EFFECT OF MULCHING ON BULB YIELD, WATER USE EFFICIENCY, PLANT WATER STATUS AND CHEMICAL COMPOSITION OF GARLIC PLANTS GROWN UNDER DIFFERENT IRRIGATION LEVELS

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ABSTRACT

Field studies were conducted for two consecutive winter seasons of 2016/2017 and 2017/ 2018 to investigate the effect of mulching; (rice straw and without mulch as control) on bulbs yield, water use efficiency, plant water status and chemical composition of garlic grown under three levels of irrigation (I_{100} = 100%, I_{80} = 80% and I_{60} = 60% of ET_C crop evapotranspiration). Bulb yield, water and potassium use efficiency, plant water status (RWC), membrane stability index (MSI) and leaf N and K significantly increased by increasing irrigation levels from I_{60} to I_{80} and further to I_{100}. I_{80} was pronounced on water use efficiency and leaf P, meanwhile I_{60} was pronounced on leaf total phenolic, flavonoids, anthocyanin, free proline and total free amino acids contents. Garlic plants growth was improved under three levels of irrigation by using rice straw mulch. Results implied that I_{100} + rice straw, significantly, increased bulbs yield, (RWC), (MSI) and leaf N and K .In addition, I_{80} + rice straw significantly, increased water use efficiency and leaf P. Howevere, I_{60} + rice straw significantly, increased leaf total phenolic, flavonoids, anthocyanin, free proline and total free amino acids contents.

Key Words- *Allium sativum* L., Irrigation levels, Mulching, Bulb yield, Water use Efficiency, Plant water status, Chemical composition.

INTRODUCTION

Garlic (*Allium sativum* L.) belongs to the family Alliaceae and second most important bulb crops after onion (Pandey *et al*., 2012). It is one of main vegetable crops in Egypt. It has been used for flavoring, soup, sausages and salads, in addition to its medical value (Ahmed *et al*., 2009). China leads in the world production followed by India, South Korea and Egypt. In Egypt, the cultivated area is 29148 Feddan produced 295845 tones with an average of 10.15 tones fed^{-1} (FAO, 2013). Increasing total yield and improving bulb quality of garlic are essential aims for both growers and consumers, but it usually depends on many environmental factors . Planting date, temperature and photoperiod prevailing at growth season, amount of water irrigation, some agricultural practices such as cultivation, pests and diseases control, irrigation and soil mulching are of these environmental factors (El-Sayed and El-Morsy, 2012).

Water is an essential factor in agriculture production in Egypt. In arid regions where irrigation is required for crop production, growers are seeking methods to save water by increasing irrigation efficiency Amer *et al*. (2009). Garlic requires adequate moisture for good establishment, growth, development bulb yield, bulb quality and storability (Karaye and Yakubu, 2007). Mulching

reduces the deterioration of soil by way of preventing the runoff and soil loss, minimizes the weed infestation and checks the water evaporation. Organic mulch properly utilized can perform all the benefits of any mulch with the possible exception of early season soil warming (Kumar and Lal, 2013). The use of rice straw mulch led to decrease the soil moisture depletion by 66, 57, 48 and 38 % compared with non-mulch treatment for 70, 80, 90 and 100 % of crop evapotranspiration, orderly. Also, the mulched treatments showed productivity increase compared to non-mulched treatments (Khalifa and El-Nemr, 2011)
Accordingly, the current investigation was proposed in order to examine the impact of mulching on bulbs yield, water and potassium use efficiency, plant water status and chemical composition of garlic grown under irrigation levels.

MATERIALS AND METHODS

Experimental site

Two experiments were conducted in two successive growing winter seasons of 2016/2017 and 2017/2018 at a private farm, Beni Suef Governorate, Egypt**.** Before the initiation of experimentas, soil samples were collected from experimentae site and analyzed according to standard methods of Wilde *et al*. (1985). Results of soil analyses have showed that the soil texture; clay, pH; 7.41 and 7.63, N (mg kg^{-1}); 9.00 and 9.33, P (mg kg^{-1}); 9.52 and 9.70 and K (mg kg^{-1}); 289 and 301 in 2016 and 2017, respectively.

