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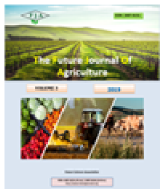

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RESPONSE OF *Cyperus alternifolius* L. PLANT TO SOME ANTI-TRANSPIRANTS AND IRRIGATION WATER LEVELS

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ABSTRACT: This investigation was carried out in the open field at the experimental nursery of Ornamental Plants and Landscape Gardening Res. Dept., Hort. Res. Inst., ARC., Giza, Egypt during 2015/2016 and 2016/2017 seasons to study the effect of different anti-transpirants (active dry yeast extract at 1, 2 and 3%, calcium carbonate at 100, 200, 300 ppm and kaolin at 1, 2 and 3%) on umbrella plant (*Cyperus alternifolius* L.) cultivated as a pot plant in 25 cm pots under different irrigation levels expressed as percentage of water holding capacity (WHC) at 100, 75, 50 and 25%. The aim of this work was to reduce irrigation water quantity to a considerable level without obvious reduction in the plant quality and its aesthetic value. Reducing irrigation levels resulted in the lowering plant quality with increasing proline content (mg/g d.w.) in the plants. The effect of irrigating at 75% WHC was close to irrigating at 100% WHC without great quality reduction in most cases. Spraying with calcium carbonate ($CaCO_3$) at 200 ppm or active dry yeast extract (ADY) at 3% resulted in the highest values for the most studied traits. Combined treatment between irrigating at 75% of WHC and spraying with $CaCO_3$ at 200 ppm produced the highest values of plant height (cm), chlorophylls a, b, carotenoids contents (mg/g f.w.) and total carbohydrates percentage. Such treatment came in the second order after the superior combination comprised irrigating at 100% WHC without significant difference between them concerning stem number/plant, stem diameter (cm), offset number/plant, fresh and dry weights of vegetative growth and underground parts weight (g) and root length (cm). Our results indicate that irrigation water quantity could be reduced by 25% without reduction in quality and atheistic value in umbrella plants planted in 25 cm pots via irrigation at 75% WHC two times/week and spraying them with $CaCO_3$ at 200 ppm monthly.

Key words: Umbrella plant, *Cyperus alternifolius*, irrigation amounts, anti-transpirants, active dry yeast, $CaCO_3$, kaolin.

INTRODUCTION

Umbrella plant or umbrella palm (*Cyperus alternifolius* L.; Syn. *C. involucratus*) fam. Cyperaceae; native to Madagascar and widely cultivated and naturalized throughout Africa. Densely tufted perennial with woody rhizomes and no basal leaves. Reaches to 45-90 cm height and 40 cm wide. Numerous winged, dark green stems each produce a terminal whorl of 11-25 deep green, arching, leaf-like bracts, 10-15 cm long. From summer to autumn, the stems are topped by small spikelets of pale yellow-brown flowers in compound umbels, to 13 cm across. Umbrella plant is grown for its foliage and unusual inflorescences, to ensure ample moisture and high humidity at all times, containers must be stood in shallow trays of water **(Brickell, 1997)**. Umbrella plant used as aquatic ornamental plant either outdoor or it may be grown indoors in a warm and humid environment, but the plants usually do not attain normal size **(Oakes, 1990)**.

Water deficit is a great problem faces Egypt and other countries. According to data estimated by **WWDR (2018)**, agriculture practices consume about 70% of effective global water withdrawals; most of it is used for irrigation. About 25% of water is lost through transpiration **(Brown, 2002)**. Reducing water loss caused by transpiration may be an effective key to reduce water consumption.

Anti-transpirants are substances intended to reduce transpiration **(Pallardy, 2008)**. According to its mode of action, anti-transpirants could be divided in to three general types: (1) film-forming, (2) stomatal-regulating and (3) reflective compounds **(Brooks, 1970)**.

Active dry yeasts are agglomerates of dehydrated cells of *Saccharomyces cerevisiae* **(Dobbs *et al*., 1982)**. Dried form of yeast possesses a longer shelf life than compressed yeast and retains stability even when stored at room temperature **(Deàk, 2003)**, so this form is suitable for using as bio-stimulants. A lot of studies proved that active dry yeast extract has a positive role on different plants when used as bio-stimulants **(El-Sayed *et al.*, 2010** on *Spathiphyllum wallisii*; **Abd El-Kafie *et al.*, 2010** on tuberose; **Hanafy *et al.*, 2012** on *Schefflera arboricola*; **El-Sayed *et al.*, 2015** on *Peperomia obtusifolia*; **El-Mahrouk *et al.*, 2016** on *Adhatoda vasica*; **El-Naggar *et al.*, 2016** on *Anthurium andreanum*; **Nofal *et al.*, 2016** on *Calendula officinalis*; **Abdel-Kader *et al.*, 2016** on *Magnolia grandiflora* **and Abdou *et al.*, 2018** on *Gladiolus grandiflorus***)**. On the other hand, active dry yeast extract led to ameliorate growth characters of plants subjected to different stress conditions. In this regard **Hammad and Ali (2014)** stated that application of 6 g/l of yeast extract increased all measurement studied of rice and led to overcome the deleterious effect of drought. Such positive effect of yeast extract either at normal or stress conditions may be due to its contents of essential amino acids, vitamins, cytokinins, nutrient elements and organic compounds (protein, carbohydrates, … etc.) as reported by **Barnett *et al.* (1990)** and **Nagodawithana (1991)**.

Calcium carbonate ($CaCO_3$) has been suggested by scientists as anti-transpirant. A lot of studies approved positive effect of $CaCO_3$ on plants grown under water deficit conditions i.e. **Abdel-Fattah (2013)** on *Hibiscus rosa-sinensis* L., **El-Khawaga (2013)** on banana, **El-Said (2015)** on eggplant and **Patanè*et al.* (2018)** on tomato. Such positive effect may be obtained by the white layer formed on the leaves after spraying filters sunlight, sunburn damage due to excessive solar irradiation **(Scharder, 2011)**.

Kaolin is a white nonabrasive fine-grained aluminosilicate mineral [$Al_4\ Si_4O_{10}(OH)_8$] that has been purified and sized so that it easily disperses in water and acts as an anti-transpirant and reducing drought stress on plants **(Puterka *et al.*, 2000)**. Kaolin as a particle film has long been used to limit the impact of water and heat stress on crops **(Azizi *et al.*, 2013)**. **Abou-Khaled *et al.* (1970)** reported that a white leaf coating of kaolinite reduced leaf temperatures 3 to 4 °C, resulting in transpiration reductions of 22 to 28% for several species. Kaolin spray was found to decrease leaf temperature by increasing leaf reflectance and to reducing transpiration rate in many plant species grown at high solar radiation levels **(Nakano and Uehara, 1996)**.

The aim of this study was to investigate the effect of different anti-transpirants (active dry yeast, calcium carbonate and kaolin) at different concentrations on umbrella plant (*Cyperus alternifolius*, L.) cultivated as a pot plant under different irrigation levels. The main goal was to reduce irrigation water quantity to a considerable level without obvious reduction in the plant quality and aesthetic value.

MATERIALS AND METHODS

This investigation was carried out in the open field at the experimental nursery of Ornamental Plants and Landscape Gardening Res. Dept., Hort. Res. Inst., ARC., Giza, Egypt during 2015/2016 and 2016/2017 seasons to study the effect of different anti-transpirants (active dry yeast, calcium carbonate and kaolin) at different concentrations on umbrella plant (*Cyperus alternifolius*, L.) cultivated as a pot plant under different irrigation levels, and with the aim to reduce irrigation water quantity to a considerable level without obvious reduction in the plant quality and aesthetic value.

Plant material

Umbrella plant clumps were purchased from Orman Botanical Garden, Giza, Egypt on October, 20^{th} during both seasons. Immediately after arrived to the nursery the clumps were divided in to signal offsets with its rhizome. Homogenized offsets were selected and planted in 25 cm-diameter-pots (one offset/pot) filled with about 1.25 kg of a mixture of peat-moss and sand (1:1, v:v). Pots have been irrigated sufficiently (day by day) after cultivation to ensure good establishment. After five months (March, 15^{th}), the plants were ready to be subjected to the experimental treatments. The plant height was about 25 cm with 5 stems per plant. Chemical and physical properties of the used peat-moss are shown in Table 1.

Table 1. Some physical and chemical properties of the used peat moss in the two seasons

Organic matter	93%	**K**	1.77 %
Ash	6%	**Fe**	421 ppm
Density (vol. dry)	85 mg/l	**Mn**	27 ppm
pH value	3.5	**Mg**	346 ppm
Water relation capacity	68%	**Zn**	41 ppm
Salinity	0.3 g/l	**Cu**	8.8 ppm
N	1.09 %	**B**	3.5 ppm
P	0.23%	**Mo**	1.2 ppm

Irrigation levels

Four irrigation levels were applied in this study based on the water holding capacity (WHC) of the used medium (100%, 75%, 50% and 25% of WHC), water holding capacity was determined according to the method described by **Brown (2002).** Irrigation has been applied two times a week with a constant amount of water for each irrigation level. These amounts are shown in Table 2.

