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Peanut (*Arachis hypogaea* l.) Response to Different Levels of Irrigation Stress and Sythsitic Soil Amendements

E. M. Aly, Wafaa M. T. El-Etr and Gehan H. Youssef
Soils, Water and Environ. Res. Inst., Agric. Res. Center (ARC), Giza, Egypt.

A FIELD experiment with three replications was conducted on drip irrigated sandy soil during two successive summer seasons (2013 and 2014) at Agricultural Research Station farm in Ismailia Governorate, Egypt. Peanut was cultivated as an indicator crop to evaluate the effect of irrigation stress and different rates of hydrogel polyvinylalcohol (PVA) as a soil amendment on peanut crop yield and macronutrients total contents along with some plant water relationships. The main plot was three irrigation treatments, *i.e.* 25%, 50% and 75% of the available soil moisture (ASMD) as well as the sub main plots were four rates of poly vinylalcohol (PVA) soil amendment (zero %, 0.05% , 0.1% and 0.2%) were added before the soil tillage. Data indicated that water consumptive use increased as soil moisture depleted decreased. The lowest water consumptive use 692.72 mm and 700.76 mm at the first and second season, respectively were obtained under dry conditions (severe soil moisture stress, irrigated at 75% ASMD). Whereas, the highest values of water use 1293 mm and 1318 mm at the first and second season, respectively were attained under soil moisture level (irrigation when 25% of ASMD is depleted). Also, the lowest and highest averages values of actual evapotranspiration were recorded by adding 0.2 and zero% of PVA, respectively. In addition, it could be used FAO modified Blaney-Criddle method for calculation of seasonal peanut crop ET_c in Ismailia condition, because the results obtained by this method are close to results obtained when irrigation achieved at 50% ASMD. Moreover, peanut yield (straw and seeds) along with total content of macronutrients (N, P and K) increased significantly under the irrigation treatment of 25% ASMD in presence of 0.20% PVA soil amendment comparing with other treatments. Finally, results showed that water use efficiency (WUE) was significant in both seasons. The values of WUE could be increased either by increasing crop yield or decreasing evapotranspiration. The highest values of WUE were gained using irrigation level of 50% ASMD irrigation treatment followed by 25 and 75% ASMD and the differences were significant. The relationship between water use efficiency (WUE) and seeds yield along with concentration of PVA was significantly positive linear correlation in successive two cultivated seasons.

Keywords: Sandy soil, Irrigation, Available soil moisture depleted, Soil amendment, Peanut, Water use efficiency.

Peanut (*Arachis hypogaea* L.) is an important crop that provides food for direct human subsistence and other several food products (Ngo Nkot *et al.*, 2008). Peanut is legume cash crop for the farmers in arid and semi-arid regions and its seeds contain high amounts of edible oil (43 - 55%), protein (25-28%) and minerals (2.5%) (Abou Kheira, 2009). Also, nuts are a good source of oil containing higher amounts of unsaturated fatty acids as compared to saturated fatty acids (Sabate, 2003). Moreover, peanut crop has a good ability for growing in lightly soil and thrives in improving the characteristics of the newly reclaimed sandy soils which commonly suffer from some constraints such as poor physical properties and nutrients deficiency.

Also, soil water is the most crucial factor in arid and semi-arid regions and yield potential is directly a function of water availability for plant growth. So, it is concluded that drought has been the major environmental constraint to peanut survival and to crop productivity in such area (Boyer, 1983). Drought is one of the limiting factors to peanut yield in many countries (*e.g.*, Awal and Ikeda, 2002 and Gohri & Amiri, 2011). Stansell *et al.* (1976) and Nageswara Rao *et al.* (1989) revealed that groundnut is resistant to water stress conditions but drought conditions have adverse effects on the pod yield and seed quality. Moreover, the effect of drought on the chemical composition of the groundnut seeds has been reported to be limited in the mid-season drought but significant in end-season drought (Conkerton *et al.*, 1989 , Musingo *et al.*, 1989 and Dwivedi e*t al.*, 1996).

El-Boraie *et al.* (2009) concluded that groundnut yield is reduced under water stress. Drought stress reduces the stabilization in leguminous plants (Hungria & Vargas, 2000 and Giller, 2001), especially in peanut (Sinclair *et al.*, 1995). Lack of enough water and its irregular scattering during growth stage has caused that water requirement is not provided for agricultural plants and they catch into water stress. In this case, a proper agricultural management could be useful (Abdzad Gohari, 2012).

Recently, Aboelill *et al.* (2012) reported that water stress affected peanut yield attributes (number of pods per plant, weight of pods and seeds per plant, and seed index), where they decreased significantly by decreasing the water regimes from 100% to 60% of the ETc. Songsri *et al.* (2009) showed that drought reduced WUE of peanut. In an arid climate, Abou Kheira (2009) revealed that better management of available soil water in the root zone in the coarse soil of the peanut season, as well as daily and seasonal accurate estimation of ETc can be an effective way for best irrigation scheduling and water allocation, maximizing yield and optimizing economic return. Supplemental irrigation during dry conditions is critical to produce high yielding and top quality peanut, because, soil and weather conditions are not always favorable for optimal growth and developments of plant (Beasley, 2006 and Garcia *et al.*, 2007).

So, scientists focused on methods increasing the efficiency of irrigation rate. Polymers amendments are usually applied in environments with alternating dry and wet conditions. Singer *et al.* (1992) reported that amendment polyvinyl affected soil physical properties under dry and wet cycles as condition compared with control treatments. Maintaining soil physical condition in an adequate state contributes toward soil and water conservation. Also, it is pointed out that, the polymers were developed to improve the physical of soil by way of increasing their water-holding capacity, soil permeability, infiltration rates, soil aggregate stability and compaction tendency (Sojka, *et al.,* 2007 and Wu *et al.*, 2010). Water and fertilizer use efficiencies, erosion, water run-off and reducing irrigation frequency were also developed. However, Nazarli and Sardashti (2010) reported that superabsorbent synthetic polymers work by absorbing and storing water and nutrients in a gel form, hydrating and dehydrating as the demand for moisture fluctuates. Superabsorbent polymers are able to absorb and store water hundreds times of their dry weight (Abedi-Koupai and Kazemi, 2006). The super absorbent polymers hydrogels can be designed to work as a controlled release system by favoring the uptake of some nutrient elements, holding them tightly and delaying their dissolution. Thus, the plant can still access some of the fertilizers, resulting in improved growth and performance rates (Liu *et al.*, 2007). Karimi *et al.* (2008) observed that using super absorbent caused an increase in nutrient including N, P and K.

Although numerous studies have been conducted on groundnut tolerance to drought and effect of nutrient, there is a few researches on polyvinyl alcohol and its effect on yield and yield components of groundnut as well as their interactions. For this reason, the aim of this study was to evaluate the effects of irrigation treatments using available soil moisture depleted (ASMD) method with different rates of synthetic soil amendments (*i.e.* polyvinyl alcohol; PVA) application on peanut yield and macronutrients total content grown in sandy soil under drip irrigation system.

Materials and Methods

The present investigation was carried out at the farm of Agricultural Research Station, in Ismailia Governorate, Egypt, during two successive summer seasons 2013 and 2014 cultivated with peanut (*Arachis hypogaea* L, cv. Giza 6). The institute farm is located at 30^{o} 35' 41.9" N latitude and 32^{o} 16' 45.8" E longitude. The main objective of this study was to determine the effect of irrigation treatments and different rates of soil amendment polyvinyl alcohol (PVA) for peanut yield and macronutrients total contents as well as some plant water relationships. The chemical analysis of the investigated soil were determined according to Page *et al.* (1982), respectively and the results presented in Tables 1 and 2.

The meteorological data

Air temperature (^oC) relative humidity (%), actual and possible sunshine (hour), solar and extra terrestrial radiation (MJ m^{-2} day^{-1}) and wind speed (m/sec) at Ismailia Station had been daily recorded and their monthly mean values were calculated during the last ten years period (Table 3).

