Research Article

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Growth and Fruit Biochemical Characteristics of Three Strawberry Genotypes under Different Potassium Concentrations of Nutrient Solution

<https://doi.org/10.1515/opag-2018-0039>

received May 8, 2018; accepted August 16, 2018

Abstract: A nutrient solution experiment was performed to evaluate the growth, yield and fruit biochemical characteristics of strawberry under different potassium levels of nutrient solution. Potassium concentrations including 235 (control), 350, 450 and 600 mg L⁻¹ were applied to three strawberry genotypes of Camarosa, Selva and Parus under hydroponic culture. In the three genotypes, the maximum leaf area was observed at 350 mg L⁻¹ K, and the maximum shoot fresh weight was either at 350 mg L⁻¹ (in Camarosa and Parus) or at 400 mg L⁻¹ (in Selva). In Selva, higher yield was produced by higher K concentrations than control (17-33%) and in Camarosa, the maximum yield was produced at 350 mg L⁻¹ (16%), whereas fruit yield in Parus was not affected by K concentrations. In Selva and Parus application of 350 mg L⁻¹ potassium produced more fruits than control. The maximum fruit vitamin C content in Camarosa and Selva was at 350 mg L⁻¹, and in Parus at 450 mg L⁻¹, while the significant lowest in three genotypes was at 600 mg L⁻¹. Fruit titratable acidity and pH in Camarosa and Selva, and fruit TSS in Parus were not affected by K levels. Fruit total soluble solids (TSS) in Camarosa and Selva were maximum in 350 and 450 mg L⁻¹. Increasing K concentrations of nutrient solution increased leaf and fruit K concentration than control. The results indicate that overall plant growth and fruit quality of three strawberry genotypes were increased by 350 mg L⁻¹ potassium, while application of 600 mg L⁻¹ reduced most traits than control. The Selva genotype had also a better response to higher concentration of K than two other genotypes.

Keywords: fertilization, fortification, fruit quality, hydroponic, Camarosa, Parus, plant nutrition, Selva

1 Introduction

Adequate supply of mineral nutrients is necessary for optimum growth and acceptable fruit quality in horticultural crops. This goal can be achieved by application of various fertilizers in soil or mineral salts in hydroponic production systems (Fageria et al. 2007; Souri 2016). Among necessary mineral nutrients, potassium (K) is a key nutrient with diverse roles in plant physiology and biochemistry (Marschner, 2011). Potassium may be a limiting factor for crop production especially in high yielding varieties (Hartz et al. 1999; Lin et al. 2004; Ebrahimi et al. 2012; Mardanlu et al. 2014). The use of K-efficient crop genotypes along with the application of K-containing fertilizers may be a viable strategy to improve the yield and reduce the cost of crop production (Fageria et al. 2007).

Potassium is the second most important nutrient, which has direct and indirect roles in many metabolic processes in plant cells including photosynthesis, primary and secondary metabolism, translocation of photo assimilates and their storage (Cerdeira et al. 2008; Marschner 2011). It has also significant metabolic functions in many quality aspects of products due to higher cell wall stability, regulation of biochemical reactions and different roles in enzymes and antioxidant activities (Demiral and Koseoglu 2005; El-Bassiony 2006; Zivdar et al. 2016). Potassium is the most abundant cation in the cytoplasm and helps to maintain the cell pH in an optimum range, by which many enzymatic reactions can take place (Human and Kotze 1990; Marschner 2011). Its various companion anions have important role in osmotic adjustment and water relation of plant tissues (Lin et al. 2004; Zivdar et al. 2016). In addition, enhanced potassium content in food

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products can guarantee their superior quality that can also promote human health conditions.

