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EFFECTS OF ENVIRONMENTAL CONDITIONS ON MORPHOLOGICAL AND PHYSIOLOGICAL CHARACTERS OF *CYNARA SCOLYMUS* L.

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Abstract

Results of environmental characters on yield and essential oils of artichoke (*Cynara scolymus* L.) showed that the regions had significant effects on measured characters. The highest fresh matter (203704 kg/ha) and dry matter (25972 kg/ha) were obtained from Esfahan city and the least of fresh matter (98274 kg/ha) and dry matter (10552 kg/ha) was produced in Alavicheh region. The highest (7.23 mg/l) and lowest (4.97 mg/l) amount of chlorogenic acid were produced by Alavicheh and Esfahan region, respectively. It seems that better climatic characters in Esfahan city, produced higher amount of pigments but decreased chlorogenic acid.

Introduction

Artichoke (*Cynara scolymus* L.) belongs to Asteraceae and is a perennial. This vegetable is cultivated for fresh and undeveloped flower head (Sałata *et al.* 2012). The artichoke needs lower temperature and specific photoperiod to form generative stem and bloom. Although after establishment, this plant has drought tolerance but for better yield, moisture and soil nutrition are necessary. Many workers indicate that compounds shorten period from planting to harvest and increases yield (Calabrese and Bianco 2000, Lattanzio *et al*. 2009, Bundy *et al*. 2009, Löhr *et al*. 2009). It is rich in cynarin, chlorogenic acid and orthophenole constituents. Other phytochemicals present include cynaropicrin and sequiterpene lactones which possess both hypoglycemic and hypolipidemic activities (Macua 2007, Melilli 2007, Visioli *et al*. 2004, Pinelli *et al*. 2007, Nazni *et al*. 2009, Riboli and Norat 2003, Ceccarelli *et al*. 2010). Environmental variations in many plants resulted change in phytochemical properties. In lower latitude, yield in strawberry plants, artemisinin content of *Artemisia annua* (Omer 2008), antioxidants in vegetable (Kalt 2005), essential oil composition and the antimicrobial properties of wild mint (Viljoen *et al*. 2006), essential oil in *Origanum vulgare* (Gonuz and Özorgucu 1999) were found to increase. Tiwari *et al*. (2013) reported that *P. roxburghii* needles showed morphological, epidermal, and anatomical variation at different altitudes. In durum wheat landraces, Zencirci (2008) showed the significant effects of altitude, such as variations between landraces were positively correlated with morphological characters. The aim of the present study was to evaluate the environmental characters on yield and essential oils of artichoke plant, in three regions of Esfahan province of Iran.

Materials and Methods

To determine the best environmental condition place of planting of artichoke, an experiment was conducted in 3 major regions of planting in Esfahan province (30°42′-34°27′ N 49°38′-55°32′ E) central Iran consists of Golpayegan, Alavicheh and Esfahan city in 2014. The properties of

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these regions presented in Table 1. Measured characters in this investigation were fresh and dry matter, plant length, canopy intensity, leaf number and content of chlorogenic acid, potassium, sodium, chlorophyll and carotenoid. The map of places are shown in Fig. 1. Seeds collected from the center of agricultural and natural resources of Esfahan province and sowing was done in March depended to weather properties of each place. The extraction was made from *C. scolymus* leaves (0.1 g accurate weight) with ethanol (70%, 250 ml) on a boiling-water bath for 1 hr. An alcoholic solution of the extract was prepared by dissolving the dry aqueous extract from *C. scolymus* leaves (0.02 g accurate weight) in ethanol (70%, 100 ml) in an ultrasonic bath at 50°C. A series of reference solutions in ethanol (70 and 0.05%) were prepared in parallel. The experimental and reference solutions were injected (20 µl) into the chromatograph. After extraction of plants, the chlorogenic acid content was measured by spectroscopy. Potassium and sodium content was measured by Atomic Emission Spectrometry (AES) and chlorophyll and carotenoids content following Arnon's method (Arnon 1949).

