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Amelioration of salinity negative effects on two hybrids of cantaloupe by nano potassium application

[1]TantawyA.S., [1]A.M.R.Abdel-Mawgoud, [1]M.F.Zaki and [2]S.A. Saleh

[1]Vegetable Research Dept., National Research Centre, Dokki, Cairo, Egypt.
[2]Horticulture Technology Dept., National Research Centre, Dokki, Cairo, Egypt.

Abstract : Two experiments were conducted during two successive spring seasons in 2014 and 2015 in Al Beheira governorate to investigate the amelioration effects of nano potassium application on two hybrids of cantaloupe plants (*Cucumis melo* L.) namely Baldo and Ideal grown under saline irrigation conditions (EC 5.47 dS/m). Through drip irrigation system, plants were supplied with different potassium compounds namely, i.e. control (without); Agro argentum (8% nano form) (0.5 cm^3/l); Leaf drip K (40% K_2O) (3.0 g/l) and Citra grow K (30% K_2O) (3.0 cm^3/l). The applications took place in the 3rd, 6th, 9th, and 12th week after transplanting. Data showed that salinity affected the growth and production of both hybrids negatively with hybrid Baldo being more affected than hybrid Ideal. Meanwhile all potassium treatments significantly improved all plant growth and production parameters as well as fruit quality. The effects of potassium compounds were in an descending order as Agro argentum (0.5 cm^3/l); Leaf drip K (3.0 g/l) and Citra grow K (3.0 cm^3/l). The interaction between hybrids and potassium treatments showed the same trend of potassium treatments however with different degree of response according to the hybrid. Hybrid Ideal supplied with Agro argentum (0.5 cm^3/l) recorded the highest significant values of all measured parameters. It could be concluded that Potassium application to cantaloupe plants can ameliorate the negative effects of salinity however, the nano form of potassium fertilizer is much more efficient in that effect compared to the conventional chemical form.
***Keywords*:** Cantaloupe, *Cucumis melo,* Nano potassium, Growth, Total yield.

Introduction:

For many decades, salinity has been documented to negatively affect growth and production of many arable crops[1,2,3,4,5].The problem of salinity has been aggregated more in the past years due to misuse of irrigation water and/or over fertilization. Due to water shortages in many region of the world and the Middle East in particular, growers has no choice except to irrigate with marginal quality water and/or reuse of their drainage water. These factors contribute substantially to the deterioration of the cultivated lands and reduce the choices of the crop patterns that can be grown with economical return. This problem is more clear in the new reclaimed lands in Northern parts of the Nile delta. [6]reported that some ninety thousands hectares are saline affected soil in Nile Delta. In those areas of the Northern West of the Nile delta where new reclaimed lands are concentrated, high agricultural investments are usually done. Investors there are always looking for all new techniques that may help reduce salinity effects on their high cash crops.

High cash crops are usually cultivated there such as cantaloupe. However, such fruit crop is highly affected by the fertile status of the soil and salinity level in the root zone in a positive and negative way respectively. The two factors, fertility and salinity, are also related somehow. In one hand, salinity may reduce the availability and/or uptake of some nutrients by the plants and in the other hand, some nutrients may increase the tolerance of the plant to salinity. The net effect of both factors is reflected on the growth and production of the plant as well as the quality of the yield. Application of some nutrients to the plants has been proven to ameliorate salinity effects on the plants[7,8,9]. Among such nutrients is potassium which can increase plant tolerance to salinity[10]. Potassium is an essential plant nutrient with the strongest influence on many quality parameters of fruits and vegetables[11]. It involves in numerous physiological processes that control plant growth, yield and quality parameters such as taste, texture and nutritional/health properties[12,13]. Sufficient K nutrition has been positively associated with increased yields, and fruit quality such as fruit size, soluble solids and ascorbic acid concentrations, improved fruit color, increased shelf life, and shipping quality of many horticultural crops. The efficiency of using potassium to increase plant tolerance to salinity has been increased substantially after the development of nano technology and its application in agriculture. Not only potassium but also phosphorus in the form of nano particles proved to improve the nutrition status of cotton plants grown under water stress conditions[14]. Advancement in nanotechnology has improved ways for large-scale production of nanoparticles of physiologically important metals, which are now used to improve fertilizer formulations for increased uptake in plant cells and by minimizing nutrient loss." Nanostructured fertilizers can increase the nutrient use efficiency through mechanisms such as targeted delivery, slow or controlled release. Nanoparticles have high reactivity because of more specific surface area, more density of reactive areas, or increased reactivity of these areas on the particle surfaces[15]. Earlier[16]mentioned that the chemical, physiological and transport characteristics are changed when nano particles are added to liquids compared to their base fluids such as enhancement of thermal conductivity.

