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EFFECT OF IRRIGATION WATER QUANTITY AND FOLIAR SPRAY WITH SOME ANTITRANSPIRANTS ON LEAF WATER STATUS, YIELD AND TUBER ROOT QUALITY OF JERUSALEM ARTICHOKE GROWN IN SANDY SOIL

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ABSTRACT: *This experiment was carried out during two successive summer seasons of 2013 and 2014 at EL-Kassasein Res. Station, Hort. Res. Inst.. Agric. Res. Center, Ismailia Governorate to study the effect of irrigation water quantity and foliar spray with some antitranspirants on growth, leaf water status, yield and tuber root quality as well as water use efficiency(WUE) of Jerusalem artichoke cv. Feusa grown in sandy soil using drip irrigation system.*

The results revealed that, irrigation water quantity at rate of 3000m^3/fed. to Jerusalem artichoke plants increased foliage dry weight, number of tuber roots/ plant, average weight of tuber root, yield/ plant and total yield/fed. as well as WUE, whereas irrigation water quantity at 4000 m^3/fed. increased total chlorophyll, total and free water (%) in leaf tissues , transpiration rate, total carbohydrates (%) as well as P and K contents in tuber roots. Meanwhile, irrigation water quantity at 2000 m^3/fed. increased proline amino acid and bound water (%) in leaves , DM% and inulin % in tuber roots.

Moreover, spraying plants with 3 or 6% $CaCO_3$ or with 3 % kaolin recorded the highest values of foliage dry weight , number of tuber roots, average weight of tuber root, yield / plant and total yield /fed. as well as WUE. Whereas, spraying with 6 % $CaCO_3$ led to increase of total chlorophyll, total and free water (%) in leaf tissues. On the other hand, spraying plants with tap water increased proline amino acid and transpiration rate in leaf tissues.

Meanwhile, the interactions between irrigation water quantity at 3000 m^3/fed. and spraying plants with 6 % $CaCO_3$ or 3 % kaolin increased foliage dry weight , number of tuber roots, average weight of tuber root, yield / plant and total yield /fed. As well as WUE but decreased proline amino acid in leaves. Also, the interactions between irrigation water quantity at 3000 m^3/fed. and spraying plants with 6 % kaolin gave the least transpiration rate in leaf tissues.

Key words: *Jerusalem artichoke, water quantity, antitranspirants, free, bound water, proline amino acid, WUE and tuber yield.*

INTRODUCTION

Jerusalem artichoke (*Helianthus tuberosus* L.) originated in North America, and had been introduced to many countries for immediate uses and further development particularly in relation to lower production cost and drought tolerance (Denoroy, 1996). Jerusalem artichoke is used for many purposes such as human food, animal feedstock and ethanol production. Currently, it is important as a source of inulin. Agricultural practices especially irrigation is the primary limiting factor for crop production under arid and semi-arid conditions.

There is a critical need to balance water availability, water requirements and water consumption in conserving water which has become a decisive consideration for agricultural expansion, particularly in arid and semi-arid regions where water is the main limiting factor for plant growth. Moreover, plants are prodigal in the water use because only roughly 5% of water uptake is used for its growth and development while the remaining 95% is lost for transpiration (Prakash, and Ramachandran, 2000). Jerusalem artichoke has been reported non-tolerant to water stress conditions because the drought may strongly influence its dry matter production (Monti *et al.* 2005), but the impact of water stress on inulin yield and WUE remains poorly documented

El-Banna *et al.* (2001) reported that application of 1560 m^3/fed. to potato plants, under drip irrigation system had significantly increased total tuber yield and WUE value compared to 1450 and 1850 m^3/fed. El-Sharkawy and El-Zohiri (2007 indicated that increasing the amount of irrigation water from 4072 m^3/fed. up to 7460 m^3/fed. reflected the highest values of plant height, number of main stem/plant and the fresh weight of plant as well as total tuber yield and its components (number and weight of tuber /plant, average tuber weight and total produced yield/fed.), nitrogen, phosphorus and potassium as well as inulin concentrations of jusralium artichoke. Youssef (2007) reported that irrigation potato plants under drip irrigation in sandy soil with 2500 m^3/fed was the best treatment for improving marketable and total yield. .Magda *et al.* (2007) reported that number of tubers/plant and total produced yield per feddan of Jerusalem artichoke were increased with increasing soil water up to 70 % of field capacity compared with other tested irrigation treatments (40, 60 and 100% of field capacity). Increasing water quantity levels from 1200 to 2400 m^3 / fed. to globe artichoke significantly increased growth characters and chemical components as N, P, K, inulin and total sugars concentrations (Saif Eldeen and Abd El-Hameed, 2010). In this concern, Yang *et al.* (2010) found that yield/ plant and total yield of Jerusalem artichoke were increased with increasing water up to 340 mm. Fresh weight and dry weight of leaf, stem, aboveground biomass and yield of Jerusalem artichoke during irrigation is remarkably higher than without irrigation (Gao, *et al.* 2011). Inulin content of Jerusalem artichoke was increased under 75 % evapotranspiration conditions, while water use efficiency was increased under both 75 and 50 % evapotranspiration conditions (Puangbuta *et al.*, 2015).

It's well known that only 5% of plant water uptake is used for its growth and development, while the remaining 95% is lost by transpiration. Actively growing plants would transpire a weight of water equal to their leaf fresh weight each hour under condition of arid and semi-arid regions if water is supplied adequately (Moftah, 1997). This figure makes it necessary to find way, by which available water could be economically utilized. One way achieve this goal is to reduce the transpiration rate in order to minimize the amount of irrigation water. Antitranspirants (AT'S) are chemical substances with some biological activities could be applied on the transpiration surface of plant to reduce the transpiration rate and mitigate plant water stress by increasing the leaf resistance and diffusion water vapor (Desoky, *et al.*2013).

Application of antitranspirants caused significant increases in yield and its components (Gawish, 1997) on potato and Gawish and Fattahallah, (1997) on taro. El-Ghamriny *et al.* (2005) indicated that the combination between water quantity at the level of 1500 m^3/fed. and spraying with kaolin or $CaCO_3$ at 6% was the superior treatment regarding plant growth and potato tuber weight/plant as well as total yield / feddan. Also, Ezzat *et al.* (2009) found that the best treatments for enhancing dry weight, total yield of potato and water use efficiency were obtained by application of 1600 m^3/ fed. under kaolin antitranspirants .

