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Developed Water Stress and Crop Coefficients of Dripped-Onion Crop under Arid Conditions of Egypt

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Abstract

The aims of this study were to develop out crop and water-stress coefficients of onion crop under deficit conditions of arid regions. Therefore, field experiments of fully irrigated and deficit conditions with standard agronomic practices of onion crop had been conducted in two successive growing seasons in 2011-2012 and 2012-2013 in order to develop out the crop coefficients of onion plants at different growing stages.

Results revealed that crop coefficient values at different growing stages under different management parameter considerations indicated that the observed values of kc are ranged above and dawn of the estimated values of FAO. Meanwhile, data analysis revealed that a general trend of increasing CWU and attributed SCWR from the beginning of cultivation up to the end of bulb formation stage (72 days after sowing seeds), then it decreasing within bulb enlargement and maturity stage.

Keywords: Sandy soils; Surface drip; Subsurface drip; Water regimes; Water management

Introduction

Igbadun and Oiganji stated that the kc values of fully irrigated-onion treatments had ranged from 0.36 to 1.15, while those values of the deficit irrigated treatments varied from 0.24 to 1.13 under Samaro district, Nigeria [1]. Meanwhile, Susan et al. [2] speculated that variations of the crop water stress index (CWSI) have been used to characterize plant water stress and schedule irrigations. Usually, this thermal-based stress index has been calculated from measurements taken once daily or over a short period of time, near solar noon or after and in cloud free conditions. A method of integrating the CWSI over a day was developed to avoid the noise that may occur if weather prevents a clear CWSI signal near solar noon. This CWSI and time threshold (CWSI-TT) was the accumulated time that the CWSI was greater than a threshold value (0.45); and it was compared with a time threshold (CWSI-TT) based on a well-watered crop. Meanwhile, Mahmoud revealed that, increasing in soil moisture up to 80% of the field capacity, significantly increased the peas growth characters, a gradual decrease in all yield characters was found as the level of irrigation water decreased, so, the highest level of water supply, i.e., 80% of the field capacity gave the highest values of the above - mentioned characters [3]. The greatest value of water use efficiency was obtained at 60% of the field capacity, while 20% of the field capacity caused the lowest water use efficiency.

Locascio and Smajstrla reported that total marketable yield was almost doubled, while yield of the highest-value extra-large fruit was tripled by irrigation [4]. The four-year average yield with the 10 kPa (10 cb) treatment was largest. In the irrigated treatments, total marketable yield declined linearly as the Natron on garlic cultivated in two interties and drip irrigated in sandy soil mulched with bitumen emulation. They found that 3 days – irrigation period and 4 rows of plants/drip line gave the best results increasing total garlic yield, plant weight, tuper parameters (bulb diameter), number of cloves, air dry weight and over dry weight of garlic cloves. Also, Steduto et al. [5] and Steduro [6] and Robert [7] emphasized that irrigation scheduling simply to know when to irrigate and how much irrigation water to apply, and concluded that an effective irrigation schedule helps to maximize profit while minimizing water and energy use.

Abdel-Mawgoud stated that the highest irrigation treatment enhanced the number of pods significantly compared to lower irrigation levels [8]. Pod quality in terms of length and diameter showed also these positive responses to the increment in irrigation levels. Pod diameter increased with increasing irrigation level to 100% evaporation pan then it was reduced when irrigation level was further increased to 120%. Metin et al. [9] indicated that by increasing irrigation level from 60% and up to 100% of Et_0 increased significantly the vegetative growth criteria; i.e., plant height, no. of branches, and pods/plant, leaves area, dry weight of stem and the whole plant dry matter. Moreover, irrigation of bean plants at 80% of the ET_o led to obtaining the highest significant values of pods yield/fed and pod length, compared to either 60 or 100% ET_o. Dennis and Aileen found that irrigation practices of strawberries can consistently produce up to 1.5 kilograms of well flavored marketable fruit per plant each season [10]. With this point of view, Abodi and Shati revealed that irrigation every 5 days was superior in ears numbers per plant, seeds per ears, seed weight and plant yield which reach 138.6 and 159.6 gm/plant for both spring seasons and 154.5 and 174.7 for both fall seasons, respectively [11]. Grain yield reached 8.673, 9.990 and 9.674, 10.938 ton/h. Irrigation depth 12 cm was superior in ears number per plant, seeds per ear, seed weight and plant yield which reached 116.3, 136.8 gm/plant and 142.1, 160.1 gm/plant.