TABLE 1. Particle size distribution and chemical characters of the studied soil

Soil depth (cm)	Soil characters															
	Particle size distribution (%)					Chemical analysis										
								Anions (meq L^{-1})				Cations (meq L^{-1})				
	Coarse Sand	Fine sand	Silt	Clay	Texture	SP	EC (dS m^{-1})	CO^{-2}	HCO^-	Cl^-	$SO4^{-2}$	Ca^{+2}	Mg^{+2}	Na^+	K^+
0-15	68.00	25.75	3.82	2.43	sandy	22.7	3.71	-	11.8	21.5	1.50	11.07	5.88	14.5	3.35
15-30	72.32	23.07	3.11	1.50	sandy	20.0	0.44	-	1.94	1.79	0.56	1.23	0.49	2.25	0.32
30-45	75.20	20.97	3.00	0.83	sandy	20.7	0.22	-	1.47	0.89	0.52	0.62	0.25	1.57	0.44
45-60	87.44	8.46	3.65	0.45	sandy	22.7	0.25	-	1.47	0.89	0.54	0.62	0.49	1.38	0.41

TABLE 2. Soil bulk densities and moisture constants of the studied soil treated with different rates of polyvinylalcohol (PVA)

(PVA) rates	Soil depth (cm)	Bulk density (g cm^{-3})	Retained moisture at field capacity (v /v)		Retained moisture at permanent wilting point(v/v)		Available moisture mm/soil depth
			%	mm/15 cm	%	mm/15cm	
0.0%	0-15	1.58	12.17	18.25	2.13	3.20	15.05
	15-30	1.62	11.01	16.52	2.01	3.02	13.51
	30-45	1.64	10.17	15.25	2.53	3.80	11.46
	45-60	1.66	7.97	11.95	2.66	3.99	8.03
							48.05
0.05%	0-15	1.55	12.77	19.16	2.13	3.20	16.55
	15-30	1.62	11.60	17.86	2.01	3.02	12.85
	30-45	1.64	10.17	15.25	2.53	3.80	11.95
	45-60	1.66	7.97	11.95	2.66	3.99	8.03
							49.38
0.1%	0-15	1.53	13.59	20.38	2.13	3.20	17.18
	15-30	1.62	11.16	16.74	2.01	3.02	12.85
	30-45	1.64	10.17	15.25	2.53	3.80	11.95
	45-60	1.66	7.97	11.95	2.66	3.99	8.03
							50.01
0.2%	0-15	1.50	14.63	21.94	2.13	3.20	19.41
	15-30	1.62	11.13	16.69	2.01	3.02	14.63
	30-45	1.64	10.17	15.25	2.53	3.80	11.95
	45-60	1.66	7.97	11.95	2.66	3.99	8.03

		54.02

TABLE 3. The meteorological data of Ismailia station during the last ten years period

Month	Parameters										
	$T_{max.}$ °C	$T_{min.}$ °C	T_{mean} °C	$RH_{max.}$ %	RH_{min} %	RH_{mean} %	W.S m/sec	ASD hour	PSD hour	STR MJm^{-2} day^{-1}	ETR MJm^{-2} day^{-1}
January	19.2	8.1	13.65	87.2	21.5	54.35	1.7	6.89	10.4	11.7	20.9
February	20.6	8.3	14.45	86.1	18.6	52.35	1.9	7.59	11.1	14.9	25.6
march	23.8	10.7	17.3	86.3	22.5	54.40	2.0	8.46	12.0	18.5	31.3
April	28.6	13.9	21.3	88.6	19.6	54.10	2.1	9.38	12.9	22.0	36.8
may	32.8	18.0	25.4	88.2	21.0	54.60	2.0	10.3	13.6	24.7	40.0
June	34.5	21.5	28.0	87.1	23.6	55.40	1.6	12.9	14.0	27.7	41.2
July	36.4	23.1	29.8	91.4	27.7	59.60	1.6	12.7	13.9	27.1	40.6
August	35.9	23.8	29.9	90.4	26.1	58.30	1.6	11.5	13.2	25.3	38.0
September	33.1	21.7	27.4	87.7	30.0	58.70	1.8	10.6	12.4	22.0	33.3
October	29.7	19.9	24.8	88.1	21.7	54.90	1.4	9.27	11.5	17.5	27.4
November	26.3	16.0	21.2	88.3	22.5	55.40	1.4	7.88	10.6	13.3	22.0
December	20.6	10.5	15.6	86.6	21.7	54.20	1.7	6.82	10.	11.0	19.6

T: temperature, RH: relative humidity, WS: wind speed, ASD: actual sun shine duration, PSD: potential sun shine duration, STR: solar terrestrial radiation, ETR: extra terrestrial radiation.

Irrigation system

The experiment was irrigated by a surface drip irrigation system. The tubes were spaced 0.6 m apart. The drip line tubing has 0.3 m spacing distances between emitters and a flow rate of 4 L h^{-1} m^{-1} at design operating pressure of 206 kPa.

Experimental layout

Peanut crop was sown in two successive summer seasons. The corresponding date for peanut crop was 5/6/2013 and 3/5/2014 for the first and second season, respectively. All cultural practices were the same as recommended for the crop except that different irrigation treatments were used and also different rates of soil amendment polyvinyl alcohol (PVA) were added. The experiment was arranged in split plot design with three replicates. The main plot was assigned as irrigation treatments while the sub plot treatments were polyvinyl alcohol rates for the two seasons. The main plots consisted of three irrigation treatments: irrigation practiced when (25%, 50% and 75%) of the available soil moisture is depleted (ASMD). The subplots consisted of four rates of polyvinyl alcohol (PVA) soil amendment: (zero, 0.05, 0.1 and 0.2% by weight) were added before soil tillage.

Irrigation water requirement

The irrigation water supply requirement at the field level was determined by the depth and the interval of irrigation. These data can be obtained from the soil water balance and are primarily determined by:

i- The total available soil water (Sa):

$$(S_a=S_{f.c}-S_{w.p}) \qquad (1)$$

ii- The depth of irrigation application (d) including application losses:

$$d = \frac{(p.S_a)D}{E_a} \qquad (2)$$

iii-The frequency of irrigation expressed as irrigation interval, days for an individual field (i) is:

$$i=\frac{(p.S_a)D}{ET_{crop}} \qquad (3)$$

where:

S_a = total available soil water mm/m soil depth

$S_{f.c}$ & $S_{w.p}$ are the soil water contents (v/v) divided by 100, for specific soil depth (m) at field capacity and wilting point (mm/m).

P = fraction of available soil water permitting unrestricted evapotranspiration.

D = rooting depth, m.

E = application efficiency, fraction.

Studied characters

Water relations

*The consumptive use (Cu) or actual evapotranspiration (ET_a):*The consumptive use (Cu) of water estimated according to the equation given by Israelson and Hansen (1962) as follows:

$$Cu = \frac{D\ Ad\ (e_2 - e_1)}{100} \qquad (4)$$

where:

Cu = the depth of irrigation application [mm],

D = depth of irrigation [mm]

Ad = soil bulk density [g/cm^3]

e_1 = soil moisture content before irrigation, [w/w]

e_2 = soil moisture content after irrigation, [w/w]

Potential evapotranspiration (ET_o)

Potential evapotranspiration (ET_o) was determined by three methods:

*Pan evaporation method :*The pan evaporation is related to the reference evapotranspiration described by Doorenbos and Pruitt (1977) as follows:

$$ET_o = K_p \text{ x } E_{pan} \quad (5)$$

where: ET_o reference evapotranspiration [mm/day]
K_p Pan Coefficient [-]
E_p Pan evaporation [mm/day]

Penman-Monteith method (mm/day): The Penman Monteith daily (PM_d) equation is as follows:

$$ET_o = \frac{0.408\Delta (R_n - G) + \gamma \frac{900}{T+273} U_2 (e_s - e_a)}{\Delta + \gamma (1+0.34u_2)} \quad (6)$$

where ET_o reference evapotranspiration [mm day^{-1}],
R_n net radiation at the crop surface [MJm^{-2} day^{-1}]
G soil heat flux density [M J m^{-2} day^{-1}]
T mean daily air temperature at 2 m height [ºC]
U_2 wind spaced at 2 m height [ms^{-1}]
e_s saturation vapour pressure [KP_a]
ea actual vapour pressure [KP_a]
e_s -e_a saturation vapour pressure deficit[KP_a]
Δ slope vapour pressure curve [K P_a $^{o-1}$C]
γ prychrometric constant [K P_a $^{o-1}$C]

Hargreaves and Samani (1985) reference evapotranspiration equation:

$$ET_o = 0.0023 (T_{mean} + 17.8) (T_{max} - T_{min})^{0.5} Ra \quad (7)$$

Crop coefficient (K_c)

The recommended values of K_c, according to Doorenbos and Kassam (1979) were used to estimate the ET_o for the conditions of the area where the experiment was done. The formula is as follows:

$$ET_c = K_c \times ET_o \quad (8)$$

where: K_c: crop coefficient.
ET_c: The measured (estimate) evapotranspition of a considered period (mm/day).
ET_o: reference evapotranspiration (mm/day) referring to the same period, calculated as average value of four formulae.