Therefore, the aim of this work is to investigate the efficiency of using nano potassium in ameliorating the negative effects of salinity on cantaloupe plants.

Material and Methods:

Seeds of two hybrids of cantaloupe plants (*Cucumis melo* L.) namely, i.e. Baldo and Ideal were sown on 10thof February 2014 and 2015 and seedlings were transplanted on the 12thof March in the two seasons of 2014 and 2015 in a sandy soil in a private farm in the area of Wadi El-Natrun, Beheira governorate, Egypt. The soil physical and chemical analysis are shown in Tables (1 and 2). Individual transplants were grown at the bottom of ridges 100 cm width at 50 cm apart. Plot area was 1x12= 12 m^2. The drip irrigation system of GR 16 was used and plants were irrigated daily using saline-well water with an EC value 5.47 dS/m and pH of 7.8. The complete chemical analysis of the irrigation water is shown in Table (3).

All standard agricultural practices other than experimental treatments were applied according to the recommendations of the ministry of agriculture, Egypt.

Experimental treatments:

After three weeks from transplanting, plants were supplied through the irrigation system with three types of potassium forms namely Agro argentum (8% in nano form) in a rate of (0.5 cm^3/l); Leaf drip K (40% K_2O) in a rate of (3.0 g/l) and Citra grow K (30% K_2O) in a rate of (3.0 cm^3/l) in addition to control (0). Applications of potassium treatments were at 3, 6, 9 and 12 weeks after transplanting.

Experimental design and statistical analysis:

Experimental plots were arranged in a split plot design with three replicates where hybrids were in the main plot and fertilizer treatments in the sub main plots. The data of treatments were compared, using least significant difference (LSD at 5 %) method as mentioned by[17].

Measurements:

- Plant height, leaf area and fresh and dry weights of leaves at 90 days after transplanting were measured.

- Total yield (ton/fed.) was measured by the end of the season when all ripe fruits were harvested. Average weight of individual fruits (g) was calculated as an average of individual fruits of the third picking. The same fruits were used to measure fruit total soluble solids (TSS).

- Total chlorophyll content at 70 days after transplanting was measured in fully expanded leaves using Minolta SPAD 501 chlorophyll meter. Also, After 70 days from transplanting total contents of K, and Na (%) were chemically analyzed and measured in leaves by Flame-photometer.

Table (1): Soil physical analysis and soil properties of the experimental farm

Soil depth (cm)	Total sand (%)	Silt (%)	Clay (%)	Texture
0-15	58.0	11.5	30.5	Sandy
15-30	57.0	13.0	30.0	Sandy

Table (2): Soil chemical analysis of the experimental farm

Soil depth (cm)	EC (dS/m)	pH	Soluble anions (ppm)			Soluble cations (ppm)			
			CO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
0-30	4.77	7.7	55.85	31.20	10.50	24.00	11.00	10.52	2.18
30-60	4.16	7.4	51.21	22.5	16.10	16.83	6.00	17.80	0.097

Table (3): Chemical analysis of irrigation water (underground well) of the experimental farm

Water sample	EC (dS/m)	pH	Soluble anions (ppm)			Soluble cations (ppm)			
			HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
Average	5.47	7.8	2.50	81.08	16.24	25.29	19.43	54.83	0.45

Results:

1. Effect of hybrids:

In all measured vegetative parameters (plant height, leaf area and fresh and dry weights), hybrid Ideal showed higher values compared to hybrid Baldo (Table 4). All these differences were significant in both growing seasons except for plant height in the growing season of 2015. Similar results have been recorded in total yield and fruit quality in terms of average fruit weight and TSS where hybrid Ideal showed significant higher values compared to hybrid Baldo (Table 5). The chemical analysis of the leaves revealed the same trends for total chlorophyll content and Na and K contents (Table 6) where hybrid Ideal showed higher significant values compared to those recorded in the leaves of hybrid Baldo.