Table 2. Amount of water applied for each irrigation level (ml/pot/time)

WHC level	Irrigation water quantity applied (ml/pot/time)
100%	314.55
75%	235.91
50%	157.28
25%	78.64

Foliar spraying with anti-transpirants

Seven applications at one month interval were applied with each anti-transpirant each season during the course of this study; the first one was done on March, 15th. The following anti-transpirants were applied: (1) Active dry yeast extract at 1, 2 and 3%. It was purchased from local supermarket. (2) Calcium carbonate ($CaCO_3$) at 100, 200 and 300 ppm. It was purchased from a local company. (3) Kaolin “aluminum silicate” [Al_4 $Si_4O_{10}(OH)_8$] at 1, 2 and 3%, it was purchased from local Egyptian company (manufactured by LobaChemie, India). All these three anti-transpirants were dispensed in tape water to prepare the desired concentrations. The plants were sprayed with each concentration till run off. In this regard control plants were sprayed with tape water only.

Experimental layout

This experiment was designed as a completely randomized block design in a factorial experiment with two factors **(Gomez and Gomez, 1984)**. Four irrigation levels represented factor A. While anti-transpirants represented factor B with 10 treatments. Thus, total number of treatments was 40 (4×10) with three replicates per treatment and 5 plants/replicate.

Data recorded

1. Vegetative growth parameters

At the end of each season (last week of September) the following data were recorded; plant height (cm), number of stems/plant (mother plant with its offsets), stem diameter (cm), number of leaves/stem, leaf area (cm^2), vegetative growth diameter expressed as umbrella width (cm) and vegetative growth fresh and dry weights (g). Leaf area was calculated by using ImageJ software as described by **Ferreira and Rasband (2012).**

2. Underground parts growth parameters

Root length (cm), number of offsets/plant and underground parts fresh and dry weights (g) including roots and rhizomes were determined at the end of each season.

3. Chemical constituents

At the end of the second season only the following chemical tests were done: pigments content (mg/g f.w.) as chlorophylls a, b and carotenoids was determined in fresh leaf samples according to **Wellburn and Lichtenthaler (1984)**, total carbohydrates percentage was determined in dry leaf samples according to the method described by **Herbert *et al.* (1971)** and proline content (mg/gd.w.) was determined in dry leaf samples according to **Bates *et al.* (1973).**

Statistical analysis

The obtained data were statistically analyzed using MSTAT Computer Program **(MSTAT Development Team, 1989)**. To verify differences among means of various treatments, means were compared using Duncan's Multiple Range Test as described by **Duncan (1955).**

RESULTS

Vegetative growth parameters

1. Plant height (cm)

As shown in Table 3, irrigating cyperus plants at either 100% or 75% WHC significantly produced the tallest plants (47.46 and 49.33 cm, for the first level and 47.73 and 50.57 cm for the second one, in the first and second seasons respectively). Reducing irrigating level up to 25% of WHC produced the shortest plants in both seasons (36.45 and 38.22 cm, respectively).

Spraying with $CaCO_3$ at 200 ppm especially during second season significantly increased plant height (cm) which reached the highest values in both seasons as recorded 49.53 and 52.81 cm, respectively. Kaolin at 3% shared the previous treatment in the first season and occupied the second position (48.33 cm) without significant deference between both treatments.

Irrigating at 75% WHC and spraying with $CaCO_3$ at 200 ppm significantly produced the tallest plants as recorded 61.17 and 68.69 cm in the first and second seasons, respectively. On the other hand irrigating at 25% WHC produced the lowest values in most possible cases (Table 3).

Table 3. Effect of water irrigation level, anti-transpirant type and concentration and their interactions on plant height (cm) and stem parameters of *Cyperus alternifolius* L. plant during 2015/2016 and 2016/2017 seasons

Anti-transpirants \ Irrigation level	First season					Second season				
	WHC (%)				Mean	WHC (%)				Mean
	25	50	75	100		25	50	75	100	
	Plant height (cm)									
Control	32.83 op	33.83 op	38.83 k-n	42.83 g-k	**37.08 D**	30.18 s	36.61 p-r	43.03 j-n	49.82 d-h	**39.91 E**
ADY 1%	30.17 p	36.33 l-o	40.83 i-l	43.83 g-j	**37.79 B**	34.39 rs	34.93 rs	41.56 l-p	44.33 h-n	**38.80 E**
ADY 2%	38.83 k-n	45.83 e-h	51.83 bc	49.33 c-e	**46.46 B**	40.73m-q	46.46 g-l	58.75 b	51.38 d-g	**49.33 B**
ADY 3%	35.17 no	48.83 c-f	44.33 f-i	39.50 j-n	**41.96 C**	37.17 o-r	52.58 c-e	48.41 e-j	39.83 m-r	**44.49 CD**
$CaCO_3$100 ppm	35.67m-o	39.83 i-m	44.17 g-i	50.83 b-d	**42.63 C**	35.76 q-s	41.10 l-q	43.60 i-n	50.82 d-g	**42.82 D**
$CaCO_3$200 ppm	40.50 i-l	45.83 e-h	61.17 a	50.60 b-d	**49.53 A**	42.68 k-o	47.66 e-k	68.69 a	52.21 c-f	**52.81 A**
$CaCO_3$300 ppm	39.50 j-n	44.17 g-i	54.97 b	46.83 d-h	**46.37 B**	38.72 n-r	42.47 k-o	53.36 b-e	46.80 f-l	**45.34 CD**
Kaolin 1%	33.17 op	42.50 h-k	43.83 g-j	47.17 d-g	**41.67 C**	36.99 o-r	42.48 k-o	43.05 j-n	49.08 e-i	**42.90 D**
Kaolin 2%	39.17 k-n	43.33 g-k	44.17 g-i	48.83 c-f	**43.88 C**	42.44 k-o	44.49h-m	50.29 d-g	51.83 c-g	**47.26 BC**
Kaolin 3%	39.50 j-n	45.83 e-h	53.17 bc	54.83 b	**48.33A B**	43.10 j-n	43.85 i-n	54.94 b-d	57.22 bc	**49.78 B**
Mean	**36.45 C**	**42.63 B**	**47.73 A**	**47.46 A**		**38.22 C**	**43.26 B**	**50.57 A**	**49.33 A**	
	Number of stems/plant									
Control	12.00 u	14.00 s-u	18.67 l-p	25.00 e-h	**17.42 G**	12.69 t	15.42 p-s	18.39 mn	25.03 f-h	**17.88 EF**
ADY 1%	15.00 r-t	16.00 p-s	20.33 j-m	24.67 e-h	**19.00 EF**	13.29 r-t	16.48 n-q	21.67 j-l	24.08 g-j	**18.88 E**
ADY 2%	16.00 p-s	19.00 l-o	20.33 j-m	26.67 d-f	**20.50 CD**	14.37 q-t	20.07 lm	22.19 i-l	27.97 de	**21.15 D**
ADY 3%	17.17 n-r	19.67 k-n	20.67 i-m	27.33 c-e	**21.21 CD**	16.40 n-q	20.27 lm	27.01 d-f	30.87 bc	**23.64 C**
$CaCO_3$100 ppm	15.67 q-s	18.00m-q	24.00 f-h	29.00 cd	**21.67 C**	16.98 n-p	20.51k-m	22.08 i-l	29.27 cd	**22.21 D**
$CaCO_3$200 ppm	22.67 g-j	25.33 e-g	32.00 ab	27.00 de	**26.75 A**	25.57 e-g	24.98 f-h	35.07 a	32.50 b	**29.53 A**
$CaCO_3$300 ppm	19.33 l-o	24.00 f-h	30.00 bc	29.00 cd	**25.58 A**	19.91 lm	22.94 h-k	32.33 b	27.62 de	**25.70 B**
Kaolin 1%	12.70 tu	14.67 r-u	20.04 j-n	23.33 g-i	**17.68 FG**	13.22 st	13.52 r-t	20.73k-m	21.91 i-l	**17.35 F**
Kaolin 2%	16.67 o-s	19.67 k-n	34.33 a	22.33 h-k	**23.25 B**	18.23m-o	20.51k-m	35.95 a	24.22 g-i	**24.73 BC**
Kaolin 3%	15.00 r-t	26.33 d-f	21.00 i-l	18.00m-q	**20.08 DE**	15.76 o-r	28.33 cd	21.95 i-l	18.37 mn	**21.10 D**
Mean	**16.22 D**	**19.67 C**	**24.14 B**	**25.23 A**		**16.64 C**	**20.30 B**	**25.74 A**	**26.18 A**	
	Stem diameter (cm)									
Control	0.57 op	0.77 i-m	0.83 g-k	0.90 f-i	**0.77 DE**	0.59 s	0.74 n-s	0.92 h-m	1.04 d-h	**0.82 CD**
ADY 1%	0.67 l-o	0.77 i-m	0.80 h-l	0.97 e-g	**0.80 CD**	0.66 q-s	0.74 n-s	0.84 j-p	0.99 e-k	**0.81 CD**
ADY 2%	0.70 k-o	0.80 h-l	0.97 e-g	1.17 a-c	**0.91 B**	0.76 m-r	0.80 l-q	0.99 e-k	1.19 cd	**0.94 B**
ADY 3%	0.77 i-m	0.80 h-l	1.13 b-d	1.30 a	**1.00 A**	0.83 k-q	0.93 h-m	1.11 c-g	1.58 a	**1.11 A**
$CaCO_3$100 ppm	0.57 op	0.77 i-m	0.80 h-l	0.97 e-g	**0.78 E**	0.39 t	0.68 o-s	0.89 h-n	1.01 e-i	**0.74 D**
$CaCO_3$200 ppm	0.73 j-n	0.83 g-k	1.27 ab	1.20 a-c	**1.01 A**	0.99 e-k	1.16 c-e	1.36 b	1.12 c-g	**1.16 A**
$CaCO_3$300 ppm	0.61 n-p	0.80 h-l	1.17 a-c	0.90 f-i	**0.87 BC**	0.62 rs	0.85 i-o	1.13 c-f	0.92 h-m	**0.88 BC**
Kaolin 1%	0.60 n-p	0.73 j-n	0.87 f-j	0.97 e-g	**0.79 C-E**	0.57 s	0.70 o-s	0.94 h-l	1.02 d-h	**0.81 CD**
Kaolin 2%	0.97 e-g	0.97 e-g	1.27 ab	1.00 d-f	**1.05 A**	0.95 g-l	1.01 e-j	1.39 b	1.05 d-h	**1.10 A**
Kaolin 3%	0.63 m-p	1.10 c-e	0.93 f-h	0.83 g-k	**0.88 B**	0.67 p-s	1.28 bc	0.98 f-k	0.90 h-n	**0.96 B**
Mean	**0.68 C**	**0.83 B**	**1.00 A**	**1.02 A**		**0.70 C**	**0.89 B**	**1.06 A**	**1.08 A**	

