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EFFECTS OF HYDROPHILIC POLYMERS, VAPOR GARD AND GLYCINE BETAINE ON GROWTH, FLOWERING AND WATER USE EFFICIENCY IN GLADIOLUS PLANTS CV "WHITE PROSPERITY" GROWING IN SANDY SOIL UNDER DIFFERENT WATER REGIMES

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ABSTRACT

Two pot experiments were conducted to investigate the effects of the hydrophylic polymer "hydrosource" (HP) 1% as soil application, vapor gard (VG) 3% as foliar spray, glycinebetaine (GB) 1.5% as foliar spray, HP+VG, HP+GB in addition to the untreated control plants on Gladiolus plants cultivar "White Prosperity" growing in sandy soil under different irrigation regimes (100%, 80%, 60% and 40% of water holding capacity, WHC). Growth, flowering character, corm and cormels production, water use efficiency were investigated. Results revealed that flowering was delayed as soil moisture level decreased up to 40% (WHC). In addition, plant growth under severe water stress (60-40% WHC), dry weight of leaves, flowering spike length and weight, flowering spike diameter, number and weight of florates, corm and cormels weight and water use efficiency were significantly decreased.

Using the HP, VG and GB as individual treatments or in combination improved the vegetative growth, flowering and corm production. The interaction between water supply treatments and polymer, VG and GB showed almost significant effects on the variables studied. These treatments tended to overcome the harmful effects of water stress and reserved plant growth particularly at low water regimes (60-40% WHC). The best treatment was recorded at HP+VG or HP+GB combined treatments at 60% water supply which gave the best growth at low water supply thus reduces the amount of water required in irrigation as a sequence of improving the water use efficiency.

Keywords: Polymer, glycinebetaine, vapor gard, salinity, gladiolus, growth, flowering

INTRODUCTION

More than any other single environmental factor, the shortage of water limits plant growth and crop productivity in many regions of the world. Moreover, even at good environmental conditions, plants grown in sandy soil require irrigation to maintain adequate moisture for normal growth otherwise they would be exposed to water stress which affects negatively the physiological processes. For instance, photosynthesis and consequently plant growth of glycophytes (drought susceptible species) are found to be reduced by water stress. In such kind of soil, plant breeding and propagation system such as mist, drip, and enclosed polyethylene tents are routinely used to minimize the loss of water by reducing water vapor pressure gradient between the plant and the air. However, these systems are not without problems, under mist, leaching of foliar nutrients can occur (Larcher, 1995) leading to chlorosis or necrosis, algal growth and water logged media (Hartmann *et al.*, 1997). He also, added that, mist and drip systems can be expensive to install and maintain and polyethylene tents require shading and careful monitoring to prevent excess heat build up. Genetic modification of plants by breeding to allow growth and yield under unfavorable conditions is a solution to problems of environmental stress. However, this approach is time consuming and demands sustained efforts and efforts. An alternative method is the use of safe substances which can increase the soil water holding capacity and reduce the water loss by transpiration without any harmful effect on plants. In addition, stomatal regulation of transpiration is one mechanism that delays the occurrence of plant water stress due to the soil water shortage (Taiz and Zeiger, 1998). Early studies showed soil-water content can be improved by using polymers as soil conditioner application (Fonteno and Bilderback, 1993), and decrease transpiration rate through controlling the stomatal status using vapor gard (Attia *et al*, 1991) and glycinebetaine (Makela *et al.*, 1996 and Moftah, 2000) as foliar treatment.

Rodrigues *et al.* (1983) stated that the fresh and dry matter yield of Alfred Nobel gladiolus cultivar decreased with decreasing soil moisture content. In addition, the different soil moisture contents affected the mobility and translocation of the photosynthates drived from CO2 through the different organs. Al-Humaid and Mazrou (1998), on Nova Lux and Rose supreme gladiolus cultivar, found that flowering stem length, number of florates/spike and fresh and dry matter yield (aerial parts and corms) as well as N,P,K content decreased with decreasing soil moisture content.

Soil conditioners, water absorbing hydrophilic polymers which absorb many times their weight of water, have the ability to increase the water holding capacity, aeration, and reduce plant watering requirements (Orzolek, 1993). Plnt survival and growth were also increased by hydrophilic amendments (Fonteno and Bilderback, 1993; Save *et al.*, 1995). In this concern, El-Awady *et al.*, (1989) reported that Hygronull (urea forming foam) a synthetic polymer improved the water holding capacity and optimized the water movement, thus increased the water use efficiency and improved seed germination and plant growth as well as yield of many ornamental plants. They found that soil conditioners increased plant height, number of leaves and leaf area.

Vapor Gard is an important anti-transpiration agent. Its mechanism of action is to form a film coating the leaf surface. This film increase the diffusive resistance of water vapor from stomata and reduce transpiration (Gale and Hagan, 1966; Davenport *et al.*, 1972). Therefore, the use of Vapor Gard before transplanting may help in improving the plant stand after transplanting especially in unfavorable conditions (hot weather and drought).

Glycinbetaine is quaternary ammonium compound accumulated by many plant species although several ornamental plant species, including gladiolus, Eucalyptus and some member of Solanacae plants, cannot synthesis it (Rhodes and Hanson, 1993). A common role of glycine betaine is as a compatible solute in osmotic adjustment of the cytoplasm compartments where it may accumulate while ions sequestered in the vacuole (Matoh *et al.*, 1987; Salisbury and Ross, 1992). In addition, Glycinebetaine was found to protect protein and membrane function from stress conditions such as drought and salt stresses, by playing an anti-transpiration agent (Hanson *et al.*, 1995). Thus, exogenous application of these compounds has been suggested as an alternative approach to genetic engineering to improve crop growth and productivity under water stress conditions (Itai and Paleg, 1982; Makela *et al.*, 1996). Moftah and Aly (2000), on pepper plants grown in sandy soil under different irrigation regimes, found that plant growing under severe water stress (60-40% of the field capacity) showed a decrease in growth as represented by plant height, leaf area and total dry weight. In addition, the HP and/or GB treatments tended to overcome the harmful effect of water stress and reserved plant growth, physiology and productivity almost near control soil water content as low as 60% WHC.

