

IV. RESULTS AND DISCUSSION

The major objectives of the current investigation are to study the effect of water stress and humic acid on growth, yield and its components of the three maize hybrids.

4.1. Growth characters

4.1.1. Plant height at harvest (cm)

Data presented in Table (3) indicate the effect of water stress and humic acid on plant height (cm) of three maize hybrids in 2013 and 2014 seasons.

Data in Table (3) showed that irrigation intervals significantly affected plant height in both seasons. The tallest plants were recorded with irrigation every 15 days, while the shortest plants were irrigated every 20 days in both seasons. The depression in plant height may be due to the retardation in cell division and cell expansion caused by water stress (**Atta – Allah, 1996**). These results are in agreement with those obtained by **El- Noemani *et al.* (1990)**, **Ibrahim *et al.* (1992)**, **Salem (1993)**, **Ghali (1997)** and **Wajid *et al.* (2004)**.

Drought stress have deleterious effects on the seedling establishment, vegetative growth, photosynthesis, root growth, anthesis, anthesis-silking interval, pollination and grain formation in maize crop. The deleterious effects of drought can be mediated by application of nutrients which may enhance tolerance to drought stress. Among the nutrients potassium can enhance the tolerance in maize plant for drought stress. The application of potassium enhanced root growth and stem elongation. Similarly, potassium increased leaf water potential, osmotic potential and turgor potential under drought stress (**Aslam *et al.*, 2013**).

Regarding maize hybrids effect on plant height, data in Table (3) show significant differences among maize hybrids for plant height in both seasons. S.C.168 hybrid recorded the tallest plants, while S.C.166 hybrid gave the shortest plants in the two growing seasons, whereas there was no significant difference between S.C.168 and T.W.C.352 hybrids. These differences between maize hybrids are mainly due to genetic differences makeup between the three hybrids. **Atta- Allah (1996) and Farhad *et al.* (2011)** who found high significant differences between maize hybrids under their studies for plant height.

The obtained results indicated that plant height was significantly affected by application of humic acid rates in both seasons, as shown from data in Table (3). The tallest plants (179.59 and 202.59 cm) were obtained by soil treated with the highest rate of humic acid (14.4 kg/ha.), while the shortest plants was recorded by untreated (control) treatment (158.22 and 181.35 cm) in the first and second seasons, respectively. The increase in plant height due to add the highest rate of humic acid may be ascribed to humic acid of microorganisms which release phytohormones which stimulate plant height. These results were parallel with those reported by **Bakry *et al.* (2009)**, **Rajpar *et al.* (2011)**, **Attia *et al.* (2013)** **Daur (2013)**, **Daur and Bakhawain (2013)** and **Osman *et al.* (2013)**.

Notably the interaction between water stress and maize hybrid cultivars showed a significant effect on plant height in both seasons (Table, 5). Likewise, irrigation every 10 days with S.C.168 hybrid (178.56 and 198.05 cm) and irrigation every 15 days with T.W.C. 352 (177.56 and 203.14 cm) gave the tallest plants in the first and the second seasons, respectively, while the shortest plants were recorded for irrigation every 20 days with S.C.166 hybrid (158.57 and 182.70 cm).

There were significant differences for the interaction between water stress and humic acid in the two growing seasons (Table, 3). The highest mean value of plant height was produced by irrigation every 15 days with application of the highest humic acid rate (14.40 kg/ha.) (186.11 and 211.47 cm), in both seasons (Table, 5). The effect of interaction between maize hybrids and humic acid rates on plant height was significant in 2013 season only (Table, 3). Whereas, S.C.168 hybrid had the tallest plants by application of 14.4 kg/ha., humic acid (181.22 cm) and without significant difference from T.W.C.352 with application of 14.40 kg/ha., humic acid (180.56 cm), while the hybrid SC.166 with 0.00 kg humic/ha., recorded the shortest maize plants (Table, 6). The interaction among irrigation intervals, maize hybrid and humic acid had significant effect on plant height in both seasons (Table, 3). Data presented in Table (7) show that irrigation every 15 days with application of 14.4 kg/ha., humic acid for the all maize hybrids gave the tallest maize plants in both seasons.

Table (3). Plant height (cm) at harvest of three maize hybrids as affected by water stress, humic acid and their interaction during 2013 and 2014 seasons

Plant height at harvest (cm)		
Treatments	Season	
	2013	2014
<u>Water stress</u>		
Irrigation every 10 days	169.93 b	189.81 b
Irrigation every 15 days	173.04 a	197.50 a
Irrigation every 20 days	163.97 c	188.25 b
LSD _{0.05}	1.35	1.67
<u>Maize hybrid</u>		
SC.166	163.93 b	186.68 b
SC.168	172.44 a	194.88 a
TWC352	170.56 a	194.01 a
LSD _{0.05}	3.04	3.61
<u>Humic acid (kg/ha.)</u>		
0	158.22 c	181.35 c
7.2	169.11 b	191.62 b
14.4	179.59 a	202.59 a
LSD _{0.05}	1.88	2.43
<u>Interactions</u>		
Water stress × Maize hybrid	**	**
Water stress × Humic acid	**	**
Maize hybrid x Humic acid	**	N.S.
Water stress × Maize hybrid x Humic acid	**	**

- Mean values in the same column marked with the same letters are not significantly different at 0.05 level of probability.
- *, **: significant at 0.05 level of probability.
- N.S. : not significant.

Table (4). Interaction between water stress and three maize hybrids on plant height (cm) during 2013 and 2014 seasons.

Plant height at harvest (cm)				
Treatments			Season	
			2013	2014
Water stress	Maize hybrid			
Irrigation every 10 days	SC.166.		166.22	186.44
	SC.168.		178.56	198.05
	TWC352.		165.00	184.96
Irrigation every 15 days	SC.166.		167.00	190.90
	SC.168.		174.56	198.46
	TWC352.		177.56	203.14
Irrigation every 20days	SC.166.		158.57	182.70
	SC.168.		164.22	188.12
	TWC352.		169.11	193.93
L. S. D. _{0.05}			5.27	6.26

Table (5). Interaction between water stress and humic acid on plant height (cm) of maize during 2013 and 2014 seasons

Plant height at harvest (cm)			
Treatments		Season	
		2013	2014
Water stress	Humic acid kg/ha.		
Irrigation every 10 days	0	157.67	178.46
	7.2	167.11	186.61
	14.4	185.00	204.38
Irrigation every 15 days	0	154.78	178.68
	7.2	178.22	202.36
	14.4	186.11	211.47
Irrigation every 20days	0	162.22	186.92
	7.2	162.01	185.91
	14.4	167.67	191.92
L. S. D. _{0.05}		3.25	4.21

Table (6). Interaction between maize hybrid and humic acid on plant height (cm) of maize during 2013 season

Plant height at harvest (cm)		
Treatments		Season
		2013
Maize hybrids	Humic acid kg/ha.	
SC.166.	0	149.89
	7.2	164.90
	14.4	177.00
SC.168.	0	163.76
	7.2	172.33
	14.4	181.22
TWC352.	0	161.00
	7.2	170.11
	14.4	180.56
L. S. D. _{0.05}		3.249

Table (7). Interaction between water stress and humic acid on plant height (cm) of three maize hybrids during 2013 and 2014 seasons

Plant height at harvest (cm)							
Treatments		Season					
		2013			2014		
		Humic acid kg/ha.					
Water stress	Maize hybrids	0	7.2	14.4	0	7.2	14.4
Irrigation every 10 days	SC.166.	152.33	159.67	186.67	176.60	178.05	204.67
	SC.168.	172.00	177.33	186.33	190.72	197.05	206.38
	TWC352.	148.67	164.33	182.00	168.05	184.72	202.10
Irrigation every 15 days	SC.166.	138.67	175.67	186.67	162.57	199.57	210.57
	SC.168.	164.66	175.33	184.00	188.23	199.23	207.9
	TWC352.	161.33	183.67	187.67	185.23	208.27	215.93
Irrigation every 20days	SC.166.	158.67	159.37	157.67	182.57	183.27	178.90
	SC.168.	155.00	164.33	173.33	178.90	188.23	197.23
	TWC352.	173.00	162.33	172.00	199.3	186.23	196.27
L. S. D. _{0.05}		5.627			7.285		

4.1.2. Leaf area index (LAI)

The effect of water stress, maize hybrid, humic acid rates and their interaction on leaf area index in 2013 and 2014 seasons are shown in Table (8).

The characterized data in Table (8) articulate the high influence of water stress on leaf area index (LAI) in both growing seasons. There are significant discrepancies between treatments of irrigation intervals on such character. Irrigation every 20 days produced the lowest values of leaf area index in both seasons.

Data in the same Table (8) exhibited that the differences between maize hybrids were not significant for leaf area index in both seasons. Similar results were obtained by **El-Karamity and Atta- Allah (1997)**.

On the other hand, **Ibrahim *et al.* (1992)** found significant differences in leaf area of five maize hybrids under different irrigation treatments. **Moursi (1997)** found that maize genotypes differed significantly in leaf area index.

The effect of humic acid treatments on leaf area index was significant in both seasons as shown from data in Table (8).

From obtained results, it could be observed that application of humic acid at 14.4 kg/ha., produced the highest value of leaf area index (5.23 and 5.21 cm²), while the lowest one was recorded from untreated (control) (4.38 and 4.12 cm²) in both seasons. Previous reports have shown the stimulatory effect of humic acid on physiological processes related to growth and productivity of maize. These results agree more or less with those obtained by **Rajpar *et al.* (2011)**, **Daur (2013)**, **Daur and Bakhawain (2013)**, **Osman *et al.* (2013)**.

All first and second order interactions between the studied factors had no significant effect on leaf area index in both seasons (Table, 8).

Table (8). Leaf area index of three maize hybrids as affected by water stress, humic acid and their interaction during 2013 and 2014 seasons

Leaf area index (LAI)		
Treatments	Season	
	2013	2014
<u>Water stress</u>		
Irrigation every 10 days	4.82 a	5.10 a
Irrigation every 15 days	4.99 a	4.51 b
Irrigation every 20 days	4.52 b	4.46 b
LSD _{0.05}	0.202	0.424
<u>Maize hybrids</u>		
SC.166.	4.76 a	4.74 a
SC.168.	4.81 a	4.73 a
TWC352.	4.76 a	4.60 a
LSD _{0.05}	0.235	0.416
<u>Humic acid (kg/ha.)</u>		
0	4.38 C	4.12 c
7.2	4.72 b	4.74 b
14.4	5.23 a	5.21 a
LSD _{0.05}	0.227	0.377
<u>Interactions</u>		
Water stress × Maize hybrid	N.S.	N.S.
Water stress × Humic acid	N.S.	N.S.
Maize hybrid x Humic acid	N.S.	N.S.
Water stress × Maize hybrid x Humic acid	N.S.	N.S.

- Mean values in the same column marked with the same letters are not significantly different at 0.05 level of probability.
- N.S.: not significant.

4.1.3. Dry matter accumulation (g)/plant

Dry matter accumulation at different sampling dates (55, 70 and 85 DAS) as affected by water stress, maize hybrids and humic acid are presented in Table (9).

Concerning the effect of irrigation intervals, dry matter accumulation per plant increased significantly with decreasing irrigation intervals at all sampling dates in both seasons, where irrigation every 15 days produced the highest dry matter at all sampling dates in the two growing seasons. Drought decreased photosynthetic rate and water potentials in leaves flower and grains, a low availability of current and reverse photosynthetic rate and disrupt carbohydrates metabolism in leaves (Kim *et al.*, 2000). Similar results were obtained by Ibrahim *et al.* (1992), Atta- Allah (1996), Rajpar *et al.* (2011) and (2013), Daur and Bakhshwain (2013), Osman *et al.* (2013)

Significant differences were found among the three tested hybrids for dry matter accumulation/plant in favor of S.C.168 hybrid at all sampling dates in the two seasons and without significant differences between S.C.168 and T.W.C.352 hybrids at the three sampling dates in the second season only.

The superiority of S.C.168 was interpreted as such hybrid had greater photosynthetic area (leaf area index), Table (9) which resulted in more photosynthesis production and consequently increased dry matter accumulation.

Application of humic acid resulted in a significant increase in dry matter accumulation/plant at all sampling dates in both seasons (Table, 9). However the application of humic acid at 14.4 kg/ha., gave the highest dry matter accumulation while the lowest one was produced by untreated (control) at all sampling dates in both seasons. This increase in dry matter accumulation by humic acid due to humic beneficial effect on soil structure, soil microbial population and increase modify mechanisms involved in plant growth stimulation by increasing elongation of the internodes reflecting increase in plant height (**Chen *et al.*, 1999**). These results were parallel with their reported by **Bakry *et al.* (2009)** and **Attia *et al.* (2012)**.

First order interaction between water stress X maize hybrids was significant for DM at two sampling dates 70 and 85 DAS in the first season only. The illustrated data in Table (10) bring into view that irrigation every 15 days of S.C.168 hybrid demonstrated the higher value of dry matter/plant at the second sampling date (135.98 g/plant). Also, irrigation every 10 days of S.C.168 hybrid gave the highest value of same character at third sampling date (211.49 g/plant) in 2013 season. The least value was achieved by irrigation every 20 days of T.W.C.352 hybrid (99.44 and 152.29 g/plant) at both sampling dates, respectively.