Means having the same letter within a column or rows are not significantly differed at 0.05 level of probability according to Duncan's multiple range test.

2. Number of stems

Data presented in Table 3 indicate that irrigating cyperus plants at 100% WHC significantly resulted in the highest values in terms of stems number (25.23 and 26.18 cm, in the first and second seasons, respectively). This was followed by irrigating at 75% WHC in both seasons, without significant difference between them in the second season only (24.14 and 25.74 stems/plant in both seasons, respectively).

Spraying with $CaCO_3$ at either 200 or 300 ppm significantly increased stem number to the maximum values in the first season as recorded 26.75 and 25.58, respectively. In the second season, the mastery was to spraying with $CaCO_3$ at 200 ppm which resulted in the highest significant number 29.53.

Irrigating at 75% WHC and spraying plants with either kaolin at 2% or $CaCO_3$ at 200 ppm produced the highest significant values as recorded 34.33 and 32.00 cm in the first season and 35.95 and 35.07 in the second one, respectively. On the other hand, irrigating at 25% WHC produced the lowest values in most cases when combined with any applied anti-transpirants (Table 3).

3. Stem diameter (cm)

Table 3 shows that irrigating cyperus plants at either 100% or 75% WHC produced the thickest stems (1.02 and 1.08 cm, for the first level and 1.00 and 1.06 cm for the second one, in the first and second seasons, respectively). Reducing irrigating level up to 25% of WHC produced the lowest values in both seasons (0.68 and 0.70 cm, respectively).

It could be noticed that spraying with either kaolin at 2%, $CaCO_3$ at 200 ppm or active dry yeast extract at 3% resulted in the highest significant values of stem diameter without significant differences between them. In this regard, spraying with kaolin at 2% produced the highest value in the first season (1.05 cm) while $CaCO_3$ at 200 ppm produced the highest value in the second one (1.16 cm).

Irrigating at 100% WHC and spraying with active dry yeast extract at 3% resulted in the highest values of stem diameter as recorded 1.30 cm and 1.58 cm in the first and second seasons, respectively. Many other combined treatments shared the previous mentioned treatment without significant differences between them i.e. irrigating at 75% WHC in addition to spraying with either $CaCO_3$ at 200 ppm (1.27 cm) or kaolin at 2% (1.27 cm). On the other hand irrigating at 25% WHC produced the lowest values in most possible cases when combined with any of anti-transpirants (Table 3).

4. Number of leaves/stem

Data tabulated in Table 4 indicate that irrigating cyperus plants at either 100% or 75% WHC produced the highest significant number of leaves (17.90 and 19.03, for the first level and 17.84 and 18.84 for the second one, in the first and second seasons, respectively). Reducing irrigating level up to 25% of WHC produced the lowest values in both seasons (13.20 and 13.17, respectively).

It could be noticed that spraying with either kaolin at 2% or active dry yeast extract at 3% resulted in the highest significant values of number of leaves/stem without significant differences between them in the first season (18.08 and 17.53, respectively). While, in the second season the mastery was to the two previous mentioned treatments in addition to spraying with $COCa_3$ at 200 ppm (19.03, 18.77 and 18.77, respectively) without significant differences among these treatments.

Irrigating at 75% WHC in addition to spraying with either $CaCO_3$ at 200 ppm and kaolin at 2% resulted in the highest significant values in number of leaves/stem as recorded 20.33 and 20.33 in the first season and 22.73 and 22.03 in the second one, respectively. Many other combined treatments shared the previous mentioned treatment without significant differences among them i.e. irrigating at 100% WHC in addition to spraying with active dry yeast extract at 3% (20.00 and 21.95 in both seasons, respectively).On the other hand, irrigating at 25% WHC produced the lowest values in most cases when combined with any of anti-transpirants (Table 4).

5. Leaf area (cm^2)

With the reference to Table 4, irrigating cyperus plants at 100% WHC resulted in the highest significant leaf area values (19.89 and 20.51 cm^2, in the first and second seasons respectively). This was followed by irrigating at 75% WHC in both seasons (18.68 and 19.66 cm^2, respectively), with significant difference between them in both seasons. On the other hand, the lowest values, were obtained by irrigating at 25% WHC as recorded 11.41 and 11.88 cm^2 in both seasons, respectively.

Active dry yeast extract at 3% recorded the highest values of leaf area (21.81 and 22.59 cm^2 in both seasons, respectively). Spraying with $CaCO_3$ at 200 ppm occupied the second position in both seasons as recorded 19.76 and 21.55 cm^2, respectively.

Irrigating at 75% WHC in addition to spraying with active dry yeast extract at 3% produced the highest leaf area in both seasons (29.14 and 30.61 cm^2, respectively). In this regard irrigating at 100% WHC in addition to spraying with $CaCO_3$ at 200 ppm shared the previous mentioned treatment in the second season only as recorded 29.89 cm^2 without significant differences between them. On the other hand all combinations included irrigating at 25% WHC resulted in the lowest values (Table 4).

Table 4. Effect of water irrigation level, anti-transpirant type and concentration and their interactions on leaves parameter and umbrella width (cm) of *Cyperus alternifolius* L. plants during 2015/2016 and 2016/2017 seasons

