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Effect of Calcium Nitrate, Potassium Nitrate and Anfaton on Growth and Storability of Plastic Houses Cucumber (*Cucumis sativus* L. cv. Al-Hytham)

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Abstract: This experiment was conducted during the period of December 2008 to May 2009 using cucumber (*Cucumis sativus* L. cv. Al-Hythum). Three concentrations of Anfaton; 0.00, 600 and 1000 mg L^{-1} and five concentrations of spray solutions; 0.00 mM (control), 10 and 15 mM of $Ca(NO_3)_2$ and 10 and 15 mM of KNO_3 in addition to the combination of anfaton and the two nutrients were used. The results revealed that the higher concentration of anfaton and both concentrations of each spray solution were superior in their effect on plant vegetative characters. Maximum flowers number was recorded by the application of KNO_3, while maximum fruit set was obtained due to the use of anfaton at 1000 mg L^{-1}. Dry weight increased due to spray with the two nutrients. All treatments significantly enhanced cucumber productivity especially at the higher concentration of anfaton and KNO_3. Nitrogen, phosphorous, potassium and calcium content increased as the concentration of anfaton increased. The highest nitrogen percent and calcium content were recorded due to the use of KNO_3 at 15 mM while the highest phosphorous and potassium content was obtained due to the use of 10 and 15 mM of $Ca(NO_3)_2$, respectively. Combination of the higher concentration of anfaton and higher concentration of each nutrient revealed a pronounced effect in most of studied characters. $Ca(NO_3)_2$ treatments produced the least weight loss compare to KNO_3 treatments. Potassium nitrate at both concentrations was the best in keeping the Total Soluble Solid (TSS) at higher levels. Also, all nutrients treatments reduced electrolyte leakage from fruits compare to control especially the $Ca(NO_3)_2$ treatments.

Key words: Cucumber, anfaton, calcium nitrate, potassium nitrate, shelf life

INTRODUCTION

Cucumber (*Cucmus sativus* L.) is one of the vegetable crops which are often grown under covers. It is the main greenhouse vegetable species cultivated in Iraq. Plant growth regulators play an important role in increasing growth and yield of many horticultural crops (Davies, 1995). Many synthetic growth regulators such as gibberellins and auxins have been used to increase fruit set, vegetative growth and total fruits and seeds yield (Sinha and Mandal, 2000; Chaudhary *et al*., 2006; Akter *et al*., 2007; El-al and Faten, 2009).

Relation between nutrition status of plant and fruit yield has been studied in different cucumber cultivars under different growth conditions (Jilani *et al*., 2009; Gomez *et al*., 2003). Potassium plays an important role in many essential processes such as; photosynthesis, synthesis of protein, enzyme activation, phloem transport, maintenance of the osmotic potential of cells in addition to cell extension and walls thickness and stability (Marschner, 1995; Sun-Hong *et al*., 2001; Cherel, 2004). Calcium is involved in cell membrane stability and permeability in addition to its involvement in cell division and elongation (Marschner, 1995; Ashraf, 2004). It was found that the increase of calcium concentration in cucumber growth medium alleviated the reduction of growth and photosynthetic rate due to salinity. Application of supplemental Ca decreased the Na content in plant parts and increased the K content (Dabuxilatu, 2005). Akinci and Simsek (2004) reported that root and shoot growth of cucumber embryos was improved by supplemental potassium nitrate at 10 mM and calcium nitrate at 20 mM. In addition, Watcharasak and Thammasak (2005), Guler and Ibrikei (2002) and Al-Karaki (2000) mentioned that application of potassium had significant effect on vegetative growth, yield and leaf nutrient contents of cucumber and tomato plants. Geetha and Shelly (2002) found that treating seeds of highly susceptible cucumber cultivars with 90 mM of $CaCl_2$ improved plant resistance to diseases. In addition, calcium ions were found to increase the osmoticants contents in green gram seedlings exposed to salinity (Misra and Gupta, 2006).