First order interaction between water stress X humic acid was significant for DM at three sampling dates 55, 70, and 85 DAS in the first season and at 55 DAS in the second season. The data in Table (11) stated that irrigation every 15 days with application of humic acid at 14.40 kg/ha., realizes the maximum DM at all sampling dates (88.11, 129.48 and 196.40 g/plant) in the first season and at the first sampling date (106.68 g/plant) in the second season, while the least value was achieved by irrigation every 20 days with untreated treatment (control) at all sampling dates (58.47, 90.28 and 136.13 g/plant) in 2013 season, respectively.

First order interaction between maize hybrid X humic acid was significant for DM at the first sampling dates (55 DAS) in the first season. The data in Table (12) indicate that S.C.168 hybrid with application of humic acid at 14.40 kg/ha., acquired the maximum DM accumulation at 55 DAS (89.44 g/plant) while the minimum DM was produced by S.C.166 hybrid with untreated (control) (58.83 g/plant) in 2013 season.

Second order interaction among water stress X maize hybrids x humic acid for DM accumulation was significant at the three sampling dates in the first season and at 55 DAS in the second season. The data in Table (14) display that irrigation every 15 days of S.C.168 hybrid with application of humic acid at 14.40 kg/ha., realized the highest DM accumulation at the three sampling dates (99.67, 174.00 and 260.88 g/plant) in 2013 season, whilst irrigation every 10 days of T.W.C.352 hybrid with application of humic acid at 14.40 kg/ha., gave the maximum DM accumulation (116.00 g/plant) at 55 DAS in 2014 season.

Table (9). Dry matter accumulation (g)/plant of three maize hybrids as affected by water stress, humic acid and their interaction during 2013 and 2014 seasons

Treatments	Dry matter accumulation (g)/plant					
	Season					
	2013			2014		
	55 DAS	70 DAS	85 DAS	55 DAS	70 DAS	85 DAS
<u>Water stress</u>						
Irrigation every 10 days	69.04 b	113.35 a	182.34 a	87.82 a	128.89 a	197.31 a
Irrigation every 15 days	79.15 a	118.42 a	180.41 a	87.62 a	123.63 a	188.23 a
Irrigation every 20 days	69.06 b	101.45 b	153.05 b	74.69 b	106.42 b	157.99 b
<u>Maize hybrids</u>						
SC.166	70.10 b	108.40 b	164.78 b	76.79 b	113.91 a	170.93 b
SC.168	79.22 a	121.26 a	186.43 a	85.15 a	122.69 a	191.65 a
TWC352	67.93 b	103.56 b	164.59 b	88.18 a	122.34 a	180.96 ab
<u>Humic acid (kg/ha.)</u>						
0.00	64.06 b	103.18 c	164.60 b	69.40 c	107.87 b	162.61 b
7.20	73.99 a	110.99 b	168.14 b	79.86 b	111.81 b	170.70 b
14.40	79.20 a	119.05 a	183.06 a	100.86 a	139.27 a	210.22 a
<u>Interactions</u>						
Water stress × Maize hybrid	N.S.	*	*	*	N.S.	N.S.
Water stress × Humic acid	**	**	**	**	N.S.	N.S.
Maize hybrid × Humic acid	*	N.S.	N.S.	N.S.	N.S.	N.S.
Water stress × Maize hybrid × Humic acid	*	**	**	**	N.S.	N.S.

- Mean values in the same column marked with the same letters are not significantly different at 0.05 level of probability.
- *, **: significant at 0.05 level of probability.
- N.S.: not significant.

Table (10). Interaction between water stress and three maize hybrids on dry matter accumulation (g)/plant at two periods 70 and 85 DAS during 2013 seasons

Dry matter accumulation (g)/plant			
Treatments		Season	
		2013	
Water stress	Maize hybrid	70 DAS	85 DAS
Irrigation every 10 days	SC.166	102.65	163.58
	SC.168	127.74	211.49
	TWC352	109.66	171.96
Irrigation every 15 days	SC.166	117.72	176.59
	SC.168	135.98	195.40
	TWC352	101.57	169.23
Irrigation every 20days	SC.166	104.84	154.17
	SC.168	100.07	152.39
	TWC352	99.44	152.59
L. S. D. _{0.05}		14.51	18.09

Table (11). Interaction between water stress and humic acid on Dry matter accumulation (g)/plant at 55 , 70 and 85 DAS of maize during 2013 and 2014 seasons

Dry matter accumulation (g)/plant					
Treatments		Season			
		2013			2014
		55 DAS	70 DAS	85 DAS	55 DAS
Water stress	Humic acid kg/ha.				
Irrigation every 10 days	0	65.54	108.41	166.37	80.98
	7.2	76.84	127.60	202.49	86.51
	14.4	64.72	104.04	178.17	95.97
Irrigation every 15 days	0	68.17	110.85	181.31	68.19
	7.2	81.18	114.94	163.51	87.99
	14.4	88.11	129.48	196.40	106.68
Irrigation every 20days	0	58.47	90.28	146.13	59.02
	7.2	63.93	90.43	138.41	65.09
	14.4	84.78	123.63	174.60	99.94
L. S. D. _{0.05}		12.10	13.29	17.65	9.67

Table (12). Interaction between maize hybrid and humic acid on Dry matter accumulation (g)/plant at 55 days sowing (DAS) of maize during 2013 season

Dry matter accumulation (g)/plant		
Treatments		Season
		2013
		55 DAS
Maize hybrids	Humic acid kg/ha.	
SC.166.	0	58.83
	7.2	68.37
	14.4	83.11
SC.168.	0	66.56
	7.2	81.66
	14.4	89.44
TWC352.	0	66.79
	7.2	71.93
	14.4	65.06
L. S. D. _{0.05}		12.09

Table (13). Interaction between water stress and humic acid on dry matter accumulation (g)/plant at 55, 70 and 85 DAS of three maize hybrids during 2013 and 2014 seasons

Seasons			Dry matter accumulation (g)/plant			
Treatments			Season			
			2013			2014
Water stress	Maize hybrids	Humic acid (kg/ha.)	55 DAS	70 DAS	85 DAS	55 DAS
Irrigation every 10 days	SC.166	0	49.33	88.14	134.85	81.97
		7.2	68.00	115.13	187.57	73.67
		14.4	66.00	104.67	168.33	87.67
	SC.168	0	80.17	135.00	214.03	88.83
		7.2	95.70	151.33	247.51	97.87
		14.4	66.00	96.90	172.93	84.23
	TWC352	0	67.13	102.08	150.23	72.13
		7.2	66.83	116.33	172.40	88.00
		14.4	62.17	110.57	193.23	116.00
Irrigation every 15 days	SC.166	0	66.33	127.93	208.03	50.90
		7.2	72.13	109.45	153.07	72.13
		14.4	95.33	115.78	168.67	103.00
	SC.168	0	69.17	107.81	159.54	74.67
		7.2	91.10	126.14	165.79	91.10
		14.4	99.67	174.00	260.88	104.00
	TWC352	0	69.00	96.81	176.37	79.00
		7.2	80.30	109.24	171.66	100.73
		14.4	69.33	98.67	159.67	113.03
Irrigation every 20days	SC.166	0	60.83	91.37	141.67	60.83
		7.2	64.97	91.37	140.50	64.97
		14.4	88.00	131.33	180.33	96.00
	SC.168	0	50.33	79.98	142.33	52.00
		7.2	58.17	87.15	134.66	61.30
		14.4	102.67	133.07	180.18	112.33
	TWC352	0	64.23	99.49	154.4	64.23
		7.2	68.67	92.33	140.07	69.00
		14.4	63.67	106.50	163.30	91.50
L. S. D. _{0.05}			20.96	23.01	30.56	16.74

4.1.4. Crop growth rate (CGR) (g/m²/day)

The data in Table (14) showed the impact of available water stress, maize hybrid, humic acid rates and their interactions on crop growth rate at two growth periods in both seasons.

Table (14) shows that crop growth rate (CGR) of maize plants was significantly affected by irrigation intervals at all growth periods in both seasons. Results indicate that decreasing irrigation intervals increased significantly CGR at all periods of growth in both seasons. Such trend may be due to the importance of water to the accumulation of dry matter or photosynthetic compounds. These results are in harmony with those obtained by **Hefni and El- Shabbagh (1993)** and **Atta- Allah (1996)**.

Results tabulated in Table (14) illustrate that maize hybrids differed significantly for CGR at two periods in the first season and (70 – 85 DAS) in the second. SC.168 hybrid gave the greatest CGR at (55 -70) and (70 – 85 DAS) in 2013 season and (70 – 85 DAS) in 2014 season where as without significant difference between S.C.168 and T.W.C.352 at (70 – 85 DAS) in the first season, respectively. Such effect reflects the superiority of S.C. 168 in dry matter accumulation as well as higher photosynthetic area through the growing season as mentioned above by **Ibrahim (1992)** and **El-Zeir et al. (1998)** who found varietal differences in CGR.

The crop growth rate was significantly affected by application of humic acid at (70 – 85 DAS) in 2013 season and two periods in 2014 season as shown in Table (14). Application of humic acid at 14.40 kg/ha., gave the highest CGR at the different growth periods in both seasons, whereas without significant difference between humic acid rates of 7.2 and 14.40 kg/ha., at (55-70 DAS) in the second season. Humic acid is one of the major components of humus. Humates are natural organic substances high in humic acid and containing most of known trace minerals. Also, trace minerals have a vital role in improve maize growth where it works as co- enzymes and as activators and enhanced amino acid formation, subsequently increased photosynthesis leading to high dry matter production (**Mayhew, 2004**).

First order interaction between water stress X maize hybrids for crop growth rate was significant at the two growth periods in the first season only (Table, 14). The described data in Table (15) elucidate that irrigation every 15 days of S.C.168 hybrid produced the upper most crop growth rate at first and second growth periods, respectively.

First order interaction between maize hybrids X humic acid for crop growth rate was significant at the two growth periods in the first season only (Table, 14). The depicted data in Table (16) indicate that S.C.166 hybrid with application of humic acid at 7.20 kg/ha., gained the maximum CGR in the two growth periods (3.63 and 5.35 g/day/m²), while the lowest CGR was attained by T.W.C.352 hybrid with humic acid application at 7.20 kg/ha. (1.89 and 3.43 g/day/m²) in both growth period in 2013 season.

First order interaction between water stress X humic acid was significant at 55 – 70 DAS in the second season only. The data in Table (17) show that irrigation every 10 days with 7.20 kg/ha., humic acid realized the maximum CGR at 55 – 70 DAS (3.44 g/day/m²). The lowest CGR in first period resulted from irrigation every 20 days and application of humic acid at 7.20 kg/ha. (1.77 g/day/m²).

Second order interaction among water stress X maize hybrid X humic acid rates for CGR was significant at the two growth periods in the first season only (Table, 14). The presented data in Table (18) manifest that the upper most CGR was obtained by irrigation every 15 days of S.C.168 hybrid and application of humic acid at 14.40 kg/ha., in the first and second growth periods (5.31 and 6.21 g/day/m²), respectively. The smallest CGR (1.69 and 3.41 g/day/m²) in the first and the second growth periods were produced by irrigation every 20 days of T.W.C.352 hybrid with application of humic acid at 7.20 kg/ha.

Table (14). Crop growth rate (CGR) (g/m²/day) at two periods 55 – 70, 70 – 85 DAS of three maize hybrids as affected by water stress, humic acid and their interaction during 2013 and 2014 seasons

Crop growth rate (CGR) g/m ² /day				
Treatments	Season			
	2013		2014	
	55 – 70 DAS	70 – 85 DAS	55 – 70 DAS	70 – 85 DAS
<u>Water stress</u>				
Irrigation every 10 days	3.17 a	4.93 a	2.93 a	4.89 a
Irrigation every 15 days	2.81 ab	4.43 ab	2.57 ab	4.61 a
Irrigation every 20 days	2.31 b	3.69 b	2.27 b	3.68 b
LSD _{0.05}	0.680	0.838	0.644	0.884
<u>Maize hybrids</u>				
SC.166	2.74 b	4.03 b	2.65 a	4.07 b
SC.168	3.00 a	4.65 a	2.68 a	4.93 a
TWC352	2.55 b	4.36 ab	2.44 a	4.19 b
LSD _{0.05}	0.218	0.355	0.5713	0.373
<u>Humic acid (kg/ha.)</u>				
0	2.79 a	4.39 ab	2.28 b	3.91 b
7.2	2.64 a	4.08 b	2.74 a	4.21 b
14.4	2.85 a	4.57 a	2.75 a	5.07 a
LSD _{0.05}	0.379	0.425	0.324	0.416
<u>Interactions</u>				
Water stress × Maize hybrid	**	**	N.S.	N.S.
Water stress × Humic acid	N.S	N.S.	*	N.S.
Maize hybrid x Humic acid	**	**	N.S.	N.S.
Water stress × Maize hybrid x Humic acid	**	**	N.S.	N.S.

- Mean values in the same column marked with the same letters are not significantly different at 0.05 level of probability.
- *, **: significant at 0.05 level of probability.
- N.S. : not significant.

Table (15). Interaction between water stress and three maize hybrids on crop growth rate (CGR) (g/m²/day) at the growth period 55 – 70, 70 – 85 DAS during 2013 season.

