Zagazig J. Agric. Res., Vol. 40 No. (4) 2013 693-707

Zagazig Journal of Agricultural Research

www.zu.edu.eg/agr/journals

RESPONSE OF GLADIOLUS PLANTS TO WATER REGIME AND GLUTATHIONE UNDER DIFFERENT IRRIGATION SYSTEMS IN NEWLY RECLAIMED SOILS

Ebtessam A. Youssef[1*], A. E. Awad[2], A. K. Dawh[2] and M. S. A. Abo El-Kheir[1]

1. Water Relations and Field Irrigation Dept., Nat. Res. Cent., Dokki, Giza, Egypt

2. Hort. Dept., Fac. Agric., Zagazig Univ., Egypt

ABSTRACT

The present work was carried out to investigate the efficiency of glutathione to overcome the harmful effect of water deficit on growth parameters and reproductive characters as well as some physiological and chemical aspects of gladiolus plants grown under surface and subsurface drip irrigation. Results showed that decreasing the amount of irrigation water from 1882 to 1129 m^3 / fad., reduced significantly plant height, total leaf area and number of leaves per plant as well as water content of plant. The same trend could be noticed regarding to flowering and corms production except vase life. Also, the photosynthetic pigments content, total carbohydrates, nitrogen, phosphorus and potassium contents in the leaf tissues were significantly reduced with decreasing the amount of irrigation water. On the contrary, proline content exhibited a remarkable increase with increasing drought stress. Foliar application of glutathione promoted all the aforementioned growth parameters and reproductive characters as well as chemical constituents compared with untreated plants. Also, foliar application of glutathione (400 ppm) at 30 and 60 days after planting could be used to improve drought tolerance and economic yield of gladiolus plants. Furthermore, there was little difference between the values of the above mentioned characters studied in gladiolus plants irrigated by surface and subsurface drip irrigation.

Key words: Gladiolus, surface drip irrigation, subsurface drip irrigation, water stress, glutathione.

INTRODUCTION

Gladiolus is an important commercial flower bulbs crop, which is extensively cultivated in many countries of the world. It has decorative spike which carries florets with many colors. The flowers can be available around the year. Irrigation under arid and semi arid regions is essential to obtain a good quality crop. Decreasing water supply either temporarily or permanently affects morphological and physiological processes in plants adversely. The reactions of plants to water stress differ significantly at various organization levels depending upon intensity and duration of stress as well as plant species and its stage of growth. Optimizing irrigation management due to water scarcity together with appropriate crops for cultivation is highly in demand; the cost of irrigation pumping and inadequate irrigation scheme capacity as well as limited water sources is among the reasons that force many countries to reduce irrigation applications.

The exposure of plants to environmental stresses as water deficits, high and low air temperatures and pollutants can result in the production of reactive oxygen species (ROS) that are thought to diminish plant performance. The term antioxidant metabolism describes the detoxification of ROS, and the chemicals involved are generally referred as antioxidants. Recent review by Blokhina *et al.* (2003) summarized a great deal of the current knowledge of antioxidants metabolism in plants. Antioxidants and their role in the plant defence

* **Corresponding author: Tel. :** +201227227299
E-mail address:tarekmsc@yahoo.com

system had received increasing attention within the last decade (Smirnoff, 1995). Glutathione is a thiol- containing tripeptide, which appears to be present in nearly all living organisms and which is involved in many important metabolic and physiological processes. This work was performed to investigate the efficiency of improving quality agent (glutathione) to overcome the harmful effect of water deficit on growth parameters and reproductive characters as well as some physiological and chemical aspects of gladiolus plants grown under surface and subsurface drip irrigation.

MATERIALS AND METHODS

This study was carried out in a newly reclaimed area in Belbeis, Sharkia Governorate, Egypt during 2008/2009 and 2009/2010 seasons to investigate the efficiency of glutathione to overcome the harmful effect of water deficit on growth parameters and reproductive characters (flowering and corm production) as well as some physiological and chemical aspects of *Gladiolus gandavensis* plants cv. Roses supreme using two irrigation systems. The first system was surface built in drip lines system (GR) with 25cm emitters spacing (SDI). 16mm diameter laterals were used at 50cm spacing. The second system was subsurface drip irrigation (SSDI), the same practices were used for laterals but they were buried at 15cm depth from soil surface.

The experiment included 24 treatments which were the combinations of three levels of water supply [60, 80 and 100% of evapotranspiration (ETc)], four concentrations of glutathione (control, 200, 300 and 400 ppm) and two irrigation systems (surface and subsurface drip irrigation). The experimental design used was split-split plot with three replicates. The irrigation systems were arranged in the main plots, while the water treatments and glutathione concentrations were randomly distributed in the sub and sub-sub plots, respectively. After twenty days from planting, gladiolus plants were subjected to three levels of water supply [60, 80 and 100% of evapotranspiration (ETc)]. The plants in every treatment were irrigated every three days.

In the two growing seasons, the amount of water needed for each treatment was calculated according to the crop coeffeicienal (K_c) and the daily reference potential evapotranspiration (ET_o). The latter was determined according to the Penman-Monteith equation depending on the predicted climatic factors at each irrigation time and the growth stage, (FAO, 1991). At the end of the last irrigation, the quantity of water applied for each of the three water treatments was calculated according to the total amount of water added from planting until harvesting for the two seasons. The average amounts of water during the two growing seasons were 1129, 1506 and 1882 m^3/ fad., for the water treatments, respectively. Fresh solution of glutathione was sprayed twice on plants at 30 and 60 days after planting.

Some physical properties of the soil and chemical constituents of the used irrigation water are shown in Tables i and ii, respectively. Particle size distribution and moisture of the soil sample were determined as described by Black *et al.* (1982), while chemical properties of the used irrigation water were performed according to Jackson (1967).

Uniform corms (20g in weight and 3cm in diameter) were planted on October 7th in both seasons and all agricultural practices were followed in this experiment as usual. The plants received the normal fertilization of this plant. Representative plant samples were collected from three replicates for each treatment after 90 days from planting in both seasons for determining growth criteria and some physiological and chemical aspects. The spikes were cut when the basal floret became colored leaving three leaves on each plant. The new corms and cormels were collected five weeks after the end of flowering.