Water use efficiency

Water use efficiency (WUE) in kg/m^3 was calculated for the deferent treatments, using the following form formulae of Vites (1965):

$$W.U.E = \frac{\text{Seed yield in kg / fed}}{\text{Actual evapotranspiration in } m^3\text{/fed}} \quad (9)$$

A normal agricultural practice for growing peanut crop was generally achieved. Soil amendment PVA was applied before peanut cultivation and sprayed on soil surface during soil preparation by thoroughly mixing with soil surface layer (0-30 cm).

All treatments received mineral fertilizers at the recommended dose from super phosphate (15% P_2O_5) at a rate of 20 kg fed^{-1} basically before sowing as well as potassium was added in the form of potassium sulfate (48% K_2O) at a rate of 50 kg fed^{-1}. Nitrogen was added in the form of ammonium nitrate (33.5% N) at the rates of 100 kg N fed^{-1}. Ammonium nitrate was added in two split equal doses after 2, 4 weeks from sowing. While potassium was divided into two equal doses, the first was added at sowing and the second after 35 days from sowing. Plants were irrigated using drip irrigation system.

Yield and its chemical composition

Dates of harvesting for peanut were 6/10/2013 and 3/10/2014 for the first and second season, respectively. Straw and seeds for peanut crop collected from each plot, oven dried at 70°C for 48 hr and the weighed up to a constant dry weight, ground and prepared for digestion according to Page *et al.* (1982). The digested samples were then subjected to determination of macronutrients (N, P, and K) total contents using procedures described by Cottenie *et al.* (1982).

Statistical analysis

All the data collected for the yield and its components and chemical composition were subjected to the statistical analysis according to Snedecor and Cochran (1967) and the mean values were compared by LSD.

Results and Discussion

Water relations of peanut crop

A summary of water consumptive use by peanut as function of ASMD and different rates of PVA (zero, 0.05, 0.10 and 0.20 %) during the period of study in two successive summer seasons 2013 and 2014 is presented in Table 4. Results clearly show that water consumptive use increased as soil moisture depleted decreased. The lower water consumptive use, 692.72 mm and 700.76 mm at the first and second season, respectively, were brought under dry conditions (severe soil moisture stress, irrigated at 75% depletion from available soil moisture). Whereas, the highest values of water use, 1293 mm and 1318 mm at the first and second season, respectively, were attained under soil moisture level (irrigation when 25% of ASMD) while under water supply (50%), the values fall in between. This trend was found to be the same in both seasons. Such results reveal that the increase in water consumptive use depends on the available soil moisture in root zone. These results are due to the availability of soil moisture to plants in addition to high evaporation opportunity from wet soil rather than a dry soil surface **(**Tayel, *et al.,* 2007**)**. With regards to the effect of added different rates of polyvinyl alcohol (PVA) amendment on seasonal water use by peanut, data showed that averages values of actual evapotranspiration in first season were 883.71, 922.53, 944.91 and 967.1 mm for 0.2, 0.1, 0.05 and zero% rates of PVA, respectively. While in second season, results indicated that values were 888.67, 935.74, 968.11 and 999.93 mm for the same respective PVA treatments. The lowest and highest values were recorded by adding 0.2 and zero% PVA, respectively.

TABLE 4. Peanut daily, monthly and total actual evapotranspiration ($ET_{a,mm}$) as affected by different irrigation treatments and PVA rates

Months		June		July		August		September		October		Total	
Irrigation Treat.	PVA rates	Daily mm	monthly mm	Daily mm	monthly mm	Daily mm	monthly mm	Daily mm	monthly mm	Daily mm	monthly mm	mm	m^3 $fed^{-1.}$
Season 2013													
25% ASMD	Zero%	4.48	116.56	11.03	341.97	19.23	596.16	9.80	294.04	4.38	21.90	1370.6	5756.7
	0.05%	4.48	116.38	10.78	329.42	18.88	585.2	9.44	283.11	4.14	20.71	1334.82	5606.2
	0.1%	4.45	115.80	10.62	318.69	17.99	557.6	9.00	269.9	3.80	18.98	1281.0	5380.2
	0.2%	4.45	115.57	8.24	255.39	17.76	538.1	8.63	259.0	3.56	17.78	1185.7	4980.1
Mean		**4.47**	**116.08**	**10.17**	**311.37**	**18.47**	**569.3**	**9.22**	**277**	**3.97**	**19.8**	**1293**	**5431**
50% ASMD	Zero%	4.46	116.06	7.29	225.9	9.19	285.0	5.76	172.8	4.90	24.50	824.27	3461.9
	0.05%	4.46	115.9	7.22	224.0	9.08	281.4	5.05	169.5	4.66	23.3	814.04	3419.0
	0.1%	4.45	115.62	7.09	219.79	8.92	276.6	5.48	164.50	4.28	21.41	797.92	3351.3
	0.2%	4.44	115.44	7.02	217.77	8.83	273.9	5.39	161.61	4.26	21.30	789.97	3317.9
Mean		**4.45**	**115.76**	**7.16**	**221.87**	**9.01**	**279.2**	**5.42**	**167**	**4.53**	**22.6**	**807**	**3388**
75% ASMD	Zero%	4.46	115.98	5.58	173.0	7.72	239.4	5.05	156.60	4.58	22.90	707.86	2973.0
	0.05%	4.46	115.88	5.51	170.67	7.57	234.70	5.17	154.99	4.56	22.80	699.0	2936.0
	0.1%	4.45	115.82	5.42	168.16	7.49	232.30	5.01	150.20	4.44	22.20	688.68	2892.5
	0.2%	4.45	115.80	5.35	165.98	7.24	224.30	4.91	147.3	4.38	21.90	675.28	2836.2
Mean		**4.46**	**115.87**	**5.47**	**169.45**	**7.51**	**232.7**	**5.04**	**152**	**4.49**	**22.5**	**692.72**	**2909**
Overall Mean for PVA	Zero%	4.47	**116.23**	**7.97**	**246.96**	**12.04**	**373.52**	**6.93**	**207.81**	**4.62**	**23.10**	**967.10**	4062
	0.05%	4.46	**116.05**	**7.79**	**241.36**	**11.84**	**367.1**	**6.60**	**198.13**	**4.45**	**22.27**	**944.91**	3969
	0.1%	4.45	**115.75**	**7.60**	**235.55**	**11.47**	**355.5**	**6.50**	**194.87**	**4.17**	**20.86**	**922.53**	3875
	0.2%	4.45	**115.60**	**6.87**	**213.05**	**11.14**	**345.43**	**6.31**	**189.30**	**4.07**	**20.33**	**883.71**	3712
Season 2014													
25% ASMD	Zero%	4.61	138.40	11.61	360.0	19.68	610.1	9.69	290.7	4.20	8.20	1407.4	5911.1
	0.05%	4.34	130.20	11.16	345.9	19.38	600.8	9.33	280.0	3.75	7.5	1364.4	5730.5
	0.1%	4.20	126.0	10.06	330.6	18.44	571.5	8.77	263.2	3.55	7.10	1298.4	5453.3
	0.2%	4.17	125.2	8.65	263.20	17.79	551.5	8.35	250.50	3.40	6.80	1202.2	5049.2
Mean		**4.3**	**130.0**	**10.4**	**324.9**	**18.8**	**583.5**	**9.0**	**271**	**3.73**	**7.40**	**1318**	**5536**
50% ASMD	Zero%	4.51	135.4	7.97	247.20	9.68	300.1	5.68	170.50	4.65	9.30	862.50	3622.5
	0.05%	4.29	128.60	7.75	240.1	9.30	288.4	5.51	165.3	4.50	9.0	831.4	3491.9
	0.1%	4.17	125.10	7.61	235.8	9.18	284.5	5.35	160.4	4.10	8.20	814.0	3418.8
	0.2%	4.12	123.70	7.44	230.7	9.06	281.0	5.19	155.60	4.00	8.00	799.0	3355.8
Mean		**4.3**	**128.2**	**7.7**	**238.5**	**9.3**	**288.5**	**5.4**	**163**	**4.31**	**8.63**	**827**	**3472**
75% ASMD	Zero%	4.15	124.5	5.8.6	181.6	8.40	260.4	5.16	154.70	4.35	8.70	729.90	3065.6
	0.05%	4.13	124.0	5.81	180.2	7.92	245.60	5.00	150.1	4.30	8.60	708.50	2975.7
	0.1%	4.11	123.3	5.70	176.60	7.75	240.1	4.88	146.4	4.20	8.40	694.8	2918.2
	0.2%	3.99	119.8	5.49	170.3	7.42	229.9	4.72	141.60	4.10	8.20	669.8	2813.2
Mean		4.1	**122.9**	**5.7**	**177.2**	**7.9**	**244.0**	**4.9**	**148**	**4.20**	**8.40**	**700.76**	2943
Overall Mean for PVA	Zero%	4.43	**132.77**	**8.48**	**262.93**	**12.59**	**390.2**	**6.84**	**205.3**	**4.37**	**8.73**	**999.93**	4200
	0.05%	4.25	**127.60**	**8.24**	**255.40**	**12.20**	**378.27**	**6.62**	**198.47**	**4.19**	**8.37**	**968.11**	4066
	0.1%	4.16	**124.80**	**7.99**	**247.67**	**8.56**	**365.37**	**6.33**	**190.00**	**3.95**	**7.90**	**935.74**	3930
	0.2%	4.10	**122.9**	**7.14**	**221.40**	**11.42**	**354.13**	**6.09**	**182.57**	**3.84**	**7.67**	**888.67**	3732

