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Full Length Article

Photosynthetic and Biochemical Properties of Selected Oregano (*Origanum onites*) Clones

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ABSTRACT

Origanum onites L. is distributed in Western and Southern Anatolia and is one of the most economically important species. A field experiment was conducted in experimental field of Ege University Turkey to understand photosynthetic and biochemical properties of fourteen selected oregano clones. Photosynthetic rate, transpiration, stomatal conductance and water use efficiency was determined by an automatic photosynthetic measurement system. Fluorometer was used to identify quantum yield of photosystem II. Variation in photosynthetic rate and composition of the essential oil were also evaluated. Clone-789 and clone-650 had higher photosynthetic rate, stomatal conductance and water use efficiency. The highest quantum yield was found in clone-732. Essential oil content of the clones ranged between 3.0 and 6.5%. Major component of essential oil was *Carvacrol* in all clones, whereas *Tymol* in clone-661. Our results suggested that clone-789 and clone-650 had higher potential regarding to photosynthetic capacity, whereas clone-732 had higher proportion of absorbed light by chlorophyll, which for use in photochemical process of PSII. These findings may be used for breeding programs focus on high productivity and better quality in *O. onites* L.

Key Words: *Origanum onites* L.; Photosynthesis; Chlorophyll florescence; Essential oil

INTRODUCTION

The genus *Origanum* belonging to *Lamiaceae* family, is mostly distributed around the regions dominated by Mediterranean climate (Davis, 1982). It comprises nearly 49 taxa (species, subspecies & varieties) throughout the world and 86% of this genus is represented in Mediterranean flora (Ietswaart, 1980; Kokkini, 1997). Coastal West and South parts of Turkey, which are considered the genetic center of the genus *Origanum* (Ceylan *et al.,* 2003) are also affected by the same type of climate conditions. *Origanum spp.* are widely distributed in these regions and 21 taxa are local Turkish endemics. Therefore, these locations of Anatolia are known as one of the biggest suppliers of oregano in the world market (Güngör *et al.,* 2005).

Origanum species are mainly adapted to arid and semi-arid environments and they are widely consumed for culinary purposes as spices and as essential oil (Ceylan *et al.*, 2003). Carvacrol is the main component of the essential oil in most of these species (Meyers, 2005; Economoua *et al.*, 2011), while Thymolis another important constituent of the oil (Peter, 2004). Essential oil content of plants is required to be more than 2% for commercial market. These species are *O. vulgare* sub sp. *Hirtum* (Greek oregano) and *O. onites* (Turkish oregano) (Kokkini, 1997). Oregano is added to foods prepared with meat, sausages, salads, soups and alcoholic beverages and used also in cosmetics. It has also antimicrobial, antioxidant, antiviral, antifungal and food-preserving properties (Bernath, 1996; Peter, 2004; Tonk *et al.*, 2010; Economoua *et al.*, 2011).

However, collection of the plants from natural flora has led to serious problem in the trade of oregano due to unsteadiness in quality and quantity of the products and environmental effects as well. For these reasons, new high yielding cultivars have been improved and registered in Ege University, Turkey in order to promote cultivation instead of collection from nature (cv. "Ceylan-2002" & cv. "Taysi-2002"). Although several studies have been conducted to practice some agricultural applications for oregano cultivation (Ceylan *et al.*, 2003; Azizi *et al.*, 2009), physiological mechanisms and biochemical properties are still not clear.

In this study improved 14 clones of oregano originated from the natural flora of west and southwest Turkey were used to determine photosynthetic and biochemical properties of plants.

MATERIALS AND METHODS

Improved 14 clones of *Origanum onites* L. collected from eight different points of Turkish natural floras were used (Table I). These clones were selected from 1362 individual plants according to their agronomic and quality performance (Ceylan *et al.*, 2003). Plants were grown in the

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experimental field of Ege University, Faculty of Agriculture, Department of Field Crops during 2009-2010 growing season. Climate of the experimental site can be characterized as a typical Mediterranean condition (latitude 38º42′ N & longitude 28º45′ E). Each clone was grown in rows at 0.4 x 0.7 m spacing. Nitrogen (30 kg/ha) and phosphorus (30 kg/ha) was provided to the experiment and plants were irrigated depending on the water status of the soil. Weeds were removed by manual elimination from experimental field.

