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Using an Infrared Gas Analyzer for Evaluation of Photosynthetic Activity in Some Iranian Pistachio Cultivars

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Abstract

Photosynthetic rates of six pistachio cultivars were studied including Ohadi, Kalleh-Ghochi, Akbari, Ahmad-Aghaii, Rezaii Zoudras and Haratii. Measurements were done using OFF and ON shoots at different stages of fruit growth and development included: 1- Beginning of endocarp growth; 2- pith hardening; 3- Beginning of endosperm rapid growth; 4- end of embryo development; 5- ripening and harvesting times and 6- post harvest. The experiment was carried out as split-plot in a randomized complete block basic design (RCBD) with 72 treatments and three replications, which each replication included the 10 OFF and ON branches. Results indicated that the highest amount of photosynthetic activity obtained by Rezaii Zoudras (4.15), which was followed by Akbari (4.08), Ohadi (3.79), Ahmad-Aghaii (3.7), Kalleh-Ghochi (3.58) and Haratii (3.42), respectively. Moreover in the course of experiment, the highest (5.65) and lowest (2.27) amounts of photosynthesis were resulted from stages of beginning of endocarp growth and ripening and harvesting times, respectively. These data illuminated that gas exchange efficiency can be consider to select and plant the best cvs. under Rafsajan and similar conditions.

Keywords: Echophysiological parameters, Photosynthesis, Pistachio (*Pistacia vera L.*)

Introduction

Pistachio is one of the most important crops in the arid region, especially in the central desert of Iran (Abrishami, 1994). Studies on leaf gas exchanges allow a direct evaluation of the physiological responses to the environmental conditions, which have an influence on the potential productivity of plants (De Palma *et al.*, 1996). Photosynthesis is the basic case for gas exchange activity, growth, and biomass production of plants. Photosynthetic responses to rising global mean temperature of terrestrial plants can potentially change carbon balance and cycling of ecosystem (Gunderson *et al.*, 2000; Rustad *et al*., 2001). A positive correlation between photosynthesis and evaporation in olive trees (David, 2002). Moreover, it was shown that low relative water content strongly reduced photosynthesis, stomatal conductance and evaporation activities in olive trees. Gas exchange activities strongly change under different environmental temperatures (Wang *et al.*, 2007). Unlike other woody species, very few studies have done on photosynthetic activities in nut crops, especially in Pistachio. There were many trials that assessed the rates of net CO_2 uptake and stomatal conductance in some pistachio cultivars (Vemmos, 1994; de Palma *et al.*, 1996), but photosynthetic activity of different pistachio genotypes were never been compared. The investigation and comparison of different cultivars tested under the same environmental conditions might allow detecting physiological variability within the species, which can be related with vegetative and productive performances. Moreover, there were many reports showing physiological activity of pistachio (Angelopoulos *et al.*, 1996). However, the leaf photosynthetic characteristics are a very good initial approach to the response of plants to environmental conditions (Dejong, 1986). Selection of suitable rootstocks, scions and their combinations among commercial ones that have the highest adaptability and are the best regarding to yield, quality, pest and disease resistance, and compatibility under undesirable weather, soil and water conditions is the most important cases in horticulture.

Regarding to climatic diversity in pistachio cultivated lands; it is not easy to recommend the all commercial cultivars for planting. Investigation on the ecophysiological parameters can result in lower damages made by chilling injuries, chilling requirement, salinity and drought stress. Regarding to climatic diversity in pistachio cultivated lands; it is not easy to recommend the all commercial cultivars for planting, therefore, it is necessary to select the best cultivar for each condition. Ecophysiological Parameters clarify the genetic variations and interactions in response to environmental stimulus. Evaluation of these parameters lead to better understanding of growth mechanisms, yield and adaptability, and can be good criteria to choose the best cultivar for each area (De Palma *et al*., 1996). This investigation was conducted to evaluate the photosynthetic activity on different stages of fruit growth and development in ON and OFF shoots of six commercial pistachio cultivars in Iran.

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Materials and Methods

This research was carried out in Rafsanjan, Iran, using 20 years old pistachio tree cultivars including Ohadi (O), Kalleh-Ghochi (KG), Akbari (A), Ahmad-Aghaii (AA), Rezaii Zoudras (RZ) and Haratii (H), as scion that grafted on Badami-Zarand as a common root stock in Iran. Photosynthetic rate (µmol m^{-2} s^{-1}) was measured in the 6 stages of nut growth and development as followed: 1- Beginning of endocarp growth; 2- pith hardening; 3- Beginning of endosperm rapid growth; 4- end of embryo development; 5- ripening and harvesting times and 6- post harvest, using an infrared gas analyzer (ADC, LAC4 Analytical Development, ADC- Bioscientific LTD, UK) between 9 and 11 AM. Selected plants were similar in height and vigor, grown under equal conditions of irrigation and nutrition programs. The experiment was carried out as split-plot in a randomized complete block basic design (RCBD) with 72 treatments and three replications, which each replication included the 10 OFF and ON branches. Means were compared using least significant difference (LSD) at 5% level of confidence.

