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EFFECT OF DIFFERENT K^+/CA^{2+} RATIOS ON YIELD, QUALITY AND PHYSIOLOGICAL DISORDER IN SOILLESS STRAWBERRY CULTIVATION

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ABSTRACT

The balance of mineral nutrients in plant nutrient solutions has an influence on yield, fruit quality and physiological disorder of strawberries grown in soilless conditions. Nutrient solutions that enhance the yield and quality of plants grown in soilless conditions are optimized through anion-cation equilibrium, optimum K^++Ca^{2+}/Mg^{2+} and K^+/Ca^{2+} ratios. In this study, the effect of three different K^+/Ca^{2+} ratios (5.5/7.0; 5.0/7.0; 6.0/6.0) on some morpho-physiological features (crown diameter, chlorophyll index, leaf temperature), fruit yield, fruit quality (fruit weight, total soluble solids, titratable acidity, ascorbic acid, firmness) and physiological disorder (tip burn) of 'Albion' and 'Festival' strawberries, were investigated. Results show that increasing K^+/Ca^{2+} ratios significantly accelerated the tip burn incidence. On the other hand, the highest yield, firmness and the lowest tip burn were achieved at 5.5/7.0 ratio of K^+/Ca^{2+} treatment.

Key words: *Fragaria* × *ananassa*, cocopeat, plant nutrition solutions, firmness, tip burn

INTRODUCTION

Strawberry is grown around the world and is the most important berry crop. Strawberry grows well in soilless production systems, and soilless cultivation is probably going to spread in Turkey. Such cultivation has recently been initiated on 20 ha of protected area [Demirsoy and Serce 2016] and has reached 70 ha in Turkey.

Fruit quality and yield are affected by genetic, environmental and cultural factors, including plant mineral nutrition and type of growing substrate in soilless culture [Dorais et al. 2001]. It is stated that nutrient solution management directly affects the yield and quality of soilless strawberries grown in greenhouse [Sarooshi and Cresswell 1994, Choi et al. 2011, Ganjehi and Golchin 2012]. In this concern, Gruda [2009] indicated that nutrient solution management, for instance, electrical conductivity (EC) of the nutrient solution, chemical forms of elements, nutrient management, temperature of the nutrient solution, pH, are the major factors that can effectively modify the product quality. Off nutrient elements, potassium (K) and calcium (Ca) are the most abundant, and they have many functions in plants [Raviv and Lieth 2008]. K serves many functions like osmotic regulation, photosynthesis, and enzyme activation. Low K levels can result in poor vigor, lower yield, and pulpy colorless fruits [Raviv and Lieth 2008]. Ca, in the form of Ca-pectate, is responsible for (holding together) stabilizing the cell walls of plants. When calcium, that is immobile, is deficient, new tissue such as root tips, young leaves, and shoot tips often exhibit distorted growth due to improper cell

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wall formation. In addition, Ca^{2+} ions show antagonism with K^+ and Mg^{2+}. Too much K can restrict the supply of Ca and Mg, and may create physiological disorders such as tip burn of emerging leaves and flowers. Main causes of tip burn disorders are high K, low Ca, high salinity and cation imbalance. Moreover, deficiency symptoms could be seen on susceptible cultivars, and under unfavorable environmental conditions [Kaya et al. 2002, Nestby et al. 2005, Raviv and Lieth 2008, Trejo-Téllez and Gómez-Merino 2012]. Due to the limited volume of substrate per plant in strawberry soilless cultivation, soilless nutrient solution applications play more important role than in conventional cultivation [Adak 2009]. Furthermore, balance between cations is more important than the anion balance in soilless cultivation [Schaik et al. 1988, Sarooshi 1995]. However, little is known about the interaction between cation ratios and total cation concentrations in terms of their effects on growth and fruit yield in hydroponically grown strawberry plants [Neocleous and Savvas 2013].