2. Effect of potassium treatments:

The effects of potassium treatments on the performance of all plants were evident and very clear. All potassium treatments showed positive and significant effect on plant vegetative parameters namely, i.e. plant height, leaf area and fresh and dry weights compared to control (Table 4). However, significant differences

Table (4): Effect of hybrids, potassium treatments and the interaction on fresh and dry weight, plant height and leaf area of cantaloupe plants during seasons of 2014 and 2015.

Hybrid	K Treatment	Fresh weight / plant (g)	Dry weight / plant (g)	Plant height (cm)	Leaf Area (cm^2)	Fresh weight / plant (g)	Dry weight / plant (g)	Plant height (cm)	Leaf Area (cm^2)
		2014 Season				**2015 Season**			
Baldo	Agro argentum (0.5 cm^3 / l)	2920.21	583.54	405.25	9900.22	2871.52	571.88	384.09	9855.33
	Leaf drip K (3 g / l)	2802.85	551.32	359.21	9751.84	2760.84	537.14	338.75	9700.71
	Citra grow K (3 cm^3 / l)	2711.63	528.11	322.14	9620.66	2666.12	516.21	301.81	9572.98
	Control	2589.46	504.71	280.89	8945.34	2540.33	494.89	271.33	8906.19
	Mean	2756.04	541.92	341.87	9554.52	2709.70	530.03	323.99	9508.80
Ideal	Agro argentum (0.5 cm^3 / l)	2991.52	598.46	417.52	9983.15	2938.55	587.61	395.11	9935.11
	Leaf drip K (3 g / l)	2868.88	567.91	370.66	9836.59	2826.91	555.12	349.34	9790.09
	Citra grow K (3 cm^3 / l)	2779.91	551.33	333.70	9710.74	2729.48	539.45	313.46	9662.24
	Control	2644.18	519.94	292.08	9025.37	2610.61	506.83	284.52	8978.06
	Mean	2821.12	559.41	353.49	9638.96	2776.39	547.25	326.61	9591.38
Mean of Treatments	Agro argentum (0.5 cm^3 / l)	2955.87	591.00	411.39	9941.69	2905.04	579.75	389.60	9895.22
	Leaf drip K (3 g / l)	2835.86	559.62	364.94	9794.21	2793.88	546.13	344.05	9745.40
	Citra grow K (3 cm^3 / l)	2745.77	539.72	327.92	9665.70	2697.80	527.83	307.64	9617.61
	Control	2616.82	512.32	286.49	8985.36	2575.47	500.86	277.93	8942.13
L.S.D at 5%	Hybrids	14.07	4.22	7.44	10.55	13.11	3.89	5.36	8.17
	Treatments	11.53	1.97	2.60	6.45	8.94	1.57	2.55	4.84
	Hybrids x Treatments	13.23	2.10	4.77	8.23	9.94	1.93	1.98	5.01

were also recorded among potassium treatments where Agro argentum (0.5 cm^3/l) showed the highest effect followed by leaf drip K (3.0 g/l) then Citra grow K (3.0 cm^3/l). These trends were consistent in both growing seasons. Similar trends were recorded in the total fruit yield production and fruit quality in terms of average individual fruit weight and TSS of the fruit (Table 5). In both seasons, all potassium treatments showed significant positive improvement in those parameters compared to control. The effect of potassium source were significantly in an descending order as Agro argentum (0.5 cm^3/l); leaf drip K (3.0 g/l) then Citra grow K (3.0 cm^3/l).Potassium treatments showed also significant positive effects on total chlorophyll and potassium contents and negative effects on sodium content of the leaves compared to control treatment (Table 6). The effect of potassium source was also as mentioned above with the descending order of Agro argentum (0.5 cm^3/l); leaf drip K (3.0 g/l) then Citra grow K (3.0 cm^3/l). These trends were consistent in both seasons with exception of total chlorophyll content in the first season between leaf drip K and Citra grow K treatments which were not significantly different from each other in the season of 2015.

3. Effect of interaction:

The interaction between treatments shows clearly a superior effect of hybrid Ideal with Agro argentum treatment which showed a significant higher difference compared to all treatments including control (Tables 4, 5 and 6). In plant vegetative growth, only plant dry weight in the growing season of 2014 that did not show significant difference between the treatments of Baldo x Leaf drip K and Ideal x Citra grow K. all other treatments were significantly different among each other. In terms of plant production and quality, in the growing season of 2014, the treatment of Ideal x agro argentum was not significantly different than the treatment of Baldo x agro argentum regarding TSS content (Table 5).