Treatments and experimental design

The experimental layout was a split plot system based on randomized complete block design (RCBD) with three replications. Treatments were divided into three water applied (IWA) levels; (I_{100} = 100%, I_{80} = 80% and I_{60} = 60% of ET_C crop evapotranspiration) and two mulch types; (rice straw mulch and without mulch). (IWA) levels and mulch types were randomly allocated within the main and sub plots, orderly. There were 6 treatments as follows: I_{100} (irrigation with100% of ET_C), I_{80} (irrigation with 80% of ET_C), I_{60} (irrigation with 60%of ET_C), I_{100} + rice straw, I_{80} + rice straw and I_{60} + rice straw. The 6 treatments were replicated three times, making a total of 18 plots, each plot including 3 rows; 3.5 m long and 70 cm wide. Each two adjacent main plots were isolated by 2 m. Nearly cloves of garlic crop cv. Sids 40 were soaked in running tap water for 12 hours prior to sowing, then were hand planted singly in both sides of inter-row spacing 10 cm on September 24^{th} and 30^{th} in 2016 and 2017, respectively.

Irrigation water applied (IWA)

The growing garlic plants were started different irrigation treatments after 30 days from planting and after that were irrigated every 15 days interval. Three irrigation water levels; 60, 80 and 100% ET_C were applied where ET_C represents the crop water evapotranspiration. The crop evapotranspiration (ET_C) were estimated using the crop coefficient according to the following equation

$$ET_C = ET_O \times Kc \qquad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where:

ET_C = crop water evapotranspiration (mm d^{-1}).

ET_O = reference evapotranspiration of crop; average monthly of Beni Suef, Egypt for 3.25, 2.59, 2.11, 1.96, 2.51 and 3.36 for October, November, December, January, February and March.

K_C = crop coefficient.

The lengths of different crop growth stages were 75, 50, 30, and 25 days for the initial, development, mid-season and late season stages, respectively. The garlic coefficients (Kc) of initial, mid and end stages were 0.7, 1.0 and 0.7, respectively according to Allen *et al*. (1998).

The amount of irrigation water applied to each plot during the irrigation treatment was determined by using the following equation

$$\mathrm{IWA} = \frac{\mathrm{A} \times \mathrm{ETc} \times \mathrm{Ii}}{\mathrm{Ea} \times 1000} + \mathrm{LR} \ldots\ldots.(2)$$

Where:

IWA = irrigation water applied (m^3). A = plot area (m^2).

ET_C = crop evapotranspiration (mm d^{-1}). Ii = irrigation intervals (d).

Ea = application efficiency (%) (Ea= 60%). LR=leaching requirements (m^3)

The amount of irrigation water applied (IWA) was controlled through plastic pipe of 50 mm diameter. The amount of water delivered through a plastic pipe was calculated using the following equation according to (Israelson and Hansen, 1962).

$$Q = CA\sqrt{2gh} \times 10^{-3} \ldots\ldots\ldots..(3)$$

Where:

Q = discharge of irrigation water (l. sec^{-1}), C= coefficient of discharge

A = cross section area of irrigation pipe (cm^2) G= gravity acceleration (cm. sec^{-2})

H = average effective head of water (cm).

The total amount of irrigation volumes applied during both seasons to different treatments were 2168, 1743.4 and 1300.8 m^3/fed for I_{100}, I_{80} and I_{60}, respectively.

Mulch type treatments

Rice straw mulch was done immediately after complete earthing (about 7 days from seed sowing) and soil uncovered with rice straw.

All experimental unites received identical doses of N, P_2O_5 and K_2O at 100, 60 and 72Kg fed^{-1}, orderly and all other agro-management practices were achieved as recommended in the commercial production of garlic. Harvesting was done after 180 days from planting, in both seasons. In each experimental unit, the plants of middle row were allocated for plant water status and chemical composition while, the plants of two outer rows were allocated to measure bulbs yield, water and potassium use efficiency.