In many fruiting crops such as strawberry, tomato and maize, the demand for K uptake is relatively high during fruit development. The general Hoagland nutrient solution concentration of K is 235 mg L⁻¹ that seems inadequate for high demanding crops (Hartz et al. 1999; Lin et al. 2004; Mardanluo et al. 2018). Strawberry is among those plants that may have a higher potassium requirement for optimum fruiting and quality (Kaya et al. 2003; Khayyat et al. 2009; Ebrahimi et al. 2012), so inadequate potassium during fruit development can result in low quality fruits and early fruit decaying. It has been shown that increasing nutrient solution K from 235 to 300 mg L⁻¹ significantly increased the strawberries yield and fruit quality traits including vitamin C and TSS (Ebrahimi et al. 2012). In pepper plants, increasing potassium in the nutrient solution to 400 and 500 mg L⁻¹ significantly increased some growth and fruit quality traits (Mardanluo et al. 2018). In addition, higher K concentrations can significantly reduce the uptake and accumulation of toxic elements such as heavy metals, nitrates and sodium in plant edible tissues (Cerdeira et al. 2008; Ghazi and Al-Karaki 2008; Khayyat et al. 2009; Yildirim et al. 2009; Marschner 2011). Therefore, in the present study different concentrations of potassium of nutrient solution were applied to evaluate their effects on growth and fruit biochemical quality parameters of three genotypes of strawberry under hydroponic system.

2 Material and Methods

This study was conducted to evaluate the growth, yield and quality responses of three strawberry genotypes to various potassium concentrations of nutrient solution under greenhouse conditions. Different concentrations of potassium of nutrient solution including 235 (control), 350, 450 and 600 mg L⁻¹ were applied to three strawberry genotypes of Camarosa, Selva and Parus (Mardanluo et al. 2018). The treatments were arranged in a randomized design with four replications. Each replicate was a pot with approximately four liters volume (filled with cocopeat and perlite mixture) containing two strawberry plants. The average record of two plants was used for each replication.

The pot medium was consisted of cocopeat: perlite in a 2:1 ratio, and the nutrient solution was prepared based on Hoagland formula with some modifications (Hoagland and Arnon 1950). Potassium sulfate was used for preparation of K concentration treatments. The initial pH of nutrient solution was adjusted to 5.8 using H₂SO₄. The pots were irrigated with nutrient solution three times

per day for 20-30 min, and every ten days pots were washed with sufficient drinking tap water for prevention of salt accumulation in pots. The day/night temperature was adjusted on 25/18 ± 3°C, and the greenhouse humidity was in range of 60-70%.

The experiment was run for five months and various plant growth traits were measured during experiment period or at harvest. Leaf SPAD value (The Soil and Plant Analysis Development) was measured using a portable SPAD meter (model 502 Plus, Illinois, USA). The average of 30 reading per pot was recorded as SPAD value of plants. Plant leaf area was measured using a leaf area meter (Model CI202, Germany) and single leaf area was presented in the results. At the end of experiment, shoot and root of plants were cut, and plant roots were precisely separated and washed from medium materials. Shoot and root fresh weights were determined using a digital balance. Plant shoot and root dry weights were determined and calculated after drying of shoots and roots at 65°C for 24 h. The cumulative number of fruits per plant was recorded during experiment. The plant yield (g) was calculated from cumulative harvest of fruits during three months of fruiting period. The fruit length and fruit diameter were measured using a caliper (model Mitutoyo Japan).

Biochemical quality parameters of fruit juice were determined from fruits of final harvest. For preparation of fruit juice, fruits were squeezed manually and then centrifuged for 10 min for separation of the supernatant. Fruit juice pH was measured using a pH meter. Vitamin C (L-ascorbic acid) concentration of fruits was determined using the indophenols method (Aslani and Sourji 2018). Briefly, 20 g of fresh fruit was crushed by hand in a mortar while receiving 20 mL of 6% metaphosphoric acid. The mixture was centrifuged at 9000 rpm at 4°C for 10 min, and thereafter 5 mL of the supernatant was diluted to 10 mL using 2% metaphosphoric acid. Dichlorophenol indophenol was used for titration of final solution, and the amount of L-ascorbic acid was determined and calculated by dilutions and the amount of used reagent following determination of various concentrations of standard L-ascorbic acid in the procedure. Total soluble solids (TSS) of fruit juice were determined using a portable refractometer (Erma-D, Japan). Titratable acidity of fruit juice was determined by titration of fruit juice against 0.1 N NaOH solution. The potassium concentration of leaves and fruits were determined using the flame photometry method.