Crop growth rate (CGR) (g/m ² /day)			
Treatments		Season	
		2013	
Water stress	Maize hybrid	55 – 70 DAS	70 – 85 DAS
Irrigation every 10 days	SC.166	2.97	4.35
	SC.168	3.37	4.98
	TWC352	3.16	4.45
Irrigation every 15 days	SC.166	2.84	4.20
	SC.168	3.52	5.24
	TWC352	2.05	4.83
Irrigation every 20days	SC.166	2.40	3.52
	SC.168	2.12	3.73
	TWC352	2.42	3.80
L. S. D. _{0.05}		0.378	0.615

Table (16). Interaction between water stress and humic acid on Crop growth rate (CGR) (g/m²/day) at the growth period 55 – 70, 70 – 85 DAS of maize during 2013 season

Crop growth rate (CGR) (g/m ² /day)			
Treatments		Season	
		2013	
Maize hybrid	Humic acid kg/ha.	55 – 70 DAS	70 – 85 DAS
SC.166	0	3.06	4.14
	7.2	3.63	5.35
	14.4	2.81	5.29
SC.168	0	3.05	5.03
	7.2	2.41	3.47
	14.4	2.96	4.78
TWC352	0	2.27	3.99
	7.2	1.89	3.43
	14.4	2.77	3.64
L. S. D. _{0.05}		0.6570	0.737

Table (17). Interaction between water stress and humic acid on Crop growth rate (CGR) (g/m²/day) at growth period (55 – 70 DAS) of maize during 2014 season

Crop growth rate (CGR) (g/m ² /day)		
Treatments		Season
		2014
Water stress	Humic acid kg/ha.	55 -70 DAS
Irrigation every 10 days	0	2.58
	7.2	2.79
	14.4	3.44
Irrigation every 15 days	0	2.78
	7.2	2.29
	14.4	2.65
Irrigation every 20days	0	2.88
	7.2	1.77
	14.4	2.15
L. S. D. _{0.05}		0.561

Table (18). Interaction between water stress and humic acid on crop growth rate (CGR) (g/m²/day) at the growth period 55 – 70, 70 – 85 DAS of three maize hybrids during 2013 season.

2013 season.				
Treatments		Crop growth rate (CGR) g/m ² /day		
		Season		
Water stress	Maize hybrids	2013		
		Humic acid (kg/ha.)	55 – 70 DAS	70 – 85 DAS
Irrigation every 10 days	SC.166	0	2.78	3.34
		7.2	3.37	5.17
		14.4	2.76	4.55
	SC.168	0	3.92	5.65
		7.2	3.97	6.87
		14.4	2.21	5.43
	TWC352	0	2.50	3.43
		7.2	3.54	4.01
		14.4	3.46	5.90
Irrigation every 15 days	SC.166	0	4.40	5.72
		7.2	2.67	3.12
		14.4	1.46	3.78
	SC.168	0	2.76	3.69
		7.2	2.50	2.83
		14.4	5.31	6.21
	TWC352	0	1.99	5.68
		7.2	2.07	4.46
		14.4	2.10	4.36
Irrigation every 20days	SC.166	0	2.18	3.59
		7.2	1.92	3.48
		14.4	3.10	3.50
	SC.168	0	2.12	4.45
		7.2	2.07	3.39
		14.4	2.17	3.36
	TWC352	0	2.52	3.92
		7.2	1.69	3.41
		14.4	3.06	4.06
L. S. D. _{0.05}			1.28	1.88

4.1.5. Relative growth rate (RGR) (g/g/week)

The data in Table (19) show the effect of water stress, maize hybrids, humic acid and their interaction on relative growth rate at two growth periods in both seasons.

Data in Table (19) indicate that irrigation intervals had no significant effect on RGR at 55 – 70 DAS in the first season and the two growth periods in the second season at 70 – 85 DAS in the first season only. RGR was reduced with increasing irrigation intervals at 70 -85 DAS in 2013 season. It is noticeable that relative growth rate does not decrease to considerable extent at 70 – 85 DAS in the first season.

RGR was significantly influenced due to maize hybrids at 70 – 85 DAS, in the first season and the two growth periods in the second season (Table, 19).

Application of humic acid rates resulted no significant increase in RGR at (70 – 85 DAS) in the first season and at (55 – 70 DAS) in the second season (Table, 19). Treated plant with humic acid at 14.40 kg/ha., recorded the highest RGR value, while the lowest one was produced by untreated (control) at (70 – 85 DAS) in 2013 season and at (55 – 70 DAS) in 2014 season, respectively. At (70 – 85 DAS) in 2013 season there was no significant difference between 7.20 and 14.40 kg/ha., humic acid.

First order interaction between water stress X maize hybrids for RGR was significant at the second growth period in the first season only. The data in Table (20) show that irrigation every 10 days of S.C.168 hybrid realized the highest RGR.

First order interaction between water stress X humic acid rates for RGR was significant at the second period (70 – 80 DAS) in the first season 2013 only (Table, 19). The data in Table (21) show that the highest value of RGR was achieved by irrigation every 10 days and humic acid application of 14.40 kg/ha., while the least RGR was produced by irrigation every 20 days and application of HA at 14.40 kg/ha.

First order interaction between maize hybrid X humic acid rate for RGR was significant at the first growth period (55 – 70 DAS) in the first season 2013 only (Table, 19). The data in Table (22) show that the highest value of RGR was produced by S.C.166 hybrid with 0 kg/ha., humic acid at (0.1192 g/g/week) in 2013 season.

Second order interaction among water stress X maize hybrids x humic acid for RGR was significant at the first growth period in both seasons (Table, 19). The described data in Table (23) indicate that irrigation every 15 days of SC.166 hybrid with untreated (control) gave the highest value of RGR (0.1428 and 0.1419 g/g/week) in the first and second seasons, respectively.

Table (19). Relative growth rate (RGR) (g/g/week) at growth period 55 – 70, 70 – 85 DAS of three maize hybrids as affected by water stress, humic acid and their interaction during 2013 and 2014 seasons

Relative growth rate (RGR) (g/g/week)				
Treatments	Season			
	2013		2014	
	55 – 70 DAS	70 – 85 DAS	55 – 70 DAS	70 – 85 DAS
<u>Water stress</u>				
Irrigation every 10 days	0.1089 a	0.1030a	0.0842 a	0.0921 a
Irrigation every 15 days	0.0879 a	0.0921ab	0.0782 a	0.0917 a
Irrigation every 20 days	0.0861 a	0.0911 b	0.0806 a	0.0864 a
LSD _{0.05}	0.0255	0.0115	0.0188	0.01335
<u>Maize hybrids</u>				
SC.166	0.0964 a	0.0911 b	0.0875 a	
SC.168	0.0930 a	0.0947 ab	0.0824 ab	0.0872 b
TWC352	0.0936 a	0.1003 a	0.0731 b	0.0852 b
LSD _{0.05}	0.0111	0.0083	0.0136	0.0069
<u>Humic acid (kg/ha.)</u>				
0	0.1040 a	0.0895 b	0.07007	0.0882 a
7.2	0.0890 a	0.0947 ab	b	0.0921 a
14.4	0.0901 a	0.1017 a	0.0741 b	0.0898 a
LSD _{0.05}	0.0145	0.0084	0.0988 a	0.0075
			0.0099	
<u>Interactions</u>				
Water stress × Maize hybrid	N.S.	**	N.S.	N.S.
Water stress × Humic acid	N.S.	*	N.S.	N.S.
Maize hybrid x Humic acid	*	N.S.	N.S.	N.S.
Water stress × Maize hybrid x Humic acid	*	N.S.	**	N.S.

- Mean values in the same column marked with the same letters are not significantly different at 0.05 level of probability.
- *, **: significant at 0.05 level of probability.
- N.S.: not significant.

Table (20). Interaction between water stress and three maize hybrid on relative growth rate (RGR) (g/g/week) at growth period 70 – 85 DAS during 2013 season

Relative growth rate (RGR) (g/g/week)		
Treatments		Season
		2013
		70 – 85 DAS
Water stress	Maize hybrid	
Irrigation every 10 days	SC.166	0.1001
	SC.168	0.1112
	TWC352	0.0971
Irrigation every 15 days	SC.166	0.0870
	SC.168	0.0784
	TWC352	0.1109
Irrigation every 20days	SC.166	0.0857
	SC.168	0.0947
	TWC352	0.0931
L. S. D. _{0.05}		0.0144

Table (21). Interaction between water stress and humic acid on relative growth rate (RGR) (g/g/week) at the growth period 70 – 85 DAS of maize during 2013 season

Relative growth rate (RGR) (g/g/week)		
Treatments		Season
		2013
		70 – 85 DAS
Water stress	Humic acid kg/ha.	
Irrigation every 10 days	0	0.0931
	7.2	0.0991
	14.4	0.1168
Irrigation every 15 days	0	0.1071
	7.2	0.0769
	14.4	0.0922
Irrigation every 20days	0	0.1048
	7.2	0.0924
	14.4	0.0761
L. S. D. _{0.05}		0.0145

Table (22). Interaction between maize hybrid and humic acid on relative growth rate (RGR) (g/g/week) at the growth period 55 – 70 DAS of maize during 2013 and 2014 seasons

Relative growth rate (RGR) (g/g/week)		
Treatments		Season
		2013
		55 – 70 DAS
Maize hybrids	Humic acid kg/ha.	
SC.166.	0	0.1192
	7.2	0.0933
	14.4	0.0766
SC.168.	0	0.1039
	7.2	0.0877
	14.4	0.0876
TWC352.	0	0.0888
	7.2	0.0859
	14.4	0.1061
L. S. D. _{0.05}		0.0252

Table (23). Interaction between water stress and humic acid on Relative growth rate (RGR) (g/g/week) at the growth period 55 – 70 DAS of three maize hybrids during 2013 and 2014 seasons.

Relative growth rate (RGR) g/g/week				
Treatments			Season	
			2013	2014
Water stress	Maize hybrids	Humic acid (kg/ha.)	55 – 70 DAS	
Irrigation every 10 days	SC.166	0	0.1255	0.0643
		7.2	0.1147	0.1027
		14.4	0.0999	0.0989
	SC.168	0	0.1122	0.0642
		7.2	0.1004	0.0637
		14.4	0.0837	0.0975
	TWC352	0	0.0989	0.1166
		7.2	0.1205	0.0796
		14.4	0.1252	0.0704
Irrigation every 15 days	SC.166	0	0.1428	0.1419
		7.2	0.0890	0.0815
		14.4	0.04207	0.0606
	SC.168	0	0.0986	0.091
		7.2	0.0708	0.0685
		14.4	0.1220	0.0841
	TWC352	0	0.0732	0.0722
		7.2	0.0723	0.0550
		14.4	0.0807	0.0482
Irrigation every 20days	SC.166	0	0.0895	0.1089
		7.2	0.076	0.0637
		14.4	0.0877	0.0650
	SC.168	0	0.1008	0.1283
		7.2	0.0917	0.0887
		14.4	0.0572	0.0548
	TWC352	0	0.0943	0.1009
		7.2	0.0650	0.0640
		14.4	0.1125	0.0512
L. S. D. 0.05			0.0436	0.0297

4.1.6. Total chlorophyll content (mg/m²)

The data in Table (24) show the effect of water stress, maize hybrid, humic acid and their interactions on total chlorophyll content in both seasons.

Results of analysis of variance at 2013 and 2014 seasons are presented in Table (24) indicated clearly that photosynthetic pigments of maize leaves were affected significantly by irrigation treatments in both seasons. Total chlorophyll content reached its maximum concentration using irrigation every 10 days and the lowest concentration was obtained by irrigation every 20 days in 2013 and 2014 seasons whereas without significant differences between irrigation every 10 and 15 days in the first seasons.

The lower concentration of chlorophyll under water stress conditions might be attributed to low rate of synthesizing photo- chrome under such conditions. These results are in harmony with those reported by **Jun-Chen and Dai-Junying (1996)**, and **Ghalichechi et al. (2012)**. Also, **Soltani et al. (2013)** showed that water deficit stress led to significant decrement of chlorophyll content in examined cultivars.

Regarding maize hybrids results presented in Table (24) for 2013 season indicated that T.W.C.352 hybrid gave the highest total chlorophyll content while S.C.168 hybrid gave the highest value of chlorophyll content in 2014 season as compared to S.C.166 hybrid in both seasons. Similar trend was reported by **Attia (1999)**.

The obtained data revealed that the effect of humic acid rates on total chlorophyll content in maize leaves was significant as shown from in Table (24). Application of the highest rate of humic acid (14.40 kg/ha.) produced the highest value of chlorophyll content. However, the lowest value of chlorophyll content was obtained by control (0.00 kg/ha.) in both cropping seasons. The increase in total chlorophyll due to adding the highest rate of humic acid may be due to that humic acid contains macro- and micro- nutrients which fix and release photohormones (**Chen et al., 2007**).

First order interaction between water stress X maize hybrids for total chlorophyll was significant in both seasons. The data in Table (25) show that irrigation every 10 days with SC.166 realized the highest chlorophyll mg/m² in the first season and irrigation every 10 days with SC.168 gave the highest chlorophyll in the second season, respectively.

First order interaction between water stress and humic acid rates for total chlorophyll was significant in both seasons. The data in Table (26) show the highest value of total chlorophyll was achieved by irrigation every 10 days with application of humic acid 14.40 kg/ha., in both seasons.

First order interaction between maize hybrids X humic acid was not significant for total chlorophyll content in both growing seasons.

Second order interaction among water stress and hybrids and humic acid for total of chlorophyll content was significant in both seasons (Table, 24). The described data in Table (27) indicate that irrigation every 10 days of SC.168 hybrid with application of humic acid at 14.40 kg/ha., gave the highest value of total chlorophyll content without significant differences from the combination among irrigation every 10 days and SC.166 hybrid and application of humic acid at 14.40 kg/ha., in both seasons.

