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Effect of Irrigation Intervals and Some Anti-transpirants on Productivity and Storability of Sweet pepper

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ABSTRACT

Water availability is one of the most important factors which limits vegetable crops productivity, so it is necessary to change/modify irrigation practice that enable plants to adapt/overcome the limited water. Therefore, the main objective of the current investigation is to assess the effects of irrigation intervals and some anti-transpirants *i.e.*, magnesium carbonate, kaolin, sorbitol and gelatin on sweet pepper performance during the seasons of 2021 and 2022. The experimental findings showed that all irrigation intervals and anti-transpirants significantly affected all studied parameters. Irrigation every 6 days gave the highest values of all parameters except for total chlorophylls, carotenoids, anti-oxidative enzymes activity which recorded the best values when plants irrigated every 14 days. Also, all studied parameters responded positively to all applied anti-transpirants, while leaf transpiration, weight loss, post-harvest decay percentage, respiration rate, and chilling injuries responded negatively. The maximum values of Malondialdehyde, 2,2-Diphenyl-1-picrylhydrazylradical scavenging activity, cell membrane stability, and number of fruits were obtained when plants irrigated every 6 days and sprayed with either kaolin or sorbitol. Additionally, either irrigation every 10 or 14 days and spraying with magnesium carbonate or kaolin increased fruits yield. Irrigation every 14 days and spraying with gelatin recorded the best values of total chlorophyll pigments, carotenoids, anti-oxidative enzymes activity, ascorbic acid, acidity, total soluble solids, calcium, and potassium contents in sweet pepper fruits. Conversely, the maximum values of leaf transpiration, respiration rate, and chilling injuries were recorded with all irrigation intervals in the absence of anti-transpirants.

Keywords: Sweet pepper - Magnesium carbonate – Kaolin - Sorbitol – Gelatin – Storability

INTRODUCTION

Sweet pepper, (*Capsicum annum* L.) is one of the most popular vegetable crops in Egypt and worldwide. According to FAOSTAT (2023) sweet pepper production was 37 million tons and the total cultivated area was 2 million hectares in the year 2022. Fruits have important economic and medical values and they are consumed as fresh, cooked or spices. Also, fruits contain wide range of antioxidants as carotenoids, ascorbic acid and phenolic compounds (Marín *et al.*, 2004). Water is considered an essential factor for sweet pepper and other crops growth. The appropriate irrigation water amount improves nitrogen use efficiency, biomass, photosynthetic assimilation, and growth as well as fruits yield (Du *et al.*, 2017 and Kabir *et al.*, 2021). In contrast, water deficit inhibits plant growth and decreases crop yield (Hu *et al.*, 2010).

Anti-transpirants are one of the means that reduce the intensity of water loss and maintaining a relative fullness suitable for growth and improving metabolic processes (Del Amor *et al.*, 2010). There are three classes of anti-transpirants differed in their action *i.e.*, stomata-closing or metabolic, reflective, and film-forming anti-transpirants (Mphande *et al.*, 2020). Metabolic anti-transpirants include substances which have either hormones or hormone-like effects, acting on guard cells by causing partial stomatal closure (Abd Allah *et al.*, 2018). Reflective anti-transpirants function depends on modifying both gas exchange and leaf temperature which consequently affects transpiration rate (Glenn, 2012). Therefore, magnesium carbonate ($MgCO_3$), Kaolin (Aluminum silicate), sorbitol, and gelatin were studied. Magnesium carbonate ($MgCO_3$) is an anti-transpirant which enhances plant physiology and growth and induces stomatal closing (Zakaria *et al.*, 2019). Exogenous application of magnesium carbonate enhanced protein content, photosynthetic pigments and reduced transpiration rate (Punetha and Trivedi, 2018 and El-Sharkawy *et al.*, 2022). Kaolin application to leaf surfaces reflects ultraviolet and infrared rays, thus reducing the transpiration process whereas, as a natural white material allows light and gaseous exchange necessary for the photosynthesis process to pass through (Creamer *et al.*, 2005) and also preserves freshness, reduces water loss, and shrinkage of fruits under cold storage conditions. Sorbitol (low molecular weight) is one of the most important alcoholic sugars produced by photosynthesis. It has a major role in plant growth, improving quality, and it accumulates in response to environmental stresses as a defense mechanism. In addition, sorbitol helps to overcome free radicals resulted from exposure to oxidative stress under storage conditions, and thus fruits shelf-life under low temperatures (Al-Azzawi and Al-Shammari, 2022). Gelatin defined as a combination of proteins and peptides which derived from the partial hydrolysis of collagen and contains

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18 amino acids (Gelatin Manufacturers Institute of America, 2012). External application with gelatin enhanced plant performance of pepper, cucumber, tomato, and broccoli (Wilson *et al.*, 2018).