Results

Analysis of variances for photosynthesis data showed that the effect of cultivar and stages of nut growth on photosynthesis was significant (P<0.01), but the effect of bearing was not significant on this parameter (Table 1). The interactive effect of cultivar and stages of nut growth, cultivar and bearing, and stages of nut growth and bearing on photosynthesis was significant (P<0.01). The interactive effect of cultivar, stages of nut growth, and bearing on photosynthesis was also significant (P<0.01) (Table 1).

Effect of cultivar on photosynthetic rate

Data showed the highest and lowest photosynthetic rate by Rezaii Zoudras and Haratii cultivars, respectively. Moreover there were no significant differences among photosynthetic rates of Rezaii Zoudras, Akbari, Ohadi, and Ahmad-Aghaii cultivars (Table 2).

Table 1. Analysis of variances for photosynthesis data

ANOVA	Mean squares									
	Rep	cv	Stage	cv *Stage	Bearing	cv *Bearing	Stage*Bearing	cv *Stage*Bearing	Error	CV
photosynthesis	0.012	2.896	74.145	3.85	0.082	2.507	5.9	1.49	0.01	19.95
df	2	5	5	25	1	5	5	25	162	
	ns	**	**	**	ns	**	**	**		

**, ^{ns}, represent significant at P ≤ 0.01, and non significant, respectively (LSD test)

Table 2. The photosynthetic rates of different pistachio cultivars Ohadi (O), Kalleh-Ghochi (KG), Akbari (A), Ahmad-Aghaii (AA), Rezaii Zoudras (RZ) and Haratii (H)

Cultivar	RZ	A	O	AA	KG	H
Photosynthesis (µmol m^{-2} s^{-1})	4.15a	4.08ab	3.79abc	3.70abc	3.58bc	3.42c

Within each column, same letter indicates no significant difference between treatments at 5% levels of LSD

Photosynthetic rate in fruit growth period

The highest and lowest photosynthetic rates were obtained at first (Beginning of endocarp growth) and fifth (ripening) stages of fruit growth and development (Table 3).

Table 3. The photosynthetic rates on different stages of fruit growth and development: T1- Beginning of endocarp growth; T2- pith hardening; T3- Beginning of endosperm rapid growth; T4- end of embryo development; T5- ripening and harvesting times and T6- post harvest

Stages	T1	T2	T3	T4	T5	T6
Photosynthesis ($\mu mol\ m^{-2}\ s^{-1}$)	5.65a	5.08b	4.37c	2.88d	2.48de	2.27e

Within each column, same letter indicates no significant difference between treatments at 5% levels of LSD

Cultivars photosynthetic rates in different stages of fruit growth and development

Data showed that the highest rate of photosynthesis was obtained at first stage of fruit growth and development by Ahmad-Aghaii, Akbari, Haratii, Ohadi, and Rezaii Zoudras cultivars. The lowest rates of photosynthetic activity were resulted at fourth stage of fruit growth and development by Ahmad-Aghaii, Haratii and Kalleh-Ghochi. Generally, it is found that the highest photosynthetic activity was in the first stage of fruit growth and development by most cultivars (Table 4).

Table 4. The photosynthetic rates of different cultivars: Ohadi (O), Kalleh-Ghochi (KG), Akbari (A), Ahmad-Aghaii (AA), Rezaii Zoudras (RZ) and Haratii (H) on different stages of fruit growth and development: T1- Beginning of endocarp growth; T2- pith hardening; T3- Beginning of endosperm rapid growth; T4- end of embryo development; T5- ripening and harvesting times and T6- post harvest.

Cultivar / Stage	O	KG	A	AA	H	RZ
T1	6.48a	3.91b	6.36a	5.54a	4.22a	7.35a
T2	4.19c	5.86a	5.54a	4.82ab	4.07ab	5.98b
T3	5.19b	3.79b	4.47b	3.93bc	3.76a-c	5.08c
T4	2.43d	2.16d	3.37c	2.22d	2.32d	2.4d
T5	1.42e	2.51cd	1.83d	2.87cd	2.95cd	2.01d
T6	3.01d	3.24bc	2.88c	2.84cd	3.19b-d	2.1d

Within each column, same letter indicates no significant difference between treatments at 5% levels of LSD.

