Journal of Plant Production

Journal homepage: www.jpp.mans.edu.eg
Available online at: www.jpp.journals.ekb.eg

Effect of Different Irrigation Levels and Methods of Humic Acid Addition on Growth, Yield and Storability of Garlic

Rizk, S. M. [1*] and T. H. M. A. Deshesh[2]

[1]Potato and Vegetatively Propagated Vegetables Dep., Hort. Res. Inst., Agric. Res. Center, Giza, Egypt.
[2]Soils, Water and Environment Res. Inst. (SWERI), Agricultural Research Center (ARC), Giza, Egypt.

Cross Mark

ABSTRACT

A field experiment was carried out to study the effect of different levels of irrigation at 40%, 60% and 80% of available soil moisture depletion (ASMD) and humic acid application methods (without, soil application, foliar application and soil application + foliar) on growth, productivity and storability of garlic cv. Sids-40. Results indicated that highest values of irrigation water applied (IWA),were found to be 3359 and 3162 m^3/fed due to 40% ASMD comparison with other two irrigation treatments in both seasons respectively. Also, results reveal that 80% ASMD irrigation treatments could save about 31.0% and 29.8% of the applied water, compared with 40% ASMD in both seasons respectively. Furthermore, the irrigation after depletion of 40%, 60% ASMD with applying soil conditioner and foliar application of humic acid increased the plant length, leaves number, neck diameter, bulb diameter, bulb fresh weight, fresh and dray weight of plant as well as the yield of bulbs, cloves fresh weight/bulb, cloves number/bulb, bulb diameter, neck diameter, average clove weight, nitrogen, phosphors, potassium and carbohydrates content. While, the proline and total pungency of garlic increased significantly and the percentage of weight loss (%) after two, four and seven months of the storage as a result of irrigation decreased after 80% ASMD with soil application plus spraying with humic acid. Also, average water utilization efficiency, increased by using 60% ASMD with soil and foliar application of humic acid (HS+ HF) followed by 80% ASMD with HS+ HF then 40% ASMD treatments with HS+ HF in both seasons.

Keywords: Garlic, Water stress, Humic acid, Growth, Yield, Weight loss percentage.

INTRODUCTION

Garlic (*Allium sativum* L.) is considered the most important vegetables for local consumption and exportation. Garlic is the second species cultivated after onion world-wide. It is used as a spice, seasoning, condiment, medicinal value. As well as, flavoring for foodstuff containing green tops and bulbs (Dufoo-Hurtado *et al.*, 2015). In Egypt, garlic is an important vegetable crop where the cultivated area is about 207045 feddan producing about two million and seventy thousands ton with average yield of 9.9 ton/feddan (Fadlallah *et al.*, 2021). Garlic has long growing season starting from October until April (180 days approximately).

Water is the major component for all living organisms. The transfer of nutrients is carried out by water to different parts of the plant. Furthermore, important component in photosynthesis in two ways, firstly it provides hydrogen for producing glucose, and secondly opening and closing of stomata is controlled by increase or decrease in the amount of water. According to Buwalda (1987) and Choi *et al.* (1980), for better growth and yield efficiency and quality, garlic needs adequate moisture from establishment to maturity, they stated that the crop did not withstand excess water application and that water deficiency could lead to a significant reduction in yield. The crop production usually decreased under condition of drought stress. It inhibits plant photosynthesis, causes alterations in the content and components of chlorophyll, and damages the photosynthetic apparatus and prevents photochemical activity and decreases enzyme activity in the Calvin cycle. The breakdown of the balance between the development of reactive oxygen species (ROS) and antioxidant protection is one of the important reasons that environmental stress inhibits the growth and photosynthetic abilities of plants, causing ROS accumulation that induces oxidative stress on proteins, membrane lipids and other cellular components.

Fertigation control is considered as one of the major practices which increase production costs and consequently affect economically the final return of garlic production. Water, or the lack of it is the environmental factor most often limiting crop growth and yield, even in humid temperate regions (Begg and Turner, 1976).

Soil conditioner is a product that is applied to the soil to improve the physical characteristics of the soil, especially its ability to provide plants with nutrition. The water use efficiency will depend not only on the transpiration efficiency of the leaves but also on the water loss from the soil and the optimization of yield per unit of water used is necessary (Neil, 1986). Net irrigation water requirement is the quantity of water necessary for crop growth. It is expressed in millimeter /year or in m^3 /ha/year (1mm= 10m /ha), Doorenbos and Pruitt (1992). Evapotranspiration ETo demand varies daily according to crop growth stages, amount and frequency of witting of the soil surface, environmental conditions, and crop management (Allen *et al.*, 2011). Khalifa *et al.*, (1997) indicated that soil hydraulic conductivity and water diffusivity of sandy soil were increased by natural soil conditioners. Moreover, humic

*** Corresponding author.**
E-mail address: sayedmansor22@yahoo.com
DOI: 10.21608/jpp.2021.90837.1049

acid and antitranspirants with considerable resistance to soil moisture deficient had been considerable an economic and efficient means of utilization drought-prone areas when appropriate management practices to reduce water loss is needed (Pereira and Shock, 2006). In general, humic acid has a number of potential benefits for plants: increased water and nutrient holding capacity; increased reserve of slow release nutrients; enhanced solubility of phosphorus, zinc, iron, manganese, and copper; increased resistance to soil pH change; improved soil aggregation; enlarged root system and increased stimulation of plant-growth due to hormones (Stevenson, 1994; Bryan and Stark, 2003 and Mikkelsen, 2005).

Therefore, the objective of the presented study is investigating the effect of applied irrigation levels and humic acid application on garlic growth and productivity.

MATERIALS AND METHODS

Two field experiments were carried out at Vegetable Research Farm, Kaha, Qalyoubia Governorate, Egypt. For two successive seasons 2018/2019 and 2019/2020, the study concerned the use of different irrigation available water levels and the addition of humic acid on growth, yield, chemical composition and storage ability of garlic (*Allium sativum* L.) cv. Sids 40.

The experimental treatments were arranged in a split-plot design with three replicates. Irrigation levels were conducted at the depleted of 40%, 60% and 80% of available soil water in the main-plots and the humic acid treatments in the sub plots, including two factors and twelve treatments, which were as follows:

A: Irrigation levels (main-plots).

1- Irrigation at 40 % of available soil moisture depletion (ASMD).
2- Irrigation at 60 % of available soil moisture depletion (ASMD).
3- Irrigation at 80 % of available soil moisture depletion (ASMD).

Irrigation treatments were started six weeks after planting. All treatments received equal amounts of water at the first and second irrigation. The total amount of irrigation water was calculated by Penman method (Penman, 1984).

B: Methods of humic acid addition (sub-plots).

1- Soil application of humic acid at a rate of 10 kg /fed (HS).
2- Foliar application of humic acid at 1g/L (HF).
3- Soil application of humic acid at a rate of 10 kg/fed plus spraying with humic acid at 1g/L (HS+HF).
4- Control (without application of humic acid).

The ground humic acid was added once during the preparation of the soil before planting. Foliar spray treatments were started after 60 days from transplanting and every 15 days four times throughout the growing season.

After obtaining the extract from saturated soil paste with the help of vacuum pump soil EC was measured using a digital Jen way electrical conductivity meter (Dellavalle, 1992). Soil bulk density was measured using core samplers and drying samples at 105Co for 24 hours in the oven. Meanwhile, soil bulk density was calculated, while total porosity (Yoder, 1936).

Soil samples were taken at the depths of 0-60 cm, in order to determine, available water (AW) by estimating soil moisture content. Table 1 illustrates weather date of the experimental site during the two seasons 2018/2019 and 2019/2020. Some soil properties before cultivation presented in Table 2 were determined according to Dewis and Freitas (1970) and Klute (1986).