Recorded Data

Vegetative growth parameters

1. Plant height (cm),
2. Total leaf area per plant (cm^2), (Bremner and Taha, 1966),
3. Number of leaves per plant,
4. Water content (%) was calculated according to the following equation:

$$\text{Water content (\%)} = \frac{\text{Fresh weight - Oven dry weight}}{\text{Fresh weight}} \text{X100}$$

Table i. Main physical properties of the soil under experimental plants

Depth (cm)	Particle size distribution (%)					Moisture content (%)			
	Coarse sand	Fine sand	Silt	Clay	Soil texture	Saturation point (S.P.)	Field capacity (F. C.)	Available water (Av. W.)	Wilting point (W.P.)
0 - 30	43.20	19.50	24.00	13.30	Silt loam	28.60	14.30	7.15	7.15

Table ii. Main chemical constituents of the used irrigation water (meq. /l.)

pH	TDS (ppm)	K	Mg	Ca	Na	Cl	CO_3	HCO_3	SO_4
7.80	263	0.20	1.00	1.40	1.50	0.90	0.01	2.55	1.34

Reproductive characters

1. Spike length (cm),
2. Number of florets per spike,
3. Vase life (day),
4. Number of fresh cormels per plant (after 5 weeks of the end of flowering),
5. Diameter of fresh corm (cm) (after 5 weeks of the end of flowering),
6. Weight of fresh corm (g) (after 5 weeks of the end of flowering).

Chemical constituents

1. Proline content (μ moles/g fresh weight) in samples of leaf was determined according to the method adopted by Bates *et al.* (1973).
2. Photosynthetic pigments content (mg/g fresh weight) was determined according to Von Wettestein (1957).
3. Total carbohydrate content (mg/g dry weight) were determined in dry leaves after 90 days from planting according to Dubois *et al.* (1956).
4. Total nitrogen percentage was determined in dry leaves after 90 days from planting according to Naguib (1969).
5. Total phosphorus percentage was determined in dry leaves after 90 days from planting according to AOAC (1975).
6. Potassium percentage was determined in dry leaves after 90 days from planting according to Jackson (1967).

Statistical Analysis

The obtained data were subjected to the statistical analysis of variance described by Snedecor and Cochran (1980) using the multiple range test (Duncan, 1955) at 5% to compare means.

RESULTS AND DISCUSSION

Effect of Irrigation Systems, Water Regimes, Glutathione and the Interaction between Irrigation Systems and Water Regime Treatments on Vegetative Growth Parameters

Plant height (cm)

The collected data in Table 1 reveal that the plant height was significantly decreased with decreasing the amount of irrigation water from 1882 to 1129m^3/fad., under the irrespective of irrigation systems in both seasons. The data indicate further that spraying glutathione up to 400 ppm increased significantly plant height in the two experimental seasons when compared with the untreated plants. As for the interaction between irrigation systems and water regime treatments, data illustrated in Table 1 indicate that the highest significant plant height was

Table 1. Effect of irrigation systems, water regimes, glutathione and the interaction between irrigation systems and water regime treatments on growth parameters of gladiolus plants after 90 days from planting during 2008/2009 and 2009/2010 seasons

Treatments \ Characters		Plant height (cm)		Total leaf area (cm^2/ plant)		No. of leaves per plant	
		1st*	2nd**	1st*	2nd**	1st*	2nd**
Effect of irrigation systems							
SDI		54.25	56.02	610.60	625.69	10.69	10.97
SSDI		54.42	56.25	609.98	624.62	10.64	10.94
Effect of water regimes							
100% ETc		57.38 A	59.87 A	637.33 A	657.97 A	11.25 A	11.75 A
80% ETc		54.79 B	56.41 B	617.04 B	631.64 B	10.71 B	11.04 B
60% ETc		50.83 C	52.12 C	576.51 C	585.85 C	10.04 C	10.08 C
Effect of glutathione concentrations							
Control		48.83D	49.16 D	558.01 D	557.37D	9.61 D	9.61 D
200ppm		53.17 C	54.50 C	598.21 C	607.60C	10.39 C	10.38 C
300ppm		55.83 B	58.22 B	624.81 B	646.52B	11.11 B	11.55 B
400ppm		59.50A	62.66 A	660.14 A	689.12A	11.56 A	12.27 A
Interaction between irrigation systems and water regimes							
	100% ETc	58.08a	60.58 a	647.35a	668.11a	11.42 a	11.91 a
SDI	**80% ETc**	55.75b	57.41 b	625.94b	641.16b	11.00 b	11.33 ab
	60% ETc	48.92d	50.08 d	558.53e	567.80e	9.67 d	9.66 d
	100% ETc	56.67ab	59.16 a	627.32b	647.83ab	11.08 b	11.58 a
SSDI	**80% ETc**	53.83c	55.41 c	608.14c	622.12c	10.42c	10.75bc
	60% ETc	52.75c	54.16 c	594.48d	603.90d	10.42c	10.50c

*= first season, **= second season.

Values having the same alphabetical litter (s) did not significantly different at 0.05 level of significance according to Duncan's multiple range test.

obtained in plants grown under 100 % ETc and irrigated with surface drip irrigation.

The decrease in plant height as a result of water deficit may be attributed to loss of turgor which affects the rate of cell division and enlargement. In this connection, Kramer and Boyer (1995) reported that the growth of plants was controlled by rates of the cell division and enlargement and by the supply of organic and inorganic compounds required for the synthesis of new protoplasm and cell walls. Cell enlargement is particularly dependent on at least a minimum degree of cell turgor, and stem and leaf elongations are quickly checked or stopped by water deficits. The depression in plant height as affected by water deficit on plants were recorded by many investigators; Meawad *et al.* (2005) on roselle, Abo El-kheir and Mekki (2007) on maize and Pereira *et al.* (2010) on gladiolus.

The enhancement effect of applied glutathione on plant height may be due to its role in activating the synthesis of amino acids, the key materials of tissue building in plants (Midan, 1986).

Total leaf area/plant (cm^2)

Data presented in Table 1 clearly show that total leaf area was significantly decreased with decreasing the amount of irrigation water from 1882 to 1129m^3/fad., under the two studied irrigation systems in both seasons. The data indicated further that spraying glutathione up to 400 ppm increased significantly total leaf area in the two experimental seasons when compared with the untreated plants. Concerning the interaction effects between the irrigation systems and water regime treatments on total leaf area per plant, data illustrated in Table 1 indicate that the highest significant plant height was obtained in plants grown under 100% ETc under surface drip irrigation.

