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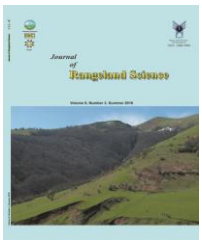

Research and Full Length Article:

Some Autecological Properties of Medicinal Plant of *Salvia hydrangea* L. in Mazandaran, Iran

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Abstract. The study of plant under environmental conditions leads to an appreciation of their physical and chemical requirements for growth and reproduction. It contributes to increase the knowledge of where the plants grow. This study was conducted to determine the main autecological characteristics of *Salvia hydrangea* L. which is an endemic plant distributed in Mazanadarn province, Iran. The habitats of this species (altitude of 1100, 1700 and 2000m) were identified (2014) and then, the climatic and edaphic characteristics of habitats were determined. Surveys of the plant in the habitats were done along the transect (100m) within quadrant ($4m^2$) with a systematically randomized method during major phenological stages of the plant. Phenological stages and some plant characteristics such as density, canopy cover, plant height and root system were studied. Results showed that in lower altitudes, vegetative growth starts in the middle of February and follows the flowering at the end of May whereas in higher altitudes, the plant starts vegetative growth in the early March and reaches fully flowered at the end of June. The mean annual rainfall and temperature of the habitats ranged from 383–540 mm and 21–24°C, respectively. Results showed that the plant density and canopy cover decreased slowly with increasing altitude while reaching the minimum value in the altitude of 2000m. The root depth of plant in the loamy sand soils was deeper than the clay loamy soils. Density and other measured vegetal factors of plant decreased with decreasing the nutrient content of soil. Loamy sand and clay loamy soils of the habitat had pH near neutral and EC varying from 0.43 to 0.90 dS m^{-1}. It was concluded that the plant generally prefers the climate conditions with high temperature and high rainfall. In lower altitudes with more soil nutrients, there are more optimal conditions for the domestication and harvesting of *S. hydrangea* L. as a medicinal plant.

Key words: Autecology, Ecological factors, Phenology, *Salvia hydrangea* L.

Introduction

Knowledge of ecological factors such as properties of soil, topography, climate, and disturbance influencing the plant species distribution is essential for the conservation, management, and recovery of rangeland ecosystems (Ajeer and Shahmoradi, 2007; Nautiyal *et al*., 2009; Fakhireh *et al*., 2012). Autecological studies are essential for the determination of ecological requirements of plant species and provide basic knowledge for relevant authorities such as range managers (Abarseji *et al*., 2007) in identifying suitable plant species for the rehabilitation of degraded rangeland (Fakhireh *et al*., 2012).

The genus *Salvia* which includes over 900 morphological species is one of the largest members of the Lamiaceae family. It is widely distributed from the coastal region of Mediterranean to Asia (Rajabi *et al*., 2014). The plant species belongs to Irano–Touranian region (Zohary, 1963). Many species of this genus are found in Iran. *S. hydrangea* L. (Lamiaceae) is a perennial and erect shrub plant with 20-60 cm height. The leaves are pinnatisect with oblong elliptic terminal segment. The petiole is 5–10 mm. The flowers are zygomorphic symmetric and arranged verticillately on the plant and 4–12 flowers are present at verticillasters. Flowers are 2-lipped pink–red in whorls forming panicles. The color of calyx is violet–pink. The fruit type is nutlet (Rechinger *et al.*, 1982).

According to Rechinger *et al*. (1982), the plant species grows wildly in many regions of Iran such as Azerbaijan, Kurdistan, Gilan, Qazvin, Tehran, Kerman, Markazi, Mazandaran, Esfahan, Lorestan, Fars, Sistan and Baluchestan provinces. The essential oils of *S. hydrangea* L. are commonly used in the food, drug and perfumery industries (Jenks and Kim, 2013; Rajabi *et al*., 2014). It is well known among people and widely used for medicinal purposes in several regions of the world (Özcan *et al*., 2003).

