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Effects of Pistachio Rootstocks on Ecophysiological Characteristics of Commercial Pistachio Cultivars

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ABSTRACT

Ecophysiological characteristics of "Ahmadaghaii" "Ohadi" "Kallehghuchi" cultivars (as scions) on four pistachio rootstocks (*Pistacia vera Cv.* Badami riz, *P. vera* Cv. Sarakhs, *P. atlantica sub sp. Mutica, P. atlantica sub sp. Atlantica*) were evaluated during the spring and summer seasons of 2005 in the Iran's Pistachio Research Institute (IPRI). Ecophysiological characteristics such as photosynthesis rate (Pn) in leaf surface (µmol $m^{-2}s^{-1}$), stomatal conductance (gs), transpiration rate (E), leaf internal CO_2 concentration (Ci) and leaf temperature (^0C) were measured in the 6 stages of nut growth and development. Results indicated that rate of photosynthesis, stomatal conductance and transpiration increased until second stage of nut growth and development and then decreased until harvesting stage. Negative correlation was found between photosynthesis and leaves internal CO_2 pressure. The highest rate of photosynthesis (16.59 µmol $m^{-2}s^{-1}$), stomatal conductance (0.456 mol $m^{-2}s^{-1}$) and transpiration rate (6.357 mmol $m^{-2}s^{-1}$), were found in Sarakhs rootstock and the lowest ($P < 0.01$) was measured in Mutica. In addition, three indexes (Pn, gs, E) decreased within Sarakhs, Atlantica, Badami riz and Mutica rootstocks, respectively.

Key Words: Ecophysiological; Cultivar; Pistacio; Stomatal conductance

INTRODUCTION

Studies on leaf gas exchanges allow a direct evaluation of the physiological responses to the environmental conditions, which can have an influence on the potential productivity of crop plants. Un-like other woody species, few studies have investigated on photosynthetic responses in nut crops, especially in *P. vera* L. Some researches have been carried out to assess the photosynthesis characteristics in seedlings or one cultivar (Lin *et al.*, 1984; Vemmos, 1994; Novello & Palma, 1995), however photosynthetic activity of different pistachio genotypes have been compared by Palma (1998). He studied photosynthetic characteristics of six Pistachio cultivars and found many differences between female and male pistachio cultivars. He also found "Larnaka" and "Bianca" cultivars with more photosynthesis rate and stomatal conductance in compare to "Kerman" and "Red Allepo" cultivars. But effects of rootstocks and scion on photosynthesis characteristics are not found in the literature. The net photosynthetic activity is subjected to seasonal changes and to diurnal changes, which are mainly influenced by the stage of shoot development, the leaf ageing, the accumulation of hormones and carbohydrates content in the leaves, as well as by the fluctuations of light intensity, leaf temperature, air temperature and humidity (Lakso, 1985; Flore & Sams, 1986; Downton *et al.*, 1987).

Effects of rootstocks and scion on morphological characteristics, quantitative and qualitative characteristics were investigated during 10 last years (1991 - 2001) in IPRI. In this research, suitable rootstock for Iranian commercial pistachio cultivars was introduced as *Pistacia vera Cv. Badami riz*. Between other rootstocks, *P. atlantica sub sp. mutica* rootstock introduced as resistant rootstock to Nematode and good rootstock for establishment in sandy soils, however *P. khinjuk* rootstock, was more resistance to drought stress and introduced suitable rootstock for dry regions. Effects of rootstock and scion on ecophysiological characteristics have not been studied in Iran. Rootstock selection is important in any pistachio orchard and must be attended at the time of orchard establishment. Selection of the most suitable and compatible rootstock and scion in order to obtain the highest yield and quality, resistance to biotic and abiotic has economical importance. In this research, effects of combination of rootstock and scion were evaluated in relation to ecophysiological characteristics.

MATERIALS AND METHODS

This research carried out in IPRI in Rafsanjan (main pistachio growing area in the world), Iran, using 20 years old pistachio. Three pistachio commercial cultivars including "Ahmadaghaii" "Ohadi" "Kallehghuchi" were evaluated on four rootstocks (Pistacia vera Cv. Badami riz, P. *vera* var. Sarakhs, *P. atlantica sub sp. mutica*, *P. atlantica sub sp. atlantica*) during the spring and summer seasons of 2005. Ecophysiological characteristics including photosynthesis rate in leaf surface (µmol $m^{-2}s^{-1}$), stomatal conductance (mol $m^{-2}s^{-1}$), transpiration rate (mmol $m^{-2}s^{-1}$), leaf internal CO_2 concentration (µmol mol^{-1}) and leaf temperature (^0C) was measured in the 6 stage of nut growth