Thus, the present work aimed to study the effect of quantities of irrigation water and some of antitranspirants on growth, leaf water statues , root tubers yield and quality as well as water use efficiency of Jerusalem artichoke plant grown under sandy soil conditions using drip irrigation system.

MATERIAL AND METHODS

This experiment was carried out during two successive summer seasons of 2013 and 2014 at EL-Kassasein Research Station, Hort. Res. Inst.. Agric. Res. Center, Ismailia Governorate to study the effect of irrigation water quantity and foliar spray with some antitranspirants on growth, leaf water status , yield and tuber root quality as well as water use efficiency of Jerusalem artichoke cv. Feusa grown in sandy soil using drip irrigation system. The physical and chemical properties of experimental soil in the two seasons showed that it was sandy in texture and had 18.02 and 17.98 water holding capacity, 8.92 and 8.01 field capacity, 3.99 and 4.02 wilting point ,0.08 and 0.09 % organic matter, 8.22 and 8.25 pH, 2.01 and 2.04 mmhos/cm EC, 5.22 and 4.98 ppm available N, 3.71 and 3.62 ppm available P and 10.02 and 9.87 ppm available K, respectively. While, the analysis of irrigation water was: 0.54 mmhos/cm for Ec, 7.87 for pH; 1.39, 1.19, 1.68, 0.13, 1.39, 1.13, 2.3 and 1.49 mol/L for Ca, Mg, Na, K, SO_4, Cl, HCO_3 and sodium adsorption ratio, respectively.

This experiment included 15 treatments, which were the combinations between three irrigation water quantities i.e., 2000, 3000 and 4000 m^3/fad. and five rates of antitranspirants, i.e., $CaCO_3$ and Kaolin at 3 and 6 % of each beside control treatment (sprayed with tap water only). These treatments were arranged in a split plot design with three replicates, irrigation water quantities were arranged in the main plots, while antitranspirants rates as foliar spray were distributed in the sup plots.

The experimental unit area was 21 m^2. It contains three dripper lines with 10 m length each and 70 cm distance between the two drippers lines. One line was used to measure the morphological and physiological traits and the other two lines were used for yield determinations. In addition, one row was left between each two experimental units as guard area to avoid the overlapping filtration and foliar sprayed. The plants were sprayed into four times beginning 60 days after transplanting with 15 days intervals.

The tuber roots of Jerusalem artichoke were planted at 50 cm apart on April 24th and 28th during the 1st and 2nd seasons, respectively. Jerusalem artichoke seeds were obtained from El-Kassassien Hort. Res. Station .

All the experimental units received 200m^3 water/*fed* during germination period (30 days). The amounts of irrigation water (m^3/fed.) were added by using water counter and pressure gauge at 0.5 bar, which were calculated and expressed in terms of time based on the rate of water flow through the dripper (2Liter/h.) to give such amounts of water. Irrigation times in every irrigation was 57.7, 89.7 and 121.77 min. for 1800, 2800 and 3800 m^3 water/fed., respectively and irrigation number was 78 for each treatment. The irrigation treatments were added each two days intervals began 24 and 28 May (30 days after planting) and ended 27 and 31 October (10 days before harvesting) in the 1st and 2nd seasons, respectively.

All experimental units received 50 kg N, 22.5 kg P_2O_5 and 96 kg K_2O / fed. as ammonium sulphate (20.6 %N) ,triple super phosphate (15.5 % P_2O_5)and potassium sulfate (48% K_2O), respectively .One third of N and K and all P_2O_5 were added at soil preparation time with 20 m^3 /fed. FYM. The rest of commercial fertilizers (two thirds) were applied weekly at equal doses through the drip-irrigation system, where the first dose was started after four weeks form planting and was continued till flowering stage (14 weeks from planting).

The agricultural practices concerning insect and disease control were conducted according to the recommendation by the Ministry of Agriculture for Jerusalem artichoke commercial production.

Data recorded:

1- Growth characteristics:

Growth traits, leaf water status and leaf chemical analyses were determined at 120 days after planting, while yield determinations were recorded at harvesting on 7 and 11 November in the 1st and 2nd seasons, respectively. Plants of one dripper line for each experimental plot were used to measure the growth traits and the other two lines were used for yield assessment. The recorded data were:

1. **Plant growth**: Three plants from each experimental unit were taken at random to determine plant height (cm), number of branches per plant and foliage dry weight (DW).
2. **Photosynthetic pigments:** Disc samples from the fourth upper leaf of the plant

were randomly taken from every plot to determine chlorophyll a, b, (a+b) and carotenoides in both seasons according to the method described by Wettestein (1957).

3. **Plant water relations**: It was recorded ih the fourth upper leaf of Jerusalem artichoke plant as total, free and bound water as well as transpiration rate according to the method described by Gosev (1960).
4. **Proline amino acid content:** it was determined in dry leaves according to the method described by Bates (1973).
5. **Yield and its components:** It included number of tuber roots/ plant, average tuber root weight (g), tuber roots yield per plant (kg), total yield (ton/ fed.) and the relative total yield (%).
6. **Water use efficiency (WUE.):** It was determined by dividing the tuber roots yield/ *fed* by the water quantity/ *fed* and expressed as kg tuber/ m^3 water (Begg and Turner 1976).
7. **Tuber roots quality:** Tuber roots quality included:

Percentages of N, P and K in tuber roots: Total Nitrogen, phosphorus and potassium percentages were determined in dried and wet digested tuber roots according to the methods described by A.O.A.C. (1990).

Carbohydrate percentage*:* It was determined colorimetrically in dry tubers following the methods described by A.O.A.C. (1990).

Dry Matter ***(%)***: it was determined by drying 100 g of grated tuber tissues at 105 ^oC till constant weight, and then DM (%) was calculated.

Inulin contents: Tuber concentration of inulin was determined according to (Winton and Winton, 1958).

Statistical Analysis: Collected data were subjected to statistical analysis of variance according to Snedecor and Cochran (1980) and means separation was done using L.S.D. at 5 % level of probability.

RESULTS AND DISCUSSION

Plant growth

a- Effect of irrigation water quantity (IWQ)

Data in Table 1 show that irrigation water quantity (IWQ) at 4000 m^3/fed. increased plant height, number of branches/ plant and foliage dry weight of Jerusalem artichoke plants with no significant differences between IWQ at 3000 and 4000 m^3/fed. with respect to foliage dry weight. This means that IWQ at 4000 m^3/fed. increased plant height and number of branches/ plant, whereas IWQ at 3000 m^3/fed. increased foliage dry weight / plant . The increase in dry weight of foliage were about 26.86 and 27.72 % for IWQ at 3000 m^3/fad. and 25.58 and 27.61 % for IWQ at 4000 m^3/fed. over the IWQ at 2000 m^3/fed. in the 1st and 2nd seasons, respectively.