Table 1. Weather data during the experiment period 2018/2019 and 2019/2020

Season	2018/2019							2019/2020						
Month	**T. max**	**T. min**	**W.S**	**R.H**	**S.S**	**S.R**	**R.F**	**T. max**	**T. min**	**W.S**	**R.H**	**S.S**	**S.R**	**R.F**
Oct.	19.7	10.1	2.3	52	6.8	319	4.8	19.6	10.1	2.3	53	6.7	32	16.8
Nov.	19.2	9.1	2.4	52	6.5	329	10.9	19.3	9.1	2.4	55	6.6	329	2.8
Dec.	19.4	10.1	2.5	62	7.8	349	9.2	19.5	10.1	2.4	60	7.8	339	23.2
Jan.	19.6	10.2	2.5	65	7.9	359	2.2	19.7	10.2	2.5	61	7.8	349	20.6
Feb.	19.7	10.3	2.6	62	7.8	349	7.7	19.8	10.4	2.6	62	7.8	349	18.0
March	22.4	10.6	2.6	68	8.4	432	11.0	22.5	10.6	2.6	65	8.5	432	82.1
April	27.7	13.1	2.6	61	9.5	514	12.8	27.7	13.1	2.6	66	9.4	514	10.3

Notes: T. max, T. min = maximum and minimum temperatures °C. W.S = wind speed (m / sec). R.H = relative humidity (%). S.S = actual sunshine duration (h/day) S.R = solar radiation (cal / cm^2 / day). RF = rain fall (mm / month).

Table 2. Soil physical and chemical properties of tested soil.

Physical properties								
Sand (%)	35.10		Field capacity (FC)					34.4
Silt (%)	33.5		Wilting Point (WP)					15.6
Clay (%)	31.4		Available water (AW)					18.8
Texture class	Clay loam		Bulk density (BD)					1.18
Chemical properties								
pH (1: 2.5 suspension)	7.75	Soluble cations and onions						
EC (dS /m soil paste)	1.00	Cations (mmol L^{-1})				Anions (mmol L^{-1})		
Organic matter (%)	1.80	K^+	Na^+	Ca^{++}	Mg^{++}	Cl^-	HCO_3	SO_4
$CaCO_3$ (%)	1.75	0.12	5.43	2.63	1.82	9.1	0.52	0.39

Soil moisture constants (Table 2) were determined using the pressure membrane apparatus, considering the saturation percent "SP" at 0 kPa, field capacity "FC" at 33 kPa (0.33 bar) and wilting point "WP" at 1.5 MPa (15 bar). Available water was considered as the difference between FC and WP (Stackman, 1966). Soil bulk density values were determined using the core method.

Surface irrigation water was adapted to the experimental plots. Nile water was the resource for irrigation. The analysis of water irrigation was presented in Table 3

Table 3. Chemical analysis of irrigation water.

Sample	PH	EC dS m^{-1}	Cations (mmol L^{-1})				Anions (mmol L^{-1})			
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Co_3^{-2}	Hco_3^{-}	Cl^{-}	So_4^{-2}
Irrigation water	7.81	1.60	4.27	2.28	8.96	0.58	0	7.29	4.98	3.82

Garlic cloves were planted on October 1st and 2nd during the first and second seasons, respectively. The experimental sub-plot area was 10.50 m^2 which contained 3 rows, with 5 m length and 0.70 m width. Garlic cloves were planted on both sides of the rows at 10 cm apart.

All agricultural practices, disease and pest control programs were followed according to the recommendations of the Egyptian Ministry of Agriculture. The NPK fertilizers at the rate of 120 kg N/fed as ammonium nitrate (33.5% N), phosphorus fertilizer was added to all plots before sowing at a rate of 80 kg P_2O_5/fed as calcium super phosphate (15.5% P_2O_5) and 72 kg K_2O/fed as potassium sulphate (48% K_2O) were applied to all treatments. Harvesting was carried out after 180 days from planting.

Soil-water relationships:

1. Amount of the irrigation water applied: The following equation was applied to calculate:

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

Where:

Q = discharge through orifice, (L/sec.).
C = coefficient of discharge, (0.61).
A = cross-sectional area of the orifice, (cm^2).
g = acceleration of gravity, (981 cm/sec2).
h = pressure head, causing discharge through the orifice (cm).

Water consumptive use (WCU):

Water consumptive use or actual evapotranspiration (ETa) values were calculated for each irrigation using the following formula (Israelsen and Hansen 1962).

$$WCU = \sum_{i=1}^{i=4} \frac{(\theta_2 - \theta_1)}{100} \times Bd \times D$$

Where:

WCU = seasonal water consumptive use (cm).
Θ2 = soil moisture content after irrigation (on mass basis, %).
Θ1 = soil moisture content before irrigation (on mass basis, %).
Bd = soil bulk density (g/cm3).
D = depth of soil layer (15cm each).
i = number of soil layer.

Soil moisture content was gravimetrically determined in soil samples taken from consecutive depths of 15 cm down to 60 cm. Soil samples were collected just before each irrigation, 48 hours after irrigation and at harvest time.

Water consumptive use as (m^3 fed^{-1}) was obtained by multiplying the value of WCU (mm) × 4.2

Depth of applied irrigation water was calculated according to the following equation:

$$AIW = \frac{ETc}{Ea} + LR$$

Where:

ETa: = water consumptive use (CU, mm/d), or actual evapotranspiration (ETa).
Ea: application efficiency (fraction) = 0.6 for surface irrigation system.
LR = leaching requirements (FAO, 1977) = $\frac{ECw}{2 Max\ ECe}$

Where:

ECw = electrical conductivity of the irrigation water (1.2 dS/m).
Max ECe = maximum tolerable electrical conductivity of the soil saturation extract for garlic crop.

Water utilization efficiency (W. Ut. E): Applied irrigation water is used to describe the relationship between production and the amount of water applied. It was determined according to the following equation (Jensen 1983):

$$W.Ut.E = \frac{Garlic\ yield, (kg/fed.)}{Seasonal\ AIW\ (m3\ water\ applied/feddan)}$$

Vegetative growth characters.

After 150 days from planting, ten plants from each experimental plot were randomly selected for measuring the following characters, *i.e.*, plant length (cm), number of leaves/plant, plant fresh and dry weight (g), neck diameter (cm), bulb diameter (cm), bulb fresh and dry weight. Proline was determined colorimetrically as (µg /g F.W) according to Bates *et al.*, (1973).

Yield and its quality

At harvest (200 days from planting), plants of each experimental plot were harvested, weighted and total yield of whole plants (ton/fed.) was calcu-lated. Ten bulbs were taken randomly from each experimental plot to measure the bulb quality of the following characters, *i.e.*, bulb fresh weight (g), bulb length (cm), bulb diameter (cm), number and weight of cloves /bulb.

Chemical constituents.

1- Total nitrogen, phosphorous, and potassium in the digested dry matter of the bulbs were determined according to methods described by Koch and McMeckin (1924), Trough and Meyer (1939) and Brown and Lilliland (1946)
2-Total carbohydrates: was determined colorimetrically according to method described by James (1995).
3- Pungency was determined as pyruvic acid (PA) in (µM /g F.W) according to Ketter and Randle (1998).

Storability (Weight loss):

After curing, two kilograms of cured bulbs without stem were randomly taken from each experimental plot in both seasons and placed in nets and stored at room temperature at 24 °C ± 5 °C with common storage conditions. Bulb weight loss was determined every month up to the end of storage period as follows:

$$\textbf{Weight loss (\%)} = \frac{(initial\ weight\ of\ storage\ bulb - weight\ at\ sampling\ date) x\ 100}{\text{initial weight of } storage \text{ bulb}}$$

Statistical analysis:

All collected data were subjected to statistical analysis according to Sndecor and Cochran (1991), where the least significant differences at 0.05% was considered when even possible.

RESULTS AND DISCUSSION

Vegetative growth characteristics.

Data in Tables 4 and 5 indicate that the vegetative growth characteristics of garlic expressed in plant height, number of leaves, fresh and dry weight of the plant, bulb neck diameter, bulb diameter, fresh and dry weight of bulb, and content of garlic leaves from proline was significantly affected by irrigation rates in the two seasons. The results showed that irrigation at 40% and 60% of available soil moisture depletion (ASMD) came first in this area. On the other hand, the lowest value of all plant growth traits was obtained under water stress, except for the garlic leaf content of proline, which increased with water stress increasing when using 80% (ASMD) in the two seasons. It could be argued that growing amounts of water added to garlic plants contributed to higher moisture content in the soil, which in turn could benefit the metabolism of plants, leading to improved growth characteristics of plants and higher dry matter production. Water stress, on the other hand, has contributed to a decrease in the absorption of nutritional components that could interrupt the physiological processes required for plant growth (Salter and Goode, 1967). Water stress also affects carbohydrate metabolism, protein synthesis and the activities of many enzymes that may reflect change in the balance between rates of synthesis and degradation leading to decrease in plant growth and dry matter accumulation (Hamlyn, 1986). On the other hand, Marschner (1995) found that, under sufficient water conditions, there were decrease in abscisic acid (ABA) and increase in gibberellins (GA), cytokinin (CYT) and indole-3-acetic acid (IAA) reflecting good growth and dry matter content. Furthermore, these results are in agreement with those reported by Abd EL-Latif and Abd EL-Shafy (2017), Mohammad (2017), Nora *et al*., (2019) and Ahmed and Kasem (2019) on garlic and El-Banna *et al.* (2001) and Anwar (2005) on potato; they reported that plant growth characters increase with increasing water quantity levels.