In this regard, it was reported that the ratios of K/N [Sarooshi and Cresswell 1994, Caruso et al. 2003], NO_3^-/NH_4^+ [Tabatabaei et al. 2006, Guo et al. 2007, Kafkafi 2008], K/Ca [Arshad et al. 2015], K/Ca/Mg [Neocleous and Savvas 2013], and levels of K [Seyedi et al. 2014], EC [D'Anna et al. 2003, Portela et al. 2012] and pH [Kim et al. 2005], were particularly important in terms of the effect of these factors in soilless cultivation systems on yield and quality of strawberry and various horticultural crops. For instance, some experiments have demonstrated that fruit quality parameters such as soluble solids content, titratable acidity and dry matter arouse due to increasing EC level of nutrient solution from 2 to 10 $dS \cdot m^{-1}$ [Chadirin et al. 2007]. Research of Bustomi Rosadi et al. [2014] indicated that increasing EC levels from 1 to 5 $dS \cdot m^{-1}$ caused an increase in total soluble solids, however, the highest yield was achieved at 3 $dS \cdot m^{-1}$ EC level. Likewise, high levels of K^+ in the nutrient solution (14.2–3.4 $meq \cdot L^{-1}$) increased the fruit dry matter, total soluble solids, content and lycopene concentration of tomato [Fanasca et al. 2006]. Trejo-Tellez and Gomez-Merino [2014] reported that when strawberry plants are well supplied with K, they can synthetize more sugar, and thereby sweeter fruits.

Few studies have previously been reported on K/Ca ratio in strawberry soilless nutrient solution. Therefore, the objective of this study was to determine the effect of different K/Ca ratios on yield and fruit quality of strawberries grown in cocopeat medium under Mediterranean climate conditions.

MATERIALS AND METHODS

Plant materials, growing conditions and treatments. The experiment was conducted under natural greenhouse conditions at a private research center (2K VEG I.C) Serik-Antalya (36°50'37"N; 30°50'31"E) in the period from October 2014 to June 2015. The greenhouse was unheated and modern (10 m wide × 40 m long × 6.5 m height) with aeration on roof and sides. Monthly average temperatures outside the greenhouse were 22.5, 18.1, 12.9, 10.4, 11.3, 13.9, 15.9, and 20.5°C from October 2014 to June 2015, respectively. Daughter plants of 'Albion' and 'Festival' strawberries (*Fragaria* × *ananassa* Duch.) were planted in growing bags. When two leaves were fully expanded, they were transferred to the greenhouse and planted into bags (100 × 15 × 7 cm) filled with cocopeat at a density of 14.2 plants·m^{-2} on 20 October 2014. Initially, the substrate was moistened to bag capacity using similar nutrient solution in all treatments. The ionic composition of this initial nutrient solution was: 11.5 mM NO_3^-, 1.5 mM $H_2PO_4^-$, 1.5 mM SO_4^{2-}, 0.5 mM NH_4^+, 3.5 mM K^+, 4.5 mM Ca^{2+}, and 1.5 mM Mg^{2+}. The EC and pH values of the initial nutrient solution were 1.55 $dS \cdot m^{-1}$ and 6.0, respectively. Two months after planting, three different nutrient solution (NS) treatments were applied during the reproductive stage (Tab. 1), which lasted from 10 December 2014 to 20 June 2015. Plants were fertigated with one of the following K^+/Ca^{2+} ratios: 5.5 $meq \cdot L^{-1}$/ 7.0 $meq \cdot L^{-1}$ (0.78), 5.0 $meq \cdot L^{-1}$/ 7.0 $meq \cdot L^{-1}$ (0.71) and 6.0 $meq \cdot L^{-1}$ / 6.0 $meq \cdot L^{-1}$ (1.00) (Tab. 1). The nutrient solutions for each treatment were in separate tanks. Irrigation was scheduled to achieve a leaching fraction of 30% of the volume applied. The bags were equipped with drippers (2 $L \cdot h^{-1}$), which could supply different nutrient solutions to each bag.

Table 1. Nutrition solutions applied to 'Albion' and 'Festival' strawberries in the period of reproductive growth

Parameters (units)	K/Ca ratio		
	Control: 5.5 meq·L^{-1}/ 7.0 meq·L^{-1} (0.78)	5.0 meq·L^{-1}/ 7.0 meq·L^{-1} (0.71)	6.0 meq·L^{-1}/ 6.0 meq·L^{-1} (1.00)
NO_3^- (mmol·L^{-1})	11.0	11.5	11.5
$H_2PO_4^-$ (mmol·L^{-1})	1.5	1.0	2.0
SO_4^{2-} (mmol·L^{-1})	1.5	1.5	1.0
NH_4^+ (mmol·L^{-1})	0.0	0.5	0.5
K^+ (mmol·L^{-1})	5.5	5.0	6.0
Ca^{2+} (mmol·L^{-1})	3.5	3.5	3.0
Mg^{2+} (mmol·L^{-1})	1.5	1.5	1.5
EC (dS·m^{-1})	1.55	1.55	1.55
pH	6.0	6.0	6.0

