Polytechnic Journal

Polytechnic Journal

Volume 12 | Issue 2 Article 26

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How to Cite This Article

Baper, Shwan Mohammed and Hawezy, Shabaq Mohammed Nafea (2025) "Yield and Fruit quality of Two Strawberry Cultivars (Fragaria x ananassa Duch.) Under Three Types of Hydroponic Systems," *Polytechnic Journal*: Vol. 12: Iss. 2, Article 26.

DOI: https://doi.org/10.59341/2707-7799.1850

Polytechnic Journal. 2022(12,1)
ISSN: 2313-5727
http://journals.epu.edu.iq/index.php/polytechnic

RESEARCH ARTICLE

Yield and Fruit quality of Two Strawberry Cultivars (*Fragaria x ananassa* Duch.) Under Three Types of Hydroponic Systems

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Received: 15 June 2022
Accepted: 23 Aug 2022
Published:

DOI

ABSTRACT

The experiment was carried out in greenhouse at Directorate of Agriculture Researches/ Ankawa - Erbil Ministry of Agriculture and water resources / Kurdistan Regional Government – Iraq during 26-9-2021 to 1-4-2022 to the aim, which are yield and fruit quality of two strawberry cultivars (Sabrina and Camarosa) production and fruit characteristics under three systems Hydroponics (Vertical Nutrient Film (NFT), deep water culture (DWC) and horizontal Nutrient Film (NFT). The results showed significant differences among the treatments, As the Sabrina cultivar had a superiority over Camarosa in terms of the size of the fruits, the percentage of un-marketed fruits, (TSS%) and (TTA%). the Camarosa cultivar outperformed the Sabrina cultivar of the number of flowers and fruits, the weight of the fruits, the total production of the plant; as well as, the percentage of marketable fruits and the percentage of iodization of juice, treatment of DWC was superior in both number of flowers.plant-1, number of fruitS.plant-1, fruit weight (g), fruit size (cm3), plant yield (g), percentage of viable and non-marketable fruits, (TSS%), (TTA%) and ratio between them, anthocyanin content in fruits and juice percentage %, The data showed non-significant differences among hydroponic systems and cultivars in terms of the percentage of vitamin C, ; however, significant differences were found in the interaction between the treatments for all studied traits.

Key words: Strawberry cultivars, Hydroponic systems, Yield, Fruit quality

INTRODUCTION

Strawberry (Fragaria ananassa Duch) is a perennial herbaceous plant of the Rosaceae family, with a beautiful shape and a delicious fruity flavor; it is one of the small fruits spread in the world for its good nutritional and health giving value (Chung et al., 2020). It is a major export crop due to its aroma, taste and high vitamin content (Dos Santos et al., 2022). Based on their response to photoperiod strawberry cultivars are short day plants, such as Sabrina, Rubygem and Camarosa (Gasic and Preece, 2014). The cultivation system plays an important role to influence fruit quality and yield, soil cultivation is the traditional method of strawberry cultivation which benefits from low investment and short-term economic advantages, and greenhouse strawberry production has higher yield per unit area, early production when market prices higher, relatively easier pest management with less use of chemicals, as well as better fruit quality (El-Sayed et al., 2016). Strawberries can be grown in hydroponic greenhouse conditions with climate control, irrigation and CO2 supply (Cantliffe et al., 2007). Since hydroponics in its concept depends on growing plant seeds or "seedlings" in a nutrient water solution, containing the main elements needed by the plant, which range from 12 to 16 elements, or growing the plant in an "inert" solid, that does not react with the nutrients in the solution (Sharma et al., 2018). Growing strawberries by hydroponics need less consumption of water, fertilizers and pesticides (Singh, 2021). on the other hand, Juber et al., (2014) confirmed that as a result of strawberry cultivation in abundance by farmers in Iraq, the plant was infected by soil-caused diseases such as (fusarium and root rot), which led to thinking about cultivation isolated from soil. Alvarado-Chávez et al., (2020) mentioned to the forms of hydroponics that differ according to the movement of water around the roots between dormant and mobile, and there are 6 basic types of hydroponic systems; including, Wick, Deep Water Culture, Reflux and Flow (Flood and Drain), Drip (Recovery or Non-Recovery), N.F.T. (Nutrient Film Technique) and Aerobic. Strawberry seedlings can be grown in soil at a rate of 6.5 to 8 plants m-2, but in hydroponic systems 20 to 24 seedlings can be grown (Mustafa and AbdulRahman, 2021). Strawberry production increases with the number of seedlings planted in hydroponic system (Engler, and Krarti, 2021). (Wan et al., 2018) indicates that the yield of 20 seedlings of strawberry was 9 kg per square meter in the Florida system of vertical hydroponics. On the other hand, (Antunes et al., 2010) confirmed that the production rate of Camarosa cultivar was (877.51 g plant-1) and also (Cervantes et al., 2020) found that the yield of Sabrina (475.3 g plant-1) which were grown in hydroponics. This study aims to:

