2000). Al-Dabbas (2003) revealed that irrigation fodder crops at an irrigation amount based on 100% class A pan evaporation produced the highest yield for sudangrass. Exposing forage sorghum plant to 80% depletion of available soil moisture significantly decreased fresh and dry yields and increased the water use efficiency. Mean values of sorghum consumptive use were 60.20, 50.80 and 39.17 cm for irrigation at 40, 60 and 80% (El-Sabbagh, 2001). Saeed and El-Nadi (1998) showed that plant height, and maximum dry matter yield were higher in the frequently watered plots than in plots where irrigation water was delivered less frequently. They also mentioned that light frequent irrigation resulted in a significantly higher water use efficiency compared to the other two irrigation treatments.

Abdel-Aal *et al.* (1991) reported that the total fresh and dry forage yields/fed. obtained from Sorden 79 were higher than those obtained from sweet sorghum. Rammah *et al.* (1984), found that Pioneer-988 gave the highest green and dry forage yields compared with NK-300, Sorgo Giza 1 and Turdan-7.

MATERIALS AND METHODS

The present investigation was conducted at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, during the summer seasons of 2004 and 2005.

A split-plot design with four replication was used. Main plots were devoted to irrigation treatments, which were irrigated at 40, 60 and 80% depletion of available soil moisture (ASMD). Sub plots were allocated to forage sorghum cvs. sorghum hybrid 102 and sorghum sudangrass. The plots were isolated by ditches of 1.5 m in width to avoid lateral movement of irrigation water to adjacent plots. The preceding crop was Egyptian clover in both seasons.

Seeds were handle drilled in rows 20 cm apart at rate of 20 kg/fed. on June 16 and 14 in the first and second seasons, respectively. The area of each sub plot are was 28 m^2 (4 x 7 m). Phosphorus and potassium fertilizers were applied as single dose before sowing at rate of 200 kg/fed. calcium superphosphate (15.5 % P_2O_5) and 50 kg/fed. potassium sulphate (48% K_2O). Nitrogen fertilizer was 45 kg N/fed./cut applied as urea (46.54% N) before the first irrigation (21 days from sowing) and after the first and second cutting. The soil was clayey in texture, whereas particle size distribution was 52.10% clay, 27.23% silt and 20.67% sand. Soil pH (1: 2.5) was 8.10 and the electrical conductivity of soil and irrigation water was 2.61 and 0.42 dSm^{-1}, respectively. The analysis was determined according to Page (1982).

Yield data were obtained from the central area 15 m^2 to avoid any border effect. Three cuts were taken throughout the growing seasons after 50, 90 and 120 days from sowing date. At each cutting, a sample of 1000 gram of fresh plants was taken from each plot, weighed, and oven-dried to a constant weight to obtain the percentage of dry matter production. The dry matter production for each plot was calculated by multiplying the fresh weight by dry matter percentage.

Field capacity, permanent wilting point and bulk density were determined according to Klute (1986). The mean values are given in Table 1.

Table (1): Soil moisture constants for the experimental site.

Soil depth (cm)	Field capacity (%)	Wilting point (%)	Bulk density (g/cm^3)	Available soil water (%)
0-15	46.14	24.78	1.11	21.36
15-30	41.21	21.29	1.21	19.92
30-45	36.84	20.38	1.24	16.46
45-60	34.91	19.13	1.32	15.78
Mean	39.78	21.40	1.22	18.38

Soil moisture content was gravimetrically determined in soil sample taken from consecutive depth of 15 cm down to a depth of 60 cm. For irrigation timing, soil samples were taken periodically until it reach the desired level of allowable moisture. Soil samples were also collected just before each irrigation, 48 hours after irrigation and at cutting time, to estimated water consumptive use (Hansen *et al.*, 1979).