In general, both hybrids responded negatively to salinity and positively to potassium treatments in the same manner and with different degree of response being higher with hybrid Ideal than those of hybrid Baldo. Also potassium treatments affected the degree of response in the descending order of Agro argentum (0.5 cm^3/l); leaf drip K (3.0 g/l) then Citra grow K (3.0 cm^3/l) with both hybrids with very few infrequent in significant difference in one of the measured parameters.

Table (5): Effect of hybrids, potassium treatments and the interaction on average fruit weight, total soluble solids and total yield of cantaloupe plants during seasons of 2014 and 2015.

Hybrids	K Treatments	Average fruit weight (g)	T.S.S (%)	Total Yield (Ton /fed.)	Average fruit weight (g)	T.S.S (%)	Total Yield (Ton /fed.)
			2014 Season			2015 Season	
Baldo	Agro argentum (0.5 cm^3 / l)	874.66	16.45	18.21	841.50	16.33	17.52
	Leaf drip K (3 g / l)	782.71	15.37	17.17	749.23	15.21	16.37
	Citra grow K (3 cm^3 / l)	695.45	14.09	16.93	660.11	14.11	16.05
	Control	605.43	13.11	12.84	575.99	13.07	12.14
Mean		739.56	14.85	16.29	706.71	14.68	15.52
Ideal	Agro argentum (0.5 cm^3 / l)	908.09	16.97	19.02	915.77	16.82	19.12
	Leaf drip K (3 g / l)	810.33	15.93	18.45	817.60	15.73	18.66
	Citra grow K (3 cm^3 / l)	734.45	14.83	17.74	740.71	14.61	17.82
	Control	650.89	13.99	13.25	656.40	13.70	13.49
Mean		775.94	15.43	17.12	782.62	15.22	17.27
Mean of Treatments	Agro argentum (0.5 cm^3 / l)	891.38	16.71	18.62	878.64	16.58	18.32
	Leaf drip K (3 g / l)	796.52	15.65	17.81	783.42	15.47	17.52
	Citra grow K (3 cm^3 / l)	714.95	14.46	17.34	700.41	14.36	16.94
	Control	628.16	13.55	13.05	616.19	13.38	12.82
L.S.D at 5%	Hybrids	0.63	0.04	0.07	0.51	0.02	0.10
	Treatments	1.89	0.07	0.12	1.74	0.06	0.15
	Hybrids x Treatments	2.59	1.08	0.19	2.38	1.10	0.26

Table (6): Effect of hybrids, potassium treatments and the interaction on total chlorophyll, Sodium and potassium contents of cantaloupe plants during seasons of 2014 and 2015.

Hybrids	**K Treatments**	**Total chlorophyll** (SPAD)	**Na** (mg / g)	**K** (mg / g)	**Total chlorophyll** (SPAD)	**Na** (mg / g)	**K** (mg / g)
			2014 Season			**2015 Season**	
Baldo	Agro argentum (0.5 cm^3 / l)	51.23	7.42	6.62	50.33	8.35	6.03
	Leaf drip K (3 g / l)	49.11	8.34	5.45	48.21	9.49	5.11
	Citra grow K (3 cm^3 / l)	48.17	8.51	5.33	47.50	9.58	4.86
	Control	38.20	11.72	2.81	38.01	12.11	2.50
	Mean	46.68	9.00	5.05	46.01	9.88	4.63
Ideal	Agro argentum (0.5 cm^3 / l)	53.71	7.20	6.73	53.11	8.16	6.55
	Leaf drip K (3 g / l)	50.82	8.15	5.51	50.60	9.22	5.30
	Citra grow K (3 cm^3 / l)	50.90	8.29	5.42	49.72	9.31	5.13
	Control	39.79	11.47	3.04	39.27	11.97	2.81
	Mean	48.81	8.78	5.17	48.18	9.67	4.95
Mean of Treatments	Agro argentum (0.5 cm^3 / l)	52.47	7.31	6.68	51.72	8.26	6.29
	Leaf drip K (3 g / l)	49.97	8.25	5.48	49.41	9.36	5.21
	Citra grow K (3 cm^3 / l)	49.53	8.40	5.38	48.61	9.45	4.99
	Control	38.99	11.60	2.93	38.64	12.04	2.66
L.S.D at 5%	Hybrids	0.61	0.04	0.02	0.08	0.02	0.01
	Treatments	0.92	0.11	0.07	0.51	0.08	0.04
	Hybrids x Treatments	1.10	0.17	0.12	0.80	0.12	0.09