The objective of this study was to determine the effect of different irrigation regimes, hydrophilic polymer amendment "Hydrosource" (HP), Vapor Gard (VG) and Glycine betaine (GB) on growth, flowering, corms and cormels production, water use efficiency as well as N, P, K content of White Prosperity gladiolus cultivar plants grown in sandy soil.

MATERIALS AND METHODS

A pot experiment was carried out during the two successive seasons of 1997/98 and 1998/99 at the Nursery of Ornamental Plants, Faculty of Agric. Minia Univ.; to investigate the effects of the hydrophilic polymer, amendment "hydrosource" (HP), Vapor Gard (VG), and glycinebetaiene (GB). Growth, flowering, corm and cormels production, dry matter, water use efficiency and N, P, K content of gladiolus cultivar, white Prospority, growing in sandy soil under water stress condition were investigated.

The gladiolus corms of such cultivar were obtained from Holland through Bassiony Nurseries, Cairo, Egypt. The average corm weight between 3.01 and 3.26 g and corm diameter between 9.36 and 9.89 cm for the 1st and 2nd season, respectively. The corms were planted in October the 1st in both seasons in 25 cm plastic pots (1 corm/pot), which were filled with 4 kg air dried sandy soil. The physical and chemical composition of the soil are shown in Table (1):

Sand%	Silt%	Clay%	EC (1:2.5)	PH (1:2.5)	Org. matr%	CaCO3 %	Total N%	P (Olsn)	K amm acetate
85.0	5.5	9.5	0.59 mmhos/cm	7.97	0.40	14.5	0.07	4.0 ppm	210 ppm

The soil was previously mixed with hydrophilic amendment (HP) incorporated at the rate of 1% as recommended by Boatright *et al.*, (1997); so each pot received 40 g of the polymer. A split plot design with three replications and 15 plants per experimental unit was followed in this experiment. Four levels of water irrigation (100, 80, 60 and 40% from the maximum water holding capacity, WHC) consisted the main plots (A) while 6 treatments namely, 1- hydrophilic polymer amendment, "hydrosource" (HP) 1%, 2- Vapor Gard (VG) 3%, 3- Glycinebetaine (GB) 1.5% (as hydroxide salt, pH 7.8, purity 97%) , 4- HP1% + VG3%, 5- HP1%+GB1.5% and 6- control plants received no HP, VG or GB, assigned to be the sub-plot (B).

In both seasons, plants were sprayed 3 times during the growing season at 2 week intervals starting 4 weeks from planting with VG 3% and GB 1.5% containing 0.1% of tween 20 as surfactant, was applied to run off onto the foliage of the plants using hand-held manual atomizer. Control received pure water and tween 20 only.

The water holding capacity (WHC) for each treatment was kept by rewatering and weighing the pot every day during the growing season. Fertilization was done for all plants at the rate of 4g ammonium nitrate (31%), 3g calcium superphosphate (15.5% P3O5) and 2g potassium sulphate (48% K2O)/pot. Amounts of fertilizer were divided into 3 equal portions and added after 4 weks, 6 weeks from planting and after flowering, the following data were recorded: average number of leaves/plant, dry weight of leaves/plant, number of days from planting till the opening of the first flower (flowering date), average spike length (cm), average length of the flowering part of the spike (cm), average spike diameter (mm) 2cm from the bottom, average spike fresh weight (g), average florets number/spike, average fresh weight of the florets (g)/spike, average corm weight (g)/plant and number and weight of cormels/plant as well as the dry matter yield of both aerial parts and new corms (g)/plant. Water use efficiency (WUE) was calculated as described by Raeini-Sarjaz *et al.* (1998) following the relation of (total dry matter per plant,g/total amount of water consumed by liter per plant). Contents of N,P and K of aerial parts and new corms were also determined according to Page *et al.* (1982). All data were statistically analyzed using ANOVA test method as reported by Snedecor and Cochran (1973). A computer program (PC-STAT) was used to perform the analysis.

RESULTS AND DISCUSSION

Vegetative growth:

Data recorded in Table (2) showed that plant growth, as represented by number of leaves and dry weight of leaves, decreased by decreasing water supply regime to reach its minimum values at 40% of the water holding capacity.

Data in the same table indicated also that all treatments (HP, VG, GB) either as single treatment or in combination improved the vegetative growth of the plants as they increased the number and dry weight of leaves as compared with control plants. It is clear from data in the table that the effect of interaction between water regime and treatments was significant. In this respect, data showed that the combined treatment of HP+VG was the best treatment in enhancing plant growth as compared with all other treatments. This treatment was found to increase the number and dry weight of leaves per plant particularly when plants were subjected to 60% of water supply, at which the vegetative growth was the best as compared with all water regimes even at 100% water supply. For the number of leaves, the differences between 100% without treatments and 60% with treatments were not significant.

Table (2): Effects of water regimes and hydrophilic polymer (HP), vapor gard (VG) and glycine betaine (GB) treatments on gladiolus plants.

Treatments (B)	Water regime (A)									
	First season					Second season				
	100%	80%	60%	40%	mean	100%	80%	60%	40%	mean
	Number of leaves /plant									
Control	8.30	8.30	7.20	6.10	7.48	8.00	7.90	6.80	5.80	7.13
HP	8.50	8.60	8.00	6.80	7.98	8.20	8.30	7.70	6.50	7.68
VG	8.40	8.40	7.60	6.40	7.70	8.10	8.10	7.20	6.10	7.38
GB	8.40	8.50	7.60	6.40	7.73	8.00	8.20	7.30	6.20	7.43
HP + VG	8.60	8.90	8.70	7.40	8.40	8.30	8.50	8.30	7.00	8.03
HP + GB	8.50	8.80	8.60	7.50	8.35	8.10	8.40	8.30	7.10	7.98
Mean	8.45	8.58	7.95	6.77		8.12	8.23	7.60	6.45	
LSD (5%)	A= 0.41		B= 0.43		AB= 0.86	A= 0.45		B= 0.54		AB= 1.08
	Dry weight of leaves (g/plant)									
Control	3.81	3.55	3.03	2.16	3.14	3.41	3.15	2.73	1.86	2.79
HP	3.39	3.94	3.58	2.38	3.45	3.49	3.54	3.28	2.09	3.10
VG	3.88	3.75	3.23	2.25	3.28	3.38	3.25	2.90	1.95	2.87
GB	3.87	3.83	3.28	2.28	3.32	3.30	3.43	2.95	1.98	2.92
HP + VG	4.09	4.68	4.21	2.41	3.85	3.69	4.25	3.90	2.11	3.49
HP + GB	3.99	4.55	3.99	2.43	3.74	3.59	4.13	3.69	2.14	3.39
Mean	3.92	4.05	3.55	2.32		3.48	3.63	3.24	2.02	
LSD (5%)	A= 0.18		B= 0.16		AB= 0.32	A= 0.20		B= 0.12		AB= 0.24
	Flowering date (days)									
Control	94.60	94.30	97.60	98.80	96.33	93.90	93.70	97.00	98.10	95.68
HP	95.50	95.10	95.70	96.70	95.75	94.70	94.30	95.10	96.00	95.03
VG	94.80	94.40	97.00	97.40	95.90	94.10	93.80	96.50	96.80	95.30
GB	94.90	94.60	96.80	97.20	95.88	94.20	93.90	96.20	96.50	95.20
HP + VG	95.60	95.40	95.00	96.70	95.68	94.90	94.50	94.20	95.80	94.85
HP + GB	95.70	95.50	94.60	96.60	95.60	94.90	94.60	94.10	95.80	94.85
Mean	95.18	94.88	96.15	97.23		94.45	94.13	95.52	96.50	
LSD (5%)	A= 1.23		B= NS		AB= NS	A= 1.35		B= NS		AB= NS