Table (24). Total chlorophyll content of three maize hybrids as affected by water stress, humic acid and their interaction during 2013 and 2014 seasons

Total chlorophyll content (mg/m ²)		
Treatments	Season	
	2013	2014
<u>Water stress</u>		
Irrigation every 10 days	168.39 a	184.59 a
Irrigation every 15 days	163.85 a	164.46 b
Irrigation every 20 days	144.91 b	163.09 b
LSD _{0.05}	13.23	7.51
<u>Maize hybrids</u>		
SC.166.	154.36 b	153.09 c
SC.168.	158.52 ab	183.50 a
TWC352.	164.27 a	175.55 b
LSD _{0.05}	8.89	6.66
<u>Humic acid (kg/ha.)</u>		
0	136.54 b	133.04 c
7.2	149.02 b	166.58 b
14.4	191.59 a	212.52 a
LSD _{0.05}	15.84	9.72
<u>Interactions</u>		
Water stress × Maize hybrid	**	**
Water stress × Humic acid	*	**
Maize hybrid x Humic acid	N.S.	N.S.
Water stress × Maize hybrid x Humic acid	*	N.S.

- Mean values in the same column marked with the same letters are not significantly different at 0.05 level of probability.
- *, **: significant at 0.05 level of probability.
- N.S. : not significant.

Table (25). Interaction between water stress and three maize hybrid on total chlorophyll content during 2013 and 2014 seasons

Total chlorophyll content (mg/m ²)			
Treatments		Season	
		2013	2014
Water stress	Maize hybrid		
Irrigation every 10 days	SC.166	189.08	163.08
	SC.168	151.59	216.67
	TWC352	164.50	174.02
Irrigation every 15 days	SC.166	149.66	145.98
	SC.168	163.96	166.31
	TWC352	177.92	176.99
Irrigation every 20days	SC.166	124.33	150.22
	SC.168	160.02	167.50
	TWC352	150.38	175.65
L. S. D. _{0.05}		15.41	11.54

Table (26). Interaction between water stress and humic acid on total chlorophyll content of maize during 2013 and 2014 seasons

Total chlorophyll content (mg/m ²)			
Treatments		Season	
		2013	2014
Water stress	Humic acid kg/ha.		
Irrigation every 10 days	0	147.09	128.45
	7.2	138.48	185.77
	14.4	219.61	239.56
Irrigation every 15 days	0	138.73	130.27
	7.2	161.89	158.52
	14.4	190.92	200.48
Irrigation every 20days	0	123.80	140.40
	7.2	146.70	155.45
	14.4	164.23	197.52
L. S. D. _{0.05}		27.44	16.84

Table (27). Interaction between water stress and humic acid on total chlorophyll content (mg/m²) of three maize hybrids during 2013 season

Total chlorophyll content (mg/m ²)				
Treatments		Season 2013		
		Humic acid kg/ha.		
Water stress	Maize hybrids	0	7.2	14.4
Irrigation every 10 days	SC.166	167.02	177.43	222.80
	SC.168	147.22	79.93	227.62
	TWC352	127.04	158.07	208.40
Irrigation every 15 days	SC.166	130.55	149.54	168.90
	SC.168	125.07	163.37	203.43
	TWC352	160.56	172.76	200.44
Irrigation every 20days	SC.166	80.67	134.42	157.90
	SC.168	150.70	166.46	162.90.
	TWC352	140.04	139.22	171.87
L. S. D. _{0.05}		47.519		

4.2. Yield and yield components

4.2.1. Ear length (cm)

Presented data in Table (28) show the effect of water stress, maize hybrid, humic acid and their interaction on ear length during 2013 and 2014 seasons.

Results of Table (28) show that water stress had a significant effect on ear length in the two seasons. The highest mean values of ear length were obtained by irrigation every 10 days as compared with the other irrigation treatments in the two growing seasons. These results reveal that increasing water stress resulted in a significant effect on maize growth which was reflected on yield attributes of maize plants (**Abdel- Aziz and El-Bialy, 2004**). The results are in accordance with those obtained by **Ibrahim et al. (1992)**, **Salem (1993)** and **Atta- Allah (1996)**.

On the other hand, **El- Sayed (1998)** found that ear length was not significantly affected by irrigation intervals.

Regarding maize hybrids the results in Table (28) indicated that T.W.C.352 gave the tallest ear length, across all water stress treatments as compared to the other maize hybrids in both seasons.

Mean of ear length for the three maize hybrids i.e., SC.166, SC. 168 and TWC.352 were 15.14, 15.95 and 17.51 cm as average of the two seasons, respectively. SC.166 hybrid had the shortest ear length in both seasons (13.55 and 16.75 cm). Ear length is an indication of the number of kernels/row and number of kernels/ear which considered among the major yield components. Similar results was reported by **Atta- Allah (1996)**.

Moursi (1997) found that genotypes differed significantly under water stress for ear length.

The obtained data revealed that the effect of humic acid rates was significant on ear length in both seasons (Table, 28). However, application of Humic acid 14.40 kg/ha., produced the highest value of ear length (15.90 and 19.39 cm) while 0.00 kg HA/ha., was accompanied with the least value of ear length (13.14 and 16.57 cm) in both season. The findings are in coincidence with those reported by **Chen et al. (2007)**, **Bakry et al. (2009)** and **Attia et al. (2012)**.

First order interaction between maize hybrids X humic acid rates for ear length was significant in the first season only (Table, 28). The data in Table (29) show that the highest value of ear length was produced by TWC.352 hybrid with application of humic acid at 14.40 kg/ha., (16.81 cm), while the lowest one was recorded for SC.168 hybrid plus control (0.00 kg HA/ha.) in 2013 season.

All other interactions between or among the studied factors had no significant effect on ear length in both seasons (Table, 28).

Table (28). Ear length (cm) of three maize hybrids as affected by water stress, humic acid and their interaction during 2013 and 2014 seasons

Ear length (cm)		
Treatments	Season	
	2013	2014
<u>Water stress</u>		
Irrigation every 10 days	16.91 a	20.37 a
Irrigation every 15 days	13.36 b	16.67 b
Irrigation every 20 days	13.18 b	16.59 b
LSD _{0.05}	1.040	1.075
<u>Maize hybrids</u>		
SC.166	13.55 b	16.73 b
SC.168	14.24 b	17.65 b
TWC352	15.66 a	19.26 a
LSD _{0.05}	0.9781	1.0402
<u>Humic acid (kg/ha.)</u>		
0	13.14 c	16.57 c
7.2	14.41 b	17.69 b
14.4	15.90 a	19.39 a
LSD _{0.05}	0.9146	0.8823
<u>Interactions</u>		
Water stress × Maize hybrid	N.S.	N.S.
Water stress × Humic acid	N.S.	N.S.
Maize hybrid x Humic acid	*	N.S.
Water stress × Maize hybrid x Humic acid	N.S.	N.S.

- Mean values in the same column marked with the same letters are not significantly different at 0.05 level of probability.
- *: significant at 0.05 level of probability.
- N.S.: not significant.

Table (29). Interaction between maize hybrid and humic acid on ear length (cm) of maize during 2013 season

Cob length (cm)		
Treatments		Season
		2013
Maize hybrids	Humic acid kg/ha.	
SC.166.	0	12.89
	7.2	13.61
	14.4	14.17
SC.168.	0	12.67
	7.2	13.33
	14.4	16.72
TWC352.	0	13.89
	7.2	16.28
	14.4	16.81
L. S. D. _{0.05}		1.584

4.2.2. Number of kernels/row

Data in Table (30 and 31) presented the effect of water stress, maize hybrid, humic acid and their interaction on number of kernels/row during 2013 and 2014 seasons.

Data in Table (30) revealed significant effect on number of kernels per row due to different irrigation treatments in the second season only.

In 2014 season the lowest number of kernels per row was given by irrigation every 15 days. No significant difference was found between irrigation every 20 days and every 10 days. In 2013 season the mean number of kernels per row was not significant due to all irrigation intervals. These results may be due to the abortion of some flowers as result of relationship between water stress via irrigation every 15 days and different physiological processes that occurs in the plant.

Results also indicated that TWC.352 had the higher number of kernels/row i.e., 25.38 and 31.01 kernels in the two successive seasons, followed by S.C.168 (22.06 and 27.29 kernels). S.C. 166 had the lowest number of kernels/row of 21.09 and 26.78 kernels in both seasons, respectively. These results are in agreement with those of **Ibrahim *et al.* (1992), and Moursi (1997)** found that number of kernels/row was significantly reduced in maize varieties under different irrigation treatments.

The effect of humic acid treatments on number of kernels/row was significant in both seasons as shown in Table (30). The highest value of number of kernels/row was produced by application humic acid at 14.40 kg/ha. (24.99 and 30.82 kernels) while the lowest value of number kernels/row resulted from untreated (control) treatment (21.51 and 27.80 kernels) in both seasons. Similar results were obtained by **Mayhew (2004)**.

First order interaction between water stress X humic acid for number of kernels/row was significant in the second season only (Table, 31). The data in Table (31) show that the highest value of number kernels/row was produced by irrigation every 15 days with application of humic acid at 14.40 kg/ha. (31.74 kernels), also without significant differences from the combination of irrigation every 20 days with application of humic acid at 14.40 kg/ha. (31.55 kernels).

Second order interaction among water stress and maize hybrids and humic acid rates on number of kernels/row was significant in both seasons (Table, 31). Data presented in Table (32) show that the highest value of number of kernels/row were produced by irrigation every 20 days and TWC352 hybrid with untreated (control) treatment (30.25 and 39.20 kernels) while the lowest one was obtained by irrigation every 15 days and SC.166 hybrid with untreated treatment (control) (16.62 and 22.19 kernels) in both seasons.

The rest of interactions were not significant in both seasons, as shown in Table (30)

Table (30). Number of kernels/row of three maize hybrids as affected by water stress, humic acid and their interaction during 2013 and 2014 seasons

Number of kernels/row		
Treatments	Season	
	2013	2014
<u>Water stress</u>		
Irrigation every 10 days	23.28 a	28.75 ab
Irrigation every 15 days	23.07 a	26.81 b
Irrigation every 20 days	22.18 a	29.53 a
LSD _{0.05}	1.223	2.266
<u>Maize hybrids</u>		
SC.166.	21.09 b	26.78 b
SC.168.	22.06 b	27.29 b
TWC352.	25.38 a	31.01 a
LSD _{0.05}	1.264	1.572
<u>Humic acid (kg/ha.)</u>		
0	21.51 b	27.80 b
7.2	22.01 b	26.46 b
14.4	24.99 a	30.82 a
LSD _{0.05}	1.593	2.061
<u>Interactions</u>		
Water stress × Maize hybrid	N.S.	N.S.
Water stress × Humic acid	N.S.	*
Maize hybrid x Humic acid	N.S.	N.S.
Water stress × Maize hybrid x Humic acid	*	**

- Mean values in the same column marked with the same letters are not significantly different at 0.05 level of probability.
- *, **: significant at 0.05 level of probability.
- N.S. : not significant.

Table (31). Interaction between water stress and humic acid on number of kernels/row of maize during 2014 season

Number of kernels/row		
Treatments		Season
		2014
Water stress	Humic acid kg/ha.	
Irrigation every 10 days	0	28.74
	7.2	28.31
	14.4	29.19
Irrigation every 15 days	0	24.99
	7.2	23.79
	14.4	31.74
Irrigation every 20days	0	29.28
	7.2	27.28
	14.4	31.55
L. S. D. _{0.05}		3.57

Table (32). Interaction between water stress and humic acid on Number of kernels/row of three maize hybrids during 2013 and 2014 seasons

Number of kernels/row							
Treatments		Season					
		2013			2014		
		Humic acid kg/ha.					
Water stress	Maize hybrids	0	7.2	14.4	0	7.2	14.4
Irrigation every 10 days	SC.166.	22.14	22.71	20.84	29.25	24.66	25.63
	SC.168.	22.79	22.19	24.32	30.23	28.16	29.97
	TWC352.	20.82	25.58	28.15	26.75	32.11	31.96
Irrigation every 15 days	SC.166.	16.62	19.07	21.53	22.19	24.56	26.52
	SC.168.	19.43	23.00	23.38	27.74	24.74	24.81
	TWC352.	23.22	22.00	31.33	27.77	22.00	41.23
Irrigation every 20days	SC.166.	20.99	21.65	24.22	27.77	28.56	31.58
	SC.168.	17.41	19.13	26.86	22.93	24.40	33.83
	TWC352.	30.25	22.79	24.32	39.20	28.87	29.23
L. S. D. _{0.05}		4.78			6.18		

4.2.3. Number of rows/ear

The effect of water stress, maize hybrids, humic acid and their interaction on number of rows/ear in 2013 and 2014 seasons are shown in Table (33).

Data in Table (33) revealed significant differences in number of rows/ear due to irrigation treatments in both seasons of the study. However irrigation every 10 days gave the highest number of rows/ear (14.13 and 11.93 rows), while the lowest one was obtained by irrigation every 20 days and without significant differences between irrigation every 10 days and 15 days in both seasons. This significant effect was previously observed in ear length. These results are in accordance with those reported by **Ibrahim et al. (1992)** , **Atta- Allah (1996)**, and **Smuel et al. (2006)**. On the other hand, Salem (1993) and **El- Sayed (1998)** found irrigation intervals were without any significant effect on number of rows/ear in both seasons.