Concentrations of other nutrients were identical in all treatments (Fe, Mn, Zn, Cu, B and Mo = 20, 20, 10, 0.75, 12, and 0.5 µmol·L^{-1}, respectively)

Data collection and statistical analysis. In the experiment, while the plant morpho-physiological characteristics (crown diameter, chlorophyll index and leaf temperature), the quality traits (fruit weight, total soluble solids, titratable acidity, ascorbic acid, firmness) and physiological disorders (tip burn), were identified in February 2015, the yield values were calculated based on the total yield obtained during the whole season. The following plant features were measured: chlorophyll indices with chlorophyll meter (FieldScoot CM1000), leaf temperature with infrared thermometer (Spectrum Technologies, Inc.), total soluble solids (TSS) in fruits with digital refractometer (REF121; Atago, Guangzhou, China), and firmness using penetrometer (FT-011, with 7 mm probe; Effegi, Italy). The titratable acidity (TA) was determined by juice titration with 0.1 N NaOH up to 8.1 pH and expressed in % of citric acid per 100 mL juice [AOAC 1980]. The ascorbic acid content (mg·100 g^{-1} FW) was determined using 2,6-dicholorophenol indophenols solution [AOAC 1995]. From all plants, the amount of glassy lesions on the leaflets, the tip burn was evaluated on all plants. The experiment was conducted in a randomized block design using 2 cultivars × 3 treatments of K/Ca ratio and 3 replications with 26 plants per plot. In the experiment, 10 plant were used for recording the morphological and chemical analysis data. The data was analyzed using the Statistical Analysis System software program, version 9.0 (SAS Ins., Cary, NC, USA) by ANOVA, and treatment means were statistically compared using the LSD test with 5% error interval.

RESULTS AND DISCUSSION

Crown diameter, chlorophyll index and leaf temperature. The effects of treatments on crown diameter, chlorophyll index and leaf temperature of 'Albion' and 'Festival' strawberries are given in Table 2. While the effect of the K/Ca treatments on crown diameter was significant, the effects on chlorophyll index and leaf temperature were not. The crown diameter values decreased depending on the K/Ca ratio, and the highest values were identified at the 5.5/7.0 and 5.0/7.0 treatments. Regarding all tested morpho-physiological features, statistical analysis showed that there were no significant differences between cultivars. The interactions between cultivars and K/Ca treatments were highly significant for crown diameter and chlorophyll index (Tab. 2). In general, the highest crown diameter values were determined at 0.78 and 0.71 ratios for both cultivars. In addition, the highest chlorophyll index values were indicated for 0.78 ratio × 'Albion' cultivar and 0.71 ratio × 'Festival' cultivar (Tab. 2).

Consequently, crown diameter was affected depending on K/Ca ratio, but there were no effect on other morpho-physiological features by K/Ca ratios. It could be suggested that fruit yield correlates with crown diameter. Related to this, no literature was found regarding the effect of different K/Ca ratios applied in the reproductive growing period on morpho-physiological features in hydroponic strawberry cultivation. As a similar criterion, Tabatabaei et al. [2006] identified the highest leaf area and yield with a 25 NH_4/75 NO_3 ratio in strawberries testing four different NH_4/NO_3 ratios (0/100, 25/75, 50/50 and 75/25). Therefore, this study revealed that nutrition element ratios have different effects on plant growth [Tabatabaei et al. 2006].

Total soluble solids (TSS), titratable acidity (TA), ascorbic acid (AA) and firmness. In the reproductive period, effects of different K/Ca ratios on total soluble solids (TSS), titratable acidity (TA), ascorbic acid (AA) and firmness in 'Albion' and 'Festival' strawberries are given in Table 3. As shown in Table 3, the effects of the treatment on TSS were not statistically significant; however, significant differences were determined between the cultivars and 'Festival' had lower values than 'Albion'. The interaction between cultivar and K/Ca treatment was significant for TSS. The highest TSS values were determined for 'Albion' at all ratios (Tab. 3). TA tended to be lower for 'Albion' than for 'Festival', but not significantly. There were no distinct differences in terms of AA content among the treatments, but 'Albion' had 12.6% higher level than 'Festival'. There was significant interaction between cultivar and K/Ca treatment for AA content. In general, the highest AA content was determined for 'Albion' at 1.00 ratio (Tab. 3).