*sowing dates at first and at second season were 5/6/2013 and 1/6/2014

**harvest dates at first and at second season were 6/10/2013 and 3/10/2014.

These results may be attributed to the enhanced high water status throughout the growing season which is necessary to maintain unimpaired crop growth and high economic yield. The imposition of some stress by longer irrigation interval, higher moisture depletion or skipping irrigation during the early vegetative growth stage and/or the maturation one could still attain similar economic yields as well as saving irrigation water. Obtained data is in agreement with Ziaeidoustan *et al.* (2013). The polymer acted by improving water content and therefore reducing bulk density of the treated soil after wetting and drying cycles (Al Rasslany, 2014).

Estimate of peanut seasonal evapotranspiration (ET_c)

Calculations of peanut crop evapotranspiration values (ET_c) involved the use of potential evapotranspiration values (ET_o) and crop coefficient values (k_c) are presented in Table 5. The (ET_o) values were calculated by five methods; namely pan evaporation method presented by Doorenbos and Pruitt (1977), modified Penman method presented by Doorenbos and Kassam (1979), Hargreaves and Samani (1985) reference evapotranspiration equation, modified Penman-Montieth method presented by Allen *et al.* (1998) and FAO modified of Blaney-Criddle method has received considerable interest; it is a temperature-based method according to Cuenca and Amegee (1987). The duration of peanut crop growth stages is 24, 40, 40 and 18 days for the initial, development, mid season and late-season, respectively. An average crop coefficient values (K_c) calculated by Doorenbos and Kassam (1979).

TABLE 5. Estimate of peanut seasonal evapotranspiration (ET_c)

Season 2013												
months / **equation**	**June**		**July**		**August**		**September**		**October**		**Total**	
	Daily	**monthly**	**Daily**	**monthly**	**Daily**	**monthly**	**Daily**	**monthly**	**Daily**	**monthly**		
	mm	**mm**	**mm**	**mm**	**mm**	**mm**	**mm**	**mm**	**mm**	**mm**	**mm**	**m^3 Fed^{-1}**
E_{pan}	2.64	66.07	4.52	140.0	5.36	166.22	4.33	129.91	3.29	16.45	518.65	2178
P-M	3.04	76.0	5.03	155.78	6.05	187.52	5.00	150.01	3.01	15.05	584.36	2454
H.equ.	2.95	73.82	5.13	153.92	5.64	174.80	4.32	129.63	2.57	12.85	545.02	2289
Mod. Pen	3.42	85.47	6.53	202.28	7.75	240.15	5.67	170.12	4.47	22.35	720.37	3026
B&C	4.21	105.22	6.72	208.32	8.13	251.98	6.30	188.88	4.44	22.20	776.6	3262
Season 2014												
E_{pan}	2.77	83.23	4.52	140.0	5.56	172.41	4.16	124.65	4.11	8.21	528.50	2220
P-M	3.19	95.74	5.03	156.0	6.27	194.49	4.80	143.93	3.01	6.02	596.18	2504
H.equ.	3.10	92.99	5.13	153.92	5.85	181.30	4.15	124.38	2.57	5.14	557.73	2342
Mod. Pen.	3.59	107.67	6.53	202.28	8.03	249.08	5.44	163.24	4.47	8.94	731.21	3071
B&C	4.42	132.55	6.72	208.32	8.43	261.35	6.04	181.23	4.44	8.88	792.33	3328

*sowing dates at first and at second season were 5/6/2013 and 1/6/2014

**harvest dates at first and at second season were 6/10/2013 and 3/10/2014

These values are 0.45, 0.75, 1.025 and 0.75 for the previous stages. The calculated peanut crop evapotranspiration (ET_c) values using Pan evaporation method, Hargreaves equation and modified Penman- Montieth method were less than actual peanut crop evapotranspiration (ET_a). On the other hand, when modified Penman method and FAO modified of Blaney-Criddle method were used, values were close to actual peanut crop evapotranspiration (ET_a). We recommend the use of FAO modified Blaney-Criddle method for calculation of seasonal peanut crop ET_c in Ismailia condition, because the results obtained by this method are close to results obtained when applying irrigation using 50% ASMD.

Peanut yield as affect by ASMD and different rates of PVA

The effect of ASMD and PVA on the peanut crop productivity expressed as straw, pods and seed yield fed.$^{-1}$ are presented in Table 6. Results indicate that the two factors significantly affected the productivity of peanut yield in both season under study. The highest peanut production was recorded at 25% of ASMD followed by 50% of ASMD, with significant differences between them. The lowest peanut production was gained from plots irrigated when 75% of ASMD is depleted due to severe water deficit. El-Boraie *et al.* (2009) concluded that groundnut yield was reduced under water stress. Significant effect was observed between severe water deficit treatment and the wet and medium water deficit. Such findings were found to be clear in both seasons under study. This trend can be attributed to the effect of water deficit on peanut growth, which was reflected on the final yield. It is mentioned that drought is one of the limiting factors to peanut yield in many countries (Awal & Ikeda, 2002 and Gohri & Amiri, 2011). Also, groundnut was resistant to water stress conditions but drought conditions have adverse effects on the pod yield and seed quality **(**Stansell *et al.,* 1976 and Nageswara Rao *et al.,* 1989).

Concerning the effect of PVA on straw, pods and seed yield of peanut, results in Table 6 indicated that PVA rates had a significant influence on straw, pods and seed yield of peanut. Increasing PVA rates were resulted in a significant increase on straw, pods and seed yield of peanut, this trend being observed in two seasons studied. The high rate of PVA (0.2%) had significantly increased the yield as compared to other PVA rates in both seasons. These results could be attributed to importance of PVA as soil amendment especially in sandy soils, which is lower in water retention. These results are in full agreement with those reported by Abedi-Koupai and Kazemi (2006) who found that super absorbent polymers are able to absorb and store water hundreds times of their dry weight. Nazarli and Sardashti (2010) mentioned that superabsorbent synthetic polymers work by absorbing and storing water and nutrients in a gel form, hydrating and dehydrating as the demand for moisture fluctuates. Ziaeidoustan *et al.* (2013) found that superabsorbent efficiently compensates water deficiency by holding the water and retraining at the time of plant sever needs. The interaction effects between water deficit and PVA amendment on straw, pods and seed yield of peanut were significant. Maximum values of straw, pods and seed peanut yield were gained from treatment irrigated frequently at 25% ASMD and received rate of 0.2% PVA.