Increasing water quantity applied to Jerusalem artichoke plant led to keep higher moisture content in the soil and this in turn might favored the plant metabolism that leads to increase the plant growth characters and to produce higher dry matter. Water stress, on the other hand, led to a reduction in the uptake of nutritional elements that might causes a disturbance in the physiological processes needed for plant growth (Salter and Goode, 1967). Water stress also affects carbohydrate metabolism, protein synthesis and the activities of many enzymes that may reflect a change in the balance between rates of synthesis and degradation leading to decrease in plant growth and dry matter accumulation (Hamlyn, 1986). On the contrary, Marschner (1995) reported that, under sufficient water conditions, there were decrease in abscisic acid (ABA) and increase in cytokinins (CYT), gibberellins (GA) and indole-3-acetic acid (IAA) reflecting good growth and dry matter content.

Theses results are in agreement with those reported by El-Banna *et al.* (2001) and Anwar (2005) on potato, El-Sharkawy and El-Zohiri, 2007 on Jerusalem artichoke and Saif Eldeen and Abd El-Hameed, 2010 on artichoke which they found that increasing water quantity levels had increased plant growth characters

Table 1: Effect of irrigation water quantity, some antitranspirants and their interactions on growth of Jerusalem artichoke plants during 2013 and 2014 seasons under sandy soil conditions.

Treatments		Plant height (cm)		Number of branches/ plant		Foliage dry weight (g/plant)		Relative increases in dry weight of foliage (%)	
		2013 season	2014 season	2013 season	2014 season	2013 season	2014 season	2013 season	2014 season
Irrigation water quantity		Effect of irrigation water quantity (IWQ m^3/fed.)							
2000 m^3/fed.		191.00	205.13	11.20	9.91	403.27	371.93	00.00	00.00
3000 m^3/fed.		209.93	230.33	13.93	13.98	511.58	475.02	26.86	27.72
4000 m^3/fed.		230.33	254.80	14.67	14.34	506.43	474.62	25.58	27.61
LSD at 5 % level		**12.61**	**11.83**	**0.60**	**0.36**	**10.47**	**10.73**	--	--
Antitranspirants		Effect of antitranspirants							
(Tap water)		191.11	209.78	11.44	10.72	405.27	358.50	00.00	00.00
3 % $CaCO_3$		206.11	221.44	12.89	12.87	456.81	404.40	12.72	12.80
6 % $CaCO_3$		223.67	249.78	13.33	11.81	484.84	438.63	19.63	22.35
3 % Kaolin		216.11	237.67	14.00	14.05	516.51	502.25	27.45	40.10
6 % Kaolin		215.11	231.78	14.67	14.26	505.37	498.84	24.70	39.15
LSD at 5 % level		**8.51**	**10.75**	**0.58**	**0.34**	**10.04**	**12.22**	--	--
Irrigation	Antitranspirants	Effect of interaction treatments							
2000	(Tap water)	170.00	190.00	10.00	9.00	331.79	311.00		
m^3/fed.								00.00	00.00
	3 % $CaCO_3$	190.00	200.00	10.33	9.44	390.67	345.66	17.75	11.14
	6 % $CaCO_3$	205.00	217.33	11.33	9.67	431.88	366.00	30.17	17.68
	3 % Kaolin	198.00	211.00	11.67	10.78	438.29	422.33	32.10	35.80
	6 % Kaolin	192.00	207.33	12.67	10.67	423.73	414.66	27.71	33.33
3000	(Tap water)	200.00	217.33	12.33	10.78	443.81	372.33		
m^3/fed.								33.76	19.72
	3 % $CaCO_3$	205.00	229.33	13.33	15.11	497.52	428.33	49.95	37.73
	6 % $CaCO_3$	222.67	247.00	13.00	11.00	494.51	462.66	49.04	48.77
	3 % Kaolin	212.00	232.00	14.67	16.00	569.88	562.14	71.76	80.75
	6 % Kaolin	210.00	226.00	16.33	17.03	552.18	549.66	66.42	76.74
4000	(Tap water)	203.33	222.00	12.00	12.39	440.22	392.18		
m^3/fed.								32.68	26.10
	3 % $CaCO_3$	223.33	235.00	15.00	14.08	482.24	439.22	45.34	41.23
	6 % $CaCO_3$	243.33	285.01	15.67	14.78	528.14	487.22	59.18	56.66
	3 % Kaolin	238.33	270.00	15.67	15.39	541.37	522.28	63.17	67.94
	6 % Kaolin	243.33	262.00	15.00	15.09	540.19	532.19	62.81	71.12
LSD at 5 % level		**14.74**	**18.63**	**1.01**	**0.60**	**17.40**	**21.18**	--	--

b- Effect of antitranspirants (AT'S)

Presented data in Table 1 indicate that spraying plants with antitranspirants (AT'S) such as $CaCO_3$ or kaolin at 3 and 6 % of each increased plant height, number of branches/ plant and foliage dry weight of Jerusalem artichoke plants compared to control (spraying with tap water) in both seasons.

Spraying Jerusalem plants with 3 or 6 % Kaolin significantly increased plant height, number of branches/ plant and foliage dry weight/plant with no significant differences between spraying with 6 % $CaCO_3$ and 3% or 6 % kaolin with respect to plant height. This means that spraying 3 % kaolin increased plant height , number of branches/ plant, and foliage dry weight / plant. The increase in dry weight of foliage were about 27.45 and 40.10 % for spraying with 3 % kaolin while it were 24.70 and 39.15 % for spraying with 6 %kaolin over the control (tap water) in the 1st and 2nd seasons, respectively.

Increasing of growth parameters resulted from AT'S treatments were attributed primarily to their effect on increasing plant water potential at a time when the growth of that particular plant more depended on water status than on photosynthesis (Boyer,1970).The reduction in transpiration by reflecting material such as kaolin was reported to increase the reflectivity of incident radiation as especially in the visible region, this would lead to reduction of net energy uptake, lower temperature and subsequently decrease in transpiration rate (Abou-Khaled *et al.*,1970).