It is necessary to extent the shelf life and keeps at best quality of the fruits and vegetables during post harvest. In developing countries, losses of fruits and vegetables during post-harvest fluctuate between 20-50% (Okezie, 1998). Storage of cucumber fruits at 24°C compare to 10°C decreased storage life, fresh weigh, ascorbic acid content and firmness (Homin and Kuenwwoo, 1999). Mengel and Kirkby (1987), Hassan (2002) and Khayyat *et al*. (2007) stated that potassium improves fruit chemical composition via increasing protein and starch content, total soluble solids, ascorbic acid content and extends fruit shelf life. Post harvest application of $CaCl_2$ to cucumber fruits stored at 20 or 13°C extend storage shelf life, decrease fresh weight loss, decrease leakage of electrolytes and ascorbic acid content and ethylene production from fruits (Kwon *et al*., 1999). Also, Khalifa *et al*. (2009) concluded that foliar spray with calcium chloride significantly increased yield and improved physical and chemical quality of Anna apple (*Malus domestica* cv. Borkh). The objective of this study was to evaluate the effects of potassium nitrate, calcium nitrate and anfaton on plant growth, yield and fruit storability under cold and room temperature storage.

MATERIALS AND METHODS

A field experiment was carried out in a plastic house at the College of Agriculture/ Al-Qadisiya University during the period of December 2008 to May 2009 to study the effect of spray with calcium nitrate and potassium nitrate and the growth stimulator commercially known as Anfaton (Composition; Naphthalene Acetamide 1.2%, Naphthalene Acetic Acid 0.45%, Inerts 98.35%) in vegetative characters, yield component and leaves and fruits mineral content of cucumber (*Cucumis sativus* L. cv Al-Hytham). The experiment was laid down as a factorial experiment with two factors; nutrient solution and anfaton in Randomized Complete Block Design (RCBD) with three replications. Seeds were sown on December 20 in Jiffy 7 pots in the plastic house at a rate of one seed per pot and transplanted into soil on January 20, 2009. Seedlings were arranged along a 24 m drip irrigation line spaced at 1m between with a planting space of 40 cm. The soil used was silt clay with the following characteristics; silt 40%, clay 37 and sand 23%; EC 3.8 dS m^{-1}; PH 7.3; total organic carbon 2.3%; total nitrogen 0.1; soluble ions: So_4^{-1} 20.1 mg L^{-1}, Cl^{-1} 15 mg L^{-1}, Na^{+1} 1.2 mg L^{-1}, K^{+1} 17.1 mg L^{-1}, Ca^{+2} 13.8 mg L^{-1} and P^{-1} 8.1 mg L^{-1}. Treatments were distributed randomly in the plastic house. Fertilization and other agriculture practices were managed as in the usual way recommended for commercial production of green house cucumber. Treatments included five concentrations of nutrient solutions; 10 and 15 mM of $Ca(NO_3)_2$ and 10 and 15 mM of

KNO_3 in addition to control (0.00 mM) and three concentrations of Anfaton; 0.00, 600 and 1000 mg L^{-1} and the combination of the two factors. Solutions of nutrients and anfaton were prepared with distilled water and sprayed on the foliage with a hand sprayer till a complete wetting. Spraying was conducted three times; first one was after 20 days of transplanting and then every 15 days for the second and third spray. Spraying was applied in early morning with one day interval between the spray with the anfaton and the spray with the nutrients. Cucumber fruits were harvested twice a week from the second week of March until the second week of May 2009, their weight and number were recorded each time. Fruits were harvested in their commercial maturity stage with length of 10-15 cm and free from decay.

Data Recorded

Plant height (cm), number of leaves plant^{-1}, leaf area plant^{-1} (dm^2 plant^{-1}), chlorophyll content and shoot dry weight were determined at the end of the experiment on May 1st, 2009. Also, total number of flowers, percent of fruit setting, number of fruits plant^{-1}, mean fruit weight and total yield of fruits of each plant were obtained. Data were subjected to ANOVA and means were compared using LSD at 5%.

Mineral Content Determination

Fully expanded leaves were taken with the same size from the upper third of plant stem. Leaves were rinsed three times in distilled water then dried in a forced air oven at 70°C for three days. Total nitrogen was determined using the micro-kjeldahl method (Johnson and Urich, 1975). Potassium was assayed using flame spectrophotometer (Allen *et al.*, 1984). Phosphorous was extracted and measured spectro-photometrically according to Jackson (1962) method. Calcium was determined according to the method of Johnson and Urich (1975). Also, fruit samples were taken from plants sprayed with the two nutrients only, cleaned, dried and N, K and Ca contents were determined.

Shelf Life Experiment

Weight loss, changes in TSS and electrolyte leakage during storage at 27 or 10°C were preformed on fruits harvested during the last week of April. Fruits were taken from plants treated with KNO_3 and $Ca(NO_3)_2$. Fruits were put in a polyethylene bag each having 24 holes of a 1-2 mm diameter and stored at the desired temperature and fruit samples were taken every three days for the analysis.