As indicated earlier in this study, HP, VG and GB may promote plant growth through their effects on nutrients and increasing water availability for growing plants. In this concern, Tripepi *et al* (1991) found that *Betula pendula* grown in media with hydrophilic polymer had higher fresh and dry weight than those grown without it. Moreover, Wang and Boogher (1987) found that Comosum plants grown in media with hydrophilic polymer were 50% larger and had more lateral shoots and better root system than control plants. The present work showed that the application of soil conditioner stimulated the vegetative growth of gladiolus plants as represented by number of leaves and dry weight of leaves at all irrigation regimes as compared with plants growing under water stress in the absence of the hydrophilic polymer. These findings are in harmony with those reported by Save *et al*, (1995) on pine seedlings and Boatright *et al*, (1997) on annual landscape beds; who observed that plant survival and growth were increased by application of hydrophilic polymer amendments. The observed trend of enhanced photosynthesis of

VG and GB treated plants could account for the apparent increase in number of leaves and dry weight of leaves of water-stressed gladiolus plants. Similar results were obtained by Itai and Paleg (1982) on water stressed *Hordeum distichum* and *Cucumis sativus* plants treated with glycine betaine and Attia *et al.* (1991) on *Eucalyptus citridora* plants with vapor gard.

Flowering:

Collected data showed clearly that flowering was delayed as water supply decreased since the number of days needed for flowering increased with decreasing water supplies (Table 2). This delay of flowering may be attributed to the high abscisic acid concentration and low water content under water stress (Moftah and Aly, 2000). Although no significant effect was found between treatments and time of flowering, treating plants with HP, VG and GB either in single or combined treatments led slightly to decrease the time taking for flowering especially at the combined (HP+VG) treatment. The interaction between HP, VG and GB treatments and water regimes showed no significant effect.

Data recorded in Table (3) indicated that flowering spike length, flowering spike diameter and flowering part length were all negatively affected by decreasing water supply. This negative effect was substantial at the lowest water regime (40%), at which spike length, diameter and flowering part length were decreased by about 35, 15 and 41%, respectively, as compared with control plants. Results in the same table showed that the polymer (HP) and Vapor Gard (VG) as well as Glycinebetaine (GB), when applied as single or combined treatments, showed positive effect on all flower characters. However, the combined treatment of HP + VG was the best among all treatments.

It is interesting to fined that the effect of HP, VG and GB was more pronounced under low than high water supply. In this regard, all treatments increased the length and diameter of flowering spike as well as the length of the flowering part under 60% water supply more than that at 100%. The best treatment in this regard was the combined HP+VG one, at which the increase in the flowering spike length was 24%, in the flowering spike diameter was 14% and in the flowering part length was 28%, as compared with untreated plants. These findings were true in the two growing seasons.

Table (3): Effects of water regimes and hydrophilic polymer (HP), vapor gard (VG) and glycine betaine (GB) treatments on gladiolus plants.

Treatments (B)	Water regime (A)									
	First season					Second season				
	100%	80%	60%	40%	Mean	100%	80%	60%	40%	mean
	Flowering spike length (cm)									
Control	69.80	66.10	60.50	45.30	60.43	67.90	64.30	58.70	43.90	58.70
HP	72.10	74.10	68.70	59.10	68.50	70.00	71.90	66.60	57.50	66.50
VG	71.80	72.80	76.50	57.40	67.38	69.70	70.70	65.50	55.70	65.40
GB	71.60	72.50	67.90	57.70	67.43	69.40	70.60	65.90	56.00	65.48
HP + VG	75.50	78.10	75.20	61.00	72.45	73.60	76.10	73.40	59.60	70.68
HP + GB	74.80	77.40	76.30	61.10	72.40	72.70	75.00	74.60	59.90	70.55
Mean	72.60	73.50	69.35	56.93		70.55	71.47	67.45	55.43	
LSD (5%)	A= 2.28		B= 2.47	AB= 4.95		A= 2.41	B= 2.61		AB= 5.21	
	Flowering spike diameter (mm)									
Control	8.00	7.90	7.40	6.80	7.53	7.92	7.83	7.30	6.71	7.44
HP	8.16	8.28	7.93	7.20	7.89	8.09	8.17	7.79	7.12	7.79
VG	8.12	8.25	7.71	7.02	7.78	8.03	8.13	7.61	6.96	7.68
GB	8.10	8.20	7.81	7.11	7.81	8.00	8.10	7.68	7.03	7.70
HP + VG	8.32	8.52	8.43	7.52	8.20	8.26	8.46	8.33	7.42	8.12
HP + GB	8.25	8.41	8.31	7.56	8.13	8.20	8.35	8.24	7.45	8.06
Mean	8.16	8.26	7.93	7.20		8.08	8.17	7.83	7.12	
LSD (5%)	A= 0.31		B= 0.34	AB= 0.68		A= 0.30	B= 0.33		AB= 0.66	
	Flowering part length (cm)									
Control	35.90	33.60	30.20	21.30	30.25	34.80	32.60	29.00	20.10	29.13
HP	36.80	38.10	35.00	29.50	34.85	35.80	37.10	34.10	28.70	33.93
VG	36.40	36.90	34.40	26.80	33.63	35.40	35.90	33.50	26.10	32.73
GB	36.10	36.80	34.50	27.30	33.68	35.10	35.70	33.60	26.60	32.75
HP + VG	38.90	40.20	38.70	31.50	37.33	37.90	39.00	37.50	31.80	36.55
HP1+GB1.5%	37.50	40.10	39.60	32.00	37.30	37.40	38.90	37.80	31.90	36.50
HP + GB	36.93	37.62	35.40	28.07		36.07	36.53	34.25	27.53	
LSD (5%)	A= 1.72		B= 1.81	AB= 3.61		A= 1.85	B= 1.89		AB= 3.80	