Data in the same Table (33) exhibited that the differences among maize hybrids were not significant on the number of rows/ear in both seasons. On the other hand **Ibrahim et al. (1992)** found significant differences among five maize varieties under different irrigation treatments in number of rows/ear. Also, **Moursi (1997)** found that maize genotypes differed significantly under water stress in number of rows/ear.

Results in Table (33) show that the effect of humic acid rates on number of rows/ear was significant in both seasons. Humic acid application at 7.20 kg/ha., gave the highest number of rows/ear (14.18 and 11.98 rows). No significant differences was found between humic acid at 7.20 and 14.40 kg/ha., in both seasons, while the lowest value of number rows/ear was produced by untreated (control) (12.56 and 10.36 rows) in both seasons. In general application of humic acid increased growth indicators over control treatments. Results indicated that the application of HA. Significantly increased number of rows/ear. Previous reports have shown stimulatory effects of humic substance on physiological process related to growth and production of maize (**Balbua and Awad 2013**).

All interactions between or among the studied factors had no significant effect on number of rows/ear in both seasons (Table, 33).

Table (33). Number of rows/ear of three maize hybrids as affected by water stress, humic acid and their interaction during 2013 and 2014 seasons

Number of rows/ear		
Treatments	Season	
	2013	2014
<u>Water stress</u>		
Irrigation every 10 days	14.13 a	11.93 a
Irrigation every 15 days	13.77 a	11.57 a
Irrigation every 20 days	12.96 b	10.76 b
LSD _{0.05}	0.612	0.612
<u>Maize hybrids</u>		
SC.166.	13.47 a	11.27 a
SC.168.	13.70 a	11.50 a
TWC352.	13.70 a	11.49 a
LSD _{0.05}	0.551	0.550
<u>Humic acid (kg/ha.)</u>		
0	12.56 b	10.36 b
7.2	14.18 a	11.98 a
14.4	14.13 a	11.93 a
LSD _{0.05}	0.856	0.856
<u>Interactions</u>		
Water stress × Maize hybrid	N.S.	N.S.
Water stress × Humic acid	N.S.	N.S.
Maize hybrid x Humic acid	N.S.	N.S.
Water stress × Maize hybrid x Humic acid	N.S.	N.S.

- Mean values in the same column marked with the same letters are not significantly different at 0.05 level of probability.
- N.S. : not significant at 0.05 level of probability.

4.2.4. Number of kernels/ear

Data in Table (34) presented the effect of water stress, maize hybrid, humic acid rates and their interaction on number of kernels/ear during two seasons.

Data in Table (34) revealed significant differences in number of kernels per ear due to irrigation treatments in both seasons of the study. Irrigation every 10 days produced higher number of kernels/ear in two seasons. There were no significant differences between irrigation every 10 and 15 days in both seasons. Otherwise, irrigation every 20days caused a marked reduction in number of kernel/ear. These results are in accordance with those reported by **Ibrahim et al. (1992) and Saleh (1999)**.

On the other hand, **El- Sayed (1998)** found that irrigation interval was without any significant effect on number of kernels/ear in both seasons.

Results also indicated significant difference between maize hybrids was significant on number of kernels/ear in both seasons (Table, 35). TWC.352 hybrid

had the highest number of kernels/ear (347.48 and 370.37 kernels) in the two successive seasons followed by S.C.168 (292.52 and 311.59 kernels). The S.C.166 hybrid had the lowest number of kernels/ear of 278.30 and 299.22 kernels in both seasons, respectively. These results are in agreement with those of **Ibrahim et al. (1992) and Moursi (1997)** who found that number of kernels/ear was significantly reduced in maize varieties under different irrigation treatments.

The obtained results indicated that number of kernels /ear was significantly affected by humic acid rates as shown in Table (34). The highest value of number of kernels/ear was obtained by treating soil with the highest rate of humic acid (14.40 kg/ha., followed by using the intermediate rate of humic acid (7.20 kg/ha.) in both seasons, while the lowest value of number of kernels/ear resulted from untreated (control) in both seasons. These findings are in coincidence with those recorded by **Chen et al. (1999), Bakry et al. (2009) and Attia et al. (2012)**.

First order interaction between water stress X humic acid rates for number of kernels/ear was significant in both seasons (Table, 34). Irrigation every 10 days gave the highest value of number of kernels/ear with the application of humic acid at 14.40 kg/ha. (380.0 and 402.0 kernels) while the lowest one was produced by irrigation every 15 days with untreated control (252.78 and 269.22 kernels) in 2013 and 2014 seasons, respectively (Table, 35).

Second order interaction among water stress X maize hybrids X humic acid rates was significant for number of kernels/ear in both seasons (Table, 34). Data in Table (36) indicate that irrigation every 10 days and TWC352 hybrid with application of humic acid at the rate 14.40 kg/ha., gave the highest number of kernels/ear (427.67 and 451.67 kernels) while the lowest number of kernels per ear was achieved by irrigation every 15 days of S.C.166 hybrid with untreated control (205.33 and 225.33 kernels)

Table (34). Number of kernels/ear of three maize hybrids as affected by water stress, humic acid and their interaction during 2013 and 2014 seasons

Number of kernels/ear		
Treatments	Season	
	2013	2014
<u>Water stress</u>		
Irrigation every 10 days	325.44 a	347.11 a
Irrigation every 15 days	298.07 b	318.63 b
Irrigation every 20 days	294.78 b	315.44 b
LSD _{0.05}	15.29	13.28
<u>Maize hybrids</u>		
SC.166.	278.30 c	299.22 b
SC.168.	292.52 b	311.59 b
TWC352.	347.48 a	370.37 a
LSD _{0.05}	13.75	13.101
<u>Humic acid (kg/ha.)</u>		
0	268.74 c	287.44 c
7.2	299.00 b	320.15 b
14.4	350.56 a	373.59 a
LSD _{0.05}	15.56	14.09
<u>Interactions</u>		
Water stress × Maize hybrid	N.S.	N.S.
Water stress × Humic acid	*	*
Maize hybrid x Humic acid	N.S.	N.S.
Water stress × Maize hybrid x Humic acid	**	**

- Mean values in the same column marked with the same letters are not significantly different at 0.05 level of probability.
- *, **: significant at 0.05 level of probability.
- N.S. : not significant.

Table (35). Interaction between water stress and humic acid on Number of kernels/ear of maize during 2013 and 2014 seasons

Number of kernels/ear			
Treatments		Season	
		2013	2014
Water stress	Humic acid kg/ha.		
Irrigation every 10 days	0	272.00	292.78
	7.2	324.33	346.56
	14.4	380.00	402.00
Irrigation every 15 days	0	252.78	269.22
	7.2	289.11	309.56
	14.4	342.44	367.56
Irrigation every 20days	0	281.44	300.33
	7.2	283.56	304.33
	14.4	329.22	351.22
L. S. D. _{0.05}		26.95	24.37

Table (36). Interaction between water stress and humic acid on Number of kernels/ear of three maize hybrids during 2013 and 2014 seasons

		Number of kernels/ear					
Treatments		Season					
		2013			2014		
		Humic acid kg/ha.					
Water stress	Maize hybrids	0	7.2	14.4	0	7.2	14.4
Irrigation every 10 days	SC.166.	269.67	295.00	341.33	291.33	317.00	363.33
	SC.168.	267.33	310.67	371.00	288.00	332.33	391.00
	TWC352.	279.00	367.33	427.67	299.00	390.33	451.67
Irrigation every 15 days	SC.166.	205.33	262.00	294.67	225.33	283.33	314.67
	SC.168.	245.33	271.67	324.33	258.00	291.67	345.00
	TWC352.	307.67	333.67	408.33	324.33	353.67	443.00
Irrigation every 20days	SC.166.	266.67	268.67	301.33	284.67	290.67	322.67
	SC.168.	218.67	263.00	360.67	237.33	281.67	379.33
	TWC352.	359.00	319.00	325.67	379.00	340.67	351.00
L. S. D. _{0.05}		46.67			42.21		

4.2.5. 100- kernel weight (g)

The effect of water stress, maize hybrid, humic acid rate and their interaction on 100- kernel weight in 2013 and 2014 season are shown in Table (37).

Data presented in Table (37) showed that irrigation intervals were significant on 100- kernel weight in the two seasons. Irrigation every 15 days resulted in the highest value of 100 – kernel weight (35.54 and 40.46 g) and (34.48 and 39.29 g) in the first and second season, respectively. While the lowest mean of 100- kernel weight was obtained by irrigation every 20 days (29.68 and 34.51 g) in the two successive seasons. Thus the higher concentration of dry weight was probably due to suspended accumulation of structural dry matter in response to the water stress treatments. Similar results were obtained by **Atta-Allah (1996)** who reported that 100- kernel weight was reduced significantly decreased with increasing irrigation interval. **Salem (1993)** reported that grain weight decreased by increasing drought period. On the other hand **El- Sayed (1998)** found that irrigation interval did not significantly affected 100- kernel weight in both seasons.

The reductions in 100- kernel weight due to irrigation treatments may be attributed to the reduction of assimilate translocation from the plant canopy to the developing grain (**Moursi, 1997**). Under high water stress condition photosynthetic activity is low and metabolites translocation to the grain was not enough to attain its maximum weight.

Results in Table (37) indicated that TWC.352 hybrid produced the highest 100- kernel weight in both seasons (34.60 and 39.36 g), with no significant

between TWC.352 and S.C.168, while SC.166 hybrid gave the lowest value (31.37 and 36.30 g) in both seasons of the study, respectively. The most sensitive period to water stress for maize plant is the reproductive stage. Therefore tolerant hybrid would be less affected by the reduction in kernel weight. These results are agreement with those obtained by **Saied (1997)**, **El- Sheikh (1999)** and **Khan et al. (2001)** who reported significant differences among maize genotypes in 100-kernel weight under different irrigation treatments.

From the obtained data in Table (37) 100 kernel weight was significantly affected by humic acid rate in both seasons. Treating maize plants with 14.40 kg/ha., HA produced the highest value of 100- kernel weight (38.46 and 43.04 g), while the lowest value of 100- kernel weight was obtained by untreated control (30.26 and 35.21 g) in both seasons.

The favorable effect of humic acid is due to water soluble organic acid naturally present in soil organic matter. It can be recognized that humic substances have many beneficial effects on modifying mechanisms involved in plant growth stimulation, dry matter accumulation and nutrient uptake and increasing 100- kernel weight (**Attia et al., 2012**). These findings are in coincidence with those recorded by **Moursi (1997)**, **Bakry et al. (2009)**, **Balba and Awad (2013)** and **Khalili et al. (2013)**.

First order interaction between water stress X humic acid rates for 100-kernel weight was significant in both seasons (Table, 37). The presented data in Table (38) brought out that irrigation every 15 days with application of humic acid at 14.40 kg/ha., resulted in the heaviest weight of 100- kernel (39.85 and 44.35 g) without significant differences with irrigation every 10 days and HA application at 14.40 kg/ha. (39.20 and 43.44 g). On the other hand the lightest weight was produced by irrigation every 20 days with untreated (control) (25.03 and 29.89 g).

The rest of the interactions were not significant in both seasons as shown in Table (38).

Table (37). 100- kernel weight (g) of three maize hybrids as affected by water stress, humic acid and their interaction during 2013 and 2014 seasons

100- kernel weight (g)		
Treatments	Season	
	2013	2014
<u>Water stress</u>		
Irrigation every 10 days	35.54 a	40.46 a
Irrigation every 15 days	34.48 a	39.29 a
Irrigation every 20 days	29.68 b	34.51 b
LSD _{0.05}	1.752	1.922
<u>Maize hybrids</u>		
SC.166.	31.37 b	36.30 b
SC.168.	33.75 a	38.60 a
TWC352.	34.60 a	39.36 a
LSD _{0.05}	1.762	1.748
<u>Humic acid (kg/ha.)</u>		
0	30.26 b	35.21 b
7.2	30.99 b	36.01 b
14.4	38.46 a	43.04 a
LSD _{0.05}	1.628	1.604
<u>Interactions</u>		
Water stress × Maize hybrid	N.S.	N.S.
Water stress × Humic acid	*	*
Maize hybrid x Humic acid	N.S.	N.S.
Water stress × Maize hybrid x Humic acid	N.S.	N.S.

- Mean values in the same column marked with the same letters are not significantly different at 0.05 level of probability.
- *, **: significant at 0.05 level of probability.
- N.S.: not significant.

Table (38). Interaction between water stress and humic acid on 100- kernel weight (g) of maize during 2013 and 2014 seasons

100- kernel weight (g)			
Treatments		Season	
		2013	2014
Water stress	Humic acid kg/ha.		
Irrigation every 10 days	0	33.01	38.02
	7.2	34.42	39.91
	14.4	39.20	43.44
Irrigation every 15 days	0	32.73	37.71
	7.2	30.87	35.82
	14.4	39.85	44.35
Irrigation every 20days	0	25.03	29.89
	7.2	27.70	32.29
	14.4	36.33	41.33
L. S. D. _{0.05}		2.82	2.78

4.2.6. Straw yield (tons/ha.)

The effect of irrigation intervals, maize hybrid, and humic acid rates as well as their interaction are presented in Table (39).

It could be observed that irrigation interval significantly affected straw yield/ha., in the second season only. Increasing water interval upto 20 days led to a significant decrease in straw yield/ha., in 2014 season. These results may be attributed to the recognized role of timely and adequate availability of water which has favorable affect on plant growth. Similar results were obtained by **Atta- Allah (1996)**

Regarding maize hybrids data in Table (39) indicated that SC.168 in 2013 season, in 2014 season gave the highest straw yield. The main straw yield as of the three hybrids SC166, SC168 and TWC352 were 7.14, 7.27 and 7.30 tons/ha., as an average of the two growing 2013 and 2014 seasons. These results are in agreement with those obtained by **Atta- Allah (1996)**.