1. Provide a reference for strawberry growers to improve fruit quality and production efficiency through hydroponics.

2. Evaluate the yield and fruit quality of two strawberry cultivars affected by a different types of hydroponic systems.

3. Study the most efficient systems and their suitability to be used by farmers.

2. Materials and Methods

The study was conducted in the Directorate of Agriculture Researches/ Ankawa - Erbil Ministry of Agriculture and water resources / Kurdistan Regional Government – Iraq. The greenhouse is oriented north-south, the number of daily lighting hours was 12 hours, it is best to use LED light features an actual wattage of between 320-480wt. The greenhouse would likely need 4 -5 grow lights which was controlled by an electronic clock, as the time of turning on and off the lights changes according to the time of sunrise and sunset. Frozen seedlings were planted of both cultivars in September-26-2021 and all values related to the fruit's characteristics in terms of production and quality were recorded until the end of the experiment in March -31- 2022.

2.1. Hydroponic Systems

2.1.1. Vertical Nutrient Film (NFT):

Three poles made of polyethylene, with a diameter of 6 inches and a length of one meter, consisting of five tiers; four plants were planted in each tier. The distance between two plants in each direction was 15 cm. The total number of seedlings planted in this system was 30 seedlings for each Camarosa and Sabrina cultivars, inside each column there was a 60 liter trough filled with the nutritional solution. The water can be pumped up by a water pump (Figure 2) (Pascual et al., 2018).

2.1.2. Deep Water Culture (DWC):

Three 60-liter basins of the solution were used and a cork was placed with holes suitable for the diameter of the seedlings dimensions 15 cm. This system contains an air pump over the basins that circulate air with a poly hose to aerate the stones in the basin. The total number of seedlings planted in this system is 30 seedlings for each Camarosa and Sabrina cultivars (Figure 1) (Yuvaraj and Subramanian, 2020).

2.1.3. Horizontal Nutrient Film (HNFT):

Three tables were prepared to be placed on four tubes measuring 1 m, 10 cm and 3 cm for L, W and H, respectively. With five holes spaced 15 cm apart, for placing the seedlings. A basin was placed under each table for the nutritional solution with a capacity of 60 liters. The solution was circulated from the sump to the pipes through a water pump located at the bottom of the sump. The number of planted seedlings was 30 for each studied cultivars (Camarosa and Sabrina) (Figure 3) (Mohapatra et al., 2020).

Fig 1: Deep Water Culture

Fig 2: Vertical NFT

Fig 3: Horizontal NFT

2.2. Strawberry Cultivars

Frozen seedling of two strawberry cultivars (Sabrina and Camarosa) were used, which were imported from Turkey, Sabrina has a sweet flavor, large, uniform conic fruits with firm, red flesh, and a robust, globose plant. Sabrina was developed for protected cultivation in Spain (Gasic and Preece, 2014). While Camarosa, a neutral American variety with large yields and a fantastic capacity for producing runners, is planted throughout the world due to its capacity to resist a variety of climatic conditions, which sets it apart from the other varieties.

