THE EFFECT OF DEFICIT IRRIGATION ON YIELD, WATER STATUS, AND WATER PRODUCTIVITY OF SOYBEAN CROP UNDER DRIP IRRIGATION SYSTEM

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ABSTRACT

Soybeans are very sensitive crops to environmental conditions during their growth stages. This study was conducted to determine the effect of ETc levels on canopy water content (CWC), soil water content (SWC), chlorophyll concentration, water productivity (WP), shelling, plant height, leaf area index (LAI) and soybean yield .Three water regimes (100% , 75% and 50% of estimated crop evapotranspiration, ETc) were used to subject soybean to various levels of watering regime. The average amount of irrigation water applied to treatments (100%, 75%and 50%ETc) was 1109.2, 831.9 and 554.6 mm, respectively. The obtained results showed that water stress levels had significant effects on growth characteristics and yield of soybean. The obtained results also indicated that reducing ETc from 100% to 75% and 50% caused significant decreases in all growth and yield characteristics. This study demonstrated that 100% ETc produced higher yield of soybean. The results further showed that the maximum value of grain yield was obtained when plants were irrigated with 100%ETc while the minimum values of grain yield were recorded with 50%ETc. The highest and lowest water productivity values of 1.3 and 0.59 kg/m^3 were obtained with 100% ETc and 50%ETc, respectively. Chlorophyll concentration values were higher in water stressed treatments and lower in the 100% ETc treatment.

Keywords: *soybean, water stress, canopy water content, water productivity, chlorophyll, early water stress(ews), late water stress(lws).*

INTRODUCTION

Soybean crop [*Glycine max L* .] is widely cultivated and is one of the world ′s most important crops. According to FAO statistical. Year book (2014) the total cultivated area of soybeans worldwide was 111,273,135 ha which produced 276,396,011 Mg at an average yield of 2.48 Mg ha^{-1}.

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Soybean has a high protein content of about 40% by weight, 32% carbohydrates, 20% fat, 5% minerals and 3% fibers and other trace substances. It is also used in industries as a source of edible oil and the by-product of the oil extraction (i.e. soybean cake used as an animals feed). It is also used as a source of protein in human food and animal feed **(Atungu and Afolabi, 2001). Elbeltagi et al. (2017)** reported that water stress caused reductions in potato yield, canopy water content and water productivity but Soil-Plant Analysis Development SPAD value was highest in water stressed treatments. **Boyer et al. (2008)** indicated that different methods can be used to determine the water status in crops such as leaf water content (LWC), canopy water content (CWC). **Nicola′s et al (2008)** reported that the first sign of water shortage is the decrease in turgor which causes a decrease in both growth and cell development especially in the stem and leaves. The growth of cells is the most important process that is affected by water stress and the decrease in the growth of cells leads to a decrease in plant height. **Gaballah et al. (2008)** showed that the highest yield was obtained under 1:2 soybean to maize intercropping pattern (1.46 Mg) under (1.0, 1.2, 0.8) pan evaporation and the highest water use efficiency of 1.34 kg/m^3 was obtained under irrigation with 1.0 pan evaporation**. Simsek and Comlekcioglu (2011)** found that soybean is very sensitive crop to water stress and during the growth season. At least equal 100%ETc or excess of the evaporated water amount was required to produce high yield, water use efficiency and plant height. **Ibrahim et al. (2015)** pointed out that the optimum scheduler model was CROPWAT for irrigation water management under Egyptian conditions. **El-Sherif and Ali (2015)** showed that the highest water use efficiency, yield and plant height of soybean under irrigation with 100% ETc compared with 80% ETc and 70%ETc. **Lisar et al. (2012)** reported that the impacts of water stress in crop plants can reduce productivity by 50% in various parts of the world. Under stress conditions, the plants present a series of changes in their morphology, physiology and biochemistry, negatively affecting their growth and productivity. **Hosny et al. (2015)** concluded that increasing water stress levels to 50% and 35% of ETo of water requirements caused significant decreases in all growth and yield characteristics (i.e., plant height , number of leaves, leaf area /plant and shoots fresh and dry weight as well as number and weights of green pods per plant and total pods yield per feddan. This research aimed to investigate the influence of water stress on soybean crop yield, water productivity, chlorophyll concentration and canopy water content.

MATERIAL AND METHODS

Experimental site

Field experiments were conducted in two successive summer seasons of 2016 and 2017 at the Research Station of the Sadat City University, Egypt (30˚2′41.185″N and 31˚14′8.1625″E). The experimental site is characterized as a semi –arid climate with moderate cold winters and warm summers. Soybean (Giza111 variety) was used for both seasons. In the first season soybean was planted on 24th April and harvested on 10th August and planted on 24th April and harvested on 14th August in the second season. Chemical and mechanical analyses of soil for the experimental site are presented in Tables 1 and 2. The experimental soil was sandy in texture as shown in table (1,2 and3). Samples of irrigation water were collected Electrical conductivity of irrigation water was 1.20 dS/m.