Cultivars photosynthetic rates regarding to ON and OFF branches

The photosynthetic activity by ON shoots of Rezaii Zoudras, Ahmad-Aghaii, Akbari, and Ohadi, was higher than OFF shoots (Table 5).

Photosynthetic rates by ON and OFF shoots in different stages of fruit growth and development

The highest rates of this variable by ON shoots were found in first, second and fourth stages. Regarding to OFF shoots, the highest rates were shown in third, fifth and sixth stages (Table 6).

Table 5. The photosynthetic rates of ON and OFF shoots of different cultivars: Ohadi (O), Kalleh-Ghochi (KG), Akbari (A), Ahmad-Aghaii (AA), Rezaii Zoudras (RZ) and Haratii (H).

Cultivar / Shoot	O	KG	A	AA	H	RZ
OFF	3.50bc	3.67bc	3.73a-c	3.70a-c	3.83ab	4.12ab
ON	4.01ab	3.50bc	4.42a	3.70a-c	3.01c	4.19ab

Within each column, same letter indicates no significant difference between treatments at 5% levels of LSD.

Table 6. The photosynthetic rates of ON and OFF shoots on different stages of fruit growth and development: T1- Beginning of endocarp growth; T2- pith hardening; T3- Beginning of endosperm rapid growth; T4- end of embryo development; T5- ripening and harvesting times and T6- post harvest.

Stage / Shoot	T1	T2	T3	T4	T5	T6
OFF	5.48ab	4.38cd	4.90bc	2.48ef	2.43ef	2.93e
ON	5.81a	5.77a	3.84d	2.49ef	2.10f	2.83e

Within each column, same letter indicates no significant difference between treatments at 5% levels of LSD

Discussion

Pistachio is a species tolerant to several environmental stress conditions occur in Rafsanjan and other dry areas of Iran. Although pistachio trees accounted as C_3 plant, however they have high photosynthetic efficiency as almond as and higher than apple, peach, plum, sweet cherry, apricot, and walnut trees (Larcher, 1969). In the current experiment, results showed different photosynthetic rates at different stages of fruit growth and development. The photosynthetic rate was higher at first and second stages compared with others, because of fully developed leaves had unlimited photosynthesis that was in agreement with other results (Fuji and Kennedy 1985). The photosynthetic rate decreased by progress toward the end of growth season; however, increased at sixth stage of fruit growth and development. It is probably that leaves senescence of pistachio in mid-season resulted in reduced photosynthesis, which was in agreement with other findings in olive trees (Proietti, 2000). In addition, membrane activities and enzymatic reaction influence by high temperatures that lead to photosynthetic variation. High summer temperatures damage actively photosynthetic tissues, which induces photorespiration (Angelopoulos *et al.*, 1996). The process is that high temperatures lead to higher membrane flowing, therefore, reduces its activities and result in oxygenation higher than carboxylation reactions, which lead to higher photorespiration.

Results showed the higher photosynthesis at sixth stage of fruit growth compared with fourth and fifth stages that resulted from lower temperature. The photosynthesis of ON in second stage was higher than by OFF shoots. However in third stage, we found that this variable increased by OFF shoots compared with ON. Yield and gas exchange activities increased by pistachio trees from beginning of spring to fill the fruit cavity (Vemmos, 1994). Moreover he showed that gas exchange activities of bearing trees are same or lower than non-bearing trees. In addition, found that bearing increase the stomatal opening that resulted in higher photosynthetic activity (Vemmos, 1994). Data showed that genotype had a significant effect on photosynthetic activities, which the highest rates were obtained by Rezaii Zoudras, Akbari, Ohadi, Ahmad-Aghaii, Kalleh-Ghochi, and Haratii, respectively.

Conclusion

In the light of this experiment we concluded that study of ecophysiological characteristics of cultivars is the best way to introduce the efficient ones under different conditions. Selecting the best cultivar reduce the orchard cost, and remove the possibility of environmental injury and so on. Results indicated that the highest amount of photosynthetic activity obtained by Rezaii Zoudras (4.15), which was followed by Akbari (4.08), Ohadi (3.79), Ahmad-Aghaii (3.7), Kalleh-Ghochi (3.58) and Haratii (3.42), respectively. Moreover in the course of experiment, the highest (5.65) and lowest (2.27) amounts of photosynthesis were resulted from stages of beginning of endocarp growth and ripening and harvesting times, respectively. These data illuminated that gas exchange efficiency can be consider to select and plant the best cvs. under Rafsajan and similar areas.

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