Concerning the humic acid application methods, It is evident from the date in Tables 4 and 5 in both seasons that the use of humic acid had a significant effect on the vegetative growth factors expressed by plant height, number of leaves, fresh and dry weight of the plant, bulb neck diameter, bulb diameter, fresh and dry bulb weight and proline content in two seasons compared to the treatment test (control). These results could be due to the role of humic acid in increasing water and nutrient holding capacity, photosynthesis process enhancement, root growth stimulation as well as proliferation of desirable micro-organisms in soil (Stevenson, 1994; Liu *et al.*, 1998; Bryan and Stark, 2003 and Mikkelsen, 2005). Similar results were reported by El- Zohiri and Asfour (2009) who, found that spraying garlic plant with Hummar as a source of humic acid at 0.25 g/L increased plant length, number of leaves (in the first season only), fresh weight and dry matter percentage of leaves. Moreover, Ahmed *et al.* (2010) on indicated that leaves fresh and dry weights/garlic plant area was significantly increased by application of humic 5 kg/acre only in the first season while plant height and number of leaves were not affected. Also, Kurdistan (2018) found that spraying garlic plants with humic acid at a concentration of 1 gram/ liter gave significant increase in leaves length. Also, Ayyub (2019) on garlic showed spraying the soil with humic acid gave significant increasing on vegetative growth characteristics and high value gained by the concentration 4 ml/L.

As for interaction between irrigation levels and humic acid application methods, it was noticed that the interaction between the amount of irrigation and humic acid for reducing water requirements had a significant effect on the growth factors in the two study seasons. The first and second levels of water irrigation 40% and 60% (ASMD) and the application of humic acid (adding ground and spraying together) had the greatest effect on all the studied vegetative growth characteristics. These results may be due to the role of humic acid in maintaining more water content in plant tissues, and this in turn, enhanced the growth rate of photosynthesis and enzyme activities

Table 4. Effect of irrigation levels and humic acid addition methods as well as their interaction on vegetative growth characteristics during 2018/2019 season.

Treatments		Plant length (cm)	Leaf number/ plant	Plant F.W (gm.)	Plant D.W (gm.)	Neck diameter (cm.)	Bulb diameter (cm.)	Bulb F.W (gm.)	Bulb D.W (gm.)	Proline (µg/ g.d.w)
Irrigation levels	**Humic acid**					**Season 2018/2019**				
40% ASMD		83.84	9.98	126.97	36.9	1.90	4.85	51.04	12.24	46.03
60% ASMD		81.33	9.71	106.38	35.83	1.79	4.77	47.24	11.36	49.11
80% ASMD		78.21	7.91	86.97	31.25	1.54	4.28	41.89	9.514	51.78
L.S.D. $p \leq 0.05$		2.68	0.62	11.77	4.49	0.32	0.53	3.77	2.62	1.27
	CO	78.33	8.38	94.80	31.00	1.60	4.13	38.70	9.438	46.39
	HF	81.50	9.17	104.50	34.99	1.77	4.61	45.82	10.33	48.93
	HS	81.62	9.53	109.81	35.56	1.78	4.80	48.91	11.89	49.75
	HF+ HS	83.06	9.72	117.99	37.09	1.83	4.99	53.46	12.49	50.83
L.S.D. $p \leq 0.05$		2.93	0.74	14.23	2.34	0.22	0.43	3.69	2.16	0.96
40% ASMD	CO	82.00	9.00	114.07	31.72	1.80	4.50	42.92	10.83	43.35
	HF	84.17	10.00	122.16	37.30	1.90	4.67	51.08	11.23	46.16
	HS	84.20	10.40	131.80	39.12	1.93	5.00	55.00	13.33	46.62
	HF+ HS	85.00	10.50	139.87	39.45	1.97	5.25	55.18	13.57	47.98
60% ASMD	CO	79.33	9.00	96.27	32.76	1.67	4.25	40.24	10.02	47.65
	HF	81.33	9.50	109.18	35.68	1.83	4.63	46.48	11.18	49.07
	HS	81.50	10.00	105.83	36.04	1.80	5.00	47.20	11.38	49.51
	HF+ HS	83.17	10.30	114.24	38.85	1.87	5.20	55.03	12.85	50.21
80% ASMD	CO	73.67	7.13	74.07	28.51	1.34	3.63	32.94	7.47	48.18
	HF	79.00	8.00	82.16	31.98	1.57	4.53	39.91	8.573	51.55
	HS	79.17	8.17	91.80	31.52	1.60	4.40	44.54	10.97	53.10
	HF+ HS	81.00	8.33	99.87	32.98	1.65	4.53	50.16	11.05	54.29
L.S.D. $p \leq 0.05$		5.08	1.28	24.65	4.05	0.38	0.75	6.38	3.73	1.66

CO = control, HF = Foliar spray of humic acid, HS = Soil application of humic acid, HF+ HS =Soil application and foliar spray of humic.

Table 5. Effect of irrigation levels and humic acid addition methods as well as their interaction on vegetative growth characteristics during 2019/2020 season.

Treatments		Plant length (cm)	Leaf number/ plant	Plant F.W (gm.)	Plant D.W (gm.)	Neck diameter (cm.)	Bulb diameter (cm.)	Bulb F.W (gm.)	Bulb D.W (gm.)	Proline (µg/ g.d.w)
Irrigation levels	Humic acid	Season 2019/2020								
40% ASMD		79.33	9.33	96.16	28.08	1.73	3.28	42.13	10.27	44.60
60% ASMD		77.83	9.00	92.36	27.05	1.61	3.08	36.28	9.28	47.71
80% ASMD		67.67	7.58	81.25	24.31	1.40	2.71	32.33	8.42	49.71
L.S.D. $p \leq 0.05$		2.60	0.84	4.53	1.36	0.26	0.27	5.63	0.96	1.68
	CO	70.33	8.11	80.75	24.55	1.49	2.68	33.07	7.61	44.69
	HF	74.78	8.56	89.02	26.74	1.58	2.93	34.94	8.89	47.71
	HS	76.56	8.67	93.49	26.79	1.59	3.00	37.74	9.45	48.05
	HF+ HS	78.11	9.22	96.46	27.83	1.66	3.48	41.91	11.35	48.91
L.S.D. $p \leq 0.05$		3.55	0.50	5.22	1.61	NS	0.41	4.95	1.56	1.51
40% ASMD	CO	75.00	9.00	87.02	25.02	1.60	3.00	38.45	8.34	41.59
	HF	78.67	8.67	94.98	27.7	1.70	3.10	40.47	9.32	45.50
	HS	81.67	9.33	98.94	29.45	1.75	3.23	39.97	10.01	44.40
	HF+ HS	82.00	10.33	103.79	30.15	1.87	3.77	49.64	13.4	46.91
60% ASMD	CO	75.00	8.67	81.63	25.01	1.57	2.93	32.75	8.27	45.38
	HF	76.67	9.17	92.00	27.86	1.60	2.97	35.61	8.93	47.74
	HS	78.67	9.00	96.01	26.89	1.60	2.97	38.14	9.30	48.85
	HF+ HS	81.00	9.17	99.78	28.42	1.67	3.47	38.62	10.62	48.88
80% ASMD	CO	61.00	6.67	73.61	23.63	1.30	2.10	28.01	6.21	47.10
	HF	69.00	7.83	80.08	24.667	1.43	2.73	28.75	8.42	49.88
	HS	69.33	7.67	85.52	24.02	1.42	2.80	35.12	9.03	50.90
	HF+ HS	71.33	8.17	85.81	24.91	1.45	3.20	37.46	10.01	50.95
L.S.D. $p \leq 0.05$		6.15	0.87	9.05	2.79	0.31	0.71	8.57	2.69	2.62

CO = control, HF = Foliar spray of humic acid, HS = Soil application of humic acid, HF+ HS =Soil application and foliar spray of humic.

Yield and its components.

