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ORIGINAL ARTICLES

Changes in growth, yield and fruit quality of cucumber (*Cucumis sativus* L.) in response to foliar application of calcium and potassium nitrate under plastic house conditions.

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ABSTRACT

This study was designed to determine the influence of foliar application of calcium and potassium nitrate concentrations (0,10 and 15 mM) on growth, yield and fruit quality of cucumber grown under plastic house conditions. The results revealed that, the higher concentration (15 mM) of each spray solution of calcium and potassium nitrate was superior in improving growth, mean fruit weight and total yield compared to the control. The highest uptake of N, P, K and Ca in plant tissues was recorded due to the foliar application of KNO_3 at 15 mM. While, the highest P and K content of fruits was obtained by foliar application of 10 mM of $CaNO_3$ and 15 mM of KNO_3 respectively. In the same respect, KNO_3 at both concentrations was the best in increasing TSS of cucumber fruits.

Key words: Cucumber, calcium and potassium nitrate, quality and yield.

Introduction

Cucumber (*Cucumis sativus* L.) is one of the vegetable crops which are often grown under covers. It is the main plastic houses vegetable species cultivated in Egypt.

Relation between nutrition status of plant and fruit yield has been studied in different cucumber cultivars under different growth conditions (Gomes *et al.*, 2003 and Jilani *et al.*, 2009).

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 as indicated by Marschner (1995) and Cherel (2004).

Calcium is involved in cell membrane stability and permeability in addition to its involvement in cell division and elongation (Ashraf, 2004). Application of supplemental Ca decreased the Na content in plant parts and increased the K content (Dabuxilatu, 2005). Moreover, Akinici and Simsek (2004) reported that, root and shoot growth of cucumber was improved by supplemental potassium nitrate at 10 mM and calcium nitrate at 20 mM. In addition, Guler and Ibrikci (2002) and Watcharasak and Thammasak (2005) mentioned that, the application of potassium nitrate had significant effect on growth, yield and fruit nutrient contents of cucumber and tomato plants. On the other hand, Al-Hamzawi (2010) found that, maximum flowers number and the highest N and Ca content in fruits as well as, TSS were obtained by the application of KNO_3. Also, foliar application of $Ca(NO_3)_2$ at high concentrations significantly increased P and K content in cucumber fruits.

In this study, we examined the influence of foliar application of calcium and potassium nitrate concentrations (0,10 and 15 mM) on growth, yield and fruit quality of cucumber grown under plastic house conditions.

Material and Methods

Two experiments were conducted in plastic house at the Experimental Station of National Research Centre at Nubaria region, North Egypt during two successive seasons 2011 and 2012. Physical and chemical properties of the soil are presented in Table (1).

Table 1: Physical and chemical properties of the experimental soil.

Physical properties							
Sand		Clay	Silt	Texture	F.C. %	W.P. %	
90.08		9.26	0.66	Sandy	16.57	5.25	
Chemical analysis							
E.C. M/m	pH	Meq/ L					
		Ca	Mg	Na	K	Hco3	Cl
1.7	8.2	7.02	0.527	0.982	0.31	1.3	0.566

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Cucumber transplants (Hybrid F1 Pracodo cv.) were transplanted in the third week of December in both seasons on one side of each ridge 50 cm apart. The agricultural practices were followed as recommended. Drip irrigation system was used. The treatments were arranged in a completely randomized block design with three replicates.

Treatments included foliar application of 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 (sprayed only with distilled water). Nutrient solutions were prepared with distilled water and sprayed 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. Cucumber fruits were harvested twice a week from the third week of March until the second week of May. 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, leaf area (was determined on the 4th leaves from the plant top using a digital leaf area meter and was calculated according to Watson (1958)), total number of flowers and percent of fruit setting was calculated according to the equation:

$$\text{Fruit set \%} = \frac{\text{No. of fruits}}{\text{Total No. of flowers}} * 100$$