Weight Loss

Weight losses, which were occurred during storage, were calculated from the weight of the fruits before and after storage on the shelf using precision balance.

Total Soluble Solids (TSS)

Fruit samples were passed through a blender in the laboratory and TSS rate of the juice was determined using hand refractometer.

Electrolyte Leakage

Cylinders of mesocarp tissue were excised with a cork borer from the mid part of three fruits per replicate. Mesocarp disks (4 mm) were cut from the mid portion of each cylinder with a stainless razor blade. Samples were cleaned of damaged tissue by rinsing gently with deionized water. Four disks from each treatment were put into 10 mL of aqueous 0.3 mannitol and shaken continuously for 3 h and the electrical conductivity of the solution measured using a digital electrical conductivity meter. Samples were boiled for 30 min and equilibrated to room temperature before obtaining a final conductivity measurement of the solution. Ion leakage was calculated as the percentage of the total electrical conductivity (Khayyat *et al.*, 2009).

RESULTS AND DISCUSSION

The results obtained in this study showed that spraying cucumber plants with calcium nitrate or potassium nitrate and anfaton increased all growth parameters studied including plant height, number of leaves per plant and leaf area (Table 1). Considerable increase in these parameters was observed due to the use of anfaton at 1000 mg L^{-1}. However, there were no significant differences in plant height or number of leaves due to the use of 0 or 600 mg L^{-1} of anfaton. This increase due to the use of anfaton was mainly because of the stimulatory effect of auxin in that material which ultimately alters the physiology of plant. Auxin causes an increase in plant height due to stimulation of cell extension and softens the cell wall by increasing plasticity (Davies, 1995).

Foliar application of $Ca(NO_3)_2$ and KNO_3 has also improved plant growth in compare to control. This result can be correlated to previous findings in which plant growth and yield were improved due to foliar application of potassium and calcium compounds under salinity stress conditions (Kaya *et al.*, 2003a; Ahmad and Jabeen, 2005; Hussein *et al.*, 2008). The higher concentration of both nutrients was superior in its effect. Interaction between the two nutrients and anfaton showed also significant effects. $Ca(NO_3)_2$ at 15 mM along with anfaton at 1000 mg L^{-1} spray registered the maximum plant height (195 cm), while the least plant height recorded at control treatment. The increased plant height might be attributed to increased cell division and cell elongation induced by the interaction between calcium nitrate and auxin. For number of leaves per plant and leaf area, the combination of calcium nitrate at both concentrations along with anfaton at 1000 mg L^{-1} registered the highest values while the control treatment gave the least values.

Maximum flowers yield was recorded by the application of potassium nitrate at both concentrations. This might be attributed to improvement in nutrient availability influenced by potassium which helped to enhance growth of plant, resulting in higher flower yield per plant. Anfaton application has no effect on flowers yield which is reasonable due to the effect of auxin on flower set rather than differentiation. With regard to the interaction

Table 1: Effect of spray with calcium nitrate or potassium nitrate and anfaton and their combination on plant height, number of leaves per plant and leaf area (dm^2 $plant^{-1}$) of cucumber cv. Al-Hytham

	Anfaton conc. (mg L^{-1})											
	Plant height (cm)				No. of leaves $plant^{-1}$				Leaf area (dm^2 $plant^{-1}$)			
Nutrient solution conc. (mM)	0	600	1000	Mean	0	600	1000	Mean	0	600	1000	Mean
0	161.0	164	175.0	166.66	32.50	35.0	44.16	37.00	70.40	71.75	68.42	70.19
10 $Ca(NO_3)_2$	172.0	165	180.0	172.33	37.33	32.5	49.66	39.33	75.46	73.34	94.93	81.24
15 $Ca(NO_3)_2$	178.0	180	195.0	184.33	36.00	42.5	49.16	42.33	77.96	85.52	94.63	86.03
10 KNO_3	170.0	166	176.0	170.66	36.83	37.0	47.50	40.00	77.04	79.45	91.19	82.56
15 KNO_3	170.0	180	186.0	178.66	35.10	37.0	45.50	39.00	77.60	91.39	90.78	86.59
Statistical analysis												
Mean	170.2	171	182.4		35.20	36.6	46.80		75.69	80.29	87.99	
LSD at 5%												
Anfaton conc.	5.8				3.10				4.95			
Nutrient conc.	6.1				3.30				3.10			
Interaction	9.7				5.90				5.95			