Recorded data in Table 6 indicate the effect of irrigation rates on total yield, bulb weight, bulb length, bulb diameter, number of cloves and clove weight in both seasons, no significant differences in total yield, bulb length, bulb diameter and clove weight were evident between the 40% and 60% (ASMD) in both seasons. Regarding bulb weight and number of cloves the data show first level 40% (ASMD) had a significant in the first and second seasons, respectively, such increments in total produced yield and its components were connected with the increase in vegetative growth rate (Tables 4 and 5). Similar results were obtained by Bideshki *et al*. (2012) on garlic, found that drought stress significantly reduced bulb yield. Drought stress decreased bulb yield and dry matter percentage significantly on garlic. Also, Bideshki *et al*. (2013) showed that drought reduced bulb weight, bulb diameter and bulb length. Similarly, Badran (2015) indicated that drought stress decreased garlic fresh weight and number of cloves significantly. Also, Ahmed and Kasem (2019) found that the highest garlic marketable yield was recorded when plants received 10 irrigations. However, the lowest values of all yield parameters were recorded when plant received 5 irrigations.

Table 6. Effect of irrigation levels and humic acid addition methods as well as their interaction on total yield and its components of garlic plant in 2018/2019and 2019/2020 seasons.

Treatments		Total yield at harvest (ton/fed.)		Bulb weight (gm.)		Bulb length (cm)		Bulb diameter (cm)		No. of cloves/ bulb		Clove weight (gm.)	
Irrigation levels	Humic acid	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
40% ASMD		8.86	7.16	72.67	50.76	5.00	4.26	6.23	5.27	15.94	14.78	4.64	3.51
60% ASMD		8.10	6.84	67.02	43.68	4.65	3.88	6.08	4.95	14.98	13.48	4.50	3.24
80% ASMD		6.74	5.65	59.36	38.61	4.21	3.55	5.13	4.35	13.85	13.15	3.57	2.91
L.S.D. $p \leq 0.05$		0.30	0.12	1.69	1.62	0.12	0.15	0.14	0.12	0.33	0.35	0.09	0.07
	CO	7.01	6.13	61.76	36.57	4.21	3.61	5.33	4.61	14.09	12.74	4.03	2.82
	HF	7.61	6.47	66.46	44.14	4.70	3.90	5.81	4.83	14.96	13.61	4.23	3.25
	HS	8.33	6.69	67.01	47.10	4.70	3.89	5.95	4.97	14.87	14.10	4.31	3.37
	HF+ HS	8.65	6.89	70.17	49.59	4.87	4.19	6.14	5.03	15.79	14.75	4.39	3.43
L.S.D. $p \leq 0.05$		0.25	0.09	1.25	1.39	0.14	0.18	0.09	0.13	0.48	0.34	0.15	0.11
40% ASMD	CO	7.52	6.76	70.17	42.62	4.50	3.83	5.73	4.95	15.00	13.67	4.48	3.13
	HF	8.24	7.18	73.33	52.81	5.17	4.27	6.43	5.30	16.03	14.83	4.60	3.60
	HS	9.74	7.29	72.25	53.31	5.07	4.40	6.27	5.33	15.40	14.90	4.71	3.63
	HF+ HS	9.93	7.39	74.93	54.31	5.27	4.53	6.50	5.50	17.33	15.74	4.77	3.66
60% ASMD	CO	7.43	6.42	62.68	35.76	4.27	3.73	5.67	4.73	14.27	12.66	4.33	2.83
	HF	7.80	6.73	65.75	40.54	4.67	3.80	6.03	4.80	15.17	13.00	4.39	3.12
	HS	8.27	6.99	67.17	47.72	4.70	3.93	6.17	5.13	15.20	13.73	4.54	3.50
	HF+ HS	8.91	7.21	72.48	50.71	4.97	4.03	6.43	5.15	15.30	14.50	4.74	3.49
80% ASMD	CO	6.07	5.22	52.43	31.32	3.87	3.27	4.60	4.13	13.00	11.90	3.28	2.50
	HF	6.78	5.51	60.29	39.08	4.26	3.63	4.97	4.40	13.67	13.00	3.68	3.01
	HS	6.99	5.78	61.61	40.28	4.33	3.32	5.43	4.43	14.00	13.66	3.69	2.97
	HF+ HS	7.11	6.08	63.09	43.75	4.36	4.00	5.50	4.43	14.73	14.03	3.65	3.13
L.S.D. $p \leq 0.05$		0.43	0.16	2.17	2.42	0.25	0.31	0.17	0.22	0.84	0.59	0.25	0.19

CO =control, HF = Foliar spray of humic acid, HS = Soil application of humic acid, HF+ HS =Soil application and foliar spray of humic.

As for addition of humic acid, it was found that total produced yield and its components, *i.e.*, bulb weight, bulb length, bulb diameter, number of cloves and clove weight. Such data reveal that all the aforementioned yield components were significantly increased as a result of humic acid in comparison with the control treatment during both seasons of study. In this regard, the highest values were recorded in all the measured yield characteristics in the case of ground addition and spraying together (adding humic acid in the soil at a rate of 10 kg/fed. plus spraying with humic acid at a rate of 1 g/L). In the same respect, The results illustrated by Chen and Avid (1990) and Stevenson (1994), demonstrated that humic materials increase the plant membranes permeability, promote the uptake of nutrients, increase soil moisture holding capacity, and stimulate plant growth (higher biomass production) by accelerating net photosynthesis, consequently bulbs development (Zhang *et al*., 2003). In this connection, Marschner (1995) reported that, under sufficient water conditions, there as decrease in ABA and increase in CYT, GA and IAA reflecting good growth, good synthesis of carbohydrates and protein and finally attained higher yield. Furthermore, obtained results are in good line with those reported by Ahmed *et al*. (2010) on garlic showed that vegetative growth, yield, quality, were increased by applying humic acid and Kurdistan (2018) on garlic indicated that spraying of humic acid (1.5 $g.L^{-1}$) have significant effect on yield and bulb quality. Also, Ayyub (2019) showed spraying the soil with humic acid gave significant increasing on yield characteristics.

Concerning the interaction between treatments, the results indicate that the application of the first level 40% and the second level 60% of the available soil water relate to the application of soil and spraying together humic acid giving the highest values for total yield, bulb weight, bulb length, bulb diameter, number of cloves, and clove weight. and its components.

Chemical constituents of bulbs

Concerning the irrigation levels, data in Table 7 show the effect of soil moisture (different percentage of available water depletion) on chemical constituents of produced bulbs expressed as total nitrogen, phosphorus, potassium and carbohydrates content during both seasons of study. The results showed that irrigation at depleting 40% and 60% of the available soil water show significant effect on minerals content compared with water stress (80% of the available soil water). That was true in two seasons of study. The results in Table 7 exhibit that the contents of pungency significantly increased when the irrigation was conducted at the depletion of 80% of available water then a significant decrease happened at the level of 40 % available water depletion. As it was previously mentioned, increasing the applied water to the soil increased the moisture content that makes minerals more available to the plant, which led to enhance mineral concentration and their uptake. These results agree with those reported by Taha *et al*. (2019), Sapt *et al*. (2019) on garlic, Anwar (2005), and Youssef (2007) on potato; they found that NPK concentration increased gradually with increasing water supply to the soil.

Table 7. Effect of irrigation levels and humic acid addition methods as well as their interaction on chemical content of garlic bulbs in 2018/2019 and 2019/2020 seasons.