Such reduction in the mean area of leaves per plant due to water stress could be attributed to its effect on mineral nutrition (uptake and transport of nutrients) and metabolism. In this regard, Ali *et al.* (1999) indicated that soil drying decreased leaf growth thereby reducing leaf water status in addition to accumulation of organic solutes to osmotic adjustment which in turn inhibit the incorporation of small substrate molecules into the polymers needed to grow new cells.

The resulting stimulation on leaf area may be explained as the antioxidants substances encourage nutrients absorption and stimulate some growth activators synthesis. Hell and Bergmann (1990) stated that glutathione functions as a storage pool for excess systeine and principal from in which organic sulfur is transport in many plants.

Number of leaves per plant

The results in Table 1 reveal that the number of leaves per plant was significantly decreased with decreasing the amount of irrigation water from 1882 to 1129m^3/fad., under the two studied irrigation systems in both seasons. The data indicated further that foliar application with glutathione up to 400 ppm increased significantly the number of leaves per plant on the treated plants during the two seasons compared with the untreated plants. It could be noticed from Table 1 that there was positive significant interaction between the irrigation systems and water regime treatments with respect to the number of leaves per plant in both seasons.

In this concern, Wu *et al.* (2005) attributed the effect of water stress on leaves number to enhancement of leaf abscission due to hormonal imbalance which arose from increased ABA and decreased IAA levels in treated plants. Similar results were obtained by El-Makawy (1999) on *Piganum harmala* and *Calotropis procera*, Youssef (2007) on gladiolus and Khalil *et al.* (2010) on basil.

In addition, Blokhina *et al.* (2003) stated that the antioxidant is currently considered to be regulators on plant growth and development owing to their effects on cell division and differentiation. Further support came from the results of Khalil *et al.* (2012) who found that the application of glutathione as foliar spray on *Capsicum annum* plants caused stimulatory effects on leaves numbers. The favorable effect of glutathione on vegetative growth was observed by Talaat and Aziz (2005) on *Matricaria chamomilla*, Mahgoub *et al.* (2006) on *Calendula oficinalis* and Khalil *et al.* (2012) on *Capsicum annuum*.

Effect of Irrigation Systems, Water Regimes, Glutathione and the Interaction between Irrigation Systems and Water Regime Treatments on Some Water Relations in Both Seasons

Water content (%)

The present results in Table 2 reveal that water content was significantly decreased with decreasing the amount of irrigation water from 1882 to 1129 m^3/fad., under the two studied irrigation systems in both seasons. The data indicate further that foliar application with glutathione up to 400 ppm increased significantly the water content of the treated plants during the two seasons when compared with the untreated plants. With respect to the interaction effect, the data of combined effect among the two tested factors showed that the highest water content value was recorded in plants grown under surface drip irrigation with 100 % ETc.

Abdel-Mawgoud *et al.* (2005) reported that increasing irrigation rate may increase water availability in the root zone resulting in improving plant water status and better stomatal conductance which eventually reflects on photo assimilates production. Similar results were obtained by Kusaka *et al.* (2005) and Khalilvand and Yarnia (2007).

The stimulatory effect of glutathione on the content of water in leaf tissues may be attributed to its effect on increasing physiological availability of water and nutrients (El-Bassiouny *et al.*, 2008).

Table 2. Effect of irrigation systems, water regimes, glutathione and the interaction between irrigation systems and water regime treatments on water content, proline and chlorophyll (a+b) of gladiolus plants after 90 days from planting during 2008/2009 and 2009/2010 seasons

Characters / Treatments		Water content (%)		Proline content (μ moles/g fresh wt.)		Chlorophyll a+b (mg/g fresh wt.)	
		1st*	2nd**	1st*	2nd**	1st*	2nd**
				Effect of irrigation systems			
SDI		85.65	85.57	60.30	61.76	4.02	4.12
SSDI		85.23	85.26	59.31	61.01	3.68	3.82
				Effect of water regimes			
100% ETc		85.84 A	85.89 A	48.95 C	50.79 C	4.14 A	4.29 A
80% ETc		85.60 A	85.60 A	58.98 B	60.29 B	3.78 B	3.90 B
60% ETc		84.88 B	84.76 B	71.49 A	73.08 A	3.63 B	3.71 B
				Effect of glutathione concentrations			
Control		84.46 C	84.31 C	64.77 A	67.40 A	3.51 C	3.53 C
200ppm		85.09 B	85.03 B	62.08 B	62.44 B	3.80 B	3.89 B
300ppm		85.64 B	85.64 B	57.90 C	59.11 C	3.90 B	4.06 B
400ppm		86.56 A	86.63 A	54.47 D	56.59 D	4.20 A	4.39 A
				Interaction between irrigation systems and water regimes			
	100% ETc	86.06	86.06	49.27	51.11	4.36	4.45
SDI	**80% ETc**	85.80	85.79	59.87	60.82	3.99	4.11
	60% ETc	85.10	84.85	71.76	73.35	3.70	3.79
	100% ETc	85.62	85.71	48.63	50.46	3.92	4.13
SSDI	**80% ETc**	85.39	85.39	58.08	59.76	3.58	3.69
	60% ETc	84.67	84.66	71.22	72.81	3.55	3.63

*= first season, **= second season.

Values having the same alphabetical litter (s) did not significantly different at 0.05 level of significance according to Duncan's multiple range test.

Proline content (μ moles/g fresh wt.)

Data in Table 2 show that decreasing the amount of irrigation water (irrigation with 80 or 60% ETc) led to significant increase in proline content in the leaves of gladiolus plants in both seasons in comparison with the control (irrigation with 100 % ETc). On the contrary, the proline content showed a gradual decrease by increasing the concentration of glutathione up to 400 ppm in both seasons as compared with the untreated plants. Concerning the interaction, the data indicate that the highest accumulation of proline content was recorded in plants grown under severe water stress (irrigation with 60% ETc) using surface drip irrigation.

Proline accumulation, increasing the osmotic pressure of the cell sap and decreasing the water content in the leaf tissues had been documented by many researches in numerous plants during drought stress and this is considered a general phenomenon in plants (Singh and Patel, 1996).