Table 2: Effect of spray with calcium nitrate or potassium nitrate and anfaton and their combination on flowers number per plant and fruit setting of cucumber cv. Al-Hytham

	Anfaton conc. (mg L^{-1})							
	Flowers No. $plant^{-1}$				Percent fruit setting			
Nutrient solution, conc. (mM)	0	600	1000	Mean	0	600	1000	Mean
0	52.16	47.50	44.66	48.10	31.60	39.75	50.86	40.73
10 $Ca(NO_3)_2$	50.00	48.66	50.16	49.60	30.90	40.53	55.90	42.44
15 $Ca(NO_3)_2$	55.50	51.16	50.66	52.44	30.55	34.66	56.07	40.42
10 KNO_3	50.50	55.50	60.00	55.30	32.40	40.78	54.92	42.70
15 KNO_3	49.00	56.66	60.00	55.20	38.60	48.00	59.30	48.63
Statistical analysis								
Mean	51.43	51.89	53.09		32.81	40.74	54.81	
LSD at 5%								
Anfaton conc.	N.S				5.75			
Nutrient conc.	3.65				3.40			
Interaction	5.33				6.50			

Table 3: Effect of spray with calcium nitrate or potassium nitrate and anfaton and their combination on chlorophyll content and shoot dry weight (%) of cucumber cv. Al-Hytham

	Anfaton conc. (mg L^{-1})							
	Chlorophyll content (mg g^{-1} f.w)				Shoot dry weight (%)			
Nutrient solution conc. (mM)	0	600	1000	Mean	0	600	1000	Mean
0	0.432	0.466	0.399	0.432	13.20	13.03	12.10	12.14
10 $Ca(NO_3)_2$	0.456	0.411	0.472	0.446	14.40	14.66	12.85	13.97
15 $Ca(NO_3)_2$	0.497	0.501	0.468	0.488	17.50	17.12	14.30	16.30
10 KNO_3	0.552	0.509	0.563	0.541	15.60	15.60	14.60	15.26
15 KNO_3	0.592	0.621	0.639	0.617	15.10	13.27	13.15	13.84
Statistical analysis								
Mean	0.505	0.501	0.508		15.16	14.77	13.40	
LSD at 5%								
Anfaton conc.	N.S				1.09			
Nutrient conc.	0.120				1.16			
Interaction	0.121				1.49			

between the nutrients concentrations and anfaton, maximum flowers number was obtained due to application of potassium nitrate at both concentrations along with anfaton at 1000 mg L^{-1} (60 flower $plant^{-1}$), while the lower number of flowers per plant was due to the use of anfaton at 1000 mg L^{-1} without the spray with nutrients. Percent fruit setting was significantly affected by the two concentrations of anfaton and the higher concentration of KNO_3. Maximum fruit set was obtained due to the use of 1000 mg L^{-1} of anfaton (54.81%) (Table 2). This effect might be due to the stimulatory action of auxin which accumulate in the ovary of flowers and increase their set.

Anfaton at both concentrations has no significant effect on chlorophyll content in leaves. Under 15 mM of KNO_3, chlorophyll content recorded the highest content of 0.617 mg g^{-1} f.w followed by 10 mM of KNO_3 of 0.541 mg g^{-1} f.w. Minimum content was observed at control treatment (Table 3). This result comes in accordance with the results of El-Tohamy *et al.* (2006), who found that spray of pepper with potassium chloride or calcium chloride maintained higher total chlorophyll content in leaves. Interaction between the two factors showed significant differences in chlorophyll content with the highest content obtained due to the use of 15 mM of KNO_3 along with 1000 mg L^{-1} of anfaton. Shoot dry weight decreased significantly at the higher concentration of anfaton. Plants sprayed either with 15 mM of $Ca(NO_3)_2$ or 10 mM of KNO_3 accumulated more dry weight (16.30 and 15.26%, respectively) than the other treatments. Regarding the interaction, different combinations of the two factors were significantly differing in their response. The highest shoot dry weight was observed due to the spray with $Ca(NO_3)_2$ at 15 mM with 0 mg L^{-1} of anfaton (17.5%), while the lowest shoot dry weight was obtained at 1000 mg L^{-1} anfaton with no spray with the two nutrients. It was found previously that supplementing irrigation water with $Ca(NO_3)_2$ resulted in an increase in dry matter and chlorophyll concentrations over plants irrigated with saline water in both melon and cucumber (Kaya *et al*., 2002). Same results were found with KNO_3 on pepper which overcame the effects of high salinity on fruit yield and whole plant biomass (Kaya and Higgs, 2003) and on strawberry by using potassium sulphate (Khayyat *et al*., 2009).