Regarding firmness, the highest value with respect to K/Ca ratio was at the 5.5/7.0 ratio and the lowest at the 6.0/6.0 ratio (Tab. 3). Concerning effect of examined cultivars on fruit firmness, the highest firmness value was in 'Albion'. The interactions between cultivars and K/Ca ratios showed significant effects on firmness. In general, the highest firmness value was obtained at 0.71 ratio × 'Albion', and the lowest value was at 1.00 ratio × 'Festival' (Tab. 3).

Table 2. Effects of different K/Ca applications on crown diameter, chlorophyll index and leaf temperature in 'Albion' and 'Festival' strawberries

K/Ca	Crown diameter (mm)		Mean
	'Albion'	'Festival'	
5.5/7.0 (0.78)	32.41 A	32.41 A	32.41 a
5.0/7.0 (0.71)	32.06 A	30.86 A	31.46 a
6.0/6.0 (1.00)	24.49 B	25.39 B	24.94 b
Mean	29.66	29.56	31.27
$LSD_{5\%\text{ for treatments}} = 4.592$; $LSD_{5\%\text{ for cultivars}} = NS$; $LSD_{5\%\text{ for treatments} \times \text{cultivars}} = 4.632$			
K/Ca	Chlorophyll index		Mean
	'Albion'	'Festival'	
5.5/7.0 (0.78)	464.00 A	430.33 AB	447.17
5.0/7.0 (0.71)	459.33 AB	470.67 A	465.00
6.0/6.0 (1.00)	403.67 AB	393.33 B	398.50
Mean	442.33	431.44	
$LSD_{5\%\text{ for treatments}} = NS$; $LSD_{5\%\text{ for cultivars}} = NS$; $LSD_{5\%\text{ for treatments} \times \text{cultivars}} = 67.29$			
K/Ca	Leaf temperature (°C)		Mean
	'Albion'	'Festival'	
5.5/7.0 (0.78)	22.71	21.21	21.96
5.0/7.0 (0.71)	22.21	21.53	21.87
6.0/6.0 (1.00)	22.68	22.93	22.80
Mean	22.53	21.88	
$LSD_{5\%\text{ for treatments}} = NS$; $LSD_{5\%\text{ for cultivars}} = NS$; $LSD_{5\%\text{ for treatments} \times \text{cultivars}} = NS$			

The comparison of the means of the cultivars is done within the same row and means of treatment in the same column and the interaction between all the values is significantly different ($P \leq 0.05$) using LSD comparison test. The mean of treatment and cultivar are shown in lowercase letters while interactions are in uppercase

Consequently, in case of internal fruit quality, cultivars significantly influenced both TSS and firmness values, and 'Albion' strawberry was better cultivar. Furthermore, the firmness fruits were obtained at 5.5/7.0 ratio of K/Ca. On the other hand, increasing K/Ca ratio led to decrease in firmness. In this concern, some authors have reported different results. Seyedi et al. [2014] studied the influence of K at 1.5, 2.6, 3 and 4.5 meq·L^{-1} and reported that TSS, TA and vitamin C contents in strawberry increased with the elevation of K levels. The optimum concentration in case of plant growth and yield was determined at 3 meq·L^{-1} K. Our results showed that increasing K/Ca ratio did not significantly affect the total soluble solid content (TSS) (Tab. 3). According to Arshad et al. [2015], the K/Ca balance in a nutrition solution could have significant effects on improvement in quality and yield. However, researchers revealed that high levels of different K/Ca concentrations (120/100, 140/100, 160/100, 100/100, 85/140, 85/100 mg·L^{-1}) (1.26, 1.47, 1.68, 1.05, 0.65 and 0.89) in strawberries resulted in a decrease in taste, anthocyanin, total phenol and vitamin C contents. The maximum antioxidant capacity and fruit taste index were identified at 140 : 100 (1.47) ratio as compared to the 80 : 100 ratio (0.89), which were 21% and 40% higher, respectively. The same study also revealed that total yield and K ratio changes in the nutrient solution showing a linear correlation. In our study, EC of 1.55 dS·m^{-1} was used in all three solutions, and the fruit firmness changed with the change in K/Ca ratio. From these results, it could be concluded that the K/Ca ratio of the nutrient solution are important in soilless culture.