Typically conical in shape, enormous in size, very symmetrical, rotation-resistant, and dark crimson in color, with a distinctive and marketable flavor (Khalil and Al-aareji, 2022). Pruning roots were done to obtain the balance between roots and vegetative growth (Suliman et al., 2020) and then treated with a fungicide solution consisting of (Topsin-M fungicide at 100 g. 100 l^{-1} of water and Rival fungicide at 250 ml. 100 l^{-1} of water) to be sterilized, then planted the transplants inside containers containing a quantity of peat moss and put them in their places in the three hydroponic systems..

2.3. Preparation Nutrient Solutions

Nutrient solution: Fertilizers were prepared in three (3) external tanks as follows:

The first solution: 6.7 kg of Calcium Nitrate and 400 g of Chelated Iron (6%) are dissolved in 40 liters of water.

The second solution: 4 kg of compound fertilizer (NPK) is dissolved (with 1.6 kg of Magnesium sulfate and 270 g of micro-elements fertilizer) in 40 liters of water.

The third solution: Adding 2 liters of Phosphoric acid or Nitric acid (commercial) in 50 liters of water.

The nutrient solutions were placed in three tanks and the solutions were transferred to the basins by a water pump. The level of oxygen in the solution was adjusted either by high-density air stone or by recycling. The EC and pH values of the water were checked and were 0.3 dS m^{-1} and 7.2, and during the flow of the nutrient solution; It was set to an EC of 1.8-2.2 dS m^{-1} (mS cm^{-1}) for the salt tolerance of plants and the pH of the solution at pH 5.5-6.5 which is the optimum range for plants uptake of nutrients from the solution. The temperature of the solution was kept at 22-26 °C. The solution in the tanks was changed completely every two weeks.

2.4. Experimental design and statistical analysis

Factorial Complete Randomized Design (CRD) was applied with two factors; two strawberry cultivars (Sabrina and Camarosa) and three hydroponic systems using three (blocks), each block contain six experimental unit each unit have 10 seedlings. Total number of plants = 2×3×3×10 =180, the collected data were analyzed using SAS statistical package (SAS, 2003). The mean were evaluated at $p<0.05$ to show significant difference using Duncan’s Multiple Range Test (Mead et al., 2017).

2.5. Studied traits

To measure these traits five plants were selected from each plot.

1- Number of flowers (flower. $plant^{-1}$):

The data were taken periodically from the beginning of flowering to the end of the experiment, and the number was calculated according the following equation: (Panigrahi, 2020).

Number of flowers= sum of flowers of five plants/ number of plants.

2- Number of fruits (fruit. $plant^{-1}$):

The number of fruits was calculated from the first harvest in 2-1-2022 to the last harvest in 31-3-2022, according to the following equation: the average number of fruits per plant = the sum of the number of fruits for the five plants/ number of plants. (Fernandez et al., 2002)

3- Fruit weight. $plant^{-1}$ (g): was calculated according to the following equation:

Average fruit weight = sum of fruit weight of five plants / total number of fruits of the same plants (Fernandez et al., 2002).

4- Fruit size (cm^3):

The average of fruit sizes was obtained of five fruits from each plant in each experimental unit to determine the size of the fruits, and a numerical cylinder filled with water was used. The size of the fruit was equal to the amount of displaced water (Fernandez et al., 2002).

5- Plant yield (g. $plant^{-1}$):

Plant yield was calculated according to the following equation:

No. of fruit in plant x Mean weight of fruit. (Kang et al., 2020)

6- Marketable fruits. $plant^{-1}$:

The marketable fruits were calculated by calculating the percentage of the desired fruits for marketing over the total fruits of five plants. (Kang et al., 2020)

7- Un-marketable fruits. $Plant^{-1}$:

The percentage of distorted fruits is calculated on the total fruits of five plants. (Kang et al., 2020)

8- Total soluble solid percentage (TSS %):

TSS was measured by using manual Refractometer, according to (A.O.A.C. 1998).