The stimulatory effect of glutathione on the content of water and proline in leaf tissues may be attributed to its effect on increasing physiological availability of water and nutrient (El- Bassiouny *et al*., 2008). In this connection, Foyer and Noctor (2005) reported that glutathione is involved in both the direct and indirect control of ROS concentrations.

Chlorophyll content (mg/g fresh wt.)

Data presented in Table 2 indicate that decreasing the amount of irrigation water from 1882 to 1129m^3/fad., caused significant reduction in chlorophyll (a+b) in leaf tissues in the two experimental seasons. The data reveal further that there was no significant difference between the quantity of irrigation water 1129 and 1506 m^3/fad., in comparison with the control (1882 m^3/fad.). As for the effect of glutathione, the results cleared that spraying gladiolus plants with glutathione at 400 ppm increased significantly chlorophyll (a+b) in both seasons without significant difference between 200 and 300 ppm concentrations of glutathione in comparison with the untreated plants (control). With respect to the interaction effect, the data of combined effect among the two tested factors showed that the highest value for chlorophyll (a+b) was recorded in plants grown under irrigation with 100 % ETc using surface drip irrigation.

In support of these results, Graca *et al.* (2010) observed that water stress reduced photosynthetic rate per unit leaf area. In addition, Abo El-Kheir (2000) indicated that decreasing the available soil moisture content led to a significant decline in the concentration of chl. a, chl. b and total chl (a+b) as well as carotenoids.

The increases in photosynthetic pigments in response to foliar application of antioxidant may be due to its role in either enhancing the photosynthetic activity and chlorophyll biosynthesis or protecting chloroplast from oxidative damage resulted from the oxidative stress (Munne-Bosch *et al.*, 2001). In addition, Foyer and Noctor (2009) reported that glutathione plays critical roles in the coordination of cellular processes with photosynthetic activity.

Effect of Irrigation Systems, Water Regimes, Glutathione and the Interaction between Irrigation Systems and Water Regime Treatments on Flowering Characters in Both Seasons

Spike length (cm)

Data in Table 3 reveal that the spike length was significantly decreased with decreasing the amount of irrigation water from 1882 to 1129m^3/fad., under the two studied irrigation systems in both seasons. Also spraying glutathione at the rate of 400 ppm increased significantly the spike length in the two experimental seasons when compared with the untreated plants. The interaction effect of irrigation systems and water regime treatments showed that the highest value for spike length recorded by SDI and 100% ETc.

The obtained data for flowering characters of gladiolus plants under water deficit showed that the various parameters were mostly significantly decreased. These results are in great accordance with those observed by D'Andria *et al.* (1996) and Bastug *et al.* (2006).

The stimulatory effects of glutathione on flowering characters could be explained as antioxidants could enhance plant cell growth and development and stimulate cell vacuolization factors that could positively reflected on plant growth (Gabo *et al.*, 1996).

Number of florets per spike

Data in Table 3 show that decreasing water supply; *i.e.*, irrigation with 80 or 60% ETc led to a significant reduction in the number of florets per spike in the two experimental seasons under the irrespective of irrigation systems in comparison with the control (irrigation with 100% ETc). On the contrary, the number of florets per spike produced by gladiolus plants was significantly increased due to the foliar application of glutathione at 400 ppm in the two experimental seasons when compared with the untreated plants. Concerning the interaction effects, the data showed that the highest mean values were observed in plants grown under irrigation with 100% ETc using surface drip irrigation. The decreasing in number of florets with decreasing water supply is in great accordance with Pereira *et al.* (2010).

In this connection, Mahgoub *et al.* (2006) found that foliar application of glutathione gave the highest significant increase in number of flowers per plant.

Vase life (days)

It could be noticed from the recorded data in Table 3 that vase life was not affected by water regime treatments. The opposite trend can be observed in case of spraying with glutathione. The results indicate that the effect of glutathione

Table 3. Effect of irrigation systems, water regimes, glutathione and the interaction between irrigation systems and water regime treatments on flowering parameters of gladiolus plants during 2008/2009 and 2009/2010 seasons

Treatments \ Characters		Spike length (cm)		No. of florets/spike		Vase life (days)	
		1st*	2nd**	1st*	2nd**	1st*	2nd**
				Effect of irrigation systems			
SDI		99.00	102.1	15.72	16.25	17.61	18.19
SSDI		98.67	101.6	15.72	16.30	17.08	17.63
				Effect of water regimes			
100% ETc		102.10A	106.25 A	16.54 A	17.25A	16.96	17.66
80% ETc		100.00 B	103.00B	15.88 B	16.37 B	18.04	18.58
60% ETc		94.38 C	96.50C	14.75 C	15.20C	17.04	17.50
				Effect of glutathione concentrations			
Control		91.67 D	92.11D	14.11 D	14.11 D	15.44 B	15.44B
200ppm		97.11 C	99.22C	15.44 C	15.72 C	15.78 B	15.94B
300ppm		101.00 B	105.22B	16.22 B	17.16 B	18.11 A	19.05A
400ppm		105.60A	111.11A	17.11 A	18.11 A	20.06 A	21.22A
				Interaction between irrigation systems and water regimes			
	100% ETc	103.70a	107.83a	16.75a	17.41a	17.67	18.41
SDI	**80% ETc**	101.40b	104.58b	16.17a	16.66bc	19.00	19.58
	60% ETc	91.92 e	94.00e	14.25c	14.66e	16.17	16.58
	100% ETc	100.60 b	104.66b	16.33a	17.08ab	16.25	16.91
SSDI	**80% ETc**	98.58 c	101.41c	15.58b	16.08cd	17.08	17.58
	60% ETc	96.83 d	99.00d	15.25b	15.75d	17.92	18.41

*= first season, **= second season.

Values having the same alphabetical litter (s) did not significantly different at 0.05 level of significance according to Duncan's multiple range test.

concentration was more pronounced especially with the high used concentration. Concerning the interaction effects, there was no significant difference among treatments regarding vase life in both seasons.

According to Delperee *et al.* (2003), water deficit affected negatively the process of flowering inflorescence in many plant species by reducing the fertility of newly formed florets.

Effect of Irrigation Systems, Water Regimes, Glutathione and the Interaction between Irrigation Systems and Water Regime Treatments on Corm and Cormels Production in Both Seasons

Data in Table 4 indicated in general, that there were no significant differences between the values of corm diameter, corm weight and number of cormels per plant during the two experimental seasons.