The aims of this study were to develop out crop and water-stress coefficients of onion crop under deficit conditions of arid regions.

Materials and Methods

Field experiments of fully irrigated and deficit conditions with standard agronomic practices of onion crop had been conducted in two successive growing seasons in 2011-2012 and 2012-2013 in order to develop out the crop coefficients of onion plants at different growing stages.

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Location and description of the experimental field

Experiments were carried out during two successive growing seasons (2011-2012 and 2012-2013) at a farm which located at Longitude 30° 13' E°, latitude 30° 25' N and 25.5 m above MSL. The analyses to determine physical and chemical properties of soil had been conducted according to standard methods and presented in (Tables 1 and 2).

Chemical analysis of irrigation water was carried out by using the standard methods, and presented in (Table 3).

Weather conditions and parameters during the growing season

The minimum and maximum temperature, humidity and wind speed and other meteorological parameters had been gathered and analyzed. However, reference evapotranspiration of the studied area had been gathered from Central Laboratory of Agricultural Climate (CLAC), Agriculture Research Center (ARC) for the cultivated growing seasons. Reference evapotranspiration (ET_o) was computed using the FAO, modified Penman-Monteith method is given.

The cultivated crop

The cultivated area was prepared and transplanted of onion seeds on December of each growing season. The cultivated variety of onion *(Allium Cepa L.)* was Giza 20. The sawing was done in row at plant spacing of 14.3 cm between plants. Meanwhile the spacing between plant's rows was varied according to the number of cultivated plant's rows around laterals. Therefore, the plant population density is varied, and could be summarized as shown in (Table 4). Harvesting took place on April of each successive growing season. The crop began to show signs of maturity (over 70% dropping of leave head) at 12 and 14 weeks after germination. Irrigation was withdrawn that same week and soil moisture measurement was stopped two weeks after. Harvesting was carried cut about one week after, particularly 10^{th}-13^{th} April. Harvesting was done by lifting onion bulbs the dry matter using a hand hoe. The area of 3 m in long and 1 m in wide in each plot were lifted (without discards), properly labeled and taken to be to laboratory to curve for about two weeks. Therefore, the onion bulbs were separated from the dry matter and weighed. However, all agronomic practices and the rate of applications were as recommended by Vegetable Research Institute, ARC, MALR.

Experimental design and layout

Split-split-split plot design was used in this experiment. The total area of the experiment was (180 × 90 m) and divided into two main plots each was (90 × 90 m) for drip irrigation systems; every plot was divided into three sub-plots each (90 × 90 m) for drip irrigation treatments(SD, and SSD_{10}), and deficit conditions. However, each sub-plot of deficit conditions was divided into three sub-sub plots (90 × 30 m) for irrigation water regime treatments (A, B and C), and every sub-sub-plot divided into three sub-sub-sub plots (30 × 30 m) for plant density treatments (1, 2 and 3), as shown in (Figure 1).

Treatments

Drip irrigation systems

SD: surface drip irrigation system.

SSD_{10}: subsurface drip irrigation system with buried laterals at 10 cm depth.

Deficit conditions

Irrigation water regimes:

A: zero deficit treatments of actual evapotranspiration.

Soil layer, cm	Particle size distribution, %			Texture class	B. D	Moisture content by weight (%)		
	Sand	Silt	Clay		(gm/cm³)	F. C	P.W.P	A.W
0-20	94.5	3.5	2	Sandy	1.65	8.03	3.33	4.7
20-40	95	3.3	1.7	Sandy	1.56	9.13	3.14	5.99
40-60	95.7	3	1.3	Sandy	1.44	10.07	2.99	7.08
F.C=Field capacity W.P=Wilting point A.W=Available water B.D=Bulk density								

Table 1: Soil physical properties of the experimental site.

Soil layer, cm	SAR	pH	E.C, dS/m 25°c	Soluble anions, meq/l				Soluble cations, meq/l			
				CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
0-20	1.66	8.23	1.46	0.1	0.93	1.98	9.61	6.23	2.24	3.44	0.51
20-40	1.74	8.11	1.56	0.1	1.15	2.05	9.85	6.45	2.26	3.76	0.58
40-60	1.84	7.97	1.63	0.1	1.33	2.11	10.16	6.65	2.29	3.91	0.65
SAR=Sodium adsorption ratio EC=Electric conductivity, ds/m											

Table 2: Soil chemical characteristics of the experimental site.

pH	E.C, dS/m at 25°C	Soluble anions, meq/l				Soluble cations, meq/l				SAR	RSC	ESP	%Ca/Na
		CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+				
7.14	1.18	0.1	4.7	10.6	8.15	1.8	2.8	18.4	0.55	12.1	0.2	78.1	9.8
RSC=Residual sodium carbonate ESP=Exchangeable sodium percentage													

Table 3: Chemical analysis of irrigation water at the studied site.