9- Total titratable acidity percentage (TTA %):

Calculated according to the following equation by using phenolphthalein indicator as described by (A.O.A.C. 1998).

TTA %= Volume of NaOH (0.1N) x Acid Equivalent Weight / Sample volume x 100

10- TSS/TTA

The ratio of TSS/TTA calculated by dividing Total soluble solid percentage by Total titratable acidity percentage (A.O.A.C. 1998).

11- Vitamin C measurement (g. cm^3):

The concentration of vitamin C in the samples was determined according to (Suntornsuk et al., 2002), Each ml of 0.01 N iodine is equivalent to 0.8806 mg ascorbic acid.

V.C (g. cm^3) = 0.88 × VL × 1000 / juice volume

VL= iodine volume

12- Fruit anthocyanin content (mg. 100^{-1} g F.Wt.):

Anthocyanin (mg. 100g-1 fresh weight) was determined by taking (2.5g) of fruit juice, then added 50 ml mixture of 85% Alcohol + 15% HCl (1.5 N), left for 24 hours at 4°C, the solution was filtered through filter paper, then anthocyanin content was it estimated by using Spectrophotometer at a wavelength of 535nm (Mustafa et al., 2019).

Anthocyanin content (mg .100-1 g F.Wt.) = Abs 535 * Ve * Tv / Vu* Wts X100

Abs = Reading of spectrophotometer, Ve = Volume of extracts, Tv = Total volume

Vu = Volume of extracts, Wts = Weight of the sample

13- Juice percentage %

Content of juice percentage was calculated by dividing the juice weight by the total fruit weight × 100 (Palei et al., 2016).

3. Results and Discussion

1- Effect of strawberry cultivars and hydroponic systems on number of flowers and fruit properties.

Table (1) indicates that the highest number of flowers was recorded in the cultivar Camarosa (32.78 flowers Plant^{-1}) compared to the cultivar Sabrina (26.22 flowers Plant^{-1}). Especially during the high temperatures in the spring, and this is consistent with (Avestan et al., 2021) who confirmed that the number of Camarosa flowers was increased significantly in the spring, reaching (24) flowers compared to the winter season, and the number of flowers was (8.1). In addition significant differences were recorded between the hydroponic systems in the number of flowers, as the DWC system was well superior followed by (VNFT) and then (HNFT) (33.33, 29.52 and 25.67 flowers respectively) ; and the difference might be due to the type of hydroponics ; mean by the increase in the root spreading area and the increase in the leaf area in the DWC system which led to an increase in the number of flowers as mentioned by (Karimi et al., 2013), in which the highest number of flowers was recorded in Open trough followed by Lay-Flat-Bag and lowest in the Verti-Gro system. There was no statistically significant differences were recorded between the interaction of strawberry cultivars Sabrina with the systems, but there are significant differences between Camarosa cultivar and systems, and this may be due to the lack of effect of cultivation systems on the percentage of flowers in Sabrina cultivar, and a larger number of flowers may help in obtaining a large group of fruits, as noted by Jafarnia et al. (2010), identified more flowers and more fruits. Murthy et al. (2016) reported that Camarosa fruit weight was decreased when the root spreading area was lower in the HNFT system compared to other systems with more root spreading. The number of fruits, weight of the fruits and their performance showed a significant difference between the two cultivars and among the three systems, the largest total number of fruits with an average of (29.94) was obtained for Camarosa cultivar, which outperformed Sabrina cultivar (10.26). On the other hand, the number of fruits was superior in seedlings grown in the DWC system, followed by VNFT, and the lowest total number of fruits in HNFT was (22.70) fruits. There were also statistically significant differences in the overlap between the categories of hydroponic systems, because the complete nutrition and the quality of hydroponics increased growth and in some cases the number of flowers and fruits in plants, and this is referred to as (Ebrahimi et al., 2012). The DWC system had the largest average fruit weight with an average of 18.85 g and VNFT and HNFT the lowest average fruit weight with an average of (15.45 g) and (14.69 g, respectively), and the results agree with work of (Fernández-Cabanás et al., 2022). There were no significant differences in the interaction between Sabrina and Camarosa cultivars with the three systems in terms of fruit weight. Sabrina cultivar recorde significant superiority over Camarosa cultivar in terms of fruit size, which was (4.67 cm3) and this, is due to the genetic characteristics of the cultivar. The DWC system outperformed the VNFT and HNFT systems and the highest value was obtained (15.59 cm^3). This may be due to the better growth of seedlings grown in the DWC system due to the size and shape of the system, which helps the spread of the roots and thus increase the number and size of fruits as shown by ((Ercisli et al., 2005) that the shape of the system produced slightly more fruits per plant compared to Verti-Gro diet. There were no significant differences in the interaction between Sabrina, VNFT and DWC systems, as well as with Camarosa in DWC and Sabrina in HNFT with Camarosa in VNFT and DWC.