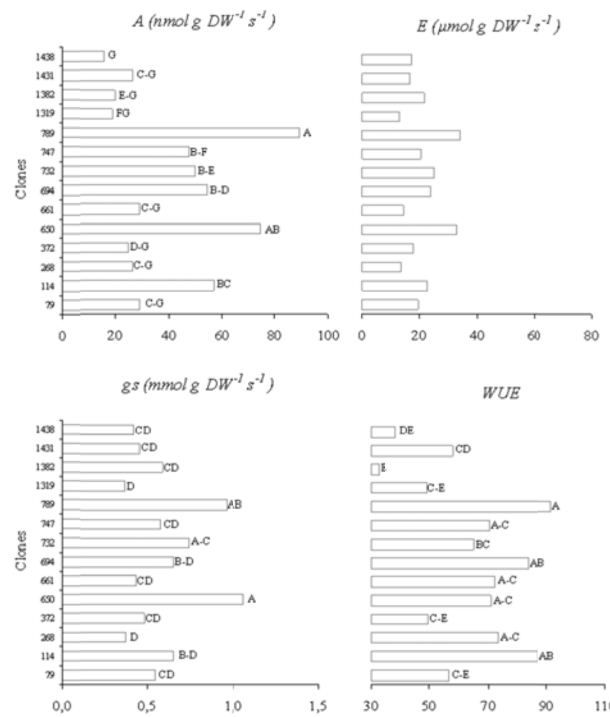
Fluorometer PAM 101 (H. Walz, Germany) was operated to determine chlorophyll fluorescence quenching parameters. The initial fluorescence yield (F_0) in week modulated light and maximum fluorescence yield (*Fm*), emitted during saturating light pulse after 5 min dark adaptation were measured. CO_2 exchange characteristics were measured using a photosynthetic system LI-6000 (Li-Cor, Lincoln, NE, USA).

Plants were sampled eight cm above the soil surface at the flowering stage to determine essential oil content and composition. Essential oils were isolated from 10 g of dried leaves (at 35ºC) by hydro-distillation for 3 h with Neo-clevenger apparatus were used according to the Wichtl (1971). The dried leaf samples were stored at 4ºC until gas chromatography (GC) analyses. An Agilent 6890 N chromatograph equipped with flame-ionization detection (GC-FID) was used to conduct GC analyses in order to determine essential oil composition. Data were analyzed by ANOVA using a completely randomized design with three replications.

Table I: Origins of fourteen *Origanum onites* L. clones used in the study

Clone	Altitude	Origin (province, town, village)
79	50	Muğla-Bodrum-Yalıkavak
114	940	Muğla-Central-Kozağaç
268	330	Muğla-Marmaris-Bayır
372	350	Muğla-Köyceğiz-Kürkçüler
650	10	Antalya-Kaş-Kekova Coast
661	10	Antalya-Kaş-Kekova Coast
694	10	Antalya-Kaş-Kekova Coast
732	10	Antalya-Kaş-Kekova Coast
747	10	Antalya-Kaş-Kekova Coast
789	10	Antalya-Manavgat-Side
1319	350	İzmir-Tire-Başköy
1382	180	İzmir-Ödemiş-Çaylı
1431	180	İzmir-Ödemiş-Çaylı
1438	180	İzmir-Ödemiş-Çaylı

Fig. 1: Photosynthetic rate (*A*), transpiration (*E*), stomatal conductance (*gs*) and water use efficiency (WUE) of fourteen *Origanum onites* L. clones