Fig. 1. Map of planting regions.

Results and Discussion

Significant differences between regions for fresh and dry matters are shown in Table 2. The highest fresh and dry weight (203704 and 25972 kg/ha), plant length (84.5 cm) and canopy intensity (7016.7 cm^2) were noticed in Esfahan city and lowest fresh and dry matter (98274 and 10552 kg/ha), plant length (53.75 cm) and canopy intensity (5597.3 cm^2) were obtained in Alavicheh, although Golpayegan and Alavicheh were in same group. There was no significant difference for leaf length character between regions (Table 4). Better morphological properties were obtained in Esfahan city. More growth and development were observed in lower altitude due to higher temperature.

Table 1. Climatic and edaphic properties of regions.

Name of region	Annual precipitation (mm)	Av. of annual temp. (ºC)	Maximum temp. (ºC)	Minimum temp. (ºC)	Altitude (m)	$CaCO_3$ (%)	Soil texture
Esfahan city	140	16	40	–17	1612	0.71	Loam
Golpayegan	132.3	14.6	35.1	–21	1818	0.56	Clay loam
Alavicheh	142	14.2	27.5	–12	1800	0.61	Sandy loam

Table 2. Analysis of variation of regions effect on morphological characters.

Source of variation	df	Mean of squares					
		Fresh weight	Dry weight	Length of plant	Canopy intensity	Leaf length	Leaf number
Replication	2	377884446	5078665.3	34.25	178329	85.54	29.17
Region	2	9661921390 *	197081200**	710.84*	1676529*	3611111$^{n.s}$	38.13*
Error	4	610536063	10902991.3	119.03	137324	128.61	8.14
C.V		14.5	12.7	11.1	8.9	7.6	6.6

* and **: Significant at 5 and 1% levels of probability, respectively.

Table 3. Analysis of variation of regions effect on physiological characters.

Source of Variation	df	Mean of squares				
		Potassium	Sodium	Chlorogenic acid	Total chlorophyll	Carotenoid
Replication	2	0.0217	0.006	3.51	40452.91	1343.22
Region	2	2.22**	0.092**	4.17**	25598.3**	24325.99**
Error	4	0.0078	0.001	0.07	3982.84	351.14
C.V		6.7	5.9	3.3	8.1	3.6

ns, * and ** : Non significant, significant at the 5 and 1% levels of probability, respectively.

Table 4. Means of morphological characters measured in Artichoke plants that are affected by regions.

Region	Fresh wt. (kg/ha)	Dry weight (kg/ha)	Length of plant (cm)	Canopy intensity (cm^2)	Leaf length (cm)	Leaf number
Esfahan city	203704^{a}	25972^{a}	84.5^{a}	7016.7^{a}	87.5^{a}	32.75^{ab}
Golpayegan	114583^{b}	13932^{b}	70.42^{ab}	5900^{b}	94.83^{a}	29.91^{b}
Alavicheh	98274^{b}	10552^{b}	53.75^{b}	5597.3^{b}	91^{a}	37^{a}

In a column, groups having same letter/s do not differ significantly at 5% level of significance.

Table 5. Means of physiological characters measured in Artichoke plants that are affected by regions.

Region	Potassium (%)	Sodium (%)	Chlorogenic acid (mg/l)	Total chlorophyll (µ gr/gr)	Carotenoid (µ gr/gr)
Esfahan city	1.32^{b}	1.04^{a}	4.97^{b}	1303.7^{a}	305^{a}
Golpayegan	2.69^{a}	0.69^{c}	6.68^{a}	1123.66^{b}	125.7^{c}
Alavicheh	1.1^{c}	0.91^{b}	7.23^{a}	1249.6^{ab}	200.6^{b}

In a column, groups having same letter/s do not differ significantly at 5% level of significance

Table 6. Correlation coefficients between different characters.