Data show that application of humic acid had significant effect on straw yield/ha in the second season only (Table, 39) whereas application of 14.40 kg/ha., HA produced the largest straw yield.

The first order interaction between water stress and humic acid for straw yield was significant in both seasons (Table, 39).

The data in Table (39) show the second order interaction among water stress X maize hybrids X humic acid rates for straw yield/ha., was significant in the second season only.

First order interaction between water stress X humic acid rates for straw yield was significant in the second season (Table, 40). The presented data in Table (41) brought out that irrigation every 10 days of TWC. 352, resulted in the heaviest weight. On the other hand the lightest weight was produced by irrigation every 20 days of S.C. 166.

The data presented in Table (41) show that the maximum straw yield/ha., was achieved by irrigation every 15 days with application of HA at 7.20 kg/ha., (8.11 tons/ha.) in the first season and irrigation every 15 days and application of 14.40 kg/ha., of HA in the second season, while the lowest one was recorded by irrigation every 20 days with untreated control (6.88 and 6.07 tons/ha.) in both seasons.

The interaction between maize hybrids X humic acid rates for straw yield/ha., was not significant in both seasons (Table, 39).

The represented data in Table (42) brought into view irrigation every 10 days and TWC352 hybrid with treated humic acid at 14.40 kg/ha., expressed the highest straw yield (10.23 tons/ha.) while the lowest one (5.39 tons/ha.) was produced by irrigation every 20 days and S.C.166 hybrid with control.

Table (39). Straw yield (tons/ha.) of three maize hybrids as affected by water stress, humic acid and their interaction during 2013 and 2014 seasons

Straw yield (tons/ha.)		
Treatments	Season	
	2013	2014
<u>Water stress</u>		
Irrigation every 10 days	7.55 a	7.96 a
Irrigation every 15 days	7.31 a	7.23 b
Irrigation every 20 days	7.10 a	6.49 c
LSD _{0.05}	1.074	0.1311
<u>Maize hybrids</u>		
SC.166.	7.57 a	6.89 b
SC.168.	7.81 a	6.89 b
TWC352.	6.59 b	7.89 a
LSD _{0.05}	0.793	0.184
<u>Humic acid (kg/ha.)</u>		
0	7.41 a	6.87 b
7.2	7.49 a	7.04 b
14.4	7.06 a	7.77 a
LSD _{0.05}	0.586	0.1928
<u>Interactions</u>		
Water stress × Maize hybrid	N.S.	**
Water stress × Humic acid	*	**
Maize hybrid x Humic acid	N.S.	N.S.
Water stress × Maize hybrid x Humic acid	N.S.	**

- Mean values in the same column marked with the same letters are not significantly different at 0.05 level of probability.
- *, **: significant at 0.05 level of probability.
- N.S. : not significant.

Table (40). Interaction between water stress and three maize hybrid Straw yield (tons/ha.) during 2014 season

Straw yield (tons/ha.)		
Treatments		Season
		2014
Water stress	Maize hybrid	
Irrigation every 10 days	SC.166	7.67
	SC.168	7.10
	TWC352	9.10
Irrigation every 15 days	SC.166	6.88
	SC.168	7.04
	TWC352	7.76
Irrigation every 20days	SC.166	6.14
	SC.168	6.53
	TWC352	6.80
L. S. D. _{0.05}		0.3191

Table (41). Interaction between water stress and humic acid on straw yield (tons/ha.) of maize during 2013 and 2014 seasons

Straw yield (tons/ha.)			
Treatments		Season	
		2013	2014
Water stress	Humic acid kg/ha.		
Irrigation every 10 days	0	7.85	7.61
	7.2	7.22	7.86
	14.4	7.57	8.41
Irrigation every 15 days	0	7.49	6.92
	7.2	8.11	6.70
	14.4	6.34	8.06
Irrigation every 20days	0	6.88	6.07
	7.2	7.13	6.56
	14.4	7.28	6.84
L. S. D. _{0.05}		1.015	0.3339

Table (42). Interaction between water stress and humic acid on Straw yield (tons/ha.) of three maize hybrids during 2014 season

Straw yield (tons/ha.)				
Treatments		Season 2014		
		Humic acid kg/ha.		
Water stress	Maize hybrids	0	7.2	14.4
Irrigation every 10 days	SC.166	7.77	7.64	7.60
	SC.168	6.66	7.26	7.39
	TWC352	8.40	8.68	10.23
Irrigation every 15 days	SC.166	6.58	6.39	7.66
	SC.168	6.71	6.68	7.75
	TWC352	7.48	7.05	8.77
Irrigation every 20days	SC.166	5.39	6.08	6.94
	SC.168	6.08	6.57	6.93
	TWC352	6.74	7.02	6.64
L. S. D. _{0.05}		0.5784		

4.2.7. Grain yield (tons/ha.)

Data cited in table (43) show the effect of water stress ,maize hybrids, humic acid rates and their interactions on grain yield/ha in 2013 and 2014 seasons.

Table (43) revealed highly significant differences between irrigation treatments for grain yield/ha in 2013 and 2014 seasons.

Grain yield was significantly higher for irrigation every 10 days (5.61 and 5.32 tons/ha.) as compared to the other irrigation treatments. Irrigation every 20 days treatment significantly decreased grain yield (4.02 and 3.99 tons/ha) in the first and second seasons ,respectively . The results indicated that maize grain yield is severely affected by drought stress at anthesis on early grain filling stages. This is the period for maximum rates of biomass accumulation .Similar results were reported by **Sinclair *et al.* (1990)**, **Hefini *et al.* (1993)** **Atta-Allah (1996)** and **El_Sheikh (1999)**.

On the other hand, **El_Sayed (1998)** found that grain yield/fed., was not significantly effect by the irrigation interval in both seasons.

Differences among the three studied cultivars across all irrigation treatments were significant as shown in table (43) results indicated that T.W.C.352 cultivar produced the highest grain yield (5.62 and 5.39 tons/ha) in 2013 and 2014 seasons ,respectively while S.C.166 cultivar produced the lowest grain yield per hectare (4.51 and 4.27 tons/ha.) in the both seasons, respectively .

The differences among the three cultivars in grain yield constitution of this cultivars rather than irrigation treatments. It was expected that S.C.168 would produce the highest grain yield However , ,T.W.C.352 produced the highest yield across all irrigation treatments .This may be due to the wide genetic base of the three- way crosses as compared to single crosses .This reflected the growth characteristics of T.W.C.352 and the consequently the grain yield its components . Similar results were obtained by **Atta-Allah (1996)**, **Attia (1999)** and **El_Sheikh (1999)**.

The effect of humic acid treatments on maize grain yield was significant in both seasons as shown from data in table (43)from obtained results it could be observed that application of humic acid at (14.4kg/ha)produced the highest value of grain yield/ha (5.53 and 5.27 tons/ha). The lowest value of grain yield /ha., resulted from control (4.51 and 4.27 tons/ha.) in both seasons .The favorable effect of humic acid treatments have been due to its effective role in improving maize growth , more dry matter accumulation and stimulated the building of metabolic product of growth characters such as plant height and ear leaf area which was reflected on increase in the different yield components such as ear length , number of kernel/ear and 100 –grain weight .These findings are in coincidence with their recorded by **Chen *et al.* (1999)**, **Bakry *et al.* (2009)**, **Attia et al (2012)** and **Khanghah *et al.* (2012)**.

First order interaction between water stress X maize hybrids for grain yield (tons/ha.) was significant in both seasons (Table, 43). The data presented in table (44) reveal that irrigation every 10 days with T.W.C.352 cultivar is marked by

giving the highest grain yield (6.89 and 6.60 tons/ha.) in the first and the second season, respectively. The least grain yield (ton/ha) is produced by irrigation every 20 days with untreated (control) treatment (3.89 and 3.64 tons/ha.) in both seasons. First order interaction between water stress X humic acid rates for grain yield /ha was significant in both seasons (Table 43), The data presented in table (45) show that the maximum grain yield (ton/ha) was achieved by irrigation every 10 days with application of humic acid at (14.40 kg/ha.) (6.23 and 5.91 tons/ha.) followed by irrigation every 15 days and application of HA at 14.4 kg/ha. (5.86 and 5.56 tons/ha.) orderly, while the smallest value came from irrigation every 20 days with untreated control were (3.82 and 3.57 tons/ha.).

The interaction between maize hybrids X humic acid rates for grain yield (tons/ha) was not significant in both seasons Table (43). The data in table (43) show that second order interaction among water stress X maize hybrids X humic acid rates for grain yield/ha., was significant in both seasons. The represented data in table (46) brought into view that irrigation every 10 days and T.W.C.352 cultivar with application of HA at 14.4 kg/ha., expressed the highest grain yield (7.94 and 7.37 tons/ha), while the lowest grain yield (3.13 and 2.89 tons/ha.) was produced by irrigation every 20 days and S.C.166 hybrid with untreated control.

Table (43). Grain yield (tons/ha.) of three maize hybrids as affected by water stress, humic acid and their interaction during 2013 and 2014 seasons

Treatments	Season	
	2013	2014
<u>Water stress</u>		
Irrigation every 10 days	5.61 a	5.32 a
Irrigation every 15 days	4.10 b	4.73 b
Irrigation every 20 days	4.22 c	3.99 c
LSD _{0.05}	0.1024	0.0864
<u>Maize hybrids</u>		
SC.166.	4.51 b	4.25 b
SC.168.	4.70 b	4.39 b
TWC352.	5.62 a	5.39 a
LSD _{0.05}	0.2254	0.1833
<u>Humic acid (kg/ha.)</u>		
0	4.53 c	4.27 c
7.2	4.77 b	4.50 b
14.4	5.53 a	5.27 a
LSD _{0.05}	0.2171	0.1900
<u>Interactions</u>		
Water stress × Maize hybrid	**	**
Water stress × Humic acid	**	**
Maize hybrid x Humic acid	N.S.	N.S.
Water stress × Maize hybrid x Humic acid	**	**

- Mean values in the same column marked with the same letters are not significantly different at 0.05 level of probability.
- *, **: significant at 0.05 level of probability.
- N.S. : not significant.

Table (44). Interaction between water stress and three maize hybrids on grain yield (tons/ha.) during 2013 and 2014 seasons.

Grain yield (tons/ha.)			
Treatments		Season	
		2013	2014
Water stress	Maize hybrid		
Irrigation every 10 days	SC.166.	5.01	4.75
	SC.168.	4.95	4.60
	TWC352.	6.89	6.60
Irrigation every 15 days	SC.166.	4.64	4.38
	SC.168.	4.87	4.54
	TWC352.	5.48	5.26
Irrigation every 20days	SC.166.	3.89	3.64
	SC.168.	4.28	4.03
	TWC352.	4.48	4.30
L. S. D. _{0.05}		0.390	0.318

Table (45). Interaction between water stress and humic acid on grain yield (tons/ha.) of maize during 2013 and 2014 seasons

Grain yield (tons/ha.)			
Treatments		Season	
		2013	2014
Water stress	Humic acid kg/ha.		
Irrigation every 10 days	0	5.08	4.81
	7.2	5.53	5.23
	14.4	6.23	5.91
Irrigation every 15 days	0	4.68	4.42
	7.2	4.45	4.20
	14.4	5.86	5.56
Irrigation every 20days	0	3.82	3.57
	7.2	4.34	4.06
	14.4	4.49	4.34
L. S. D. _{0.05}		0.376	0.329

Table (46). Interaction between water stress and humic acid on grain yield (tons/ha.) of three maize hybrids during 2013 and 2014 seasons.

Grain yield (tons/ha.)							
Treatments		Season					
		2013			2014		
		Humic acid kg/ha.					
Water stress	Maize hybrids	0	7.2	14.4	0	7.2	14.4
Irrigation every 10 days	SC.166.	4.56	5.03	5.44	4.36	4.77	5.10
	SC.168.	4.42	5.09	5.33	4.16	4.76	4.89
	TWC352.	6.27	6.46	7.94	5.90	6.18	7.73
Irrigation every 15 days	SC.166.	4.31	4.10	5.51	4.08	3.89	5.16
	SC.168.	4.47	4.44	5.69	4.21	4.18	5.25
	TWC352.	5.24	4.81	6.39	4.98	4.55	6.27
Irrigation every 20days	SC.166.	3.13	3.84	4.71	2.89	3.58	4.44
	SC.168.	3.84	4.33	4.66	3.58	4.07	4.43
	TWC352.	4.50	4.86	4.08	4.24	4.52	4.14
L. S. D. _{0.05}		0.6512			0.5701		

4.2.8. Biological yield (tons/ha.)

The apparent data in table (47) describe the impact of water stress, maize hybrid, humic acid rates and their interactions on biological yield (tons/ha) in both seasons.

Biological yield (t/ha) considerably was affected by reducing water stress in both seasons. It diminished that with increasing water stress. Irrigation every 10 days gave the highest biological yield /ha., in both seasons without significant differences between irrigation every 10 and every 15 days on the first season only while the lowest biological yield was produced by irrigation every 20 days in both seasons. The average of biological yield over the two seasons 13.19, 12.14 and 10.85 (tons/ha.) for irrigation treatments at every 10, 15 and 20 days, respectively. Similar results were obtained by **Hefini et al. (1993)**. On the other hand, **El_Sayed (1998)** found that irrigation intervals was not biological yield of maize plants.