Irrigation level / Anti-transpirants	First season					Second season				
	Number of leaves/stem									
	WHC (%)				**Mean**	**WHC (%)**				**Mean**
	25	**50**	**75**	**100**		**25**	**50**	**75**	**100**	
Control	10.99 q	14.67 no	16.00 j-n	17.33 f-j	**14.75 E**	10.75 t	13.76 q	15.64m-o	17.47 ij	**14.41 E**
ADY 1%	12.33 pq	14.67 no	16.00 j-n	17.33 f-j	**15.08 E**	11.75 s	13.83 q	15.74 mn	17.89 g-j	**14.81 E**
ADY 2%	13.67 op	15.44 l-n	17.67 e-i	19.67 a-c	**16.61 CD**	14.40 pq	15.35 no	18.30 f-h	19.44 de	**16.87 C**
ADY 3%	14.67 no	16.67 h-l	18.78 b-f	20.00 ab	**17.53 AB**	15.39 no	17.82 g-j	19.94 cd	21.95 a	**18.77 A**
$CaCO_3$100 ppm	11.00 q	15.67 k-n	16.33 i-m	17.67 e-i	**15.17 E**	10.82 t	15.51 no	17.64 h-j	19.50 de	**15.87 D**
$CaCO_3$200 ppm	15.00m-o	16.00 j-n	20.33 a	18.00 d-h	**17.33 BC**	14.52 pq	17.72 h-j	22.73 a	20.11 cd	**18.77 A**
$CaCO_3$300 ppm	12.67 p	16.00 j-n	19.33 a-d	17.00 g-k	**16.25 D**	12.77 r	16.60 kl	21.03 b	18.91 ef	**17.33 B**
Kaolin 1%	11.00 q	14.67 no	16.67 h-l	18.33 c-g	**15.17 E**	11.72 s	14.88 op	17.19 jk	18.62 fg	**15.60 D**
Kaolin 2%	17.00 g-k	17.00 g-k	20.33 a	18.00 d-h	**18.08 A**	15.84 l-n	18.27 f-i	22.03 a	19.96 cd	**19.03 A**
Kaolin 3%	13.67 op	19.00 a-e	17.00 g-k	15.67 k-n	**16.33 D**	13.70 q	20.67 bc	18.14 f-i	16.44k-m	**17.24 BC**
Mean	**13.20 C**	**15.98 B**	**17.84 A**	**17.90 A**		**13.17 C**	**16.44 B**	**18.84 A**	**19.03 A**	
	Leaf area (cm2)									
Control	7.89 r	12.16 n-p	13.11 l-o	14.11 k-n	**11.82 F**	9.35 st	13.32 n-q	13.68m-q	15.34 i-m	**12.92 F**
ADY 1%	8.55 r	12.30 n-p	15.98 g-k	16.24 g-j	**13.27 E**	9.85 st	12.61 p-r	15.55 i-m	17.59 f-h	**13.90 E**
ADY 2%	13.18 l-o	14.84 i-l	17.91 fg	24.82 c	**17.69 C**	12.98 o-r	16.29 h-k	19.37 ef	25.78 b	**18.60 C**
ADY 3%	15.25 h-k	19.79 d-f	29.14 a	23.04 c	**21.81 A**	14.72 j-o	20.39 de	30.61 a	24.64 bc	**22.59 A**
$CaCO_3$100 ppm	9.39 qr	14.32 j-m	16.79 g-i	19.61 d-f	**15.03 D**	9.14 t	15.00 j-n	17.11 g-i	19.85 de	**15.27 D**
$CaCO_3$200 ppm	14.40 j-m	16.98 gh	20.74 de	26.93 b	**19.76 B**	15.66 i-l	18.91 e-g	21.72 d	29.89 a	**21.55 B**
$CaCO_3$300 ppm	11.83 op	16.13 g-j	24.35 c	21.01 d	**18.33 C**	12.05 qr	17.22 g-i	25.43 bc	20.80 de	**18.88 C**
Kaolin 1%	8.45 r	8.63 qr	12.66m-o	18.99 ef	**12.18 F**	9.42 st	9.47 st	13.05 o-r	16.99 hi	**12.23 F**
Kaolin 2%	14.63 j-l	16.84 gh	19.98 de	19.78 d-f	**17.81 C**	14.37 k-p	17.66 f-h	23.69 c	19.86 de	**18.90 C**
Kaolin 3%	10.54 pq	19.04 ef	16.18 g-j	14.37 j-m	**15.03 D**	11.21 rs	21.54 d	16.38 h-j	14.37 l-p	**15.87 D**
Mean	**11.41 D**	**15.10 C**	**18.68 B**	**19.89 A**		**11.88 D**	**16.24 C**	**19.66 B**	**20.51 A**	
	Umbrella width (cm)									
Control	29.67 n-p	30.50m-p	33.00 i-n	35.67 g-k	**32.21 G**	27.06 r	33.17m-p	35.73 l-o	37.20 j-m	**33.29 G**
ADY 1%	29.83m-p	31.83 k-n	35.17 g-l	40.83 b-e	**34.42 EF**	29.66 p-r	33.50m-p	39.36 i-l	41.26 d-j	**35.95 EF**
ADY 2%	30.00m-p	32.67 i-n	40.50 b-f	44.33 ab	**36.88 CD**	31.94 o-q	35.85 l-o	40.43 e-k	48.44 a-c	**39.16 CD**
ADY 3%	32.50 j-n	38.17 d-g	41.50 b-d	47.67 a	**39.96 AB**	33.11m-p	39.43 h-l	44.40 c-f	50.86 a	**41.95 AB**
$CaCO_3$100 ppm	26.67 p	31.50 k-n	37.50 d-g	41.00 b-e	**34.17E-G**	26.90 r	33.99m-p	37.66 i-m	41.87 d-i	**35.11 FG**
$CaCO_3$200 ppm	36.33 f-j	40.17 b-f	48.17 a	42.83 bc	**41.88 A**	36.52 k-n	40.07 f-l	51.18 a	43.98 c-h	**42.94 A**
$CaCO_3$300 ppm	31.00 l-o	37.33 d-h	43.00 bc	39.93 c-f	**37.82 CD**	32.17 n-p	37.50 i-m	45.65 b-d	39.86 f-l	**38.80 CD**
Kaolin 1%	26.83 op	30.83m-p	33.17 h-n	40.50 b-f	**32.83 FG**	27.38 qr	30.82 p-r	36.28 k-o	44.03 c-g	**34.63 FG**
Kaolin 2%	31.33 l-n	38.13 d-g	44.33 ab	40.17 b-f	**38.49 BC**	31.11 p-r	36.76 j-m	49.04 ab	41.98 d-i	**39.72 BC**
Kaolin 3%	30.17m-p	42.67 bc	36.83 e-i	34.00g-m	**35.92 DE**	29.44 p-r	44.72 b-e	39.48 g-l	36.06 k-o	**37.42 DE**
Mean	**30.43 D**	**35.38 C**	**39.32 B**	**40.69 A**		**30.53 C**	**36.58 B**	**41.92 A**	**42.55 A**	

Means having the same letter within a column or rows are not significantly differed at 0.05 level of probability according to Duncan's multiple range test.

6. Umbrella width (cm)

For atheistic values umbrella width was measured. Irrigating plants at 100% WHC recorded the highest values for umbrella width in both seasons (40.96 and 42.55 cm, in the first and second seasons, respectively). This influence was significant when compared with other irrigating levels in the first season, while in the second one there was no significant difference between irrigating at 100% WHC and 75% WHC which recorded 41.92 cm (Table 4).

Both $CaCO_3$ at 200 ppm and active dry yeast extract at 3% gave the highest significant values of umbrella width (41.88 and 42.94 for $CaCO_3$ and 39.96 and 41.95 cm for active dry yeast in both seasons, respectively).

Irrigating at 75% WHC in addition to spraying with $CaCO_3$ at 200 ppm recorded the widest umbrella in both seasons as recorded 48.17 and 51.18 cm, respectively. Such treatment did not significantly differ than some other combined treatments i.e.; kaolin at 2% + WHC at 75%, active dry yeast at 2% + WHC at 100% and active dry yeast at 3% + WHC at 100% as illustrated in Table 4.

7. Vegetative growth fresh weight (g)

As it shown in Table 5, there was a great superiority to irrigating cyperus plants at 100% WHC as it resulted in the highest significant vegetative growth fresh weight in both seasons (64.76 and 68.83 g in both seasons, respectively). This was followed by irrigating at 75% WHC in both seasons (62.89 and 67.28 g, respectively), with significant difference between them in both seasons. On the other hand, the lowest values were obtained by irrigating at 25% WHC as recorded 45.28 and 46.25 g in both seasons, respectively.

It could be noticed that spraying with active dry yeast extract at 3% significantly increased vegetative growth fresh weight to the highest values in both seasons (66.60 and 70.74 g, respectively). While, spraying with $CaCO_3$ at 200 ppm occupied the second position (63.99 and 68.23 g, respectively).

Both combined treatments between irrigating at 100% WHC in addition to spraying with active dry yeast extract at 3% and irrigating at 75% WHC in addition to spraying with $CaCO_3$ at 200 ppm produced the heaviest vegetative growth fresh weights in both seasons without significant differences between them (80.88 and 89.91 g in case of the first treatment and 78.25 and 86.83 in case of the second one, in both seasons, respectively). On the other hand, all combined treatments comprising irrigating at 25% WHC produced the lowest values (Table 5).

8. Vegetative growth dry weight (g)

Irrigating cyperus plants at 100% WHC resulted in the highest significant vegetative growth dry weight in both seasons (15.77 and 16.82 g in both seasons, respectively). This was followed by irrigating at 75% WHC in both seasons (15.09 and 16.10 g, respectively), with significant difference between them in both seasons. On the other hand, the lowest values were obtained by irrigating at 25% WHC as recorded 9.87 and 9.32 g in both seasons, respectively (Table 5).

It could be noticed that spraying with active dry yeast extract at 3% significantly increased vegetative growth dry weight to the highest values in both seasons (15.68 and 16.79 g, respectively). This was followed by spraying with $CaCO_3$ at 200 ppm without significant difference in the first season (15.13 g) and with significant difference in the second one (15.64 g).