No. of rows	Row spacing, cm	No. of plants per m²	No. of plants per each plot
4	25	28	25200
6	16.7	46	41400
8	12.5	56	50400

Table 4: Plant population density at each treatment plot.

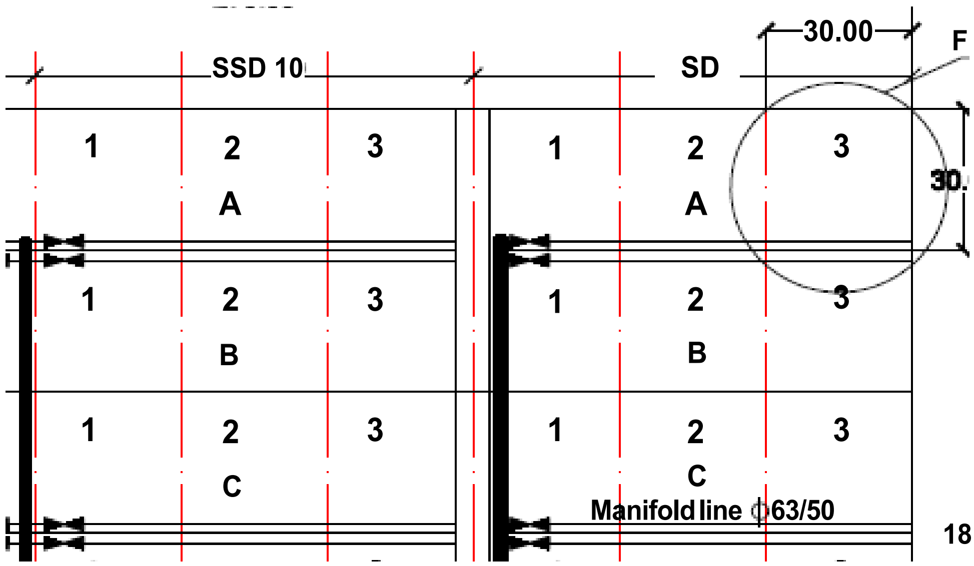

Figure 1: Experimental layout.

Growing season	Drip irrigation system	Index	Onion Growth stages/days after planting											
			Establishment (0-16)	Vegetative (17-44)				Bulb formation (45-72)				Bulb enlargement to maturity (73-101)		
			0-16	17-23	24-30	31-37	38-44	45-51	52-58	59-65	66-72	73-79	80-87	88-101
Growth stages duration, day			16	7	7	7	7	7	7	7	7	7	7	14
2011-2012	ET_0, mm/day		2	2.1	2.4	2.4	2.4	2.55	2.6	2.8	3.25	3.25	3.45	3.45
	SD	Kc	0.68	0.69	0.76	0.75	0.78	1.04	1.14	1.06	1.05	0.93	0.68	0.47
		Ks	1.12	0.76	0.74	0.81	0.82	0.81	0.80	0.94	0.98	0.97	1.05	1.21
		CWU, mm/time of investigation	24.36	7.74	9.46	10.26	10.68	15.06	16.5	19.52	23.5	20.58	17.2	27.54
	SSD_{10}	Kc	0.5	0.59	0.66	0.7	0.87	1.02	1.06	1.09	1.02	0.93	0.79	0.51
		Ks	1.41	0.77	0.76	0.82	0.83	0.83	0.81	0.96	1.00	0.95	1.03	1.19
		CWU, mm/time of investigation	22.5	6.68	8.38	9.7	12.06	15.08	15.68	20.5	23.3	20.14	19.56	29.24
2012-2013	ET_0, mm/day		1.8	2	2.2	2.2	2.2	2.8	3.4	3.5	5.6	5.6	5.6	5.6
	SD	Kc	0.68	0.68	0.67	0.66	0.78	0.91	1.02	1	1.02	0.83	0.69	0.63
		Ks	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		CWU, mm/time of investigation	19.584	9.52	10.318	10.164	12.012	17.836	24.276	24.5	39.984	32.536	27.048	49.392
	SSD_{10}	Kc	0.51	0.56	0.54	0.68	0.98	1.06	1.16	1.09	1.04	0.95	0.76	0.42
		Ks	1.25	0.54	0.54	0.48	0.46	0.42	0.28	0.41	0.40	0.37	0.43	0.38
		CCWU, mm/time of investigation	18.43	4.2	4.46	5.02	7.01	8.74	7.64	11	16.32	13.7	12.7	12.5
Average values of the two growing seasons	SD	Kc	0.68	0.685	0.715	0.705	0.78	0.975	1.08	1.03	1.035	0.88	0.685	0.55
		Ks	1.060	0.882	0.870	0.907	0.908	0.906	0.898	0.970	0.992	0.986	1.024	1.107
		CWU, mm/time of investigation	21.40	5.97	6.96	7.64	8.85	11.90	12.07	15.26	19.91	17.14	14.95	20.02
	SSD_{10}	Kc	0.505	0.575	0.6	0.69	0.925	1.04	1.11	1.09	1.03	0.94	0.775	0.465
		Ks	1.33	0.65	0.65	0.65	0.64	0.62	0.54	0.69	0.70	0.66	0.73	0.78
		CWU, mm/time of investigation	20.465	5.44	6.42	7.36	9.535	11.91	11.66	15.75	19.81	16.92	16.13	20.87

