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REGULATION OF JERUSALEM ARTICHOKE GROWTH USING ALAR AND POTASSIUM TO OVERCOME DROUGHT DEPRESSIONS

Sabah M. A. El-Gamal and Mervat E. Sorial
Agric. Botany Dept., Fac. of Agric., Minufiya Univ., Shibin El-Kom, Egypt.

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ABSTRACT: ***Two field experiments were conducted during the summer seasons of 2007 and 2008 to evaluate the effect of Alar, potassium (K^+) and its combination (Alar + K^+) on Jerusalem artichoke (Helianthus tuberosus, L.) under water stress conditions.***

Data showed that, water stress (W_2) significantly decreased plant height, dry weight of shoots, relative water content (RWC), chlorophyll (a + b), carotenoids, total soluble sugars (TSS), total free amino acids (TAA) and N, P, K contents in leaves compared with normal irrigation (W_1) . Also, a reduction in tuber yield, dry matter and inulin was recorded . Meanwhile, the reverse effect was obtained in No. of lateral shoots and proline concentration. The application of Alar or potassium and its combination led to enhancing vegetative growth characters, relative water content, chl. (a + b), carotenoids, TSS, TAA, proline concentration, adjustant C/N ratio, as well as yield and its components as compared with the control plants. It can be concluded that, Alar, potassium and its combination not only alleviated the deleterious effects of water stress but also improved tubers productivity and its quality.

Key words: ***Jerusalem artichoke, Alar, potassium, drought tolerance, C/N ratio, yield.***

INTRODUCTION

Jerusalem artichoke is a vegetable crop and it is not truly an artichoke but a variety of sunflower with lumpy, brown skinned tuber that after resembles a ginger root and belongs to the family *Asteraceae* and classified as *Helianthus tuberosus,* L. a species of sunflower. Its potato like tubers, most favored as a food in Europe and China, contains inulin and used to produce alcohol. Moreover, in Egypt, there are a wide areas from new reclaimed soil suitable for growing Jerusalem artichoke plants for export processing and medicinal purposes.

Water is generally considered the most limiting factor in higher plants than any other single environmental factor. Exposing plants to water stress, adversely affected plant growth and productivity (Meek *et al.,* 2003 and Namich, 2007).

Many researches clearly reported that, growth retardants posses the ability to convert the shape of many plant species (Basra, 1994 and Barras, 2002). Alar, (succinic acid 2-2 dimethylhydrazide) was highly effective as growth retardant, especially in a wide range of ornamental plants and treated plants were less likely to wilt and recovered more quickly from stress (El-Meleigy *et al.,* 1999), reduced plant height of chrysanthemum (El-Sheibany *et al.,* 2008). Under drought conditions, Alar caused remarkable increase in soluble sugars, polysaccharides, amino acids and protein. Moreover, plants treated with Alar resulted in accumulation of P, Mg, Ca, Fe and Bo (Abdalla *et al.,* 1993).

Potassium is one of the most important essential element that play major physiological and biochemical roles in plant growth (Beringer *et al.,* 1990). Also, this element plays an important role in tolerance to water stress (Robin *et al.,* 1989) and osmotic adjustment (Cerda *et al.,* 1995). Potassium application has been shown to improve vegetative growth, yield and quality of Jerusalem artichoke cultivars (local and fuseau) and inulin content (Mansour *et al.,* 2001).

The aim of this study is to evaluate the possible mode of interaction between water stress, potassium and Alar to change C / N ratio by reducing vegetative growth (Alar) and increasing tuber formation (potassium) under limiting water condition in Jerusalem artichoke plants.

MATERIALS AND METHODS

Two field experiments were carried out during the two successive summer seasons, 2007 and 2008, at the Experimental Farm of Shibin El-Kom, Minufiya University. The present study was conducted using a local cultivar of Jerusalem artichoke (*Helianthus tuberosus*, L.). Tubers were planted on April 12th and 15th in both seasons respectively, which obtained from the Department of Vegetable Crops of Horticulture Research Station, El-Kanater El-Khairia, Kalubia, Govern. Egypt.

The physical and chemical properties of the soil are represented in Table (1). All experimental units received identical levels of phosphorus, nitrogen and potassium fertilizers. Calcium superphosphate (15.5 % P_2O_5) was base dressed during soil preparation with a rate of 150 kg per feddan. Ammonium sulfate at 300 kg (20.6% N) was used as nitrogen source equally divided and side dressed at 60 and 90 days after planting.

In addition to the recommended rate of potassium (96 kg / fed) (Tawfik *et al.,* 2003), the double rate (192 kg K_2O / fed) was added as sulfate of potash (48% K_2O) as a treatment alone (K^+) or combined with Alar (Alar + K^+) under water level conditions at three equal doses applied at 60, 75 and 90 days after planting.

Table (1). Chemical and physical characteristics of the experimental soil (determined by the method described by Cohenie, 1980).

Property	Value	Property	Value
Physical analysis:		Soluble cation me/q/100 g soil:	
Sand %	26.0	$Ca^{+2} + Mg^{+2}$	1.25
Silt %	39.0	Na^{+}	1.12
Clay %	35.0	K^{+}	0.33
Texture	clay loam	Soluble anions meq/100 gm soil	
OM %	0.78	Cl	0.80
pH	7.8	CO_3	-
Ecd sm^{-1}	1.5	HCO_3	0.95
		SO_4	0.95
		Total N %	0.12
		P (ppm)	9.9

Alar at 1000 mg/l was applied twice as foliar spray, one month intervals, beginning from 60 days after planting. Tween 20 was added to the spraying solution at 0.5% as a surfactant.

The experimental design was a split plot with three replications for each treatment. Plot, consisted of 6 rows each of 5 m long and 1 m width, comprising an area of 30 m^2. The main plots comprised two irrigation intervals:

a. Two weeks interval (normal irrigation) W_1.

b. Four weeks interval (water stress) W_2.

