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Effect of Different Substrates on Herbaceous Pigments and Chlorophyll Amount of Strawberry in Hydroponic Cultivation System

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Abstract: To evaluate the effect of substrate on herbaceous pigments of strawberry in hydroponic cultivation system, a study was performed in 2010-2011 in the greenhouse of Azad University, Jiroft Branch, Iran. The experiment was done in factorial form based on completely randomized design and the effect of three kinds of substrates (peat + sand + perlite, coocpeat + perlite+ sand + large grain perlite) and three strawberry species (Camaosa, Silva and Parus) was studied in three replications on herbaceous pigments and chlorophyll amount. The results showed that cocopeat + perlite substrate had the most effect on chlorophyll a, chlorophyll b, total chlorophyll, carotenoid, SPAD indicator in the old and young leaves of strawberry. But the most amount of FV/FM was gotten from sand + large grain perlite.

Key words: Hydroponic · Strawberry · Substrate · Chlorophyll

INTRODUCTION

Strawberry is one of precocious garden crop which has high nutritional value. The increase of demand has caused the modern strawberry producing systems such as without soil cultivation or hydrophonic system to replace the old and traditional systems. One of the success factors in without soil cultivation system is nutrient solution and substrate management [1, 2]. One of the physiological reasons of growth decrease may be due to a disorder in the plant photosynthetic system. One of the ways to study realizing disorders in photosynthesis is studying chlorophyll fluorescence and the features related to it. Absorbed light energy in chlorophyll is used in different forms [3]. Nearly ten kinds of chlorophylls have been distinguished so far which have different physical and chemical features. Chlorophyll a is one of superabundant kinds of them and is seen in nearly all creatures that are able to do photosynthesis. Chlorophyll b is mostly special for developed plants and green algae. Chlorophyll a's proportion to chlorophyll b is variable in different plants and the proportion of these changes is usually about 2 to 3.5 [4]. The whole provoked chlorophyll energy may be consumed in photochemical and photo-physical reactions. The energy may be distributed in the form of heat or apart of energy may be dispatched in the form of heat and the rest of it in the form of radiation. In this case, dispatched radiant energy has less energy and more wave length compared to absorbed radiant energy. If molecule energy is radiated the form of heat energy or fluorescence, energy for photochemical reactions will be less. Conversely, if the whole energy of a pigment molecule is provoked and entered into photochemical reactions, no fluorescence will dispatch. Considering the difference between fluorescence dispatching spectrum with the absorption light spectrum, its function can be measured. The relationship between chlorophyll fluorescence and plant photosynthetic efficiency has been investigated in many studies [5-9] and it has been identified that the difference in total proportion of chlorophyll/carotenoids can be an indicator for tension study in the plants [10].

The use of chlorophyll fluorescence from intact, attached leaves proved to be a reliable, nonintrusive method for monitoring photosynthetic events and for judging the physiological status of the plant [11]. Fluorescence induction and derived indices have been used as empirical diagnostic tools in stress physiology [12]. The variable to maximum fluorescence ratio (Fv/Fm) is indicative of potential or maximum quantum yield of

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PSII [13]. It is an important parameter of the physiological state of the photosynthetic apparatus. The declining slope of Fv/Fm is a good indicator to evaluate photo-inhibition of plants exposed to environmental stresses such as drought and heat, accompanied by high irradiance [9]. Except chlorophyll, there are other color combinations in green organs of the plants which have relatively important role in photosynthesis including carotenoids. Their color is usually covered by the existent chlorophyll in the organ and their color is revealed when chlorophyll disappears. The major function of color combinations in the plants are increasing photosynthesis process with absorbing wide spectrum of sun light by green plants. Photosynthesis actions and reactions are special for the tissues which contain chlorophyll [4]. Complete nutrition and suitable substrate increases growth and in some cases increases the number of flowering and fruit in the plants. Yield and other growth traits of plant may be due to suitable conditions existence around root in perlite substrate from ventilation and water maintenance [14].