Hence, the objective of the present experiment is to study the impact of irrigation intervals and some anti-transpirants such as magnesium carbonate, kaolin, sorbitol, and gelatin on biochemical components, productivity as well as fruits nutritional value and storability of sweet pepper.

MATERIALS AND METHODS

This work was carried out to evaluate the effects of irrigation intervals (6, 10, and 14 days), some anti-transpirants such as magnesium carbonate ($MgCO_3$), kaolin (aluminum silicate), sorbitol, gelatin and their interactions on sweet pepper plants. Pots experiments were conducted in the experimental farm, Faculty of Agriculture, Mansoura University, Dakahlia Governorate, Egypt in the two summer seasons 2021 and 2022.

The experimental treatments were arranged in a split plot in a complete randomized block design. Irrigation intervals (6, 10 and 14 days) were randomly arranged in the main plots, while foliar treatments of anti-transpirants (as a foliar spray) i.e., of magnesium carbonate (500ppm), kaolin (500ppm), sorbitol (500ppm), gelatin (500ppm) plus the control (spray with tap water) were randomly arranged in the sub plots. All applied foliar substances were mixed with tween 20 (0.05%) and sprayed after 30 days from transplanting for four times with 10 days intervals in both growing seasons.

Sweet pepper seedlings (var. California wonder) were planted on 19th May 2021 and 2022 seasons in pots (40 cm diameter, 40 cm height, and contain 10 kg soil). Some physical and chemical properties of the experimental soil were analyzed according to the methods described by Dane and Topp (2020) and Sparks et al. (2020) and presented in Table (1). All agricultural practices were conducted as recommended by the Ministry of Agriculture and Soil Reclamation

Table 1. Some physical and chemical properties of the experiment soil

Sand (%)	Silt (%)	Clay(%)	Texture	N(mg/kg)	P(mg/kg)	K(mg/kg)	$CaCo_3$	pH	Organic matter (%)
50.00	40.00	10.00	loam	40.25	8.00	198.30	1.13	8.45	0.85

Recorded data: the following measurements were taken:

Biochemical components:

Leaves were collected after 70 days from transplanting to determine:

Malondialdhyde (MDA): was measured according to Murshed *et al. (*2008) method.

Leaf transpiration: was calculated according to Gong et al. (2018).

Radical scavenging activity percentage (DPPH): was measured using the protocol of Brands-Willims *et al.* (1995).

Cell membrane stability percentage: was estimated according to Blum and Ebercon (1981**)** method.

Yield parameters:

Harvesting at the green/yellow stage started after 90 days from transplanting. Both number of fruits /plant and total yield (g/plant) were measured.

Storage parameters:

Fruit samples (250 g) from the last picking (the fourth one) were collected, and cool-stored in perforated paper bags at (7◦C and 95% relative humidity) for two weeks. After storage period, the following measurements were performed on stored fruits:

Total chlorophylls and carotenoids: were estimated according to Lichtenthaler (1987) method.

Weight loss (%): the percentage of loss in weight was calculated according to AOAC (2007) follows:

Weight loss (%) = loss in weight at the sampling date/ the initial weight of the fruits ×100.

Post-harvest decay (PDP%): was calculated according to the following equation as described by EL-Mougy *et al. (*2012).

PDP (%) = number of fruits with decay symptoms/number of total fruits ×100.

Respiration rate: was measured according to Jacxsens *et al. (*1999) method.

Chilling injures was determined by method of Wang and Qi (1997).

Catalase enzyme activity: was estimated by the method of Blackwell *et al., (*1990).

Peroxidase enzyme activity: was measured by the method described by Elavarthi and Martin (2010).

Ascorbic acid was estimated according to Freed (1966) method.

Total soluble solid percentage was measured by Atomic Absorption Spectrophotometer according to the method of AOAC (2012).

Titratable acidity percentage was measured according to Mitcham *et al.*, (1996).

Total Calcium percentage was estimated according to Jackson (1973) method.

Total potassium percentage: was determined according to Smith (1979).

Statistical analysis:

Data were analyzed by analysis of variance using COSTAT software and the least significant differences at 5% was calculated according to Gomez and Gomez (1984) to compare differences between means.

RESULTS AND DISCUSSION

Results

Effect of irrigation intervals, anti-transpirants, and their interactions on biochemical components in sweet pepper leaves

Table (2) clarify the impact of irrigation intervals (6, 10, and 14 days), anti-transpirants and their interactions on MDA, leaf transpiration, DPPH activity, and cell membrane stability in sweet pepper leaves. All applied irrigation intervals differed significantly, irrigation every 6 days recorded the highest values, while irrigating plants every 14 days recorded the lowest values of mentioned parameters. Also, MDA, DPPH activity, and cell membrane stability in sweet pepper leaves responded positively to the exogenous anti-transpirants, while leaf transpiration responded negatively. Among the applied foliar substances, kaolin treatment is the superior and recorded the best values of MDA, DPPH activity, and cell membrane stability. In contrast, it recorded the lowest values of leaf transpiration.

