

Original Article

Evaluation of Morphological Traits and Oil Contents of *Achillea aucheri* from Different Altitudes

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Abstract

Yarrow (*Achillea* spp.) belonging to the family of Asteraceae with useful properties, such as anti-diaphoretic, anti-hemorrhagic, anti-inflammation, anti-biotic, anti-fungal, anti-bacterial, Carminative and anti-oxidant effects. The present investigation assessed the morphological diversity of *Achillea aucheri*, which is indigenous plant from Damavand mountain of Iran. The samples were collected from five heights of Damavand and the morphological traits were studied. For estimating the percentage of essential oil, aerial parts were collected and oil was isolated by hydro distillation using Clevenger-type apparatus. The results of present study demonstrated that the highest plant height, internodes, biomass and number of leaves per node obtained at lowest altitude (3900 meters from sea level). In addition, fresh weight and dry weight of plant had the highest amount in altitude of 3900 meter from sea level. But essential oil content increased from low altitude to high altitude from 0.681% to 0.954%. Also high altitude had high significantly differences on the essential oil content. It revealed that plants in lower altitudes produce more biomass than higher altitudes, but essential oil content of plants was more in higher altitudes. It seems that a part of photosynthetic energy of plants in higher altitudes expend to produce secondary metabolites especially essential oils to overcome stress and survival in inappropriate conditions.

Key words: *Achillea aucheri*, Morphology, Essential oil content, Altitude, Medicinal Plant

Introduction

The Iranian plateau is a special unit of geographic on the earth causes different climates. For this reason, a lot of variety of plant species spread on it. The plant communities of Iran includes more than 7,500 species and major of these plants, are medicinal [1]. Medicinal plants have a traditional history of use with strong roles in cultural heritage and in the appreciation of food and its links to health [2]. Among medicinal plants families, Asteraceae (Compositae) is one of the most important families with more than 900 genus and 2000 species [3]. *Achillea* is one of the most important genres of the Asteraceae family.

Achillea spp. contains more than 115 species, which distributed mainly in Europe, Asia and North Africa. Nineteen species of this genus described in Flora Iranica, which *Achillea aucheri* Boiss is one of these species that is found in the central Alborz region [4]. In Persian language, its name is Bumadaran. *A. aucheri* used as anti-inflammatory, anti-spasmodic, diaphoretic, diuretic, immunologic agents and for treatment of hemorrhage, pneumonia, rheumatic pain and wounds since antiquity [5].

Achillea aucheri has many active substances, like 1-8 cineol, α -terpineol, α -pinene and β -pinene. Morphological and phytochemical variations occur with changes in environmental factors and these

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variations help organisms to adapt the new environmental conditions [6]. Some of the important environmental factors that affect quality and quantity of the active substances of medicinal plants are temperature, light, altitude, water and soil [7]. Ebrahimi *et al* (2011) have found that the low temperature treatment significantly increased biomass, flower yield, essential oil content and plant height of chamomile and significantly difference observed in plants between low and high temperature [8]. According to another research by Zheng *et al.* (2012), light quality is very important on plant secondary metabolites. They showed explants of *Dendrobium candidum* under red light contained significantly more alkaloids and polysaccharides than explants cultured under blue light.

Altitude also is another important environmental factor that influences Climatic factors [9]. Nchabeleng *et al.* (2012) found that bush tea harvested from different areas and altitude had different chemical compositions, with bush tea grown in high altitudes contained highest polyphenol content compared to bush tea grown in low altitudes of South Africa. Meanwhile, they showed a positive correlation between altitude and total polyphenol content as compared to the other climatic and soil factors [10].

Since detailed investigations about the variation of morphological properties of *A. aucheri* in Iran have not yet been performed, the aim of this research was to determine the morphological properties of

A. aucheri in Mount Damavand, which is located in the middle Alborz Range. In addition, since morphological properties of plants can be used as a marker in plant taxonomy. This study will be helpful in assessing populations of *A. aucheri*.