The obtained results are agreeable with those reported by Gawish and Fattahallah (1997) on taro, El-Ghamriny *et al.* (2005) and Ezzat *et al.* (2009) on potato and Saif Eldeen and Abd El-Hameed (2010) on artichoke.

c- Effect of interaction between IWQ and AT'S

The obtained results in Table 1 illustrate that the interactions between IWQ at 4000 m^3/fed. and spraying plants with 6 % $CaCO_3$ or 3 or 6 % kaolin increased plant height, whereas, the interactions between IWQ at 3000 m^3/fed. and spraying with 6 % kaolin increased number of branches and foliage dry weight/ plant with no significant differences between the interactions between 3000 m^3/fed. and spraying with 3 % kaolin and the interactions between IWQ at 3000 m^3/fed. and spraying with 6% kaolin . This means that the interactions between IWQ at 3000 m^3/fed. and spraying with 3 % kaolin increased foliage dry weight, whereas the interactions between IWQ at 3000 m^3/fed. and spraying with 6 % kaolin increased number of branches/ plant.

The increase in foliage dry weight / plant were about 71.76 and 80.75 % for the interactions between 3000 m^3/fed. and spraying with 3% kaolin and 66.42 and 76.74 % for the interactions between 3000 m^3/fed. and spraying with 6 % kaolin over the interactions between 2000 m^3/fed. and tap water in the 1st and 2nd seasons, respectively.

These results may be due to the role of AT'S to keep more water content in plant tissue and this in turn led to enhance the growth rate. These results are in harmony with those reported by Ezzat *et al.* (2009) on potato and Saif Eldeen and Abd El-Hameed (2010) on artichoke.

Leaf pigments and proline amino acid

a- Effect of IWQ

Data in Table 2 indicate that IWQ at 4000 m^3/fed. increased chlorophyll a, b and total chl (a+b), except chlorophyll b in the 1st season, whereas IWQ at 2000 m^3/fed. increased proline content in leaf tissues in both season. These results are agreed with those reported by Abou El-Khair *et al.*, (2011) on potato

b- Effect of AT'S

The obtained results in Table 2 show that spraying Jerusalem artichoke plants with 6 % $CaCO_3$ significantly increased chlorophyll a, b and total (a+b), except

Table 2: Effect of irrigation water quantity, some antitranspirants and their interactions on leaf pigments (mg/gm DW) and praline amino acid of Jerusalem artichoke plants during 2013 and 2014 seasons under sandy soil conditions.

Treatments		Chlorophyll a		Chlorophyll b		Total chlorophyll		Proline amino acid in leaves [mg/100 gm dry weight]	
		2013 season	2014 season	2013 season	2014 season	2013 season	2014 season	2013 season	2014 season
Irrigation water quantity		Effect of irrigation water quantity (IWQ m^3/fed.)							
2000 m^3/fed.		2.43	2.60	1.59	1.46	4.02	4.06	105.48	94.38
3000 m^3/fed.		2.68	2.73	1.62	1.56	4.31	4.29	91.39	85.22
4000 m^3/fed.		2.99	3.15	1.63	1.67	4.62	4.83	72.51	68.23
LSD at 5 % level		**0.11**	**0.21**	**NS**	**0.08**	**0.23**	**0.17**	**6.09**	**7.57**
Antitranspirants		Effect of antitranspirants							
(Tap water)		2.47	2.61	1.50	1.50	3.97	4.12	114.22	100.60
3 % $CaCO_3$		2.68	2.81	1.62	1.59	4.30	4.40	90.19	83.41
6 % $CaCO_3$		2.89	3.00	1.65	1.61	4.54	4.61	85.83	79.85
3 % Kaolin		2.72	2.84	1.66	1.57	4.37	4.40	81.10	76.27
6 % Kaolin		2.75	2.87	1.64	1.57	4.39	4.43	77.61	72.94
LSD at 5 % level		**0.11**	**0.09**	**0.08**	**NS**	**0.22**	**0.16**	**5.01**	**5.50**
Irrigation	Antitranspirants	Effect of interaction treatments							
2000 m^3/fed.	(Tap water)	2.39	2.55	1.49	1.35	3.88	3.90	130.74	113.23
	3 % $CaCO_3$	2.39	2.56	1.48	1.36	3.87	3.92	110.98	99.18
	6 % $CaCO_3$	2.54	2.70	1.54	1.41	4.08	4.11	101.53	90.46
	3 % Kaolin	2.40	2.58	1.69	1.58	4.09	4.16	95.57	88.20
	6 % Kaolin	2.43	2.60	1.73	1.60	4.16	4.20	88.59	80.87
3000 m^3/fed.	(Tap water)	2.47	2.66	1.46	1.63	3.93	4.29	117.52	102.07
	3 % $CaCO_3$	2.65	2.76	1.75	1.67	4.40	4.43	87.57	86.47
	6 % $CaCO_3$	2.83	2.77	1.73	1.58	4.56	4.35	83.46	85.64
	3 % Kaolin	2.72	2.66	1.65	1.46	4.37	4.12	86.01	77.62
	6 % Kaolin	2.74	2.78	1.53	1.48	4.27	4.26	82.37	74.32
4000 m^3/fed.	(Tap water)	2.55	2.63	1.55	1.53	4.10	4.16	94.41	86.50
	3 % $CaCO_3$	3.01	3.12	1.62	1.73	4.63	4.85	72.02	64.59
	6 % $CaCO_3$	3.29	3.53	1.69	1.83	4.98	5.36	72.50	63.46
	3 % Kaolin	3.03	3.27	1.63	1.66	4.66	4.93	61.72	62.99
	6 % Kaolin	3.07	3.22	1.67	1.62	4.74	4.84	61.88	63.64
LSD at 5 % level		**0.19**	**0.16**	**0.14**	**NS**	**0.38**	**0.28**	**8.66**	**9.51**

chlorophyll b in the 1[st] season, whereas control treatment (spraying with tap water) increased proline content in leaf tissues of Jerusalem artichoke . This mean that spraying with 3 and 6 % $CaCO_3$ or kaolin increased chlorophyll a, b and total (a+b) in leaf tissues compared to control (tap water), whereas the same treatments decreased proline content in leaf tissues compared to control treatment (tap water).

Film forming and reflecting AT'S were found to be non-toxic and have longer period of effectiveness than metabolic types (Gawish, 1992). Moreover, in contrast to most film forming AT'S which are impermeable to CO_2 exchange and thus may reduce the rate of photosynthesis (Moftah, 1997). In addition, a reflective kaolin spray was found to decrease leaf temperature by increasing leaf reflecting and to reduce transpiration rate more than photosynthesis in many plant species grown at high solar radiation levels (Nakano and Liehara, 1996).