Table (1) Mechanical analysis of the experimental soil

Soil depth(cm)	Sand(%)	Silt(%)	Clay(%)	Soil texture
0-30	97	2.0	1.0	Sandy
30-60	96	2.1	1.9	Sandy
Average	96.5	2.05	1.45	Sandy

Table (2) Chemical analysis of the experimental soil

Soil depth(cm)	pH	Anions,				Cations,			
		Na	Mg	K	Ca	Co_3	HCo_3	Cl	So_4
0-30	7.9	14.0	7	0.4	16	3.3	5.0	11	18.1
30-60	7.7	15.2	16	2.8	20	4.6	6	20	23.4

Table (3) Hydrophysical analysis of the experimental soil

Depth (cm)	Field capacity (%)			Wilting point (%)			Bulk density g/cm^3		
	I	II	mean	I	II	mean	I	II	Mean
0-15	13.0	12.8	12.5	3	3	3	1.50	1.51	1.5
15-30	12.0	13.2	12.6	3	3	3	1.48	1.50	1.45
30-45	13.5	13.0	13.25	3	3	3	1.53	1.46	1.49

I=sample 1 and II=sample 2.

Experimental Layout

The experimental design included three levels of ETc [T1 , irrigated with 100% ETc;T2, irrigated with 75%ETc ; and T3 ,irrigated with 50% of ETc]. Under 100 and 75% ETc there are also two stages for stress (late stage and early stage). 6 rows space spacing 50 cm were allocated for each treatment. For 100% ETc, Nitrogen fertilizer as ammonium nitrate (NH_4NO_3 33.5%) was added after 30 days from planting date (initial and mid stages). A drip irrigation system was used to irrigate different plots. Emitters of 4 L/h discharge rate were used to control the flow of water from the lateral to soybean plants. Diameters of mainline and lateral were 50, 16 mm, respectively. The experimental area consisted of eighteen lines of 50 m length. Valves were installed at the start of each lateral line to manage irrigation time. The drip irrigation network and experimental layout are depicted in Figure 1. Early and late water stress for 2016 season were applied from June 13, 2016 to June 26, 2016 and from June 29, 2016 to Jul 24, 2016 respectively. Whereas, early and late water stress for 2017 season were applied from May 15, 2017 to Jun 4, 2017 and from June 6, 2017 to July 11, 2017 respectively.

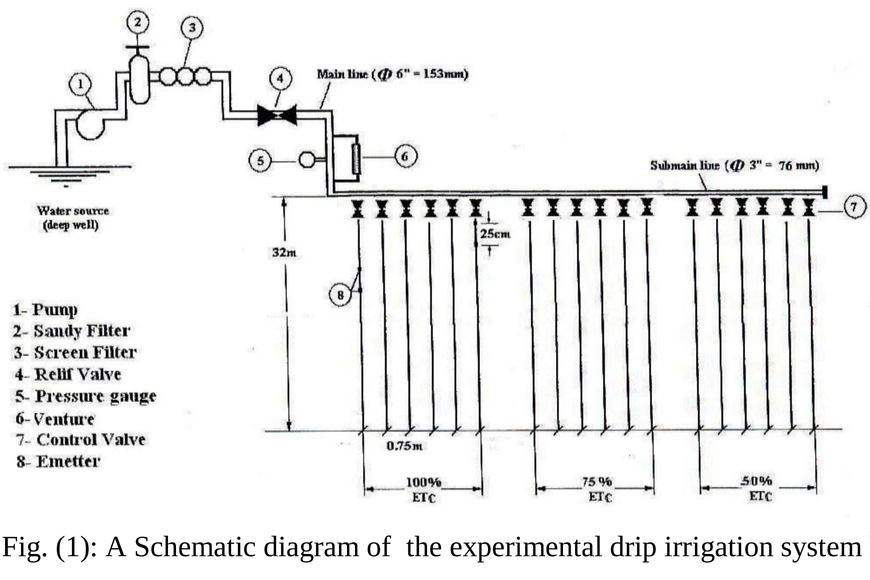


Fig. (1): A Schematic diagram of the experimental drip irrigation system layout

Irrigation Water Requirements

In this study FAO CROPWAT software 8.0 by **Smith, (1992)** was used to decide when to irrigate and how much water to be applied to experimental replicates. FAO Penman-Monteith method was used by this software as the standard method for the computation of the reference evapotranspiration. This method is preferred where data of temperature, humidity, wind speed, sunshine duration are available. The weather data for the experimental site were obtained from **(Word weather online, 2015)**. The weather data were used in daily basis. FAO Penman-Monteith equation was used to calculate ETo according to **(Allen et al., 1998).**

$$\mathrm{ETO} = \frac{0.408\Delta(\mathrm{Rn} - \mathrm{G}) + \gamma \frac{900}{T+273} \; U2(es - ea)}{\Delta + \gamma(1 + 0.34\mathrm{U2})} \ldots\ldots\ldots..(\quad 1 \,)$$

Where; ETo: reference evapotranspiration [mm day^{-1}], Rn: net radiation at the crop surface [MJm^{-2} day^{-1}], G:soil heat flux density [MJm^{-2} day^{-1}], T:air temperature at 2 m height [°C], U2 :wind speed at 2 m height [ms^{-1}] , e_s: saturation vapor pressure [KPa], e_a: actual vapor pressure [KPa], e_s- e_a: saturation vapor pressure deficit [KPa], Δ :slope of vapor pressure curve [$KPa°C^{-1}$] , γ: psychometric constant [$KPa°C^{-1}$].