Treatments		N (%)		P (%)		K (%)		Carbohydrates (gm./100 gm. d.w.)		Pungency (µM (PA) /g FW)	
Irrigation levels	**Humic acid**	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
40% ASMD		2.50	2.43	0.298	0.295	1.64	1.52	28.35	27.59	36.30	35.13
60% ASMD		2.44	2.37	0.295	0.286	1.60	1.50	27.71	26.70	37.34	36.52
80% ASMD		2.32	2.27	0.274	0.253	1.46	1.4	26.26	25.21	37.94	36.92
L.S.D. $p \leq 0.05$		0.12	0.07	0.02	0.02	0.11	0.10	0.81	1.56	1.21	1.50
	CO	2.12	2.07	0.274	0.254	1.36	1.32	23.31	22.73	35.07	34.11
	HF	2.36	2.36	0.286	0.280	1.53	1.43	27.71	26.64	37.20	36.02
	HS	2.54	2.46	0.299	0.286	1.61	1.52	28.56	27.86	38.06	36.86
	HF+ HS	2.66	2.53	0.274	0.292	1.76	1.62	30.17	28.76	38.43	37.77
L.S.D. $p \leq 0.05$		0.12	0.10	0.01	0.02	0.23	0.09	0.79	0.90	0.60	1.11
40% ASMD	CO	2.20	2.10	0.276	0.269	1.42	1.35	24.33	23.82	35.26	34.55
	HF	2.47	2.50	0.273	0.293	1.64	1.47	28.72	27.62	36.92	35.63
	HS	2.63	2.53	0.316	0.306	1.68	1.58	29.13	28.80	38.46	37.86
	HF+ HS	2.70	2.57	0.316	0.313	1.82	1.69	31.22	30.12	38.69	38.02
60% ASMD	CO	2.10	2.03	0.273	0.250	1.36	1.33	24.11	23.45	35.71	34.88
	HF	2.37	2.37	0.308	0.294	1.52	1.45	27.39	26.06	37.92	37.02
	HS	2.60	2.47	0.306	0.300	1.68	1.55	29.04	28.32	38.92	37.26
	HF+ HS	2.70	2.60	0.305	0.299	1.82	1.65	30.27	28.97	39.19	38.52
80% ASMD	CO	2.07	2.07	0.273	0.243	1.32	1.29	21.48	20.92	34.23	32.90
	HF	2.23	2.20	0.276	0.253	1.42	1.35	27.02	26.24	36.76	35.41
	HS	2.40	2.37	0.275	0.252	1.46	1.43	27.51	26.47	36.80	35.46
	HF+ HS	2.57	2.43	0.274	0.264	1.64	1.51	29.02	27.19	37.42	36.76
L.S.D. $p \leq 0.05$		0.21	0.18	0.02	0.03	0.40	0.15	1.36	1.56	1.04	1.92

CO = control, HF = Foliar spray of humic acid, HS = Soil application of humic acid, HF+ HS =Soil application and foliar spray of humic.

Regarding the humic acid application methods, data in Table 7 indicate that humic acid (foliar application of humic acid at 1g/L, Soil application of humic acid at a rate of 10 kg/fed. and soil application of humic acid at a rate of 10 kg/fed. plus spraying with humic acid at 1 g/ liter significantly increased total nitrogen, phosphorus, potassium, total carbohydrates and pungency content in bulb garlic compared with the control treatment. In addition, the highest values in all determined chemical constituents were recorded in case of the treatment of humic as soil application (10 kg/fed.) plus humic acid as spraying (1 g/ liter) together .Such results are true during both seasons of study. These results may be attributed to the effect of humic acid on enhancing of root growth and hence increasing the uptake of nutrients (Liu *et al.,* 1998 and Awad and El-Ghamry, 2007). Similar results were reported by Ahmed *et al*. (2010) and Manas *et al*. (2014) on garlic they found that N, P, K and pungency contents of bulbs and leaves were increased by applying humic acid.

As for the interaction effects on nitrogen, phosphorus, potassium, carbohydrates and pungency contents, results in Table 7 show significant differences in this respect. Soil application of humic acid at a rate of 10 kg / fed plus spraying with humic acid at 1 g/ liter to garlic under 1st (40%) or 2nd (60%) levels of irrigation significantly increased nitrogen, phosphorus, potassium, carbohydrates and pungency contents to other treatments, in both season of study

Weight loss percentage:

It is clear from presented data in Table 8 that there were significant differences among the different treatments of irrigation in weight loss percentage after two, four and seven months of the storage.

As for the irrigation levels, data in Table 8 showed that the average weight loss values for the irrigation at 40% (ASMD) were more than those of the 60% and 80% treatment, respectively. These variations may be attributed to the difference in the amounts of applied irrigation where more weight loss was noticed with more water added. The obtained results agreed with those reported by Satyendra *et al.* (2007), suggesting that irrigation at 0.80 Ep (pan evaporation) resulted into minimum physiological loss in weight (%) during onion storage. The results agreed also with those of Ahmed and Kasem (2019), they reported that irrigation garlic plants every 28 days significantly decreased weight loss after two, four and six months under storage in both seasons.

Table 8. Effect of irrigation levels and humic acid addition methods as well as their interaction on weight loss % after two, four and seven months of the storage periods during 2018/2019 and 2019/2020 seasons.

Treatments		weight loss %					
		After 2 month		After 4 month		After 7 month	
Irrigation levels	Humic acid	1st	2nd	1st	2nd	1st	2nd
40% ASMD		11.20	7.47	13.08	12.03	19.59	18.33
60% ASMD		8.45	5.08	11.95	8.89	13.56	12.56
80% ASMD		6.22	3.13	9.98	7.39	12.36	11.78
L.S.D. $p \leq 0.05$		1.05	0.67	0.70	0.57	1.17	0.30
	CO	9.62	6.74	12.17	11.19	17.54	16.77
	HF	8.81	5.04	12.71	9.46	14.99	14.31
	HS	8.24	4.81	11.51	8.63	14.58	13.36
	HF+ HS	7.81	4.29	10.29	8.47	13.57	12.46
L.S.D. $p \leq 0.05$		0.76	0.57	0.83	0.71	0.72	0.76
40% ASMD	CO	13.23	9.67	13.90	15.67	24.93	23.27
	HF	11.23	7.60	13.00	12.50	18.47	18.10
	HS	10.37	6.33	12.77	9.93	17.80	16.47
	HF+ HS	9.97	6.27	12.63	10.00	17.17	15.50
60% ASMD	CO	8.70	6.83	12.97	10.90	14.10	13.77
	HF	8.63	4.37	12.63	8.00	13.97	12.63
	HS	8.60	4.97	11.73	8.47	13.53	12.53
	HF+ HS	7.87	4.13	10.47	8.20	12.63	11.30
80% ASMD	CO	6.93	3.73	10.87	7.00	13.60	13.27
	HF	6.57	3.17	12.17	7.87	12.53	12.20
	HS	5.77	3.13	9.13	7.50	12.40	11.07
	HF+ HS	5.60	2.47	7.77	7.20	10.90	10.57
L.S.D. $p \leq 0.05$		1.31	0.99	1.44	1.23	1.26	1.31

CO = control, HF = Foliar spray of humic acid, HS = Soil application of humic acid, HF+ HS =Soil application and foliar spray of humic.

Concerning the effect of humic acid on storability of garlic bulbs, data in Table 8 show that, storability of garlic bulbs was markedly influenced by the application of humic acid. Generally, treated plants with humic acid had better storability than untreated plants during storage in both seasons. Similar results were reported by Ahmed *et al*., (2010), Abd El-Razzak and EL-Sharkawy (2013) they found that the use of humic acid increased garlic storability

The interactions between irrigation and humic acid treatments significantly enhanced garlic storability during the two experimental seasons (Table 8), the total weight loss, significantly reduced during storage periods, in both seasons by the irrigation at 80% (ASMD) and the application of humic acid (soil application and spraying together).

Effect of irrigation levels and humic acid on Moisture content.

Field Capacity (FC)

Field capacity (FC) values varied from 36.68 to 46.20% at different treatments. The lowest (FC) value was 36.68% which recorded in the at all the tested soil moisture content. The highest value of (FC) was 46.20% which noticed with soil application of humic acid at 40% available water depletion. In addition, the individual effects of humic addition followed the order (HS) > (HF), as shown in Table 9.

Table 9. effect of irrigation rates and different humic acid application methods on B.D, TP and moisture content.

Irrigation	Humic appli.	B.D.	TP	FC	WP	AW
40% ASMD	Co	1.52	42.64	39.41	17.21	22.2
	HF	1.45	45.28	40.31	19.52	20.79
	HS	1.41	46.79	45.20	20.30	24.9
	HF+ HS	1.40	47.17	46.53	21.61	24.92
Means		1.45	45.47	42.86	19.66	23.20
60% ASMD	Control	1.51	43.02	39.68	16.91	19.77
	HF	1.49	43.77	40.10	17.65	22.45
	HS	1.43	46.04	43.50	19.45	24.05
	HF+ HS	1.42	46.42	43.21	18.95	24.26
Means		1.46	44.81	41.62	18.24	22.63
80% ASMD	Co	1.51	43.02	39.80	16.96	22.84
	HF	1.48	44.15	40.91	17.52	23.39
	HS	1.40	47.17	42.20	18.13	24.07
	HF+ HS	1.39	47.55	41.93	19.64	22.29
Means		1.45	45.47	41.21	18.06	23.15

CO= control, HF= Foliar spray of humic acid, HS = Soil application of humic acid, HF+ HS =Soil application and foliar spray of humic.

Wilting Point (WP)

Wilting point (WP) values varied significantly due to different treatments, cropping patterns, and their interaction. The results showed that, the lowest (WP) value was achieved with irrigation at 80% available water depleted. The highest values of wilting point was found in irrigation at 40% available water depletion and soil application of humic acid, as shown in Table 9.

