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RESEARCH PAPER

Quantitative and qualitative characteristics of fruit of some strawberry cultivars under hydroponic cultivation

Mohammad Gerdakaneh [1]*, Rahmatollah Gholami [1], Issa Arji [2]

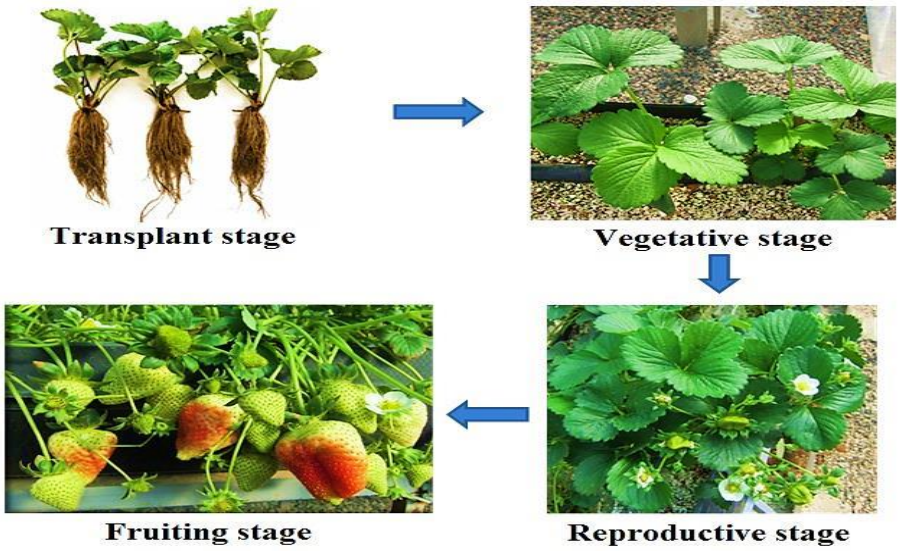
[1] Crops and Horticultural Science Research Department, Kermanshah Agricultural and Natural Resources Research and Education Center, AREEO, Kermanshah, Iran

[2] Department of Production Engineering and Plant Genetics, Campus of Agriculture and Natural Resources, Faculty of Science and Agricultural Engineering, Razi University, Kermanshah, Iran

Highlights

- Increasing local market demand for strawberries has led to modern strawberry production systems such as soilless cultivation, which include nutrient solution management and planting medium.
- Hydroponic cultivation is developing rapidly due to its many benefits.
- Five strawberry cultivars including Paros, Queen ElIza, Selva, Kamarosa, and Aromas were grown in hydroponic greenhouses to measure some quantitative and qualitative characteristics.

Graphical Abstract



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Abstract

The cultivated strawberry is a fruit plant for fresh consumption and food processing. It is one of the early-fruiting garden products with high nutritional value. To determine the appropriate strawberry cultivar for the hydroponic system, an experiment was conducted in a randomized complete block design with 3 replicates. Strawberry cultivars included Paros, Queen Eliza, Selva, Kamarosa, and Aromas, for which a medium of cocopeat and perlite (6:4) was used. Characteristics measured included yield per plant, yield per hectare, average fruit weight, number of fruits per plant, percentage of soluble solids, and acidity. The results showed that the Paros variety had the highest yield per plant (585.33 g), the highest yield per hectare (70.20 tons) and the lowest average fruit weight (18.28 g), while the Selva variety had the lowest. The highest number of fruits per plant (45.00) was observed in the variety Queen Eliza and the lowest in the variety Kamarosa. The highest soluble solids percentage was found in the Kamarosa variety (8.21%) and the lowest in the Aromas variety (6.25%). The highest percentage of fruit acidity was found in the Kamarosa variety and the lowest value in the Selva and Paros varieties.