The treatments also significantly enhanced cucumber productivity as average fruit weight, total number of fruits per plant and total yield (Table 4). The results indicated that the higher leaves. The increase in total nitrogen of plants can be explained by the positive concentration of anfaton was superior in increasing the value of the three parameters. With regard to the use of the two kinds of nutrients, it was obvious that potassium nitrate at both concentrations was more effective than calcium nitrate in increasing weight and number of fruits and total yield. The increase in these parameters as a result of the use of KNO_3 could be attributed to the increase of photosynthesis production due to the more chlorophyll biosynthesis coupled with the use of KNO_3. The role of KNO_3 foliar spray in improving fruit weight and yield has been reported by other workers (Kaya and Higgs, 2003).

When compared to control, the total N percent of plant leaves increased significantly due to the use of 1000 mg L^{-1} of anfaton in compare to control treatment (Table 5). However, there were no significant differences in nitrogen percent between the two concentrations of anfaton. Potassium nitrate at both concentrations was more pronounced in increasing the total N percent of plant effect of potassium foliar application on plant growth and metabolism or may be due to that K increased efficiency of the plant for the utilization of nitrogen (Adam *et al*., 1996; Fawzay *et al*., 2007). Data in the same table show significant interaction between the used anfaton and the two nutrients on nitrogen percent. The highest nitrogen percent was obtained using KNO_3 at 15 mM along with anfaton at 1000 mg L^{-1} (6.16%) while the lowest percent was obtained at control treatment. The significance of the interaction may be due to the positive effect of both compounds. It seems that leaves phosphorous content was not affected by the two concentrations of anfaton. However, it was found previously that auxin (2,4-D) treatments increased the seed N, P and K contents but their contents in stalk were higher in cycocel treatment rather than 2, 4-D treatment in pigeon pea

Table 4: Effect of spray with calcium nitrate or potassium nitrate and anfaton and their combination on average fruit weight (g), total number of fruits per plant, and total yield (kg $plant^{-1}$) of cucumber cv. Al-Hytham

	Anfaton conc. (mg L^{-1})											
	Average fruit weight (g)				Total No. of fruits $plant^{-1}$				Total yield (kg $plant^{-1}$)			
Nutrient solution conc. (mM)	0	600	1000	Mean	0	600	1000	Mean	0	600	1000	Mean
0	103.20	101.2	103.25	102.55	14.90	20.60	20.9	18.80	1.537	2.084	2.157	1.926
10 $Ca(NO_3)_2$	96.60	105.6	111.40	104.53	14.80	19.90	28.3	21.00	1.429	2.101	2.762	2.097
15 $Ca(NO_3)_2$	105.40	105.5	106.50	104.13	17.80	16.70	23.4	19.30	1.876	1.678	2.492	2.015
10 KNO_3	111.00	121.4	118.45	116. 95	16.00	20.50	26.8	21.10	1.776	2.488	3.174	2.479
15 KNO_3	114.50	116.2	124.50	118.40	20.10	20.70	28.6	23.33	2.301	2.488	3.174	2.645
Statistical analysis												
Mean	106.14	108.98	112.82		16.72	19.68	25.6		1.783	2.167	2.751	
LSD at 5%												
Anfaton conc.	N.S				4.55				0.290			
Nutrient conc.	6.45				3.30				0.390			
Interaction	8.66				4.95				0.650			

Table 5: Effect of spray with calcium nitrate or potassium nitrate and anfaton and their combination on nitrogen (%) and phosphorous (mg g^{-1} f.w) in leaves of cucumber cv. Al-Hytham

	Anfaton conc. (mg L^{-1})							
	Nitrogen (%)				Phosphorous (mg g^{-1} f.w)			
Nutrient solution conc. (mM)	0	600	1000	Mean	0	600	1000	Mean
0	4.66	4.64	5.14	4.81	4.93	5.11	5.05	5.03
10 $Ca(NO_3)_2$	4.58	5.50	5.93	5.33	5.73	5.75	5.84	5.77
15 $Ca(NO_3)_2$	5.24	5.30	5.27	5.27	5.11	5.45	5.78	5.44
10 KNO_3	5.23	5.40	5.75	5.46	5.42	5.39	5.65	5.48
15 KNO_3	5.61	5.83	6.16	5.86	5.99	5.22	5.55	5.58
Statistical analysis								
Mean	5.06	5.33	5.65		5.43	5.38	5.57	
LSD at 5%								
Anfaton conc.	0.42				N.S			
Nutrient conc.	0.60				0.40			
Interaction	0.88				0.68			

