

EFFECTS OF NUTRITIONAL ELEMENTS LEVEL ON NUTRITIONAL CHARACTERS AND PHYTOCHEMISTRY OF STRAWBERRY IN HYDROCULTURE

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ABSTRACT

This study was conducted to evaluate the impacts of nutrient elements on phytochemistry characters and qualities of strawberry in soilless culture system. The experiment was carried out in a factorial experiment based on randomized complete design with three replications. Treatments consisted of 6 groups of strawberry growing on soilless medium made of perlite and coco peat that were treated with different ratio of nutrient solutions. According to the results modified nutrient improved fruit nutritional characters but it was not unique. TSS_s, TA, vitamin C and pH often were increased by increasing nutritional elements but anthocyanin was decreased by increasing some nutritional elements.

- Keywords: hydroculture, nutritional elements, nutrient solution, strawberry -

INTRODUCTION

Strawberry (*Fragaria × ananassa* Duch.) is one of the most commonly consumed berries, both in fresh and processed forms such as jams, yoghurts, desserts or juices. The relevant nutritional value of strawberry fruits has been remarkably correlated (HANNUM 2004) with the high level of micronutrients such as minerals, vitamin C and folate which are essential for health, and, more recently, to the high levels and different phytochemical constituents (TULIPANI *et al.*, 2009).

Since strawberry is an adaptable plant, and its fruit can be obtained almost in all seasons, its growing areas are being widely expanded in the world. On the other hand since the fruits can be obtained early in the season, when there are no fresh fruits in the markets, its marketability is high. Another important aspect is that it can bring back the investment in a short period; therefore it is suitable for family hobby (ILGM, 2006).

Because of increased demand for more products with high quality and offseason, greenhouse production is increasing. Soilless media are popularly used in greenhouse crop production because they are relatively lightweight, free from diseases, readily available, more uniform and more suitable for growing in containers than soil (YUAN *et al.*, 1996). The choice of the medium should be based on physical characteristics as well as availability and cost (LIETEN *et al.*, 2004; TABATABAEI and MOHAMMADREZAEI, 2006).

Hydroponics is a method of growing plants using mineral nutrient solutions without soil. In this method, growing substrate may be an organic material (peat moss, shredded bark, foam or other organic materials) or an inorganic material such as sand, perlite, vermiculite and rock wool. To support and anchor the root system; plant nutrition is provided through a nutrient solution circulating in the substrate.

One of the advantages of plant nutrition in soilless culture derives from the possibility of precise control of nutrient elements (JOHNSTON *et al.*, 2010) which is not possible with soil substrate (ARZANI, 2007). Coco peat is the best medium for growing summer crops, flowers and strawberry because it has high porosity, and it has a good capacity of holding water and nutrients. Porosity in perlite provides good air exchanges and soil watering and it improves soil aeration promoting the growth of the root system (NOGUERA *et al.*, 2003). Perlite has rich inorganic materials such as iron, sodium, calcium and rare organic materials, since it is based on an organic feature (DJEDIDI, 1999; EBRAHIMI *et al.*, 2012).

Strawberry requires high amounts of potassium because this element is a major component

of the fruit and has a positive correlation with fruits size, color and acidity (BEHNAMIYAN and MASIHA, 2002).

The research was designed and performed to evaluate the effect of different concentrations of nutrients elements via nutrient solution in soilless system composed of 50% perlite and 50% coco peat on phytochemical and quality characters of greenhouse grown strawberries cultivar Gaviata (AMERI *et al.*, 2012).

MATERIAL AND METHOD

Plant material and growth conditions

The study was conducted from March to August, 2013, in an experimental greenhouse of the plant production department, Imam Khomeini higher educational center Karaj, Iran. Strawberry plants cv Gaviata were grown in 2 liters pots on a soilless medium made of 50% perlite and 50% coco peat (v:v) with three plants per pot. Day/ night temperatures were kept at 22/17°C. and were treated with different ratios of a nutrient solution. The full nutrient solution formula was made up with the following stock solutions of the different nutrients: 2.6 KH₂PO₄, 1.9 KNO₃, 2.4 Ca(NO₃)₂ 4H₂O, 0.65 MgSO₄ 7H₂O and 0.46 K₂SO₄. Microelements for the full nutrition solution were provided in the following amounts: 0.16 H₃BO₃, 0.09 MnSO₄, 0.07 ZnSO₄, 0.01 CuSO₄ and 0.002 H₂MoO₄. To provide iron, a stock solution containing 0.1 Fe-EDTA was prepared (ARZANI, 2007).