Field Measurements

Chlorophyll meter

A portable SPAD chlorophyll meter (Konica-Minolta, Osaka, Japan) was employed to measure chlorophyll. The SPAD means The Soil- Plant Analysis Development that determines the chlorophyll by measuring the leaf absorbance in red and near-infrared regions.

Soil water content (SWC)

Soil water content was determined employing the following equation :

$$\mathrm{SWC}(\%) = \frac{\mathrm{Mwater}}{\mathrm{Mdry}} = \frac{(\mathrm{Mwet} - \mathrm{Mdry})}{\mathrm{Mdry}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (\, 3.7 \,\,)$$

Where:

M_{water}= mass of water

M_{dry}= mass of dry soil

Soil water content (SWC) is expressed on a gravimetric basis. The gravimetric water content is the mass of water per mass of dry soil. Soil water content was measured in the laboratory by weighing soil samples before and after drying. The samples were dried in an oven at 105 °C for 24 hours.

Soybean canopy water content (CWC)

Soybean plants arial biomass was cut just above the ground level for all experimental plots. Thereafter, a representative subsample was placed in an oven at 70°C for 24 hours until a constant weight. Samples were weighted before and after drying to determine canopy water content. The percentage of canopy water content was calculated as follows:

$$CWC = \frac{FW - DW}{FW} \times 100 \qquad \ldots\ldots\ldots\ldots\ldots\ldots..(2)$$

Where; FW= the fresh weight, and DW= the dry weight

Water productivity and yield of soybean

To determine the soybean yield, twelve plants per each treatment were harvested and the final yield was identified. Water productivity is defined as the yield obtained per unit of water consumed. Water productivity (WP) was calculated according to **(Akhter 2017)** using the following equation :

$$WP\left(\frac{kg}{\mathrm{m3}}\right) = \frac{\mathrm{Y}}{\mathrm{WR}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (\quad 3 \quad)$$

Where; Y= yield (kg/fed), WR= the total amount of water applied in the field (m^3/fed)

Grain yield

Soybean was harvested manually on August10th, 2016 and August14th, 2017. At harvesting time, random samples of 12 plants ($2m^2$) were collected from each treatment to determine the grain yield for each treatment. After pod drying naturally, the pod and the seed yield ($Mg.fed^{-1}$) as well as shelling (%) were determined. The shelling percentage (%) was calculated using the following equation:

$$\text{Shelling (\%)} = \frac{seed\ yield\ .plant^{-1}}{pod\ yield.plant^{-1}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (\quad 5 \quad)$$

Leaf area index (LAI)

Twenty soybean plants were sub sampled and all leaves were removed, then fresh weight was recorded. Twenty discs of 3×3 cm were taken from different leaves randomly of the sub sample at different locations on each leaf from leaf tip to leaf base and then the total leaf area was calculated as follows:

$$\textbf{The whole leaf area} = \frac{WT \times DA}{DW} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(6\ )$$

Where; WT is the weight of the whole sample, DA is the area of a specific number of discs, DW is the weight of these discs. After calculating the leaf area for each treatment, the leaf area index was calculated by dividing the total leaf area for each sample by the area occupied by these plants as follow:

$$LAI = \frac{LA}{SA}$$

Where; LA I is the leaf area index, LA is the leaf area per sample, SA is the occupied land area

Plant height

Plant height was recorded bi-monthly during the first and second season of soybean crop . plant height was measured by meter

Statistical Analysis

SPSS 19 for windows version 10 (SPSS Inc., Chicago, IL) was used for the statistical analysis. Simple regressions were calculated to analyze the relationship between canopy water content, soil water content, water productivity, chlorophyll concentration , shelling and leaf area index. Coefficients of determination (R^2) and significance test were determined. A nominal alpha value of 0.05 was used.

RESULTS AND DISCUSSION

Effect of ETc levels on soil water content, canopy water content , water productivity and yield

Effect of water regime levels on soil water content (%), canopy water content (%), water productivity and yield of soybean crop is tabulated in Table (4) shows the maximum, minimum, mean values and standard deviation of SWC (%), CWC (%), WP (kg/m^3) and yield (Mg/fed). In general , it could be concluded that the 100% ETc produced higher values for SWC (%), CWC (%), WP (kg/m^3) and yield (Mg /fed) than the obtained records under 75% ETc levels and stressed conditions as shown in Figures 4 through 7.

Comparing the results SWC in both seasons , it was found that the highest SWC of 27.3 and 27.9% were recorded with the treatments 100% ETc in

2016 and 2017 respectively , while the minimum values of SWC of 10.2 and 11.3% were recorded with the treatment received 75% ETc(ews) in 2016 and 2017 respectively . The slope was (-3.0911) and coefficient of determination was (0.96) under ETc levels and water stress.