Table 5: Crop coefficient and crop water stress coeficient of onion under fully irrigated conditions, Nubaria district, Egypt.

B: 30% deficit treatments of actual evapotranspiration.

C: 60% deficit treatments of actual evapotranspiration.

Plant population densities:

A: 4 rows of plants cultivated around the lateral line.

B: 6 rows of plants cultivated around the lateral line.

C: 8 rows of plants cultivated around the lateral line.

Growing season	Drip irrigation system	Deficit conditions: Irrigation regime	Deficit conditions: plant population /m²	Index	Onion Growth stages/days after planting: Establishment (0-16)	Vegetative (17-44)				Bulb formation (45-72)				Bulb enlargement to maturity (73-101)		
					0-16	17-23	24-30	31-37	38-44	45-51	52-58	59-65	66-72	73-79	80-87	88-101
Average values of kc according to FAO (zaytoun, 2007)					*0.5*	*0.75*				*1.05*				*0.85*		
2011-2012	ET$_0$, mm/day				*2*	*2.1*	*2.4*	*2.4*	*2.4*	*2.55*	*2.6*	*2.8*	*3.25*	*3.25*	*3.45*	*3.45*
	SD	Average kc of 100% of Et$_o$			*0.68*	*0.685*	*0.715*	*0.705*	*0.78*	*0.975*	*1.08*	*1.03*	*1.035*	*0.88*	*0.685*	*0.55*
		I$_{70}$	28	kc	0.64	0.67	0.66	0.66	0.78	0.91	1.02	1.00	1.02	0.83	0.69	0.63
				ks	0.99	0.89	0.64	0.94	0.98	0.82	1.06	1.10	0.79	0.89	0.89	0.41
			56	kc	0.64	0.67	0.66	0.66	0.78	0.91	1.02	1	1.02	0.83	0.69	0.63
				ks	0.99	0.89	0.64	0.94	0.98	0.82	1.06	1.10	0.79	0.89	0.89	0.41
		I$_{40}$	28	kc	0.47	0.49	0.46	0.5	0.54	0.68	0.94	0.91	0.88	0.64	0.52	0.54
				ks	0.77	0.70	0.52	0.71	0.81	0.63	0.65	0.69	0.53	0.66	0.68	0.27
			56	kc	0.47	0.49	0.46	0.5	0.54	0.68	0.94	0.91	0.88	0.64	0.52	0.54
				ks	0.77	0.70	0.52	0.71	0.81	0.63	0.65	0.69	0.53	0.66	0.68	0.27
	SSD$_{10}$	Average kc of 100% of Et$_o$			*0.505*	*0.575*	*0.6*	*0.69*	*0.925*	*1.04*	*1.11*	*1.09*	*1.03*	*0.94*	*0.775*	*0.465*
		I$_{70}$	28	kc	0.5	0.59	0.66	0.7	0.87	1.02	1.06	1.09	1.02	0.93	0.79	0.51
				ks	0.95	0.76	0.48	0.55	0.48	0.40	0.56	0.55	0.60	0.79	0.78	0.50