As for hybrids, data exhibited that in the second season three maize hybrids were significantly differed in biological yield /ha. Hybrid T.W.C.352 gave higher biological yield/fed (13.28tons/ha) than S.C.166 cultivar (11.15 tons/ha).

Concerning humic acid rates, it could be noticed that application of humic acid had significant effect on biological yield /ha., in both seasons. (Table, 47). Application of humic acid at 14.4kg/ha., resulted the highest mean value of biological yield/ha (13.59 and 13.03 tons /ha.) while the lowest value of biological yield /ha., was produced by untreated treatment (control) (11.93 and 11.13 tons/ha.), without significant between HA 7.2 kg/ha., and untreated (control) in the first season. Similar results were obtained by **Chen et al. (1999)**.

First order interaction between water stress X maize hybrids was significant for biological yield in the second season only in Table(47) .The data in Table (48) show that irrigation every 10 days with T.W.C. 352 hybrid generated the highest value of biological yield (15.7 tons/ha.). The lowest mean values of biological yield (9.77 tons/ha) was produced by irrigation every 20 days with S.C.166 hybrid.

Significant interaction between water stress X humic acid rates was obtained in second season for biological yield (ton/ha) Table (47). The data in Table (49) reveal that irrigation every 10 days with application of humic acid at (14.4kg/ha.) gave the highest mean values of biological yield (14.32 tons/ha.). While the smallest biological yield (9.64 tons/ha) was produced by irrigation every 20 days with untreated control.

First order interaction between maize hybrids X humic acid rates for biological yield (ton/ha) was significant in the first season only (table 47) .The data in table (50) reveal that .T.W.C.352 cultivar treated with humic acid (14.4 kg/ha) gave the highest value of biological yield /ha (13,68 tons/ha.) while the lowest one was obtained by S.C.166 hybrid with untreated treatment (control) (11.62 tons/ha.) .

Second order interaction among water stress X maize hybrids X humic acid rates for biological yield/ha., were significant in the second season only (Table 47). The data in Table 51) show that the highest value of biological yield/ha., was recorded by irrigation every 10 days and T.W.C.352 hybrid with application of humic acid at 14.4 kg/ha., was (17.95 ton/ha) ,while the lowest value of biological yield/ha was produced by irrigation every 20 days and S.C.166 cultivar with control (8.29 tons/ha.).

Table (47). Biological yield (tons/ha.) of three maize hybrids as affected by water stress, humic acid and their interaction during 2013 and 2014 seasons

Biological yield (tons/ha.)		
Treatments	Season	
	2013	2014
<u>Water stress</u>		
Irrigation every 10 days	13.16 a	13.27 a
Irrigation every 15 days	12.31 ab	11.96 b
Irrigation every 20 days	11.31 b	10.47 c
LSD _{0.05}	1.073	0.2135
<u>Maize hybrids</u>		
SC.166.	12.08 a	11.15 b
SC.168.	12.50 a	11.28 b
TWC352.	12.21 a	13.28 a
LSD _{0.05}	0.7183	0.3644
<u>Humic acid (kg/ha.)</u>		
0	11.93 b	11.13 c
7.2	12.6 ab	11.54 b
14.4	12.59 a	13.03 a
LSD _{0.05}	0.5272	0.3779
<u>Interactions</u>		
Water stress × Maize hybrid	N.S.	**
Water stress × Humic acid	N.S.	**
Maize hybrid x Humic acid	*	N.S.
Water stress × Maize hybrid x Humic acid	N.S.	**

- Mean values in the same column marked with the same letters are not significantly different at 0.05 level of probability.
- *, **: significant at 0.05 level of probability.
- N.S. : not significant.

Table (48). Interaction between water stress and three maize hybrids on grain yield (tons/ha.) during 2014 season

Biological yield (tons/ha.)		
Treatments		Season
		2014
Water stress	Maize hybrid	
Irrigation every 10 days	SC.166.	12.42
	SC.168.	11.70
	TWC352.	15.70
Irrigation every 15 days	SC.166.	11.25
	SC.168.	11.59
	TWC352.	13.03
Irrigation every 20days	SC.166.	9.77
	SC.168.	10.55
	TWC352.	11.10
L. S. D. _{0.05}		0.6312

Table (49). Interaction between water stress and humic acid on biological yield (tons/ha.) of maize during 2014 season

Biological yield (tons/ha.)		
Treatments		Season
		2014
Water stress	Humic acid kg/ha.	
Irrigation every 10 days	0	12.41
	7.2	13.09
	14.4	14.32
Irrigation every 15 days	0	11.35
	7.2	10.91
	14.4	13.61
Irrigation every 20days	0	9.64
	7.2	10.61
	14.4	11.17
L. S. D. _{0.05}		0.6546

Table (50). Interaction between maize hybrid and humic acid on Biological yield (tons/ha.) of maize during 2013 season

Biological yield (tons/ha.)		
Treatments		Season
		2013
Maize hybrids	Humic acid kg/ha.	
SC.166.	0	11.62
	7.2	12.03
	14.4	12.58
SC.168.	0	12.60
	7.2	12.78
	14.4	12.12
TWC352.	0	11.58
	7.2	11.97
	14.4	13.08
L. S. D. _{0.05}		0.9131

Table (51). Interaction between water stress and humic acid on biological yield (tons/ha.) of three maize hybrids during 2014 season

Biological yield (tons/ha.)				
Treatments		Season 2014 Humic acid kg/ha.		
Water stress	Maize hybrids	0	7.2	14.4
Irrigation every 10 days	SC.166	12.13	12.41	12.70
	SC.168	10.81	12.01	12.28
	TWC352	14.29	14.86	17.95
Irrigation every 15 days	SC.166	10.67	10.27	12.81
	SC.168	10.91	10.85	13.00
	TWC352	12.46	11.59	15.03
Irrigation every 20 days	SC.166	8.29	9.65	11.38
	SC.168	9.66	10.63	11.36
	TWC352	10.97	11.54	10.77
L. S. D. _{0.05}		1.134		

4.2.9. Harvest index (HI %)

Table (52) show the effect of water stress, maize hybrids ,humic acid and their interactions on harvest index in both seasons .

There are significant differences among irrigation treatments for harvest index in both seasons.

Irrigation every 10 days gave the highest harvest index (42.79 and 39.80 %) in 2013 and 2014 seasons, but without significant difference on harvest index between irrigation every 10 and 15 days in the first season. While irrigation every 20 days gave the lowest harvest index (37.65 and 37.91 %) in both seasons respectively. On the other hand, **El- Sayed (1998)** found that irrigation intervals had not significant effect on harvest index.

Harvest index differed significantly among the three maize hybrids. T.W.C 352 hybrid produced higher harvest index than the other two hybrids i.e., S.C.166 and S.C.168.

Results indicated that harvest index was significantly affected by Humic acid rates in both seasons (Table 53) .Meanwhile , application of humic acid at rate 14.07 kg/ha., while the lowest value of harvest index was produced by untreated treatment (control) in both seasons.

First order interaction between water stress X maize hybrids for harvest index was significant in both seasons (Table 52). The data in Table (53) show that irrigation every 10 days with T.W.C.352 cultivar gave harvest index (52.36 and 41.94 %) while the lowest value of harvest of harvest index was produced by

irrigation every 20 days with S.C. 166 hybrid (34.44 and 36.97%) in the first and second seasons, respectively

First order interaction between water stress X humic acid rates was significant for harvest index in 2013 and 2014 seasons in Table (52) . The depicted data in Table (54) declared that the highest harvest index was produced by irrigation every 15 days and application of humic acid at the rate of 14.4 kg/ha., (48.31 and 40.76 %), without significant difference from irrigation every 10 days with treated humic acid at rate of 14.4 kg/ha., (45.33 and 40.99 %). While the lowest harvest index value was obtained by irrigation every 20 days and control of HA (36.43 and 36.82 %) in both seasons. First order interaction between maize hybrids X humic acid rates for harvest index was significant in the second season only (Table 53) .The represented data in Table (55) brought into view that T.W.C. 352 cultivar treated with humic acid at rate of 14.04 %, while the lowest harvest index (36.37%) was produced by S.C.166 with untreated treatment (control) from HA. Second order interaction among water stress X maize hybrids X humic acid rates was significant for harvest index in the second season only (Table, 57) indicate that irrigation every 10 days of T.W.C.352 with treated humic acid at rate (14.4 kg/ha.) gave the highest harvest index achieved by every 20 days of S.C.166 hybrid with control of HA.

Table (52). Harvest index (HI %) of three maize hybrids as affected by water stress, humic acid and their interaction during 2013 and 2014 seasons
Harvest index (HI %)

Treatments	Season	
	2013	2014
<u>Water stress</u>		
Irrigation every 10 days	42.79 a	39.80 a
Irrigation every 15 days	41.03 ab	39.38 b
Irrigation every 20 days	37.65 b	37.91 c
LSD _{0.05}	3.515	0.226
<u>Maize hybrids</u>		
SC.166.	37.52 b	37.98 c
SC.168.	38.03 b	38.81 b
TWC352.	45.92 a	40.30 a
LSD _{0.05}	3.307	0.4208
<u>Humic acid (kg/ha.)</u>		
0	38.33 b	38.08 c
7.2	39.07 b	38.83 b
14.4	44.07 a	40.18 a
LSD _{0.05}	2.549	0.4208
<u>Interactions</u>		
Water stress × Maize hybrid	*	**
Water stress × Humic acid	**	**
Maize hybrid x Humic acid	N.S.	**
Water stress × Maize hybrid x Humic acid	**	N.S.

- Mean values in the same column marked with the same letters are not significantly different at 0.05 level of probability.
- *, **: significant at 0.05 level of probability.
- N.S. : not significant.

Table (53). Interaction between water stress and three maize hybrids on harvest index (HI %) during 2013 and 2014 seasons

Harvest index (HI %)			
Treatments		Season	
		2013	2014
Water stress	Maize hybrid		
Irrigation every 10 days	SC.166.	39.76	38.19
	SC.168.	36.23	39.27
	TWC352.	52.36	41.94
Irrigation every 15 days	SC.166.	38.34	38.78
	SC.168.	40.40	39.11
	TWC352.	44.34	40.25
Irrigation every 20days	SC.166.	34.44	36.97
	SC.168.	37.44	38.06
	TWC352.	41.07	38.69
L. S. D. _{0.05}		5.728	0.7289

Table (54). Interaction between water stress and humic acid on harvest index (HI %) of maize during 2013 and 2014 seasons

Harvest index (HI %)			
Treatments		Season	
		2013	2014
Water stress	Humic acid kg/ha.		
Irrigation every 10 days	0	39.50	38.53
	7.2	43.53	39.87
	14.4	45.33	40.99
Irrigation every 15 days	0	39.06	38.89
	7.2	35.72	38.49
	14.4	48.31	40.76
Irrigation every 20days	0	36.43	36.82
	7.2	37.94	38.12
	14.4	38.59	38.78
L. S. D. _{0.05}		4.416	0.7288

Table (55). Interaction between maize hybrid and humic acid on harvest index (HI %) of maize during 2014 season

Harvest index (HI %)		
Treatments		Season
		2014
Maize hybrids	Humic acid kg/ha.	
SC.166.	0	36.37
	7.2	37.77
	14.4	39.80
SC.168.	0	37.98
	7.2	38.76
	14.4	39.69
TWC352.	0	39.90
	7.2	39.94
	14.4	41.04
L. S. D. 0.05		0.7288

Table (56). Interaction between water stress and humic acid on harvest index (HI %) of three maize hybrids during 2014 season

Harvest index (HI %)				
Treatments		Season		
		2014		
		Humic acid kg/ha.		
Water stress	Maize hybrids	0	7.2	14.4
Irrigation every 10 days	SC.166	38.25	40.90	40.15
	SC.168	32.57	37.95	38.17
	TWC352	47.68	51.76	57.66
Irrigation every 15 days	SC.166	37.20	31.66	46.16
	SC.168	36.27	35.14	49.82
	TWC352	43.71	40.38	48.94
Irrigation every 20days	SC.166	28.56	35.80	38.96
	SC.168	33.31	35.53	43.50
	TWC352	47.42	42.49	33.29
L. S. D. 0.05		7.648		

4.3. Grain protein content

4.3.1. Protein percentage (%)

The apparent data in Table (57) explicate the action of water stress, maize hybrid, humic acid and their interaction on grain protein content in maize grain in both seasons.

Water stress has significant distinct impact on grain protein % in the two growing seasons. As shown in the data, grain protein content tended to increase with increasing water stress in both seasons. Exposing maize plants to irrigation every 20 days conducted to augmentation of the grain protein content (11.09 and 10.38 %) while the lowest value of grain protein was recorded by irrigation every 10 days (10.54 and 9.79 %) in both seasons, respectively. Similar results were obtained by **Atta – Allah (1996) and Attia (1991)**. Also, **El- Sayed (1998)** reported that grain protein content was not significantly affected by the irrigation interval in both seasons.

There was a significant difference among the three tested hybrids in the first season only in protein %. TWC352 hybrid gave high grain protein content as compared to SC.168 in 2013 season and without significant difference between TWC352 and SC166. This is due to the superiority of TWC352 in grain yield/ha. Varietal differences in protein content were found by **Ibrahim et al. (1992) and Atta- Allah (1996)**.