The decrement in the amount of proline in leaf tissues after spraying with AT'S may be attributed to that AT'S led to decrease water loss from plant through evaporation and transpiration, and this in turn increase the amount of water content in the tissue, resulting to decrease in proline content (Saif Eldeen and Abd El-Hameed, 2010). The present results are confirmed with those reported by Irmak *et al.*, (1999) on tomato and Tworkoski *et al.* (2002) who indicated that the particle-film-type antitranspirants enhanced chlorophyll biosynthesis and increased the chlorophyll content of bean leaves.

c- Effect of interaction between IWQ and AT'S

Data in Table 2 illustrate that the interactions between IWQ at 3000 m^3/fed. and spraying plants with 6 % $CaCO_3$ increased chlorophyll a, b and total (a+b), except chlorophyll b in the 2[nd] season. The interactions between IWQ at 2000 m^3/fed. and control (spraying with tap water) increased proline amino acid followed by the interactions between IWQ at 3000 m^3/fed. and control (tap water). These results are agreed with those reported by Saif Eldeen and Abd El-Hameed (2010) on artichoke .

Plant water relations and transpiration rate

a- Effect of IWQ

Presented data in Table 3 show that total and free water (%) as well as transpiration rate in leaf tissues increased with increasing IWQ from 2000 up to 4000 m^3/fed., whereas bound water (%)decreased with increasing IWQ. This means that IWQ at 4000 m^3/fed. gave the highest values of total and free water (%) as well as transpiration rate and IWQ at 2000 m^3/fed. gave the highest values of bound water (%) in leaf tissues .

These results agree with those reported by, El-Ghamriny *et al.* (2005), Youssef (2007) , Ezzat *et al.* (2009) and Abou El-Khair *et al.*, (2011) on potato. They found that total and free water as well as transpiration rate in leaf tissues increased with increasing water quantity applied to plants.

b-Effect of AT'S

The obtained results in Table 3 show that spraying plants with AT'S such as $CaCO_3$ and kaolin at 3 and 6 % of each increased total and free water (%) and decreased bound water (%) and transpiration rate compared to control treatment (spraying with tap - water). Spraying plants with 6 % $CaCO_3$ or 6 % kaolin increased total and free water (%), whereas control treatment (spraying with tap water) increased bound water (%) and transpiration rate in leaf tissues in both seasons.

Spraying with antitranspirants led to form a layer on the foliage surface, which in turn decreased transpiration rate, and hence led to keep more water in plant tissues such as total and free water (Ezzat *et. al.*, 2009).

Table 3: Effect of irrigation water quantity, some antitranspirants and their interactions on plant water statues and transpiration rate in Jerusalem artichoke leaves during 2013 and 2014 seasons under sandy soil conditions.

Treatments		Total water (%)		Free water (%)		Bound water (%)		Transpiration rate ($mg/cm^2/h$)	
		2013 season	2014 season	2013 season	2014 season	2013 season	2014 season	2013 season	2014 season
Irrigation water quantity				Effect of irrigation water quantity (IWQ m^3/fed.)					
2000 m^3/fed.		80.79	80.46	44.43	53.09	36.36	27.37	1.705	1.408
3000 m^3/fed.		84.34	82.75	50.97	58.24	33.20	24.51	1.791	1.477
4000 m^3/fed.		85.88	85.34	53.63	62.77	32.25	22.57	1.909	1.567
LSD at 5 % level		**1.38**	**0.90**	**0.58**	**0.88**	**0.57**	**0.27**	**0.038**	**0.026**
Antitranspirants				Effect of antitranspirants					
(Tap water)		81.81	79.94	45.57	53.55	36.24	26.39	2.112	1.786
3 % $CaCO_3$		83.28	82.37	49.45	57.90	33.83	24.47	1.843	1.478
6 % $CaCO_3$		84.28	84.67	51.36	61.17	32.92	23.49	1.733	1.373
3 % Kaolin		83.73	82.50	50.02	56.94	33.44	25.55	1.805	1.440
6 % Kaolin		85.247	84.78	51.97	60.60	33.27	24.18	1.514	1.341
LSD at 5 % level		**1.32**	**0.86**	**0.55**	**0.84**	**0.55**	**0.26**	**0.036**	**0.025**
Irrigation	Antitranspirants			Effect of interaction treatments					
2000 m^3/fed.	(Tap water)	78.20	76.10	40.16	47.15	38.04	28.95	1.987	1.771
	3 % $CaCO_3$	80.75	80.48	46.09	53.38	34.66	27.10	1.771	1.397
	6 % $CaCO_3$	81.96	82.70	46.43	56.45	35.53	26.25	1.670	1.267
	3 % Kaolin	80.42	80.33	44.14	52.98	36.28	27.35	1.728	1.354
	6 % Kaolin	82.66	82.73	45.33	55.52	37.33	27.21	1.365	1.250
3000 m^3/fed.	(Tap water)	82.72	80.28	46.24	54.20	36.48	26.08	2.137	1.678
	3 % $CaCO_3$	83.29	82.09	49.64	57.99	33.65	24.10	1.804	1.460
	6 % $CaCO_3$	84.24	84.32	52.38	61.45	31.86	22.87	1.714	1.414
	3 % Kaolin	84.91	82.55	52.28	57.33	31.83	25.22	1.768	1.426
	6 % Kaolin	86.54	84.53	54.33	60.25	32.21	24.28	1.466	1.352
4000 m^3/fed.	(Tap water)	84.52	83.44	50.32	59.30	34.20	24.14	2.173	1.875
	3 % $CaCO_3$	85.82	84.56	52.64	62.35	33.18	22.21	1.913	1.545
	6 % $CaCO_3$	86.66	86.99	55.28	65.63	31.38	21.36	1.768	1.400
	3 % Kaolin	85.88	84.62	53.65	60.52	32.23	24.10	1.864	1.496
	6 % Kaolin	86.54	87.10	56.26	66.05	30.28	21.05	1.663	1.381
LSD at 5 % level		**2.29**	**1.49**	**0.96**	**1.47**	**0.96**	**0.45**	**0.061**	**0.042**

c- Effect of interaction between IWQ and AT'S

Data in Table 3 illustrate that the interactions between IWQ at 4000 m^3/fed. and spraying plants with 6 % $CaCO_3$ or 6 % kaolin increased total and free water in leaf tissues, whereas the interactions between IWQ at 2000 m^3/fed. and control (spraying with tap water) increased bound water (%) in both seasons. The interactions between IWQ at 4000 m^3/fed. and control (spraying with tap water) increased transpiration rate followed by the interactions between IWQ at 3000 m^3/fed. or at 2000 m^3/fed. and control (spraying with tap water). Similar findings were reported by El-Ghamriny *et al.* (2005) on potato and Saif Eldeen and Abd El-Hameed (2010) on artichoke.