Corm diameter (cm)

Data in Table 4 revealed that the diameter of corm in both seasons decreased as soil moisture stress increased by irrigation with 80 or 60%ETc under the two studied irrigation systems in comparison with the control (irrigation with 100 % ETc). Regarding the effect of glutathione application, the data indicated that spraying gladiolus plants with glutathione up to 400ppm increased significantly the diameter of corm in both seasons in comparison with the untreated plants. Data of corm diameter as affected by interaction, indicated that the combined effect between irrigation systems and water regime treatments gave the highest diameter (5.08cm) in plants grown under 100% ETc and irrigated by using surface drip irrigation.

Table 4. Effect of irrigation systems, water regimes, glutathione and the interaction between irrigation systems and water regime treatments on corm and cormels parameters of gladiolus plants during 2008/2009 and 2009/2010 seasons

Treatments \ Characters		Corm diameter (cm)		Corm weight (g)		No. of cormels	
		1st*	2nd**	1st*	2nd**	1st*	2nd**
				Effect of irrigation systems			
SDI		4.52	4.61	22.12	22.85	24.64	25.63
SSDI		4.51	4.72	22.09	22.80	24.61	25.33
				Effect of water regimes			
100% ETc		4.88 A	5.01 A	24.46 A	25.43 A	28.13 A	29.20 A
80% ETc		4.60 B	4.77 B	22.71 B	23.45 B	25.58 B	26.37 B
60% ETc		4.06 C	4.22 C	19.13 C	19.59 C	20.17 C	20.87 C
				Effect of glutathione concentrations			
Control		3.82 D	3.88D	17.50 D	17.61D	17.61 D	18.27D
200ppm		4.36 C	4.47C	21.05 C	21.57C	23.06 C	23.50C
300ppm		4.71 B	4.95B	23.40 B	24.32B	26.67 B	27.44B
400ppm		5.18 A	5.35A	26.46 A	27.80A	31.17 A	32.72A
				Interaction between irrigation systems and water regimes			
	100% ETc	5.01a	5.08a	25.31a	26.33a	29.42a	30.58a
SDI	**80% ETc**	4.73b	4.81b	23.49b	24.23b	26.75b	27.66b
	60% ETc	3.83e	3.93d	17.55e	17.98e	17.75e	18.66d
	100% ETc	4.75b	4.94ab	23.62b	24.53b	26.83b	27.83b
SSDI	**80% ETc**	4.48c	4.72bc	21.92c	22.67c	24.42c	25.08c
	60% ETc	4.29d	4.50c	25.31a	26.33a	22.58d	23.08c

*= first season, **= second season.

Values having the same alphabetical litter (s) did not significantly different at 0.05 level of significance according to Duncan's multiple range test.

From the aforementioned results, it could be suggested that increasing water quantity applied to gladiolus plants led to keep higher moisture content in the soil, further support came from the results of Youssef (2007) who observed that increasing soil moisture stress decreased significantly the diameter of new corm. Such finding could be agreed with the observations of many authors (El-Noemani *et al.*, 1990; Reddy *et al.*, 2004; El-Saidi, 1994).

The promotive effect of glutathione on cormels characters could be explained as antioxidants activate plant metabolism and consequently dry matter accumulation, which in turn reflected on bulbs yield (Midan and El-Dinary, 2008).

Corm weight (g)

Data in Table 4 show that decreasing the amount of irrigation water through irrigation with 80 or 60% ETc led to significant decrease in weight of corm under the two studied irrigation systems in both seasons in comparison with the control (irrigation with 100 % ETc). This means that, higher water quantities attained heavier weight. The data revealed also that spraying with glutathione up to 400 ppm significantly increased the weight of corm as compared with the control. As for the effect of interaction, the combination between irrigation systems and water regime treatments showed that the highest corm weight was recorded in plants grown under 100% ETc and using surface drip irrigation.

Regarding the effect of water stress, the obtained data show that corm weight was significantly decreased. Such finding could be agreed with the observations of many authors (El-Saidi, 1994; Youssef, 2007).

In this concern, Bielawski and Joy (1986) reported that glutathione contribute to maintain the integrity of cell structure and the proper functions of various metabolic pathways.

Number of cormels per plant

Data presented in Table 4 indicate that decreasing the amount of irrigation water; *i.e.* irrigation with 80 or 60% Etc, decreased significantly the number of cormels per plant under the two studied irrigation systems in both seasons in comparison with the control (irrigation with 100 % ETc). Whereas, the number of cormels were significantly increased with increasing the concentration of glutathione up to 400ppm in comparison with the untreated plants. Concerning the interaction effects, the highest significant of cormels number was recorded in plants grown under 100% ETc and using surface drip irrigation. The obtained data for cormels characters of gladiolus plants under water deficit showed that the various parameters were mostly significantly decreased. These results are in great accordance with those observed by El-Saidi (1994) and Youssef (2007).

In addition, Apel and Hirt (2004) demonstrated that glutathione not only participates in the direct detoxification of ROS, it may also protect cells against unfavorable stress effects through the activation of various defense mechanisms due to its involvement in redox signaling.

Effect of Irrigation Systems, Water Regimes, Glutathione and the Interaction between Irrigation Systems and Water Regime Treatments on Some Chemical Constituents in Both Seasons

Total carbohydrates content (mg/g dry wt.)

The collected data (Table 5) indicate that the total carbohydrate content was significantly decreased with decreasing the amount of irrigation water from 1882 to 1129 m^3/fad., during the two seasons under the two tested irrigation systems. With regard to glutathione application, data showed that increasing glutathione up to 400 ppm increased significantly the total carbohydrates content in gladiolus shoots as compared with the untreated plants. Concerning the interaction, the data of the combined effect of irrigation systems and water regime treatments showed that the highest significant value for total carbohydrate content was recorded in plants grown under irrigation with 100 % ETc and using surface drip irrigation.

Soil moisture stress tended to decrease the content of the total carbohydrates. Such finding agreed with the observations of many authors (Al-Moftah and Al-Humaid, 2005; Youssef, 2007). The increment in total carbohydrates content due to glutathione treatment is in accordance with the findings of Fayed (2010). Abd El-Naem, (2005) who reported that citric acid was reported to stimulate nutrient absorption and growth activators synthesis.