Table 2. Effect of irrigation intervals, some anti-transpirants and their interactions on biochemical measurements in leaves of sweet pepper plants.

Treatments	The mean and standard division of two seasons 2021and 2022							
	Malonyldialdehyde (MDA) (µmol g^{-1} F.W)				**Leaf transpiration (mmol $H_2O.m^{-2}.S^{-1}$)**			
	IR 6	**IR 10**	**IR 14**	**Mean B**	**IR 6**	**IR 10**	**IR 14**	**Mean B**
Control	7.23±0.13	6.09±0.09	4.58±0.06	5.97^{e}	10.09±0.13	7.15±0.10	7.06±0.02	8.10^{a}
Magnesium carbonate	8.61±0.09	6.57±0.05	5.27±0.09	6.81^{c}	9.38±0.13	5.84±0.11	6.95±0.16	7.06^{b}
Kaolin	8.86±0.11	6.77±0.06	5.49±0.06	7.04^{b}	8.38.±0.11	6.29±0.16	5.16±0.03	6.25^{c}
Sorbitol	8.14±0.09	6.38±0.08	5.07±0.05	6.53^{d}	7.30±0.16	6.74±0.13	5.24±0.03	6.54^{d}
Gelatin	7.11±0.12	8.12±0.07	4.01±0.06	6.41^{a}	7.73±0.13	5.41±0.12	6.58±0.04	6.57^{d}
Mean A	7.99^{a}	6.79^{b}	4.88^{c}		10.29^{a}	7.86^{c}	7.754^{b}	
LSD 5%	A=0.10 B=0.08 A*B=0.16				A=0.14 B=0.16 A*B=0.25			
Treatments	Radical scavenging activity percentage (DPPH)				Cell membrane stability percentage			
	IR 6	IR 10	IR 14	Mean B	IR 6	IR 10	IR 14	Mean B
Control	38.13±0.09	32.94±0.22	29.09±0.03	33.38^{e}	50.48±0.16	45.04±0.16	39.23±0.30	44.92^{e}
Magnesium carbonate	40.92±0.06	35.76±0.33	31.09±0.11	35.92^{b}	54.08±0.04	48.17±0.15	43.05±0.11	48.43^{b}
Kaolin	41.74±0.11	36.85±0.14	31.86±0.14	36.82^{a}	55.19±0.04	49.56±0.09	43.93±0.11	49.56^{a}
Sorbitol	39.32±0.20	34.97±0.26	30.25±0.06	34.85^{c}	52.46±0.18	47.09±0.09	41.76±0.16	47.10^{c}
Gelatin	38.73±0.58	34.12±0.08	29.68±0.09	34.18^{d}	51.75±0.11	46.00±0.17	40.58±0.08	46.11^{d}
Mean A	39.77^{a}	34.93^{b}	30.39^{c}		52.79^{a}	47.17^{b}	41.71^{c}	
LSD 5%	A=0.21 B=0.26 A*B=0.46				A=0.14 B=0.18 A*B=0.31			

IR 6: Irrigation every 6 days; IR 10: Irrigation every 10 days; IR 14: Irrigation every 14 days. All of anti-transpirants treatment applied with 500 ppm.

Regarding the impact of interaction, the findings indicate that all irrigation intervals (6, 10, and 14 days) in the absence of anti-transpirants decreased the values of MDA, DPPH activity, and cell membrane stability of sweet pepper leaves, but increased the values of leaf transpiration. The maximum values of MDA, DPPH activity, and cell membrane stability are recorded with irrigation every 6 days and sprayed with either kaolin or sorbitol in most cases. The maximum values of leaf transpiration are recorded with irrigation every 6 days in the absence of anti-transpirants.

Effect of irrigation intervals, anti-transpirants and their interactions on yield parameters

The influence of irrigation intervals (6, 10, and 14 days), anti-transpirants on fruits number and fruits yield per plant of sweet pepper was illustrated in table (3). The maximum values of fruits number and fruit yield were recorded when plants irrigated every 6 days followed by irrigation every 10 days without significant differences in both seasons.

Table 3. Effect of irrigation intervals, some anti-transpirants and their interactions on yield parameters of sweet pepper plants during seasons 2021 and 2022.