Yield and its components and water use efficiency

a- Effect of IWQ

The obtained results in Tables 4 and 5 illustrate that IWQ at 3000 m^3/fed. significantly increased number of tuber roots/ plant (41.12 and 42.65 tuber roots/ plant), average weight of tuber root (45.95 and 44.35 g/ tuber root), yield / plant (1.893 and 1.891 kg/plant) and total yield/fed. (22.604 and 22.553 ton/fed.) in the 1st and 2nd seasons, respectively. The increases in total yield were about 61.72 and 57.60 % for IWQ at 3000 m^3/fed. and 44.44 and 53.06 % for IWQ at 4000 m^3/fed. over the IWQ at 2000 m^3/fed. in the 1st and 2nd seasons, respectively.

These results may be due to that IWQ at 3000 m^3/fed. increased foliage dry weight (Table, 1), number of tuber roots/ plant and average weight of tuber root (Table 4)

Respecting water use efficiency (WUE), data in Table 5 show that IWQ at 3000 m^3/fed. gave the highest values of WUE (7.535 and 7.518 kg tuber roots/m^3 water in the 1st and 2nd seasons, respectively) followed by IWQ at 2000 m3/fed. (6.989 and 6.955 kg tuber roots/m^3 water in the 1st and 2nd seasons, respectively). Results are harmony with those obtained by El-Sharkawy and El-Zohiri (2007), Magda *et al.* (2007), Yang *et al.* (2010), Gao *et al.* (2011) and Puangbuta *et al.* (2015) on Jerusalem artichoke.

b- Effect of AT'S

Presented data in Tables 4 and 5 illustrate that spraying of Jerusalem artichoke plants with 6 % $CaCO_3$ and 3 or 6% kaolin increased yield and its components as well as WUE compared to control (spraying with tap water) in both seasons. Meanwhile, spraying plants with 6 % $CaCO_3$ and with 3 or 6 % kaolin increased number of tuber roots/ plant, average weight of tuber root, yield / plant and total yield/fed. as well as WUE in both seasons. This means that spraying plants with 6 % $CaCO_3$ and with 3 % kaolin increased yield and its components as well as WUE.

The increases in total yield were about 8.24 and 6.66 % for spraying with 3 % $CaCO_3$, 13.38 and 15.03 % for spraying with 6% $CaCO_3$, 13.33 and 16.38 % for spraying with 3% kaolin and 11.03 and 14.06 % for spraying with 6 % kaolin over the control treatment (spraying with tap water) in the 1st and 2nd seasons, respectively.

It could be suggested that spraying with AT'S led to form a layer on the foliage surface which in turn decreased transpiration rate, and hence led to keep more water in plant tissues that would reflect favorable effect on plant metabolism, photosynthetic rate and increased outward transportation of photosynthesis from the foliage to the tubers (*Ezzat et al.*, 2009). These results coincided with those reported by (Gawish, 1997) on potato , Gawish and Fattahallah, (1997) on taro, El-Ghamriny *et al.* (2005) and Ezzat *et al.* (2009) on potato.

c- Effect of interaction between IWQ and AT'S

The obtained results in Tables 4 and 5 indicate that the interactions between IWQ at 3000 m^3/fed. and spraying with 6 %

Table 4: Effect of irrigation water quantity, some antitranspirants and their interactions on yield and its components and water use efficiency of Jerusalem artichoke during 2013 and 2014 seasons under sandy soil conditions

Treatments		Number of Tuber roots/ plant		Average weight of tuber root (g)		Yield / plant (kg)		Total yield (ton/fad.)		Relative increases in total yield (%))	
		2013 season	2014 season	2013 season	2014 season	2013 season	2014 season	2013 season	2014 season	2013 season	2014 season
Irrigation water quantity		Effect of irrigation water quantity (IWQ m^3/fed.)									
2000 m^3/fed.		33.62	33.55	35.10	35.63	1.203	1.196	13.977	14.310	0.00	0.00
3000 m^3/fed.		41.12	42.65	45.95	44.35	1.893	1.891	22.604	22.553	61.72	57.60
4000 m^3/fed.		40.16	42.01	42.02	43.59	1.690	1.833	20.189	21.903	44.44	53.06
LSD at 5 % level		**0.78**	**0.60**	**0.57**	**0.38**	**0.089**	**0.054**	**0.842**	**0.738**	--	--
		Effect of antitranspirants									
(Tap water)		37.17	38.61	38.49	38.15	1.450	1.484	17.329	17.741	0.00	0.00
3 % $CaCO_3$		37.97	39.08	40.86	40.05	1.568	1.581	18.757	18.912	8.24	6.66
6 % $CaCO_3$		38.67	39.55	41.66	42.77	1.663	1.714	19.649	20.408	13.38	15.03
3 % Kaolin		38.83	40.00	42.13	42.64	1.652	1.725	19.642	20.648	13.33	16.38
6 % Kaolin		38.87	39.78	41.96	42.33	1.642	1.697	19.242	20.236	11.03	14.06
LSD at 5 % level		**NS**	**0.58**	**0.54**	**0.36**	**0.072**	**0.063**	**0.628**	**0.928**	--	--
Irrigation	Antitranspirants	Effect of interaction treatments									
2000	(Tap water)	32.1	33.18	32.18	34.19	1.033	1.114	12.334	12.545		
m^3/fed.										0.00	0.00
	3 % $CaCO_3$	33.1	32.25	35.14	35.47	1.163	1.143	13.922	13.693	12.87	9.15
	6 % $CaCO_3$	34.0	33.33	35.01	35.75	1.297	1.291	14.836	14.651	20.29	16.79
	3 % Kaolin	34.3	34.00	36.14	36.00	1.239	1.224	14.450	14.264	17.16	13.70
	6 % Kaolin	34.6	35.00	37.03	36.74	1.281	1.285	14.344	14.400	16.30	14.79
3000	(Tap water)	40.3	42.38	43.18	40.59	1.744	1.720	20.876	20.596		
m^3/fed.										69.26	64.18
	3 % $CaCO_3$	40.7	43.19	45.27	42.49	1.847	1.835	22.057	21.928	78.83	74.79
	6 % $CaCO_3$	42.0	43.00	47.22	47.80	1.983	2.055	23.676	24.332	91.96	93.96
	3 % Kaolin	41.6	42.66	47.75	46.88	1.989	2.000	23.764	23.891	92.67	90.44
	6 % Kaolin	41.0	42.00	46.33	43.97	1.900	1.847	22.648	22.019	83.62	75.52
4000	(Tap water)	39.1	40.26	40.12	39.68	1.572	1.598	18.776	19.082		
m^3/fed.										52.23	52.11
	3 % $CaCO_3$	40.1	41.79	42.17	42.19	1.694	1.763	20.292	21.115	64.52	68.31
	6 % $CaCO_3$	40.0	42.33	42.76	44.77	1.710	1.895	20.434	22.641	65.67	80.48
	3 % Kaolin	40.6	43.33	42.50	45.04	1.728	1.952	20.711	23.390	67.92	86.45
	6 % Kaolin	41.0	42.33	42.53	46.27	1.744	1.959	20.733	23.288	68.10	85.64
LSD at 5 % level		**1.30**	**1.01**	**0.94**	**0.63**	**0.124**	**0.109**	**1.086**	**1.605**	---	--