The effect of humic acid treatments for grain protein content was significant in both seasons (Table, 57). However the highest value of grain protein content was recorded for application of humic acid at the rate of 14.40 kg/ha., were (11.97 and 11.27 %) while the lowest value of grain protein content was produced by untreated control were (9.83 and 9.09 %) in both seasons, respectively. Similar results were obtained by **Bakry et al. (2009) and Balbaa and Awad (2013)**.

The interactions between water stress X maize hybrids and HA for grain protein % were not significant in both seasons (Table, 57).

First order interaction between water stress X humic acid rates for protein % in grains was significant in both seasons (Table, 57). The data in Table (58) show that irrigation every 20 days with application of humic acid at 14.40 kg/ha., gave the highest grain protein content (12.46 and 11.62 %) in both seasons.

The data in Table (57) show that second order interactions had no significant effect on grain protein content in both seasons.

Table (57). Protein percentage (%) of three maize hybrids as affected by water stress, humic acid and their interaction during 2013 and 2014 seasons

Protein percentage (%)		
Treatments	Season	
	2013	2014
<u>Water stress</u>		
Irrigation every 10 days	10.54 b	9.79 b
Irrigation every 15 days	10.64 b	9.87 b
Irrigation every 20 days	11.09 a	10.38 a
LSD _{0.05}	0.2883	0.3813
<u>Maize hybrids</u>		
SC.166	10.70 ab	9.95 a
SC.168	10.61 b	9.90 a
TWC352	10.97 a	10.17 a
LSD _{0.05}	0.3291	0.3572
<u>Humic acid (kg/ha.)</u>		
0	9.83 c	9.09 c
7.2	10.47 b	9.66 b
14.4	11.97 a	11.27 a
LSD _{0.05}	0.2677	0.2451
<u>Interactions</u>		
Water stress × Maize hybrid	N.S.	N.S.
Water stress × Humic acid	**	**
Maize hybrid × Humic acid	N.S.	N.S.
Water stress × Maize hybrid × Humic acid	N.S.	N.S.

- Mean values in the same column marked with the same letters are not significantly different at 0.05 level of probability.
- *, **: significant at 0.05 level of probability.
- N.S. : not significant.

Table (58). Interaction between water stress and humic acid on protein percentage (%) of maize during 2013 and 2014 seasons

Protein percentage (%)			
Treatments		Season	
		2013	2014
Water stress	Humic acid kg/ha.		
Irrigation every 10 days	0	9.10	8.57
	7.2	10.16	9.34
	14.4	12.36	11.46
Irrigation every 15 days	0	10.03	9.17
	7.2	10.49	9.68
	14.4	11.41	10.74
Irrigation every 20days	0	10.37	9.56
	7.2	10.76	9.95
	14.4	12.16	11.62
L. S. D. _{0.05}		0.4637	0.4245

4.4. Water characters

4.4.1. Relative water content (RWC)

The results in Table (59) show the effect of the three factors under study in RWC.

Concerning the irrigation intervals the results clear that RWC for maize plants was significantly decreased by increasing irrigation intervals from one to three weeks in the first season only, where the highest value of RWC was recorded by irrigation every 15 days. Similar results were obtained by **Hammed (2008)** and **Gohari (2014)** who reported that RWC increased as the available soil moisture increased whereas water use efficiency increased under dry soil conditions compared with wet conditions.

Data listed in Table (59) show that hybrid TWC352 had the highest RWC value and the lowest one was recorded by SC.168 hybrid in both seasons.

Regarding the effect of humic acid application results indicated that the maximum RWC was achieved when plants were treated with humic acid at 14.40 kg/ha., in the two cropping seasons, whereas, the lowest RWC was achieved at the untreated treatment (control) in both seasons.

First order interaction between water stress X maize hybrid for RWC was significant in the first season only (Table, 6) data in Table (61) show that irrigation every 10 days with TWC.352 gave the maximum value, while the lowest RWC was recorded by irrigation every 15 days with SC. 166 hybrid in 2013 season.

First order interaction between water stress X humic acid for RWC was significant in both seasons Table (59). The data in Table (61) showed that irrigation every 10 days with application of humic acid at the rate of 14.40 kg/ha., gave the highest value of RWC in both seasons.

The interaction between maize hybrids and humic acid for RWC was not significant in both seasons (Table, 59).

Second order interaction among water stress and maize hybrids and humic acid for RWC was significant in 2013 season (Table, 59). The data in Table (62) revealed that irrigation every 15 days and S.C.166 hybrid with application of humic acid at the rate of 14.40 kg/ha., gave the highest value of RWC in the first season.

Table (59). Relative water content of three maize hybrids as affected by water stress, humic acid and their interaction during 2013 and 2014 seasons

Relative water content (RWC)		
Treatments	Season	
	2013	2014
<u>Water stress</u>		
Irrigation every 10 days	88.70 a	88.34 a
Irrigation every 15 days	88.52 a	88.35 a
Irrigation every 20 days	88.16 b	88.25 a
LSD _{0.05}	0.304	0.246
<u>Maize hybrids</u>		
SC.166.	88.39 b	88.35 ab
SC.168.	88.25 b	88.16 b
TWC352.	88.74 a	88.43 a
LSD _{0.05}	0.329	0.245
<u>Humic acid (kg/ha.)</u>		
0	88.07 c	88.10 b
7.2	88.45 b	88.38 a
14.4	88.86 a	88.46 a
LSD _{0.05}	0.240	0.270
<u>Interactions</u>		
Water stress × Maize hybrid	*	N.S.
Water stress × Humic acid	*	*
Maize hybrid x Humic acid	N.S.	N.S.
Water stress × Maize hybrid x Humic acid	**	N.S.

- Mean values in the same column marked with the same letters are not significantly different at 0.05 level of probability.
- *, **: significant at 0.05 level of probability.
- N.S. : not significant.

Table (60). Interaction between water stress and three maize hybrids on relative water content during 2013 season

Relative water content (RWC)		
Treatments		season
Water stress	Maize hybrid	2013
Irrigation every 10 days	SC.166.	88.10
	SC.168.	88.14
	TWC352.	88.97
Irrigation every 15 days	SC.166.	88.33
	SC.168.	88.34
	TWC352.	88.89
Irrigation every 20days	SC.166.	87.85
	SC.168.	88.28
	TWC352.	88.36
L. S. D. _{0.05}		0.5706

Table (61). Interaction between water stress and humic acid on relative water content of maize during 2013 and 2014 season

Relative water content			
Treatments		Season	
		2013	2014
Water stress	Humic acid kg/ha.		
Irrigation every 10 days	0	88.45	87.97
	7.2	88.38	88.30
	14.4	89.28	88.75
Irrigation every 15 days	0	87.82	88.15
	7.2	88.70	88.26
	14.4	89.04	88.64
Irrigation every 20days	0	87.94	88.17
	7.2	88.27	88.58
	14.4	88.26	87.99
L. S. D. _{0.05}		0.4159	0.4679

Table (62). Interaction between water stress and humic acid on relative water content of three maize hybrids during 2013 season

Relative water content (RWC)				
Treatments		Season 2013		
		Humic acid kg/ha.		
Water stress	Maize hybrids	0	7.2	14.4
Irrigation every 10 days	SC.166	88.89	88.77	89.32
	SC.168	87.88	87.29	89.24
	TWC352	88.57	89.06	89.27
Irrigation every 15 days	SC.166	86.98	88.75	89.27
	SC.168	88.13	88.53	88.35
	TWC352	88.34	88.81	89.51
Irrigation every 20days	SC.166	87.84	87.84	87.85
	SC.168	88.14	88.59	88.09
	TWC352	87.85	88.39	88.85
L. S. D. _{0.05}		0.7204		

4.4.2. Water use efficiency (WUE)

Water use efficiency by the three maize hybrids under various treatments is presented in Table (63).

Water use efficiency by the three maize hybrids expressed as kg grain produced by m³ of water consumed in complete evapotranspiration as affected by irrigation intervals and humic acid treatments for 2013 and 2014 seasons are presented in Table (63).

Results showed that WUE values for irrigation intervals treatments was significantly differed in both seasons. Irrigation every 15 days resulted in high WUE value as compared with irrigation every 10 days without significant difference with irrigation every 20 days in both growing seasons. Similar results were obtained by **El- Naggar *et al.* (1992), Saied (1997), Hammed (2008) and Gohari (2014).**

Concerning maize hybrids, data revealed that the WUE for TWC.352 was significantly higher than for SC.166 hybrid in the two seasons.

Regarding humic acid treatments, results showed significant effect of the tested treatments on WUE value. Application of humic acid at (14.40 kg/ha.) gave the highest value of WUE than untreated treatment in both seasons. These results may be due to that humic acid encourages roots to absorb more water in addition to improve drought tolerance.

First order interaction between water stress and maize hybrids for WUE was significant in both seasons in Table (63). The data in Table (64) show that irrigation every 10 days with TWC352 gave the highest efficiency of use water, while the lowest was recorded by irrigation every 20 days with SC.166 hybrid in both seasons.

First order interaction between water stress X humic acid for WUE was significant in both cropping seasons in Table (63).the data in Table (65) reveal that irrigation every 10 days with application of humic acid at the rate of 14.40 kg/ha., gave the highest value of WUE while the lowest value of WUE was recorded by irrigation every 20 days with untreated treatment (control) in both growing seasons.

The interaction between maize hybrids X humic acid for WUE was not significant in both seasons (Table, 63).

Second order interaction among water stress X maize hybrids X humic acid for WUE was significant in both seasons. Data in Table (66) show that irrigation every 10 days and TWC352 hybrid with application of humic acid at the rate 14.40 kg/ha., gave the highest value of WUE, while the lowest value was recorded by irrigation every 20 days and SC.166 hybrid with untreated treatment in both seasons.

Table (63). Water use efficiency (WUE) of three maize hybrids as affected by water stress, humic acid and their interaction during 2013 and 2014 seasons

Water use efficiency (WUE)		
Treatments	Season	
	2013	2014
<u>Water stress</u>		
Irrigation every 10 days	1.60 b	1.52 b
Irrigation every 15 days	1.67 a	1.58 a
Irrigation every 20 days	1.68	1.59 a
LSD _{0.05}	0.0327	0.0339
<u>Maize hybrids</u>		
SC.166.	1.50 b	1.42 b
SC.168.	1.58 b	1.48 b
TWC352.	1.86 a	1.79 a
LSD _{0.05}	0.0828	0.0648
<u>Humic acid (kg/ha.)</u>		
0	1.51 c	1.43 c
7.2	1.60 b	1.51 b
14.4	1.84 a	1.76 a
LSD _{0.05}	0.0751	0.0654
<u>Interactions</u>		
Water stress × Maize hybrid	**	**
Water stress × Humic acid	**	**
Maize hybrid x Humic acid	N.S.	N.S.
Water stress × Maize hybrid x Humic acid	**	**

- Mean values in the same column marked with the same letters are not significantly different at 0.05 level of probability.
- *, **: significant at 0.05 level of probability.
- N.S.: not significant.

Table (64). Interaction between water stress and three maize hybrids on Water use efficiency (WUE) during 2013 and 2014 seasons.

Water use efficiency (WUE)			
Treatments		Season	
		2013	2014
Water stress	Maize hybrid		
Irrigation every 10 days	SC.166.	1.43	1.36
	SC.168.	1.41	1.31
	TWC352.	1.97	1.89
Irrigation every 15 days	SC.166.	1.55	1.46
	SC.168.	1.62	1.51
	TWC352.	1.83	1.75
Irrigation every 20days	SC.166.	1.54	1.45
	SC.168.	1.71	1.61
	TWC352.	1.79	1.72
L. S. D. _{0.05}		0.1434	0.1123

Table (65). Interaction between water stress and humic acid on water use efficiency (WUE) of maize during 2013 and 2014 seasons

WUE			
Treatments		Season	
Water stress	Humic acid kg/ha.	2013	2014
Irrigation every 10 days	0	1.45	1.37
	7.2	1.58	1.50
	14.4	1.78	1.69
Irrigation every 15 days	0	1.56	1.47
	7.2	1.48	1.40
	14.4	1.95	1.85
Irrigation every 20days	0	1.51	1.43
	7.2	1.74	1.62
	14.4	1.79	1.73
L. S. D. _{0.05}		0.1302	0.1133

Table (66). Interaction between water stress and humic acid on water use efficiency (WUE) of three maize hybrids during 2013 and 2014 seasons

Water use efficiency (WUE)				
Treatments		Season		
Water stress	Maize hybrids	Humic acid (kg/ha.)	2013	2014
Irrigation every 10 days	SC.166	0	1.30	1.25
		7.2	1.44	1.36
		14.4	1.55	1.46
	SC.168	0	1.26	1.19
		7.2	1.45	1.36
		14.4	1.52	1.40
	TWC352	0	1.79	1.68
		7.2	1.85	1.77
		14.4	2.27	2.20
Irrigation every 15 days	SC.166	0	1.44	1.36
		7.2	1.37	1.30
		14.4	1.84	1.72
	SC.168	0	1.49	1.40
		7.2	1.48	1.39
		14.4	1.90	1.75
	TWC352	0	1.74	1.66
		7.2	1.60	1.52
		14.4	2.13	2.09
Irrigation every 20days	SC.166	0	1.19	1.16
		7.2	1.54	1.43
		14.4	1.88	1.78
	SC.168	0	1.54	1.43
		7.2	1.73	1.63
		14.4	1.86	1.77
	TWC352	0	1.80	1.69
		7.2	1.94	1.81
		14.4	1.63	1.65
L. S. D. _{0.05}			0.2254	0.1962