Data were analyzed using SPSS (version 16), and comparison of means was performed at 5% confidence level of Duncan multiple range test.

Ethical approval: The conducted research is not related to either human or animal use.

3 Results

The results showed that leaf SPAD values of three strawberry genotypes were not significantly influenced by K concentrations of nutrient solution (Table 1), however in Parus and Selva higher K levels resulted in slightly higher leaf SPAD value compared to control. Plant leaf area was significantly affected by K levels and in the three cultivars the significant maximum leaf area was observed in 350 mg L⁻¹ K and the lowest leaf area was in 600 mg L⁻¹ K of nutrient solution (Table 1). The maximum plant shoot fresh weight of Camarosa was in 350 mg L⁻¹, and of Selva was in 400 mg L⁻¹, and of Parus was in 350 and 400 mg L⁻¹ K of nutrient solution (Table 1). The significant lowest shoot fresh weight was in 235 (control) and 600 mg L⁻¹ K of nutrient solution in all three cultivars.

Plant shoot dry weight of Camarosa was maximum at 350 mg L⁻¹, while in Selva and Parus was maximum at 450 mg L⁻¹ K levels, which showed no significant difference to 350 and 600 mg L⁻¹ treatments (Table 2). The lowest shoot dry weight in three cultivars was in control. Plant root fresh weight of Camarosa was not affected by K levels, but

in Selva and Parus the maximum root fresh weight was in 350 mg L⁻¹ K (Table 2). Root dry weight in Camarosa and Parus was not affected by K levels, while in Selva the maximum root dry weight was in 350 mg L⁻¹ that showed significant difference to control and 600 mg L⁻¹ K.

Plant fruit fresh yield was not affected by K levels in Parus, but in Selva three higher K levels produced higher yield compared to control (Table 3); however, the maximum yield was obtained from 450 mg L⁻¹ K level. In Camarosa 350 mg L⁻¹ K produced the maximum yield that showed difference with control and 600 mg L⁻¹ K levels (Table 3). Fruit number per plant was not affected by K levels in Camarosa, but in Selva and Parus, treatment with 350 mg L⁻¹ K produced more fruits compared to control and 600 mg L⁻¹ K treatments (Table 3). In Camarosa and Parus fruit length was highest in 350 mg L⁻¹ K of nutrient solution, and there was no difference among other K levels (Table 3). Similarly, in Selva the maximum fruit length was in 350 mg L⁻¹ K that showed significant difference only to control plants, while there was no significant difference among high K levels.

In Parus cultivar fruit diameter was not affected by K levels of nutrient solution (Table 4). In Camarosa and Selva the significant maximum fruit diameter was in 350 mg L⁻¹ K; however, the lowest fruit diameter of Camarosa was in

Table 1. Leaf SPAD value, leaf area and shoot fresh weight of strawberries plant under different K levels of nutrient solution.

K Levels (mg L ⁻¹)	Leaf SPAD value			Leaf area (cm ²)			Shoot FW (g)		
	Camarosa	Selva	Parus	Camarosa	Selva	Parus	Camarosa	Selva	Parus
235	23±2.1a	24±1.4a	21±2.4a	104±1.9b	102±4.2ab	106±3.3ab	51±3.9b	57±5.1b	49±5b
350	23±1.6a	26±2.5a	23±1.3a	110±4.2a	109±4.6a	113±8.5a	59±5.9a	62±7.8ab	61±7a
450	22±2.2a	25±2.1a	23±2.8a	102±5.1b	105±7.5ab	105±6.8ab	52±4.8ab	66±9.1a	58±5.1a
600	21±2.5a	24±3.7a	22±2.7a	100±7.9b	98±2.8b	98±4.6b	50±5.5b	57±6.5b	56±8.2ab

- FW represents fresh weight.