Table 5: Effect of irrigation water quantity, some antitranspirants and their interactions on water use efficiency of Jerusalem artichoke during 2013 and 2014 seasons under sandy soil conditions

Antitranspirants / IWQ (m^3/fed.)	Tap water		3 % $CaCO_3$		6 % $CaCO_3$		3 % Kaolin		6 % Kaolin		Average	
Season	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
2000 m^3/fed.	6.852	7.525	7.734	7.607	8.242	7.917	8.028	8.146	٧.٩٦٩	٨.٥٥٦	**7.765**	**7.950**
3000 m^3/fed.	7.456	7.356	7.878	7.831	8.456	8.690	8.487	8.533	8.089	7.864	**8.073**	**8.055**
4000 m^3/fed.	4.941	5.022	5.340	5.557	5.377	5.958	5.450	6.155	5.456	6.128	**5.313**	**5.764**
Average	**6.416**	**6.634**	**6.984**	**6.998**	**7.358**	**7.522**	**7.322**	**7.611**	**7.171**	**7.516**	–	–

$CaCO_3$ or 6 % kaolin increased significantly number of tuber roots/ plant, average weight of tuber root, yield / plant and total yield/fed. as well as WUE in both seasons.

The increases in total yield were about 91.95 and 93.45 % for the interactions between IWQ at 3000 m^3/fed. and spraying with 6% $CaCO_3$, and 92.67 and 90.44 % for the interactions between IWQ at 3000 m^3/fed. and spraying with 3 % kaolin over the interactions between IWQ at 2000 m^3/fed. and control treatment (spraying with tap water) in the 1st and 2nd seasons, respectively.

The interaction treatments between IWQ at 3000 m^3/fed. and $CaCO_3$ at 6 % or kaolin at 3 % gave the highest values of WUE (7.892 and 8.111 kg/m^3 water or 7.921 and 7.964 kg/m^3 water in the 1st and 2nd seasons, respectively). The previous findings coincided with those obtained by Abd El-Aal *et al.* (2008) on eggplant.

Tuber roots quality

a- Effect of IWQ

Presented data in Table 6 illustrate that N,P, K and total carbohydrates contents in tuber roots increased with increasing IWQ to 4000 m^3/fed., whereas DM % and inulin content decreased with increasing IWQ. On the other hand, IWQ at 2000 m^3/fed. increased DM % and inulin content in tuber roots in both seasons.

As it was previously mentioned, increasing the applied water to the soil increased the moisture content that makes minerals more available to the plant, which led to enhance mineral concentration in tuber roots. These results agree with those reported by Anwar (2005), and Youssef (2007) on potato. They found that NPK contents in tubers increased gradually with increasing water supply to the soil.

b-Effect of AT'S

The obtained results in Table 6 indicate that in general, spraying with 6 % $CaCO_3$ and spraying with 3 and 6 % kaolin increased N,P, K, DM, inulin and total carbohydrates in tuber roots.

c- Effect of interaction between IWQ and AT'S

The interactions between IWQ and AT'S had significant effect on tuber root quality , except N content in the 2nd season (Table 6). The interactions between IWQ at 2000 m^3/fed. and spraying with 6 % kaolin increased DM%, whereas the interactions between IWQ at 2000 m^3/fed. and spraying with 6% $CaCO_3$ or with 3 % kaolin increased inulin content.

The interactions between IWQ at 4000 m^3/fed. and spraying with 3 and 6 % or kaolin increased total carbohydrates in tuber roots.

Generally, It could be concluded that, irrigation Jerusalem artichoke plants with 3000 m^3/fed. and spraying plants with antitranspirants 6 % $CaCO_3$ or with 3 % Kaolin were the best treatments for enhancing plant growth, yield and its components as well as water use efficiency under sandy soil conditions.

Table 6: Effect of irrigation water quantity, some antitranspirants and their interactions on tuber root quality of Jerusalem artichoke at harvest during 2013 and 2014 seasons under sandy soil conditions