Also, number of fruits / plant, mean fruit weight and total yield of fruits / plant were determined. In addition, plant uptake and fruits contents of N were determined using the micro-kjeldahl method according to Johnson and Urich (1975). K and Ca (mg / g fresh weight) was assayed using flame spectrophotometer according to Allen *et al* (1984). Phosphorous (mg / g fresh weight) was extracted and measured by spectrophotometer according to Jackson (1965) method**.** TSS % was determined using hand refractometer**.** Dry matter of fruit tissues was determined according the method described by Dubois *et al* (1959).The obtained data of experiments were subjected to the statistically analysis of variance procedure and means were compared using the LSD method at 5% level of significance according to Gomez and Gomez (1984)

Results and Discussion

1- Plant growth characters:

The results obtained in this study showed that, spraying cucumber plants with calcium nitrate or potassium nitrate ($Ca(NO_3)_2$ or KNO_3) increased all growth characters studied compared to control including plant length, number of leaves/plant and leaf area (Table 2). However, the higher concentration of both nutrients (15 mM) was superior in its effect. In the same respect, Ca $(NO_3)_2$ and KnO_3 at 15 mM spray registered the maximum plant growth characters expressed as, plant length (cm), number of leaves/ plant and leaf area plant. While the least plant growth characters recorded at control treatment. The increased plant growth might be attributed to increased cell division and cell elongation induced by calcium and potassium nitrate at high concentration. This result can be correlated to previous finding in which plant growth and yield were improved due to foliar application of calcium and potassium compounds (Kaya *et al* 2003 ; Ahmad and Jabeen 2005; Hussein *et al* 2008 and Al-Hamzawy 2010).

Table 2: Effect of spray with Ca $(NO_3)_2$ or KNO_3 on growth characters of cucumber plant under plastic house (combined data of two seasons).

Treatments	Plant length (cm)	Number of leaves /plant	Leaf area (cm^2)
Control	167.33	36.67	69.51
Ca $(NO_3)_2$ 10 (mM)	171.67	39.00	80.34 *
Ca $(NO_3)_2$ 15 (mM)	183.00 *	42.33 *	87.04 *
KNO_3 10 (mM)	170.67	39.33	82.44 *
KNO_3 15 (mM)	178.00 *	41.00 *	86.01 *
LSD at 5% level	6.11	3.29	3.00

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2- Number of flower / plant and fruit setting %:

It is clear from Table (3) that foliar application with higher concentrations of potassium nitrate (15 mM) significantly increased number of flower /plant and fruit setting % compared the other treatments and control. On the other hand, the higher level of calcium nitrate increased number of flower per plant compared to control treatment. This might be attributed to improvement in nutrient availability influenced by calcium and potassium application which helped to enhance growth of plants, resulting in higher flower yield per plant and fruit setting %. This result comes in accordance with the results of El-Tohamy *et al* (2006), they found that, spraying of pepper plant with potassium chloride or calcium chloride maintained higher total chlorophyll content. This in turn might affect flower number and fruit setting of cucumber in the present study.

Table 3: Effect of spray with Ca $(NO_3)_2$ or KNO_3 on flower number/ plant and fruit setting of cucumber plant under plastic house (combined data of two seasons).

Treatments	Number of flowers / plant	Fruit setting %
Control	47.91	40.77
Ca $(NO_3)_2$ 10 (mM)	49.53	41.99
Ca $(NO_3)_2$ 15 (mM)	51.66 *	42.33
KNO_3 10 (mM)	55.40 *	42.67
KNO_3 15 (mM)	55.82 *	46.55 *
LSD at 5% level	3.63	3.04

3- Minerals uptake:

The results of N % and P, K and Ca uptake (mg/ g fresh weight) of cucumber plants as affected by foliar application of calcium nitrate or potassium nitrate are shown in Table (4), which indicated that the highest and significant N, P, K and Ca uptake were found in the tissues of cucumber plants which fertilized by foliar application of potassium nitrate at high concentration (15 mM) followed in descending order by those foliar application of potassium nitrate at 10 mM and both concentrations of calcium nitrate. While the least of N, P, K and Ca uptake (mg/ g fresh weight) recorded at control treatment. From these results it can be reported that, higher content of N, P K and Ca uptake were recorded by foliar application of higher concentration of potassium nitrate with emphasize the role of K in plant metabolism and its involvement in many associated processes (Marschner,1995). The obtained results are in good accordance with which obtained by Najaich *et al* (1999) and AbdEl-Al *et al* (2005) on onion plant and Al-Hamzawi (2010) on cucumber plants. They found that, uptake of phosphorus and potassium was higher with increasing potassium levels applied.