Irrigation water applied (IWA):

The amount of water applied at each irrigation was determined on the basis of raising the soil moisture content to its field capacity plus 10% as a leaching requirements. Irrigation water applied was calculated according to the following equation (Michael, 1978).

$$d = D * B_d * \frac{F_c - M_c}{100}$$

Where:

d = amount of water to be applied during an irrigation event, cm.
D = soil depth within the root zone, 60 cm.
B_d = soil bulk density, g cm^{-3}
F_c = field capacity moisture content (% by weight).
M_c = moisture content before irrigation (% by weight).

Submerged flow orifice with fixed dimension was used to measure the amount of water applied according to the following equation (Michael, 1978).

$$Q = CA\sqrt{2\,gh}$$

Where:

Q = discharge through orifice, (1/sec.)
C = coefficient of discharge, (0.61).
A = cross-sectional area of the orifice, (cm^2)
g = acceleration of gravity, (cm/sec^2) (981 cm/sec.).
h = pressure head, causing discharge through the orifice (cm).

Water consumptive use (CU):

Water consumptive use from a soil depth was calculated using the following equation (**Hansen *et al.*, 1979**).

$$CU = \sum_{i=1}^{i=4} D_i * D_{bi} * \frac{Pw_2 - Pw_1}{100}$$

Where:

CU = water consumptive use (cm) in the effective root zone (60 cm).
D_i = soil layer depth (15 cm).

D_{bi} = soil bulk density, (g/cm^3) for this depth.
Pw_1 = soil moisture percentage before irrigation.
Pw_2 = soil moisture percentage, 48 hours after irrigation.
i = number of soil layers (15 cm).

Crop water use efficiency (CWUE):
Crop water use efficiency was calculated according to Michael (1978).

$$CWUE = Y/C.U$$

Where:
Y = dry yield in kg
C.U = seasonal water consumptive use in cm.

Field water use efficiency (FWUE):
It was calculated according to Jensen (1983).

$$FWUE = \frac{\text{Dry yield in kg}}{\text{Amount of applied water (cm)}}$$

Soil moisture extraction pattern (S.M.E.P.):
It was calculated using the following equation (Hansen *et al.*, 1979).

$$S.M.E.P. = \frac{C.U. (layer)}{C.U (seasonal)} \times 100$$

Where:
C.U (layer) = Sum of extracted soil moisture in each soil layer (15 cm).
C.U (seasonal) = Total sum of moisture extracted in all soil layers (60 cm).

Regression:

Regression slopes values between water consumptive use, and fresh yield, dry yield and water use efficiency were calculated according to Snedecor and Cochran (1980).

The data were subjected to the standard analysis of variance procedure. The combined analysis was conducted for the data of both seasons. The differences between the means were compared by Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Plant height:

Plant height as influenced by soil moisture stress and forage cultivars, over both seasons, is presented in Table 2.

Results revealed that exposing sorghum crop to water stress significantly decreased plant height at three cuts. The reduction in plant height due to increasing soil moisture stress from 40 to 80% was 2.7, 2.4 and 2.4% at the three cuts, respectively.

Exposing plants to drought caused a reduction in plant height as a result of losing turgidity and cell enlargement (Kramer, 1975). Similar results obtained by Marei (1992), Saeed and El-Nadi (1998), Kazemi *et al.* (2000) and El-Sabbagh (2001), who found that plant height was short as soil water in the root zone was depleted.

Data in Table 2 indicated that the forage cultivars differed significantly in plant height at the first, second and third cuts, over both seasons. Forage sorghum hybrid 102 gave taller plant while forage sorghum sudangrass gave shorter plants at the three cuts. The increment in plant height was 2.0, 2.4 and 1.7% for the three cuts respectively. These results is similar to those of Gheit (1990) and Tabosa *et al.* (2002) who found that such differences in plant height among genotypes due to genetic variation. Insignificant effect of interactions among years, soil moisture stress and cultivars was obtained (Table 2).

Table (2): Average plant height (cm) as affected by irrigation treatments and sorghum cultivars over both growing seasons.