Both combined treatments between irrigating at 100% WHC in addition to spraying with active dry yeast extract at 3% and irrigating at 75% WHC in addition to spraying with $CaCO_3$ at 200 ppm produced the heaviest vegetative growth dry weights in both seasons. The differences between both combined treatments were insignificant in the first season (21.13 and 20.42 g, respectively), while, in the second one there were a significant difference between them (23.96 and 21.19 g, for the first and second combined treatments, respectively). On the other hand, all combined treatments comprising irrigating at 25% WHC produced the lowest values (Table 5).

Underground part growth parameters

1. Root length (cm)

Data in Table 6 indicate that, irrigating cyperus plants at 100% WHC resulted in the longest roots (85.72 and 90.68 cm, in the first and second seasons, respectively). This was followed by irrigating at 75% WHC in both seasons (81.26 and 86.08 cm, respectively), with significant difference between them in both seasons. On the other hand, the lowest values were obtained by irrigating at 25% WHC as recorded 57.20 and 58.06 cm in both seasons, respectively.

It could be noticed that spraying with either kaolin at 2% or $CaCO_3$ at 200 ppm significantly increased root length to the highest values in the first season (91.83 and 89.44 cm, respectively). While, in the second season the mastery was to spraying with $CaCO_3$ at 200 ppm (96.96 cm).

Table 5. Effect of water irrigation level, anti-transpirant type and concentration and their interactions on vegetative growth fresh and dry weights (g) of *Cyperus alternifolius* L. plants during 2015/2016 and 2016/2017 seasons

Irrigation level / Anti-transpirants	First season					Second season				
	Vegetative growth fresh weight (g)									
	WHC (%)				Mean	WHC (%)				Mean
	25	50	75	100		25	50	75	100	
Control	36.23 wx	53.55m-p	56.66 j-m	65.46 d-f	**52.98 F**	38.11 o	50.81 lm	59.79 h-j	64.59 fg	**53.32 E**
ADY 1%	46.80 s-u	53.55m-p	60.16 g-k	69.49 b-d	**57.50 E**	44.77 n	53.53 kl	60.91 g-i	73.72 cd	**58.23 D**
ADY 2%	50.60 o-t	55.72 k-n	64.47 e-g	72.87 b	**60.91 C**	50.95 lm	56.38 jk	65.05 fg	79.92 b	**63.08 C**
ADY 3%	55.03 l-o	60.93 g-j	69.58 b-d	80.88 a	**66.60 A**	57.42 i-k	63.37 f-h	72.26 d	89.91 a	**70.74 A**
$CaCO_3$100 ppm	37.25 wx	48.03 r-u	59.30 h-l	63.60 e-h	**52.05 FG**	38.41 o	48.61 mn	61.23 g-i	67.04 ef	**53.82 E**
$CaCO_3$200 ppm	53.00m-q	57.21 i-m	78.25 a	67.51 c-e	**63.99 B**	53.70 kl	61.23 g-i	86.83 a	71.15 de	**68.23 B**
$CaCO_3$300 ppm	44.13 uv	55.68 k-n	70.52 bc	62.65 f-h	**58.24 DE**	44.62 n	55.81 jk	80.03 b	63.70 f-h	**61.04 C**
Kaolin 1%	37.37 wx	46.22 tu	49.06 p-t	53.74m-o	**46.60 H**	38.87 o	50.20 lm	54.08 kl	59.85 h-j	**50.75 F**
Kaolin 2%	52.03 n-r	57.50 i-m	69.64 b-d	62.56 f-h	**60.43 CD**	50.66 lm	58.42 ij	76.50 bc	64.93 fg	**62.63 C**
Kaolin 3%	40.34 vw	61.71 f-i	51.22 n-s	48.86 q-t	**50.53 G**	45.01 n	66.37 f	56.16 jk	53.53 kl	**55.27 E**
Mean	**45.28 D**	**55.01 C**	**62.89 B**	**64.76 A**		**46.25 D**	**56.47 C**	**67.28 B**	**68.83 A**	
	Vegetative growth dry weight (g)									
Control	8.44 pq	10.33 no	12.89 h-j	15.48 de	**11.78FG**	7.61 tu	10.93 n-s	12.98 j-m	16.66 f-h	**12.05 EF**
ADY 1%	7.72 qr	10.89 l-o	14.13 f-h	16.46 cd	**12.30EF**	7.62 tu	11.21 n-r	15.21 hi	18.47 c-e	**13.13 DE**
ADY 2%	10.20 no	13.08 hi	14.69 e-g	18.81 b	**14.19C**	9.92 q-s	12.59 j-n	16.43 gh	19.95 b-d	**14.72 C**
ADY 3%	12.17 i-l	13.59 gh	15.83 de	21.13 a	**15.68A**	11.77m-p	14.30 ij	17.13 e-g	23.96 a	**16.79 A**
$CaCO_3$100 ppm	8.80 p	10.82m-o	12.13 i-l	15.93 c-e	**11.92G**	6.87 u	10.43 o-s	13.69 i-l	16.71 f-h	**11.93 F**
$CaCO_3$200 ppm	11.17 k-n	13.23 hi	20.42 a	15.69 de	**15.13AB**	11.13 n-r	13.79 i-l	21.19 b	16.43 gh	**15.64 B**
$CaCO_3$300 ppm	9.61 op	12.26 i-k	17.16 c	14.17 f-h	**13.30D**	9.84 rs	12.35 k-n	18.39 d-f	15.10 hi	**13.92 CD**
Kaolin 1%	8.86 p	9.99 no	11.77 j-m	13.29 hi	**10.98H**	7.32 u	10.20 p-s	12.04 l-o	13.24 j-m	**10.70 G**
Kaolin 2%	12.02 i-m	13.85 f-h	18.78 b	15.01 ef	**14.91B**	11.92m-p	14.27 ij	20.14 bc	16.09 gh	**15.60 B**
Kaolin 3%	9.66 op	15.59 de	13.12 hi	11.75 j-m	**12.53E**	9.22 st	16.78 e-h	13.83 i-k	11.60m-q	**12.86 E**
Mean	**9.87 D**	**12.36 C**	**15.09 B**	**15.77 A**		**9.32 C**	**12.69 C**	**16.10 B**	**16.82 A**	

Means having the same letter within a column or rows are not significantly differed at 0.05 level of probability according to Duncan's multiple range test.

Irrigating at 100% WHC in addition to spraying with active dry yeast extract at 3% produced the longest root length in both seasons (112.00 and 118.20 cm, respectively). Irrigating at 75% of WHC in addition to spraying with $CaCO_3$ at 200 ppm significantly came in the second position in the first season (105.20 cm), while in the second season there was no significant difference between this combined treatment (as recorded 111.60 cm) and the above-mentioned treatment. On the other hand, all combined treatments comprising irrigating at 25% WHC produced the lowest values (Table 6).

2. Number of offsets/plant

Irrigating cyperus plants at 100% WHC resulted in the highest significant values in terms of number of offsets/plant (2.33 and 2.50, in the first and second seasons respectively). This was followed by irrigating at 75% WHC in both seasons (1.93 and 2.17, respectively), with significant difference between them in both seasons. On the other hand, the lowest values were obtained by irrigating at 25% WHC as recorded 1.10 and 1.07 in both seasons, respectively (Table 6).

Active dry yeast extract at 3% was the most effective treatment in this regard as resulted the highest values of number of offsets/plant (2.67 for each season). Spraying with $CaCO_3$ at 200 ppm occupied the second position in both seasons as recorded 2.00 and 2.19, respectively.

Irrigating at 100% WHC in addition to spraying with active dry yeast extract at 3% produced the highest number of offsets/plant in both seasons (4.00 and 4.1, respectively). In this regard, irrigating at 75% WHC in addition to spraying with $CaCO_3$ at 200 ppm occupied the second position in both seasons as recorded 3.33 and 3.92, respectively. On the other hand all combinations included irrigating at 25% WHC resulted in the lowest values (Table 6).