Data Recorded

At the end of experiment, all plants in each experimental plot were harvested and cured for approximately 15 days and were then weighed using electronic scale and converted to total bulb yield fed^{-1}. WUE values of applied water were calculated (as kg yield per m^3water) for different treatments after harvest and cured according to the following equation (Jensen, 1983):

$$\text{Water use efficiency} = \frac{\text{Bulbs yield (kg fed}^{-1}\text{)}}{\text{Water applied (m}^3\text{ fed}^{-1}\text{)}}$$

Leaf samples for membrane permeability measurements, were collected from four randomly selected plants in each experimental unit, after 160 days from culturing date, were collected, washed with tap water, rinsed three times with distilled water. Relative water content (RWC) were determined using the formula of Hayat *et al.* (2007). Membrane stability index (MSI) was estimated as described by (Sairam, 1994). Random leaf samples were washed with tap water, rinsed three times with distilled water and dried at 70 C^o in a forced- air oven till the weight became constant. Dried leaf samples were ground in a Wiley mill to pass 30 mesh screen. Weights of 0.2 g of fine leaf powder samples were digested using a mixture of sulphuric and perchloric acids to measure the leaf N mg g^{-1} DW; colorimetrically determined by using the technique of (Hafez and Mikkelsen, 1981), leaf P mg g^{-1} DW; colorimetrically estimated according to the stannous molybdate chloride method as illustrated in (A. O. A. C, 1995). Leaf K and mg g^{-1} DW; photometrically measured using Flame photometer as mentioned by Wilde et al. (1985). The free proline (mg g^{-1} DW) were measured using the colorimetric method outlined by Bates *et al*. (1973) and (Dubey and Rani, 1989). Leaf anthocyanin content (mg g^{-1} DW) were measured using the apparatus of spectrophotometer at wave length 510 nm and 700 nm as outlined by Meyers *et al*. (2003) and . Leaf total free amino acids content (mg g^{-1} dry weight) were calorimetrically measured at wave length of 570 nm as outlined by (Dubey and Rani, 1989). While the leaf contents of total phenolics (mg g^{-1} DW) were measured using colorimetric method was reported by (Swain and Hillis, 1959) and leaf contents of total flavonoids (mg g^{-1} DW) was determined following a method by Park *et al.* (2008).

Statistical analysis

All data were subjected to analysis of variance (ANOVA) for a randomised complete block design, after testing for homogeneity of error variances according to the procedure outlined by (Gomez and Gomez, 1984) using InfoStat software estadistico, (2016). Significant differences between treatments were compared at $P \leq 0.05$ by Duncan's multiple range test.

RESULTS AND DISCUSSION

Total bulbs yield, water use efficiency

Total bulbs yield (tone fed^{-1}) and water use efficiency (yield bulbs kg/water m^{-3}), of garlic grown under different mulching and three levels of irrigation (I_{100} = 100%, I_{80} = 80% and I_{60} = 60% of ET_C) are presented in table1. Statistical analysis carried out on total bulbs yield and water use efficiency, revealed highly significant differences ($P < 0.05$) between mulching and irrigation levels. Increasing irrigation amount from 60 to 80 and further to 100 % ET_C accompanied, significantly, increments on total bulbs yield meanwhile, irrigation amount 80 % ET_C was pronounced on water use efficiency followed by irrigation percent's 60 and 100 % ET_C, respectively. Data clearly showed that covering soil with rice straw mulch significantly improved total bulbs yield and water use efficiency to the controls. Although maximum values of total bulbs yield was obtained with the I_{100} + rice straw treatment, meanwhile, I_{80} + rice straw treatment was pronounced on water use efficiency.

TABLE 1: Effect of soil mulching and irrigation levels on total bulbs yield (tone fed^{-1}) and water use efficiency (yield bulbs kg/water m^{-3}) of garlic plants in two seasons (SI) and (SII).

Treatments	Total bulbs yield		Water use efficiency (yield bulbs kg/water m^{-3})	
	SI	SII	SI	SII
I_{100}	7.91[b#]	8.11[b]	3.65[e]	3.74[e]
I_{80}	7.27[d]	7.45[d]	4.19[b]	4.29[b]
I_{60}	5.30[f]	5.41[f]	4.08[c]	4.16[c]
I_{100} + Rice straw	8.13[a]	8.39[a]	3.75[d]	3.87[d]
I_{80} + Rice straw	7.49[c]	7.74[c]	4.32[a]	4.46[a]
I_{60} + Rice straw	5.54[e]	5.80[e]	4.26[ab]	4.46[a]

[#]Values marked with the same letter(s) are statistically similar using Duncan's multiple range test. †Mean values (n = 30; 3 replicate × 10 plants) in each column for each year. I_{100} = irrigation with 100% of ETc, I_{80} = irrigation with 80% of ETc and I_{60} = irrigation with 60% of ETc.