2- Effect of strawberry cultivars and hydroponic systems on yield.

Table (2) indicates significant differences in the total plant yield in the Camarosa variety, as it was obtained (634.76 g. plant^{-1})compared to the Sabrina cultivar, (358.47 g. plant-1), and this agree with (Neetu, 2018) and (Maheshgowda et al., 2016) for both cultivars respectively, this may due to the maximum flowering and fruits with greater weight. In terms of hydroponic systems, a superiority was observed to DWC system, which was recorded the largest production of (628.43 g. plant^{-1}), followed by the VNFT system with (502.68 g.plant^{-1}), and then the HNFT system with (358.72 g. plant-1) it may be due to the existence of suitable conditions around the roots where adequate ventilation and oxygen are provided in the DWC system compared to other systems as mentioned by (Roosta et al., 2018). Significant differences were recorded in the interaction between Camarosa in DWC system (754.56 g. plant^{-1}) and Sabrina (502.30 g. plant^{-1}) in the same system, and this may be due to the effective factors were identified in the improvement quantification of this process which are nutrition, oxygen supply, EC and PH stabilization of nutrient solution and system quality in hydroponics (Al-Rawahy et al., 2019). The percentage of marketable fruits in Camarosa cultivar was recorded a significant difference 79.73 %) compared to Sabrina (72.00%) because of the characteristics of Camarosa varieties and the quality of the flowers, which are bisexual, which needs insects or wind for the purpose of increasing the rate of flower pollination and thus increasing the percentage of marketable fruits (Yoshida et al., 2012). While the marketable fruits were much higher (83.37%) produced in DWC system compared to VNFT system (77.86%) and HNFT system (66.36%). There were statistically significant differences in the interaction between the Camarosa cultivar in the DWC system, as it was obtained (88.66 %), followed by VNFT (80.86%), then HNFT (69.66%), as well as the superiority of Sabrina (63.05 %, 74.86% and 78.08% in all systems DWC, VNFT and HNFT, respectively) The difference may be attributed to the specific characteristics of Camarosa cultivar as well as to the type of system that may later lead to increased nutrient uptake by plants. Mohamed et al, (2021) reported that due to the appropriate level of nitrogen and potassium absorbed by strawberry, vegetative growth and thus the rate of photosynthesis increased resulting in the promotion of marketable fruit. On the other hand, the factor for reduction in marketable fruit can be low light level which causes stamen sterility and poor pollen quality hence reduction in fertilization rate that might contribute to malformed fruit production (Smeets, 1980).