Available Water (AW)

Available water (AW), it was found that (AW) affected by different treatments, where the order of irrigation (40%) > (60%) > (80%), while in case of different humic acid application follows the order of (HS) > (HF). However, available water showed increase trend at irrigation 40% available water depletion. The interaction between irrigation rates and humic acid application methods, the results showed that irrigation at 40% with soil application of humic acid gave highest values compared with other treatments, as shown in Table 9.

Water Relations:

Irrigation water applied (IWA, m^3/fed/year):

Results presented in Table 10 clearly show that the values of applied water increased under irrigation at 40% of available soil moisture depletion (ASMD) treatment compared with the other two irrigation treatments 60% and 80% (ASMD). The highest values were 3359 and 3162 m^3/fed/year due to 40% (ASMD) treatment, where the lowest values were obtained under 80% (ASMD) treatment as 2320 and 2220 m^3/fed/ year in the two growing seasons, respectively. Also, results reveal that 80% (ASMD) irrigation treatments could save about 31.0% and 29.8% of the applied water, compared with 40 % (ASMD) in both growing seasons respectively, In addition under 60% (ASMD) irrigation treatment, the same trend was noticed with reduction percentages values reached 17.3% (means of the two seasons), as compared with 40% (ASMD). This is logic and expected results that might be due to increasing number of irrigations accompanied with reducing irrigation period and hence increasing amount of the irrigation water applied. These results are in harmony with those obtained by Younis *et al.* (2010) and Abdalla *et al.* (1990) who found that, the highest water consumptive use occurred when irrigation was done upon reaching a moisture of 70 to 80 % of the field capacity.

Table 10. Monthly and seasonal applied irrigation water to garlic by irrigation levels in 2018/2019 and 2019/2020 growing seasons.

Irrigation levels	40% ASMD		60% ASMD		80% ASMD	
Month	m^3/day	m^3/ Month	m^3/day	m^3/ Month	m^3/day	m^3/ Month
2018/2019						
Oct	9.53	295.4	9.53	295.4	9.53	295.4
Nov	11.51	356.9	10.27	318.5	7.91	245.1
Dec	12.93	387.9	11.44	343.3	8.79	263.7
Jan	14.60	452.7	12.75	395.1	9.76	302.6
Feb	20.05	561.3	17.22	482.1	13.14	367.8
Mar	23.83	738.6	20.12	623.8	15.29	474.1
Apr	18.89	566.6	16.21	486.3	12.37	371.0
Seasonal (m^3/fed.)		3359		2649		2320
2019/2020						
Oct	8.59	266.2	8.59	266.2	8.59	266.2
Nov	11.95	358.5	10.66	319.8	8.37	251.1
Dec	12.86	398.7	10.58	328.0	8.94	277.2
Jan	17.07	529.3	13.09	405.8	10.79	334.4
Feb	20.62	577.3	15.76	441.4	12.99	363.6
Mar	19.62	608.2	15.76	488.5	13.19	408.9
Apr	13.68	424.1	11.82	366.3	10.27	318.4
Seasonal (m^3/fed.)		3162		2616		2220

Monthly applied irrigation water.

Results in Table 10 and Figures. (1 and 2) show that monthly applied water values began to raise during January then gradually increased to reach its maximum during March in both seasons. Monthly water consumption started low when plants were small and increased gradually with increasing plant growth and increases in air temperature and solar radiation reaching the maximum in March mainly, it causes increased demand for water by plants. The increase in evapotranspiration from the beginning of the growth season till harvesting maturity can be explained on the basis of the plants coverage. In this respect Ibrahim (1981) concluded that the increase in evaportanspiration by maintaining soil moisture at a high level is attributed to excess available water in the root zone. Also, Weagand (1962) pointed out that, the drying rate of a bare soil is positively related to the water content and relatively related to time, and that a drying front advances into the soil linearly.

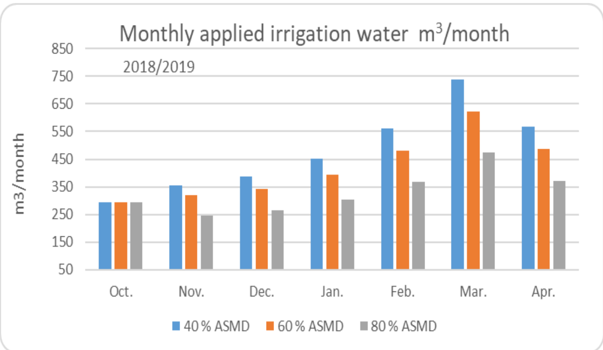

Fig. 1. Monthly applied irrigation water under irrigation treatments in 2018/2019season.

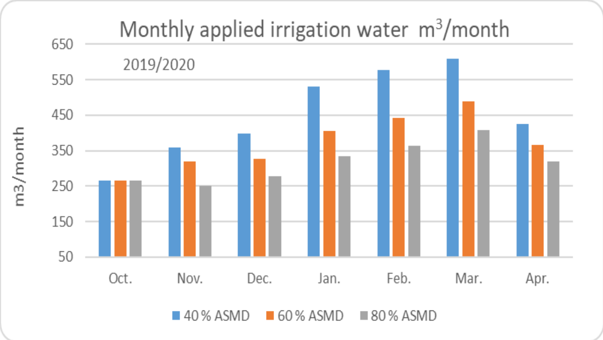

Fig. 2. Monthly applied irrigation water under irrigation treatments in 2019/2020 season.

Water utilization efficiency (W.Ut.E):

Table 11 clearly indicates that the different irrigation practices had major effect on water use efficiency (W.Ut.E) of garlic. The highest average water use efficiency occurred in 60% ASMD followed by 80% then 40% ASMD treatments in both growing seasons, respectively. The average values were 2.68 and 2.23 Kg garlic bulbs/m^3 water of irrigation for 60% ASMD treatment. Whereas, the lowest average values were 2.34 and 1.95 Kg garlic bulbs /m^3 water of irrigation obtained under 40% ASMD treatment in the two growing seasons, respectively. The present results are in line with those reported by El-Atawy (2007), who mentioned that the efficiency of water use decreased as the soil moisture was maintained high by the frequent irrigation. However, water use efficiency significantly increased with decreasing the irrigation water (Leskovar and Xu, 2013).

Table 11. Effect of irrigation levels and humic acid addition methods as well as their interaction on water utilization efficiency in 2018/2019 and 2019/2020 seasons.

Humic acid addition methods	Water utilization efficiency (W.Ut.E)				
	Humic acid (B)				
Irrigation Levels (A)	control	HF	HS	HS+HF	Mean
			2018/2019		
40% ASMD	1.94	2.16	2.60	2.66	2.34
60% ASMD	2.43	2.57	2.74	2.99	2.68
80% ASMD	2.19	2.49	2.58	2.63	2.47
Mean	2.19	2.41	2.64	2.76	
L.S.D. $p \leq 0.05$	A = 0.09		B = 0.12	Ax B = 0.21	
			2019/2020		
40% ASMD	1.82	1.95	1.99	2.02	1.95
60% ASMD	2.07	2.19	2.29	2.37	2.23
80% ASMD	2.09	2.23	2.37	2.51	2.30
Mean	1.99	2.12	2.22	2.30	
L.S.D. $p \leq 0.05$	A = 0.02		B = 0.023	Ax B = 0.05	

CO = control, HF= Foliar spray of humic acid, HS= Soil application of humic acid, HF+ HS=Soil application and foliar spray of humic.

The main effects of humic acid treatments showed a significant increase in water utilization efficiency (W.Ut.E) in both seasons. The highest value was given by soil application and foliar spray of humic acid treatment and the lowest one was by the control. Mean values were as follows: soil application and foliar spray of humic acid gave water utilization efficiency of 2.76 and 2.30 kg garlic bulbs/m^3 irrigation water followed by soil application of humic acid which gave 2.64 and 2.22 kg garlic bulbs/m^3 irrigation water then foliar spray of humic acid 2.41 and 2.12 kg garlic bulbs/m^3 irrigation water and the lowest was by the control 2.19 and 1.99 kg garlic bulbs/m^3 irrigation water in 2018/2019 and 2019/2020 seasons, respectively. Soil application and foliar spray of humic acid treatment also slow down leaf senescence, and leaf function was maintained for a longer period. During exposure to dry winds, the evapotranspiration rate of sprayed plants was higher than that of the unsprayed control. This seemed to be due to reduction in function of the leaves of control plants which were obviously damaged. That stomatal conductance and transpiration could be decreased by humic substances (Mei and Yang 1983). Karakurt *et al.* (2009) reported that the foliar spray of humic acid substances promote growth, and increase yield and quality in a number of plant species at least partially through increasing nutrient uptake, serving as a source of mineral plant nutrients and regulator of their release.