Whereas, (1) Alar at 1000 mg/l (2) potassium at 192 kg K_2O / fed (K^+), (3) Alar at 1000 mg/L + potassium at 192 kg/fed (Alar + K^+) and (4) control (without Alar or k^+) were considered as the sub-plot units.

At 120 days after planting, three plants samples were randomly taken from each sub-plot, hence the following data were recorded:

1- **Growth characters: plant height (cm), number of lateral shoots / plant and dry weight of shoots g /plant.**
2- **Relative water content. was measured according to Larcher (1995).**
3- **Chemical constituents: a) Photosynthetic pigments were determined in the leaves using the method described by Witham *et al.* (1971). b) Total soluble sugars, total free amino acids and proline concentration were estimated in the leaves according to the methods described by Dubois *et al.* (1956), Rosen (1957) and Bates *et al.* (1973), respectively. c)**

Total carbohydrates content (Dubois *et al.,* 1956) and C/N ratio was calculated. d) Total nitrogen was determined in dry leaves using microkjeldahl methods as described by Ling (1963), while P and K were determined as mentioned by A.O.A.C. (1990).

4- **Yield and its components:** Each experimental unit was harvested individually after 180 days from planting and the following yield data were recorded: Total tuber yield (ton / feddan) average tuber weight (g) and tuber dry matter (%) was determined by drying the tuber slices (100 g) at 70 C^{o} for 72 hours according to the methods of Dogras *et al.,* (1991).

Tolerance index: Tolerance index of each plant against each of untreated plant was calculated according to the following formula (Hertstein and Jager, 1985):

$$\text{Tolerance index} = \frac{\text{Mean total tuber yield treated plants ton/fed}}{\text{Mean total tuber yield control plants ton/fed}} \times 100$$

5- **Tuber quality after harvest:** Inulin concentration was determined in tubers according to Whistler *et al.* (1962), total soluble sugars and total free amino acids were estimated as described previously.

All obtained data were subjected to statistical analysis with the help of CO-STAT-C programe, Duncan's Multiple Range Test was used to test for significant differences among means at $p \leq 0.05$ and calculated according to Duncan (1955) and Gomez and Gomez (1984).

RESULTS AND DISCUSSION

1. Growth characters:

Data in Table (2) indicated that, water stress conditions (W_2) significantly decreased plant height and dry weight of shoots compared with the normal irrigation (W_1) whereas, number of lateral shoots was increased. Water stress could restrict internode elongation and leaf expansion through inhibiting cell expansion (Namich, 2007). Also, drought could lower biomass accumulation by driving the plant to minimize water loss through transpiration by inducing stomatal closure and since carbon gain can occur only while water is being lost (Radin, 1989), this could decline the photosynthetic rate (Yi *et al.,* 2000) and reduce dry matter accumulation on a whole plant basis.

Table (2). Effect of Alar and potassium fertilizer on some growth characters of Jerusalem artichoke plant grown under water stress conditions during two summer seasons.

Agents / Water levels	First season (2007)					Second season (2008)				
	0	Alar	K^+	Alar + K^+	Mean	0	Alar	K^+	Alar + K^+	Mean
	Plant height (cm)									
W_1	186.7^b	160.0^d	210.0^a	178.3^c	183.8^A	183.3^b	148.3^e	191.0^a	184.7^b	176.8^A
W_2	156.7^d	127.7^f	170.0^c	145.0^e	149.9^B	140.3^d	128.5^f	175.2^c	148.7^e	148.2^B
Mean	171.7^B	143.9^D	190.0^A	161.7^C		161.8^B	138.4^D	183.1^A	166.7^C	
	No. of lateral shoots / plant									
W_1	90.7^c	99.4^b	90.6^c	96.8^b	94.4^B	87.3^b	90.1^b	87.3^b	96.3^a	90.30^A
W_2	85.1^d	103.5^a	88.7^d	110.4^a	96.9^A	80.0^c	95.5^a	88.7^b	102.7^a	91.70^A
Mean	87.9^C	101.5^A	89.7^B	103.6^A		83.7^B	92.8^D	88.0^C	99.5^A	
	Dry weight of shoots g / plant									
W_1	710.0^d	760.0^c	833.3^b	923.3^a	806.7^A	660.0^c	726.7^{ab}	783.3^a	793.3^a	740.8^A
W_2	510.7^e	766.7^c	829.3^b	925.3^a	758.0^B	573.0^d	690.0^b	700.0^b	800.0^a	690.8^B
Mean	610.4^D	763.4^C	831.3^B	924.3^A		616.5^D	708.4^C	741.7^B	796.7^A	

Regarding the effect of agents (Alar, K^+ and its compination) on growth characters, data in Table (2) recorded a significant reduction in plant height with Alar and / or Alar + K^+. These data are in agreement with El-Sheibany *et al.* (2008). It is reported that, Alar may be blocked gibberellin transformation into active forms (Menhenett, 1980), the transport to intensively growing zones, as well as to enhance conjugation into glucoside and glycosil-esters (Takeno *et al.,* 1981). Moreover, Auxin content is also reduced after plants treated with Alar (Jindal and Dalbro 1977).

Number of lateral shoots and dry weight of shoots significantly increased by Alar, potassium fertilizer and Alar + K^+ treatment (Table 2). The highest increases were obtained by Alar + K^+ followed by K^+ and / or Alar treatment, during the two growing seasons. The interaction between irrigation intervals and agents showed positive effect on No. of lateral shoots and dry weight when plants treated with Alar + K^+ under drought conditions. This may be a mean of osmotic adjustment by which potassium exerted the previously reported improvement in leaf turgor pressure and water potential under water stress. In addition Shibairo *et al.* (1998) reported that, increased K-application reduced the moisture loss in carrots by increasing root size and maintaining tissue turgidity. Anjuthakur *et al.* (2002) reported that, potassium significantly

lessened the deleterious impacts of water stress in bell pepper. Barras (2002) reported that, Alar treated chrysanthemum have a more branched root system, providing firmer anchorage and better nutrient and moisture extracting capacity. Alar also improve the rooting system of chrysanthemum and resistance dry conditions . Moreover, Alar treatment reduced the apical dominance and this indicates the increases in lateral branches (El-Sheibany *et al.,* 2008).