3- Response chemical properties of strawberry fruits to cultivars and hydroponic system:

Table (3) indicates that small differences in the percentage of TSS were recorded between Sabrina (7.51%) and Camarosa (7.16%), while the highest percentage of TSS (7.57%) in the fruits produced in the DWC system was recorded in Sabrina cultivar, which outperformed VNFT (7.28%) and HNFT (7.14%). There were also significant differences in the interaction between cultivars and systems, in which Sabrina (7.67%) and Camarosa (7.47%) and DWC system outperformed the interaction between Sabrina in HNFT system (7.25%) and Camarosa in HNFT (7.03%) and VNFT (7.00%), due to the location of the systems according to the direction of the sun inside the nursery(Garrido-Bigotes et al., 2018). There was significant superiority in terms of TTA between cultivars, as Sabrina outperformed (1.09%) Camarosa (0.99%) as well as statistically significant differences between the systems, where the DWC system was scored superiority over the other systems and resulted (1.15%) as having a high percentage of acid content in the fruits; While recorded, the VNFT% system had a minimum acid content of (0.97%), which may be due to the fact that the vertical system, especially the seedlings planted below the column, are: The northern part of the arboretum is therefore less exposed to sunlight compared to the other two systems, and this was confirmed by (Kang et al., 2020). There were statistically significant differences in the interaction between cultivars and systems, as Sabrina cultivar and DWC clearly outperform (1.21%) Camarosa (1.09%) and other systems, and the reason may be due to the type of the system (Cecatto et al., 2013). On the other hand, it showed that there were no statistically significant differences between the cultivars, but there were significant differences between the systems in terms of the rate of TSS / TA, and the VNFT system outperformed the other two systems and scored a rate of (7.67), while the DWC system recorded (6.8) as a minimum and at the same time there were significant differences In the overlap between Sabrina in the DWC system with the other Camarosa systems. There were no significant differences in the percentage of vitamin C present in both strawberry cultivars, as well as the same for the systems and the interaction between them. This indicates that the percentage of vitamin C is not be affected by the type of hydroponics system, as well as between cultivars, and this agrees with the explanation of (Tohidloo et al., 2018). There were no significant differences in the percentage of anthocyanin between both cultivars, but there were significant differences between the systems, as VNFT recorded the highest value (240.26 mg. $100g^{-1}$ F.Wt.), while HNFT recorded the lowest value (196.03). mg. $100g^{-1}$ F.Wt.) and this difference may be due to the location of the vertical system on the southern side of the greenhouse, which leads to an increase in the exposure of the seedlings to sunlight; then results to an increase in the contents of the fruit from the proportion of anthocyanin and this was confirmed by (Paul et al., 2017). In addition, there are significant differences in the overlap between both cultivars in HNFT and other systems. There are significant differences between the cultivars in terms of the content of strawberry fruits on the juice percentage, where the Camarosa cultivar recorded the highest percentage (87.26%) compared to the minimum cultivar Sabrina (84.11%), and there were significant differences between the systems where the DWC system clearly outperformed and scored higher percentage (90.51%) while VNFT recorded the lowest percentage (77.87%) This result is similar with (Palei et al., 2016). There are also significant differences in the interaction between the Camarosa and Sabrina cultivars in the VNFT system with other cultivars and systems, the reason may be due to the plant's ability and efficiency to absorb potassium, knowing that potassium is an essential element involved in photosynthesis, sugar biosynthesis and translocation, and this was confirmed by (Tohidloo et al., 2018).

4. Conclusion:

It was noted that the Camarosa cultivar is the most suitable compared to Sabrina for cultivation in our region with the hydroponics system, it had high productivity, sweet taste, desirable shape and quality. On the other hand, the study indicates that the DWC system is more efficient, easier and more productive compared to the rest of the other systems, and the cultivation of Camarosa in the DWC system is more suitable with more productivity and better growth. In addition, preparing the nutrient solution and adjusting the EC and pH of the solution daily, as well as placing the beehive inside the nursery for the purpose of flower pollination, are very important technical matters.