- Comparison of means was performed at 5% level of Duncan's multiple range test.

- Plants were grown for five months with treatments.

Table 2. Shoot dry weight, root fresh weight and root dry weight of strawberries plant under different K levels of nutrient solution.

K Levels (mg L ⁻¹)	Shoot DW (g)			Root FW (g)			Root DW (g)		
	Camarosa	Selva	Parus	Camarosa	Selva	Parus	Camarosa	Selva	Parus
235	9.5±0.7b	10.4±0.6b	9.2±0.4b	15.9±2a	16.1±1.4ab	15.7±1.6ab	2.9±0.3b	3.1±0.3b	3.1±0.2a
350	10.7±1.6a	11.7±1.3a	11.5±2.3a	16.2±1.9a	18.7±2.5a	16.5±1.6a	3.1±0.1a	3.6±0.2a	3.1±0.1a
450	9.6±0.5b	12.3±1a	11.8±1.7a	16.1±1.8a	15.4±1.2b	15.2±2.8b	3±0.4a	3.4±0.2ab	3±0.3a
600	10.4±1.0ab	11.9±1.3a	11.5±1.9a	16.2±1.4a	15±1.8b	13.8±2.4c	3.1±0.2a	3.2±0.4b	3.1±0.4a

- FW and DW represent the dry weight and fresh weight, respectively.

- Comparison of means was performed at 5% level of Duncan's multiple range test.

- Plants were grown for five months with treatments.

Table 3. Plant fruit yield, fruit number and fruit length of strawberry plants under different K levels of nutrient solution.

K Levels (mg L ⁻¹)	Fruit fresh yield (g plant ⁻¹)			Fruit No per plant			Fruit length (cm)		
	Camarosa	Selva	Parus	Camarosa	Selva	Parus	Camarosa	Selva	Parus
235	167±18b	261±17c	165±20a	14.7±2.2a	24.8±1.7b	14.5±2.1b	3.3±0.23b	3.1±0.14b	3.1±0.22b
350	194±37a	323±36ab	170±14a	15.3±3.2a	290 ±2.6a	16.8±3.1a	3.7±0.36a	3.4±0.24a	3.7±0.31a
450	175±10ab	347±24a	174±7a	15±2.4a	26±2.2ab	15.7±2ab	3.1±0.12b	3.3±0.26ab	3.1±0.20b
600	164±13b	305±18b	163±8a	14.8±2.2a	25.2±2.8b	14.7±2.5b	3.1±0.21b	3.3±0.15ab	3.0±0.21b

- Comparison of means was performed at 5% level of Duncan's multiple range test.

- Plants were grown for five months with treatments.

Table 4. Fruit diameter, vitamin C and titratable acidity content of strawberry cultivars under different K levels of nutrient solution.

K Levels (mg L ⁻¹)	Fruit diameter (cm)			Vitamin C (mg 100 g FW ⁻¹)			Titratable acidity (%)		
	Camarosa	Selva	Parus	Camarosa	Selva	Parus	Camarosa	Selva	Parus
235	2.8±0.07b	2.8±0.04ab	2.9±0.07a	28.7±2.6ab	28.1±3.3ab	24.1±2.5b	1.14±0.03a	1.18±0.05a	0.92±0.12b
350	3.0±0.06a	2.9±0.05a	2.8±0.08a	31.1±3.5a	33.1±4.2a	22.9±3.4bc	1.16±0.02a	1.17±0.04a	0.94±0.10b
450	2.9±0.07ab	2.8±0.09ab	2.8±0.09a	27.9±2.1ab	28.3±3.1ab	30±2.1a	1.17±0.02a	1.2±0.04a	1.13±0.03a
600	2.9±0.06ab	2.7±0.15b	2.7±0.14a	26.1±1.6b	26.7±3.8b	20.3±3c	1.15±0.03a	1.18±0.03a	1.10±0.02a

-FW represents fresh weight.