Total nitrogen percentage

Illustrated data in Table 5 show that water stress (irrigation with 80 or 60% ETc) led to significant reduction in nitrogen percentage in both seasons in comparison with the control (irrigation with 100 % ETc). This was true under the two studied irrigation systems. It is obvious from the same data that spraying gladiolus plants with glutathione up to 400 ppm increased significantly the nitrogen percentage as compared to the untreated plants. As for the effect of interaction, the data showed that the combination between irrigation systems and water regime treatments indicated that the greatest significant value of nitrogen percentage was obtained in plants grown under irrigation with 100% ETc using surface drip irrigation.

Total phosphorus percentage

Data in Table 5 show that decreasing water supply, *i.e.*, irrigation with 80 or 60% ETc significantly decreased phosphorus percentage in gladiolus plants in the two experimental seasons under the two studied irrigation systems in comparison with the control (irrigation with 100% ETc). On the contrary, phosphorus percentage was significantly increased with increasing the concentration of glutathione up to 400 ppm in both seasons when compared with the untreated plants and without significant difference between the 200 and 300 ppm concentrations. Concerning the interaction, the highest phosphorus value was obtained in plants

Table 5. Effect of irrigation systems, water regimes, glutathione and the interaction between irrigation systems and water regime treatments on chemicals parameters of gladiolus plants after 90 days from planting during 2008/2009 and 2009/2010 seasons

Characters / Treatments		Total carbohydrate contents (mg/g dry wt.)		N%		P%		K%	
		1st*	2nd**	1st*	2nd**	1st*	2nd**	1st*	2nd**
Effect of irrigation systems									
SDI		14.422	18.430	4.383	4.478	0.399	0.413	1.036	1.061
SSDI		17.762	18.755	4.415	4.508	0.403	0.418	1.044	1.097
Effect of water regimes									
100% ETc		18.899A	20.205A	4.522A	4.644A	0.420A	0.411A	1.073A	1.105A
80% ETc		18.006B	18.988B	4.438B	4.530B	0.406B	0.422B	1.050B	1.075A
60% ETc		15.871C	16.584C	4.238C	4.305C	0.376C	0.384C	0.977C	1.056A
Effect of glutathione concentrations									
Control		14.481C	14.661D	4.107C	4.124D	0.351C	0.354C	0.962C	0.967B
200ppm		17.209B	17.912C	4.363B	4.429C	0.394B	0.405B	1.030B	1.103A
300ppm		17.824B	19.141B	4.421B	4.544B	0.404B	0.424B	1.046B	1.078A
400ppm		20.854A	22.656A	4.705A	4.874A	0.455A	0.479A	1.121A	1.166A
Interaction between irrigation systems and water regimes									
	100% ETc	19.246a	20.582a	4.555a	4.680a	0.426a	0.477a	1.081a	1.155a
SDI	**80% ETc**	17.884ab	18.870b	4.427b	4.519b	0.405a	0.420c	1.047b	1.072a
	60% ETc	15.135b	15.837d	4.169d	4.235d	0.367a	0.372e	0.978d	0.996a
	100% ETc	18.522b	19.827ab	4.489ab	4.609ab	0.415a	0.435b	1.064ab	1.096a
SSDI	**80% ETc**	18.128c	19.107b	4.449b	4.541b	0.408a	0.424c	1.053ab	1.078a
	60% ETc	16.608d	17.330c	4.307c	4.375c	0.384a	0.396d	1.015c	1.117a

*= first season, **= second season.

Values having the same alphabetical litter (s) did not significantly different at 0.05 level of significance according to Duncan's multiple range test.

grown under irrigation with 100% ETc using surface drip irrigation.

Potassium percentage

Data in Table 5 indicated that as soil moisture stress increased potassium percentage was significantly decreased in both seasons under the two studied irrigation systems in comparison with the control. While, spraying gladiolus plants with glutathione up to 400 ppm increased significantly potassium percentage in both seasons in comparison with the untreated ones. As for the effect of interaction, the highest potassium value was obtained in plants grown under irrigation with 100 % ETc using surface drip irrigation.

The decreased levels of each of N, P, and K in response to water deficit were ascertained by the work of Al-Moftah and Al-Humaid (2005) and Youssef (2007). Such reduction in their contents were attributed primarily to soil water deficiency which markedly reduces the flow rates of elements in soil, their absorption by stressed root cells and also its ability to translocate through the different organs and tissues within the plants (Sawhney and Singh, 2002). El-Ghamriny *et al.* (2005) mentioned that the highest level of water quantity, in general, showed enhancing effect on minerals concentrations, while they were minimum under water stress.

The increment in N, P and K concentrations due to glutathione treatment are in accordance with the findings of Fayed (2010). Hanafy (1996) mentioned that foliar spray with ascorbic acid might be increased the organic acids exerted from the roots into the soil and consequently increased the solubility of most nutrients which release slowly into the rhizosphere zone where it may be utilized by plants.

REFERENCES

Abdel-Mawgoud, A.M.R., M. El-Desuki, S.R. Salman and S.D. Abou-Hussein (2005). Performance of some snap bean varieties as affected by different levels of mineral fertilizers. J. Agron., 4 (3): 242-247.

Abd El-Naem, G.F. (2005). Effects of three antioxidants on some chemical constituents, enzymatic browning of tomato and browning prevention by polyphnol oxidase inhibitors. Minia J. Agric. Res. Dev., 25(5): 815-842.

Abo El-Kheir, M.S.A. (2000). Growth parameters, yield characters and grain chemical composition of maize plants as affected by zinc foliar spray and water stress conditions J. Agric. Sci., Mansoura Univ., 25 (5): 2611-2620.

Abo El-Kheir, M.S.A. and B.B. Mekki (2007). Response of maize single cross-10 to water deficits during silking and grain filling stages. World J. Agric. Sci., 3(3): 269-272.

Ali, M., C.R. Jensen, V.O. Mogensen, M.N. Andersen and I.E. Henson (1999). Root signalling and osmotic adjustment during intermittent soil drying sustain grain yield of field grown wheat. Field Crops Res., 62 (1): 35-52.

Al-Moftah, A.E. and A.R.I. Al-Humaid (2005). Response of vegetative and reproductive parameters of water stressed tuberose plants to Vapor Gard and Kaolin antitranspirants. Arab Gulf J. Scientific Res., 23 (1): 7-14.