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*Corresponding author: mgerdakaneh@gmail.com (M. Gerdakaneh)

1. Introduction

Strawberry is a perennial herbaceous plant belonging to the family *Rosaceae* and genus *Fragaria*. The species cultivated today is *F. ananassa*, which is derived from a cross between *F. virginiana* and *F. chiloensis*. Strawberries have a short stem from which leaves, adventitious roots, decumbent stems and inflorescences emerge (Hancock, 2008). Strawberry is one of the early fruiting garden products with high nutritional value. Increasing demand in local markets has led to modern strawberry production systems such as soilless cultivation replacing traditional and old systems, in which one of the success factors is nutrient solution management and planting medium (Shirdel et al., 2017). Strawberries need essential nutrients and favorable environments for vegetative and reproductive growth. Soilless cultivation is the best way to produce strawberries because they are less prone to disease. This system can fit higher plant density in a small area than the traditional system with less use of water and fertilizer (Madhavi et al., 2021). Because strawberries are a plant with shallow roots, nutrient management is essential for optimal production (Raja et al., 2018). Due to the importance of fresh strawberry consumption, the physical and biochemical quality is of great importance, due to its large amount of sugars and minerals (Luna-Zapien et al., 2016). Hydroponic cultivation is developing rapidly due to its many benefits. The existence of advantages such as controlling plant nutrition, the possibility of increasing planting density, reducing the incidence of diseases and pests and increasing the quantity and quality of the product compared to soil cultivation has led horticultural producers to use this method (Afsharipoor and Roosta, 2010). Growing greenhouse strawberries in the soil, regardless of the rotation, leads to some soil-derived problems. For this reason, soil disinfection has become a common practice in the production of strawberries, even on farms. An important advantage of soilless cultivation of strawberries is the lack of need to disinfect the soil (Ercisli, et al., 2005). One of the most important ways to achieve maximum yield in the shortest time and with excellent quality is to grow plants in a soilless (hydroponic) greenhouse (Asadi and Jalilian, 2021).

2. Materials and Methods

In this study, five strawberry cultivars including Paros, Queen Eliza, Selva, Kamarosa and Aromas in cocopeat + perlite 6:4 (40% : 60%) was evaluated using a randomized complete block design with 3 replications in 2018 in hydroponic greenhouse of Kermanshah Agricultural and Natural Resources Research Center. At the end of October, transplants of cultivars were prepared and removed before planting by washing the soil residue around their roots. They were then kept in Mancozeb 2/1000 fungicide solution for 10 minutes. For each cultivar, 150 plants were considered in three replications with a density of 12 plants/m^2. Regarding the handling of the nutrient solution, during the first seven days it was watered only with water, later it was watered with nutrient solution. A nutrient solution with EC 1.9 mmhos/cm was used. The solution was applied several times, including 3 to 4 times, for 15 minutes. In the first months of cultivation, irrigation 3 times a day, which increased to 4 times as the weather warmed up. The hydroponic system of the greenhouse was open, ie the nutrient solution was passed through the root site only once and then removed. In this study, the nutrient solution of Table 1 was used. The pH of the nutrient solution was adjusted to the desired level of 0.2 ± 5.8. Nitric acid was used to adjust the pH. For vegetative growth control, pruning was carried out every two weeks, in which old leaves and stelons were removed. The measured traits included yield per plant, yield per hectare, average fruit weight, number of fruits per plant, percentage of soluble solids and acidity. All the reproductive growth parameters were measured after 16 weeks after the cultivation period and yield attributing parameters like the number of fruit set and the number of fruits per plant were measured beginning and end of the reproductive stage. To evaluate the yield, strawberries harvested during each period were weighed. The weight of the fruit, were measured by using Sartorius balance with accuracy of 0.001 g. The total yield per plant and per hectare was determined. Also, fruit number per plant and acidity were measured and recorded. The fruit total soluble solids (TSS) were determined by using hand refractometer. Finally, all data obtained during the research were statistically analyzed using SAS software. Duncan multiple range test was used to compare the mean.

Table 1. Specifications of the test nutrient solution (mmol/L).

Electrical conductivity (mmhos/cm)	Sulfur	Magnesium	Calcium	potassium	Phosphorus	Nitrogen	Acidity
1.9	2.40	2.10	3.00	4.10	0. 90	9.50	5.80

2.1. Data analysis

Statistical analysis and analysis of variance were performed using SAS software (version: 9.1, Kerry, North Carolina) and comparisons of means were performed using Duncan's multiple range test. The design used was randomized complete blocks with three replications (Dixit, 2020).

3. Results and Discussion

3.1. Yield per plant

Yield per plant was affected by cultivar effect. The results of mean comparison showed that Paros cultivar in terms of yield per plant with 585.33 gr/plant and then Queen Eliza cultivar with 462.466 gr/plant had the highest value and the lowest value related to Selva cultivar with 585.33 gr/plant was (Table 2). Genetic diversity in strawberries, despite its not-so-long crop history, is enormous. Strawberry cultivars are very specific in terms of ecological needs. Each cultivar demands its own environmental needs, so different cultivars are not the same in terms of morphophysiological characteristics, and there are significant differences between cultivars in terms of growth, yield and fruit quality (Klamkowski and Treder, 2007; Sarker et al., 2020; Sepahvand et al., 2021).