Discussion:

Nowadays, Egypt is facing many constrains for increasing the national food production to meet the needs of the rapid increasing population. Among those constrains is salinity either in the irrigation water and/or in the soil. Salinity not only narrow the number of crop types that can be cultivated but also affect negatively plant growth and production to some level according to the tolerance level of each crop. This study aimed at alleviating those negative effects by improving the nutrition status of the plant since salinity may cause disturbance to the uptake and metabolism of some nutrients[18]. According to this, supplemental potassium in different forms and concentrations was applied to cantaloupe plants and showed positive results towards our aim. These positive results may be brought about by providing potassium in sufficient amount to meet plant needs compared to control plants since its deficiency causes severe reduction in photosynthetic CO_2 fixation and impairment in partitioning and utilization of photosynthates[19]. The latter suggested that the improvement of K-nutritional status of plants might be of great importance for the survival of crop plants under environmental stress conditions, such as drought, chilling, and high light intensity and this can be applied also to this study.Earlier[20]stated that potassium had a beneficial effect on plant growth, especially on fresh matter production and this is what has been observed also in this study. As fresh weight is a product of dry weight and water content, the latter two parameter must have been improved due to potassium application. Indeed[20] reported that the water status of leaves (water content, pressure potential and osmotic potential) responded more sensitively to potassium supply. This may be due to the role of potassium in controlling the movement of guard cells hence the control of transpiration. As almost all of vegetable crops specially fruit vegetables have above 95% water content, those processes must have been reflected on total production of the plant and this is what was observed in this study in the fresh weight and total yield of the plants supplied with potassium compared to control. Therefore, potassium is essential for plant survival in saline conditions, it is the most prominent in organic plant solute, and as such makes a major contribution to lower the osmotic potential in the stele of roots that a prerequisite for turgor pressure driven solute transport in xylem and the water balance of plants[21]. Another explanation showed that potassium known to be excluded Na^+ ions at absorption sites of plant root surfaces and in turn the growth case under salt stress condition[22]. In other words, it is of great importance to provide potassium in the external medium to maintain the selectivity and turgidity of cell membrane hence the osmotic control of plant cell under saline condition, and consequently the resulted positive response of growth and yield parameters[23].

Among potassium treatments there were significant differences in their effects and this was mainly due to concentrations of the K_2O content. However, the superior effect of Agro argentum (0.5 cm3/l) compared to leaf drip K (3.0 g/l) and Citra grow K (3.0 cm3/l) is due to the form of supplied potassium. This may be due to the fact that the available nutrients present in the conventional fertilizer chemical forms are not fully accessible to plants and in most of the cases the utilization of most of the macronutrient is very low due to their inversion to insoluble form once they are added into the soil. Crop plants typically use less than half of the chemical fertilizers applied[24]. On the other hand, potassium in Agro argentum compound is manufactured in nano-form which is changing the characteristics of the material. Nano form of a particle change its surface area to volume ratio which gives the particle unique characteristics. Nano-particles have high reactivity because of more specific surface area, more density of reactive areas, or increased reactivity of these areas on the particle surfaces. These features simplify the absorption of fertilizers and pesticides that produced in nano scale[25]. Hence, nanostructured fertilizers can increase the nutrient use efficiency through mechanisms such as targeted delivery, slow or controlled release. It has been reported that nano-fertilizers can improve crop productivity by enhancing the rate of seed germination, seedling growth, photosynthetic activity, nitrogen metabolism, and carbohydrate and protein synthesis[26].The results of our study confirm most of these findings where cantaloupe plants improved more under the treatment of supplemental nano potassium compared to the other forms of potassium. This improvement was observed in all recorded parameters including fresh and dry weights and total fruit yield.

Although the two hybrids showed the same trend of response to salinity and potassium treatments, their degree of response differed significantly. This is simply due to the genetic characteristics of each hybrid and its expression in response to the surrounding environment.

Conclusion:

It could be concluded that the application of potassium to cantaloupe plants can ameliorate the negative effect of salinity however, the nano form of potassium fertilizer is much more efficient in that effect compared to the conventional chemical form.

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