	1	2	3	4	5	6	7	8	9	10	11
Traits	Potassium (%)	Sodium (%)	Total chlorophyll (µgr/gr)	Carotenoid (µ gr/gr)	Chlorogenic acid (mg/l)	Fresh weight (kg/ha)	Dry weight (kg/ha)	Length of plant (cm)	Canopy intensity (cm^2)	Leaf length (cm)	Leaf number
1	-	–0.79**	–0.54	–0.71*	0.17	–0.23	–0.19	0.13	–0.14	0.21	–0.53
2	-	-	0.49	0.83**	–0.31	0.62	0.55	0.25	0.58	–0.35	0.45
3	-	-	-	0.64	–0.04	0.13	0.17	0.24	0.56	0.05	–0.02
4	-	-	-	-	–0.67*	0.72*	0.71*	0.44	0.72*	–0.28	0.15
5	-	-	-	-	-	–0.78*	–0.8**	-0.5	–0.5	0.18	0.23
6	-	-	-	-	-	-	0.97**	0.75*	0.69*	–0.09	–0.1
7	-	-	-	-	-	-	-	0.74*	0.71*	–0.08	–0.28
8	-	-	-	-	-	-	-	-	0.65	0.27	–0.25
9	-	-	-	-	-	-	-	-	-	–0.32	–0.23
10	-	-	-	-	-	-	-	-	-	-	–0.25

*,**: Significant at the 5 and 1% levels of probability, respectively.

There were significant differences in respect of potassium, sodium, chlorophyll, carotenoid, chlorogenic acid content in Table 3. However, Esfahan city produced lowest chlorogenic acid (4.97 mg/l) but made maximum fresh and dry matter then maximum total chlorogenic acid produced in Esfahan city. It seems that in lower altitude produced more fresh and dry matter due to more temperature (Table 5).

By increasing chlorogenic acid content, fresh and dry matter of plants and carotenoid content decreased. Made higher amount of potassium and then diminish in sodium and carotenoid content, resulted to increase of chlorogenic acid content. Perhaps by better climatic properties resulted more fresh weight, dry weight, length of plant and canopy intensity lesser chlorogenic acid content obtained (Table 6).

Higher temperature created drought and salinity and therefore sodium content in soil increased. Sodium can be replaced by potassium, due to that absorption of sodium in plant was high. Latitude by effect of soil type, varied physiological properties for example Artemisinin Content of *Artemisia Annua* (Omer 2008), antioxidants in vegetable (Kalt 2005), essential oil composition and the antimicrobial properties of Wild Mint (Viljoen *et al*. 2006), essential oil in *Origanum vulgare* (Vokou *et al*. 1993).

Since the chlorogenic acid oil content of artichoke plants is one of the great importance for the Iranian economy, the effects of altitudinal variation on this parameter were examined in the samples collected from different altitudes and different sites. The high altilute soils are non calcarious and lower one is calcarious (Table 1). Chlorogenic acid content increases in parallel with an increase in average annual temperature and decrease in altitude (Table 1). Although many studies on volatile oil content from various sites have been made none dealt with the changes in the volatile oil content in relation to altitude. However, relying on the findings of Rhizopoulou *et al.* (1991), Gonuz and Özrgucu (1999) and of Vokou *et al*. (1988) that volatile oil content increased due to decrease in soil moisture and adapted well to summer drought and had high production of volatile oil. It can be concluded that chlorogenic acid oil content increased with the variation altitude even in the similar reasons. Many environmental factors change due to changes in altitude. For instance, the amounts of precipitation and radiation increase with an increase in altitude together with the effects of wind, daily temperature differences, cloudiness and humidity. On the other hand, evaporation and mean temperature decrease with an altitudinal increase and vegetative phases and the process of pedogenesis shorten (Koçman 1989). All these changes in relation to altitude, affect plant life, in particular the morphological and physiological characteristics.

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