Table 6: Effect of spray with calcium nitrate or potassium nitrate and anfaton and their combination on potassium (mg g^{-1} f.w) and calcium (mg g^{-1} f.w) content in leaves of cucumber cv. Al-Hytham

	Anfaton conc. (mg L^{-1})							
	Potassium (mg g^{-1} f. w)				Calcium (mg g^{-1} f.w)			
Nutrient solution conc. (mM)	0	600	1000	Mean	0	600	1000	Mean
0	36.10	44.30	46.3	42.23	9.83	10.80	10.52	10.38
10 $Ca(NO_3)_2$	48.56	50.20	44.1	47.60	12.45	11.30	9.910	11.22
15 $Ca(NO_3)_2$	54.20	52.30	47.6	51.36	10.82	10.95	11.08	10.95
10 KNO_3	41.50	52.60	60.7	51.60	9.34	11.30	13.77	11.47
15 KNO_3	45.10	50.20	55.3	50.20	11.50	11.60	11.60	11.56
Statistical analysis								
Mean	45.08	49.92	50.8		10.78	11.19	11.37	
LSD at 5%								
Anfaton conc.	2.20				0.45			
Nutrient conc.	1.95				0.74			
Interaction	2.70				1.10			

(*Cajanus cajan* L.) genotypes (Kashyap *et al*., 2003). Foliar application of potassium nitrate and calcium nitrate resulted in significant increase in cucumber leaves phosphorous content. The highest increase was reached by using $Ca(NO_3)_2$ at 10 mM (5.77 mg g^{-1} D.W).

For the interaction between the anfaton and the two nutrients, it was evident that the combination of 15 mM of KNO_3 with 0 mg L^{-1} of anfaton gave the highest phosphorous content in plant leaves (5.99 mg g^{-1} D.W.); while the control treatment gave the lowest content (4.93 mg g^{-1} D.W). From these results it can be noted that higher content of N and P were recorded by using higher concentration of potassium nitrate which emphasize the role of K in plant metabolism and its involvement in many associated processes (Marschner, 1995). This result comes with an agreement with previous ones reported by other investigators on eggplant (Fawzay *et al*., 2007) and sweet pepper (Fawzay *et al*., 2005). Potassium and calcium content in cucumber leaves increased with the increase of anfaton concentration (Table 6). Also, they were increased over the control due to the use of both nutrient spray solutions. Such results are in agreement with the results reported by Nadia (2006) and Najaich *et al*. (1999) who found that uptake of phosphorous and potassium was highest with increasing potassium levels applied. In addition, it was found that foliar application of calcium chloride significantly increased leaf content from nitrogen, phosphorous, potassium and calcium in Anna apple trees (Khalifa *et al*., 2009). On the other hand, potassium foliar application had no significant effect on phosphorous percentage

Table 7: Effect of calcium nitrate and potassium nitrate on fruits dry matter and N, K, and Ca content of cucumber cv. Al-Hytham

Nutrient solution conc. (mM)	Dry matter (%)	N (%)	K (mg g^{-1} D.W)	Ca (mg g^{-1} D.W)
0	3.95	4.35	54.15	11.10
10 $Ca(NO_3)_2$	4.15	4.50	62.20	14.50
15 $Ca(NO_3)_2$	4.20	4.58	68.25	16.60
10 KNO_3	4.00	5.20	67.52	16.66
15 KNO_3	3.90	5.20	76.35	16.90
LSD at 5%	0.18	0.32	5.55	2.40

(El-Bassiony, 2006; Adam *et al*., 1996) while foliar spray of $Ca(NO_3)_2$ increased calcium and nitrogen content in cucumber and melon plants (Kaya *et al*., 2002). In *Vigna unguiculata* L. Walp. it was found that foliar application of calcium nitrate was effective in partially alleviating adverse effect of sodium chloride (Amador *et al*., 2006).