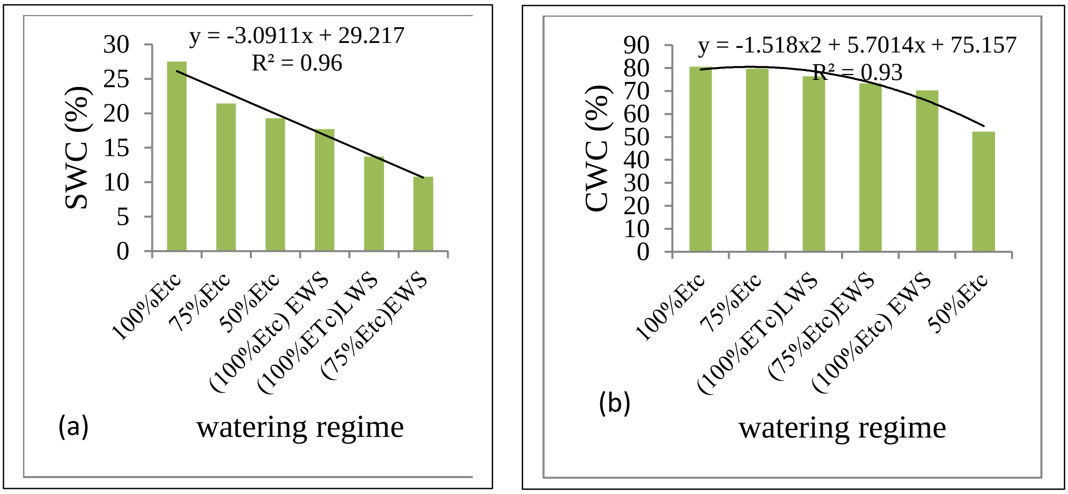
Table(4)Minimum .maximum and mean values of soil water content (%), canopy water content(%) ,water productivity (kg/ m^3) and yield (Mg/fed) value under ETc levels for two season.

Measured Parameters	Treatments	2016 season				2017season			
		Min	Max	Mean	SD	Min	Max	Mean	SD
SWC(%)	100%ETc (control) 100%ETc(Ews) 100%ETc(Lws) 75% ETc 75%ETc(EWS) 50%ETc	25.7 11.2 15.5 20.1 8.3 18.3	29.02 14.9 19.2 23.1 12.0 21.34	27.37a 13.06d 17.3c 21.6b 10.2e 19.84b	2.6 1.1 2.8 1.3 0.8 1.0	26.5 11.3 16.4 19.9 8.7 19.3	39.3 15.3 19.6 22.4 11.9 22.1	27.9a 14.0d 18.05c 21.2b 11.3e 18.7bc	2.2 1.7 2.0 0.8 0.6 0.8
CWC(%)	100%ETc(control) 100%ETc(Ews) 100%ETc(Lws) 75%ETc 75%ETc(EWS) 50%ETc	80.1 76.0 70.0 78.2 70.1 74.5	86.0 83.2 78.1 84.0 77.3 80.4	83.1a 79.6ab 72.5d 81.1ab 73.7c 77.5bc	1.8 1.3 2.0 2.3 1.9 4.6	74.3 71.5 68.4 76.7 70.9 71.4	88.2 81.6 79.6 82.8 74.0 78.6	759b 73.0c 56.0d 78.3a 72.4c 73.0c	0.9 1.4 5.4 2.5 1.9 1.4
WP (kg/m^3)	100%ETc (control) 100%ETc(Ews) 100%ETc(Lws) 75% ETc 75%ETc(EWS) 50%ETc	1.1 0.5 0.56 0.62 0.50 0.37	1.50 0.99 0.94 0.99 0.92 0.74	1.3a 0.76b 0.75b 0.80b 0.71b 0.55b	0.5 0.3 0.29 0.25 0.17 0.21	1.1 0.61 0.76 0.69 0.64 0.48	1.4 0.92 1.07 1.00 0.95 0.78	1.3a 0.76bc 0.92b 0.84bc 0.79bc 0.63c	0.43 0.30 0.19 0.31 0.16 0.18
Yield (Mg/fed)	100%ETc (control) 100%ETc(Ews) 100%ETc(Lws) 75%ETc 75%ETc(EWS) 50%ETc	1.2 0.94 0.99 0.73 0.66 0.47	1.51 1.34 1.3 1.3 1.18 1.04	1.4a 1.14b 1.16b 1.02bc 0.85cd 0.63d	0.22 0.35 0.41 0.21 0.14 0.19	1.23 0.95 1.06 1.05 0.75 0.54	1.44 1.16 1.27 1.25 0.96 0.74	1.34a 1.05b 1.16b 1.15b 0.86c 0.64d	0.12 0.15 0.26 0.18 0.17 0.14