TABLE 6. Effect of various soil moisture stress and polyvinylalcohol amendment rates on peanut straw and seed yields

Irrigation treatments	PVA rates	Season 2013				Season 2014			
		Straw Ton fed^{-1}	Pods ardb fed^{-1}	Seed ardb fed^{-1}	Seed Kg fed^{-1}	Straw ton fed^{-1}	Pods ardb fed^{-1}	Seed ardb fed^{-1}	Seed Kg fed^{-1}
25% ASMD	Zero%	1.70c	16.4c	21.9d	876d	1.70c	18.1d	25.2d	1008d
	0.05%	1.80c	16.8c	22.6c	905c	1.80c	19.6c	26.5c	1061c
	0.10%	1.90b	18.4b	24.9b	996b	2.20b	20.4b	27.8b	1111b
	0.20%	2.10a	20.5a	27.9a	1115a	2.50a	23.7a	30.1a	1203a
Mean for irrigation		**1.86**	**18.0**	**24.3**	**973**	**2.05**	**20.4**	**27.3**	**1096**
50 % ASMD	Zero%	1.30d	13.1f	18.5g	739g	1.22e	12.8h	18.0h	720h
	0.05%	1.38d	14.07e	19.8f	791f	1.27e	13.6g	19.5g	779g
	0.10%	1.42d	15.57d	20.9e	837e	1.43d	15.6f	21.7f	867f
	0.20%	1.73c	16.60c	22.5c	900c	1.50d	17.2e	23.9e	956e
Mean for irrigation		**1.46**	**14.8**	**20.4**	**817**	**1.36**	**14.8**	**20.8**	**830**
75% ASMD	Zero%	0.70f	7.03i	8.5i	340i	0.69h	7.13k	8.43k	337k
	0.05%	0.71f	7.33h	8.97i	359i	0.78hg	7.90jk	9.07jk	363jk
	0.10%	0.77f	8.13g	9.53h	381h	0.87fg	8.27ig	9.83ij	393jk
	0.20%	0.92e	9.07h	9.97h	399h	0.97f	9.03i	10.63i	425i
Mean for irrigation		**0.77**	**7.89**	**9.24**	**370**	**0.83**	**8.08**	**9.49**	**380**
Mean for soil amendment rates									
Zero%		1.22d	12.2d	16.3d	652d	1.19d	12.7d	17.2d	688d
0.05%		1.29c	12.7c	17.1c	685c	1.29c	13.7c	18.4c	734c
0.10%		1.36b	14.0b	18.5b	738b	1.50b	14.8b	19.8b	790b
0.20%		1.57a	15.4a	20.1a	804a	1.66a	16.6a	21.5a	861a

Peanut water use efficiency (WUE)

Effects of irrigation treatments and polyvinyl alcohol amendment rates on water use efficiency (WUE) by peanut in successive two cultivated summer seasons 2013 and 2014 are presented in Fig. 1. Results showed that the WUE was significantly influenced by different irrigation treatments in both seasons. The values of WUE could be increased by increasing either crop yield or decreasing evapotranspiration. The highest values of WUE were gained when irrigated at 50% ASMD irrigation treatment, corresponding values being 0.329 and 0.321 in the first and second seasons, respectively. On the other hand, the lowest values of WUE were produced from the dry treatment which is 75% ASMD irrigation treatment, corresponding values being 0.204 and 0.206 in the first and second seasons, respectively. The significantly positive effects of all irrigation treatments followed the order 50 > 25> 75 % ASMD. The highest values of WUE revealed a relative decrease in seasonal ET by increasing irrigation intervals (decreasing available soil moisture, *i.e.* from 25 to 75% ASMD), the obtained result was similar to decrease in peanut yield. Data indicated that moderate soil moisture stress is preferable for consuming water more efficiently. It is well know that plant roots extract water from greater depths than plants kept irrigated to optimum levels, thus water is used more efficiently. Similar results were found by Sexton *et al.* (1997).

With respect to the effect of PVA on water use efficiency by peanut crop, data showed that the application of different PVA rates gave significant positive influences on WUE in both seasons. Results clearly indicated that WUE values were increased from 0.225 to 0.308 and from 0.223 to 0.326 for first and second season, respectively. In other words, the productivity of peanut per unit volume of water could be improved by increasing the rate of PVA application increased in such lower retention water in sandy soils. Similar results were reported by Karimi *et al.* (2008) who observed that superabsorbent, in the limitation of available water, stored the water and helped the plant to resist against severe drought.

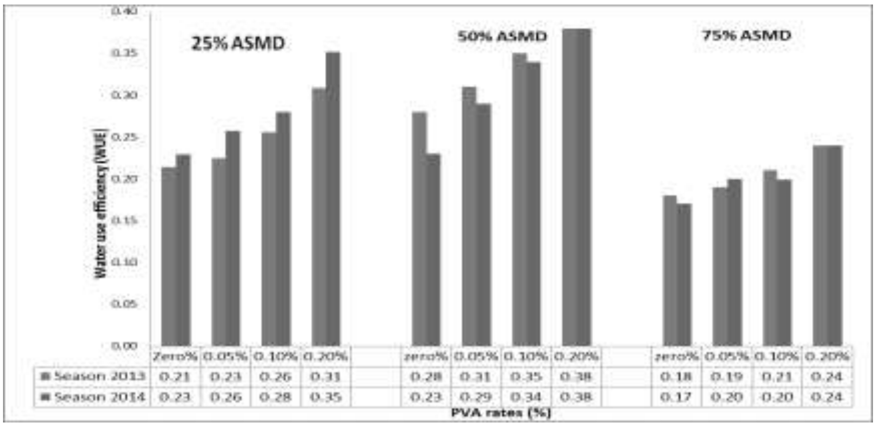

Fig. 1. Water use efficiency (WUE) as affected by different irrigation treatments (ASMD) and polyvinylalcohol soil amendment application of peanut crop

Data revealed that the highest significant WUE at two seasons was recorded for the high rate of PVA application with irrigation frequently at 25 % ASMD, these results are similar to those obtained for yield components. Obtained data agreed with that obtained by Ziaeidoustan *et al.* (2013) who mentioned that superabsorbent efficiently compensates water deficiency by holding the water and retraining at the time of plant sever needs. To complete the picture, the relationship between water use efficiency (WUE) and seeds yield are shown in Fig. 2. In this study, positive significant linear correlations were (R^2 = 0.996), (R^2 = 0.984) and (R^2 = 0.952) for 25, 50 and 75 % ASMD irrigation treatments, respectively at first season); against second season were (R^2 = 0.984), (R^2 = 0.960) and (R^2 = 0.973). This finding is in agreement with Khonok *et al.* (2015).

Also, study of the relationship between concentration of PVA and WUE in two successive cultivated summer seasons 2013 and 2014 is presented in Fig. 3. Data explained that increasing the application PVA polymer rates increased the WUE at two seasons as compared to control, and linearly value was (R^2 = 0.97) for both seasons. These may be due to increase of available water and field capacity in soil, reflected on water use efficiency; these results are similar to those obtained by Al Rasslany (2014).