Although the growth and increase in the quantity and quality of substance in medicinal plants take place mainly due to genetic processes, ecological factors also play an important role in this regard. Such factors help to bring about certain changes in the growth and yield of medicinal plant (Omidbeigi, 2005; Mahdavi *et al*., 2013). Beside climatic conditions at the growing site, other factors are the edaphic ones (Manukyan, 2011). Voirin *et al*. (1990) reported that photoperiod affected the plant growth. Other studies have also reported the influences of mineral nutrients (Graven *et al*., 1991; Pluhár *et al*., 2007; Ardakani and Mafakheri, 2011; Moradi *et al*., 2014), drought (Ardakani and Mafakheri, 2011), and light intensity and altitude (Ebrahimi-Kebria, 2002; Jaakola *et al*., 2004; Alonso-Amelot *et al*., 2007; Haider *et al*., 2009; Mahdavi *et al*., 2013) on the plant growth.

Totally, these factors can also trigger the abrupt activation of qualitative changes in secondary metabolite production (Lommen *et al.*, 2008; Mahdavi *et al*., 2013). Since plants cannot escape from the environmental extremes of light, temperature, and drought and move to the regions with better nutritional conditions; thus, they have evolved highly complex mechanisms to integrate physiology and metabolism in order to adapt the conditions to which they are exposed (Ncube *et al*., 2012).

The present study attempts to investigate some autecological characteristics of *S. hydrangea* L. to reveal its ecological requirements in Mazandaran, Iran.

Materials and Methods

The study area

The study areas are located in Mazandaran province (36°13′34″ N, 52°31′54″ E, North of Iran). The regional climate is classified as cold and semiarid. According to data available for the period of 2006–2013 from National Meteorological Information Center of Iran, the mean annual rainfall is 483 mm with the mean

annual maximum and minimum temperature of 38.5 and 12.8°C, respectively. Mean relative humidity and annual evaporation were 70% and 900 mm over previous 20 years, respectively. Only three habitats of *S. hydrangea* L. were identified in Mazandaran province (Fig 1). The collection habitats were near Chaloos village (loamy sand soil) and Langar village (loamy sand soil) in Kiasar region and Sorkh-Geryeh village (clay loamy soil) in Hezarjarib Behshahr region (Table 1). The climatic (temperature, rainfall), topographic (slope, altitude), and edaphic (physical and chemical) properties of the habitats were determined in the key areas. Meteorological data including rainfall, temperature, evaporation, and relative humidity were obtained from Airport Meteorological Station of Mazandaran.

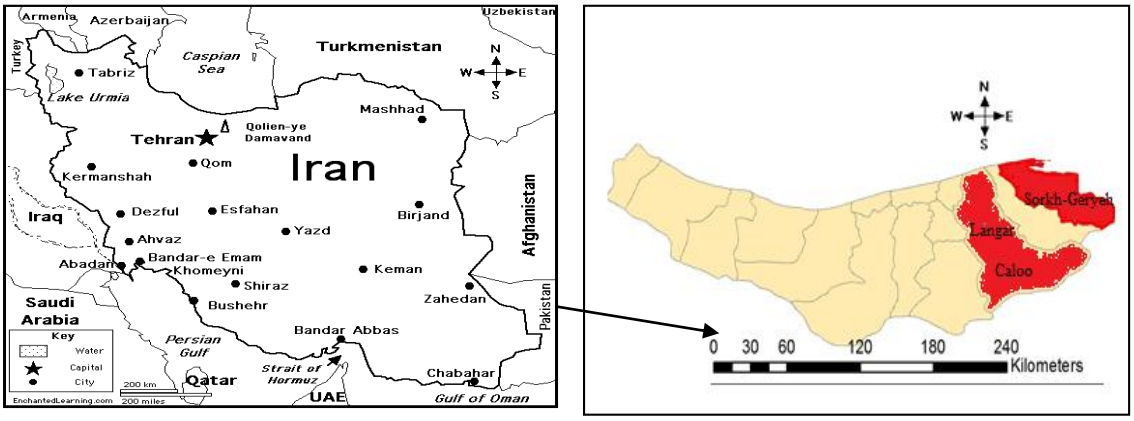

Fig. 1. Map of Habitats of *S. hydrangea* L. in Mazandaran province, Iran

Table 1. Geographical position and meteorological data of sampling sites of *S. hydrangea* L. in this study