	1 cut	2 cut	3 cut
Irrigation treatments:			
40% ASMD	123.4 a	120.2 a	118.6 a
60% ASMD	121.8 b	118.6 b	116.9 b
80% ASMD	120.2 c	117.4 b	115.8 c
Cultivars:			
Sorghum hybrid 102	123.0 a	120.1 a	118.1 a
Sorghum sudangrass	120.6 b	117.3 b	116.1 b
Interaction:			
Irrigation x cultivars	n.s	n.s	n.s
Irrigation x year	n.s	n.s	n.s
Cultivars x year	n.s	n.s	n.s
Irrigation x cultivars x year	n.s	n.s	n.s

ASMD = Available soil moisture depletion.

Fresh forage yield:

Results in Table 3 indicated that increasing soil moisture stress from 40 to 80% significantly decreased fresh forage yield at the three cuts and their total. The reduction was 28.7, 25.3, 32.0 and 28.2% at each cutting as well as the total yield, respectively. These results indicated that the importance of maintaining soil moisture at a desirable level in the root zone of plants for maximizing forage sorghum yield (El-Sabbagh, 2001; Grigorov and Borovi, 2002; Kruzhilin *et al.*, 2002; Kruzhilin and Dronova, 2003; Fagnano and Postiglione, 2002 and Grigorov *et al.*, 2004).

The first cut produced the highest fresh forage yield for all irrigation treatments and then subsequent cuts yielded less as shown in Table 3. Similar findings were reported by Gheit (1990) and El-Sabbagh (2001).

Table (3): Average fresh forage yield (t/fed.) as affected by irrigation treatments and sorghum cultivars over both growing seasons.

	1 cut	2 cut	3 cut	Total
Irrigation treatments:				
40% ASMD	17.64 a	13.58 a	7.98 a	39.19 a
60% ASMD	15.15 b	12.49 b	6.05 b	33.69 b
80% ASMD	12.57 c	10.14 c	5.43 c	28.14 c
Cultivars:				
Sorghum hybrid 102	16.74 a	13.04 a	7.02 a	36.80 a
Sorghum sudangrass	13.50 b	11.10 b	5.95 b	30.55 b
Interaction:				
Irrigation x cultivars	n.s	n.s	n.s	**
Irrigation x year	n.s	n.s	n.s	n.s
Cultivars x year	n.s	n.s	n.s	n.s
Irrigation x cultivars x year	n.s	n.s	n.s	n.s

ASMD = Available soil moisture depletion.

As for cultivars effect, forage sorghum hybrid 102 yielded 24.0, 17.5, 18.0 and 20.5% more than sorghum sudangrass cultivar for the first, second and third cuts as well as total fresh yield respectively. Such differences might be due to that genotypic variation exists among forage sorghum cultivars. These results agreed with those obtained by Fagnano and Postiglione (2002) and Amaral *et al.* (2003).

All the interactions failed to exert any significant effect, except the interaction between irrigation and cultivars on total cutting was statistically significant as shown in Table 3.

Results depicted in Table 4 revealed that the highest fresh forage yield (44.55 t/fed.) was produced from irrigation at 40% ASMD using sorghum hybrid 102 cultivar, while the lowest one was 27.61, t/fed., recorded from irrigation at 80% ASMD using sudangrass cultivar.

Table (4): Total fresh forage yield (t/fed.) as affected by interaction between irrigation treatments and sorghum cultivars over both growing seasons.

Treatments	Irrigation		
	40% ASMD	60% ASMD	80% ASMD
Cultivars:			
Sorghum hybrid 102	44.55 a	37.19 b	28.67 e
Sorghum sudangrass	33.84 c	30.19 d	27.61 f

ASMD = Available soil moisture depletion

Dry forage yield:

Statistical analysis in Table 5 indicated that water stress had significant effect on dry forage yield. Irrigation at 40% depletion of available soil water content produced 2.43, 1.69, 1.32 and 5.44 t/.fed. at the three cuts and total dry yield. However, irrigation at 80% depletion of available soil water yielded 1.71, 1.43, 1.19 and 4.33 t/fed. for the three cuts and total dry forge, respectively.