Table 3. Effects of different K/Ca applications on total soluble solids, titratable acidity, ascorbic acid and firmness in 'Albion' and 'Festival' strawberries

K/Ca	Total soluble solids (%)		Mean
	'Albion'	'Festival'	
5.5/7.0 (0.78)	8.67 A	7.26 B	7.96
5.0/7.0 (0.71)	8.73 A	7.23 B	7.98
6.0/6.0 (1.00)	8.73 A	7.20 B	7.96
Mean	8.71 a	7.23 b	
$LSD_{5\% \text{ for treatments}}$ = NS; $LSD_{5\% \text{ for cultivars}}$ = 0.312; $LSD_{5\% \text{ for treatments} \times \text{cultivars}}$ = 0.542			
K/Ca	Titratable acidity (% citric acid)		Mean
	'Albion'	'Festival'	
5.5/7.0 (0.78)	0.77	0.85	0.81
5.0/7.0 (0.71)	0.77	0.82	0.79
6.0/6.0 (1.00)	0.79	0.80	0.80
Mean	0.77	0.82	
$LSD_{5\% \text{ for treatments}}$ = NS; $LSD_{5\% \text{ for cultivars}}$ = NS; $LSD_{5\% \text{ for treatments} \times \text{cultivars}}$ = NS			
K/Ca	Ascorbic acid (mg·100 g^{-1} FW)		Mean
	'Albion'	'Festival'	
5.5/7.0 (0.78)	27.65 B	27.67 B	27.66
5.0/7.0 (0.71)	31.23 AB	26.43 B	28.87
6.0/6.0 (1.00)	33.83 A	27.00 B	30.42
Mean	30.93 a	27.03 b	
$LSD_{5\% \text{ for treatments}}$ = NS; $LSD_{5\% \text{ for cultivars}}$ = 3.195; $LSD_{5\% \text{ for treatments} \times \text{cultivars}}$ = 5.534			
K/Ca	Firmness (lb·in^{-2})		Mean
	'Albion'	'Festival'	
5.5/7.0 (0.78)	1.02 AB	0.95 ABC	0.98 a
5.0/7.0 (0.71)	1.08 A	0.76 CD	0.92 ab
6.0/6.0 (1.00)	0.81 BCD	0.66 D	0.73 b
Mean	0.97 a	0.79 b	
$LSD_{5\% \text{ for treatments}}$ = 0.211; $LSD_{5\% \text{ for cultivars}}$ = 0.123; $LSD_{5\% \text{ for treatments} \times \text{cultivars}}$ = 0.213			

Explanations as in Table 2

Fruit weight and fruit yield. The effects of K/Ca ratio treatments on fruit weight and yield in 'Albion' and 'Festival' strawberry cultivars are given in Table 4. As seen in Table 4, the fruit yield was found statistically different according to K/Ca treatments. Fruit weight was not affected, however, there were statistical differences between cultivars. Regarding the yield, the highest average value of cultivars was achieved at K/Ca ratios 5.5/7.0 and 5.0/7.0, while the lowest yield was at 6.0/6.0 ratio (Tab. 4). Concerning the yield value, there were no statistical differences between the two cultivars. Interactions between cultivar and K/Ca ratios showed significant effects on yield. In general, the highest yield was achieved at 0.78 ratio × 'Albion' and the lowest at 1.00 ratio × 'Festival' (Tab. 4).

In the case of fruit yield, 5.5/7.0 and 5.0/7.0 K/Ca ratios are superior to 6.0/6.0 ratio in strawberry soilless cultivation. These results are similar to those reported by other authors [Lieten 2006, Ganjehi and Golchin 2012, Neocleous and Savvas 2013]. Lieten [2006] reported that the highest yield and fruit weight were achieved at the K : Ca : Mg ratios of 2 : 4.5 : 1, 5 : 3 : 1 and 5 : 2 : 2. Ganjehi and Golchin [2012] revealed that, except for number of fruits, the K level significantly affected the yield and plant growth. The highest yield was obtained with 120 $mg \cdot L^{-1}$ K (6.31 $mmol \cdot L^{-1}$). Reported K levels in the literature [Ganjehi and Golchin 2012] was close to those in our study findings. In another study carried out on the K : Ca : Mg ratios in hydroponic strawberries, Neocleous and Savvas [2013] reported that the highest yield was at 6 : 3 : 1.4 (as mmol) and 6 : 5 : 1.4 (as mmol) in terms of yield as compared to 10 : 5 : 2.33 and 3.27 : 5 : 0.76 ratios.