RESULTS AND DISCUSSION

Physiological and biochemical approaches have a great relevance in order to understand complex mechanism underlying plant productivity. Among these approaches photosynthesis is a major process in plant dry matter production (Loomis & Connor, 1992). A large variation was found in photosynthetic rate (*A*) of selected oregano clones in presents study. Highest *A* was recorded in clone-789 and clone-650, whereas lowest in clone-1438 (Fig. 1). However, plants showed insignificant differences in transpiration rate (*E*). On the average 21.2 µmol H_2O was transpired per second in a unit leaf dry weight. Stomatal conductance (*gs*) was higher in clone-650 comparison to other clones and lowest values were found in clone-1319 and clone-268 (Fig. 1). Stomata give plants the ability to regulate transpiration but also the opportunity control water use efficiency (transpiration efficiency) (Loomis & Connor, 1992). Water use efficiency (WUE) of clone-789 was higher than other oregano clones whereas it was lowest in clone-1382 (Fig. 1). Decrease in *A* and internal CO_2 concentration and finally inhibition of photosynthesis metabolism are generally attributed to stomatal limitation (Reddy *et al.*, 2004). Higher *gs* caused higher CO_2 fixation in oregano clones in also present study. Since there were no discernable differences in transpiration rate of the clones, WUE of plants was regulated mostly by *A* rather than *E*. Eventually, our findings suggested that clone-789 and clone-650 were more pronounced genotypes, because of their high photosynthetic capacity due to higher *A* and high WUE.

Chlorophyll fluorescence another yardstick to measure photosynthetic performance of plants has been proposed to use for reflecting phenological differences (Araus *et al.*, 2001). Fryer *et al.* (1998) stated that quantum yield of photo system II (PSII), which is the primary output of the fluorescence measurement is highly correlated with CO_2 fixation. A highest quantum yield was found in leaves of clone-732, while lowest one in clone-747 (Fig. 2).

Table II: Chemical composition of the essential oils of fourteen *Origanum onites* L. clones (relative percentage area of GC peaks)

Clones	γ-Terpinene	ρ-Cymene	Linalool	β -Caryophyllene	Terpinen-4-ol	Borneol	Carvone	Thymol	Carvacrol	Total identified
79	4.00	2.03	0.35	0.89	0.90	2.12	0.39	0.58	85.3	96.5
114	5.77	3.02	0.70	0.66	1.03	1.67	0.76	0.47	80.1	94.1
268	4.21	1.62	0.50	0.50	1.18	1.85	1.59	0.92	84.3	96.7
372	2.18	1.22	0.52	0.85	1.12	0.89	0.88	0.49	90.4	98.6
650	2.56	2.37	0.29	0.49	1.13	0.63	0.27	0.32	88.5	96.6
661	4.04	2.96	0.33	0.82	0.70	2.38	0.43	80.44	4.8	96.9
694	2.94	2.48	0.29	0.68	0.66	1.03	0.36	0.24	87.7	96.4
732	1.16	0.67	0.00	0.73	0.60	1.57	0.00	0.00	93.2	97.9
747	3.73	2.27	0.35	0.42	0.76	0.50	0.31	0.22	87.3	95.8
789	0.48	0.00	0.63	0.96	0.84	1.37	1.15	0.00	90.0	95.4
1319	9.36	3.23	0.46	1.09	0.74	1.00	0.95	0.37	77.7	95.0
1382	3.80	1.95	0.36	0.66	0.82	1.47	0.60	0.77	86.2	96.7
1431	3.34	1.68	0.35	1.25	0.80	0.43	0.52	0.37	88.3	97.0
1438	1.86	1.42	0.40	0.85	0.75	1.43	0.42	0.52	88.7	96.4

Our results indicated that clone-732 had a potential to have higher proportion of absorbed light by chlorophyll for use photochemical processes of PSII.

Essential oil rate of fourteen clones are given in Fig. 3. Highest essential oil rates were found in clone-747 (6.5%) and clone-661 (6.0%), whereas lowest in clone-789 (3.0%) and clone-372 (3.1%). Başer (1993) reported that essential oil in dry herbage of *O. onites* L. collected from Turkish flora ranged between trace to 3.9%. However, the oil content was higher than these findings but similar with the results of Ceylan *et al.* (2003) in the present study.