Table 6. Effect of water irrigation level, anti-transpirants type and concentration and their interactions on root length (cm), number of offsets/plant of *Cyperus alternifolius* L. plants during 2015/2016 and 2016/2017 seasons

Anti-transpirants \ Irrigation	First season					Second season				
	Root length (cm)									
	WHC (%) 25	50	75	100	Mean	WHC (%) 25	50	75	100	Mean
Control	42.09 v	50.38 tu	62.50 o-r	68.67 l-o	**55.91 F**	40.86 w	58.32 r-t	72.04 no	81.36 j-m	**63.14 G**
ADY 1%	42.17 v	55.19 st	67.88m-p	79.50 g-j	**61.18 E**	43.52 x	57.18 s-u	70.17 n-p	85.98 g-k	**64.21 G**
ADY 2%	45.83 uv	59.67 q-s	77.00 h-k	87.83 d-f	**67.58 D**	44.51 vw	66.43 o-q	82.96 h-l	93.84 d-f	**71.93 E**
ADY 3%	56.25 r-t	68.17m-o	80.00 g-i	112.00 a	**79.10 BC**	55.63 tu	74.78 mn	88.69 e-i	118.20 a	**84.32 C**
$CaCO_3$100 ppm	48.58 uv	60.75 q-s	73.08 j-m	85.83 e-g	**67.06 D**	50.65 uv	64.85 p-r	67.25 o-q	95.18 c-e	**69.48 EF**
$CaCO_3$200 ppm	72.83k-m	85.83 e-g	105.20 b	93.92 cd	**89.44 A**	85.53 h-k	92.81 d-g	111.60 ab	97.83 cd	**96.96 A**
$CaCO_3$300 ppm	61.50 p-s	75.86 h-k	98.67 bc	89.67 de	**81.42 B**	62.80 q-s	79.66k-m	102.00 c	88.14 f-j	**83.14 C**
Kaolin 1%	55.50 st	59.67 q-s	69.11 l-n	74.83 i-l	**64.78 D**	56.92 s-u	66.30 o-q	70.12 n-p	80.26k-m	**68.40 F**
Kaolin 2%	82.33 f-h	89.67 de	102.00 b	93.33 cd	**91.83 A**	82.07 i-l	84.72 h-k	110.40 b	89.17 e-h	**91.60 B**
Kaolin 3%	64.92 n-q	91.33 de	77.17 h-k	71.58k-m	**76.25 C**	63.53 p-s	92.66 d-g	85.49 h-k	76.82 l-n	**79.63 D**
Mean	**57.20 D**	**69.65 C**	**81.26 B**	**85.72 A**		**58.60 D**	**73.77 C**	**86.08 B**	**90.68 A**	
	Number of offsets/plant									
Control	1.00 h	1.00 h	1.67 fg	2.33 de	**1.50 D-F**	1.00 o	1.10 m-o	1.85 h-l	2.61 de	**1.64 DE**
ADY 1%	1.00 h	1.00 h	1.33 gh	2.33 de	**1.42 EF**	1.00 o	1.09 no	1.72 i-l	2.65 d	**1.62 DE**
ADY 2%	1.00 h	1.33 gh	2.00 ef	3.00 bc	**1.83 BC**	1.02 o	1.38 l-o	2.17 d-j	3.40 bc	**1.99 BC**
ADY 3%	2.00 ef	2.33 de	2.33 de	4.00 a	**2.67 A**	1.65 j-m	2.11 d-k	2.52 d-f	4.41 a	**2.67 A**
$CaCO_3$100 ppm	1.00 h	1.00 h	1.00 h	2.67 cd	**1.42 EF**	1.00 o	1.05 no	1.15 m-o	2.64 d	**1.46 EF**
$CaCO_3$200 ppm	1.00 h	1.67 fg	3.33 b	2.00 ef	**2.00 B**	1.01 o	1.60 k-n	3.92 ab	2.23 d-i	**2.19 B**
$CaCO_3$300 ppm	1.00 h	1.00 h	3.00 bc	2.00 ef	**1.75 B-D**	1.00 o	1.11 m-o	3.28 c	1.93 g-l	**1.83 CD**
Kaolin 1%	1.00 h	1.00 h	1.00 h	2.00 ef	**1.25 F**	1.00 o	1.00 o	1.16 m-o	2.06 e-k	**1.31 F**
Kaolin 2%	1.00 h	1.00 h	2.33 de	2.00 ef	**1.58 C-E**	1.02 o	1.16 m-o	2.47 d-g	2.03 f-k	**1.67 DE**
Kaolin 3%	1.00 h	2.00 ef	1.33 gh	1.00 h	**1.33 EF**	1.00 o	2.29 d-h	1.43 l-o	1.06 no	**1.45 EF**
Mean	**1.10 D**	**1.33 C**	**1.93 B**	**2.33 A**		**1.07 D**	**1.39 C**	**2.17 B**	**2.50 A**	

Means having the same letter within a column or rows are not significantly differed at 0.05 level of probability according to Duncan's multiple range test.

3. Roots fresh weight (g)

Irrigating cyperus plants at either 75% or 100% WHC resulted in the highest significant roots fresh weight (84.43 and 87.54 g for the first treatment and 83.65 and 87.46 g for the second one in the first and second seasons, respectively). On the other hand, the lowest values were obtained by irrigating at 25% WHC as recorded 39.97 and 40.91 in both seasons, respectively (Table 7).

It could be noticed that spraying with active dry yeast extract at 3% produced the highest significant values of roots fresh weight in both seasons as recorded 97.27 and 103.70 g respectively. In this regard, spraying with $CaCO_3$ at 200 ppm occupied the second position as recorded 81.94 and 84.08 g in both seasons, respectively.

Irrigating at 100% WHC in addition to spraying with active dry yeast extract at 3% significantly produced the highest roots fresh weight in both seasons (135.30 and 144.10 g, respectively). Irrigating at 75% of WHC in addition to spraying with $CaCO_3$ at 200 ppm came in the second position in both seasons (123.00 and 129.60 g, in the first and second seasons, respectively). On the other hand, all combined treatments comprising irrigating at 25% WHC produced the lowest values (Table 7).

4. Roots dry weight (g)

Irrigating cyperus plants at either 75% or 100% WHC resulted in the highest significant roots dry weight in both seasons (35.94 and 38.20 g for 75% WHC and 35.16 and 37.59 g for 100% WHC in the first and second seasons, respectively). On the other hand, the lowest values were obtained by irrigating at 25% WHC as recorded 14.69 and 15.30 g in both seasons, respectively (Table 7).

Spraying with active dry yeast extract at 3% or kaolin at 2% significantly increased roots dry weight to the highest values in both seasons (37.59 and 39.85 g for active dry yeast extract at 3% and 35.92 and 38.37 g for kaolin at 2% in the first and second seasons, respectively) without significant differences between them. This was followed by spraying with $CaCO_3$ at 200 ppm (31.48 and 33.48 g in both seasons, respectively).

Both combined treatments between irrigating at 100% WHC in addition to spraying with active dry yeast extract at 3% and irrigating at 75% WHC in addition to spraying with $CaCO_3$ at 200 ppm produced the heaviest roots dry weight in both seasons (59.69 and 63.40 g for the first combined treatment and 56.12 and 61.08 g for the second combined treatment in the first and second seasons, respectively) without significant differences between them. On the other hand, all combined treatments comprising irrigating at 25% WHC produced the lowest values (Table 7).

Table 7. Effect of water irrigation level, anti-transpirants type and concentration and their interactions on underground parts fresh and dry weights (g) of *Cyperus alternifolius*, L. plants during 2015/2016 and 2016/2017 seasons

Irrigation level / Anti-transpirants	First season					Second season				
	Underground parts fresh weight (g)									
	WHC (%)				Mean	WHC (%)				Mean
	25	50	75	100		25	50	75	100	
Control	28.30 s	51.77k-m	54.31k-m	66.06 i	**50.11 EF**	29.11 u	54.72 n-q	57.51 l-p	68.33 i-m	**52.42 EF**
ADY 1%	33.67 q-s	45.83 l-p	74.31 hi	91.93 ef	**61.43 D**	35.45 s-u	48.66 o-r	70.87 i-k	95.71 ef	**62.67 CD**
ADY 2%	40.82 o-q	65.00 ij	94.74 de	111.50 c	**78.01 B**	42.67 q-t	69.27 i-m	97.95 d-f	110.80 cd	**80.17 B**
ADY 3%	56.29 jk	92.30 ef	105.20 c	135.30 a	**97.27 A**	60.34 k-o	101.20c-e	109.20 cd	144.10 a	**103.70 A**
$CaCO_3$100 ppm	29.00 s	45.04m-p	52.42k-m	65.50 ij	**47.99 F**	29.50 u	46.74 p-s	56.78m-p	69.99 i-l	**50.75 F**
$CaCO_3$200 ppm	52.93k-m	67.63 i	123.00 b	84.15 fg	**81.94 B**	52.08 n-r	69.46 i-m	129.60 b	85.13 f-h	**84.08 B**
$CaCO_3$300 ppm	40.39 p-r	56.38 jk	102.30 cd	67.51 i	**66.65 C**	41.70 r-u	53.63 n-r	102.10c-e	73.95 h-j	**67.83 C**
Kaolin 1%	30.92 rs	41.45 n-q	54.85 kl	85.71 e-g	**53.23 E**	30.65 tu	45.91 p-s	63.90 j-n	89.42 e-g	**57.47 DE**
Kaolin 2%	50.96 k-n	72.36 hi	109.70 c	78.88 gh	**77.98 B**	53.00 n-r	76.84 g-i	111.40 c	85.85 f-h	**81.77 B**
Kaolin 3%	36.38 p-s	95.21 de	73.41 hi	49.91 k-o	**63.73 CD**	34.64 s-u	94.89 ef	76.20 h-j	51.31 n-r	**64.26 C**
Mean	**39.97 C**	**63.30 B**	**84.43 A**	**83.65 A**		**40.91 C**	**66.13 B**	**87.54 A**	**87.46 A**	
	Underground parts dry weight (g)									
Control	8.84 z	18.26 r-w	22.65 n-r	32.58 g-i	**20.58 E**	8.57 t	20.18 l-p	23.77 j-l	35.47 fg	**22.00 EF**
ADY 1%	13.69w-z	19.65 p-u	30.84 h-j	33.82 gh	**24.50 D**	12.36 r-t	21.21 k-o	31.18 f-i	36.65 ef	**25.35 D**
ADY 2%	17.62 s-x	23.69 l-p	36.26 e-g	45.80 c	**30.84 B**	18.08m-q	24.71 j-l	36.56 ef	49.53 c	**32.22 BC**
ADY 3%	21.22 o-t	28.45 i-l	41.02 c-e	59.69 a	**37.59 A**	22.12 k-n	28.11 h-j	44.67 cd	63.40 a	**39.58 A**
$CaCO_3$100 ppm	9.20 z	15.60 u-x	23.18m-q	27.60 j-m	**18.89 E**	9.16 t	15.76 o-s	24.34 j-l	30.73 g-i	**20.00 F**
$CaCO_3$200 ppm	16.29 u-x	22.95 m-r	56.12 ab	30.58 h-k	**31.48 B**	16.86 n-r	22.81 j-m	61.08 ab	33.16 f-h	**33.48 B**
$CaCO_3$300 ppm	13.29 x-z	20.01 p-u	39.22 ef	27.07 j-n	**24.90 CD**	14.23 q-t	20.25 l-p	41.55 de	28.32 h-j	**26.09 D**
Kaolin 1%	10.74 yz	16.49 t-x	25.80 k-o	40.53 de	**23.39 D**	10.99 st	16.47 o-s	26.49 i-k	42.64 d	**24.15 DE**
Kaolin 2%	21.86 o-s	30.80 h-j	53.27 b	35.22 f-h	**35.29 A**	25.65 i-l	34.49 fg	57.74 b	35.61 fg	**38.37 A**
Kaolin 3%	14.14 v-y	45.00 cd	31.00 h-j	18.69 q-v	**27.20 C**	14.96 p-s	49.53 c	34.58 fg	20.34 l-p	**29.85 C**
Mean	**14.69 C**	**24.09 B**	**35.94 A**	**35.16 A**		**15.30 C**	**25.35 B**	**38.20 A**	**37.59 A**	