The results obtained indicated that adequate soil water content resulted in increasing the capacity of plants to accumulate dry matter and favoured cell division and expansion. These results agreed with those obtained by Bakheit and Abd El-Rahim (1984), Tawadros *et al.* (1984), Lima *et al.* (1999), Kazemi *et al.* (2000), Naescu (2001) and El-Sabbagh (2001), who reported that drought in the early growing phase decreased dry matter yield.

The effect of forage sorghum cultivars on dry forage yield was significant at the three cuts and seasonal dry forage yield, over both seasons (Table 5). Data showed that c.v sorghum hybrid 102 produced 1.92, 3.85, 8.33 and 4.13% more dry forage yield than c.v sorghum sudangrass. Such differences might be due to genetic variability among forage sorghum cultivars (Lima *et al.,* 1999;

Martura *et al.*, 2002; Bartholomew *et al.*, 2003 and Monteiro *et al.*, 2004).

Insignificant effect was detected with any of the interactions among the two variables studied (Table 5).

Table (5): Average dry forage yield (t/fed.) as affected by irrigation treatments and cultivars over both growing seasons.

	1 cut	2 cut	3 cut	Total
Irrigation treatments:				
40% ASMD	2.43 a	1.69 a	1.32 a	5.44 a
60% ASMD	2.15 b	1.64 b	1.24 b	5.03 b
80% ASMD	1.71 c	1.43 c	1.19 c	4.33 c
Cultivars:				
Sorghum hybrid 102	2.12 a	1.62 a	1.30 a	5.04 a
Sorghum sudangrass	2.08 b	1.56 b	1.20 b	4.84 b
Interaction:				
Irrigation x cultivars	n.s	n.s	n.s	n.s
Irrigation x year	n.s	n.s	n.s	n.s
Cultivars x year	n.s	n.s	n.s	n.s
Irrigation x cultivars x year	n.s	n.s	n.s	n.s

ASMD = Available soil moisture depletion.

Irrigation water applied (IWA):

The average values of irrigation water applied over both seasons were 3750.00, 3285.10 and 2710.00 m^3/fed. for 40, 60 and 80% ASMD, respectively as shown in Table 6. It is obvious that treatment which irrigated at 40% ASMD had the highest value of irrigation water applied, distributed on eleven applications including the seeding irrigation. While, the treatment irrigated at 80% ASMD was accompanied with the least value distributed on five irrigations having the seeding one. The other treatments lie in between. Moreover, seeding and first irrigation were the same for all treatments. This findings may be attributed to the availability of soil moisture in the root zone.

Water consumptive use:

The data in Table 7 showed that irrigation at 40% depletion in the available water content resulted in maximum water consumptive use to be 61.1 cm, over both seasons, followed by water consumption of 51.5 cm when irrigation was timed at 60% depletion of plant-available soil water while minimum of water consumption was 39.9 cm when it applied at 80% depletion of available soil water, over both seasons.

Table (6): Amounts of water applied/each cut as affected by soil moisture depletion, over both seasons.

Variables	Irrigation treatments		
	40% ASMD	60% ASMD	80% ASMD
Seeding irrigation	490.00 m^3/fed. (11.67 cm)	490.00 m^3/fed. (11.674 cm)	490.00 m^3/fed. (11.67 cm)
1st cut	1198.50 m^3/fed. (28.54 cm)	1023.60 m^3/fed. (24.37 cm)	791.25 m^3/fed. (18.84 cm)
2nd cut	1178.00 m^3/fed. (28.05 cm)	1062.90 m^3/fed. (25.31 cm)	952.50 m^3/fed. (22.68 cm)
3rd cut	883.50 m^3/fed. (21.04 cm)	708.60 m^3/fed. (16.87 cm)	476.25 m^3/fed. (11.34 cm)
Irrigation water applied	3750.00 m^3/fed. (89.29 cm)	3285.10 m^3/fed. (78.22 cm)	2710.00 m^3/fed. (64.52 cm)

Table (7): Water consumptive use (cm) as affected by irrigation treatments and sorghum cultivars in 2004 and 2005 growing seasons.