Concerning the effect of water supply and conditioning treatments on fresh weight of flowering spike and florets as well as number of florets/spike, data in Table (4) showed that decreasing water supply led to significant decrease in all characters. As for HP, VG and GB, results indicated clearly that all treatments significantly improved flower characters when applied either as single or combined treatments. The effect of the interaction of water regime and treatments was significant, but unsignificant differences in the number of florets. In this concern, the best treatment was the HP+VG in combined form, which improved the flowering characters of plants received 60% of the water supply to make them even better than those receiving 100%. The increase in flowering spike fresh weight, number of florets and fresh weight of florets under such treatment reached about 44, 19, and 33% respectively, compared with untreated plants. These results were true in both seasons as indicated by the data collected in the same table.

Table (4): Effects of water regimes and hydrophilic polymer (HP), vapor gard (VG) and glycine betaine (GB) treatments on gladiolus plants.

Treatments (B)	Water regime (A)									
	First season					Second season				
	100%	80%	60%	40%	mean	100%	80%	60%	40%	Mean
	Flowering spike fresh weight (g/plant)									
Control	20.30	18.20	16.60	13.90	17.25	19.10	17.20	15.70	13.00	16.25
HP	21.40	21.60	20.00	17.20	20.05	20.10	20.50	18.90	16.10	18.90
VG	21.10	21.30	19.70	16.80	19.73	19.80	20.10	18.50	15.60	18.50
GB	21.00	21.20	19.80	16.90	19.73	19.70	19.90	18.70	15.80	18.53
HP + VG	22.60	24.50	23.90	18.10	22.28	20.30	22.20	21.70	16.70	20.23
HP +GB	21.80	23.80	23.60	18.20	21.85	20.50	21.70	21.40	16.80	20.10
Mean	21.37	21.77	20.60	16.85		19.92	20.27	19.15	15.67	
LSD (5%)	A= 1.03		B= 1.33		AB= 2.66	A= 1.10		B= 1.51		AB= 3.02
	Number of florets/spike									
Control	9.33	9.17	8.32	7.63	8.61	9.11	8.82	8.03	7.32	8.32
HP	9.52	9.66	8.75	7.96	8.97	9.36	9.49	8.56	7.73	8.79
VG	9.41	9.45	8.68	7.85	8.85	9.23	9.25	8.35	7.53	8.59
GB	9.31	9.36	8.76	7.94	8.84	9.15	9.18	8.45	7.63	8.60
HP + VG	9.82	10.18	9.87	8.12	9.50	9.63	10.05	9.62	7.94	9.31
HP + GB	9.60	9.99	9.74	8.23	9.39	9.42	9.83	9.56	8.05	9.22
Mean	9.50	9.64	9.02	9.96		9.32	9.38	8.76	7.90	
LSD (5%)	A= 0.56		B= NS		AB= NS	A= 0.55		B= NS		AB= NS
	Fresh weight of florets (g/spike)									
Control	34.50	32.10	29.70	23.90	30.05	32.90	30.40	28.10	22.20	28.40
HP	36.50	36.90	34.60	30.90	34.73	34.80	35.10	32.90	29.40	33.05
VG	35.80	36.10	34.00	29.30	33.80	34.20	34.30	32.40	27.90	32.20
GB	35.40	36.00	34.10	29.80	33.83	33.80	34.20	32.50	28.40	32.23
HP + VG	38.70	41.50	39.60	31.20	37.75	37.00	39.70	38.40	29.70	36.20
HP + GB	38.20	41.10	39.70	31.30	37.58	36.50	39.40	38.10	30.10	36.03
Mean	36.52	37.28	35.28	29.40		34.87	35.52	33.73	27.95	
LSD (5%)	A= 1.88		B= 1.99		AB= 3.97	A= 1.78		B= 2.12		AB= 4.24

The reduction in flowering characters as represented by spike length, spike diameter and weight, number and weight of florets under low water regime could be attributed to several factors such as reducing vegetative growth, photosynthesis and plant water status. The negative effect of water stress on the flowering characters of gladiolus was also reported that by Al-Humaid and Mazrou (1998) and Bres and Weston (1993) on tomato. On the other side, incorporating the sandy soil with hydrophilic polymer amendment or treating plant with vapor gard or glycine betaine significantly increased flowering characters as it increased vegetative growth and increased spike length, spike diameter and weight, number and weight of florets and early flowering. The increment in gladiolus flowering characters as a result of application of soil conditioner may be due to promoting plant growth through their effect on water availability, increasing spike length weight and spike diameter, number and weight of florets. In earlier studies, it has been found that soil polymer conditioner and glycine betaine treatments in the flowering of tomato (Bres and Weston, 1993), snap been (Al-Sheikh and Al-Darby, 1996), pepper (Moftah and Aly, 2000), and El-Sawy *et al.* (1988) on pepper, treated plants with VG.

Corms and cormels production

As for the fresh weight of corms and cormels, data presented in Table (5) showed that lowering water supply led to decreases in the values of weight of corms and cormels. The lowest values were recorded at water supply of 40% regime. On the other side, results showed that the application of HP, VG and/or GB either individually or in combination improved the weight of corms and cormels and led to an increase in their fresh weight. The best treatment in this matter was reported at HP+VG combination followed by HP+GB treatment.

Data in the same table indicated that the interaction of water supply treatments and polymers, VG as well as GB on the weight of corms and cormels was significant. In this respect the HP+VG treatment showed an advanced improvement more than any other treatment particularly at low water supplies.