2. Relative Water content (RWC):

It can be observed that, RWC decreased under water stress (Table 3) as compared to normal irrigation. Similar results were obtained by Gawish and Fattahallah (1997) in taro leaves. The RWC was significantly increased in the plants treated with agents in both seasons, compared with the control. The best results were obtained by combination between Alar + K^+ in both seasons, thus, agents, in general, were effective in improving plant water status under unfavorable conditions. In this regard, Anjuthakur *et al.* (2002) reported that, K reversed / lessened deleterious effects of water stress, higher water use efficiency, drought tolerance efficiency. Also, K^+ has been known to be an essential factor determining the resistance to water stress and water balance in white clover (Robin *et al.,* 1989).

Table (3). Effect of Alar and potassium fertilizer on relative water content (RWC), photosynthetic pigments and total free amino acid of Jerusalem artichoke plant grown under water stress conditions during two summer seasons.

Agents / Water levels	First season (2007)					Second season (2008)				
	0	Alar	K^+	Alar + K^+	Mean	0	Alar	K^+	Alar + K^+	Mean
	Relative water content (%)									
W_1	81.79^{c}	84.56^{b}	88.16^{a}	88.55^{a}	85.77^{A}	75.97^{c}	75.80^{c}	77.92^{b}	85.17^{a}	78.72^{A}
W_2	71.39^{e}	79.90^{d}	83.72^{b}	88.46^{a}	80.87^{B}	63.98^{d}	74.22^{c}	77.82^{b}	83.07^{a}	74.77^{B}
Mean	76.59^{D}	82.23^{C}	85.94^{B}	88.51^{A}		69.98^{D}	75.01^{C}	77.87^{B}	84.12^{A}	
	Chlorophyll (a + b) mg / g d.wt									
W_1	3.06^{d}	3.46^{bc}	3.78^{b}	3.49^{bc}	3.45^{A}	3.54^{c}	3.81^{b}	3.60^{bc}	3.90^{b}	3.71^{A}
W_2	1.37^{e}	3.85^{ab}	3.33^{c}	4.05^{a}	3.15^{B}	2.0^{e}	3.91^{b}	3.71^{c}	4.25^{a}	3.47^{B}
Mean	2.22^{D}	3.66^{C}	3.56^{B}	3.77^{A}		2.77^{D}	3.86^{B}	3.66^{C}	4.08^{A}	
	Carotenoids (mg / g d. wt)									
W_1	1.40^{b}	1.47^{b}	1.45^{b}	1.62^{a}	1.49^{A}	1.60^{b}	1.69^{b}	1.79^{b}	1.94^{a}	1.76^{A}
W_2	1.00^{c}	1.59^{a}	1.53^{ab}	1.64^{a}	1.44^{A}	1.03^{c}	1.83^{ab}	1.73^{b}	1.97^{a}	1.64^{B}
Mean	1.20^{C}	1.53^{B}	1.49^{B}	1.63^{A}		1.32^{C}	1.76^{B}	1.76^{B}	1.96^{A}	
	Total free amino acid (mg / g d. wt)									
W_1	9.53^{d}	11.56^{c}	12.14^{b}	13.57^{a}	11.70^{A}	10.60^{c}	12.70^{b}	13.40^{b}	14.70^{a}	12.85^{A}
W_2	8.32^{e}	9.36^{d}	9.27^{d}	13.60^{a}	10.14^{B}	8.40^{e}	12.40^{b}	10.30^{c}	15.30^{a}	11.60^{B}
Mean	8.93^{C}	10.46^{B}	10.71^{B}	13.59^{A}		9.50^{C}	12.55^{B}	11.85^{B}	15.00^{A}	

3. Chemical constituents:

a. Photosynthetic pigments:

Results in Table (3) showed that, water stress caused a significant decrease in chl. a + b and carotenoid concentrations in leaves, whereas, Alar, K^+ and Alar + K^+ treatments led to an increase in this respect compared with control treatment.

The interaction between irrigation intervals and agents generally showed positive effects when plants treated with Alar + K^+ followed by Alar then K^+ treatment under drought condition. El-Sheibany *et al.* (2008) reported that, Alar increased stem and leaf thikness and increased the number of palisade cells which, in turn, achieved darker green colour correlates with high amount of chlorophyll content.

b. Total soluble sugars (TSS), total free amino acids (TAA) and proline concentrations:

It is obvious from Table (3) and Fig. (1) that plants subjected to water stress conditions decreased TSS and TAA concentrations in leaves compared with normal irrigation. This reduction could ascribed to water stress-induced loss of solutes (mainly K^+) from guard cells, which resulted in a selective reduction in guard cell turgor, leading to stomatal closure (Hsiao and Acevedo, 1974). Meanwhile the obtained, results indicated that, the usage of agents caused increase in TSS and TAA.

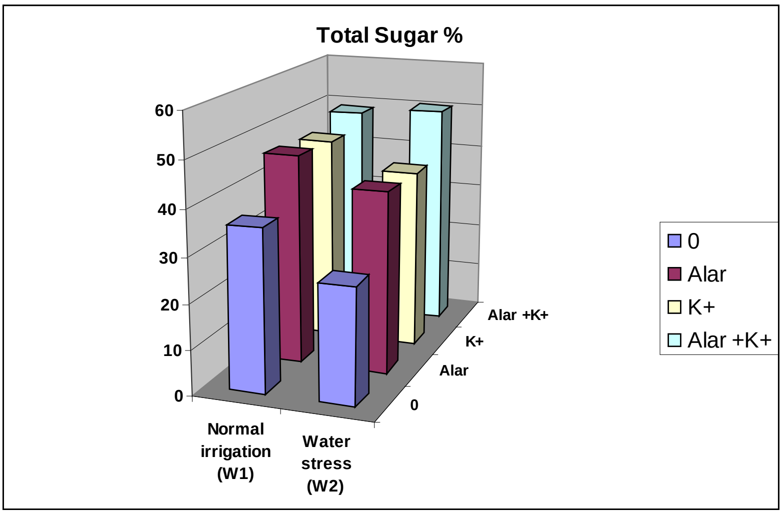


Fig.(1): Effect of Alar and Potassium fertilizer on total soluble sugars of Jerusalem artichoke plant grown under water stress conditions during summer season of 2008 .