Treatments		N (%)		P (%)		K (%)		DM (%)		Inulin (%)		Total carbohydrates %	
		2013 season	2014 season	2013 season	2014 season	2013 season	2014 season	2013 season	2014 season	2013 season	2014 season	2013 season	2014 season
Irrigation water quantity		Effect of irrigation water quantity (IWQ m^3/fed.)											
2000 m^3/fed.		1.36	1.46	0.348	0.338	2.62	2.83	22.36	22.66	10.83	11.39	15.50	15.09
3000 m^3/fed.		1.46	1.54	0.348	0.349	2.74	3.02	22.03	22.01	10.51	9.90	15.11	15.87
4000 m^3/fed.		1.53	1.57	0.359	0.374	2.96	3.37	21.98	21.01	9.91	9.60	16.99	16.79
LSD at 5 % level		**0.10**	**NS**	**0.005**	**0.009**	**0.15**	**0.17**	**0.32**	**0.39**	**0.21**	**0.19**	**0.30**	**0.46**
Antitranspirants		Effect of antitranspirants											
(Tap water)		1.34	1.43	0.334	0.334	2.47	2.73	20.61	20.87	9.84	9.68	14.86	14.87
3 % $CaCO_3$		1.41	1.50	0.341	0.349	2.62	2.86	21.93	21.39	10.08	10.18	16.19	15.64
6 % $CaCO_3$		1.47	1.53	0.353	0.363	2.87	3.29	22.36	21.91	11.04	10.70	16.50	16.10
3 % Kaolin		1.48	1.57	0.356	0.370	2.91	3.19	22.70	22.26	10.63	10.48	16.75	16.47
6 % Kaolin		1.54	1.58	0.376	0.354	2.99	3.28	23.02	23.03	10.50	10.43	15.04	16.51
LSD at 5 % level		**0.10**	**NS**	**0.005**	**0.008**	**0.15**	**0.16**	**0.30**	**0.37**	**0.20**	**0.18**	**0.29**	**0.44**
Irrigation	Antitranspirants	Effect of interaction treatments											
2000 m^3/fed.	(Tap water)	1.28	1.34	0.318	0.322	2.31	2.54	21.23	21.49	10.18	10.01	13.18	13.25
	3 % $CaCO_3$	1.35	1.45	0.322	0.327	2.50	2.67	22.14	22.36	10.45	11.34	15.28	14.79
	6 % $CaCO_3$	1.38	1.49	0.365	0.340	2.51	2.99	22.30	22.60	11.49	12.20	16.01	15.09
	3 % Kaolin	1.36	1.51	0.367	0.367	2.88	2.83	22.52	22.95	11.05	11.90	16.40	16.15
	6 % Kaolin	1.41	1.52	0.369	0.334	2.92	3.10	23.63	23.90	10.99	11.50	16.66	16.19
3000 m^3/fed.	(Tap water)	1.32	1.47	0.338	0.338	2.45	2.74	20.45	20.74	10.18	9.65	15.18	15.18
	3 % $CaCO_3$	1.41	1.51	0.339	0.342	2.61	2.78	21.89	21.03	10.34	9.75	16.13	15.35
	6 % $CaCO_3$	1.48	1.52	0.342	0.372	2.70	3.01	22.44	22.55	10.82	10.00	16.56	16.41
	3 % Kaolin	1.50	1.57	0.351	0.354	2.91	3.20	22.61	22.75	10.27	9.80	16.80	16.25
	6 % Kaolin	1.58	1.61	0.370	0.341	3.01	3.35	22.79	22.99	10.95	10.30	10.90	16.18
4000 m^3/fed.	(Tap water)	1.41	1.49	0.347	0.342	2.65	2.92	20.17	20.38	9.16	9.38	16.23	16.18
	3 % $CaCO_3$	1.47	1.53	0.361	0.377	2.76	3.12	21.78	20.79	9.45	9.45	17.18	16.78
	6 % $CaCO_3$	1.54	1.59	0.351	0.376	3.40	3.88	22.35	20.60	10.80	9.90	16.95	16.80
	3 % Kaolin	1.59	1.64	0.350	0.390	2.95	3.53	22.97	21.10	10.57	9.75	17.06	17.03
	6 % Kaolin	1.64	1.62	0.388	0.386	3.05	3.40	22.65	22.20	9.56	9.50	17.56	17.16
LSD at 5 % level		**0.18**	**NS**	**0.009**	**0.014**	**0.26**	**0.29**	**0.53**	**0.64**	**0.35**	**0.32**	**0.51**	**0.77**

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تأثير كمية مياه الرى وبعض مضادات النتح على الحالة المائية للاوراق ، المحصول وجودة الجذور المتدرنة فى الطرطوفة المنزرعة فى ارض رملية

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الملخص العربى

أجريت هذه التجربة خلال موسمى صيف ٢٠١٣ ، ٢٠١٤ وذلك بمزرعة التجارب الزراعية بالقصاصين – معهد بحوث البساتين– مركز البحوث الزراعية– محافظة الاسماعيلية – بهدف دراسة تأثير كمية مياه الرى والرش الورقى ببعض مضادات النتح على النمو ، الحالة المائية للاوراق ، والمحصول وجودة الجذور المتدرنة وكذلك كفاءة استخدام مياه الرى فى الطرطوفة صنف فيوزا المنزرعة فى ارض رملية وباستخدام نظام الرى بالتنقيط .

أدى رى نباتات الطرطوفة بمعدل ٣٠٠٠ م^{3}/فدان لزيادة كل من الوزن الجاف للمجموع الخضرى ، عدد الجذور المتدرنة للنبات ، متوسط وزن الجذر المتدرن ، محصول النبات ، والمحصول الكلى وكذلك كفاءة استخدام ماء الرى . بينما سجلت معاملة الرى بمعدل ٤٠٠٠ م^{3}/فدان الى زيادة كل من الكلورفيل الكلى ، الماء الكلى والحر ومعدل النتح فى أنسجة الورقة ، و محتوى الجذور المتدرنه من الكربوهيدرات الكلية والفوسفور والبوتاسيوم ، على الجانب الاخر فقد أدى الرى بمعدل ٢٠٠٠ م^{3}/فدان الى زيادة محتوى الاوراق من الحمض الامينى البرولين والماء المرتبط ، النسبة المئوية للمادة الجافة والانيولين فى الجذور المتدرنة.

سجل رش النباتات بكربونات الكالسيوم بمعدل ٣ أو ٦ % والكاؤلين بمعدل ٣ % أعلى القيم للوزن الجاف للمجموع الخضرى ، عدد الجذور المتدرنة للنبات ، متوسط وزن الجذر المتدرن ، محصول النبات ، والمحصول الكلى وكذلك كفاءة استخدام ماء الرى . بينما أدى رش النباتات بكربونات الكالسيوم بمعدل ٦%الى زيادة كل من الكلورفيل الكلى ، الماء الكلى والحر فى أنسجة الورقة ، على الجانب الاخر فقد ادى رش النباتات بالماء فقط الى زيادة محتوى الاوراق من الحمض الامينى البرولين ومعدل النتح.

سجلت معاملة التفاعل بين كمية ماء الرى ٣٠٠٠ م^{3}/فدان ورش النباتات بكربونات الكالسيوم بمعدل ٦% أو الكاؤلين بمعدل ٣% الى زيادة الوزن الجاف للمجموع الخضرى ، عدد الجذور المتدرنة للنبات ، متوسط وزن الجذر المتدرن، محصول النبات ، والمحصول الكلى وكذلك كفاءة استخدام ماء الرى وانخفاض محتوى الاوراق من الحمض الامينى البرولين. ايضا فقد اعطت معاملة التفاعل بين كمية ماء الرى ٣٠٠٠ م^{3}/فدان ورش النباتات بالكاؤلين بمعدل ٦% الى الحصول على اقل معدل للنتح فى انسجة الورقة.