Table 4: Effect of spray with Ca $(NO_3)_2$ or KNO_3 on minerals uptake of cucumber plant under plastic house (combined data of two seasons).

Treatments	N %	(mg / g fresh weight)		
		P	K	Ca
Control	4.77	5.02	44.0	10.36
Ca $(NO_3)_2$ 10 (mM)	5.00	5.41	46.2	10.95
Ca $(NO_3)_2$ 15 (mM)	5.33	5.48	48.4	11.21
KNO_3 10 (mM)	5.66	5.58	55.4	11.48
KNO_3 15 (mM)	5.87	5.77	60.5	11.57
LSD at 5% level	0.61	0.40	1.84	0.73

4- Total yield of fruits:

The treatments significantly enhanced cucumber productivity as number of fruits per plant, average fruit weight and total yield of fruits per plant (Table 5). The results indicated that, the higher concentrations of both potassium and calcium were superior in increasing the values 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 number, weight of fruits and total yield of fruits/ plant. It could be concluded that, the highest fruit yield which obtained by foliar spray of KNO_3 may be attributed to the best uptake of N, P, K and Ca (Table 4) and the best vigor of plant growth characters (Table 3). There is no doubt that K, as important nutritional elements, plays its part in regulation of many physiological criteria in plant which in turn affect the

resulted total yield. The trends of obtained results are in good accordance with that of the previous investigators such as Kaya *et al* (2002) and Al-Hamzawi (2010) on cucumber plants.

Table 5: Effect of spray with Ca $(NO_3)_2$ or KNO_3 on number of fruits, average fruit weight and total yield of cucumber plant under plastic house conditions (combined data of two seasons).

Treatments	Number of fruits / plant	Average fruit weight (g)	Total yield kg / plant
Control	17.61	101.55	1.876
Ca $(NO_3)_2$ 10 (mM)	19.33	104.12	2.014
Ca $(NO_3)_2$ 15 (mM)	21.00	104.52	2.096
KNO_3 10 (mM)	21.87	116.85	2.477
KNO_3 15 (mM)	23.33	118.41	2.644
LSD at 5% level	3.20	6.44	0.391

5- Dry matter, TSS and chemical analysis of fruits:

Data recorded in Table (6) shows clearly that, the highest values of dry matter %, TSS, N%, K and Ca (mg / g fresh weight) in cucumber fruit tissues were obtained by foliar spray of potassium nitrate at both concentrations compared to other treatments and control. However, concerning to the values of dry matter, N, K and Ca in fruits tissues, the obtained data cleared that, with increasing calcium and potassium nitrate level, their contents in cucumber fruit tissues raised to reach the highest values.

Table 6: Effect of spray with Ca $(NO_3)_2$ or KNO_3 on TSS, dry matter and chemical content of cucumber fruits under plastic house conditions (combined data of two seasons).

Treatments	TSS	Dry matter	N	P	K	Ca
	%			mg / g fresh weight		
Control	4.33	3.85	4.33	5.44	55.11	12.11
Ca $(NO_3)_2$ 10 (mM)	4.67	4.05	4.50	5.67	60.00	13.33
Ca $(NO_3)_2$ 15 (mM)	4.67	4.25	4.60	5.33	66.33	14.55
KNO_3 10 (mM)	4.70	4.60	5.00	5.54	69.01	16.67
KNO_3 15 (mM)	4.75	4.89	5.20	5.65	75.67	16.90
LSD at 5% level	NS	0.17	0.31	NS	5.02	2.33

The statistical analysis of the obtained data reveals that, the differences within different foliar spraying of nutrients calcium and potassium nitrate were great enough to be significant with the exception of TSS and P value. It could be concluded that, increasing the levels of potassium nitrate foliar spray raised the availability of nutrient elements which favored to enhancement their absorption and hence increased its concentration in fruits. The trends of obtained results are in good accordance to the previous investigators such as Jiang *et al* (1998), Gue *et al* (1999), Sing and Mohanty (2000), AbdEl-Al *et al* (2005) and Al- Hamzawi (2010).

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