and development. Measurements were made between 9 and 11 am in the orchard and the photosynthetic active radiation (PAR), which was more than 1600 µmol $m^{-2}s^{-1}$ throughout experiments. The experiment was conducted under similar condition such as irrigation, soil, using a randomized complete block design with split-plot layout in three replicates. Measurements were done in 12 branch from each block in the 6 stage of nut growth and development (1-time of beginning endocarp growing, 2-completing of endocarp growing & starting of endocarp lignifications, 3-beginning of rapid endosperm growth, 4-embryo & cotyledon growth completion & digestion of endosperm, 5-harvesting time, 6-After harvesting) with apparatus infrared gas analyzer (ADC, LCA-4, Analytical Development ADC-Bioscientific LTD, U.K.) from leaves in the middle of selected branch. Leaf relative water content (RWC) also measured in each stage as method of Yamasaki and Dillenburg (1999).

MSTATC software (Michigan State University, USA) was used for computing analysis of variance. The lowest significant difference test (LSD) was used to compare the means.

RESULTS

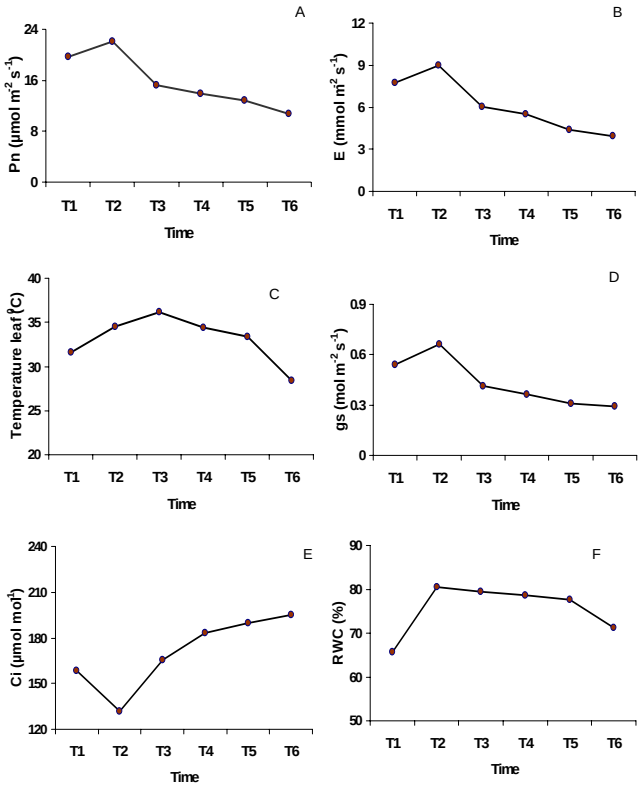
Seasonal change of photosynthesis rate, stomatal conductance, transpiration rate, internal CO_2 concentration, leaf temperature and relative water content of three Iranian commercial pistachio on four main pistachio rootstocks showed the most photosynthesis rate, stomatal conductance, transpiration rate and leaf relative water content in second stage of nut growth and development (T2), then the amount of mentioned parameters decreased until the end of seasonal growth gradually (Fig. 1) Whereas, internal CO_2 concentration deceased until second stage of nut growth, then increased until the end of seasonal growth gradually (Fig. 1). The most leaf temperature was observed in 3rd stage of nut growth and development then decreased till end of season gradually (Fig. 1). Between rootstocks most photosynthesis rate (16.6 µmol $m^{-2}s^{-1}$), stomatal conductance (0.46 mol $m^{-2}s^{-1}$) and transpiration rate (6.4 mmol $m^{-2}s^{-1}$) found in *P. vera* var Sarakhs and then significant decreasing in *P. atlantica sub sp. atlantica, P. vera* Cv. Badami riz and *P. atlantica sub sp. Mutica*, respectively and leaf relative water content between rootstocks was not significant (Table I). The highest internal CO_2 concentration was measured in *P. atlantica sub sp. mutica* (180 µmol mol^{-1}) and the lowest in *P. vera* var Sarakh (165 µmol mol^{-1}). The comparison of the means of photosynthesis and transpiration rate within the cultivars showed no significant differences, while stomatal conductance, leaf relative water content and internal CO_2 concentration was significant (Table I). The most stomatal conductance was observed in "Ohadi" "Ahmadaghaii" and "Kallehghuchi", respectively (Table I). Whereas, leaf relative water content and internal CO_2 concentration was seen in "Ohadi" "Kallehghuchi" and "Ahmadaghaii". Effects