			56	kc	0.5	0.59	0.66	0.7	0.87	1.02	1.06	1.09	1.02	0.93	0.79	0.51
				ks	0.95	0.76	0.48	0.55	0.48	0.40	0.56	0.55	0.60	0.79	0.78	0.50
		I$_{40}$	28	kc	0.5	0.49	0.61	0.75	0.76	0.98	1.02	1.02	1.1	0.88	0.71	0.51
				ks	1.09	0.83	0.59	0.72	0.94	0.85	0.99	0.96	0.73	0.78	0.93	0.63
			56	kc	0.5	0.49	0.61	0.75	0.76	0.98	1.02	1.02	1.1	0.88	0.71	0.51
				ks	0.63	0.37	0.25	0.40	0.51	0.47	0.48	0.50	0.44	0.45	0.65	0.33
2012-2013	ET$_0$, mm/day				*1.8*	*2*	*2.2*	*2.2*	*2.2*	*2.8*	*3.4*	*3.5*	*5.6*	*5.6*	*5.6*	*5.6*
	SD	Average kc of 100% of Et$_o$			*0.68*	*0.685*	*0.715*	*0.705*	*0.78*	*0.975*	*1.08*	*1.03*	*1.035*	*0.88*	*0.685*	*0.55*
		I$_{70}$	28	kc	0.64	0.67	0.66	0.66	0.78	0.91	1.02	1.00	1.02	0.83	0.69	0.63
				ks	1.06	0.80	0.52	0.60	0.52	0.37	0.43	0.44	0.35	0.46	0.48	0.31
			56	kc	0.64	0.67	0.66	0.66	0.78	0.91	1.02	1	1.02	0.83	0.69	0.63
				ks	0.83	0.70	0.52	0.64	0.59	0.41	0.44	0.48	0.35	0.52	0.55	0.25
		I$_{40}$	28	kc	0.47	0.49	0.46	0.5	0.54	0.68	0.94	0.91	0.88	0.64	0.52	0.54
				ks	0.64	0.55	0.43	0.48	0.48	0.31	0.27	0.30	0.23	0.38	0.42	0.17
			56	kc	0.47	0.49	0.46	0.5	0.54	0.68	0.94	0.91	0.88	0.64	0.52	0.54
				ks	0.74	0.39	0.36	0.65	0.79	0.62	0.40	0.45	0.32	0.36	0.54	0.19
	SSD$_{10}$	Average kc of 100% of Et$_o$			*0.505*	*0.575*	*0.6*	*0.69*	*0.925*	*1.04*	*1.11*	*1.09*	*1.03*	*0.94*	*0.775*	*0.465*
		I$_{70}$	28	kc	0.5	0.59	0.66	0.7	0.87	1.02	1.06	1.09	1.02	0.93	0.79	0.51
				ks	0.82	0.54	0.44	0.52	0.49	0.41	0.40	0.39	0.34	0.43	0.52	0.39
			56	kc	0.5	0.59	0.66	0.7	0.87	1.02	1.06	1.09	1.02	0.93	0.79	0.51
				ks	0.82	0.54	0.44	0.52	0.49	0.41	0.40	0.39	0.34	0.43	0.52	0.39
		I$_{40}$	28	kc	0.5	0.49	0.61	0.75	0.76	0.98	1.02	1.02	1.1	0.88	0.71	0.51
				ks	0.82	0.66	0.48	0.49	0.56	0.42	0.42	0.42	0.32	0.45	0.57	0.39
			56	kc	0.5	0.49	0.61	0.75	0.76	0.98	1.02	1.02	1.1	0.88	0.71	0.51
				ks	0.47	0.37	0.28	0.28	0.32	0.24	0.24	0.24	0.18	0.26	0.33	0.22

Table 6: Developed crop coefficient and crop water stress of onion under deficit conditions, Nubaria district, Egypt.