It is worthy to note that potassium content was obviously increased with the increasing $Ca(NO_3)_2$ concentrations in the spray solution from 10 to 15 mM while Ca content decreased at the same time. Also, Ca content was higher under KNO_3 treatments rather than $Ca(NO_3)_2$ treatments. These results are in agreement with previous ones on barley (Nadia, 2006). However, there were no significant effects of increasing KNO_3 concentrations from 10 to 15 mM on Ca content. The relationships between Ca and K contents are complicated, they can be either antagonistic or synergistic (Gunes *et al*., 1998). In our trial the synergistic relationships of Ca and P become evident and this result comes in agreement with the result of Dabuxilatu (2005) who found that the application of supplemental Ca increased K content in soybean and cucumber plants. The data also show that the interaction between the two nutrients and anfaton revealed significant effect on potassium and calcium content in cucumber leaves. The highest potassium and calcium content was obtained by using KNO_3 at 10 mM and anfaton at 1000 mg L^{-1} (60.7 and 13.77 mg g^{-1} D.W, respectively) while the lowest was obtained under control treatment (36.1 and 9.83 mg g^{-1} D.W for K and Ca, respectively).

The average dry matter of fruits was between 3.90-4.20% (Table 7). Calcium nitrate treatments were more effective in increasing the percent dry mater significantly. It was obvious that potassium nitrate at both concentrations increased significantly the nitrogen percent in cucumber fruits while calcium nitrate had no effect. Potassium and calcium content in fruits increased significantly due to the use of both nutrients. However, the higher concentration of both nutrients was more effective in increasing potassium content in fruits than the other concentration.

Cucumber fruits are very sensitive to post-harvest storage conditions and their quality is highly reduced after harvesting because of the loss of water, shriveling and yellowing. Nutrient element applications during plant growth could help in storage improvement (Baker and Gawish, 1992). Storage temperature as well as other keeping quality treatments is very important factors in maintaining quality and shelf life of fresh produce. The senescence symptoms of fresh produce could be reduced by cold storage. Figure 1a and b show the effect of storage temperature on weight loss of fruits which were taken from plants sprayed with different concentrations of KNO_3 and $Ca(NO_3)_2$. Weight loss increased with the extension of storage time. Overall weight loss was greater at 27°C compare to that at 10°C. This result is agreed with previous ones on cucumber (Kasim and Kasim, 2008) and white and violet salad sovay plant (Kim *et al*., 2004). Low temperature prolongs storage life by reducing respiration rate and senescence (Luna-Guzam *et al*., 1999; Roura *et al*., 2000). It was found that storage life of cucumber was greatest when fruits were packed in perforated polyethylene and stored at 10°C and this temperature also gave the highest fresh weight, ascorbic acid content and firmness of fruits (Homin and Kuenwoo, 1999).

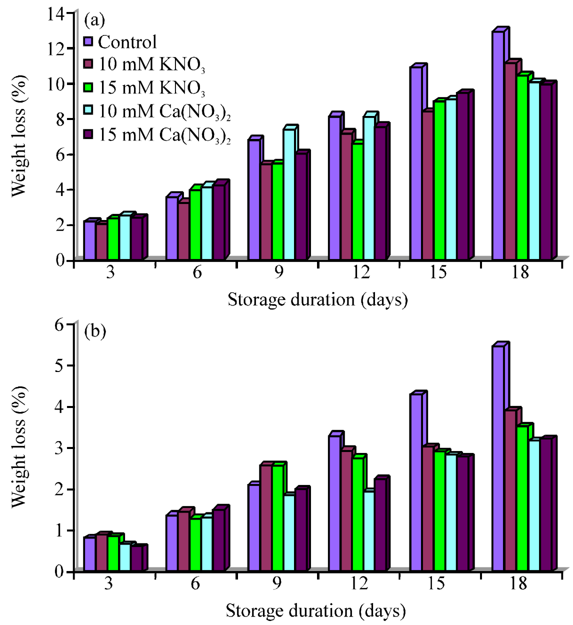

Fig. 1: Weight losses during storage of cucumber fruits at 27°C (a) or 10°C (b) which were taken from plants treated with KNO_3 or $Ca(NO_3)_2$

Total Soluble Solids (TSS) for cucumber fruits at harvest was between 4.5 to 4.75%. Storage at 27°C for 18 days causes dramatic decrease in TSS while storage at 10°C had less effect (Fig. 2a, b). This result comes with an agreement with the result of Homin and Kuenwoo (1999). It seems that KNO_3 at both concentrations was the best in keeping the level of about 3.9-4.1%.