The essential oil compositions of each clone are shown in Table II. The main components of the essential oils in fourteen clones were γ-terpinene, ρ-cymene, linalool, β – caryophyllene, terpinen-4-ol, borneol, carvone, thymol and carvacrol. Among all these constituents carvacrol was the major component of essential oil, whereas it was thymol in clone-661. This discrepancy between clone-661 and other clones have been reported in previous studies (Marquard *et al.*, 1996; Tonk *et al.*, 2010). Carvacrol ranged between 77.7 and 93.2% these 13 clones in present study. Highest carvacrol content was found in clone-732. Ratio of thymol was 80.4% in clone-661 as major component of the essential oil. Carvacrol and thymol contents were higher than reported by Özel and Kaymaz (2004), Sokovic *et al.* (2002) and Azcan *et al.* (2000). The second major chemical constituent of the oil was γ-terpinenein clone-79 (4.00%), clone-114 (5.77%), clone-268 (4.21%), clone-372 (2.18%), clone-650 (2.56%), clone-694 (2.94%), clone-747 (3.73%), clone-1319 (9.36%), clone-1382 (3.80%), clone-1431 (3.34%) and clone-1438 (1.86%). However, borneal was secondary higher component of essential oil in clone-732 (1.57%) and 789 (1.37%), whereas it was carvacrol in clone-661 (4.80%). The γ-terpinene, borneol and β – caryophyllene contents were lower than those reported by Skoula *et al.* (1999), whereas ρ-cymene, linalool, terpinen-4-olandcarvone higher in present study. Azcan *et al.* (2000) found higher content of secondary components in the essential oil of *O. onites* comparison to current study,

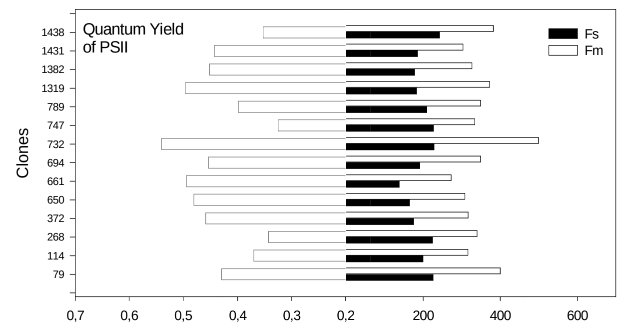
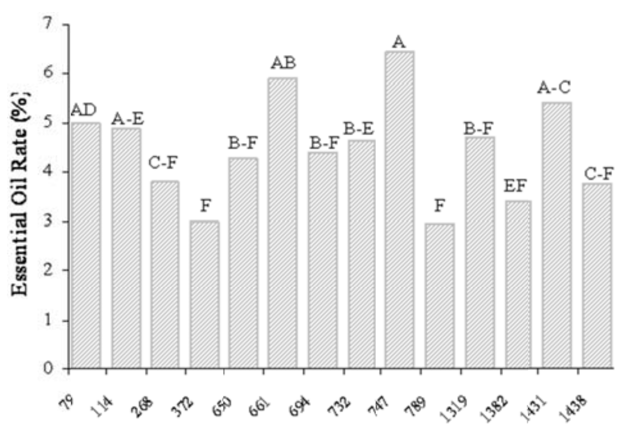


Fig. 3: Essential oil rates of fourteen *Origanum onites* L. clones



whereas carvacrol content was lower as a result of different dissociation of chemical constituents.

CONCLUSION

There was significant variation in photosynthetic activity and quantum yield of fourteen clones of *O. onites* L. Clone-789 and clone-650 had higher potential regarding to photosynthetic capacity, whereas clone-732 was better in terms of having higher proportion of absorbed light by chlorophyll, which is used in photochemical process of PSII. Essential oil content of the clones ranged between 3.0 and 6.5%. Major constituent of essential oil was carvacrol in all clones, whereas main proportion consists of tymol in clone-661. These results may serve to breeding programs, which focus on high productivity or better quality in *O. onites*.

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