AOAC (1975). Official Methods of Analysis of the Association of Official Agricultural Chemists. 12ed., Washington, D. C., USA.

Apel, K. and H. Hirt (2004). Reactive oxygen species: metabolism, oxidative stress, and signal translocation. Ann Rev Plant Biol., 55: 373 - 379.

Bastug, R., O. Karaguzel, K. Aydinsakir and D. Buyuktas (2006). The effects of drip irrigation on flowering and flower quality of glasshouse gladiolus plant. Agric. Water Mana., 81 (1/2): 132-144.

Bates, L.S., R.R. Walren and I.D. Tears (1973). Rapid determination of proline for water stress studies. Plant and Soil, 39:205-207.

Bielawski, W. and K.W. Joy (1986). Reduced and oxidized glutathione reductase activity in tissues of *Pisum sativum*. Planta, 169:267-272.

Black, C.A., D.D. Evans, L.E. Ensminger, G.L. White and F.E. Clarck (1982). Methods of Soil Analysis. Part2. Agron. Inc. Madison. Wisc.

Blokhina, O.B., T.V. Chirkova and K.V. Fagerstedt (2003). Anoxic stress leads to hydrogen peroxide formation in plant cells. J., Experimental Botany, 52: 1-12.

Bremner, P.M. and M.A. Taha (1966). Studies in potato agronomy 1- The effects of variety, seed size and spacing on growth, development and yield. J. Agric. Sci., 66: 241-252.

D'Andria, R., M. Mori and G. Morelli (1996). Effects of water regime on yield and water use efficiency in two gladiolus cultivars. Irrigazionee Drenaggio, 43(3): 22 - 27.

Delperee, C., J.M. Kinet and S. Lutts (2003). Low irradiance modifies the effect of water stress on survival and growth-related parameters during the early developmental stages of buckwheat (*Fagopyrum esculentum*) Physiol. Plant, 119: 211-220.

Dubois, M., K.A. Gilles, J. Hamilton, R. Rebers and F. Smith (1956). Colorimetric method for determination of sugars and related substances. Annal. Chem., 28:350.

Duncan, D.B. (1955). Multiple range and multiple "F" test. Biometrics, 11: 1-42.

El-Bassiouny, H.M., H.A. Mostafa, S.A. El-Khawas, R.A. Hassanein, S.I. Khalil and A.A. Abd El-Monem (2008). Physiological responses of wheat plant to foliar treatments with arginine or putrescine. Aust. J. Basic Appl. Sci., 2: 1390-1403.

El-Ghamriny, E.A., A. Bardisi, A.N. Fayad and R.S. Anwar (2005). Growth, plant water relations and chemical constituents of potato plants as affected by water quantity and some antitranspirants under sandy soil conditions. Zagazig J. Agric. Res., 32(3):739-766.

El-Makawy, M.A. (1999). Effect of certain cultural treatments on growth and chemical compositions of some medicinal plants grown under North Sinai conditions. Ph. D. Thesis, Fac. Environmental Agric. Sci., Suez Canal Univ., Egypt.

El-Noemani, A.A., H.A. El-Zeiny and T.G. Behairy (1990). Yield and quality of faba bean (*Vicia faba* L.) as affected by irrigation intervals and nitrogen. J. Agric. Tanta Univ., 16 (2): 218-228.

El-Saidi, M.T. (1994). Growing different economic plants under severe conditions of drought and salinity in Sinai Desert. Proceedings of the IV Inter. Conf. on Desert Devel., 25-30 July, Mexico, 193 – 201.

FAO (1991). Localized irrigation. Irrigation and Drainage, Paper, 36: 144.

Fayed, T.A. (2010). Effect of compost tea and some antioxidant applications on leaf chemical constituents, yield and fruit quality of pomegranate. World Journal of Agric. Sci., 6 (4): 402-411.

Foyer, C.H. and G. Noctor (2005). Redox homeostasis and antioxidant signaling: a metabolic link between stress perception and physiological responses. Plant Cell., 17: 1866-1875.

Foyer, C.H. and G. Noctor (2009). Redox regulation in photosynthetic organisms signaling, acclimation, and practical implications. Antioxid Redox Signal, 11: 861-905.

Gabo, R.C., J.A. Gonzalez, F. Cordoba and P. Naves (1996). Rooting hastened in onion by ascorbate and ascorbate free radical. Plant Growth Reagulation, 15: 53-56.

Graca, J.P., F.A. Rodrigues, J.R.B. Forias, M.C.N. Oliveira, C.B. Hoffmann-Campo and S.M. Zingaretti (2010). Physiological Parameters in sugarcane cultivars submitted to water stress. Brazilian J. Plant Physiology, 22 (3): 189-197.

Hanafy, A.H. (1996). Physiological studies on tiploun and nitrate accumulation on lettuce plants. J. Agric. Sci., Mansoura Univ., 21: 3971- 3994.

Hell, R. and L. Bergmann (1990). g-Glutamylcysteine synthetase in higher plants: catalytic properties and subcellular localization. Planta, 180- 603- 612.

Jackson, M.I. (1967). Soil Chemical Analysis. Printice Hall of India Private Limit. New Delhi.

Khalil, S.E., N.G. AbdEl-Aziz and B.H. Abo Leila (2010). Effect of water stress and ascorbic acid on some morphological and biochemical composition of *Ocimum basilicum* plant. J. Amer. Sci., 6 (12): 33-44.

Khalil, A.M., S.E. Khalil and T.B. Ali (2012). Effect of water stress, antioxidants and humic acid on *Capsicum annuum,* L. growth, yield and active ingredient under sandy soil conditions. Egypt. J. Appl. Sci., 27 (1): 35-56.

Khalilvand, B. and M. Yarnia (2007). The effects of water deficit stress on some of the physiological characters of sunflower in the different density of planting. J. Agric. Sci., Islamic Azad Univ., Tabriz Branch, 1 (2): 37- 52.

Kramer, P.J. and J.S. Boyer (1995). Water Relations of Plants and Soils. Academic Press. New York.

Kusaka, M., A.G. Lalusin and T. Fujimura (2005). The maintenance of growth and turgor in pearl millet (*Pennisetum glaucum* L.) cultivars with different root structures and osmo-regulation under drought stress. Plant Sci., 168:1-14.