Irrigation	Cultivars	2004				2005				Seasonal mean
		1 cut	2 cut	3 cut	Seasonal	1 cut	2 cut	3 cut	Seasonal	
40% ASMD	Sorghum hybrid 102	23.9	21.1	16.4	61.4	23.5	22.1	16.1	61.7	61.6
	sorghum sudangrass	23.7	20.8	16.1	60.6	23.1	21.8	15.8	60.7	60.7
Mean		23.8	21.0	16.3	61.0	23.2	22.0	16.0	61.2	61.1
60% ASMD	Sorghum hybrid 102	21.4	18.2	12.6	52.2	20.4	18.6	12.8	51.8	52.0
	sorghum sudangrass	21.1	17.9	12.4	51.4	20.1	18.0	12.3	50.4	50.9
Mean		21.3	18.1	12.5	51.8	20.3	18.3	12.6	51.1	51.5
80% ASMD	Sorghum hybrid 102	19.1	11.7	9.7	40.5	18.8	11.5	9.9	40.2	40.4
	sorghum sudangrass	18.4	11.5	9.5	39.4	18.5	11.3	9.8	39.6	39.5
Mean		18.8	11.6	9.6	40.0	18.7	11.4	9.9	39.9	39.9
Cultivars mean		Sorghum hybrid 102 = 51.3 cm; sorghum sudangrass = 50.4 cm								

ASMD = Available soil moisture depletion.

These results may be attributed to the more available soil water content resulting in some luxury consumption of water, which ultimately resulted in increasing transpiration besides high evaporation from the soil. These results are reported by Saeed and El-Nadi (1998) and El-Sabbagh (2001), who found that water consumption increased as soil moisture maintained highly by frequent irrigations.

Regarding c.vs. forage sorghum on water consumption, it can notice that they had no obvious effect on water consumption (Table 7).

Crop water use efficiency (CWUE):

The results in Table 8 showed that crop water use efficiency values increased as the soil water in the root zone was depleted. Irrigation at 80% depletion of available soil water content increased crop water use efficiency by 34.32 and 19.56% compared to irrigation at 40 and 60% depletion, respectively, over both seasons.

Sorghum hybrid 102 utilized water more efficiently than sorghum sudangrass as shown in Table 8.

Table (8): Average crop water use efficiency (kg dry matter/cm of water consumed) as affected by irrigation treatments and cultivars over both growing seasons.

	1 cut	2 cut	3 cut	Mean
Irrigation treatments:				
40% ASMD	103.3 a	78.9 c	79.5 c	87.23 c
60% ASMD	103.8 a	90.3 b	99.9 b	98.00 b
80% ASMD	91.5 b	124.5 a	135.5 a	117.17 a
Cultivars:				
Sorghum hybrid 102	101.8 a	101.7 a	107.1 a	103.53 a
Sorghum sudangrass	97.3 b	94.1 b	102.0 b	98.10 b

ASMD = Available soil moisture depletion.

These results could be due to the highly significant between values of dry matter production for forage sorghum cultivars as well as the differences between the water consumption values. These results are in agreement with Tawadros *et al.* (1984), Saeed and El-Nadi (1998), El-Sabbagh (2001), Grismer (2001) and Naescu (2001).

Field water use efficiency (FWUE):

Results presented in Table 9 revealed that field water use efficiency significantly affected by soil moisture depletion. Mean values were 61.5, 66.05 and 74.64 kg dry matter/cm of irrigation water applied for 40, 60 and 80% depletion of available soil moisture, respectively.