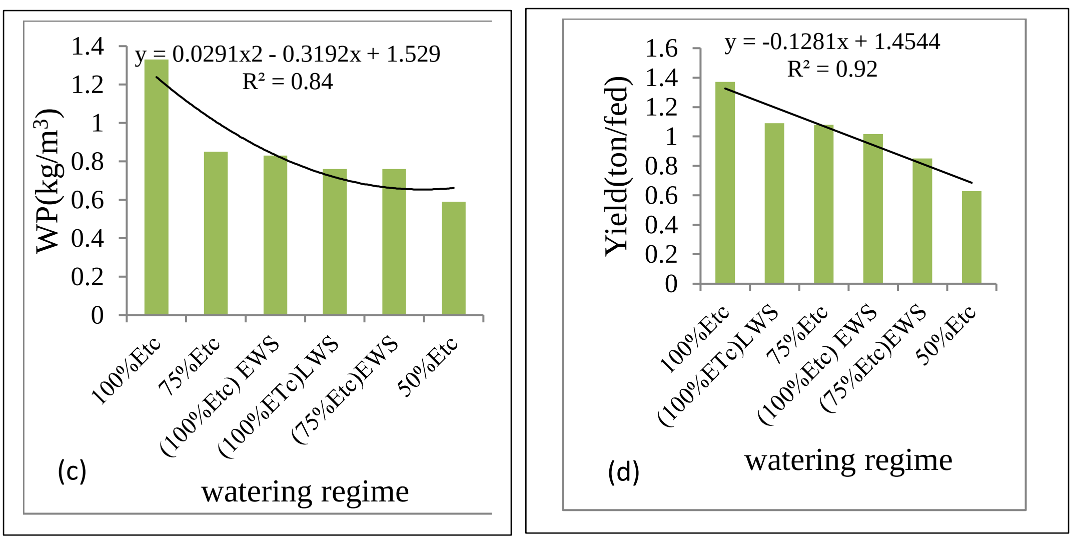
CWC=canopy water content , SWC=soil water content, WP=water productivity, EWS=early water stress, LWS=late water stress , SD=standard deviation Values with the same letter are not significantly different(P≥0.05) among treatments according to Duncan′s test.

Average over all ETc levels, the highest CWC of 83.1 and 78.3 were recorded with the treatments 100% ETc and 75%ETc in 2016 and 2017 respectively , while the minimum values of CWC of 72.5 and 56 were recorded with the treatment received 100% ETc(lws) in 2016 and 2017 respectively. Figure(2b) show quadratic equation and coefficient of determination at 5%level was (0.93)under ETc levels and water stress . In general , one can say that values of CWC are bigger in 100% ETc , and their descending order with respect to watering conditions was75% ETc (ews), 100% ETc(ews), 75%ETc(lws) and 50%ETc.

Meanwhile for both seasons at three ETc levels , water productivity was the highest of 1.3 and 1.3 kg/m^3 that were recorded with the treatments 100% ETc in 2016 and 2017 respectively , while the minimum values of WP of 0.55 and 0.63 kg/m^3 were recorded with the treatment received 50% ETc in 2016 and 2017 respectively . Figure(3c) show quadratic equation and coefficient of determination at 5%level was (0.84)under ETc levels and water stress.



Fig(2) Relationship between watering regimes ETc levels with (a) soil water content , (b) canopy water content



Fig(3) Relationship between watering regimes ETc levels with (c) water productivity , (d) yield

It is obvious that increasing the ETc the water productivity at 100% ETc were much higher than it is values in other treatments. These results agree with **Simsek and Comlekcioglu (2011)** who found that soybean water use efficiency ranged from 1.90 to1.73 kg/m^3 under 133%ETc and100% ETc respectively . These results agree with **onder.et al (2005)** who found that water stress significantly affected potato yield and yield parameters at irrigation levels 0,33,66,100 of fully irrigated.

Effect of ETc levels on plant height, chlorophyll concentration , LAI and shelling of soybean crop.

Table (5) shows the values of LAI ,plant height(cm) , shelling(%) and chlorophyll concentration value at ETc levels under 100% ETc, 100% ETc(ews), 100% ETc (lws), 75%ETc, 75%ETc (ews) and 50%ETc respectively as shown in Figures (8 throught11).

Results show that the chlorophyll concentration, generally increased with increasing water stress for two seasons , the highest chlorophyll concentration of 41.9 and 40.4 were recorded with the treatments 100% ETc(ews) and 100%ETc(lws) in 2016 and 2017 respectively , while the minimum values of chlorophyll concentration of 29.0 and 28.6 were recorded with the treatment received 50% ETc in 2016 and 2017 respectively . The slope was(2.5231) and coefficient of determination was (0.99) under ETc levels and water stress.

Meanwhile for both season at three ETc levels , the highest LAI of 0.03 and 0.03 were recorded with the treatments 100% ETc in 2016 and 2017 respectively , while the minimum values of LAI of 0.01 and 0.01 were recorded with the treatment received 50%ETc and 75% ETc(ews) in 2016 and 2017 respectively. Figure(4b) show quadratic equation and coefficient of determination at 5%level was (0.90)under ETc levels and water stress.

Shelling generally increased with increasing ETc and reduced with early, late water stress and ETc 50%.For both seasons, the highest shelling of 47 and 50.8% were recorded with the treatments 100% ETc in 2016 and 2017 respectively , while the minimum values of shelling of 31.9 and 31.8% were recorded with the treatment received 50% ETc in 2016 and 2017 respectively . Figure(5d) show quadratic equation and coefficient of determination at 5%level was (0.92) under ETc levels and water stress.