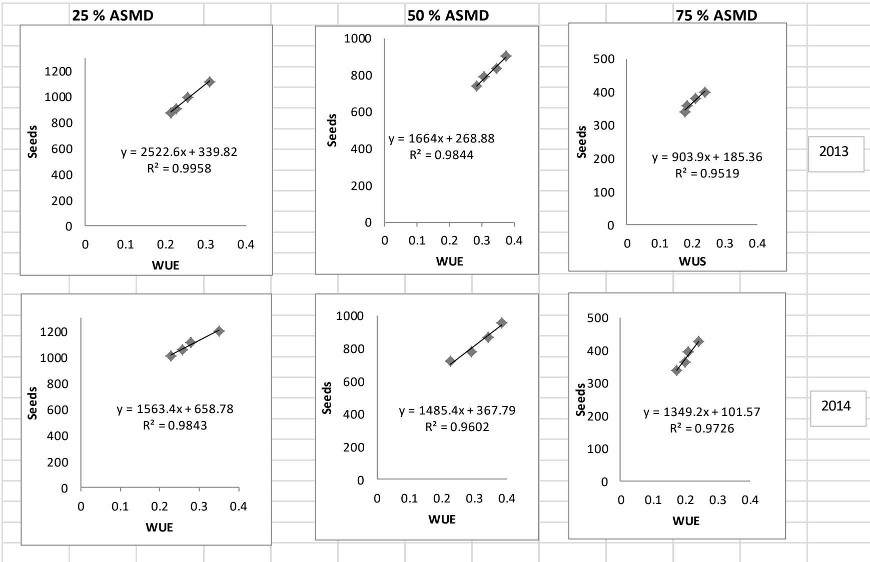

Fig.2. Relationships between water use efficiency (WUE) and seeds yield as affected with different treatments at successive two cultivated summer seasons.

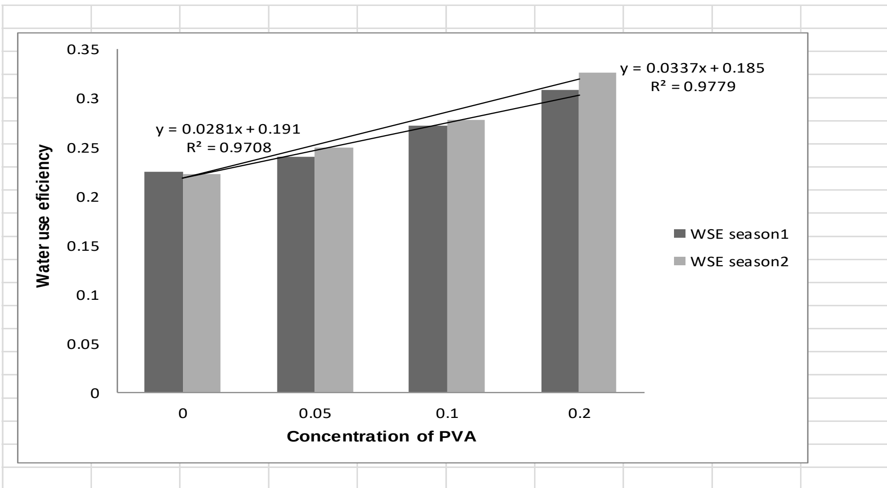

Fig. 3. Relationships between concentration of PVA and water use efficiency (WUE) at two successive summer seasons.

Total macronutrients content of peanut crop

Data in Table 7 revealed macronutrients total contents of peanut crop during two successive summer seasons. The results showed that low available soil moisture depletion 25% (ASMD) gave the maximum seeds and straw macronutrients total contents (N, P, and K) followed by the other irrigation treatments. The irrigation treatments 75% (ASMD) recorded the lowest values for N, P and K in seeds and straw for both season. Similar results were obtained by Kulkarni *et al.* (1988) who showed that N, P and K uptake of groundnut is reduced by moisture stress. Drought stress also delays nodule formation in plant (Reddy and Reddy, 1995). So seemingly the reduction of available water severed the signs of N deficits as nitrogen fixation reduced in drought condition.

It is suggested that stress fertilizer uptake by plants is reduced by water stress (Kulkarni *et al.,* 1988). Also, Pimratch *et al.* (2008) showed that under drought stress conditions, the number of nodes and the nodes of nitrogen activity and drastically reduce weight. It is explained that adsorption of adequate amounts of nitrogen by a plant leads to more protein content and larger cereal and legume seeds (Khonok *et al.*, 2015). Generally, nitrogen is the main element in the chlorophyll synthesis and its fixation could lead to more growth of aerial parts.

Regarding the application of different rates of PVA soil amendment, results obtained generally showed that applied 0.2 % PVA compared to other treatments, was significantly higher for N, P and K total content, for straw and seeds of peanut crop. Furthermore, values of nutrients total content were more stimulated with application of the second and third rates as compared to control (without PVA) application. In this perspective, Nazarli and Sardashti (2010) showed that superabsorbent synthetic polymers work by absorbing and storing water and nutrients in a gel form, hydrating and dehydrating as the demand for moisture fluctuates. Abedi-Koupai and Kazemi (2006) added that super absorbent polymers (SAP) are able to absorb and store water hundreds times of their dry weight. Also, SAP designed to work as a controlled release system by favoring the uptake of some nutrient elements, holding them tightly and delaying their dissolution, thus the plant can still access some of the fertilizers, resulting in improved growth and performance rates (Liu *et al.*, 2007).

Moreover, the interaction analyses in Table 7 showed that all applied treatments increased the total content of macronutrients over the control treatment; this trend was true for both straw and seeds of peanut crop during two successive summer seasons. The high-frequency of irrigation 25% ASMD and applied 0.20% gave the maximum seeds and straw N, P and K total contents for peanut crop followed by the other treatments. The lowest values of total content N, P and K were recorded fewer than 75% ASMD irrigation treatment without applied PVA. Obtained data are in agreement with Ziaeidoustan *et al.* (2013) who mentioned that superabsorbent caused an increase in nutrient (NPK) uptake. It seems that superabsorbent in the limitation of available water, stored the water and helped the plant to resist against severe drought. On the other hand, it helped the N fixation bacteria to gain their needed moisture and nodulation which helped to uptake the soil nitrogen and increased the yield.

TABLE 7. Total contents of peanut macronutrients as effected by irrigation treatments and rates of polyvinylalcohol (PVA) during two successive seasons

Irrigation treat.	PVA rates .	Season 2012-2013						Season 2013-2014					
		Straw total content Kg fed-1			Seed total content Kg fed-1			Straw total content Kg fed-1			Seed total content Kg fed-1		
		N	P	K	N	P	K	N	P	K	N	P	K
25% ASMD	Zero%	22.2d	4.03ad	11.2ce	25.2cd	3.22be	2.36bc	22.0cd	4.03be	11.1bd	28.9cd	3.68ad	2.72cd
	0.05%	24.4cd	4.69abc	13.2bd	26.5cd	3.99ac	3.68a	24.8c	4.78bc	13.4b	31.1ac	4.68ac	4.32a
	0.10%	29.5b	5.38ab	15.8ab	32.5ab	4.69ab	3.08ab	33.9b	6.15ab	18.3a	36.3ab	5.21ab	3.45ac
	0.20%	33.7a	5.88a	18.3a	34.5a	5.26a	3.79a	40.9a	7.07a	22.3a	37.3a	5.64a	4.09ab
Mean for irrig.		27.4a	4.99a	14.6a	29.7a	4.29a	3.23a	30.4a	5.51a	16.3a	33.4a	4.80a	3.65a
50% ASMD	Zero%	17.3ef	2.79ce	9.02eg	21.3d	2.59cf	1.90cd	16.2ef	2.60cf	8.32cf	20.8e	2.52cf	1.85df
	0.05%	20.4de	3.05be	9.48dg	22.8cd	3.08bf	2.29bc	18.8de	2.81cf	8.76be	22.4de	3.04bf	2.27ce
	0.10%	21.4d	3.32be	10.8cf	25.3cd	3.32ad	2.35bc	21.6cd	3.34cf	10.9bd	26.2ce	3.44ae	2.43ce
	0.20%	27.5bc	4.81ac	14.4abc	27.9bc	4.17ac	2.91ac	23.7cd	4.17bd	12.4bc	29.8bc	4.47ac	3.12bc
Mean for irrig.		21.7b	3.49b	10.9b	24.3b	3.29b	2.36b	20.1b	3.23b	10.1b	24.8b	3.37b	2.42b
75% ASMD	Zero%	8.23h	1.27e	3.64h	9.05e	1.09f	0.77e	8.44h	1.31f	3.71f	8.98f	1.08f	0.76f
	0.05%	9.18h	1.54e	4.33h	9.90e	1.28ef	0.89de	10.0gh	1.68ef	4.69ef	9.99f	1.29ef	0.89f
	0.10%	11.3gh	1.78de	5.55gh	11.3e	1.45df	1.02de	12.9fh	2.00df	6.28df	11.6f	1.49df	1.05f
	0.20%	13.8fg	2.24de	6.93fgh	11.9e	1.62df	1.18de	14.6eg	2.37cf	7.32df	12.8f	1.73df	1.26ef
Mean for irrig.		10.6c	1.71c	5.11c	10.5c	1.36b	0.96c	11.5c	1.84c	5.50c	10.8c	1.39b	0.99c
Mean for PVA. amendment													
Zero%		15.9c	2.69b	7.95c	18.5b	2.29b	1.68b	15.5c	2.65b	7.72b	19.6c	2.43b	1.78b
0.05%		17.9c	3.09ab	9.01bc	19.7b	2.78ab	2.29a	17.9c	3.09b	8.95b	21.2bc	3.01ab	2.49a
0.10%		20.8b	3.49ab	10.7b	23.0a	3.15ab	2.15ab	22.8b	3.83ab	11.8a	24.7ab	3.38ab	2.30ab
0.20%		25.0a	4.31a	13.2a	24.8a	3.68a	2.63a	26.4a	4.54a	14.0a	26.6a	3.95a	2.82a