Regarding the influence of irrigation treatments on total bulbs yield the obtained results showed that, irrigation treatments 80 and/or 100 % ET_C, increased total bulbs yield than irrigation treatment 60 % ET_C. Such favourable effect of irrigation treatments at the intermediate and/or higher than low irrigation treatment might be due to better availability of moisture in root zone during the entire of garlic growth period and it is well known that water plays a crucial in nutrients uptake and transport and photosynthesis which favoured the growth and reflected on bulbs yield and its components. The obtained results were in agreement with those obtained by Tayel *et al*. (2010) and (Mandefro and Shoeb, 2015) who reported that, irrigation treatments 80 and/or 100 % ET_C, significantly, provided higher total and marketable bulbs yield, weight $bulb^{-1}$, clove weight and cloves number $bulb^{-1}$ than irrigation 60 treatment % ET_C. The obtained results, also, illustrated that, irrigation percent 80 % ET_C was a pioneer on water use efficiency. Similar results of El-Atawy, (2007) and Gyanendra *et al*. (2016) who indicated that, irrigation treatment 75% of pan evaporation was the highest value of water use efficiency and declined with irrigation treatments 100 and 125% of pan evaporation. The effect of rice straw mulch versus to control was evaluated, during the two successive winter seasons where results indicated that, I_{100} + rice straw treatment, increased total bulbs yield and I_{100} + rice straw treatment increased water use efficiency in comparison to controls. The increments noticed in rice straw mulch in the previous phenomena can be discussed on the basis that, using rice straw mulch on soil surface depressed infiltration rate caused efficient in reduction of nutrients leaching, regulated soil temperature, much conserved soil moisture, stimulated soil flora activity, reduced weed growth, added organic matter to soil and adequate micro atmosphere surrounding plants which reflected on the growth and productivity of garlic. Many authors working on mulch materials on different crops as Wang *et al*. (2004) who observed that straw mulch resulted in higher yield compared to polythene mulch (black or transparent) and no mulch. The increments noticed in water use efficiency by rice straw mulch might be to conserve soil moisture (Khalifa and El-nemr, 2011; Gouranga and Ashwani, 2007), depressed soil infiltration rate so, solution nutrients are available especially potassium and therefore, led to water and potassium use efficiency were increased. Similar information were published by (Abdul-Halim, 2000)

Plant water status

Data in table 2 illustrates the effect of different mulches on leaf relative water content RWC and membrane stability index MSI of garlic grown under three levels of irrigation (I_{100} = 100%, I_{80} = 80% and I_{60} = 60% of ET_C). Statistical analysis carried out on (RWC) and (MSI) revealed highly significant differences ($P < 0.05$)between mulching and irrigation levels. Increasing irrigation amount from 60 to 80 and to 100 % ET_C obviously, significantly, increased leaf relative water and membrane stability index contents. Data clearly showed that covering soil with rice straw mulch significantly improved RWC and MSI to the controls. Although maximum values of (RWC) and (MSI) were obtained with the I_{100} + rice straw mulch treatment.

TABLE 2: Effect of soil mulching and irrigation levels on leaf relative water content (%) and membrane stability index content (%) of garlic plants in two seasons (SI) and (SII).

Treatments	Leaf relative water (%) content		Membrane stability index content (%)	
	SI	SII	SI	SII
I_{100}	67.92[b#]	73.00[a]	78.06[a]	79.43[a]
I_{80}	61.73[d]	64.17[c]	73.89[b]	70.88[c]
I_{60}	56.65[e]	59.88[d]	61.59[c]	63.07[d]
I_{100} + Rice straw	70.24[a]	73.71[a]	78.80[a]	79.46[a]
I_{80} + Rice straw	64.54[c]	65.98[b]	75.77[b]	72.92[b]
I_{60} + Rice straw	57.52[e]	59.99[d]	61.80[c]	63.84[d]

[#]Values marked with the same letter(s) are statistically similar using Duncan's multiple range test. †Mean values (n = 30; 3 replicate × 10 plants) in each column for each year. I_{100} = irrigation with 100% of ETc, I_{80} = irrigation with 80% of ETc and I_{60} = irrigation with 60% of ETc.