- Comparison of means was performed at 5% level of Duncan's multiple range test.

- Plants were grown for five months with treatments.

control, and of Selva was in 600 mg L⁻¹ K. Determination of fruit vitamin C content in three strawberry cultivars showed that fruit vitamin C was significantly influenced by K levels of nutrient solution (Table 4). In Camarosa and Selva, the changes of vitamin C were almost similar, in which the maximum fruit vitamin C was in 350 mg L⁻¹ K and the significant lowest was in 600 mg L⁻¹ K. In Parus cultivar, the maximum fruit vitamin C was in 450 mg L⁻¹ K and the lowest value was in 600 mg L⁻¹ K of nutrient solution (Table 4). Fruit titratable acidity was not affected by K levels in Camarosa and Selva cultivars, while in Parus the two maximum K levels (450 and 600 mg L⁻¹ K) resulted in significantly higher titratable acidity than other two concentrations (Table 4).

Fruit TSS was not affected by K levels in Parus cultivar (Table 5). In Camarosa and Selva fruit TSS was significantly higher in 350 and 450 mg L⁻¹ K compared to control (Table 5). Fruit juice pH was not affected by K levels in Camarosa and Selva cultivars (Table 5). Fruit juice pH in Parus was significantly higher in 350 and 450 mg L⁻¹ K treatments compared to control and 600 mg L⁻¹ K treatment (Table 5).

Determination of leaf potassium concentration (Table 6) showed that the maximum value in three cultivars was in maximum K level of nutrient solution (600 mg L⁻¹ K) that in Selva and Parus showed no significant difference to

450 mg L⁻¹ K treatment. In the three genotypes the lowest leaf K concentration was observed in control plants. Fruit K concentration (Table 6) was not followed leaf N concentration in Camarosa and Selva cultivars. However, in the three cultivars fruit K concentration showed no significant difference among 350, 450 and 600 mg L⁻¹ K levels, while the maximum fruit K in Camarosa was in 359 mg L⁻¹ K, in Selva was in 450 mg L⁻¹ K and in Parus was in 600 mg L⁻¹ K of nutrient solution. In the three cultivars the lowest fruit K concentration was in control treatment (Table 6).

4 Discussion

In the present study it was shown that the three strawberry genotypes had general positive response to higher potassium levels of nutrient solution. However, various growth, yield and quality traits had different responses to K levels of nutrient solution in the three genotypes. Application of 350 mg L⁻¹ and for some traits 450 mg L⁻¹ potassium instead of routine Hoagland K concentration of 235 mg L⁻¹ (as control) significantly improved vegetative, yield and quality parameters of the three strawberry genotypes. Increase in plant growth characteristics and quality parameters via application of potassium have

Table 5. Fruit total soluble solids (TSS) and fruit pH of three strawberry cultivars under different K levels of nutrient solution.

K Levels (mg L ⁻¹)	Fruit TSS (%)			Fruit juice pH		
	Camarosa	Selva	Parus	Camarosa	Selva	Parus
235	5.3±0.04b	5.1±0.07b	5.2±0.08a	1.35±0.06a	1.48±0.04a	1.42±0.04b
350	5.5±0.08a	5.3±0.11a	5.2±0.09a	1.37±0.05a	1.54±0.06a	1.54±0.07a
450	5.5±0.04a	5.3±0.07a	5.2±0.05a	1.39±0.04a	1.53±0.04a	1.58±0.07a
600	5.4±0.06ab	5.1±0.10b	5.2±0.07a	1.34±0.03a	1.46±0.04a	1.44±0.08b

- TSS represents the Total Soluble Solids.

- Comparison of means was performed at 5% level of Duncan's multiple range test.

- Plants were grown for five months with treatments.

Table 6. Potassium concentration of leaf and fruits of three strawberry genotypes under different K levels of nutrient solution.