Treatments	First season (2021)							
	Number of fruits				**Total yield (g/plant)**			
	IR 6	**IR 10**	**IR 14**	**Mean B**	**IR 6**	**IR 10**	**IR 14**	**Mean B**
Control	3.33±0.58	3.00±0.00	2.33±0.58	2.89^{a}	155.40±12.30	139.77±3.09	150.40±10.00	148.52^{b}
Magnesium carbonate	4.00±1.73	3.67±0.58	2.67±1.15	3.44^{a}	186.63±9.85	193.07±4.10	191.47±4.08	190.39^{a}
Kaolin	4.67±0.58	4.00±0.00	3.00±1.73	3.89^{a}	176.80±12.68	168.70±1.05	191.47±4.08	178.99^{ab}
Sorbitol	3.33±0.58	3.33±0.58	3.67±0.58	3.44^{a}	174.27±2.25	178.70±1.05	189.53±5.45	180.83^{a}
Gelatin	3.33±0.58	3.00±0.00	3.00±0.00	3.11^{a}	192.03±8.08	169.47±6.64	170.43±6.09	177.31^{ab}
Mean A	3.73^{a}	3.40^{ab}	2.93^{b}		177.03^{a}	169.94^{ab}	178.66^{a}	
LSD 5%	A=0.61 B=0.79 A*B=1.36				A=5.28 B=6.82 A*B=11.81			
Treatments	Second season (2022)							
	Number of fruits				Total yield (g/plant)			
	IR 6	IR 10	IR 14	Mean B	IR 6	IR 10	IR 14	Mean B
Control	3.00±0.00	5.00±0.00	2.67±0.58	3.56^{b}	158.79±10.54	145.57±4.97	150.54±10.16	151.63^{a}
Magnesium carbonate	5.67±0.58	3.00±0.00	4.67±0.58	4.44^{a}	165.68±39.20	130.65±51.84	192.50±2.91	162.94^{a}
Kaolin	5.00±0.00	4.33±1.15	4.67±0.58	4.67^{a}	158.82±50.55	175.70±4.96	197.53±5.87	177.35^{a}
Sorbitol	4.33±0.58	5.00±0.00	4.00±0.00	4.44^{a}	179.52±1.75	182.08±3.27	191.23±4.50	184.28^{a}
Gelatin	4.33±0.58	4.67±0.58	4.67±0.58	4.56^{a}	160.88±53.11	181.64±3.38	180.83±10.01	174.45^{a}
Mean A	4.47^{a}	4.40^{a}	4.13^{a}		164.74^{a}	163.13^{a}	182.52^{a}	
LSD 5%	A=0.39 B=0.50 A*B=0.86				A=19.31 B=24.92 A*B=43.17			

IR 6: Irrigation every 6 days; IR 10: Irrigation every 10 days; IR 14: Irrigation every 14 days.All of anti-transpirants treatment applied with 500 ppm.

All applied anti-transpirants increased the mentioned parameters in both seasons as compared with control. Exogenous application of kaolin recorded the maximum values followed by the application of sorbitol without significant differences. Concerning the interaction, irrigation every 6 days and spraying with either kaolin or magnesium carbonate revealed the maximum values of fruits number in both seasons, while either irrigation every 10 or 14 days and spraying magnesium carbonate or kaolin increased fruit yield in the two seasons.

Effect of irrigation intervals, anti-transpirants and their interactions on storage parameters

Total chlorophylls, carotenoids, weight loss, post-harvest decay percentages, respiration rate, and chilling injuries of sweet pepper fruits:

The influence of irrigation intervals anti-transpirants and their interactions on total chlorophyll, carotenoids, weight loss, post-harvest decay percentages, respiration rate, and chilling injuries of sweet pepper fruits after storage at 7˚C and 95% Rh for two weeks is presented in table (4a). Results indicated that irrigation every 14 days recorded the maximum values of both total chlorophylls and carotenoids. Exogenous application of magnesium carbonate, kaolin, sorbitol, and gelatin enhanced both parameters compared with the control. Spraying with gelatin increased total chlorophylls and carotenoids in fruits followed by sorbitol. Concerning the interaction, irrigation every 14 days and spraying with either gelatin or sorbitol recorded the best values of total chlorophylls and carotenoids in sweet pepper fruits.

Table 4a. Effect of irrigation intervals, some anti-transpirants and their interactions on storage parameters of sweet pepper fruits.