MSI% and RWC%,the measurements of plant water status, reflecting the metabolic activity in plant tissues and used as one of the meaningful indices to identify differences in dehydration tolerance (Abd El-Mageed *et al*., 2016).The effect of irrigation levels on leaf relative water and membrane stability index contents were evaluated, during the successive winter seasons, where the results referred to increasing irrigation up to 100 % ET_C increased, significantly, gradually leaf relative water and membrane stability index contents. These results were in accordance with those reported by several investigators as Abd El-Mageed *et al*. (2017) and Moustafa *et al*. (2017) who concluded that, increasing irrigation from 40 to 60 and further to 80 and 100 % ET_C increased leaf relative water content of garlic. The effect of rice straw mulch versus to control was evaluated, during the two successive winter seasons where results indicated that, I_{100} + rice straw treatment, increased RWC % and MSI % comber to control. Using rice straw mulch on soil surface depressed infiltration rate caused efficient in reduction of nutrients leaching, regulated soil temperature, much conserved soil moisture, stimulated soil flora activity, reduced weed growth, added organic matter to soil and adequate micro atmosphere surrounding plants which reflected on the growth, productivity, physiological characters and leaf chemical constituents of garlic. Many authers working on mulch materials on different crops as Islam *et al.* (2010) and Rahman e*t al*. (2013) on onion.

Chemical constituents

Leaf N, P and K contents

Data in Table 3 illustrate the effect of different mulches on leaf N, P and K contents, of garlic grown under three levels of irrigation during the two investigated seasons. The influence of irrigation amounts on leaf N, P and K contents was significant, in the two seasons. Increasing irrigation percent from 60 up to 100 % ET_C, intrinsically, was cross ponding on leaf N and K contents while, irrigation amount 80 % ET_C was, significantly, a pioneer on leaf P content, in both seasons. Covering soil with rice straw mulch significantly improved leaf N, P and K compared to the controls. The maximum values of leaf N and K were obtained with the I_{100} + rice straw treatment, meanwhile, I_{80} + rice straw treatment was pronounced on leaf P.

TABLE 3: Effect of soil mulching and irrigation levels on leaf nitrogen (mg g^{-1} dry weight), phosphorus (mg g^{-1} dry weight) and potassium (mg g^{-1} dry weight) contents of garlic plants in two seasons (SI) and (SII).

Treatments	Leaf nitrogen content (mg g^{-1} dry weight)		Leaf phosphorus content (mg g^{-1} dry weight)		Leaf potassium content (mg g^{-1} dry weight)	
	SI	SII	SI	SII	SI	SII
I_{100}	27.50[bc#]	27.98[ab]	3.70[d]	3.94[cd]	20.90[a]	21.05[b]
I_{80}	27.06[c]	27.47[c]	4.49[b]	4.65[b]	19.53[b]	20.31[cd]
I_{60}	25.82[e]	26.42[e]	3.51[e]	3.80[d]	18.85[c]	19.33[e]
I_{100} + Rice straw	28.13[a]	28.31[a]	4.23[c]	4.01[c]	21.30[a]	21.62[a]
I_{80} + Rice straw	27.57[b]	27.84[bc]	4.92[a]	4.93[a]	19.87[b]	20.52[c]
I_{60} + Rice straw	26.37[d]	26.87[d]	3.58[de]	4.01[c]	19.50[b]	20.11[d]

[#] Values marked with the same letter(s) are statistically similar using Duncan's multiple range test. †Mean values (n = 30; 3 replicate × 10 plants) in each column for each year. I_{100} = irrigation with 100% of ETc, I_{80} = irrigation with 80% of ETc and I_{60} = irrigation with 60% of ETc.

Leaf anthocyanin, free proline contents and total free amino acids

The data in table 4 showed that leaf anthocyanin, free proline contents and total free amino acids were intrinsic increased with decreased the irrigation amount. However, covering soil with rice straw mulch significantly increased leaf anthocyanin, free proline contents and total free amino acids cumbered to the controls. Maximum values of leaf anthocyanin, free proline contents and total free amino acids were obtained with the I_{60} + rice straw mulch treatment cumbered to others treatment

TABLE 4: Effect of soil mulching and irrigation levels on leaf anthocyanin (mg g^{-1} dry weight) , free proline contents (mg g^{-1} dry weight) and total free amino acids (mg g^{-1} dry weight) of garlic plants in two seasons (SI) and (SII)..