CONCLUSION

It could be recommended that irrigation of garlic plants at 40% and 60% available soil moisture depletion (ASMD) with applying soil conditioner and foliar application of humic acid increased the was the most efficient treatment for growth, yield, quality. While the proline and total pungency of garlic increased significantly and the percentage of weight loss (%) of the storage as a result of irrigation decreased after 80% ASMD with soil application of humic acid at a rate of 10 kg /fed plus spraying with humic acid at 1g /L. Also, average water utilization efficiency, increased by using 60% ASMD with soil and foliar application of humic acid (HF+ HS) followed 80% ASMD with HF+ HS then 40% ASMD treatments with HF+ HS. This means that about 80% ASMD irrigation treatments.

REFERENCE

Abd El-Latif, K. M. and A. A. Abdel shafy. (2017). Response of garlic productivity to surface and drip systems and irrigation amounts. Middle East Journal of Agriculture Research. (6): 981-995.

Abd El-Razzak, H. S and G.A. EL-Sarkawy (2013). Effect of biofertilizer and humic acid applications on growth, yield, quality and storability of two garlic (allium sativum L.) cultivars [2013]. Asian J of Crop Sci., 5(1):48-64.

Abdalla, I. M., N. S. Shafashak., F.A. Abo-Sedera and L. A. Abd El-Rahman. (1990). Effect of water regime and level on NPK fertilization on carrot. I. vegetative growth and its chemical composition. Annals of Agric. Sc., Moshtohor, 28 (4): 2517-2528.

Ahemd, M.E.M., A.A. El-Aidy, E.A Radwan and T.S. Abd-Bary. (2010). Response of garlic plants to humic acid and different application methods of potassium fertilizer. Minufiya J. Agric. Res. 35(6): 2159-2175.

Ahmed, S. I. and Kasem, E. S. (2019). Effect of Irrigation Numbers and Plant Density on Growth, Yield of Garlic Cultivar Eggaseed -1. J. of Soil Sciences and Agricultural Engineering, Mansoura Univ., Vol. 10 (11):711-718.

Allen, R. G., S. P. Luis., A. H. Terry and E. J. Marvin. (2011). Evapotranspiration information reporting: II. Recommended documentation. Agricultural Water Management. Volume 98, Issue 6, April 2011, Pages 921-929.

Anwar, R. S. (2005). Response of potato crop to biofertilizers, irrigation and antitranspiration under sandy soil conditions. Ph. D. Thesis, Fac. Agric., Zagazig Univ., Egypt, pp 172.

Awad, E.M.M. and A.M. El-Ghamry. (2007). Effect of humic acid, effective microorganisms (EM) and magnesium on potatoes in clay soil. J. Agric. Sci. Mansoura Univ., 32(9): 7629-7639.

Ayyub, J. A. (2019): Effect of addition method of organic fertilizer (humic acid) on growth,yield and active ingredients of allium sativum L. Journal of University of Garmian .NO 4 (1) 153-159.

Badran, A. E. (2015). Comparative analysis of some garlic varieties under drought stress conditions. Journal of Agricultural Science. 7(10): 271-280

Bates, L.S., R.P. Waldern and D. Teare. (1973). Rapid determination of free proline for water stress studies. Plant and Soil, 39: 205–207.

Begg, J. E. and N.C. Turner. (1976). Crop water deficits. Adv, Agron., 28: 161- 217.

Bideshki, A., M. J. Arvin and K. Maghsoudi. (2012). Effect of indole-3 Butyric acid (IBA) foliar application on growth, bulb yield and allicin of garlic (*Allium sativum* L.) under water deficit stress in field. Iranian Journal of Medicinal and Aromatic Plants; 2012. 28(3): 567-577.

Bideshki, A., M. J. Arvin and M. Darini. (2013). Interactive effects of Indole-3 butyric acid (IBA) and salicylic acid (SA) on growth parameters, bulb yield and allicin contents of garlic (Allium sativum) under drought stress in field. International Journal of Agronomy and Plant Production. 4(2):271-279.

Brown, J. and O. Lilliland. (1946). Rapid determination of potassium and sodium in plant material and soil extracts by flame photometric. Proc. Amer. Soc. Hort. Sci, 48: 341- 346.

Bryan, H. and J. Stark. (2003). Humic acid effects on potato response to phosphorus. Idaho Potato Conference, USA, January 22-23, pp 5.

Buwalda J.G. (1987). Nitrogen nutrition of garlic (Allium satium L.) under irrigation. Crop Growth Dev. Sci. Hortic., 29, 55-68.

Chen, Y. and T. Aviad. (1990). Effect of humic substances on plant growth. *In*: Y. Chen and T. Aviad (eds.). Humic Substances in Soil and Crop Siences. pp. 161-186. Amer. Soc. Agron. Soil Sci. Amer., Madison. Wis.

Choi J.K., Ban C.D. and Y.S. Kwon (1980). Effects of the amount and times of irrigation on bulbing and growth in garlic research reports on the effect of rural development. Hortic. Sericul. Swun, 22, 20-33.

Dellavalle, N. B. (1992) Determination of specific conductance in supernatant 1:2 soil: water solution, In" Handbook on Reference Methods for Soil Analysis", Soil and Plant Analysis Council, pp: 44-50.

Dewis, J. and F. Freitas. (1970). F.A.O. Soils Bulletin 1970 No.10 pp.275 pp.

Doorenbos, J. and W.D. Pruitt. (1992). Guidelines for predicting crop water requirements. FAO Irrigation and Drainage Paper No. 24, (revised) FAO, Rome, Italy.

Dufoo-Hurtado, M.D., J.A. Huerta-Ocampo., P. A. Barrera., A.P. B. Rosa and E.M. Mercado-Silva. (2015). Low temperature conditioning of garlic (Allium sativum L.) "Seed" cloves induces alterations in sprouts proteome. Frontiers in Plant Science, 6 (332), 1- 15.

El-Atawy, E.E.I. (2007). Irrigation and fertilization management under the conditions of Kafr El-Sheikh Governorate soil. Ph.D. Thesis, Soil Dept. Fac. of Agric., Mansoura Univ., Egypt.

El-Banna, E. N., A. F. H. Selim and H. Z. Abd El-Salam. (2001). Effect of irrigation methods and water regimes on potato plant (*Solanum tuberosum* L.) under Delta soil condition. Minufiya J. Agric. Res., 26 (1): 1-11.

El-Zohiri, S.S. M and H.E. Asfour. (2009). Effect of some organic compounds on growth and productivity of some potato cultivars Annals of Agric. Sci., Moshtohor. 74 (3): 403- 415.

Fadlallah A. M., T A. A. Eid and N. M. Ibrahim. (2021). Effect of Irrigation Levels and Some Soil Applied Herbicides on Weeds, Water Use efficiency and Productivity of garlic (*Allium sativum* L.). Annals of Agric. Sci., Moshtohor 58(3) (2020), 563 – 578.

FAO. (1977). Guidelines for predicting crop water requirements. Doorenbos, J. and W.O. Pruitt. Irrigation and Drainage Paper no. 24. Rome, Italy. 144p.

Hamlyn, G.J. (1986). Drought and Drought Tolerance in Plants and Microclimate. Cambridge Univ. Press, Cambridge, London, New York, New Rochelle, Melbourne, Sydney, pp. 212-237.

Ibrahim, M.A. (1981). Evaluation of different methods for calculating potential evopotranspiration in north Delta region –Ph .D. thesis, Fac. Agri. Alex. Univ.

Israelsen, O. W. and V. E. Hansen. (1962). Irrigation principles and practices, 3rd ed., John Willey and Sons Inc., New York, USA.

James, C. S. (1995). Analytical chemistry of foods Blokie Academic, proffessional, London.

Jensen, M.E. (1983). Design and operation of farm irrigation systems. Amer. Soc. Agric. Eng. Michigan, USA, p. 827.

Karakurt, Y., H. Unlu and H. Padem, (2009). The influence of foliar and soil fertilization of humic acid on yield and quality of pepper. Acta Agriculturae Scandinavica Section B Plant Soil Science, 59(3): 233- 237.