Mahgoub, M.H., N.G. AbdEl-Aziz and A.A. Yousef (2006). Influence of foliar spray with paclobutrazol or glutathione on growth, flowering and chemical composition of *Calendula oficinalis* L. plant. J. Appl. Sci. Res., 2 (11): 879-883.

Meawad, A.A., A.M. Fiad and M.M. Hafez (2005). Effect of irrigation interval treatments on growth, yield, anthocyanin production and some chemical constituents of roselle plants under sandy soil and drip irrigation system conditions. Zagazic. J. Agric. Res., 32 (2): 441- 454.

Midan, A.A. (1986). Effect of IAA, NAA, Vit B1 and Vit C applications on tomato growth, chemical constituents and yield. Zagazig J. Agric. Res., 13(2):78-99.

Midan, S.A. and M.E. El-Dinary (2008). Antioxidants application in relation to garlic growth, bulbs yield and dilsease incidence. Zagazig J. Agric. Res., 35 (1): 33-46.

Munne-Bosch, S., K. Scharz and L. Algere (2001). Water deficit in combination with high solar radiation leads to midday depression of α-tocopherol in field grown lavender (*Lavandula stoechas*) plants. Aust. J. Plant Physiol., 28:315-321.

Naguib, M. I. (1969). Colorimetric determination of nitrogen components in plant tissues. Bull. Fac. Agric. Sci., Cairo Univ., 43:1: 16.

Pereira, J.R.D., J.de.A. Carvalho, P.D. de O. Paiva, D.J. da Silva, A.M.G. de Souza and K.J. de Souza (2010). Growth and production of gladiolus floral stems under different soil water tensions. Cienciae Agrotecnologia, 33 (4): 965-970.

Reddy, A.R., K.V. Chaitanya and M. Vivekanandan (2004). Drought-induced responses of photosynthesis and antioxidant metabolism in higher plants. J. Plant Physiology, 161: 1189- 1202.

Sawhney, V. and D. P. Singh (2002). Effect of chemical desiccation at the post-anthesis stage on some Physiological and biochemical changes in the flag leaf of contrasting wheat genotypes. Field Crops Res., 77: 1-6.

Singh, J. and A.L. Patel (1996). Water status, gaseous exchange, proline accumulation and yield of wheat in response to water stress. Annals of Biology, 12 (1): 77-81.

Smirnoff, N. (1995). Antioxidant systems and plant response to the environment. In: N. Smirnoff (Ed.) Environment and Plant Metabolism: flexibility and acclimation. BIOS Scientific Publishers. Oxfored, UK.

Snedecor, G. W. and W. G. Cochran (1980). Statistical Methods. 7th ed. Iowa State Univ. Press, Iowa, USA.

Talaat, I.M. and E.E. Aziz (2005). Stimulatory effects of glatathion, nicotinic acid and ascorbic acid on matricaria. Egypt. J. Appl. Sci., 20: 218 - 231.

Von Wettestein, D. (1957). Chlorophyll Lethal und Submik roskopische fromivechsel der Plastiden Exptl. Cell Res., 12: 427-433.

Wu, Q., R. Xia and Y. Zou (2005). Reactive oxygen metabolism in mycorrhizal and non-mycorrhizal citrus (*Poncirus trifoliate*) seedlings subjected to water stress. J. Plant Physiology, 51: 437- 447.

Youssef, E.A. (2007). Increasing drought tolerance of gladiolus plants through application of some growth regulators. M. Sc. Thesis, Fac. Agric., Zagazig Univ., Egypt.

استجابة نباتات الجلاديولس للمقننات المائية والجلوتاثيون تحت نظم الري المختلفة في الأراضي المستصلحة حديثا

ابتسام عبد المعز يوسف[1]- عبدالرحمن العريان عوض[2] - عبد العزيز كامل ضوه[2]- محمود سيد أحمد أبو الخير[1]

١- قسم العلاقات المائية والرى الحقلى - المركز القومى للبحوث - الدقى- الجيزه- مصر

٢- قسم البساتين - كلية الزراعة - جامعة الزقازيق - مصر

أجرى هذا العمل للتحقق من كفاءة بعض معاملات تحسين الجودة (الجلوتاثيون) للتَغلُب على التأثير الضار لنقص الماء و تأثيرها على قياسات النمو الخضري، والصفات الإنتاجية، بالإضافة إلى بَعْض العمليات الفسيولوجيةِ والكيميائيةِ لنباتات الجلاديولس النامية تحت نظم الريِّ بالتنقيط السطحي والري تحت السطحي، وقد أظهرت النتائج أن نقص كمية ماء الري من ١٨٨٢ إلى ١١٢٩ م^{3} / فدان /موسم خفضت معنويا من ارتفاع النبات، وعدد الأوراق على النبات، ومساحة الأوراق على النبات، ومحتوى النبات من الماء وقد أظهرت أيضاً كل من صفات التزهير وإنتاج الكريمات نفس الأتجاه السابق باستثناء فترة بقاء الزهرة، كما أدى النقص فى كمية ماء الرى إلى انخفاض معنوي في محتوى أنسجة الأوراق من الصبغات، ومحتواها من الكربوهيدرات، والنيتروجين، والفسفور، والبوتاسيوم، وعلى العكس فان زيادة الإجهاد المائى على النبات أدى إلى زيادة ملحوظة في محتوى السائل الخلوي من البرولين. أدت المعاملة بالرش الورقي للجلوتاثيون بتركيز ٤٠٠ جزء في المليون بعد ٣٠ و ٦٠ يوم من الزراعة إلى زيادة معنوية في الصفات السابقة سواء قياسات النمو الخضري أو الصفات الانتاجية في هذه الدراسة وكذلك التركيب الكيماوي للنباتات المعاملة مقارنة مع النباتات غير المعاملة. كما توصى الدراسة بأن الرش بالجلوتاثيون أدى إلى زيادة القدرة على تحمل العطش والمحصول الأقتصادى للنباتات، وبالإضافة إلى ذلك فكان هناك أختلاف قليل بين نظامى الرى فيما يتعلق بقيم كل الصفات التي درست فى نباتات الجلاديولس.

المحكمون:

١- أ.د. بدور حلمى أبوليلة أستاذ متفرغ بالمركز القومى للبحوث – الدقى.

٢- أ.د. على عبدالحميد معوض أستاذ الزينة – قسم البساتين – كلية الزراعة – جامعة الزقازيق.