Irrigation at 80% depletion of available soil moisture resulted in the highest FWUE, and it increased FWUE by 22.06 and 13.01% compared to irrigation at 40 and 60% depletion of available soil moisture, respectively. This finding is expected since water use efficiency of crop was mainly affected by the yield of crop. Also, due to the minimum water applied of 80% ASMD. Kramer (1975) reported that the most promising method of obtained increased efficiency of water was not by decreasing the use of water but instead encouraging the production of dry matter.

Results in Table 9 showed that field water use efficiency was not affected significantly by sorghum cultivars, over both seasons.

Table (9): Field water use efficiency (kg dry matter/cm of irrigation water applied) as affected by soil moisture depletion and sorghum cultivars, over both seasons.

	1 cut	2 cut	3 cut	Seasonal mean
Irrigation treatments:				
40% ASMD	60.61 a	60.17 b	62.68 c	61.15 c
60% ASMD	59.79 a	64.49 a	73.88 b	66.05 b
80% ASMD	56.08 b	63.11 a	104.74 a	74.64 a
Cultivars:				
Sorghum hybrid 102	59.64 a	63.93 a	80.67 a	68.08 a
Sorghum sudangrass	58.01 a	61.25 a	80.20 a	66.49 a

ASMD = Available soil moisture depletion.

Soil moisture extraction pattern (SMEP):

Results in Table 10 showed that the most of water extracted by sorghum cultivars was removed from the soil surface layer (0-30 cm). The highest percentage of the moisture uptake was occurred at the surface layer of 15 cm of the soil profile.

Table (10): Percentage of soil moisture extraction pattern by forage sorghum roots from soil depths as affected by irrigation treatments and cultivars, over both seasons.

Irrigation treatments	Sorghum cultivars	Soil depths				Average	
		0-15	15-30	30-45	45-60	0-30	30-60
40% ASMD	Sorghum hybrid 102	48.94	33.77	15.64	1.65	82.71	17.29
60% ASMD		46.28	30.65	16.17	6.90	76.93	23.07
80% ASMD		39.16	27.87	24.12	8.85	67.03	32.97
Mean		44.79	30.76	18.64	5.85	75.56	24.44
40% ASMD	Sorghum sudangrass	48.43	33.24	15.60	2.73	81.67	18.33
60% ASMD		46.10	30.08	15.98	7.84	76.18	23.82
80% ASMD		38.99	27.81	23.90	9.30	66.80	33.20
Mean		44.51	30.77	18.49	6.62	74.88	25.12

ASMD = Available soil moisture depletion.

Irrigation at 40% ASMD increased SMEP in the upper 30 cm by 7.35 and 22.8% compared to irrigation at 60 and 80% ASMD, respectively. It means that SMEP increased as a result of more frequent irrigation. The same results were formed by Mitchell and Rusell (1971) who reported that a relative higher water uptake from the top layers occurred compared to deep layers, as a result of the high root density in the upper layers.

Regression:

Regression slope between water consumptive use (CU) and fresh forage yield (GY t/fed.), dry forage yield (DY t/fed.) and crop water use efficiency (kg dry matter/cm consumed WUE) is listed in Table 11. Each one centimeter of water consumed produced 1.05 and 0.14 t/fed., fresh and dry forage yields, respectively (Eq. 1 and 2) and gave higher crop water use efficiency (Eq. 3), compared with the second and third cuttings. It means that the first cutting utilized irrigation water more efficiently in dry matter production compared to other cuttings.

Liner equations of 4, 5, 7 and 8 showed that fresh and dry forage yields which produced as a result of 1 cm of water consumed reduced from the second and third cutting. Therefore, crop water use efficiency of the second and third cuttings was reduced because the productivity of dry matter was decreased per one centimeter of water consumed (Eq. 6 and 9).