Moosavi [15] studied the effect of substrates and different nutrient solutions on the quantitative and qualitative traits of capsicum annum in hydroponic system and announced that pure perlite substrate has caused significant decrease in total yield, commercial yield, fruit weight, fruit calcium amount, growth indices and water content in the leaves and it has increased tiny fruit percentage. The substrates which contain 50-75% perlite caused the production of the highest yield in capsicum annum.

The aim of the study was studying the effect of different substrates on herbaceous pigments and chlorophyll amount in strawberry in hydroponic system.

MATERIALS AND METHODS

Herbaceous pigments measurement: to measure chlorophyll a, chlorophyll b and whole carotenoids, first 0.25 grams fresh leaf was chopped and then was grounded in porcelain mortar with 10 ml 80% acetone to form a uniform mass. Then obtained mixture was poured in 20 cc Falcon pipes and was centrifuged for 10 minutes with 3500 rpm. Light absorption amount of upper solution was read using spectrometer set model T 80UV/VIS spectrometer PG Instruments Ltd in 480, 510, 645, 652 and 663 n and finally chlorophyll and carotenoids concentration was calculated by means of the following relations [16].

- Chlorophyll a (mg/g) = 12.7 (D. 663) - 2.69 (D. 645) * V/100 * W
- Chlorophyll b (mg/g) = 22.9(D. 645) - 4.68 (D.663) * V/1000* W
- Total chlorophyll (mg/g) = D.652 *1000/34.5 * V/1000*W
- D= plant reading
- V= 10 cc (consumed acetone volume)
- W= 0.25 g (being used sample volume)

Chlorophyll amount: by means of SPAD502 set during 3 stages (20 days after cultivating seedling, every other week), the amount of chlorophyll was measured in old and new leaves.

Fluorescence maximum to variable (Fv/ FM): To measure fluorescence maximum to variable, chlorophyll fluorimeter model pocket PEA was used. One adult leaf was chosen from each plant and was put in special clips to make darkness condition for 15 minutes and after this time FV/FM was read. For analyzing the data we used SAS software's.

RESULTS AND DISCUSSION

Chlorophyll a and b had a significant difference in 1% level in substrate attendance (Table 1). The most chlorophyll a and b amounts respectively with an average of 0.61 and 0.06 (mg/g) belonged to cocopeat + perlite substrate (Table 2). Boonet [17] stated that peat usage in plants cultivation by itself usually indicates the symptoms of nutritional elements lack, while its combination with mineral soils, has useful effects on plant growth and it is due to peat role of effective chemical processes in providing nutrient elements and their balance. Cocopeat is an organic material with medium ion absorption capacity and it has aerial porosity and good capacity of water and nutrient maintenance and it can be the best substrate for planting summer crops, flower and strawberry [18]. Total chlorophyll showed a significant difference in 5% level cultivation substrate attendance (Table 1) so that the most total chlorophyll gotten was 22% (mg/g) from cocopeat + perlite substrate (Table 2). Perlite is a proper cultivation environment from providing enough air points of view. Porosity existence in perlite, provides aerial and gas interchanges in soil easily for the root of the plant, so it reforms soil airing and watering systems and improves ventilation function in the soil. Performance increase and other growth features of the plant are proper for the root environment in perlite of

Table 1: Analysis of variance for studied traits.

		Means Square						
S.O.V	d.f	Chlorophyll a	Chlorophyll b	Total Chlorophyll	Carotenoids	SPAD Value old leaf	SPAD Value young leaf	FM / FV
Substrate(S)	2	13.12×10^{-3}**	0.002**	0.008*	6×10^{-4} n.s	19.45**	25.41*	6×10^{-4} **
Cultivar)C)	2	0.028 n.s	4×10^{-4} n.s	9×10^{-4} n.s	9×10^{-4} n.s	14.32n.s	25.70n.s	2×10^{-4}n.s
S × C	4	0.064 n.s	9×10^{-4} n.s	0.003n.s	2×10^{-4} n.s	11.95n.s	6.17n.s	10^{-4} n.s
Error	18	0.006	2×10^{-4}	6×10^{-4}	10^{-4}	1.18	3.8	2×10^{-4}
C.V	%	13.5	14.88	14.5	13.78	2.37	4.79	2.21

**,* and Ns, significant at 1, 5% level of probability and non-significant, respectively.

Table 2: Mean comparison of substrates on studied traits.