Measurement and Calculations

Computation of crop coefficient under deficit irrigation treatments (k_c)

The crop coefficient (K_C) for the field the irrigated treatments were determined on weekly basis, according to FAO publication and other references under the same conditions [12]. Meanwhile, the crop coefficient of the deficit irrigation treatments (referred to as $K_{c_{deficit}}$) was computed as a ratio of the average daily crop water use of deficit irrigated treatments to the average daily ET_o for the week.

$$Kc_{deficit} = \frac{CWU_{deficit}}{ET_o}$$

Computation of water stress coefficient (K_s)

The water stress coefficient (K_s) integrate the crop and soil factors that make the actual crop water use of the deficit irrigated conditions differ from crop use under fully irrigated conditions. The relationship was exposed by Allen. The values of K_c, $Kc_{deficit}$, and K_s for the four growth stages of onion crop were computed by finding the average of the weekly coefficients values for the growth stages. The water stress coefficients can be classified on the basis of its impact on seasonal consumptive use as (Critical: $0.1 < K_s \le 0.5$, Severe: $0.5 < K_s \le 0.75$, Moderate: $0.75 < K_s \le 0.9$, Minor: $0.9 < K_s \le 0.99$).

Computation of onion crop water use (CWU) and seasonal crop water requirements (SCWR)

Onion plant-water requirements were calculated and scheduled

Growing season	Drip irrigation system	Irrigation water regime	Onion Growth stages/days after planting												Accumulative CWU, mm/ growth seasn	SCWU, mm/fed		SCWR, m³/fed
			Establishment (0-16)	Vegetative (17-44)				Bulb formation (45-72)				Bulb enlargement to maturity (73-101)				Leaching requirments, 10%	Irrigation requirements, mm/ed	
			0-16	17-23	24-30	31-37	38-44	45-51	52-58	59-65	66-72	73-79	80-87	88-101				
Growth stages duration, day			16	7	7	7	7	7	7	7	7	7	7	14				
2011-2012	ET_0, mm/day		**2**	**2.1**	**2.4**	**2.4**	**2.4**	**2.55**	**2.6**	**2.8**	**3.25**	**3.25**	**3.45**	**3.45**				
	SD	I_{100}	24.36	7.74	9.46	10.26	10.68	15.06	16.5	19.52	23.5	20.58	17.2	27.54	*202.40*	20.24	247.38	*1038.99*
		I_{70}	17.05	5.42	6.62	7.18	7.48	10.54	11.55	13.66	16.45	14.41	12.04	19.28	*141.68*	14.17	173.16	*727.29*
		I_{40}	9.744	3.096	3.784	4.104	4.272	6.024	6.6	7.808	9.4	8.232	6.88	11.016	*80.96*	8.10	98.95	*415.59*
	SSD_{10}	I_{100}	22.5	6.68	8.38	9.7	12.06	15.08	15.68	20.5	23.3	20.14	19.56	29.24	*202.82*	20.28	247.89	*1041.14*
		I_{70}	15.75	4.68	5.87	6.79	8.44	10.56	10.98	14.35	16.31	14.10	13.69	20.47	*141.97*	14.20	173.52	*728.80*
		I_{40}	9	2.672	3.352	3.88	4.824	6.032	6.272	8.2	9.32	8.056	7.824	11.696	*81.13*	8.11	99.16	*416.46*
2012-2013	ET_0, mm/day		**1.8**	2	2.2	2.2	2.2	2.8	3.4	3.5	5.6	5.6	5.6	5.6				
	SD	I_{100}	19.584	9.52	10.318	10.164	12.012	17.83	24.276	24.5	39.984	32.536	27.048	49.392	*277.16*	27.72	338.76	*1422.78*
		I_{70}	13.71	6.66	7.22	7.11	8.41	12.48	16.99	17.15	27.99	22.78	18.93	34.57	*194.01*	19.40	237.13	*995.94*
		I_{40}	13.7088	6.664	7.2226	7.1148	8.4084	12.481	16.9932	17.15	27.9888	22.7752	18.9336	34.5744	*194.01*	19.40	237.13	*995.94*
	SSD_{10}	I_{100}	18.43	4.2	4.46	5.02	7.01	8.74	7.64	11	16.32	13.7	12.7	12.5	*121.72*	12.17	148.77	*624.83*
		I_{70}	12.90	2.94	3.12	3.51	4.91	6.12	5.35	7.70	11.42	9.59	8.89	8.75	*85.20*	8.52	104.14	*437.38*
		I_{40}	7.372	1.68	1.784	2.008	2.804	3.496	3.056	4.4	6.528	5.48	5.08	5	*48.69*	4.87	59.51	*249.93*
Average values of the two growing seasons	ET_0, mm/day		**1.9**	2.05	2.3	2.3	2.3	2.675	3	3.15	4.425	4.425	4.525	4.525				
	SD	I_{100}	21.97	8.63	9.89	10.21	11.35	16.45	20.39	22.01	31.74	26.56	22.12	38.47	*239.78*	23.98	293.07	*1230.88*
		I_{70}	15.38	6.04	6.92	7.15	7.94	11.51	14.27	15.41	22.22	18.59	15.49	26.93	*167.85*	16.78	205.15	*861.62*
		I_{40}	11.73	4.88	5.50	5.61	6.34	9.25	11.80	12.48	18.69	15.50	12.91	22.80	*137.49*	13.75	168.04	*705.77*
	SSD_{10}	I_{100}	20.465	5.44	6.42	7.36	9.535	11.91	11.66	15.75	19.81	16.92	16.13	20.87	*162.27*	16.23	198.33	*832.99*
		I_{70}	14.3255	3.808	4.494	5.152	6.6745	8.337	8.162	11.025	13.867	11.844	11.291	14.609	*113.59*	11.36	138.83	*583.09*
		I_{40}	8.186	2.176	2.568	2.944	3.814	4.764	4.664	6.3	7.924	6.768	6.452	8.348	*64.91*	6.49	79.33	*333.19*