Treatments	The mean and standard division of two seasons 2021and 2022											
	Total chlorophylls (mg g^{-1})				Carotenoids (mg g^{-1})				Weight loss (%)			
	IR 6	IR 10	IR 14	Mean B	IR 6	IR 10	IR 14	Mean B	IR 6	IR 10	IR 14	Mean B
Control	1.30±0.03	1.30±0.02	1.40±0.02	1.33^{e}	0.15±0.02	0.14±0.03	0.13±0.01	0.14^{d}	50.07±9.78	54.35±6.49	34.81±5.92	46.41^{a}
Magnesium carbonate	1.33±0.02	1.38±0.03	1.43±0.02	1.38^{c}	0.17±0.01	0.19±0.02	0.21±0.01	0.19^{b}	21.79±2.57	8.08±3.03	8.81±3.15	12.89^{b}
Kaolin	1.31±0.01	1.37±0.03	1.41±0.03	1.36^{d}	0.17±0.01	0.19±0.02	0.20±0.02	0.19^{b}	11.24±1.90	11.92±7.31	8.75±2.89	10.64^{b}
Sorbitol	1.33±0.03	1.39±0.02	1.44±0.01	1.39^{b}	0.18±0.01	0.19±0.03	0.21±0.03	0.19^{b}	12.45±7.66	8.85±2.59	7.48±2.84	9.60^{b}
Gelatin	1.34±0.01	1.40±0.04	1.45±0.01	1.40^{a}	0.18±0.02	0.19±0.02	0.22±0.02	0.20^{a}	9.33±0.30	14.68±6.69	10.53±5.71	11.51^{b}
Mean A	1.33^{c}	1.39^{b}	1.44^{a}		0.17^{c}	0.18^{b}	0.19^{a}		20.98^{a}	19.58^{a}	14.08^{b}	
LSD 5%	A=0.02 B=0.03 A*B=0.05				A=0.02 B=0.03 A*B=0.04				A=3.92 B=5.06 A*B=8.77			
Treatments	Post-harvest decay (%)				Respiration rate (ml CO_2 kg^{-1} h^{-1})				Chilling injuries			
	IR 6	IR 10	IR 14	Mean B	IR 6	IR 10	IR 14	Mean B	IR 6	IR 10	IR 14	Mean B
Control	55.55±50.92	55.55±50.92	66.66±33.33	59.26^{a}	21.64±0.21	20.46±0.46	16.71±0.49	19.60^{a}	3.92±0.05	2.69±0.01	2.21±0.01	2.94^{a}
Magnesium carbonate	0.00±0.00	22.22±38.49	0.00±0.00	7.41^{b}	20.51±0.38	19.19±0.37	14.58±0.40	18.09^{b}	3.14±0.03	2.39±0.01	1.52±0.03	2.35^{d}
Kaolin	11.11±19.24	22.22±38.49	0.00±0.00	11.11^{b}	20.43±0.30	18.25±2.18	13.88±0.30	17.52^{b}	2.92±0.09	2.39±0.05	1.37±0.03	2.23^{e}
Sorbitol	22.22±38.49	22.22±38.49	0.00±0.00	14.81^{b}	20.47±0.49	19.40±0.37	15.21±0.37	18.36^{b}	3.70±0.11	2.43±0.03	1.92±0.05	2.68^{c}
Gelatin	0.00±0.00	0.00±0.00	22.22±38.49	7.41^{b}	21.39±0.37	18.60±0.78	15.91±0.24	18.63^{b}	3.75±0.06	2.67±0.04	2.09±0.02	2.83^{b}
Mean A	17.78^{a}	24.44^{a}	17.78^{a}		20.89^{a}	19.18^{b}	15.26^{c}		3.48^{a}	2.51^{b}	1.82^{c}	
LSD 5%	A=22.84 B=29.49 A*B=51.07				A=0.66 B=0.85 A*B=1.48				A= 0.05 B=0.06 A*B=0.11			

IR 6: Irrigation every 6 days; IR 10: Irrigation every 10 days; IR 14: Irrigation every 14 days. All of anti-transpirants treatment applied with 500 ppm.

Regarding weight loss, post-harvest decay percentages, respiration rate, and chilling injuries of sweet pepper fruits, a reduction in weight loss and post-harvest decay percentages was recorded when plants irrigated every 14 days. In contrast, irrigation every 6 days increased the mentioned percentages. Significant differences were observed between magnesium carbonate, kaolin, sorbitol, gelatin foliar applications and the control. The control plants showed an increment in weight loss, post-harvest decay percentages, respiration rate, and chilling injuries of sweet pepper fruits. All irrigation intervals increased studied parameters in the absence of foliar substances, irrigation every 6 days recorded the maximum values of weight loss percentage, while irrigating every 14 days recorded the maximum values of post-harvest decay percentage. A reduction in both weight loss and post-harvest decay percentages of sweet pepper fruits was recorded with irrigation every 14 days and spraying sorbitol. Similarly, spraying with either magnesium carbonate or kaolin reduced post-harvest decay percentage, respiration rate, and chilling injuries when plants irrigated every 14 days.