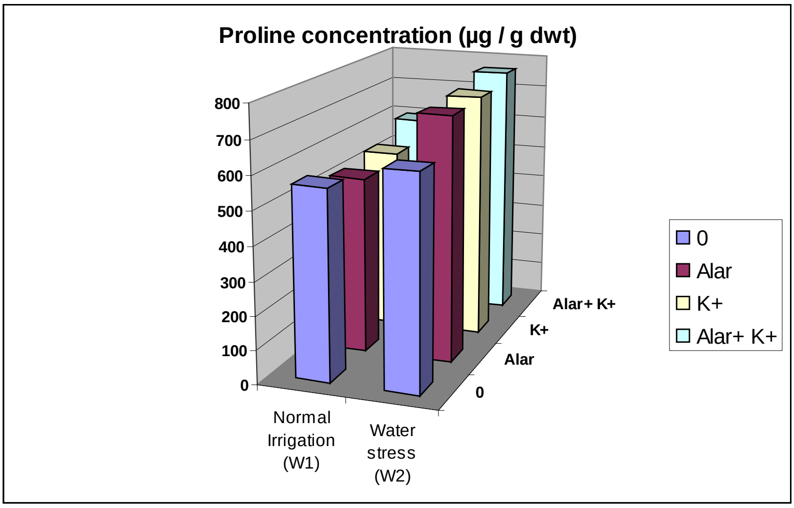


Fig.(2): Effect of Alar and Potassium fertilizer on proline concentration of Jerusalem artichoke plant grown under water stress conditions during summer season of 2008 .

The interaction between irrigation intervals and agents had significant effects on the previous aspects which significantly increased compared the untreated plants. This may be a mean of osmotic adjustment by which used agents improved leaf turgor pressure and water potential under water stress conditions. El-Meleigy *et al.* (1999) and Abdalla *et al.* (1993) found that, applying growth retardant on stressed plants alleviate the adverse effect of drought stress by increasing sugars and amino acids.

Plants subjected to water stress conditions accumulated more proline concentration in leaves (Fig. 2) as compared to the normal irrigation. The increase may be due to an increase in protein hydrolysis as a result of increasing the activity of hydrolytic enzymes (Nayyar and Walia, 2003) and / or to increase the synthesis, of proline.

Plants treated with Alar + K^+ caused a significant increase in proline content of leaves compared with the control. Moreover, under water stress Alar, K^+ and Alar + K^+ treatments mostly increased proline concentration compared the untreated plants. This increase may be due to its accumulation owing to stimulate proline synthesis, inhibition its oxidation and impaired protein synthesis (Stewart and Hanson, 1980), or to mitigate the loss of activity of several enzymes (Singh and Sahay, 1990). Moreover, proline accumulation have also been proposed to include, proline acts as a storage compound for energy and reduced carbon and nitrogen needs (Stewart and Lee, 1974).

c. Total carbohydrate content and C/N ratio:

Data presented in Table (4) clearly indicated that, water stress significantly decreased total carbohydrates compared with normal irrigation. Meanwhile, Alar, K^+ as well as Alar + K^+ treatments significantly increased total carbohydrates in both seasons when compared with the control plants.

Regarding to C/N ratio of Jerusalem artichoke leaves significantly increased by water stress conditions (W_2) compared with W_1. The effective treatments in reducing C/N ratio were Alar, K^+ and Alar + K^+ especially under drought conditions which became nearly to normal irrigation. It is believed that, the proper balance of carbohydrates and nitrogen i.e., C/N ratio is needed for proper vegetative growth and flowering which reflect higher yield (Swiader *et al.,* 1994).

Table (4). Effect of Alar and potassium fertilizer on total carbohydrates, mass of carbon, N, P, K and C/N ratio of Jerusalem artichoke plant grown under water stress conditions during two summer seasons.