Each one centimeter of seasonal water consumption yielded 0.54 and 0.05 t/fed. fresh and dry forage yields (Eq. 10 and 11), respectively. On the other hand, water consumptive use decreased CWUE at a rate of 0.93 kg dry matter/cm of water consumed (Eq. 12).

Table (11): Regression equations between water consumptive use (CU) and fresh forage yield (GY), dry forage yield (DY) and crop water use efficiency (CWUE).

	Liner equation Y = a + bx		
1st cut	2nd cut	3rd cut	Seasonal yield
GY = - 6.9 + 1.05 CU (1)	GY = 6.1 + 0.40 CU (4)	GY = 1.2 + 0.35 CU (7)	GY = 6.4 + 0.54 CU (10)
DY = - 0.9 + 0.14 CU (2)	DY = 1.1 + 0.03 CU (5)	DY = 0.98 + 0.02 CU (8)	DY = 2.3 + 0.05 CU (11)
CWUE= 56 + 2.1 CU (3)	CWUE= 178 - 4.7 CU (6)	CWUE= 215-8.6 CU (9)	CWUE= 145 - 0.93 CU (12)

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تأثير النقص فى الرطوبة الأرضية على العلاقات المائية ومحصول صنفين من سورجم العلف

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أجريت هذه الدراسة بمزرعة محطة البحوث الزراعية بسخا ــ محافظة كفرالشيخ عامى ٢٠٠٤ ، ٢٠٠٥م بهدف دراسة تأثير الرى عند مستويات مختلفة من الرطوبة الأرضية على العلاقات المائية وإنتاجية صنفين من سورجم العلف.

واستخدم تصميم القطع المنشقة فى أربع مكررات حيث وزعت معاملات الرى بالقطع الرئيسية وهى الرى عند فقد ٤٠ ، ٦٠ ، ٨٠% من الماء الميسر ووزعت الأصناف (هجين سورجم ١٠٢ ، سودان جراس) بالقطع الشقية ويمكن تلخيص أهم النتائج فيما يلى:

١- أدى الرى عند فقد ٤٠% من الماء الميسر إلى زيادة معنوية فى ارتفاع النبات والمحصول الطازج والجاف (طن/فدان).
٢- وجد أن الاحتياجات المائية ٣٧٥٠,٠م٣/فدان (٨٩.٢٩سم) ، ٣٢٨٥,١٠م٣/فدان (٧٨.٢٢سم) ، ٢٧١٠م٣/فدان (٦٤.٥٢سم) وذلك بالرى عند فقد ٤٠ ، ٦٠ ، ٨٠% من الماء الميسر على الترتيب.
٣- زاد الاستهلاك المائى الموسمى بزيادة الرطوبة الأرضية فى منطقة الجذور (الرى عند فقد ٤٠% من الماء الميسر).
٤- أدى الرى عند فقد ٨٠% من الماء الميسر إلى زيادة كفاءات الرى.
٥- وجد أن النبات استهلك أكبر كمية من الماء الذى يحتاج إليه من الطبقة السطحية للتربة (صفر ــ ٣٠سم).
٦- تفوق الصنف هجين سورجم ١٠٢ فى صفة ارتفاع النبات والمحصول الطازج والجاف وكفاءة استخدام مياه الرى (كيلو جرام مادة جافة/سم ماء مستهلك) ومعدل استنفاذ الرطوبة من التربة بواسطة الجذور من الطبقة (صفر ــ ٣٠سم).
٧- لم يكن لصنفى السورجم تأثير معنوى على كفاءة الرى الحقلية (ك. جـ مادة جافة/سم ماء مضاف).
٨- وجد أن ميل خط الإنحدار بين الاستهلاك المائى الموسمى والوزن الطازج والجاف الموسمى وكفاءة استخدام مياه الرى يساوى ٠,٥٤ ، ٠,٠٥ ، -٠,٩٣ على الترتيب.