Ketter, C.A.T., W.M. Randle (1998). Pungency assessment in onions.Tested Studies for Laboratory Teaching. 19: 177-196.

Khalifa E.M., M.I. Abo-Zeid., I.N. Nassar and S.M. Esmail. (1997). Effect of a sugarcane industry by-product (filter mud cake) on some physical properties of soils. The First Scientific Conference of Agric. Sci. Fac. Agric.Univ., 13-14 December 1, 467-482

Klute, A. (1986). Methods of Soil Analysis: Part I: Physical and Mineralogical Methods. (2nd Ed), Am. Soc. Agron., Monograph No. 9, Madison, Wisconsin. USA.

Koch, F. C. and T. L. McMeekin. (1924). A new direct nasalization micro keldahl method and ammonium. J. Amer. Soc. Chem.., 46: 521.

Kurdistan, H. Y. (2018). Effect of humic acid and seaweeds extracts on growth, yield and nutrient content of garlic (*Allium sativum* L.) Journal of University of Duhok., Vol. 21, No.1 (Agri. and Vet. Sciences), Pp 8-18

Leskovar, D. and C. Xu. (2013). Irrigation strategies and water use efficiency of globe artichoke. Acta Hort. 983: 261–268.

Liu, C. R., J. Cooper, and D. C. Bowman. (1998). Humic acid application affects photosynthesis, root development and nutrient content of creeping bentgrass, Hort Science, 33: 1023-1025.

Manas. D., G. Soumya and S.Kheyali. (2014). Effect of humic acid application on accumulation of mineral nutrition and pungency in garlic (*Allium Sativum* L.). International Journal for Biotechnology and Molecular Biology Research. Vol. 5(2) pp. 7-12,

Marschner, H. (1995). Mineral Nutrition of Higher Plants. 2nd Ed. Academic Press, Harcourt Brace and Company, Publishers. London, New York, Tokyo, 864 pp.

Mei H. S. and J. J. Yang. (1983). A comparative study of inhibiting stomatal opening between the humate and photohormones. Acta Phytophysiologia Sinica 9, 143-50.

Mikkelsen, R.L. 2005. Humic materials for agriculture. Better Crops, 89 (3): 6-10.

Mohammad. R. and U. Z. Rokon. (2017). Response of Garlic Yield and Storability to Varying Frequencies of Irrigation. Agriculturae Conspectus Scientifi cus . Vol. 82 No. 1 (7-11).

Neil, C. T. (1986). Crop water deficits: A decade of progress advances in agronomy, 39: 1-51.

Noura M. T., H. A. Shaimaa and A. H. Fadl. (2019). Improving yield and quality of garlic (*Allium sativum* L.) under water stress conditions. Middle East Journal of Agriculture Research. vol 8 (1):330 -346.

Penman, S. H. (1984). "Timeliness of Reporting and the Stock-Price Reaction to Earnings Announcements," Journal of Accounting Research, Wiley Blackwell, vol. 22(1), pages 21-47. Handle: RePEc:

Pereira, A. B. and C. C. Shock. (2006). A review of agro meteorology and potato production. Chapter 13E, pp. 39. Available on-line at http://www. agrometeorology.org/.

Salter, P .J. and T. E. Goode. (1967). Crop response to water at different stages of growth. Franham Reyal, Common Welth Agric., Bureaux.

Sapt, W.M., M.E.Ragab., H.G. Abd El-Gawad and A.E. Omran. (2019). Effect of irrigation levels, soil conditioner and foliar application of potassium silicate or glycine betaine on vegetative growth and chemical composition of garlic. Arab Univ. J. Agric. Sci., Ain Shams Univ., Cairo, Egypt 27(3), 1947-1953

Satyendra, K., M. Imtiyaz, A. Kumar, and R. Singh. (2007). Response of onion (*Allium cepa* L.) to different levels of irrigation water. Agricultural Water Management, 1-2:161-166.

Sndecor, G. W. and W.G. Cocharn. (1991). Statistical methods. 8th E.d., lowa State Univ. press, lowa. USA.

Stackman, W.P. (1966). Determination of pore Size by the air bubbling pressure method proceeding unesce Symp. On water in the unsaturated zone 366- 372.

Stevenson, F. J. (1994). Humus Chemistry: Genesis, Composition, Reaction. 2nd Ed. John Wiley and Sons, Inc., New York.

Taha, N. M., S. H. Abd-Elrahman and F. A. Hashem (2019). Improving yield and quality of garlic (*Allium sativum* L.) under water stress conditions. Middle East Journal of Agriculture Research Vol: 8 (1):330-346

Trough, E. and A. H. Meyer. (1939). Improvement in denies calorimetric method for phosphorus and arsenic. Indian English Chemistry Analysis edition.1:136- 139.

Weagand, G.L. (1962). Drying pattern of a sandy clay loam in relation to optimal depth of seeding. Agron. J. 54: 473 – 476.

Yoder, R. E. (1936) A direct method of aggregate analysis of soils and the study of the physical nature of erosion losses, Journal of American Society of Agronomy, 28: 337-51.

Younis, S. I., N.M. Rashed and E.A. Moursi. (2010). Effect of water stress and potassium fertilizer on the growth, yield and composition of essential oil of fennel plant. J. Plant Production, Mansoura Univ., 7: 931-946.

Youssef, M. S. (2007). Effect of some agricultural treatments on the growth, productivity, quality and storageability of potato. Ph. D. Thesis, Fac. Agric., Zagazig University, pp: 188.

Zhang, X., E. H. Ervin and R. E. Schmidt. (2003). Physiological effects of liquid applications of a seaweed extract and a humic acid on creeping bentgrass. J. Amer. Soc. Hort. Sci., 128 (4): 492-496.

تأثير معدلات الري المختلفة وطرق اضافة حمض الهيوميك على النمو والمحصول والقدرة التخزينية للثوم

سيد منصور رزق[١] وطارق هاشم محمد عبد العزيز دشيش[٢]

[١] قسم بحوث البطاطس والخضر خضرية التكاثر-معهد بحوث البساتين -مركز البحوث الزراعية -الجيزة – مصر

[2]معهد بحوث الأراضي والمياه والبيئة -مركز البحوث الزراعية -الجيزة – مصر

أجريت تجربة حقلية لدراسة تأثير مستويات الري المختلفة عند استنزاف ٤٠٪ و٦٠٪ و٨٠٪ من المياه المتاحة وطرق تطبيق حمض الهيوميك (بدون إضافة وإضافة أرضية ورش ورقى وإضافة أرضية + رش ورقى) على نمو وإنتاجية وتخزين الثوم صنف سدس ٤٠. أشارت النتائج إلى أن أعلى قيم لمياه الري المطبقة كانت ٣٣٥٩ و٣١٦٢ متر مكعب / فدان نتيجة استنزاف ٤٠٪ من المياه المتاحة مقارنة مع معاملتي الري الأخرى في كلا الموسمين على التوالي. كما أظهرت النتائج أن الري بعد استنزاف ٨٠٪ من الماء المتاح يمكن أن توفر حوالي ٣١,٠٪ و٢٩,٨٪ من المياه المطبقة مقارنة بـ ٤٠٪ في كلا الموسمين على التوالي. علاوة على ذلك فإن الري بعد استنزاف ٤٠٪ و٦٠٪ من الماء المتاح مع الإضافة الأرضية والرش الورقي بحمض الهيوميك أدى إلى زيادة طول النبات وعدد الأوراق وقطر العنق وقطر البصيلة ووزن البصلة الطازج والوزن الطازج والجاف للنبات أيضًا محصول الابصال والوزن الطازج للبصلة وعدد الفصوص / البصلة وقطر البصلة وقطر العنق ومتوسط وزن الفص والنيتروجين، والفوسفور والبوتاسيوم والكربوهيدرات. بينما ارتفع البرولين والحرافة الكلية وانخفضت النسبة المئوية للفقد في الوزن بعد اثنين وأربع وسبع شهور من التخزين بشكل ملحوظ نتيجة الري بعد استنفاد ٨٠٪ من الماء المتاح مع الإضافة الأرضية + الرش بحمض الهيوميك. كما زاد متوسط كفاءة استخدام المياه باستخدام ٦٠٪ من الماء المتاح مع إضافة التربة والرش الورقى لحمض الهيوميك تليها ٨٠٪ من الماء المتاح مع إضافة أرضية والرش الورقي لحمض الهيوميك ثم ٤٠٪ من الماء المتاح مع إضافة أرضية والرش الورقي لحمض الهيوميك في كلا الموسمين.