Agents / Water levels	First season (2007)					Second season (2008)				
	0	Alar	K^+	Alar + K^+	Mean	0	Alar	K^+	Alar + K^+	Mean
	Total carbohydrates (%)									
W_1	20.31^{c}	21.88^{bc}	22.21^{b}	24.08^{a}	22.12^{A}	18.75^{c}	20.31^{b}	21.05^{b}	25.04^{a}	21.29^{A}
W_2	14.84^{e}	21.68^{bc}	18.75^{d}	23.44^{a}	19.68^{B}	12.50^{d}	18.75^{c}	20.06^{b}	26.54^{a}	19.46^{B}
Mean	17.58D	21.78^{B}	20.48^{B}	23.76^{A}		15.63^{D}	19.53^{C}	20.56^{B}	25.79^{A}	
	Mass of carbon (%)									
W_1	8.88^{c}	9.57^{b}	9.71^{c}	10.53^{a}	9.67^{A}	8.19^{d}	8.88^{d}	9.20^{c}	10.95^{ab}	9.31^{A}
W_2	6.49^{d}	9.47^{b}	8.19^{c}	10.24^{a}	8.60^{B}	5.46^{e}	8.19^{d}	8.77^{d}	11.60^{a}	8.51^{B}
Mean	7.69^{D}	9.52^{B}	8.37^{C}	10.39^{A}		6.83^{C}	8.54^{B}	8.99^{B}	11.28^{A}	
	N (%)									
W_1	2.32^{c}	$2.54a^{b}$	2.63^{a}	2.65^{a}	2.54^{A}	2.44^{cb}	2.54^{b}	2.63^{a}	2.69^{a}	2.58^{A}
W_2	0.99^{d}	2.44^{b}	2.53^{ab}	2.72^{a}	2.17^{B}	1.00^{d}	2.50^{b}	2.60^{a}	2.73^{a}	2.21^{B}
Mean	1.66^{C}	2.49^{B}	2.58^{B}	2.69^{A}		1.72^{D}	2.52^{C}	2.62^{B}	2.71^{A}	
	P (%)									
W_1	0.44^{b}	0.45^{b}	0.50^{a}	0.53^{a}	0.48^{A}	0.49^{b}	0.50^{b}	0.50^{b}	0.53^{b}	0.51^{A}
W_2	0.28^{c}	0.40^{b}	0.43^{b}	0.56^{a}	0.42^{B}	0.21^{d}	0.32^{c}	0.45^{b}	0.68^{a}	0.42^{B}
Mean	0.36^{D}	0.43^{C}	0.47^{B}	0.55^{A}		0.35^{D}	0.41^{C}	0.48^{B}	0.61^{A}	
	K (%)									
W_1	2.50^{d}	2.81^{c}	3.33^{b}	3.59^{a}	3.06^{A}	2.47^{c}	2.50^{c}	3.10^{b}	3.79^{a}	2.97^{A}
W_2	1.62^{e}	2.85^{c}	3.60^{a}	3.60^{a}	2.92^{B}	1.00^{d}	2.60^{c}	3.30^{b}	3.87^{a}	2.69^{B}
Mean	2.06^{C}	2.83^{B}	3.47^{A}	3.60^{A}		1.74^{D}	2.55^{C}	3.20^{A}	3.83^{B}	
	C/N ratio									
W_1	3.83^{b}	3.77^{b}	3.69^{b}	3.97^{b}	3.82^{B}	3.36^{c}	3.50^{c}	3.50^{c}	4.07^{b}	3.61^{B}
W_2	6.56^{a}	3.88^{b}	3.24^{b}	3.77^{b}	4.36^{A}	5.46^{a}	3.28^{c}	3.37^{c}	4.25^{b}	4.09^{A}
Mean	5.20^{A}	3.83^{B}	3.51^{C}	3.90^{B}		4.41^{A}	3.39^{B}	3.44^{B}	4.16^{A}	

d. Minerals content:

It is obvious from Table (4) that water stress significantly decreased N, P and K content in leaves as compared with normal irrigation.

Regarding the effect of agents, data showed that, plants treated with Alar, K^+ and Alar + K^+ caused significant increase in this respect as compared to the control. The highest increase in potassium content was obtained by Alar + K^+ followed by K^+ treatment. The interaction between irrigation intervals and agents proved to be more effective in increasing N, P and K content when plants treated with Alar + K^+ under drought conditions. Barras (2002) reported that, Alar-treated chrysanthemum recorded a better nutrient content and moisture extracting capacity. Arisha and Bardisi (1999), reported that K^+ fertilization under drought condition tended to encourage the accumulation of N in potato leaves.

4. Yield and its components:

The reduction in total yield ton / feddan, , average tuber weight and dry matter (Table 5 and Fig. 3 A and B) as a results of water stress is logical result of the reduction in vegetative growth (Table 2). The yield reduction may be due to a decrease in xylem and phloem tissues thickness, resulting in a lower accumulation of water necessary for photosynthesis which lead to show translocation of photo-assimilates towards the developing seed (Hussien, 2000). Meanwhile, applying Alar, K^+ and Alar + K^+ had a significant increase in tuber yield compared with untreated plants. The interaction between water stress and agents led to a significant increase in this respect. These results are in agreement with those obtained by Abdalla *et al.* (1993) and Namich (2007). The increases in tubers yield might be due to Alar effects on vegetable growth (decreasing plant height and increasing No. of lateral shoots table (2)) or a more branched root system (El-Sheibany *et al.* 2008), and enhances uptake of minerals (Abdalla *et al.,* 1993). Also, Alar or K^+ treatments had stimulatory effects on the relative water content and physiological constituents (Table 3).

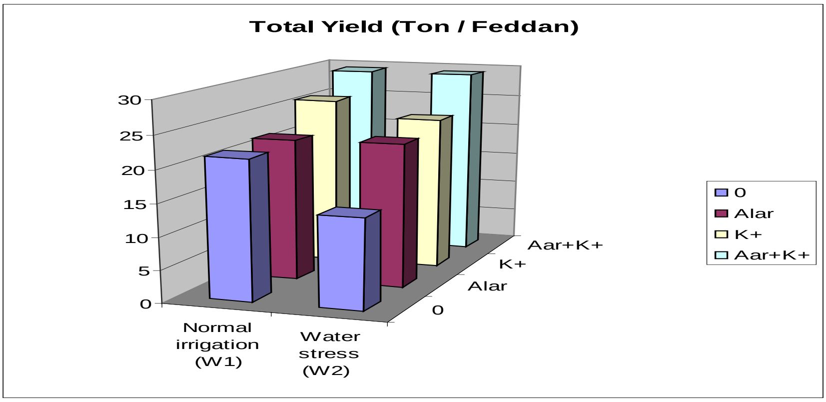
Moreover, the data of tolerance index presented in fig. (4), clearly show that Jerusalem artichoke plants were more tolerant when treated with Alar or K^+ as well as highly significant increased tolerant index with Alar + K^+ under drought stress .

The stimulation of adventitious root initiation by Alar is a possible consequence of the inhibition of gibberellins biosynthesis by growth retardants (Grossmann,1990). Growth retardants treatment induced cytokinin level and an effective inhibitor of ethylene production in plant organs (Tari and Nagy,1994), which promoted adventitious root formation of stem cuttings.

Table (5). Effect of Alar and potassium fertilizer on dry matter, inulin concentration, total soluble sugars and total free amino acid in tubers of Jerusalem artichoke plant grown under water stress conditions during two summer seasons.