Means having the same letter within a column or rows are not significantly differed at 0.05 level of probability according to Duncan's multiple range test.

Chemical constituents

1. Pigments content in the leaves (mg/g f.w.)

Data in Table 8 indicate that, irrigating cyperus plants at 75% led to increase chlorophyll a, b and carotenoids in the leaves to the highest values (0.626, 0.325 and 0.085 mg/g f.w., respectively). This increment was significant in case of chlorophyll b only. While, in case of chlorophyll a, irrigating at 100% WHC shared the previous mentioned treatment the same order and gave 0.622 mg/g f.w. without significant differences. In this regard, irrigating at 50% WHC give the same value of carotenoids that obtained by irrigating at 75% WHC (0.085 mg/g f.w.).

It could be observed that spraying cyperus plants with $CaCO_3$ at 200 ppm produced the highest significant values regarding chlorophyll a, b and carotenoids as recorded 0.879, 0.491 and 0.112 mg/g f.w., respectively.

Irrigating cyperus plants at 75% WHC in addition to spraying with $CaCO_3$ at 200 ppm resulted in the highest pigments content as recorded 0.897, 0.542 and 0.119 mg/g f.w. for chlorophyll a, b and carotenoids, respectively. This increment was significant in case of chlorophyll b only. While, in case of chlorophyll a and carotenoids many other combined treatments shared this treatment the same order i.e.; irrigating at 100% WHC in addition spraying with $CaCO_3$ at 200 ppm in case of chlorophyll a (0.885 mg/g f.w.) and irrigating at 50% WHC in addition to spraying with $CaCO_3$ at 200 ppm in case of carotenoids (0.115 mg/g f.w.). These results are shown in Table 8.

2. Total carbohydrates percentage

Irrigating cyperus plants at either 75% or 100% WHC resulted in the highest significant value of total carbohydrates percentage as recorded 25.150 and 25.080%, respectively. On the other hand, the lowest values were obtained by irrigating at 25% WHC as recorded 23.470% (Table 9).

Spraying with $CaCO_3$ at 200 ppm was superior in increasing total carbohydrates percentage as recorded 34.350%. While, control treatment (without spraying) produced the lowest significant percentage (12.190%).

The highest significant total carbohydrates percentage (37.060%) was obtained by irrigating at 75% WHC in addition to spraying with $CaCO_3$ at 200 ppm. On the other hand, the lowest total carbohydrates were obtained with control treatment (Table 9).

3. Proline content (mg/g d.w.)

It is clear that the highest significant proline content was obtained as a result to irrigate the plants with the lowest irrigation level (25% of WHC) when compared with other levels as recorded (0.517 g/g d.w.). The ore the irrigation level was increased, the less proline content was obtained (Table 9).

The highest significant proline content (0.506 mg/g d.w.) was obtained when plants did not concomitant with spray with any anti-transpirants or sprayed with active dry yeast extract at 1% (0.505 mg/ g d.w.). While, spraying with $CaCO_3$ at 200 ppm reduced proline content to the lowest value (0.376 mg/g d.w.).

Irrigating at the lowest level (25% of WHC) without any anti-transpirants led to produce the highest significant proline content (0.605 mg/g d.w.). On the other hand, the combined treatments between irrigating at either 75 or 100% WHC in addition to spraying with $CaCO_3$ at 200 ppm resulted in the lowest proline contents (0.334 and 0.320 mg/g d.w., respectively) (Table 9).

DISCUSSION

The above-mentioned results regarding the negative effects of water deficit were in harmony with those obtained by **Khalil *et al.* (2012)** who reported that reducing irrigation water level led to reduce plant height and fresh and dry weights, this was accompanied with increasing proline content of *Jatropha curcas* L. Also, **Noor El-Deen *et al.* (2018)** concluded that gradually reducing irrigation water level of *Zinnia elegans* plants led to gradually reduce all studied trait values except for proline content which was increased. On the contrary, increasing level of water significantly increased growth and productivity of *Ziziphus mauritiana* **(Mukherjee *et al.*, 2004).** Also, **Gomaa *et al.* (2005)** emphasized these results on cucumber.

This study emphasized that reducing water led to reduce plant growth and quality. Reducing photosynthesis by closing stomata, decreasing the efficiency of carbon fixation process, suppressing leaf formation and expansion are the common negative effects of water deficit **(Pallardy, 2008).** It is well known that water accounts for between 80–95% of the fresh biomass of non-woody plants and plays an important role in many aspects of plant

Table 8. Effect of water irrigation level, anti-transpirant type and concentration and their interactions on pigments content (mg/g f.w.) of *Cyperus alternifolius* L. plant during 2017 season

Anti-transpirants \ Irrigation level	WHC (%) 25	50	75	100	Mean
	Chlorophylls a (mg/g f.w.)				
Control	0.235 t	0.237 t	0.237 t	0.238 t	**0.237 J**
ADY 1%	0.589 m	0.594 m	0.653 l	0.670 l	**0.626 F**
ADY 2%	0.700 k	0.705 k	0.712 jk	0.718 jk	**0.709 E**
ADY 3%	0.780 g-i	0.800 f-h	0.801 f-h	0.808 e-g	**0.797 C**
$CaCO_3$100 ppm	0.736 j	0.770 i	0.771 i	0.779 hi	**0.764 D**
$CaCO_3$200 ppm	0.854 bc	0.878 ab	0.897 a	0.885 a	**0.879 A**
$CaCO_3$300 ppm	0.812 d-f	0.830 c-e	0.839 cd	0.838 cd	**0.830 B**
Kaolin 1%	0.349 qr	0.364 q	0.424 p	0.426 p	**0.391 H**
Kaolin 2%	0.485 o	0.486 o	0.581 m	0.530 n	**0.520 G**
Kaolin 3%	0.311 s	0.323 rs	0.339 qr	0.324 rs	**0.324 I**
Mean	**0.585 C**	**0.599 B**	**0.626 A**	**0.622 A**	
	Chlorophylls b (mg/g f.w.)				
Control	0.107 r	0.120 r	0.123 qr	0.139 o-q	**0.122 H**
ADY 1%	0.164 mn	0.284 i	0.376 ef	0.322 h	**0.287 E**
ADY 2%	0.291 i	0.294 i	0.409 d	0.414 d	**0.352 C**
ADY 3%	0.343 g	0.376 ef	0.384 e	0.251 j	**0.339 D**
$CaCO_3$100 ppm	0.317 h	0.382 e	0.360 f	0.339 g	**0.350 C**
$CaCO_3$200 ppm	0.441 c	0.486 b	0.542 a	0.494 b	**0.491 A**
$CaCO_3$300 ppm	0.438 c	0.442 c	0.420 d	0.415 d	**0.429 B**
Kaolin 1%	0.155 m-o	0.168 m	0.192 l	0.149 n-p	**0.166 G**
Kaolin 2%	0.209 k	0.220 k	0.287 i	0.299 i	**0.254 F**
Kaolin 3%	0.137 pq	0.150 n-p	0.159 mn	0.217 k	**0.012 I**
Mean	**0.260 D**	**0.292 C**	**0.325 A**	**0.304 B**	
	Carotenoids (mg/g f.w.)				
Control	0.079 n-q	0.077 o-s	0.076 p-s	0.072 s	**0.076 E**
ADY 1%	0.083 k-n	0.089 ij	0.106 de	0.108 cd	**0.097 B**
ADY 2%	0.087 i-l	0.091 hi	0.104 de	0.107 de	**0.097 B**
ADY 3%	0.095 gh	0.079 n-q	0.098 fg	0.096 gh	**0.092 C**
$CaCO_3$100 ppm	0.063 t	0.081 m-p	0.103 d-f	0.080 m-p	**0.082 D**
$CaCO_3$200 ppm	0.102 ef	0.115 ab	0.119 a	0.113 bc	**0.112 A**
$CaCO_3$300 ppm	0.057 u	0.085 j-m	0.049 v	0.077 o-s	**0.067 F**
Kaolin 1%	0.083 k-n	0.074 q-s	0.051 v	0.038 w	**0.062 G**
Kaolin 2%	0.107 de	0.088 i-k	0.062 tu	0.051 v	**0.077 E**
Kaolin 3%	0.078 n-r	0.073 rs	0.082 l-o	0.043 w	**0.069 F**
Mean	**0.083 B**	**0.085 A**	**0.085 A**	**0.079 C**	