Treatments	Leaf anthocyanin (mg g^{-1} dry weight)		Leaf free proline (mg g^{-1} dry weight)		Leaf total free amino acids (mg g^{-1} dry weight)	
	SI	SII	SI	SII	SI	SII
I_{100}	**$0.385^{e\#}$**	**0.399^{e}**	**0.77^{e}**	**0.68^{e}**	**8.76^{e}**	**7.59^{e}**
I_{80}	**0.398^{d}**	**0.407^{d}**	**0.99^{c}**	**0.88^{c}**	**9.78^{c}**	**9.65^{c}**
I_{60}	**0.425^{b}**	**0.444^{b}**	**1.16^{b}**	**1.01^{b}**	**10.27^{b}**	**9.67^{c}**
I_{100} + Rice straw	**0.392^{de}**	**0.407^{d}**	**0.82^{d}**	**0.73^{d}**	**9.00^{d}**	**7.89^{d}**
I_{80} + Rice straw	**0.414^{c}**	**0.424^{c}**	**1.01^{c}**	**0.87^{c}**	**10.21^{b}**	**10.05^{b}**
I_{60} + Rice straw	**0.443^{a}**	**0.458^{a}**	**1.19^{a}**	**1.06^{a}**	**10.70^{a}**	**10.83^{a}**

\# Values marked with the same letter(s) are statistically similar using Duncan's multiple range test. †Mean values (n = 30; 3 replicate × 10 plants) in each column for each year. I_{100} = irrigation with 100% of ETc, I_{80} = irrigation with 80% of ETc and I_{60} = irrigation with 60% of ETc.

Leaf total phenolic and flavonoids contents

Table 5 displays the effect of different mulches; (rice straw and without mulch) leaf total phenolic and flavonoids contents of garlic grown under three levels of irrigation (I_{100}, I_{80} and I_{60}) , in winter seasons of 2016/2017 and 2017/2018 . The effect of irrigation amounts on leaf total phenolic and flavonoids contents was true, in both experimental seasons. Increasing irrigation amount up to 100% ET_C, significantly, decreased progressively on leaf total phenolic and flavonoids contents, in both seasons. However, covering soil with rice straw mulch significantly increased leaf total phenolic and flavonoids compared to the controls. Maximum values of leaf total phenolic and flavonoids were obtained with the I_{60} + rice straw mulch treatment compared to others treatment.

TABLE 5: Effect of soil mulching and irrigation levels on leaf total phenolic (mg g^{-1} dry weight and total flavonoids (mg g^{-1} dry weight)of garlic plants in two seasons (SI) and (SII).

Treatments	Leaf total phenolic (mg g^{-1} dry weight)		Leaf total flavonoids (mg g^{-1} dry weight)	
	SI	SII	SI	SII
I_{100}	**$0.67^{f\#}$**	**0.63^{f}**	**1.44^{f}**	**1.30^{e}**
I_{80}	**0.81^{d}**	**0.79^{d}**	**1.82^{d}**	**1.70^{d}**
I_{60}	**1.04^{b}**	**0.90^{b}**	**2.55^{b}**	**2.14^{b}**
I_{100} + Rice straw	**0.69^{e}**	**0.65^{e}**	**1.49^{e}**	**1.35^{e}**
I_{80} + Rice straw	**0.84^{c}**	**0.85^{c}**	**1.92^{c}**	**1.93^{c}**
I_{60} + Rice straw	**1.09^{a}**	**0.96^{a}**	**2.65^{a}**	**2.32^{a}**

\#Values marked with the same letter(s) are statistically similar using Duncan's multiple range test. †Mean values (n = 30; 3 replicate × 10 plants) in each column for each year. I_{100} = irrigation with 100% of ETc, I_{80} = irrigation with 80% of ETc and I_{60} = irrigation with 60% of ETc.