The following treatments were applied:

Full nutrient solution (G1), a modified nutrient solution with either 10% less (G2) or more (G3) amount of Fe, ZnSO₄, B₂SO₄, MgSO₄, KNO₃, a modified nutrient solution with either 10% more (G4) or less (G5) amount of Fe, Ca(NO₃)₂, KHPO₄, MnSO₄, CuSO₄, MoSO₄ and a modified nutrient solution consisting of +10% Ca (NO₃)₂, KHPO₄, MnSO₄, CuSO₄, MoSO₄ (G6).

The hydroponic system was open. Nutrient solution formula for the group containing chemical treatment was prepared according to KEREJ *et al.* (1999) instruction (Table 1). The pH and EC of nutrient solution were adjusted to 5.7 and from 0.9 to 1.4 dS m⁻¹, respectively.

The pots were arranged in the glasshouse according to a randomized complete design with three replications per treatment.

Determination of Total Anthocyanin Content (ACY)

The ACY of the hydroalcoholic extract of fruits was determined using the pH differential method previously described by GIUSTI (2001). ACY concentration was calculated from the calibra-

Table 1 - Analysis of variance for strawberry phytochemical characters under different nutrient solutions.

| Treatment | df | TSS (Brix) | TA (mg/100 g F.W.) | Phytochemical Vitamin C(mg/g F.W.) | Characters Total Anthocyanin (mg/100 g F.w.) | pH |
|-------------------|----|---------------|-----------------------|--|--|---------|
| Nutrient Solution | 5 | 2.957* | 0.0024* | 0.0306* | 7527570.5** | 0.045** |
| Error | 15 | 0.944 | 0.0008 | 0.0084 | 435379.3 | 0.006 |
| CV | | 10.1 | 10.9 | 8.3 | 26.6 | 1.9 |

** , * , ns and CV, significant at 1 , 5% level of probability, non-significant and Coefficient of Variation, respectively.

tion curve using pelargonidin- 3-glucoside (Pg-3-gluc) as a standard. Results are expressed as mg of Pg-3-gluc equivalents per 100 g of fresh weight (FW) of strawberry. Data are reported as a mean value (SD for six measurements) (TULIPANI *et al.*, 2008).

Total soluble solids (TSSs), total titratable acidity (TA), and pH determinations

Twenty fruits from each replicate were wrapped in cheesecloth and squeezed with a hand press, and the juice was analyzed. TSSs, was determined at 20°C by an Atago DBX-55 refractometer (Atago Co. Ltd, Tokyo, Japan). pH was measured with a pH meter. TA was determined by titrating to pH 8.2 using 0.1 mol/l NaOH after appropriate dilution (AOAC, 2000).

Determination of vitamin C

Ascorbic acid was measured by HPLC as described by HELSPER *et al.* (2003). Briefly, vitamin C was extracted by sonication of 0.5 g of wet frozen powder in 2 ml of ice cold water with 5% metaphosphoric acid and 1 mM DTPA, followed by centrifugation at 2500 rpm for 10 min, filtering, and immediate analysis on an HPLC system. Quantification was made through a standard calibration curve prepared by running standard concentrations of vitamin C prepared similarly and measured in duplicate at the beginning and end of the analysis. Results are expressed as mg of vitamin C per g of FW (TULIPANI *et al.*, 2008).

Statistical analyses

Data were analyzed by the general linear model ANOVA by Minitab® Release 13.2 (Minitab Inc.). Following ANOVA, treatment means were compared using the LSD test at $P = 0.05$. Statistical procedures were performed using the PC SAS software package.