Material and Methods

Samples of *Achillea aucheri* Boiss. (Fig. 2) were collected in 27 July 2013, during the flowering stage, from mount Damavand (3900 m to 4300m) in north of Tehran, Iran (Fig. 1). The information of regions has been shown in table 1.

Experimental design

Achillea aucheri Boiss. Samples from five altitudes including 3900, 4000, 4100, 4200, and 4300 meter were collected and used for analysis.

Aerial parts of *A. aucheri* were dried at room temperature. The seeds were collected early of autumn. For extraction of essential oil content, the plants were harvested at full bloom stage. Aerial parts (100 g) were collected and subjected to hydro distillation in a Clevenger-type apparatus for 4 h. After extraction, the oils were collected in screw capped glass vials and weighed with digital scale.

Data analysis

Obtained data were analysed using SPSS program (Version.19) and mean comparison was done with Duncan multi range test in 5% and 1% probability level.

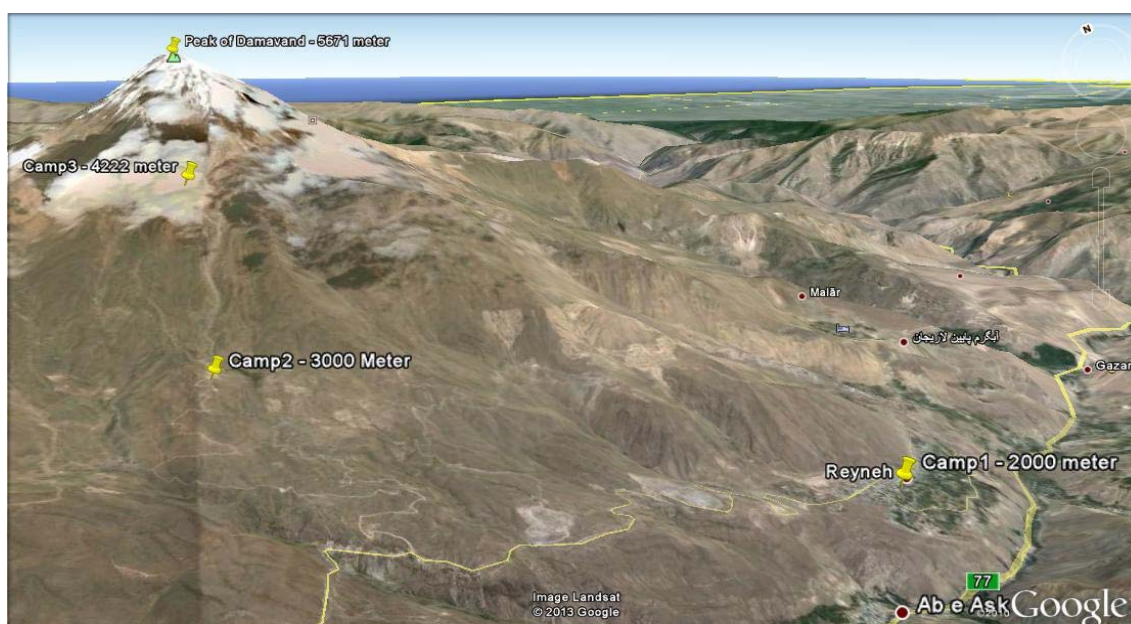


Fig. 1 Map of Damavand mount with 3 camps that the samples of *Achillea aucheri* were collected at track between camp 2 and 3.