Catalase enzyme, peroxidase enzymes activity, ascorbic acid, total soluble solids percentage

Data in table (4b) clarify the effect of irrigation intervals, anti-transpirants as well as their interactions on the activity of catalase as well as peroxidase enzymes, ascorbic acid, and total soluble solids percentage of sweet pepper fruits.

Table 4b. Effect of irrigation intervals, some anti-transpirants and their interactions on storage parameters of sweet pepper fruits.

Treatments	The mean and standard division of two seasons 2021and 2022							
	Catalase enzyme (mM H_2O min^{-1} g^{-1} FW)				Peroxidase enzyme (mM H_2O min^{-1} g^{-1} FW)			
	IR 6	IR 10	IR 14	Mean B	IR 6	IR 10	IR 14	Mean B
Control	25.31±0.49	27.07±0.25	30.01±0.64	27.46^{b}	0.14±0.01	0.12±0.01	0.17±0.01	0.14e
Magnesium carbonate	24.74±0.20	26.09±0.50	28.65±0.42	26.49^{d}	0.16±0.03	0.27±0.03	0.35±0.03	0.26^{c}
Kaolin	24.46±0.26	26.29±0.40	28.32±0.46	26.35^{e}	0.16±0.03	0.27±0.06	0.33±0.01	0.25^{d}
Sorbitol	25.87±0.29	26.93±0.15	29.29±0.75	27.36^{c}	0.19±0.03	0.30±0.03	0.36±0.03	0.28^{b}
Gelatin	25.18±0.27	27.85±0.35	30.03±0.12	27.69^{a}	0.23±0.03	0.31±0.03	0.36±0.02	0.30^{a}
Mean A	25.11^{c}	26.84^{b}	29.26^{a}		0.18^{a}	0.25^{b}	0.39^{a}	
LSD 5%	A= 0.39 B=0.50 A*B=0.87				A= 0.02 B=0.03 A*B=0.05			
Treatments	Ascorbic acid (mg.100g^{-1})				Total soluble solids (TSS %)			
	IR 6	IR 10	IR 14	Mean B	IR 6	IR 10	IR 14	Mean B
Control	86.05±0.39	89.55±0.59	93.28±0.57	89.83^{c}	4.71±0.02	4.10±0.04	5.24±0.01	4.68^{e}
Magnesium carbonate	86.94±0.39	89.86±0.42	92.05±0.11	89.61^{d}	4.51±0.02	4.81±0.01	5.16±0.01	4.83^{c}
Kaolin	88.82±1.03	90.96±0.25	91.09±0.88	88.90^{e}	4.45±0.01	4.78±0.02	5.07±0.02	4.77^{d}
Sorbitol	87.40±0.28	89.96±0.12	92.01±0.82	90.29^{b}	4.55±0.01	4.91±0.01	5.37±0.02	4.94^{b}
Gelatin	88.69±0.64	90.27±0.43	93.57±0.65	90.84^{a}	5.16±0.73	5.04±0.01	5.29±0.02	5.16^{a}
Mean A	87.58^{c}	90.12^{b}	92.40^{a}		4.67^{c}	4.91^{b}	5.22^{a}	
LSD 5%	A=0.54 B=0.70 A*B=1.21				A=0.12 B=0.23 A*B=0.40			

IR 6: Irrigation every 6 days; IR 10: Irrigation every 10 days; IR 14: Irrigation every 14 days.All of anti-transpirants treatment applied with 500 ppm.

Results indicate that irrigating every 14 days enhanced all studied parameters followed by irrigating every 10 days. Catalase and peroxidase enzymes, ascorbic acid, and total soluble solids percentage responded positively to the all applied anti-transpirants. Exogenous application of either gelatin or sorbitol recorded the maximum activity of the mentioned parameters. also, an increment in these parameters was observed in plants irrigated every 14 days and sprayed with gelatin.

Acidity, total calcium, and total potassium content in sweet pepper fruits:

The effect of irrigation intervals (6, 10, and 14 days), anti-transpiration as well as their interaction on acidity, total calcium, and total potassium contents in sweet pepper fruits was shown in table (4c). Results indicated that acidity, calcium, and potassium contents increased when plants irrigated every 14 days, while the minimum values were obtained when plants irrigated after 6 days. Also, the mentioned parameters responded positively to all applied foliar substances compared with the control. In this concern, foliar application with sorbitol recorded the best values followed by gelatin. Exogenous application of either gelatin or sorbitol and irrigation every 14 days recorded the best values of acidity, calcium, and potassium contents, while all irrigation intervals in the absence of foliar substances recorded lower values.

Table 4c. Effect of irrigation intervals, some anti-transpirants and their interactions on storage parameters of sweet pepper fruits.