Table (5): Effects of water regimes and hydrophilic polymer (HP), vapor gard (VG) and glycine betaine (GB) treatments on gladiolus plants.

Treatments (B)	Water regime (A)									
	First season					Second season				
	100%	80%	60%	40%	mean	100%	80%	60%	40%	Mean
	Corm fresh weight (g/plant)									
Control	37.60	35.30	31.20	26.10	32.55	37.00	34.70	30.60	25.30	31.90
HP	40.20	41.60	38.40	32.60	38.20	39.70	41.10	37.80	32.00	37.65
VG	39.00	41.30	37.80	31.70	37.45	38.40	40.70	37.30	31.40	36.95
GB	38.80	41.00	38.10	32.00	37.48	38.30	40.50	37.60	31.60	37.00
HP + VG	43.00	44.70	42.10	33.60	40.85	42.40	44.10	41.50	33.00	40.25
HP + GB	42.90	44.10	41.60	33.90	40.63	42.20	43.50	40.90	33.30	39.98
Mean	40.25	41.33	38.20	31.65		39.67	40.76	37.61	31.10	
LSD (5%)	A= 2.01		B= 2.10		AB= 4.20	A= 1.99		B= 2.33		AB= 4.66
	Number of cormels/plant									
Control	18.00	20.40	22.20	13.00	18.40	18.50	20.60	21.90	12.50	18.38
HP	17.10	19.10	21.10	13.60	17.73	18.00	19.40	21.00	13.10	17.88
VG	17.90	20.20	22.00	13.10	18.30	18.30	20.40	21.70	12.70	18.28
GB	17.70	20.00	21.80	13.20	18.18	18.20	20.20	21.50	12.90	18.20
HP + VG	16.90	18.50	21.20	13.80	17.58	17.70	18.80	21.20	13.40	17.78
HP + GB	16.80	18.10	20.50	13.90	17.33	17.40	18.50	20.60	13.60	17.53
Mean	17.40	19.38	21.45	13.42		18.02	19.65	21.32	13.03	
LSD (5%)	A= 1.68		B=0.66		AB= 1.33	A= 1.63		B= 0.48		AB= 0.96
	Fresh weight of cormels (g/plant)									
Control	6.32	5.90	5.12	4.03	5.34	6.10	5.75	4.86	3.78	5.12
HP	6.83	7.02	6.53	4.86	6.31	6.65	6.88	6.31	4.76	6.15
VG	6.64	6.70	6.30	4.71	6.09	6.46	6.52	6.11	4.57	5.92
GB	6.56	6.75	6.32	4.82	6.11	6.38	6.64	6.18	4.71	5.98
HP + VG	7.15	7.43	6.97	4.95	6.63	6.95	7.29	6.84	4.86	6.49
HP + GB	6.92	7.23	6.72	5.02	6.47	6.75	7.07	6.57	4.90	6.32
Mean	6.74	6.84	6.33	4.73		6.55	6.69	6.15	4.60	
LSD (5%)	A= 0.40		B= 0.44		AB= 0.87	A= 0.51		B= 0.46		AB= 0.93

The increase in storage organs production as a result of increasing soil moisture level could be explained through the effective role of water in increasing leaf building, consequently producing more metabolites, which are necessary for corm and cormels formation. These results are in accordance with those obtained by Robinson *et al.* (1983) and Al-Humaid and Mazrou (1989) on gladiolus plants. The HP, VG and GB treatments tended to overcome the harmful effect of water stresses and received plant growth, physiology and productivity almost near control at soil water content as low as 60-40% of WHC.

Dry matter yield:

Data present in Table (6) indicated that decreasing water supply led to a decrease in the dry weights of the aerial parts, corms and cormels as well. Thus, total dry weight of the plant decreased progressively as field capacity decreased. These results could be supported by the findings of Al-Humaid and Mazrou (1989) on gladiolus, who mentioned that the incorporation of amino acid into protein was inhibited by longer water stress, consequently reducing cell division and producing lower dry matter.

Table (6): Effects of water regimes and hydrophilic polymer (HP), vapor gard (VG) and glycine betaine (GB) treatments on gladiolus plants.

Treatments (B)	Water regime (A)									
	First season					Second season				
	100%	80%	60%	40%	mean	100%	80%	60%	40%	Mean
	Dry weight of areal part (g/plant)									
Control	8.51	8.04	6.71	4.87	7.03	8.01	7.56	6.31	4.47	6.59
HP	8.89	9.00	8.13	5.74	7.94	8.57	8.68	7.84	5.54	7.66
VG	8.78	8.71	7.69	5.60	7.70	8.37	8.30	7.33	5.34	7.34
GB	8.72	8.75	7.76	5.63	7.72	8.31	8.34	7.40	5.37	7.36
HP + VG	9.43	10.12	9.23	6.43	8.80	9.08	9.65	8.71	6.17	8.65
HP + GB	9.17	10.20	8.49	6.46	8.54	8.83	9.60	8.13	6.19	8.19
Mean	8.92	9.11	8.00	5.79		8.53	8.69	7.62	5.51	
LSD (5%)	A= 0.52		B= 0.53		AB= 1.06	A= 0.53		B=0.55		AB= 1.09
	Dry weight of corms & cormels (g/plant)									
Control	6.97	6.58	5.76	3.91	5.81	6.66	6.19	5.31	3.50	5.42
HP	7.39	7.46	6.72	4.66	6.56	7.16	7.02	6.38	4.17	6.18
VG	7.30	7.22	6.62	4.70	6.46	6.98	6.90	6.32	4.28	6.12
GB	7.25	7.26	6.63	4.72	6.47	6.93	6.94	6.34	4.41	6.16
HP + VG	7.93	8.79	7.77	5.38	7.47	7.68	8.51	7.52	5.20	7.23
HP + GB	7.71	8.67	7.46	5.41	7.31	7.47	8.40	7.23	5.24	7.09
Mean	7.43	7.66	6.83	4.80		7.15	7.33	6.52	4.47	
LSD (5%)	A= 0.43		B=0.37		AB= 0.74	A= 0.42		B= 0.36		AB= 0.72
	Total dry weight (g/plant)									
Control	15.48	14.62	12.47	8.80	12.84	14.67	13.75	11.62	7.97	12.00
HP	16.28	16.46	14.85	10.40	14.50	15.73	15.70	14.22	9.71	13.84
VG	16.08	15.93	14.21	10.30	14.13	15.35	15.20	13.63	9.62	13.45
GB	15.97	16.01	14.39	10.35	14.18	15.24	15.28	13.74	9.78	13.51
HP + VG	17.36	18.91	17.00	11.81	16.27	16.76	18.07	16.23	11.37	15.61
HP + GB	16.88	18.69	16.40	11.87	15.96	16.30	18.00	15.36	11.43	15.27
Mean	16.34	16.77	14.89	10.98		15.68	16.00	14.13	9.98	
LSD (5%)	A= 0.67		B= 0.62		AB= 1.25	A= 0.65		B= 0.61		AB= 1.22