Water levels \ Agents	First season (2007)					Second season (2008)				
	0	Alar	K^+	Alar + K^+	Mean	0	Alar	K^+	Alar + K^+	Mean
	Tuber dry matter (%)									
W_1	17.61^b	17.35^b	22.39^a	19.95^b	19.33^A	17.7^d	20.00^c	24.68^a	22.47^b	21.21^A
W_2	13.06^c	16.73^b	18.35^b	22.95^a	17.77^B	14.47^e	18.97^d	19.17^c	25.67^a	19.57^B
Mean	15.34^D	17.04^C	20.37^B	21.45^A		16.09^D	19.49^C	21.93^B	24.07^A	
	Inulin concentration (mg / g d. wt)									
W_1	16.37^b	18.61^b	22.62^a	20.42^a	19.51^A	17.04^b	20.17^a	21.01^a	19.47^a	19.42^A
W_2	15.06^{bc}	17.37^b	21.80^a	22.95^a	19.30^A	14.64^c	20.07^a	19.57^a	19.57^a	18.46^B
Mean	15.72^D	17.99^C	22.21^A	21.69^B		15.84^D	20.12^B	20.29^A	19.52^C	
	Total soluble sugars of tuber (%)									
W_1	70.73^b	76.00^a	73.87^b	78.67^a	74.82^A	67.03^b	76.70^a	70.60^b	78.10^a	73.11^A
W_2	51.20^c	77.93^a	73.93^b	80.53^a	70.90^B	52.97^c	73.97^b	68.37^b	80.40^a	68.93^B
Mean	60.97^D	76.97^B	73.90^C	79.60^A		60.00^D	75.34^B	69.49^C	79.25^A	
	Total free amino acid of tuber (mg/g d.wt.)									
W_1	11.89^c	17.24^a	13.14^b	18.32^a	15.15^A	14.90^c	20.30^a	16.17^b	21.50^a	18.22^A
W_2	9.57^d	13.80^b	13.54^b	19.27^a	14.05^B	11.60^d	16.90^b	15.00^b	22.30^a	16.45^B
Mean	10.73^D	15.52^B	13.34^C	18.80^A		13.25^D	18.6^B	15.59^C	21.9^A	

(A)



(B)

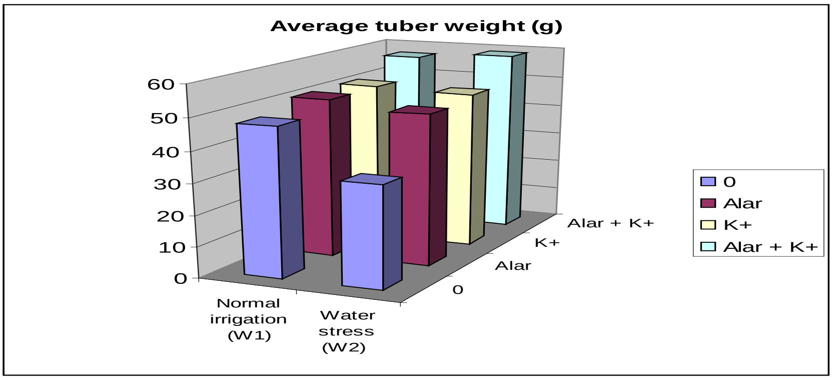


Fig.(3A and B): Effect of Alar and Potassium fertilizer on total yield and average tuber weight of Jerusalem artichoke plant grown under water stress conditions during summer season of 2008

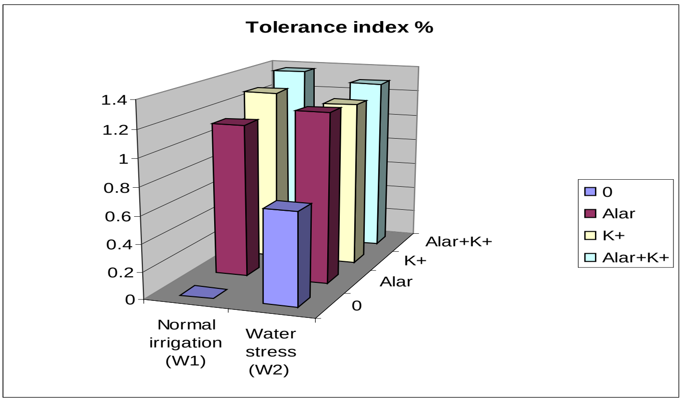


Fig.(4) : Tolerance index of jerusalem artichoke as affected by Alar and Potassium fertilizer grown under water stress conditions during summer season of 2008 .

5. Tuber quality:

Water stress significantly decreased inulin, tubers total soluble sugars and total free amino acid concentrations, which may be due to the inhibition of carbohydrate formation or the degradation as a result of increasing hydrolytic enzymes. It is clear from Table (5) that, Alar, K^+ and Alar + K^+ treatments had a significant increase in tuber quality compared with the control. The interaction between irrigation intervals and agents had significant effects on these characters. This may be a mean of osmotic adjustment by which potassium exerted the previously reported improvement leaf turgor and water potential under water stress conditions (Cerda *et al.,* 1995). Moreover, these agents may play an important role in translocation of nutrients and synthesis of soluble sugars and amino acids, which lead to fast translocation of photo-assimilates towards the developing tubers.

Finally, it can be concluded from this work, that potassium application not only reversed the deleterious effects of water stress but also improved Jerusalem tubers productivity and its quality. This is interesting as well as desirable. The combined effects of Alar and potassium have enabled to maintain higher yield potential under drought conditions probably by regulating vital photosynthesis, water maintenance, regulating C/N ratio and higher osmoregulation which increased drought tolerance.

REFERENCES

Abdalla, Mona M., K. A. El-Telwany and R. A. Hassanein (1993). The interactive effect of water stress and each of ABA, Alar and proline on

certain metabolic activities in red radish plants. Egypt. J. Physiol. Sci., 17 (2): 271 – 285.

Anjuthakur, P. S. Thaknr and S. P. Kananjia (2002). Reversal of water stress effects II. Influence of growth regulator, mulching and potassium on the field performance of *Capsicum annuum* L. under water stress. Indian J. Hort., 59 (4): 416 – 422.