Treatments	The mean and standard division of two seasons 2021and 2022											
	Acidity percentage (%)				Total calcium (%)				Total potassium (%)			
	IR 6	IR 10	IR 14	Mean B	IR 6	IR 10	IR 14	Mean B	IR 6	IR 10	IR 14	Mean B
Control	0.20±0.01	0.21±0.01	0.29±0.01	0.23^{e}	1.12±0.01	1.12±0.03	1.22±0.02	1.15^{e}	2.21±0.00	2.46±0.03	2.66±0.03	2.44^{c}
Magnesium carbonate	0.19±0.01	0.26±0.01	0.35±0.01	0.26^{d}	1.08±0.01	1.33±0.04	1.49±0.01	1.30^{b}	2.24±0.01	2.43±0.02	2.60±0.01	2.42^{e}
Kaolin	0.18±0.01	0.30±0.01	0.33±0.01	0.27^{c}	1.01±0.01	1.25±0.01	1.47±0.01	1.24^{d}	2.34±0.02	2.39±0.02	2.55±0.01	2.43^{d}
Sorbitol	0.23±0.01	0.28±0.01	0.37±0.02	0.29^{a}	1.12±0.01	1.37±0.03	1.54±0.01	1.34^{c}	2.28±0.01	2.54±0.02	2.72±0.01	2.51^{a}
Gelatin	0.20±0.01	0.25±0.01	0.38±0.01	0.28^{b}	1.17±0.02	1.41±0.02	1.58±0.02	1.38^{a}	2.31±0.03	2.53±0.05	2.67±0.02	2.50^{b}
Mean A	0.20^{c}	0.28^{b}	0.36^{a}		1.12^{c}	1.30^{b}	1.46^{a}		2.27^{c}	2.47^{b}	2.64^{a}	
LSD 5%	A=0.01 B=0.01 A*B=0.03				A=0.02 B=0.03 A*B=0.05				A=0.02 B=0.03 A*B=0.05			

IR 6: Irrigation every 6 days; IR 10: Irrigation every 10 days; IR 14: Irrigation every 14 days.All of anti-transpirants treatment applied with 500 ppm.

Discussion

Deficit irrigation is an irrigation practice that plants irrigated with less water amounts than their requirements for optimal growth. It can improve water productivity, so it may be a tool to achieve the goal to reduce irrigation water use. Plants are seriously endangered when water is scarce. Drought affects plant growth, productivity, and thus its survival. However, plants do have some self-protection against drought, as it can make some structural adjustments to avoid or tolerate drought. In addition, plants have internal defense mechanisms that are activated in an attempt to limit water loss when predicted to be scarce. Plants grown under inappropriate conditions of water balance are characterized by the following characteristics: First: Structural appearances: increased root system size, whereas reduced shoot system size, small leaf cells size, small stomata and blade area and increased hairs number per unit area, increased thickness of cell walls, increased thickness of palisade mesophyll and increased formation of lipids on surfaces. Second: Functional appearances: decreased starch/sugar ratio, increased osmotic pressure, decreased protoplasm viscosity, increased membranes permeability and precocious flowering and fruiting. These findings are in harmony with those obtained by Abbas *et al.,* (2019); El-Sayed *et al.,* (2019); Díaz-Pérez *et al.,* (2021) and Alnaddaf *et al.,* (2023) on pepper plants.

The main objective of this research is to enhance adaptation of plants to water deficit, so some anti-transpirants were applied as a defensive method to preserve the survival of the plant. Anti-transpirants is the application of a substance, mostly of lipid nature, that forms a thin hydrophobic film on the surface of the plant, thereby a buffer layer between the outer atmosphere and the plant which serves to reduce water loss by transpiration and renders plant surfaces less susceptible to infection (Faralli *et al.,* 2016). Also, these substances help to reduce free water on the leaf surface to prevent the growth of pathogens. Anti-transpirants work to reduce transpiration from plant tissues, which improves growth and increases productivity, especially in arid and semi-arid conditions. Application of anti-transpirants before harvesting helps to enhance the biochemical components, prolongs the shelf-life, reduces infection rate, water loss percentage, respiration rate, increase dry matter, and reduce weight loss in fruits during storage. These findings are in accordance with those obtained by Creamer *et al.,* (2005) on Chile pepper, Crusciol *et al.,* (2009) on potato, Abraheem, (2017) on wheat plants and Kocaman, (2024) on strawberry. Stress resulting from high temperature and fluctuating irrigation to which pepper plants are exposed negatively affects the rate of respiration and transpiration and is reflected on the total yield as it leads to physiological changes within plant and its metabolic processes.