3.2. Yield per hectare

Cultivars were significantly different for yield per hectare at a probability level of 1%. The results of mean comparison showed that the highest yield per hectare, with 70.20 tons/ha belonged to Paros cultivar and the lowest value with 42.84 tons/ha belonged to Selva cultivar (Shirdel et al., 2017). Studies were performed on 10 strawberry cultivars in Jiroft region in autumn and winter (Table 2). The results showed that the highest yield was related to Paros cultivar, followed by Kamarosa, Pajaru, Queen Eliza cultivars and the lowest yield was related to Mishioneri and Kurdistan cultivars (Khoshkam, 2013).

3.3. Fruit weight

Fruit weight under the influence of cultivar was significant at the level of 1% probability. Comparison of means showed that the highest fruit weight was observed in Paros cultivar with 18.28 g and the lowest fruit weight was observed in Selva cultivar with 10.20 g (Table 2). In strawberries, fruits are divided into two groups that can be marketed (10 gr or larger fruits) that are used for fresh eating and fruits smaller than 10 gr that are used for processing (Lovaisa, et al., 2016). The most important factor that caused higher yield of Paros cultivar than other cultivars was the average weight of each fruit and the length of flowering period. In a study conducted in Jiroft, it was found that Queen Eliza and Paros cultivars had the highest average fruit weight and Paros cultivar was introduced as the best cultivar in this region (Khoshkam, 2013).

3.4. Number of fruits per plant

The results showed that the number of fruits per plant was affected by cultivar. The highest number of fruits with 45 fruits per plant was observed in Queen Eliza and the lowest number with 30 fruits was related to Kamarosa cultivar (Table 2). The strawberry yield depend on, the more crowns and inflorescences in plant and higher average fruit weight (Capocasa et al., 2008).

3.5. Percentage of soluble solids

The percentage of soluble solids under the influence of cultivar was significant at the level of 1% probability. In terms of percentage of soluble solids, the highest value was observed in Kamarosa cultivar with 8.21% and the lowest value was obtained in Aromas cultivar with 6.25% (Table 2). The amount of TSS is one of the

important quality indicators that have a direct relationship with the edible quality of fruit at ripening and consumers are more inclined to fruits with high TSS (Burdon et al., 2004). TSS levels vary depending on species, cultivar, stage of maturity, and climatic conditions (Antunes et al., 2010).

3.6. Acidity

Fruit acidity under the influence of cultivar was significant at the level of 1% probability. The results of mean comparison showed that the highest percentage of fruit acidity was observed in Kamarosa cultivar and the lowest was observed in Selva and Paros cultivars (Table 2).

Table 2. Mean comparison of strawberry fruit cultivars for qualitative and quantitative characteristics.

Cultivar	Yield per plant (gr)	Yield per hectare (tons)	Fruit weight (gr)	Number of fruits per plant	Percentage of soluble solids	Acidity
Paros	585.33 ^{a}	70.20 ^{a}	18.28 ^{a}	32.00 ^{bc}	6.90 ^{c}	3.20 ^{d}
Queen Eliza	462.66 ^{b}	55.44 ^{b}	10.26 ^{d}	45.00 ^{a}	6.34 ^{d}	3.30 ^{c}
Kamarosa	375.00 ^{d}	45.36 ^{d}	12.50 ^{c}	30.00 ^{c}	8.21 ^{a}	3.50 ^{a}
Selva	357.33 ^{e}	42.84 ^{e}	10.20 ^{e}	35.00 ^{b}	7.13 ^{b}	3.20 ^{d}
Aromas	439.00 ^{c}	52.68 ^{c}	13.30 ^{b}	33.00 ^{bc}	6.25 ^{e}	3.40 ^{b}

The means with the same letters in each column are not significantly different at the 5% level using Duncan's multiple range test.

4. Conclusion

In this study, five strawberry cultivars including Paros, Queen Eliza, Selva, Kamarosa and Aromas was evaluated in hydroponic culture. The results showed that Paros cultivar with the highest yield per hectare and average fruit weight was suitable for hydroponic culture in greenhouse conditions.

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