Electrolyte leakage of fruits was increased obviously during storage time. The result in Fig. 3a and b show that electrolyte leakage was less when fruits stored at 10°C in compare to that at 27°C. Same results were reported early in cucumber discs stored at 10°C (Kasim and Kasim, 2008). Also, all nutrients treatments reduced leakage compare to control treatment. $Ca(NO_3)_2$ treatments were more effective in reducing leakage. These results come in agreement with the results of Kaya *et al.* (2002, 2003b) who found that supplementing $Ca(NO_3)_2$ restored membrane permeability in melon, cucumber and strawberry. In addition, it was found previously that less electrolyte leakage was observed from cucumber fruits treated with $CaCl_2$ and fruits had good cell wall structure and membrane integrity during storage (Kwon *et al.*, 1999). In pepper, membrane permeability was reduced by supplementary KNO_3 (Kaya and Higgs, 2003). In tomatoes, it was found that fruits dipped in 2% potassium nitrate maintain good quality (Bombelli and Wright, 2006). In addition, in cantaloupes, it was found that dipping fresh-cut cylinders from the fruits in calcium salts at concentration of 2.5% maintained firmness throughout cold storage (Luna-Guzam and Barrett, 2000).

It is worthy to note that after two weeks of storage at room temperature fruits deteriorate and become unacceptable to consume while those stored at 10°C retain acceptable quality. This result is with an agreement with previous ones who recommend the storage period of Beit Alpha cucumber to be up to 14 days at 10°C without significant loss in quality (Villalta *et al.*, 2003).

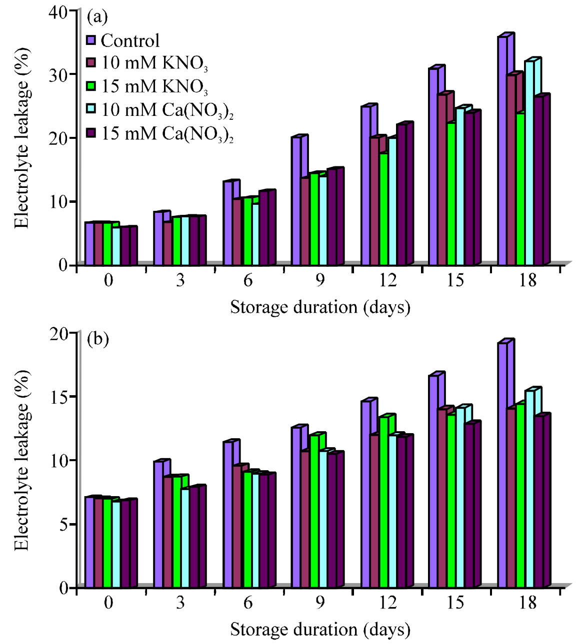

Fig. 2: Electrolyte leakage during storage of cucumber fruits at 27°C (a) or 10°C (b) which were taken from plants treated with KNO_3 or $Ca(NO_3)_2$

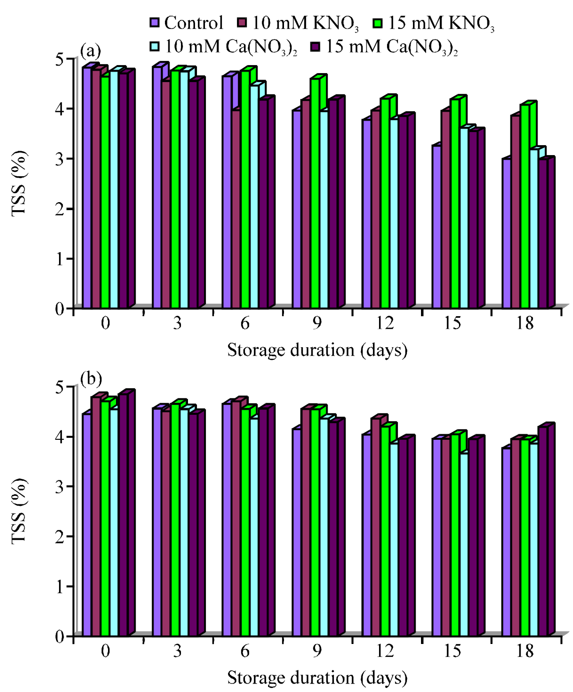

Fig. 3: Total Soluble Solids (TSS) during storage of cucumber fruits at 27°C (a) or 10°C (b) which were taken from plants treated with KNO_3 or $Ca(NO_3)_2$

In conclusion, anfaton at higher concentration and both concentrations of the two nutrients have positive effect in most of characters studied. The higher content of N, Ca, P and K was obtained due to the use of the higher concentration of spray nutrients. Also, spray plants with $Ca(NO_3)_2$ and KNO_3 was of beneficial in controlling fruit weight loss and maintaining TSS at higher level during storage.

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