Data in the same table showed that HP, VG and GB improved the dry weight of plants when applied either individually or in combined treatments. However, the dry weight of aerial parts and corms were much better in case of combined treatments as compared with individual ones. The effect of the interaction between water regime and conditioning treatments was significant. At any case, the best treatment was recorded with HP+VG followed by HP+GB combined treatments, at which total dry weight of plant was increased by 36% and 32% compared with untreated plants, respectively, when plants were grown under 60% water regime. In this respect, it seems that the increase in total dry weight was related to the positive effect of the treatment on the weight of aerial part, corms and cormels.

The HP and or VG, GB treatments tended to overcome the harmful effect of water stress and increased dry matter yield at soil water content as low as 60% WHC. The application of HP as soil conditioner showed to be useful for regulating plant water stress, plant growth and protecting plants from the dehydration. Vapor gard and glycine betaine may posses anti-transpiration properties and has potential to improve drought tolerance and reduce the amount of water used for irrigation (Moftah and Aly, 2000).

Water consumption and Water use efficiency:

Data recorded in Table (7) showed that total water consumption and water use efficiency decreased linearly with decreasing water supplies to reach minimum amount at 40% water supply. HP,.VG and or GB treatments influenced the water consumption as all treatments improved the growth and made the plants more vigorous and healthy. The effect of the interaction between water regime and conditioning treatments was significant, so that water uptake was much more pronounced as compared with untreated plants particularly at water regimes less than 100%. The best treatments showed highest water consumption and water use efficiency was the combination of HP+VG followed by HP+GB at these treatments water consumption was increased by 10.4 and 9.5%, while WUE was increased by 23.4 and 20.2%, respectively, at the first season. Results at the second season followed almost the same trend as that of the second one.

As discussed above, as water consumption increases, water use efficiency increases (Table 7). This increase is probably because the increase in the total dry weights of the plant. In this respect, all HP, VG and/or GB increased the water use efficiency as compared with untreated plants.

It is worthwhile to clear that the WUE indicated the performance of a crop growing under any environmental conditions and it is mostly depending on the atmospheric evaporative demand, water status, CO2 fixation, and dry matter production (Payn *et al*, 1992; Raeini-Sarjaz *et al*., 1998). Therefore, two reasons may involve in the increased WUE under water-stress conditions (Nobel, 1991; Comstock and Ehleringer, 1993; Raeini-Srajaz *et al*., 1998): the first is increased leaf thickness, as a result of increasing chlorenchyma cell numbers and mesophyll cell wall area, leads to an increase in dry matter content; and the second is the decrease in transpiration rate causes less traspirational accumulative water-loss thus the dwt/H_2O ratio increases.

Table (7): Effects of water regimes and hydrophilic polymer (HP), vapor gard (VG) and glycine betaine (GB) treatments on gladiolus plants.

Treatments (B)	Water regime (A)									
	First season					Second season				
	100%	80%	60%	40%	mean	100%	80%	60%	40%	Mean
	Total water consumption (liter/plant)									
Control	9.32	9.02	8.14	6.08	8.14	8.73	8.38	7.49	5.41	7.50
HP	9.49	9.44	9.05	6.38	8.58	9.07	8.90	8.57	5.86	8.10
VG	9.45	9.35	8.83	6.36	8.50	8.92	8.82	8.37	5.84	7.99
GB	9.45	9.37	8.86	6.40	8.57	8.92	8.84	8.36	5.95	8.02
HP + VG	9.72	9.59	8.99	6.59	8.72	8.28	9.06	8.48	6.24	8.27
HP + GB	9.83	9.70	8.91	6.61	8.76	9.39	9.24	8.42	6.26	8.33
Mean	9.54	9.42	8.80	6.43		9.05	8.87	8.28	5.93	
LSD (5%)	A= 0.35		B= 0.42		AB= 0.84	A= 0.31		B= 0.40		AB= 0.81
	Water use efficiency (g/L)									
Control	1.661	1.621	1.532	1.447	1.565	1.680	1.641	1.551	1.473	1.586
HP	1.715	1.744	1.641	1.630	1.683	1.734	1.764	1.659	1.657	1.704
VG	1.702	1.704	1.609	1.619	1.659	1.721	1.723	1.628	1.647	1.680
GB	1.690	1.709	1.624	1.617	1.660	1.709	1.729	1.644	1.644	1.682
HP + VG	1.786	1.972	1.891	1.792	1.860	1.806	1.994	1.914	1.822	1.884
HP + GB	1.717	1.927	1.841	1.796	1.820	1.736	1.948	1.824	1.826	1.834
Mean	1.712	1.780	1.690	1.650		1.731	1.800	1.703	1.678	
LSD (5%)	A= 0.021		B=0.040		AB= 0.081	A= 0.027		B=0.045		AB= 0.090

As often the case of stress conditions, results of the present study indicated that, under water stress, particularly at 40% (WHC), the transpiration process was affected more dramatically than the CO_2 fixation. This is because in order for the plant to take up a small portion of CO_2, plenty of water would be give off by transpiration via stomata. Thus water-stressed plants, in the presence or absence of HP and VG or GB, maintained a relatively high WUE due to the decrease in transpiration rate as affected by stomatal resistance. The expected increase in water holding capacity and regulating the transference of water from soil through plant by the application of HP might also be concurred with improved WUE of treated plants. These findings are confirmed with those of Tu et al., (1985) on cineraria and Boatright *et al.*, (1997) on annual landscape beds who reported that the addition of soil conditioner polymer to sandy soil reduced infiltration and evaporation rates from soil thus increased the WUE of growing plants.