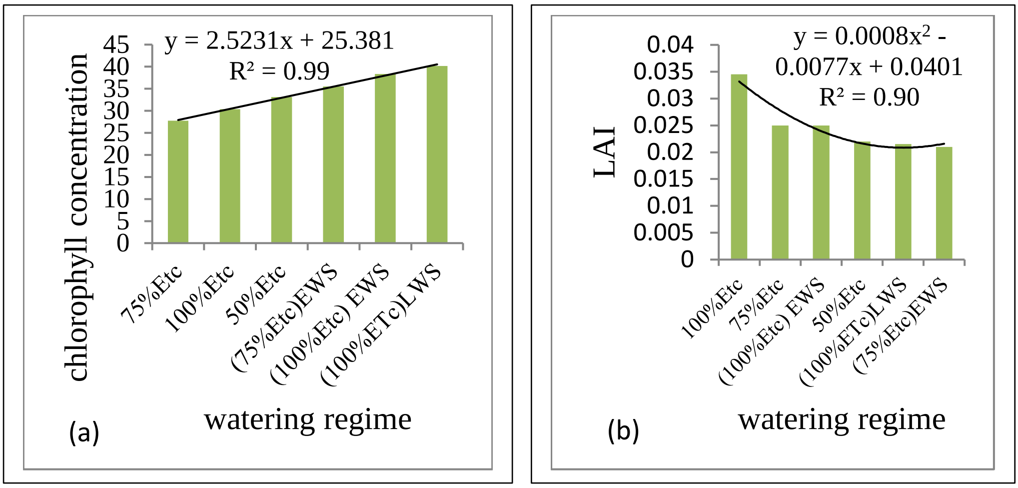
On the other hand, the highest plant height of 97 and 100 cm were recorded with the treatments 100% ETc in 2016 and 2017 respectively, while the minimum values of plant height of 78 and 79 cm were recorded with the treatment received 50% ETc in 2016 and 2017 respectively .

Table(5):Maximum , minimum and mean values of chlorophyll concentration ,leaf area index, shelling (%)and plant height (cm) under ETc levels and water stress for two season.

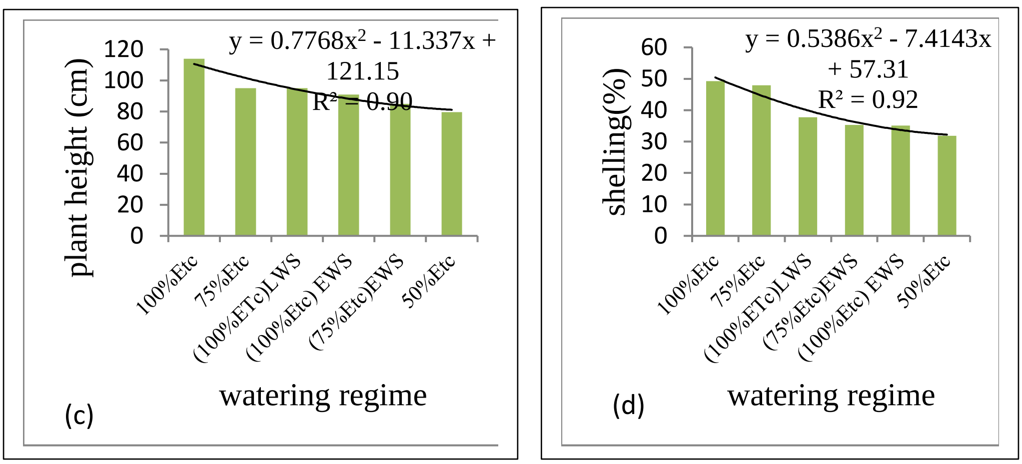
Measured Parameters	treatments	2016 season				2017 season			
		Min	Max	Mean	SD	Min	Max	Mean	SD
Chlorophyll concentrate	100%ETc(control)	27.04	31.05	29.0d	4.1	29.66	33.81	31.7b	4.8
	100%ETc(Ews)	39.44	44.36	41.9a	1.5	36.23	40.38	38.3a	2.6
	100%ETc(Lws)	34.35	38.37	36.3c	3.8	38.34	42.50	40.4a	2.0
	ETc75%	28.95	32.96	30.9d	3.0	22.37	26.52	24.4d	1.9
	75%ETc(EWS)	37.57	42.49	40ab	2.3	28.92	33.07	31bc	4.7
	50%ETc	35.67	39.69	37bc	4.1	26.63	30.63	28.6c	4.0
LAI	100%ETc(control)	0.037	0.041	0.03a	0.0	0.025	0.036	0.03a	0.004
	100%ETc(Ews)	0.021	0.026	0.02c	0.002	0.015	0.026	0.02b	0.004
	100%ETc(Lws)	0.025	0.029	0.02b	0.004	0.019	0.030	0.02a	0.004
	ETc75%	0.027	0.030	0.02b	0.003	0.018	0.029	0.02a	0.002
	75%ETc(EWS)	0.021	0.025	0.02c	0.002	0.014	0.025	0.01b	0.004
	50%ETc	0.018	0.022	0.01d	0.007	0.020	0.030	0.02b	0.002
Plant height (cm)	100%ETc(control)	89	110	97a	5.2	90	115	100a	5.2
	100%ETc(Ews)	85	93	90b	1.7	90	97	95b	3.7
	100%ETc(Lws)	80	92	90b	6.50	89	95	91b	7.2
	ETc75%	80	91	86c	4.7	82	95	90b	3.1
	75%ETc(EWS)	78	90	84c	9.5	79	90	85c	5.5
	50%ETc	69	87	78d	5.2	71	89	79d	2.5
Shelling(%)	100%ETc(control)	44.63	50.60	47.6a	6.8	47.53	54.13	50.8a	6.2
	100%ETc(Ews)	32.47	39.77	36.1b	4.4	35.98	42.58	39.2b	4.1
	100%ETc(Lws)	31.54	38.43	34.9b	5.00	31.95	38.56	35bc	5.7
	ETc75%	43.14	48.87	46.0a	5.5	46.55	53.15	49.8a	7.2
	75%ETc(EWS)	29.99	37.29	33.6b	2.9	33.76	40.36	37.0b	6.0
	50%ETc	28.93	34.90	31.9b	4.1	28.97	34.97	31.8c	4.4