K Levels (mg L ⁻¹)	Leaf K con. (% DW)			Fruit K con. (mg kg FW ⁻¹)		
	Camarosa	Selva	Parus	Camarosa	Selva	Parus
235	1.5±0.12c	1.6±0.17b	1.7±0.13c	1557±125b	1632±171b	1890±118b
350	1.8±0.20b	1.8±0.14ab	2.0±0.18bc	1720±103a	1981±192ab	2011±122a
450	1.8±0.22b	2.0±0.15a	2.2±0.25ab	1629±83ab	2097±128a	2040±67a
600	2.3±0.31a	2.0±0.18a	2.5±0.24a	1621±77ab	1938±109ab	2102±70a

- FW and DW represent the dry weight and fresh weight, respectively.

- Comparison of means was performed at 5% level of Duncan's multiple range test.

- Plants were grown for five months with treatments.

been also reported in other studies (Kaya et al. 2003; Kaye et al. 2006; Fageria et al. 2007; Cerda et al. 2008; Ghazi and Al-Karaki 2008; Mardanlu et al. 2014; Mardanlu et al. 2018). However, in *Galia melon*, fruit number and fruit firmness but not fruit yield was improved by 400 and 600 mg L⁻¹ than 200 mg L⁻¹ potassium concentration (Demiral and Köseoglu 2004). In strawberry, it was shown that increasing the concentration of potassium to 300 mg L⁻¹ in nutrient solution increased vitamin C content, TSS, fruit number, fruit weight, plant yield, root biomass and root length (Ebrahimi et al. 2012).

Potassium is key element involved in photosynthesis, sugar biosynthesis and translocation, stomata behavior and plant water relations, osmotic adjustment, anion-cation equilibrium, cell and plant growth, root growth, increasing nutrients particularly nitrogen use efficiency, with extra roles in plant tolerance to biotic and abiotic stress, and many other functions (Kaya et al. 2003; Walter and Difonzo 2007; Marschner 2011; Mardanlu et al. 2014). Due to these fundamental roles, there may be always positive response of plants to applied potassium particularly to the root medium. Foliar application of potassium on olive trees (Zivdar et al. 2017), tomato plants (Hartz et al. 1999), melons (Lester et al. 2006) and

strawberry (Yildirim et al. 2009) has increased the plant vegetative growth, phytochemicals, fruit quality and marketable yield.

In our study, quality traits of strawberry fruits were also improved by higher K concentrations of 350 and for some other traits by 450 mg L⁻¹. Different potassium concentrations of nutrient solution on *Cucumis melo* cv. *reticulatus* showed that increasing K levels resulted in higher levels of sugars, soluble solids, glutamic acid, aspartic acid, alanine, and volatile acetate compounds in fruit tissues, despite there was no significant effect of K levels on fruit size and its appearance (Lin et al. 2004). Application of K in soil or on foliages during fruit growth in melons can improve fruit quality, sugar content, ascorbic acid and β-carotene (Laster et al. 2006).

Potassium is a key mineral in plant photoassimilate production, their translocation and storage in plant tissues and higher K levels, depending on plant species and environmental conditions, may improve plant photosynthesis and photoassimilate production (El-Bassiony 2006; Marschner 2011; Zivdar et al. 2016). So it can be deduced that in the present study potassium with increasing higher chlorophyll efficiency and photosynthesis rate has affected many enzymatic

reactions toward better biochemical and quality traits (Rubio et al. 2010; Marschner 2011; Mardanluo et al. 2018).