Table 1 Information of regions which used in this experiment

No. Region	Altitude (meters above sea level)	latitude	longitude
1	3900	35° 55'32.3"N	52° 6'26.8"E
2	4000	35° 55'36.5"N	52° 6'29.6"E
3	4100	35° 55'41.3"N	52° 6'34.0"E
4	4200	35° 55'47.5"N	52° 6'33.8"E
5	4300	35° 55'54.0"N	52° 6'32.3"E

**Fig. 2** A bush of *Achillea aucheri* in Damavand mount

Results and Discussion

In this study, 23 morphological characteristics of *A. aucheri* were evaluated. The mean comparison of traits showed significant difference among them (table 2). The stem height and internode length had significantly differences in 0.01 levels and numbers of nodes was significantly different in 0.05 levels. These traits were influenced by increasing the altitude. At the lowest height (3900 m) stem height and internodes were the highest with 260 and 17.66 millimeters, respectively. On the other hands, at the highest altitude (4300 m) these traits showed the lowest level. It seems that by increasing altitude, temperature reduced and subsequently the growth period of plants reduced, then plants has less time to grow, therefore showed lower growth indices. In addition by increasing altitude intensity of UV rays increased and it may affects growth hormones and plants growth and development, but the number of internodes not affected significantly by altitude variations [11].

Zuk-Golaszewska *et al.* (2002) reported that UV-B radiation on *Avena fatua* L. and *Setaria viridis* (L.) P.Beauy caused the plants height decreased [12]. Also based on Furness *et al.* (1999) reports, after a few weeks of UV-B exposure, leaf area and plant dry weight of rice significantly reduced [13]. This results confirmed by earlier studies of Agrawal *et al.* (2011) and Bjorn *et al.* (1999) [14,15].

Average number of leaves per node was 9.66 in 3900 m altitude, which is the maximum among the altitudes and was significant in 0.05 levels. According reports, UV intensity increased with latitude increasing and these radiations can reduce photosynthetic capacity. As a result, leaf area and cell division reduction could be due to disruption of photosynthesis caused by UV intensity. In addition, stem thickness in 4300 m reached to the lowest value.

Table 2 Mean comparison of traits in *A. aucheri* from different altitudes

No.	altitudes	Traits	1 (3900 m)	2 (4000m)	3 (4100m)	4 (4200m)	5 (4300m)
1		Stem height (mm)	260.00 a	243.33 a	196.67 b	143.33 c	140.00 c
2		Internode (mm)	17.66 a	16.33 a	14.00 b	12.00 b	12.66 b
3		Crown diameter (mm)	1.53 a	1.53 a	1.63 a	1.40 a	1.38 a
4		Stem diameter (mm)	1.76 a	1.93 a	1.90 a	1.70 a	1.20 b
5		Number of node	15.33 a	15.00 a	15.00 a	12.33 b	12.33 b
6		Leaf width (mm)	2.16 a	1.90 a	2.73 a	2.43 a	2.73 a
7		Leaf length (mm)	12.66 a	16.33 a	15.33 a	14.66 a	15.66 a
8		Number of leaf per node	9.66 a	8.00 b	7.66 b	7.00 b	7.33 b
9		Length to width of leaf	5.90 a	6.16 a	6.24 a	6.19 a	5.94 a
10		Number of flower	7.33 a	7.33 a	7.00 a	6.66 a	6.33 a
11		Pedicle length (mm)	5.66 a	5.00 a	6.33 a	5.33 a	5.66 a
12		Inflorescence width (mm)	22.66 a	19.33 ab	18.66 ab	18.33 ab	16.33 b
13		Inflorescence height (mm)	24.66 a	20.00 ab	19.00 b	18.00 b	17.33 b
14		width to height of Inflorescence	0.66 a	0.96 a	0.98 a	1.02 a	0.94 a
15		Number of ray floret	8.00 a	7.66 ab	7.33 ab	7.66 ab	7.00 b
16		Length of ray floret (mm)	1.96 a	2.20 a	2.00 a	2.06 a	2.00 a
17		Length of calyx (mm)	7.33 a	7.00 a	7.33 a	7.00 a	7.66 a
18		Width of calyx (mm)	5.00 a	5.66 a	5.66 a	5.33 a	6.00 a
19		Length to width of calyx	1.15 a	1.26 a	1.38 a	1.32 a	1.31 a
20		Length of disk flower (mm)	4.16 b	4.06 b	4.53 b	4.26 b	5.16 a
21		Fresh weight to dry weight	3.06 a	3.10 b	3.14 b	3.24 c	3.24 c
22		Fresh weight (gr/Bush)	49.83 a	47.93 a	41 b	35.76 c	35.55 c
23		Dry weight (gr/Bush)	15.94 a	15.14 a	12.80 b	10.81 c	10.73 c
24		% essential oil	0.681 d	0.762 c	0.856 b	0.949 a	0.954 a

Means in a row followed by the same letter are not significantly different ($P>0.05$ or $P>0.01$).