Table 7: Crop water use (CWU) and seasonal crop water requirements (SCWR) of onion under deficit irrigation conditions, Nubaria district, Egypt.

according to investigated level of treatments. ET_o data were processed by using CropWat 8.1 model, for all calculation. The irrigation water requirements at each irrigation events under different onion plants growing stage were computed.

Results and Discussion

Effect of drip irrigation systems on water stress coefficient

Data are illustrated in (Tables 5 and 6) indicated that the highest significant effects were due to the plant population density and drip irrigation systems.

Regarding the k_s response to the investigated drip irrigation systems. Data revealed that, the lowest k_s values at bulb formation stage were 0.57 and 0.59 under SSD_{10} and SD respectively. Based on the k_s classification it could be concluded that the water stress coefficients were minor except at vegetative growth stage of onion plants, wherever, it had moderate effect. The seasonal k_s values of I_{70} and I_{40} had been ranged from moderate to severe under SD compared with SSD_{10}. However, K_s values were noticed to have similar trends for agronomic management parameters and drip irrigation systems SD and SSD considerations that imply the impacts of deficit irrigation condition were consistent irrespective of cropping methodologies and onion crop variety. The abovementioned results are agreed with that had been observed by Moustafa.

Crop coefficient as response to deficit irrigation conditions

Results revealed that there is no significant effect on the onion crop coefficients due to plant population density; however, the highly significant effect was due to the irrigation water regimes treatments. This observation is in agreements with other related works. On the other hand, data indicated that the specific amounts of the applied irrigation water and its distribution patters within soil profile had a significant effect of the crop coefficient within specific growing stages. Moreover, data analysis of crop coefficient values at different growing stages under different management parameter considerations indicated that the observed values of k_c are ranged above and dawn of the estimated values of FAO. This may be indicated that several effects had to be taken into consideration regarding the improving of on-farm irrigation water uses under different domestic macro-climatic. With this point of view, data analysis indicated that the highest k_c values were obtained under I_{100} followed by I_{70} and I_{40} respectively. These data are in agreement with Igbadun and Oiganji [1].

Crop water use (CWU) and seasonal cop water requirements (SCWR) of onion

Data illustrated in (Table 7) showed that the average daily (CWU) and seasonal crop water requirements (SCWR) within the two successive growing seasons, under deficit irrigation conditions. A general trend of increasing CWU and attributed SCWR from the beginning of cultivation up to the end of bulb formation stage (72 days after sowing seeds), then it decreasing within bulb enlargement and maturity stage. This is normally observation due to the crop water requirements and the change of micro-climate factors and attributed reference evapotranspiration, as well as, changes of either crop coefficient or crop water stress coefficient. In addition, from data analyses it could be noticed that, the highest values of CWU reduced under establishment, vegetative growth, bulb fermentation and bulb enlargement and maturity stages respectively. These observations are in agreement with Igbadun and Oiganji [1] and Fereres and David [13].

Conclusion

Finally study concludes that crop coefficient values at different growing stages under different management parameter considerations indicated that the observed values of Kc are ranged above and dawn of the estimated values of FAO. Moreover, data analysis revealed that a general trend of increasing CWU and attributed SCWR from the beginning of cultivation up to the end of bulb formation stage (72 days after sowing seeds), then it decreasing within bulb enlargement and maturity stage.

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