A.O.A.C. (1990). Official methods of analysis of the Association of Official Analytical Chemists. 15th Ed..

Arisha, H. M. and A. Bardisi (1999). Effect of mineral and organic fertilizers on growth, yield and tuber quality of potato under sandy soil conditions. Zagazig J. Agric. Res., 26 (2): 391 – 405.

Barras, A. (2002). Effect of plant growth retardant Alar on growth and flowering of chrysanthemum. M.Sc. Thesis, Garyounis University Libya.

Basra, A. S. (1994). Mechanisms of plant growth and improved productivity (Modern Approaches). Marcel Dekker. INC.

Bates, L. S., R. P. Waldren, I. D. Teave (1973). Rapid determination of free proline for water stress studies. Plant and Soil, 39: 205 – 207.

Beringer, H., K. Koch and M. G. Lindhauer (1990). Source: Sink relationship in potato(*Solanum tuberosum*) as influenced by potassium chloride or potassium sulphate nutrition. Plant and soil. 124: 287-290

Cerda, A., J. Pardines, M. A. Botella and V. Martinez (1995). Effect of potassium on growth, water relations, and the inorganic and organic solute contents for two maize cultivars grown under saline conditions. Journal of Plant Nutrition, 18 (4): 839 – 851.

Cohenie, A. (1980). Soil and plant testing. FAO Soils Bulletin, Roma.

Dogras, C., Siomos and C. Psomakelis (1991). sugar and dry matter changes in potatoes stored in a clamp in a mountainous region of Northern Greece. Potato Res., 34: 211-214.

Dubois, M., A. Gilles, J. K. Hamilton, P. A. Robers and P. A. Smith (1956). A colorimetric method for determination of sugar and related substances. Annal. Chem., 28: 350 -356.

Duncan, D. B. (1955). Multiple range and multiple F-test Biometrics, 11: 142.

El-Meleigy, E. A., R. A. Hassanein and D. Abdelkader (1999). Improvement of drought tolerance in *Arachis hypogaea* L. plant by some growth substances. I. Growth and productivity. Bull. Fac. Sci., Assuit Univ., 28: 159 – 185.

El-Sheibany, O. M., N. A. El-Malki and A. A. Barras (2008). Effect of growth retardant Alar on some anatomical and chemical changes in local cultivar of *Chrysanthemum morifolium*. Journal of Science and its Applications, 2 (1): 1 – 5.

Gawish, Ragaa A. and M. A. Fattahallah (1997). Modification of irrigation requirements of taro (*Colocasia esculenta* L. Schott) through the

application of antitranspirants. Minufiya J. Agric. Res., 22 (5): 1353 – 1387.

Gomez, K. A. and A. A. Gomez (1984). Statistical Procedures of Agricultural Research. Second Ed. Wielly Inter Science Publ., John Wiley and Sons. New York, pp. 357 – 423.

Grossmann K. (1990) . Plant growth retardants as a tools in physiological research. Physiol. Plant., 78:640-648.

Hertstein, U. and H. J. Jager (1985). Tolerances of different population of three grass species to cadmium and other metals. Environ. Exp. Bot., 26: 309 – 319.

Hsiao, T. C. and E. Acevedo (1974). Plant responses to water deficits, water use efficiency and drought resistance. Agric. Meteorology, 14: 59 – 84.

Hussien, M. S. F. (2000). Structural and physiological studies and oil constituents of canola plants under salinity conditions. M.Sc. Thesis, Fac. of Agric., Mansoura Univ., Egypt.

Jindal, K. K. and S. Dalbro (1977). Effect of succinic acid. 2, 2-dimethylhydrazide on endogenous auxin level in apple shoots. Physiol. Plant., 39: 119 – 122.

Larcher, W. (1995). Plant water relations. In "Physiological Plant Ecology" 3rd ed. Springer, Berlin. pp. 215 – 275.

Ling, E. R. (1963). Determination of total nitrogen by semimicro-kjeldahl method. Dairy Chem., 11: 23 – 84.

Mansour, S. A., Z. A. El-Sharkawy, A. A. Tawfik and H. M. Ramaddan (2001). Response of some Jerusalem artichoke cultivars to nitrogen and potassium levels in drip - irrigated sandy soil. African Crop Science Conference Proceedings, 5: 853 – 860.

Meek, C., D. Oosterhis and J. Gorham (2003). Does foliar applied glycine betaine affect endogenous betaine levels and yield in cotton online. Crop Management doi. 10-1904/CM-2003-0804-02-RS.

Menhenett, R. (1980). Evidence that daminozide, but not two other growth retardants, modifies the fate of applied gibberellin A_9 in *Chrysanthemum morifolium* Ramat. J. Exp. Bot., 31: 1631 – 1642.

Namich, Alia A. M. (2007). Response of cotton cultivar Giza 80 to application of glycine betaine under drought conditions. Minufiya J. Agric. Res., 32 (6): 1637 – 1651.

Nayyar, H. and D.P. Walia (2003). Water stress induced proline accumulation in contrasting wheat genotypes as affected by calcium and abscisic acid. Biol. Plant., 46: 275 – 279.

Radin, J. W. (1989). When is stomatal control of water loss consistent with the thermal kinetic window concept. Proc. Beltwide cotton Conf., 1: 46 – 49.

Robin, C., L. Shamsun-Noor and A. Gnckert (1989). Effect of potassium on the tolerance to PEG-induced water stress of two white clover varieties (*Trifolium repens* L.). Plant and Soil, 120: 153 – 158.

Rosen, H. (1957). A modified field ninhydrin colourimetric analysis for acid nitrogen. Arch. Biochem. Biophys., 67: 10 – 15.

Shibairo, S. L., M. Npadhyaya and P. M. A. Toivonen (1998). Potassium nutrition and postharvest moisture loss in carrots. J. Hort. Sci. and Biotechnol., 73 (6): 862 – 866.