Greenberg *et al.* (1997) reported that UV-B radiation caused plant height, leaf weight ratio, leaf numbers, leaf area and leaf area ratio decreased [16].

UV-B in several ways can damage cells. First, direct photochemical damage in which DNA absorbs a photon, and the excitation of the molecule results in a molecular change, second photochemical reactions involve other molecules in which radicals or active oxygen species generated and attack DNA. Therefore, this radiation can disrupt photosynthesis and reduced leaf yield and biomass, certainly [14].

According to the results by increasing altitude, amount of fresh weight and dry weight of *A. aucheri* reduced. Fresh weight of plant reached from 49.83 g to 35.55 g and dry weight of plants reduced from 15.94 g to 10.73 g. Both of these factors had significantly differences in 0.01 level.

As we know the expansion range of this species is narrow, just from 3900 to 4300 altitudes it spreads, but with this low expansion rang, plants showed significantly morphological and phytochemical diversity.

Increasing altitude affects environmental factors such as temperature, UV radiation, humidity and

other growth requirements that in high altitudes growth conditions is hardly determinate and unfavorable for plant growth, thus the plants has a limited growth stage for biomass production, and produce fewer biomass.

Important secondary metabolite of *A. aucheri* is essential oils. The results showed that essential oils content of plants significantly increased by increasing altitude with the 0.68% and 0.95% based on dry weight at the lowest and highest altitudes respectively. Altitudes of 4200 and 4300 meters had no significantly differences but other altitudes showed significantly differences.

Similar results were also reported by Nchabeleng *et al.* (2012) on total polyphenol content of *Athrixia phylicoides* DC. at different altitude. The result showed increase in total polyphenol contents with increase in altitude [10]. Ahmad *et al.* (2003) reported that at Battal location, at an altitude of 1500 m, polyphenol content was higher than in tea samples collected from NTRI location, which was in 1000 m altitude [17].

However, one of the roles of secondary metabolite is defense and makes adaptations in plants on unpleasant conditions, so in high altitudes that the plant exposed by variety of environmental stresses

such as low temperature, light quality, ultraviolet radiation, and so on. It is clear that the plant will produce more secondary metabolites to tolerate these stresses. Nadim *et al.* (2011) addressed a study to evaluate the effect of tropical climatic conditions on essential oil content and composition of the temperate plant, *Achillea millefolium* L. the result demonstrated that the tropical conditions resulted in the accumulation of more quantities of thujane type compounds. *A. millefolium* cultivated under tropical climate is characterized by its high sabinene, borneol and alpha-pinene contents which are otherwise slightly in lesser quantity under temperate conditions [18]. Furthermore, the increasing altitude affects the number of disk florets and this event can be due to the increasing of the content of essential oil. Among the characteristics of stem and crown diameter, just stem thickness difference was significant at the 0.05 level. This difference is related to the altitude of 4300 meters and there were no significant differences between the other regions. Parameters like Leaf length, leaf width, flower number, Pedicles length, flower width; number of ray flowers, ray flower length and the length and width of calyx was not significantly different.

Conclusion

Results of this research showed, low altitudes had high significantly effects on plant height and internodes. But slightly affected number of nodes, length of disk flower and stem diameter, with no significant differences on other indices such as flower numbers, number of ray flowers. Also high altitude had high significantly differences on the essential oil content. It revealed that essential oil content of plants was more in higher altitudes. It seems that a part of photosynthetic energy of plants in higher altitudes expend to produce secondary metabolites especially essential oils to overcome stress and survival in inappropriate conditions.

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