Increase in biochemical quality traits of strawberry by higher K levels indicates higher potassium requirements of plants particularly during fruiting stage. Similar results were reported on chili pepper and bell pepper using higher K levels, in which 400 mg L⁻¹ K in nutrient solution improved many quality parameters including vitamin C and TSS (Mardanlu et al. 2014; Mardanluo et al. 2018). The highest yield and fruit quality parameters including fruit length/diameter ratio, fruit dry matter percentage, fruit vitamin C, total soluble solids, and titratable acidity in chili pepper and bell pepper were obtained under application of 300 and 400 mg L⁻¹ K in nutrient solution, respectively. In either cultivar there was increase in leaf K, nitrogen, and zinc concentrations, while in bell pepper calcium was reduced by higher K levels in the nutrient solution (Mardanluo et al. 2018). Foliar application of potassium on olive trees significantly improved fruit biochemical and oil characteristics (Zivdar et al. 2017). Application of higher K levels of 400 and 600 mg L⁻¹ increased fruit biochemical characteristics such as soluble solids in Galia melons, whereas the leaf concentration of N, P, Ca, Mg and Zn were not affected by K levels of nutrient solution, but leaf K content was higher than the control by higher K rates and Fe and Mn was reduced by application of 600 mg L⁻¹ K in nutrient solution (Demiral and Köseoglu 2004).

Higher potassium concentration in plant tissues is always a quality factor and may have various beneficial effects including; amelioration of the negative effects of salinity on strawberry plant growth and fruit yield (Kaya et al. 2003; Rubio et al. 2010), higher chlorophyll efficiency, more photosynthesis, better translocation and storage of photoassimilate, and increased biochemical quality parameters (Hartz et al. 1999; Kaye et al. 2006; Marschner 2011; Ebrahimi et al. 2012). Plant genotypes that have better tolerance to salinity or drought generally have improved K uptake and concentrations (Ghazi and Al-Karaki 2008; Marschner 2011). In cucumber and pepper under NaCl salinity, supplementary K restored dry matter and chlorophyll concentrations to levels similar to the control plants (Kaya et al. 2001). In tomato, genotypes with higher K uptake generally show increased water use efficiency and salinity tolerance (Ghazi, and Al-Karaki 2008). Higher K levels may also restrict disease and damage by pests (San Bautista et al. 2009), as it has been shown that aphid population densities are higher on potassium-deficient than on healthy soybeans (Walter and Difonzo 2007).

In the present study, Selva genotype responded better to increasing K levels of nutrient solution than other two

genotypes of Camarosa and Parus. Among three cultivars, Selva had the maximum number of fruits per plant and yield production. There was no effect of K levels on fruit yield (in Parus), fruit number (in Camarosa), root dry weight (in Camarosa and Parus), fruit titratable acidity (in Camarosa and Selva), and fruit TSS (in Parus). However, different K levels of nutrient solution showed significant effects on these traits in the case of other genotype(s). Genetic differences among various plant species and cultivars are well known regarding their ability to absorb or translocate the nutrient elements (Marschner 2011). Such differences also exist particularly regarding K uptake and translocation (Fageria et al. 2007). Maize cultivars respond differently to low and high K levels of nutrient solution (Cerdeira et al. 2008). In low K, the growth of maize cultivars showed no difference while at higher K “Spirit” cultivar produced 1.5 times more biomass than “Jubileo” cultivar (Cerdeira et al. 2008). However, in Galia melons different K concentrations of nutrient solution had no effect on yield, but it improved fruit quality by applying as much as 600 mg L⁻¹ additional K to the plants without a reduction in yield (Demiral and Köseoglu 2004). Similar results were obtained on growth and fruit quality of chili pepper and bell pepper under hydroponic system (Mardanlu et al. 2014; Mardanluo et al. 2018).

5 Conclusion

The results indicate that plant overall growth and fruit quality of three strawberry genotypes had positive response to 350 mg L⁻¹, while application of 600 mg L⁻¹ potassium reduced most of plant growth and quality traits than control (235 mg L⁻¹). Among genotypes Selva had better response to higher concentration of K than two other genotypes of Camarosa and Parus. Therefore, increasing K concentration of nutrient solution to 350 mg L⁻¹ can benefit plant growth and improve several fruit quality-related traits in strawberry.

Conflict of interest: Authors declare no conflict of interest.

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