Means having the same letter within a column or rows are not significantly differed at 0.05 level of probability according to Duncan's multiple range test.

Table 9. Effect of water irrigation level, anti-transpirant type and concentration and their interactions on total carbohydrates percentage and proline content (mg/g d.w.) of *Cyperus alternifolius* L. plant during 2017 season

Irrigation level / Anti-transpirants	WHC (%)				Mean
	25	50	75	100	
	Total carbohydrates (%)				
Control	9.991 ^	11.410]	12.420 \	14.920 [	**12.190 J**
	20.280 w	20.970 v	21.560 uv	22.020 u	**21.210 H**
ADY 2%	23.750 qr	24.190 q	24.870 p	25.130 op	**24.480 F**
ADY 3%	27.980 j	28.600 i	29.180 hi	29.580 h	**28.830 C**
$CaCO_3$100 ppm	22.680 t	22.830 st	23.110 st	23.410 rs	**23.010 G**
$CaCO_3$200 ppm	32.340 d	33.660 c	37.060 a	34.340 b	**34.350 A**
$CaCO_3$300 ppm	29.670 gh	30.250 fg	31.280 e	30.730 ef	**30.480 B**
Kaolin 1%	25.220 op	25.460 n-p	25.720 m-o	25.900 mn	**25.570 E**
Kaolin 2%	26.170 m	26.860 l	27.610 jk	27.180 kl	**26.960 D**
Kaolin 3%	16.580 z	19.950 w	18.740 x	17.530 y	**18.200 I**
Mean	**23.470 C**	**24.420 B**	**25.150 A**	**25.080 A**	
	Proline content (mg/g d.w.)				
Control	0.605 a	0.568 b	0.468 f-h	0.380 l-n	**0.506 A**
ADY 1%	0.553 b	0.521 cd	0.488 e	0.456 g-j	**0.505 A**
ADY 2%	0.535 c	0.454 h-j	0.389 lm	0.379 l-n	**0.439 D**
ADY 3%	0.467 f-h	0.450 ij	0.386 lm	0.366 n	**0.417 F**
$CaCO_3$100 ppm	0.482 ef	0.444 i-k	0.431 k	0.369 n	**0.431 E**
$CaCO_3$200 ppm	0.458 g-i	0.392 l	0.334 o	0.320 o	**0.376 G**
$CaCO_3$300 ppm	0.511 d	0.447 ij	0.447 ij	0.376 mn	**0.445 D**
Kaolin 1%	0.520 cd	0.506 d	0.474 ef	0.456 g-j	**0.489 B**
Kaolin 2%	0.521 cd	0.512 d	0.471 fg	0.453 h-j	**0.490 B**
Kaolin 3%	0.519 d	0.481 ef	0.447 ij	0.440 jk	**0.472 C**
Mean	**0.517 A**	**0.478 B**	**0.434 C**	**0.400 D**	

Means having the same letter within a column or rows are not significantly differed at 0.05 level of probability according to Duncan's multiple range test.

growth, development, metabolism, etc. In the same manner soil water is critical to plant growth and development. It is the solvent in which soil nutrients are dissolved before they can be absorbed by plant roots. Also, water is the medium of transportation of solutes and is required in photosynthesis **(Acquaah, 2009).**

Our results show the effective role of spraying with $CaCO_3$ especially under stress conditions. Such results were in harmony with those obtained by **Gaballah *et al.* (2014)** on sunflower, **Patanè *et al.* (2018)** on tomato and **Silva *et al.* (2019)** on *Vitis labrusca* L. In this regard, **El-Khawaga (2013)** reported that using calcium carbonate weekly at 2% under 60% of available water depletion improved productivity as well as saving irrigation water amount of Grand Naine banana plants. **Abdel-Fattah (2013)** proved that spraying with $CaCO_3$ thrice with one month intervals reverse the harmful effects of water defect on *Hibiscus rosa-sinensis* L. for all studied traits especially plant height, stem diameter, leaves, stems and roots fresh and dry weights, root length, chlorophylls and carotenoids contents and reduced proline content. Also, **Ramadan and Omar (2017)** concluded that the treatment of 80% replenishment of evaporation within 3% $CaCO_3$ was the best combination and it could be recommended for cabbage (c.v. Balady).

Results regarding the positive effect of active dry yeast (wither under normal or stress conditions) were in harmony with those obtained by **El-Sayed *et al.* (2010)** on *Spathiphyllum wallisii*; **Abd El-Kafie**

***et al.* (2010)** on tuberose; **Hanafy *et al.* (2012)** on *Schefflera arboricola*; **El-Sayed *et al.* (2015)** on *Peperomia obtusifolia*; **El-Mahrouk *et al.* (2016)** on *Adhatoda vasica*; **El-Naggar *et al.* (2016)** on *Anthurium andreanum*; **Nofal *et al.* (2016)** on *Calendula officinalis*; **Abdel-Kader *et al.* (2016)** on *Magnolia grandiflora* **and Abdou *et al.* (2018)** on *Gladiolus grandiflorus*. **Hammad and Ali (2014)** reported that yeast extract at 6 g/l produced the highest leaf area of wheat plants subjected to drought (80% depletion of available soil water).

Also, this study showed that calcium carbonate was more effective than active dry yeast extract and kaolin under water stress conditions in most cases. This result was in harmony with those obtained by **Ramadan and Omar (2017)** who suggested that calcium carbonate ($CaCO_3$) can prevent stomata from opening fully by affecting stomatal guard cells and this led to decreasing losses of water vapor. Also, **Abdel-Fattah (2013)** interpreted such positive role of spraying $CaCO_3$ as anti-transpirant under water deficit conditions to the increase in Ca^+ concentration in plant tissues as a result to spraying with $CaCO_3$. This accumulated ion may play a fundamental role in facilitating high turgor maintenance under water deficit conditions. When diluted concentrations of $CaCO_3$ was applied, the white suspension can penetrate leaves through stomata, increasing the photosynthetic activity of the plant in relation to the increased level of CO_2 deriving from the calcium carbonate **(Attia *et al.*, 2014)**. Results obtained by **Silva *et al.* (2019)** showed that films formed by spraying with either $CaCO_3$ or CaO were efficient to provide artificial shading, the temperature of the leaves was significantly reduced in plants with these films, which also provided greater efficiency to control the energy absorption and the electrons fluxes energized by the photosystems and the electron transport chain.

The role of yeast under dehydration conditions couldn't be neglected. Dehydration conditions lead to the accumulation of reduced photosynthetic electron transport components that can reduce molecular oxygen and give rise to the production of reactive oxygen species (ROS) such as superoxide and hydroxyl radicals as well as hydrogen peroxide H_2O_2, thus causing oxidative damage in chloroplasts. In yeast cells, different types of enzymatic systems (i.e. catalase) have been found, catalase is an essential enzyme in the decomposition of such intracellular ROS such as H_2O_2 **(Petrova *et al.*, 2002)** and this in turn led to mitigate the harmful effect of water deficit.

In conclusion irrigation water of *Cyperus alternifolius* could be reduced by 25% without reduction in quality and atheistic value by irrigating plants planted in 25-cm-pots at 75% WHC two times/week and spraying them with $CaCO_3$ at 200 ppm monthly.

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