It contributes to the reflection of rays on plant, as a result of reducing the severity of high temperatures and increasing the concentration of some important compounds in fruits. The obtained results are in harmony with those of Abou-Baker, (2011) on bean plants, Kamal, (2013) on pepper plants. The experimental results show that spraying anti-transpirants led to a significant increase in the concentrations of potassium, calcium and vitamin C, because it overcame the damage of free radicals thus facilitated the movement of nutrients thereby increasing total soluble solids and acidity after storage in low temperature. These conclusions were supported by Kausar *et al.,* (2016) and Abd El-Samad *et al.,* (2018).

Gelatin is composed of about 98-99% protein, about 1-2% water and small amounts of minerals, vitamins, antioxidants and calcium. Gelatin contains the highest amount of the amino acid glycine. The external addition of gelatin increased the plant's biotic and a biotic stress tolerance, improved the efficiency of the photosynthesis process, increased the activity of antioxidant enzymes activities, and increased fruits setting through increasing the activity of plant hormones. Also, it contributed to reducing chilling injuries, weight loss rate, and senescence consequently preserved fruits from spoilage after storage at low temperature for two weeks at 7°C, 95% RH. These results agree with EL-Bassiouny *et al.,* (2019) and Dinis *et al*., (2018). Drought stress can promote reactive oxygen species production which induce the degradation of membranes and proteins, decreasing photosynthesis and limiting plant growth. The results of the present investigation indicated that magnesium carbonate, kaolin, sorbitol and gelatin particles induced peroxidase and catalase activities under water stress conditions. Their combined effect leads to the conversion of O2− to H2O2 then to detoxify H2O2, consequently increasing the plant's drought stress tolerance. These results are in line with those obtained by Marques *et al*., (2014) and Bernardo *et al.*, (2017) on eggplant.

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تأثير فترات الري وبعض مضادات النتح على الإنتاجية والقدرة التخزينية للفلفل الحلو

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الملخص

تعتبر الزراعة تحت ظروف ندرة المياه من العوامل التى تؤثر على إنتاجية محاصيل الخضر لذا يجب تعديل/تغيير الممارسات الزراعية الخاصة بالري لترشيد استهلاك المياه وتعظيم الاستفاده منها. تهدف التجربة دراسة تأثير فترات الري (الرى كل 6 أو 10 أو 14 يوم) وبعض مضادات النتح (كربونات المغنسيوم والكاؤلين والسوربيتول والجيلاتين) بتركيز 500 جزء في المليون لجميع المواد بالاضافه إلى معاملة الكنترول على نباتات الفلفل الحلو خلال موسمي الزراعة 2021 و 2022. تم استخدام تصميم القطاعات العشوائية الكاملة بنظام القطع المنشقة مره واحده حيث تم توزيع فترات الري في القطع الرئيسية ومضادات النتح في القطع الفرعية. أظهرت نتائج التجربة أن جميع فترات الري ومضادات النتح أثرت معنوياً على جميع الصفات محل الدراسة. حيث سجلت معاملة الري كل 6 أيام أعلى القيم لجميع الصفات باستثناء الكلوروفيل الكلي والكاروتينات ونشاط الانزيمات المضادات للأكسدة بثمار الفلفل التي سجلت أفضل القيم عند ري النباتات كل 14 يوماً. كما استجابت جميع الصفات المدروسة بشكل إيجابي لجميع مضادات النتح المستخدمة، في حين استجاب معدل نتح الأوراق، والفقد في الوزن، ونسبة التالف بعد الحصاد، ومعدل التنفس، وأضرار البرودة بشكل سلبي. تم تسجيل أعلى القيم لنشاط MDA و DPPH وثبات غشاء الخلية وعدد الثمار عند ري النباتات كل 6 أيام ورشها إما بالكاؤلين أو السوربيتول. بالإضافة إلى ذلك، أدى الري كل 10 أو 14 يومًا مع الرش بكربونات المغنيسيوم أو الكاؤلين إلى زيادة إنتاجية الثمار. وأيضا سجلت معاملة الري كل 14 يوم والرش بالجيلاتين أفضل القيم لمحتوى الثمار من الكلوروفيل والكاروتينات ونشاط الإنزيمات المضادات للأكسدة وحامض الأسكوربيك والمواد الصلبة الذائبة الكلية والحموضة والكالسيوم والبوتاسيوم. وعلى العكس من ذلك، تم تسجيل أعلى القيم لمعدل نتح الأوراق ومعدل التنفس وأضرار البرودة مع جميع فترات الري في غياب مضادات النتح (الكنترول).

الكلمات الدالة: الفلفل الحلو – كربونات الماغنسيوم - الكاؤلين – السوربيتول – الجيلاتين - القدرة التخزيني