RESULTS

The results showed under G_1 nutrient solution (first group) the fruit regarded indexes that affect its aroma and taste are in acceptable level, however when we used modified nutritional solution for the other groups (G_2 - G_6), increasing levels of some of the characters was detectable. The highest level of TSS and vitamin C observed in group four that had higher percentage of Fe, N, P, S, Mn, Cu and K against the group that treated with G_1 nutrient solution (first group). Fruits produced under treatment G_3 (group3) that received higher amount of Fe, S, Mg, Zn, N and K than the other groups exhibited the highest level of TA, whereas levels of TSS and vitamin C were almost similar to group G_4 . Fruits treated with modified nutrient solution number 5 that contained lower level of Fe, N, P, S, Mn, Cu and K against normal nutrient solution, showed the highest level of anthocyanin and the highest amount of pH was detectable in fruits treated with modified nutrient solutions G_6 and G_2 that received higher level of N,Ca,P,K,S,Mn,Cu and Mo and Fe, Zn, B,S,N,K,Mg respectively (Table 2).

Table 2 Effect of different concentration of nutrient solution on strawberry phytochemical characters.

| Treatment | TSS (Brix) | TA (mg/100 gF.W.) | Phytochemical Vitamin C (mg/g F.W.) | Characters Total Anthocyanin (mg/100 g F.W.) | pH |
|-----------|---------------|----------------------|---|--|-------|
| G1 | 10.33ab | 0.28b | 1.03ab | 3997.3ab | 3.77b |
| G2 | 9.00b | 0.26b | 1.10ab | 3744.3b | 4.02a |
| G3 | 9.67ab | 0.32a | 1.10ab | 2343.0c | 3.85b |
| G4 | 11.00a | 0.24b | 1.26a | 2067.3c | 3.81b |
| G5 | 9.17b | 0.25b | 1.13ab | 4996.8a | 3.85b |
| G6 | 9.00b | 0.26b | 1.20ab | 1378.1c | 4.06a |

Analysis of variance showed that interaction between nutritional elements of nutrient solution supplied with nutritional characters of the fruits was significant; TSS, TA and vitamin C in 5% level and anthocyanin and PH in 1% level of probability (Table 1). Nutrient solution treatment with different ratio chemical nutritional elements showed significantly influence on total soluble solids (TSS), total acidity (TA), vitamin C ($P>0.05$), anthocyanin and pH ($P<0.001$).

DISCUSSION

Considering the results of the present study using a modified nutrient improved fruit nutritional characters but it was not unique; different nutritional formula showed different effect on each index. However often characters increased following enhanced nutritional elements (micro and macro), but anthocyanin decreased with increasing some nutritional elements (micro and macro) (Table 2). SEYYEDI (2005) studied the effect of four kinds of nutrient solution in hydroculture system on the quantitative and qualitative traits of *Silva* strawberry. He showed that by increasing potassium up to 3meq/l in nutrient solution, the soluble solid material increases. FARZANEH *et al.* (2009) studied the effect of different nitrogen and potassium levels on yield and density of nitrogen and potassium of tomato leaf in perlite environment and reported that the most yield of fruit was gained with 200 mg/L nitrogen consumption, and higher levels of nitrogen reduced the yield and different levels of potassium did not have any significant effect on the yield. HARTZ *et al.* (1999) studied different levels of potassium on the quality of muskmelon. They found that 240 mg/L potassium level caused a significant increase in total sugar, TSS, glutamic acid, aspartic acid and acetate volatile components in fruit flesh, which have an effect on its taste and flavor. MASHHADI-JAFARLOO *et al.* (2009) showed that the most strawberry yield was obtained in 100% coconut medium and cocopeat + perlite (50% + 50%) placed in the next stages (EBRAHIMI *et al.*, 2012; ANIEL *et al.*, 2007). According previous studies the result showed that increasing nutritional element until a definite level has positive effect on the fruit nutritional characters.

Whereas fruits treated with nutrient solution formula exhibited significant effect on nutritional characters in fruit quality, were not the highest level but almost all of them were in limited amount. However with using of modified nutrient solution, some of the indexes decreased though some of them increased, so it seems that under a usual condition and using G_1 nutrient solution we have strawberries with satisfying aroma and taste. When we used a growing medium

containing 50% perlite and 50% coco peat treated with G_1 nutrient solution formula, produced strawberries with more acceptable nutritional characters comparing the fruits that produced under other nutrient solution. However in these conditions some nutritional characters exhibited to increase but the others decreased. Therefore based on the experiment results fruits produced under G_1 conditions are the best.

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