With respect to the leaf chemical constituents contents, the results showed that, increasing irrigation amount from 60 to 80 and 100 % ET_C was correspondingly N and K while, decreased correspondingly leaf total phenolic, anthocyanin, free proline, total free amino acids and flavonoids contents, in both seasons. The results, also, irrigation 80 % ET_C was a pronounced on leaf P content, in both seasons. Such favorable effect of increasing irrigation amount up to 100 % ET_C on leaf N and K was possibly attributed to the available nutrients of soil solution and both nutrients (N and K) uptake by the roots and transport from roots to shoots therefore, leaf N and K contents have increased. Plants under abiotic stresses, including salinity, drought and extremes temperature, accumulate number of osmoprotectants that function for osmotic adjustment which improves plant's tolerance to oxidative stresses. Our results were in accordance, to great extent, with the results of Foyer *et al*. (1994) and Li *et al*. (1998) Mafakheri *et al*. (2010) on chick pea and Abd El-Mageed *et al*. (2018) on squash reported that, drought increased leaf proline content. Similar findings on leaf total phenolic, anthocyanin, total free amino acids and flavonoids were recorded as reported by Farooq *et al*. (2009). The effect of rice straw mulch under irrigation levels versus to controls was evaluated, during the two successive winter seasons where results indicated that, rice straw mulch increased leaf chemical constituent contents (N, P, K, total phenolic, anthocyanin, free proline, total free amino acids and flavonoid) in comparison to controls. The increments noticed in rice straw mulch in the previous phenomena can be discussed on the basis that, using rice straw mulch on soil surface depressed infiltration rate caused efficient in reduction of nutrients leaching, regulated soil temperature, much conserved soil moisture, stimulated soil flora activity, reduced weed growth, added organic matter to soil and adequate micro atmosphere surrounding plants which reflected on the leaf chemical constituents of garlic. Many authers working on mulch materials on different crops as (Ning and Hu, 1990) declared that, the organic and inorganic mulch may be improve efficiently of microclimate surrounding on plant growth. Similar information were published by Abdul-Halim, (2000), Islam *et al*. (2007) on garlic, Islam *et al.*, (2010) and Rahman e*t al*. (2013) on onion.

CONCLUSION

Bulbs yield, water use efficiency, plant water status and chemical composition of garlic grown under three levels of irrigation were improved by using rice straw mulch. Results implied that I_{100} + rice straw significantly increased bulb yield, potassium use efficiency, RWC, MSI and leaf N and K. Also, I_{80} + rice straw significantly increased water use efficiency and leaf P. Howevere I_{60} + rice straw significantly, increased leaf total phenolic, flavonoids anthocyanin, free prolene and total free amino acids contents.

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تأثير التغطية على محصول الرؤوس، وكفاءة استخدام مياه الرى ، والحالة المائية ، والمحتوى الكيميائي لنباتات الثوم النامية تحت مستويات مختلفة من الرى

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الخلاصة

اجريت دراسات حقلية لموسمين شتويين متتاليين لعامى 2016/٢٠١٧، ٢٠١٧/٢٠١٨ لدراسة تأثير انواع مختلفة من التغطية (قش الأرز، وبدون التغطية) على محصول الرؤوس، وكفاءة استخدام مياه الرى ، والحالة المائية للنبات، والمحتوى الكيميائي لنباتات الثوم النامية تحت ثلاث مستويات من الرى (I_{100}=100% - I_{80} =80% - I_{60} = 60% من البخرنتح للمحصول). أوضحت النتائج أن كل من محصول الرؤوس، وكفاءة استخدام مياه الرى ، والحالة المائية للنبات محتويات الورقة من الماء النسبى ودليل ثبات الأغشية، ومحتوى الورقة من النيتروجين والبوتاسيوم يزداد معنويا بزيادة مستويات الرى من I_{60} إلى I_{80} وصولا إلى I_{100}. مستوى الرى I_{80} كان هو الأفضل فى كفاءة استخدام مياه الرى، ومحتوى الأوراق من الفوسفور، في حين كان مستوى الرى I_{60} هو الأفضل في محتوى الأوراق من الفينولات الكلية، الفلافونيدات، صبغة الأنثوسيانين، البرولين الحر والأحماض الأمينية الكلية الحرة. ونباتات الثوم النامية تحت المستويات الثلاثة المختلفة من الرى تحسن نموها باستخدام تغطية قش الارز. وأوضحت النتائج أن مستوى الرى I_{100} + قش الارز يزيد معنويا كل من محصول الرؤوس، محتويات الورقة من الماء النسبى، دليل ثبات الأغشية، ومحتوى الأوراق من النيتروجين والبوتاسيوم، أيضا مستوى الرى I_{80} + قش الارز يزيد معنويا كفاءة استخدام مياه الرى ومحتوى الأروراق من الفوسفور. بينما مستوى الرى I_{60} + قش الارز يزيد معنويا محتوى الأوراق من الفينولات الكلية، الفلافونيدات، صبغة الأنثوسيانين، البرولين الحر والأحماض الأمينية الحرة الكلية.