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Table (1) Effect of strawberry cultivars and Hydroponic systems on number of flowers and fruit properties*

Cultivar		**Parameters**			
		No. flowers plant^{-1}	**No. fruits plant^{-1}**	**Fruit weight (g)**	**Fruit size (cm^3)**
Sabrina		26.22 b	26.10 b	13.20 b	14.67 a
Camarosa		32.78 a	29.94 a	19.46 a	11.22 b
Hydroponic System					
VNFT		29.52 b	27.87 b	14.69 c	13.78 b
DWC		33.33 a	33.50 a	18.85 a	15.59 a
HNFT		25.67 c	22.70 c	15.45 c	9.47 c
Interaction (Cultivar* Hydroponic System)					
Sabrina	**VNFT**	27.00 c	25.40 bc	12.13 cd	16.82 a
	DWC	27.67 c	32.33 a	15.70 bcd	17.02 a
	HNFT	24.oo c	20.57 c	11.77 d	10.17 bc
Camarosa	**VNFT**	32.00 b	30.33 ab	17.25 abc	10.73 bc
	DWC	39.00 a	34.66 a	22.00 a	14.17 ab
	HNFT	27.33 c	24.83 bc	19.13 ab	8.77 c

*Values within each column followed by the same letter are not significantly different from each other according to Duncan's Multiple Range Test at <0.05 level of probability.

VNFT: Vertical Nutrient Film, DWC: Deep Water Culture, HNFT: Horizontal Nutrient Film.

Table (2) Effect of strawberry cultivars and Hydroponic systems on yield*

Cultivar	**Parameters**		
	Plant yield g. plant^{-1}	**Marketable fruits %**	**Unmarketable fruits %**
Sabrina	358.47 b	72.00 b	26.77 a
Camarosa	634.76 a	79.73 a	19.15 b
Hydroponic System			
VNFT	502.68 b	77.86 b	22.13 b
DWC	628.43 a	83.37 a	14.78 c
HNFT	358.72 c	66.36 c	31.97 a
Interaction (Cultivar* Hydroponic System)			

Sabrina	**VNFT**	331.00 c	74.86 bc	25.13 b
	DWC	502.30 bc	78.08 b	18.23 bc
	HNFT	242.11 c	63.05 d	36.93 a
Camarosa	**VNFT**	674.37 ab	80.86 b	19.13 bc
	DWC	754.56 a	88.66 a	11.33 c
	HNFT	475.33 bc	69.66 cd	27.00 b

*Values within each column followed by the same letter are not significantly different from each other according to Duncan's Multiple Range Test at <0.05 level of probability.

Table (3) Effect of strawberry cultivars and Hydroponic systems on some chemical properties of fruits*

Cultivar		**Parameters**					
		Juice percentage (%)	**TSS (%)**	**TTA (%)**	**TSS/TTA**	**Vt. C (mg. 100g^{-1} fw)**	**Anthocyanin (mg.100 g^{-1} F.Wt)**
Sabrina		84.11 b	7.50 b	1.00 b	7.11 a	36.97 a	28.51 a
Camarosa		87.26 a	7.80 a	1.07 a	7.22 a	35.96 a	29.68 a
Hydroponic system							
VNFT		77.87 c	6.13 b	0.98 b	7.70 a	37.36 a	30.26 a
DWC		90.51 a	7.90 a	1.13 a	6.59 c	35.97 a	29.45 b
HNFT		88.82 b	6.25 b	0.99 b	7.23 b	36.05 a	25.03 c
Interactions (Cultivar* Hydroponic system)							
Sabrina	**VNFT**	75.40 b	5.57 c	1.03 ab	7.41 ab	38.31 a	29.46 ab
	DWC	89.52 a	6.67 b	1.13 a	6.43 c	37.14 a	29.25 ab
	HNFT	87.71 a	5.63 c	1.04 a	7.51 ab	35.44 a	24.75 c
Camarosa	**VNFT**	80.33 b	9.20 a	0.94 b	7.95 a	36.41 a	32.07 a
	DWC	91.51 a	6.70 b	1.13 a	6.75 c	34.80 a	29.66 ab
	HNFT	89.94 a	6.87 b	0.93 b	6.97 bc	36.66 a	27.32 bc

*Values within each column followed by the same letter are not significantly different from each other according to Duncan's Multiple Range Test at <0.05 level of probability.