Conclusion

In conclusion, water consumptive use increased as soil moisture depleted decreased. Also, the lowest and highest average values of actual evapotranspiration were recorded by adding 0.2 and zero% of PVA, respectively. Moreover, peanut yield (straw and seeds) along with total content of macronutrients (N, P and K) increased significantly under the irrigation treatment of 25% ASMD in presence of 0.20% PVA soil amendment as compared to other treatments. The highest values of WUE were gained when irrigated at 50% ASMD irrigation treatment followed by 25 and 75% and the differences were significant. There was a positive linear correlation between water use efficiency (WUE) and seeds yield whether at 25, 50 and 75 % ASMD irrigation treatments. Also, increasing the application PVA polymer rates increased the WUE at two seasons as compared to control and linearly value was $R^2 = 0.97$ for both seasons.

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References

Abdzad Gohari, A. (2012) Effect of nitrogen fertilizer and various irrigation regimes on yield and physiological traits in peanut (*Arachis hypogaea* L.), *International Journal of Farming and Allied Sciences,* **1,** 26-32.

Abedi-Koupai, J. and Asad kazemi, J. (2006) Effects of a hydrophilic polymer on the field performance of an ornamental plant (*Cupressusarizonica*) under reduced irrigation regimes. *Iranian Polymer J.,* **15,** 715-725.

Aboelill, A.A., Mehanna, H.M., Kassab, O.M. and Abdallah, E.F. (2012) The Response of peanut crop to foliar spraying with potassium under water stress conditions. *Aust. Jour. of Basic and Appl. Sci*., **6,** 626-634.

Abou Kheira, A.A. (2009) Macro management of deficit irrigated peanut with sprinkler irrigation. *Agri. Water Manage.* **96**, 1409-1420.

Allen, R.G., Pereira, L.S., Raes, L. and Smith, M. (1998) Crop evapotranspiration guideline for computing crop water requirements. *Irrig. Drain paper No 56*. Food and Agriculture Organization of the United Nations, Rome, Italy.

AL Rasslany, I.A.A. (2014) Effects of poly vinyl alcohol/starch as soil conditioners on the physical properties of loamy sand and loam soils following different wetting and drying cycles. *Jour. Nat. Sci.,* **4,** 36-41.

Awal, M.W. and Ikeda, T. (2002) Recovery strategy following the imposition of Episodic soil moisture deficit in stands of peanut (*Arachishypogaea* L.). *Jour. Agron. Crop Sci.,* **188,** 185-192.

Beasley, J.P. (2006) Irrigation strategies. In: Garcia AGY, Guerra LC, Suleiman A (Ed.) 2006, *Peanut Update*, the University of Georgia, cooperative extension. CAES, pp. 6-7.

Boyer, J.S. (1983) Environmental stress and crop yields In Rapper, C.D. Jr., Kramer, P. J. (Ed.) *Crop Reactions to Water and Temperature Stress in Humid, Temperate Climates.* West view Press. Boulder, CO. pp. 3–7.

Conkerton, E.J., Ross, L.F., Daigle, D.J., Kvien, C.S. and Mc Combs, C. (1989) The effect of drought stress on peanut seed com position. II. Oil, protein and minerals. *Oleagineux.,* **44**(12), 593-602.

Cottenie, A., Verloo, M., Kiekens, L., Velghe, G. and Amertynck, R. (1982) *Chemical Analysis of Plants and Soils.* Laboratory of Analytical and Agrochemistry State University, Ghent, Belgium. Pp.50-70.

Cuenca, R.H. and Amegee, K.Y. (1987) Analysis of evapotranspiration as a regionalized variable. *Advances Irrigation*, vol .4.

Doorenbos, J. and Kassam, A.H. (1979) Yield response to water. Irrg. Drain paper No 33. Food and Agriclture Organization of the United Nations, Rome, Italy.

Doorenbos, J. and Pruitt, W.O. (1977) Yield response to water. *Irrg. Drain paper No 24*. Food and Agriculture Organization of the United Nations, Rome, Italy.

Dwivedi, S.L., Nigam, S.N., Nageswara Rao, R.C., Singh, U. and Rao, K.V.S. (1996) Effect of drought on oil, fatty acids and protein contents of groundnut (*Arachis hypogaea* L.) seeds. *Field Crops Res.*, **48,**125-133.

El-Boraie, F.M., Abo-El-Ela, H.K. and Gaber, A.M. (2009) Water requirements of peanut grown in sandy soil under drip irrigation and biofertilization. *Aust. Jour. of Basic and Appl. Sci.,* **3,** 55-65.

Garcia, A. Y. G., Guerra, L. C., Suleiman, A. A., Paz, J. O. and Hoogenboom, G. (2007) Peanut water use under optimum conditions of growth and development: a simulation approach. In: *Proceedings of the Georgia water resources conference,* March 27–29, Georgia.

Giller, K.E. (2001) *Nitrogen Fixation in Tropical Cropping Systems*. CAB International, Wallingford.

Gohri, A.A. and Amiri, E. (2011) The effect of nitrogen fertilizer and irrigation management on peanut (*Arachis hypogaea* L.) yield in the North of Iran. *ICID 21st International Congress on Irrigation and Drainage,* 15-23 October 2011, Tehran, Iran.

Hargreave, G. H. and Samani, Z. A. (1985) Estimating potential evapotranspiration. *J. Irrig. and Drainage, ASCE,* 108(3).

Hungria, M. and Vargas, M.A.T. (2000) Environmental factors affecting N2 fixation in grain legumes in the tropics, with an emphasis on Brazil. *Field Crops Res,* **65,** 151-164.

Israelson, O.W. and Hansen, V.E. (1962) *Irrigation Principles and Practices,* John Wily and Sons Inc. New York.

Jackson, M.L. (1973) *Soil Chemical Analysis,* Constable and Co. Ltd. Prentice Hall of India, Pvt. Ltd., New Delhi. pp. 10-114. seed.

Karimi, A., Noushadi, M. and Ahmad Zadeh, M. (2008) Effect of water superabsorbent (Igita) amendment material on water soil, plant growth and irrigation intervals. *J. Sci. Tech. Agric. Natural Sour.* **46,** 403- 414.

Khonok, A., Amiri, E. and Babazadeh, H. (2015) Irrigation management and fertilizer of peanut (*Arachis hypogaea* L) with a drip irrigation system: yield, HI and water use efficiency. *Biological Forum – an international J.* **7,** 609-616.

Kulkarni, J.H., Ravindra, V., Sojitra, V.K. and Bhatt, D.M. (1988) Growth, nodulation and N uptake of groundnut (*Arachis hypogaea* L.) as influenced by water deficits stress at different phenophase. *Oleagineus*, **43**, 415-419.

Liu, M., Liang, R., Zhan, F., Liu, Z. and Niu, A. (2007) Preparation of slow superabsorbent release nitrogen fertilizer by inverse suspension polymerization. *Poly. Int.* **56,** 729-737.