Chemical Composition:

Data recorded in Table (8) indicated that, contents of nitrogen, phosphorous and potassium were decreased by decreasing water supply to reach minimum contents at 40% treatment. On the other side, HP, VG and GB improved the absorption of nutrients and increased their contents either in single or combined forms.

Table (8): Effects of water regimes and hydrophilic polymer (HP), vapor gard (VG) and glycine betaine (GB) treatments on gladiolus plants.

Treatments (B)	Water regime (A)									
	First season					Second season				
	100%	80%	60%	40%	mean	100%	80%	60%	40%	Mean
	Nitrogen content of aerial parts (mg/plant)									
Control	157.5	148.8	131.5	98.4	134.1	151.2	142.7	126.6	93.3	128.5
HP	164.5	166.6	155.3	116.0	150.6	161.7	163.7	150.8	113.9	147.5
VG	162.5	161.2	150.7	113.2	146.9	157.9	156.6	146.6	110.9	143.0
GB	161.4	161.9	152.0	113.8	147.3	156.8	157.3	147.9	111.5	143.4
HP + VG	174.3	187.3	180.8	130.0	168.1	170.8	181.6	173.6	127.7	163.4
HP + GB	169.6	185.5	166.3	130.1	162.9	166.3	180.7	162.2	127.9	159.3
Mean	165.0	168.6	156.1	116.9		160.8	163.8	151.3	114.2	
LSD (5%)	A= 5.12		B= 5.71		AB= 11.43	A= 5.63		B= 5.95		AB= 11.89
	Phosphorous content of aerial parts (mg/plant)									
Control	22.98	21.71	16.73	11.20	18.16	21.96	20.42	15.42	10.03	16.96
HP	24.01	24.30	20.30	13.20	20.45	23.26	22.87	19.27	11.81	19.55
VG	23.80	23.52	19.20	12.88	19.85	22.76	22.48	18.33	11.72	18.82
GB	23.64	23.62	19.37	12.95	19.90	22.60	22.58	18.52	12.00	18.95
HP + VG	25.56	27.32	23.04	14.79	22.68	24.75	26.45	22.30	14.30	21.95
HP + GB	25.86	27.05	22.19	14.86	22.49	25.06	26.21	21.51	14.39	21.79
Mean	24.31	24.59	20.14	13.31		23.40	23.50	19.23	12.39	
LSD (5%)	A= 1.71		B=1.65		AB= 3.30	A= 1.82		B= 1.81		AB= 3.61
	Potassium content of aerial parts (mg/plant)									
Control	173.7	164.1	106.0	89.2	133.3	166.5	157.3	103.7	84.9	128.1
HP	181.4	183.7	128.4	105.1	149.7	177.9	180.2	126.8	104.4	147.3
VG	179.2	177.8	121.5	102.5	145.2	173.8	172.2	118.8	100.7	141.4
GB	178.0	178.6	122.6	103.1	145.6	172.6	173.2	119.9	101.3	141.8
HP + VG	192.5	206.5	145.8	117.7	165.6	188.4	199.9	140.6	115.9	161.2
HP + GB	187.1	204.5	134.1	118.3	161.0	183.2	198.9	132.9	116.4	157.9
Mean	182.0	185.8	126.4	106.0		177.1	180.3	123.8	103.9	
LSD (5%)	A= 4.98		B= 5.23		AB= 10.43	A= 5.10		B= 5.34		AB= 10.69

Concerning the effect of the interaction between water regime levels and treatments on nutrient minerals, data in the same table showed that HP, VG and GB improved the nutrient concentrations at 60% water supply which showed an increase by the conditioning treatments more than that recorded at 100% water supply. Best treatment in this matter was HP+VP combined treatment, followed by HP+GB application. In this concern, HP+VG combined treatment was the best one in enhancing the uptake of N, P and K by about 37, 38, and 38%, respectively, in the first season. Data in the second season followed the same trend as shown in the second one.

Data tabulated in Table (9) referred that, the mineral N, P and K contents in new corms was decreased by decreasing water regimes. While treating plants by HP, VG and/or GB in single or combined treatments produced an improvement in the nutrients content as that observed in the aerial part except that the content in new corms was much higher than that recorded for the aerial part. The interaction between water regime and conditioning treatments were significant. The best treatments, in this concern, were observed at HP+VG combined treatment. At which the N, P, and K contents were increased by about 34, 35 and 38%, respectively; followed by HP+GB one; at which these increases were 28, 30 and 23%, at the first season. In the second seasons results showed same pattern as in the first one. These results could be explained through the increase in the corresponded produced dry weight as a result of raising soil moisture level. The increased contents of N,P, and K in aerial parts and new corms of gladiolus plants as a result of HP, VG and GB application might be due to the high rate of absorption, utilization and accumulation of such elements (Moftah and Aly, 2000).

Table (9): Effects of water regimes and hydrophilic polymer (HP), vapor gard (VG) and glycine betaine (GB) treatments on gladiolus plants.