LAI=leaf area index, EWS=early water stress, LWS= late water stress - Values with the same letter are not significantly different($p \geq 0.05$) among treatments according to Duncan′s test.

Figure(5c) show quadratic equation and coefficient of determination at 5%level was (0.90) under ETc levels and water stress. These results agreed with **Yuan et al. (2003)** who showed that plant height, biomass amount and tubers were increased by increasing the irrigation water at irrigation regimes (125,100,75,50 and 25) of evaporated water. It is obvious that increasing the ETc the plant height at 100% ETc and 75% ETc are higher than early ,late water stress and 50%ETc. **Simsek and Comlekcioglu (2011)**found that soybean plant height ranged from 101.60 to 8.67 cm and from 100.90 to 69cm under 133%ETc and 100% ETc respectively. These results agree with **Saenjan et al.(2012)** found that LAI and the grain yield of the three soybean cultivars , LAI ranged (0.010 ,0.076 ,0.27 and 0.52)under 30 , 45 , 60 and above 60 days respectively , shelling (%) ranged from 34.60 to 47.10 .



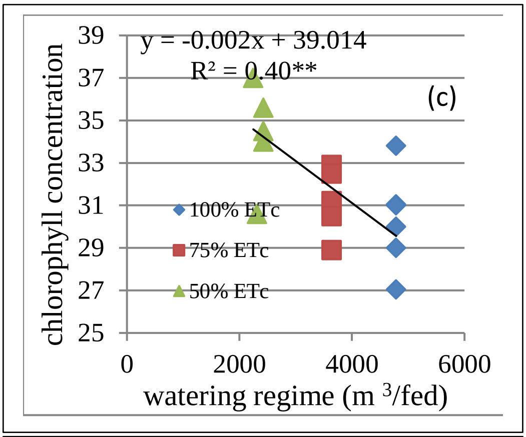
Fig(4) Relationship between watering regimes ETc levels with (a) chlorophyll concentration , (b) leaf area index

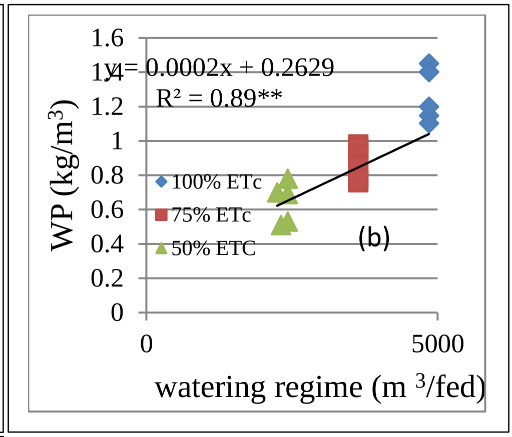


Fig(5) Relationship between watering regimes ETc levels with (c) plant height , (d) shelling

Relationships between watering regime with canopy water content, water productivity, chlorophyll concentration

As shown in Figure 7, there are linear relationships between watering regime and CWC (%), water productivity and chlorophyll concentration. The slope between watering regime with CWC was (0.002) and the intercepts was (73.887) and the coefficient of determination were (0.65**) under ETc levels. The slope between watering regime with WP was (0.0002) and the intercepts was (0.2629) and the coefficient of determination were (0.89**) under ETc levels . The slope between watering regime with chlorophyll concentration was(0.002) and the intercepts was (39.014) and the coefficient of determination were (0.40**) under ETc levels .