Table I. Effects rootstock and scion on photosynthesis rate (Pn), stomatal conductance (gs), transpiration rate (E), internal CO_2 concentration (Ci) and relative water content (RWC)

Rootstock	Pn (µmol m^{-2} s^{-1})	Gs (mol m^{-2} s^{-1})	E (mmol m^{-2} s^{-1})	Ci (µmol mol^{-1})	RWC (%)
Sarakhs	16.59 a	0.456 a	6.357 a	166.1 b	75.54 ab
Atlantica	16.16 ab	0.425 b	6.095 b	167.3 b	75.53 ab
Badami riz	15.11 b	0.424 b	6.008 b	171.3 ab	74.35 b
Mutica	15.1 b	0.418 b	5.993 b	181 a	76.58 a
Scion					
Ahmadaghaii	15.94 a	0.441 a	6.146 a	160.0 b	73.60 c
Kallehghuchi	15.80 a	0.407 b	6.010 ab	171.1 b	75.62 b
Ohadi	15.47 a	0.444 a	5.917 b	183.1 a	77.22 a

Values are means of 6 replicates. Means within a column followed by the same letter are not significantly different at *P*=0.05
*P<0.05, ** P<0.01, ns= not significant

Fig. 1. Seasonal change of Photosynthesis rate (A), Stomatal conductance (B), Transpiration rate (C) Internal CO_2 concentration, (D) Leaf temperature (E) and Relative water content (F) of three Iranian commercial pistachio on four main pistachio rootstocks.



rootstock and scion in transpiration rate was significant. Between rootstock and scion most transpiration rate was evaluated with combination of *P. vera* var Sarakhs rootstock and scion "Ahmadaghaii" (6.631) and least transpiration was in rootstock *P. atlantica sub sp. mutica* and scion "Kallehghuchi" (5.824).

DISCUSSION

Enhancing photosynthesis could be due to an increase in the demand for photosynthesis products by growing fruits. Plant organs, which act as sinks of carbohydrate can regulate the rate of photosynthesis (HO, 1992). There are numerous reports indicating that the increase in sink demand in plant will result in both an increase in the rate of photosynthesis CO_2 fixation and the rate of photosynthesis export from leaves and vise versa (Peet & Kramer, 1980; Tekalign & Hammes, 2005). Pammenter *et al*. (1993) have also proposed that low in sink demand will result in an accumulation of photosynthetic products in leaves causing a decrease in the rate of photosynthesis. Other aspects of fruit effects on photosynthesis could be due to growth regulators effects (lenz, 1979). Since young and developing fruits are rich in growth regulators (Luckwill, 1979) one can expect that these hormones to regulate enzymes such as ribulose-1, 5-bisphosphate carboxylase/oxygenase (RUBISCO) (Wareing, 1969). Our results show a decline in photosynthesis in trees in the middle of growing season, which could be due to natural senescence of pistachio leaves. Similar decline in photosynthesis by aging leaves has been reported for apple trees (Watson & Landsberg, 1979) and olive trees (Proiettie, 2000). It has also been reported that the decrease in leaf photosynthesis in summer could be due to temperature damage to photosystems and to an increase in the rate of photorespiration (Angelopoulos *et al*., 1996). It is not exactly known as how fruits control stomatal conductance and transpiration rate. However some researchers propose the hypothesis that the decrease in ABA level by growing fruits cause an increase in stomatal conductance followed by an increase in transpiration. The role of ABA in stomatal movement has been very well documented (Salisbury & Ross, 1992). Luckwill (1975) has also reported that leaves at the proximity of growing fruits have less ABA and thus more stomatal conductance than the more distal ones. Photosynthesis rate, stomatal conductance, transpiration rate and internal CO_2 pressure are under influence relative water content. These results are similar to David (2002) show whit decrease relative Water Content %, decrease photosynthesis, stomatal conductance, transpiration rate and internal CO_2 concentration. Also the enhancing effect of fruits on photosynthesis could be due to an increase in both stomatal conductance and leaf transpiration. Such a positive correlations have also been reported by others (Proctor, 1981; Flexas *et al*., 2001) for some trees. Our results show a negative correlation between photosynthesis and leaves internal CO_2 pressure. Similar results have been reported by Proieti (2000) for olive trees. According to these results between rootstocks may be concluded that *P. vera* var *Sarakhs* is the most effective in photosynthesis and can be suitable rootstock for Iranian commercial pistachio cultivars. However, Esmaeilpour (2000) also found *Pistacia vera Cv. Badami riz,* cultivar best rootstocks for Iranian commercial pistachio cultivar in point view of yield and quality of pistachio.

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