Treatments (B)	Water regime (A)									
	First season					Second season				
	100%	80%	60%	40%	mean	100%	80%	60%	40%	Mean
	Nitrogen content of new corms (mg/plant)									
Control	303.1	286.4	253.0	189.3	258.0	294.6	276.1	238.2	174.5	245.9
HP	321.4	324.4	292.2	202.6	285.2	316.4	320.3	288.3	194.3	279.8
VG	317.5	314.0	287.9	204.4	281.0	308.6	305.1	279.8	191.1	271.2
GB	315.3	316.7	289.2	205.9	281.8	306.4	308.3	285.2	192.3	273.1
HP + VG	344.9	382.3	337.9	333.9	349.8	339.6	375.2	332.1	327.8	343.7
HP + GB	335.3	377.1	324.5	322.0	339.7	329.9	370.3	319.5	315.1	333.7
Mean	322.9	333.5	297.5	243.0		315.9	325.9	290.5	232.5	
LSD (5%)	A= 6.8		B= 6.6		AB= 13.3	A= 7.10		B= 6.80		AB= 13.60
	Phosphorous content of new corms (mg/plant)									
Control	29.53	27.88	24.40	16.56	24.59	28.22	26.23	22.49	14.82	22.94
HP	31.31	31.61	28.47	19.74	27.78	30.33	29.75	27.03	17.66	26.19
VG	30.90	30.56	28.02	19.89	27.34	29.55	29.21	26.75	18.11	25.91
GB	30.70	28.04	25.60	18.23	25.64	29.34	26.80	24.48	17.03	24.41
HP + VG	33.60	37.24	32.92	22.79	31.64	32.54	36.05	31.86	22.03	30.62
HP + GB	32.67	36.74	31.61	22.92	30.99	31.65	35.60	30.64	22.20	30.02
Mean	31.45	32.01	28.50	20.02		30.27	30.61	27.21	18.64	
LSD (5%)	A= 2.10		B=1.95		AB= 3.90	A= 2.20		B= 1.99		AB= 3.97
	Potassium content of new corms (mg/plant)									
Control	320.8	305.1	252.8	180.4	264.8	311.5	293.1	245.0	162.0	252.9
HP	335.1	338.3	304.7	211.3	297.4	329.7	332.3	294.3	198.1	288.6
VG	331.0	327.4	300.2	213.1	292.9	324.5	320.9	291.5	199.1	284.0
GB	328.7	329.3	300.7	214.1	293.2	320.8	321.8	293.8	200.7	284.3
HP + VG	355.5	394.0	348.2	241.1	334.7	349.3	388.0	342.9	236.5	329.2
HP + GB	345.7	388.7	334.5	222.6	322.9	339.9	329.2	329.2	224.9	305.8
Mean	336.1	347.1	306.9	213.8		329.3	330.9	299.5	203.6	
LSD (5%)	A= 7.40		B= 7.10		AB= 14.30	A= 7.80		B= 7.28		AB= 14.57

In conclusion the present study provided important clues to the physiological roles of the hydrophilic polymer as soil conditioner and vapor gard and glycine betaine as anti-transpiration agents in possibly improving plant performance under conditions of drying soils. The data revealed that growth, flowering characters, corms and cormels dry matter yield, water consumption and water use efficiency are all improved in HP and/or VG and GB-treated gladiolus plants when subjected to water stress conditions.

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تأثير إضافة محسن التربه هيدروسورس والفابورجارد والجلايسين ببيتايين علي النمو والأزهار ومحصول الكورمات والكريمات وكفاءءه استهلاك المياة لنبات الجلاديولس النامي في تربه رمليه تحت مستويات مختلفه من الرطوبه

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أجري هذا البحث بمشتل كليه الزراعه جامعه المنيا في تجربه أصص خلال موسمين متتاليين ١٩٩٨/١٩٩٧, ١٩٩٩/١٩٩٨, وذلك بهدف دراسه تأثير المحتوي المائي للتربه علي النمو والأزهار ومحصول الكورمات والكريمات وكفاءة أستهلاك المياه ومحتوي النبات من العناصر الكبري(ن,فو,بو) لنبات الجلاديولس صنف White Prosperity (ويت بروسبرتي) النامي في تربه رمليه كما أستهدف البحث دراسه امكانيه التغلب علي التأثير الضار الذي يسببه الجفاف للنمو والأزهار بأستخدام بعض المعاملات ولقد أستخدم في هذه التجربه ستة معاملات وهي:١- محسن التربه هيدرو سورس بمعدل ١%(معاملة تربه).٢- الفابورجارد بمعدل٣% (معاملة رش للنبات).٣- المركب الأمنيومي جلايسين بيتايين بمعدل١,٥%(معاملة رش) ٤- هيدروسورس ١%+فابورجارد٣%.٥-هيدروسورس ١%+جلايسين بيتايين ١,٥% ٦-نباتات بدون معامله (عدم معامله التربه اورش النبات) ولقد تم ري النباتات بأربع معدلات ري وهي:١٠٠%,٨٠%,٦٠%,٤٠% من السعه الحقليه وتم أضافه محسن التربه للتربه الرمليه قبل الزراعه وتم رش الفابورجارد والجلايسين بيتايين ثلاث مرات علي المجموع الخضري ولقد تم تصميم التجربه بطريقة القطع المنشقه مره واحده,ويمكن تلخيص أهم النتائج:كلما انخفض مستوي الرطوبه في التربه (من ٨٠%إلي ٤٠% من السعه الحقليه)أدي ذلك إلي تأخير الأزهار ونقص وزن الأوراق وعددها وكذالك قل طول الشمراخ الزهري ووزنه وقطره وطول الجزء الحامل للأزهار وعدد الزهيرات ووزنها وكذلك يقل وزن الكورمات والكريمات وتقل كفاءة أستهلاك المياه ومحتوي النبات من العناصر الكبري(ن,فو,بو).أدت معاملات محسن التربه هيدروسورس منفرد, محسن التربه هيدروسورس +الفابورجارد, محسن التربه هيدروسورس +جلايسين بيتايين ألي تحسين واضح في النمو والأزهار ومحصول الكورمات. التفاعل بين مستويات الرطوبه ومعاملات مقاومه الجفاف بأستخدام محسن التربه ومانعات البخر أوضحت النتائج أنه بأستخدام محسن التربه هيدروسورس منفردا أو محسن التربه هيدروسورس +الفابورجارد ,أو محسن التربه هيدروسورس+الجلايسين بيتايين إلي تحسين واضح في النمو والأزهار ومحصول الكورمات والكريمات وكفاءة استهلاك المياه ومحتوي النبات من العناصر الكبري (ن,فو,بو)وذلك بالنسبه للنباتات المعرضه للأجهاد المائي والمنزرعه عند مستوي رطوبه٦٠%,٤٠% من السعه الحقليه ولقد امكن التغلب علي نقص الرطوبه بالمعاملات السابقه. نستخلص من هذا البحث أنه يمكن استعمال محسن التربه هيدروسورس بمعدل ١%(أضافه للتربه)+الفابورجارد بمعدل ٣%(معامله رش) أو محسن التربه هيدرو سورس بمعدل ١%+ الجلايسين بيتايين بمعدل ١,٥%(معامله رش) والري بمعدل ٦٠% من السعه الحقليه للحصول علي أعلي معدل للنمو ومواصفات الأزهار ومحصول الكورمات والكريمات وكفاءة عاليه للأستهلاك المائي لنبات الجلاديولس المنزرع في أرض رمليه وبالتالي يمكن الأقتصاد في مياه الري.