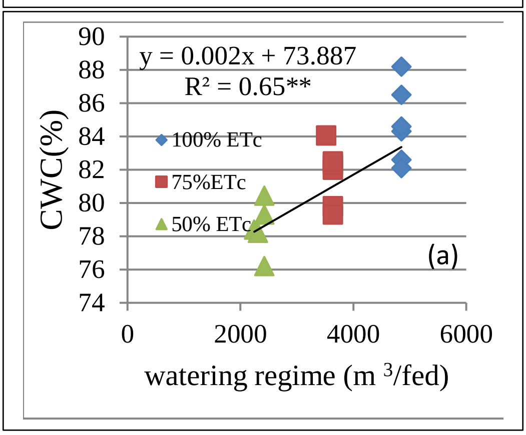


Fig.(6):Relationship between watering regime and(a)canopy water content (b)water productivity (c) chlorophyll concentration

CONCLUSIONS

In conclusions, there are obvious effects of ETc levels and water stress on canopy water content, soil water content, yield, water productivity, chlorophyll concentration, leaf area index, shelling and plant height. Water productivity, canopy water content and leaf area index were higher in 100% ETc than 75% ETc more than 50%ETc and water stress. In contrast, chlorophyll concentration was the highest in water stress.

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الملخص العربي

تأثير الري المنقوص علي الانتاجية والحالة المائية وانتاجية المياه لمحصول فول الصويا تحت نظام الري بالتنقيط

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ان نقص المياه يؤثر علي انتاجية المحاصيل اذا كانت المحاصيل حساسة للمياه خاصة اذا كانت في المناطق الجافه وشبه الجافه لذلك يعتبر معدل وتوقيت اضافة المياه من العوامل الهامه في تحسين محصول فول الصويا وجودته. وتهدف هذه الدراسة الي دراسة تأثير الاجهاد المائي على انتاجية محصول فول الصويا وانتاجية المياه. لتحقيق اهداف الدراسة تم اجراء تجربتان في مزرعة معهد البحوث والدراسات البيئية بجامعة مدينة السادات. اجريت التجربتين في فصلي الصيف ٢٠١٦و ٢٠١٧ وتمت زراعة التجربة الاولي فى ٢٤ ابريل٢٠١٦ والحصاد في ١٧ اغسطس ٢٠١٦ بينما اجريت التجربة الثانية٢٤ فى ابريل ٢٠١٧ والحصاد فى ١٤ اغسطس ٢٠١٧ وتم اجراء الاجهاد المائي المبكر في الفترة من ١٣ يونيو٢٠١٦ الي٢٦ يونيو٢٠١٦للموسم الاول وكذلك الفترة من ١٥ مايو٢٠١٧ الي٤ يونيو٢٠١٧للموسم الثاني وكذلك تم اجراء الاجهاد المائي المتأخرمن٢٩ يونيو ٢٠١٦ الي٢٤ يوليو٢٠١٦للموسم الاول وكذلك الفترة من ٦ يونيو٢٠١٧ الي١١ يوليو٢٠١٧للموسم الثاني. حيث انه تم اخذ جميع القراءات في فترات الاجهاد المختلفة وتمت عملية جدولة الري باستخدام برنامج (CROPWAT ver.8.0) علي اساس بيانات يومية.

اوضحت النتائج ان اعلي القيم كانت تحت البخر نتح ١٠٠% ثم ٧٥% ما عدا ان قراءات جهاز الكلوروفيل كانت عالية تحت ظروف الاجهاد المائي مقارنة بالقراءات تحت الظروف المثلي. حيث انه يوجد علاقه بين قراءات جهاز قياس الكلورفيل تحت تأثير المستويات المختلفه من البخر نتح وكان معامل التحديد تحت ظروف الري المختلفه وخلال فترة الاجهاد يساوي ٠,٩٩ بتاثير مستوي معنويه عالي .ومن جانب اخر وجد ان المحتوي المائي للماده الخضراء يزداد في ظروف الري المثلي ويقل تحت تأثير الاجهاد المائي حيث تراوحت قيم المحتوي المائي للماده الخضراء لكلا الموسمين تحت مستويات الري المختلفة من٨٠,٥%الي ٥٢,٢٨% كما تراوحت تحت ظروف الاجهاد المائي من ٧٣,٣٤% الي ٧٠,٣١% وكان معامل التحديد تحت ظروف الري المختلفه وخلال فترة الاجهاد يساوي ٠,٩٣ بتاثير مستوي معنويه عالي.

كما اوضحت النتائج ايضا ان متوسط قيم انتاجية المياه تحت مستويات الري المختلفة في كلا الموسمين تساوي ١,٣٣و ٠,٨٢ و٠,٥٩ كجم/م^{٣} وايضا تحت تأثير الاجهاد المائي ٠,٧٦و ٠,٨٣و ٠,٧٦ كجم/م^{٣} علي التوالي. حيث كان الاجهاد المائي و مستوي الري ٥٠% اكثر تأثيرا علي الانتاجية . وفي المتوسط تم توفير ٧,١٧% من الماء خلال فترة الاجهاد المائي ادت الي نقص الانتاجيه بنسبة ١٩%و١٨% و ٤٠% علي التوالي.

لذلك تبين الدراسة بانه يمكن استخدام المحتوي المائي للمجموع الخضري بمحصول فول الصويا في التنبؤ بالحالة المائية للنبات وكذلك الانتاجية.

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