Substrate	Chlorophyll a	Chlorophyllb	Total chlorophyll	SPAD Value old leaf	SPAD Value young leaf	FV/FM
Peat+sand+perlite	0.49b	0.05ab	0.18b	45.58b	33c	0.77ab
Cocopeat+ perlite	0.61a	0.06a	0.22a	49.5a	38.5a	0.79ab
Sand+perlite	0.38c	0.04ab	0.17b	46.00b	35.5b	0.81a

Values with the same superscript letters are non-significantly different at $P < 0.05$.

views. Perlite contains rich organic materials such as ferrous, sodium, calcium and other rare minerals [19]. Perlite existence as a mineral material in organic substrate combinations decreases cations interchange capacity and it affects fruit acidity [20]. Cocopeat is a good replacement for peat due to being cheap, dcreasing consideration amount, capability of being moist quickly and more suitable pH [21].

Fv/Fm had significant difference in 1% level in substrate attendance (Table 1), so that the most maximum to variable fluorescence was gotten from sand + large grain perlite substrate with an average of 0.79 (Table 2). Perlite is considered as a substrate with excellent features in without soil cultivation since it has high water absorption, increases watering efficiency, uses the substrate once again in the next cultivations and consequently decreases producing costs. Accessible water in perlite gradually increases [19, 22].

Substrate did not have a significant effect on cartenoids amount (Table 1). SPAD indicator in young leaves become significant in 5% level in substrate attendance (Table 1) and the highest SPAD indicator young leaves (38.5) was gotten in Cocopeat + perlite substrate (Table 2). Cocopeat and perlite substrate is effective in the root due to better interchange of the elements especially cations inside the substrate and proper moist distribution that finally affects root system and plant growth [23]. SPAD indicator in old leaves also showed a significant difference in 1% level in substrate attendance (Table 1) and the most amount belonged to cocopeat + perlite with an average of 49.5 (Table 2). Using different organic and inorganic substrates gives the plant an opportunity of the best nutrients absorption and proper growth, water consumption optimization and oxygen maintenance. Also, substrate has a direct effect on root system's development and performance. Therefore choosing the substrate among several materials is necessary for producing the plants [24]. Perlite and cocopeat substarates are not suitable in nutrient absorption. It is due to moist decrease in perlite and airing decrease in cocopeat. Adding cocopeat to perlite increases cations interchanges capacity in substrate. Measuring relative chlorophyll content (SPAD) is considered as a proper criteria in reformatory programs to increase photosynthesis amount.

The substrates which have more water maintenance capacity are more successful in production increase and growth indicator. This subject can be related to ability amount of the substrates in water maintenance, nutrient and porosity for creating proper conditions for the root from air and other physical and chemical features points of views. Organic substrates have physical and chemical features which makes their usage different compared to organic substrates, for example peat, asfagnum and pine skin have somehow absorption and surface absorption capabilities. So that these substrates are more similar to soil while inorganic substrates such as perlite, gravel, sand, etc. do not have these features. Organic substrates have tampon or buffer capacity, which are for the benefit of producer as saving mechanism for necessary elements and they decrease the probability of lack or excess of the elements [25].

Mashhadi-Jafarloo *et al.* [26] showed that the most strawberry yield was obtained in 100% coconut substrate and cocopeat + subs + perlite (50% + 50%) placed in the next stages. Ercisli *et al.* [27] reported that the effect of different cultivation substrate was statistically significant on the growth and development of strawberry.

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