Singh, D. and R. K. Sahay (1990). Proline accumulation in relation to yield reduction and biomass recovery under stress conditions in cotton (*Gossypium* spp.). Indian J. Agric. Sci., 60 (11): 739 – 741.

Stewart, C. R. and A. D. Hanson (1980). Proline accumulation as a metabolic response to water stress. In: N.C. Turner and P. J. Kramer (Eds), Adaptation of plant to water and high temperature stress. John Wiley, New York, pp. 173 – 189.

Stewart, G. R. and J. A. Lee (1974). The role of proline accumulation in halophytes. Planta, 120: 279 – 289.

Swiader, J. M., S. K. Sipp and R. G. Brown (1994). Pumpkin growth, flowering and fruiting response to nitrogen and potassium sprinkler fertigation in sandy soil. J. Amer. Soc. Hort. Sci., 119 (3): 414 – 419.

Takeno, K., R. L. Leggl and R. P. Pharis (1981). Effect of growth retardant B-9 (SADH) on endogenous GA level and transport and conversion of exogenously applied ^{3}(H) GA_{20}. In Alaska Pea.Plant Physiol., 167, Suppl. 581.

Tari, I. and M. Nagy (1994). Enhancement of extractable ethylene at light,dark transition in primary leaves of paclobutrazol – treated *Phaseolus vulgaris* seedlings. Physiol. Plant., 90:353-357.

Tawfik, A. A., R. S. Bekhit, M. R. Emara, A. H. Khereba and Z. A. El-Sharkawy (2003). Effect of cultivar and potassium fertilization rate on total yield, chemical constituent and storability of Jerusalem artichoke tubers. J. Agric. Sci., Mansoura Univ., 28 (1): 301 – 320.

Whistler, R. L., M. L. Woffrom, J. N. Bemiller and F. Shofizadeh (1962). Methods in carbohydrate chemistry analysis and preparation of sugars Published by Academic Press Inc., London, 1: 116 – 117.

Witham, F. H.; D. F. Blaydes and P. M. Devlin (1971). Experiments in plant physiology, pp. 55 – 58, van Nosland Reinhold Co., New York.

Yi, LH.; Y. Q. Zhon and T. M. Hua (2000). The effect of soil moisture on the chlorophyll content and photosynthetic rate of different cotton cultivars. China Cottons, 27 (2): 21 – 22.

تنظيم نمو نبات الطرطوفة باستخدام الألار والبوتاسيوم لمقاومة أضرار الجفاف

صباح محمد أحمد الجمل ، مرفت ادوارد سوريال

قسم النبات الزراعى – كلية الزراعة – شبين الكوم – جامعة المنوفية

الملخص العربى

تم زراعة درنات الطرطوفة (الصنف المحلى) فى الحقل ، خلال الموسم الصيفى لعامى ٢٠٠٧ و ٢٠٠٨ تحت ظروف حالتين للرى وهما الرى العادى وتحت ظروف التعطيش. وأجرى هذا البحث فى مزرعة كلية الزراعة جامعة المنوفية وذلك لدراسة تأثير الآلار (كمؤخر نمو) والبوتاسيوم كسماد معدنى والآلار+ البوتاسيوم بالإضافة إلى معاملة الكنترول على صفات النمو والعلاقات المائية والصبغات والمحتوى الكيماوى للأوراق والدرنات وكذلك المحصول لنباتات الطرطوفة النامية تحت ظروف الرى العادى والتعطيش .

وكانت أهم النتائج المتحصل عليها كالتالى :

- أدى التعطيش إلى نقص معنوى فى طول النبات والوزن الجاف للساق والأوراق ومحتوى الماء النسبى والصبغات وكذلك محتوى السكريات الكلية الذائبة والأحماض الأمينية وعناصر النيتروجين والفوسفور والبوتاسيوم فى الأوراق. بينما حدث العكس لعدد الأفرع الجانبية ومحتوى الأوراق من البرولين ، ولذلك حدث نقص فى المحصول ومكوناته والأنيولين والمادة الجافة للدرنات مقارنة بالرى العادى .
- أدى استعمال الآلار أو البوتاسيوم والآلار + البوتاسيوم إلى زيادة معنوية فى عدد الأفرع الجانبية والوزن الجاف ومحتوى الماء النسبى و كلوروفيل أ + ب والكاروتين والسكريات الذائبة الكلية والأحماض الأمينية والبرولين فى الأوراق وكذلك زيادة السكريات الكلية والأحماض الأمينية والأنيولين والمادة الجافة فى الدرنات مقارنة بالكنترول .
- **C/N ratio** لقد أدى التعرض للتعطيش إلى زيادة فى هذه النسبة زيادة معنوية بالنسبة للكنترول ولكن أدت المعاملات تحت الدراسة وخاصةً الآلار والبوتاسيوم معاً إلى إنقاص هذه النسبة حيث كانت قريبة من نباتات المقارنة حتى تحت ظروف التعطيش .

- أدت المعاملـة بـالآلار أوالبوتاسـيوم أوالاثنـين معـاً إلـى زيـادة فـى محصـول الـدرنات للفـدان مقارنـةً بالكنترول .
- فيما يتعلق بالتفاعل بين حالات الرى والمعاملات تحت الدراسة فقد كان معنويا فى معظم الصفات المدروسة ويُمكن أن نستخلص من هذه الدراسة أن المعاملة بالآلار أو البوتاسيوم أو الآلار + البوتاسيوم قد أدت إلى تحور فى بعض الصفات المورفولوجية حيث أدت إلى زيادة الأفرع الجانبية مع قصر طول النبات وزيادة فى محتوى الماء النسبى و السكريات و الاحماض الامينية والعناصر المعدنية (ن ، فو ، بو) التى أدت إلى تُحسّن صفات النبات تحت الظروف العادية والتعطيش مما يعنى إمكانية استخدام الآلار والبوتاسيوم فى زيادة مقاومة نباتات الطرطوفة للعطش مع زيادة في إنتاجية وجودة المحصول .