Musingo, M.N., Basha, S.M., Sanders, T.H., Cole, R.J. and Blankenship, P.D. (1989) Effect of drought and temperature stress on peanut (*Arachis hypogaea* L.) seed composition. *J. Plant Physiol.,* **134,** 710-715.

Nageswara Rao, R.C., Williams, J.H. and Singh, M. (1989) Genotypic sensitivity to drought and yield potential of peanut. *Agron. J.,* **81,** 887-893.

Nazarli, H. and Zardashti, M.R. (2010) The effect of drought stress and super absorbent polymer (A200) on agronomical traits of sunflower of (*Helianthus annuus* L.) under field condition. *Cercetări Agronomiceîn Moldova* Vol. XLIII, No. 3.

Ngo Nkot, L., Krasova-Wadem, T., Etoa, F.X., Sylla, S.N. and Nwaga, D. (2008) Genetic diversity of rhizobia nodulating *Arachis hypogaea* L. in diverse land use systems of humid forest zone in Cameroon. *Applied Soil Ecology,* **40**, 411-416.

Page, A.L., Miller, R.H. and Keeney, D.R. (1982) *"Methods of Soil Analysis"* Part II. Amer. Soc. Agron., Madison, Wisconsin, USA.

Pimratch, S., Jogloy, S., Vorasoot, N. and Toomsan, B. (2008) Effect of drought stress on trait related to N2 fixation in eleven peanut (*Arachis hypogaea* L.) Genotypes differing in degree of resistance to drought. *Asian Journal of Plant Science,* **7**, 334-342.

Reddy, G.H.S. and Reddy, T.Y. (1995) *Efficient Use of Irrigation Water*. Kalyani Publishers, New Delhi.

Sabate, J. (2003) Nut composition and body weight. *Amer. Jour. of Clinical Nutrition*, **78,** 647s-650s.

Sendecor, G.W. and Cochran, W.G. (1967) *Statistical Methods*. Oxford and I.B.H. publishing G.6th ed. pp. 299-310.

Sexton, P.J., Benett, J.M. and Boote, K.J. (1997) The effect of dry pegging zone soil on pod formation of logrunner peanut. *Peanut Sci.* **24,** 19–24.

Sinclair, T.R., Leilah, A.A. and Schreffler, A.K. (1995). Peanut nitrogen fixation (C2H2 reduction) response to soil dehydration. *Peanut Sci.,* **16,** 162-166.

Singer, M. J., Southard, R. J., Warrington, D. N. and Janitzky, P. (1992) Stability of synthetic sand-clay aggregates after wetting-drying cycles. *Soil Sci. Soc. Am. J.,* **566,** 1843–1848.

Sojka, R.E., Bjorneberg, D.L., Entry, J.A., Lentz, R.D. and Orts, W.J. (2007) Polyacrylamide in agriculture and environmental land management. *Adv. Agron.,* **92,** 75-162.

Songsri P., Jogloy, S., Holbrook, C.C., Vorasoot, N., Kesmala, T.C., Akkasaeng, C. and Patanothai, A. (2009) Association of root, specific leaf area and SPAD chlorophyll meter reading to water use efficiency of peanut under different available soil water. *Agric. Water Management,* **96,** 790-798.

Stansell, J.R., Shepard, J.L., Pallas, Jr. J.E., Bruce, R.R., Minton, N.A., Bell, D.K. and Morgan, L.W. (1976) Peanut responses to soil water variables in the Southeast. *Peanut Sci.,* **3,** 44-48.

Tayel, M.Y., El Gindy, A.M., Abd- El- Hady, M. and Ghany, H.A. (2007) Effect of irrigation systems on: yield, water and fertilizer use efficiency of grape. *Applied Sciences Research,* **3,** 367-372.

Wu, S.F., Wu, P.T., Feng, H. and Bu, C.F. (2010) Influence of amendments on soil structure and soil loss under simulated rainfall China's loess plateau. *Afr. J. Biotechnol.,* **9,** 6116-6121.

Ziaeidoustan, H., Azarpour, E. and Safiyar, S. (2013) Study the effects of different levels of irrigation interval, nitrogen and superabsorbent on yield and yield component of peanut. *Intl. J. Agric. Crop Sci.,* **5,** 2071-2078.

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إستجابة الفول البلدي (*Arachis Hypogaea* L.) لمستويات مختلفة من الإجهاد الرطوبي ومحسنات التربة الصناعية

السيد محمد علي ، وفاء محمد طه العتر و جيهان حسنى يوسف
معهد بحوث الأراضى والمياه والبيئة – مركز البحوث الزراعية – الجيزة – مصر.

أقيمت تجربتان حقليتان في موسميين صيفين متتالين (2013 – 2014) فى تصميم قطع منشقة مرة واحدة فى ثلاث مكرارات تحت نظام الري بالتنقيط فى اراضى رملية بالمزرعة البحثية بمحطة البحوث الزراعية بالاسماعيلية- محافظة الاسماعيلية – مصر. وتوجد المزرعة علي خط عرض N ""41.04 35 °30 وعلي خط طول E "45.8 16 °32 . تم زراعة الفول السودانى كدليل محصولي لتقيم تأثير الاجهاد الرطوبي و معدلات مختلفة من المحسن الصناعي البولي فينيل الكحول علي انتاجية الفول السودانى و المحتوي الكلي من العناصر الكبري بجانب بعض العلاقات المائية بالنبات. تم اختبار ثلاث معاملات ري 25%، 50%، 75% استنزاف رطوبى من الماء الميسر للتربة (ASMD) فى القطع الرئيسية بينما القطع تحت رئيسية كانت 4 معدلات من المحسن الصناعى البولى فينيل الكحول (صفر، 0.05، 0.10، 0.20%) التى تم اضافتها قبل حرث الارض.

أشارت النتائج الى زيادة الاستهلاك المائى المستخدم بانخفاض الاستنزاف الرطوبى للتربة. وأقل استهلاك مائى مستخدم تم الحصول عليه هو 692.72 مم و 700.76 مم فى كل من الموسم الاول و الثانى على التوالى تحت الظروف الجافة (الاجهادالرطوبى الشديد للتربة، الرى عند 75 % استنزاف رطوبى من الماء الميسر للتربة). بينما أعلى قيم للاستهلاك المائى المستخدم سجلت 1293 مم و 1318 مم فى كل من الموسم الاول و الثانى على التوالى تحت مستوى رطوبى 25% استنزاف رطوبى من الماء الميسر للتربة. أيضا، سجلت أقل و أعلى قيم متوسطات للبخر نتح الفعلى عند 0.2 و صفر % من البولى فينيل الكحول على التوالى.

بالاضافة الى ذلك، يمكن الاشارة الى ان استخدام معادلة الـ FAO و المعدلة بطريقة Blaney criddle لحساب البخر نتح لمحصول الفول السودانى تحت ظروف الاسماعيلية لان النتائج المتحصل عليها بهذه الطريقة تكون اقرب للنتائج التى تم الحصول عليها عند تطبيق 50% استنزاف رطوبى من الماء الميسر للتربة.

فضلا عن ذلك، فان محصول القش و الحبوب للفول السودانى بجانب محتواها الكلى من العناصر الكبرى (نيتروجين و فوسفور و بوتاسيوم) أعطت زيادة معنوية تحت معاملة الرى 25% استنزاف رطوبى من الماء الميسر للتربة وفى وجود 0.2% من محسن التربة البولى فينيل الكحول مقارنة بالمعاملات الاخرى.

وفى النهاية أوضحت النتائج ان كفاءة استخدام الماء (WUE) كانت معنوية فى كل من الموسميين. وان قيم WUE زادت سواء بزيادة المحصول او انخفاض البخر نتح. وسجلت أعلى قيم WUE عند الرى 50% استنزاف رطوبى من الماء الميسر للتربة و يتبعه 25% و 75% استنزاف رطوبى من الماء الميسر للتربة وكان الاختلاف معنوى. وجد ان علاقة الارتباط الخطى بين كفاءة استخدام الماء ومحصول الحبوب و تركيز المحسن الصناعى البولى فينيل الكحول كانت موجبة معنويا خلال الموسميين المدروسيين 2013 و2014 على التوالى.