Table 4. Effects of different K/Ca applications on fruit weight and fruit yield in the 'Albion' and 'Festival' strawberry cultivars

K/Ca	Fruit weight (g)		Mean
	'Albion'	'Festival'	
5.5/7.0 (0.78)	28.09	26.66	27.37
5.0/7.0 (0.71)	30.13	24.28	27.20
6.0/6.0 (1.00)	28.22	26.43	27.32
Mean	28.82	25.79	
$LSD_{5\% \text{ for treatments}}$ = NS; $LSD_{5\% \text{ for cultivars}}$ = NS; $LSD_{5\% \text{ for treatments} \times \text{cultivars}}$ = NS			
K/Ca	Fruit yield (g/m^2)		Mean
	'Albion'	'Festival'	
5.5/7.0 (0.78)	7245.65 A	7052.78 AB	7149.21 a
5.0/7.0 (0.71)	6886.22 AB	7096.62 AB	6991.42 a
6.0/6.0 (1.00)	5939.42 BC	5632.58 C	5786.00 b
Mean	6690.4	6594.0	
$LSD_{5\% \text{ for treatments}}$ = 1170.7; $LSD_{5\% \text{ for cultivars}}$ = NS; $LSD_{5\% \text{ for treatments} \times \text{cultivars}}$ = 1181.00			

Explanations as in Table 2

Table 5. Effects of different K/Ca applications on tip burn in the 'Albion' and 'Festival' strawberry cultivars

K/Ca	Tip burn (%)		Mean
	'Albion'	'Festival'	
5.5/7.0 (0.78)	2.33 B	4.67 B	3.50 b
5.0/7.0 (0.71)	3.67 B	6.00 B	4.83 b
6.0/6.0 (1.00)	11.67 A	16.67 A	14.17 a
Mean	5.89 b	9.11 a	
$LSD_{5\% \text{ for treatments}}$ = 4.970; $LSD_{5\% \text{ for cultivars}}$ = 2.895; $LSD_{5\% \text{ for treatments} \times \text{cultivars}}$ = 5.014			

Explanations as in Table 2

Physiological disorder. According to treatments and cultivars, data concerning tip-burn incidence during February 2015 are given in Table 5. Treatments and cultivars significantly influenced the tip-burn, and the highest tip-burn incidence was determined at 6.0/6.0 (1.00) K/Ca ratio with 14.17 % of tested plants; however, the lowest incidence was at 5.5/7.0 (0.78) ratio with 3.50 %. For cultivar, a higher tip-burn incidence was observed in 'Festival' than in 'Albion'. The interaction between cultivar and K/Ca ratios showed significant effects on physiological disorder. In general, the highest tip-burn incidence was indicated at 1.00 ratio with 'Festival' and the lowest tip burn incidence was at 0.78 ratio with 'Albion' cultivar (Tab. 5). From these results, it can be concluded that tip-burn physiological disorder sensitivity was significantly affected by cultivar and nutrient solution treatment. Consequently, 'Albion' cultivar proved that it is more tolerant than 'Festival' cultivar in terms of tip-burn incidence. Furthermore, 5.5/7.0 (0.78) K/Ca ratio was superior to the ratios 5.0/7.0 (0.71) and 6.0/6.0 (1.00) regarding reduction in this physiological disorder. Our results are in accordance with previous findings. In fact, too much K can restrict the supply of Ca and Mg, and may create the tip-burn of emerging leaves and flowers [Mason and Guttridge 1974, 1975, Ehret and Ho 1986, Ho et al. 1993, Lieten 2006].

CONCLUSIONS

It can be concluded that genotype, environmental conditions and nutrient solution affected the yield, fruit quality and physiological disorders in strawberry soilless cultivation. While the response of different strawberry cultivars on soilless cultivation system varied, nutrient solution treatments directly affected the yield and quality. In this regard, balancing of nutrient elements such as potassium, calcium and magnesium ions, adjustment of EC and pH, and regulation of irrigation schedule are important. Therefore, it should be determined suitable cation ratios, salinity levels and general nutrient elements balance in strawberry soilless cultivation systems. In our study, it was found that different K/Ca ratios applied to the reproductive growth period showed different effects on yield, fruit firmness and tip-burn incidence. Therefore, 0.78 K/Ca ratio should be recommended during the reproductive growth period in strawberry soilless cultivation as outstanding in terms of the yield and quality.

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