Sites	Elevation	Rainfall	Geographical Position		Annual Temperature °C			Evaporation	Relative
	(m)	(mm)	Longitude	Latitude	Max	Min	Mean	(mm)	Humidity (%)
Chaloo	1100	540	53°32′11″	35°14′12″	37	13	24	973	69
Langar	1700	500	53°37′03″	36°12′13″	35	11	23	970	69
Sorkh-Geryeh	2000	383	54°37′03″	36°26′36″	32	10	21	892	68

*Temperatures are yearly maximum, minimum and average as measured during 2007, 2009, 2014
M R H: Mean relative humidity, E: Evaporation

Sampling Method

The distribution areas of *S. hydrangea* L. were delineated through searching the literature involving the published reports, land use maps, and vegetation type maps as well as field inspection. Three key areas (500 m × 2200 m) with five replications were selected in the wild habitats of *S. hydrangea* L. with respect to its distribution pattern. The measurements were performed only in the selected key areas. Surveys of plant species in wild habitats were done along transects (100 m) within quadrants (4 m^2 each) with a systematically randomized method during major phenological stages of the plant species by weekly field inspections and interviews with rural villagers. In each key area, five transects were established in two directions of general slope. In total, 15 transects (75 plots) were sampled in the sites.

Data on the plant height, canopy cover, frequency and density of *S. hydrangea* L. were directly obtained in the field using transect and quadrate method (Hanley, 1978). Species identification and nomenclature were carried out in the laboratory of Zabol University, Iran according to Rechinger *et al.* (1982). In

each key area, soil samples from the root zone were collected from each surveyed quadrate. The soils were put in plastic bags with a label; thereafter, they were air dried, ground to pass through a 2 mm sieve, and taken to the laboratory of Agriculture and Natural Resources Research Center, Mazandaran, Iran for the analysis of soil physical and chemical properties. The soil texture was determined using a laser diffractometry (Wang *et al*., 2012); then, pH was determined in a 1:5 soil to distilled water slurry after one hour of agitation using a digital pH–meter (Model 691, Metrohm AG Herisau Switzerland) (Thomas, 1996). Electrical conductivity of saturated soil paste extract (EC) was computed using an EC–meter (Rhoades, 1996). Organic matter content was determined using the methods described by Lo *et al*. (2011). Available phosphorus was determined by the method of Bray and Kurtz (1954). Potassium was measured by flame photometry method (Knudsen *et al*., 1982). Saturation percent (SP) was determined by the weighing method (Wilcox, 1951). Mg, Fe, Cu, Zn and Mn were determined by the atomic absorption method using ICP/OES (GBC Avanta, Australia) (Allan, 1958). Calcium carbonate was determined volumetrically by a calcimeter (Allison and Moodie, 1965).

Statistical analysis

The statistical processing was mainly conducted by the analysis of variance. Before performing the analysis, data were first checked for their normality with the Kolmogorov–Smirnov test and for the homogeneity of variance with the Levene's test ($p<0.05$) and if necessary, data were log-transformed. All the reported results are the means of five replicates and deviations were calculated as the standard errors of mean (SEM). Duncan test analysis was performed to define which specific mean pairs were significantly different. A probability of 0.05 or a lower one was considered significant. All the statistical calculations were performed using SPSS release 18.0.

Results

Phenological stags and vegetation characteristics

At lower altitudes (1100 m), *S. hydrangea* L. started the vegetative growth in the middle of February, reached a peak growth at the end of April, and fully flowered at the end of May. In the middle of June, seeds appeared (Table 2) whereas in higher altitude (1700 m and 2000 m), the plant species started vegetative growth in the early March, reached a peak growth at the end of May, and fully flowered at the end of June. Seed production started in the early of July (Table 2).

Table 2. Phenological stages of *S. hydrangea* L.

Altitude	Vegetative stage	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Chaloo (1100 m)	Initial growth	■											
	Vegetative growth		■	■	■								
	Flowering				■	■							
	Seed production					■	■						
	Seed maturity						■						
	Dormancy							■	■	■	■	■	
Langar and Sorkh-Geryeh (1700-2000 m)	Initial growth		■	■									
	Vegetative growth				■								
	Flowering					■	■						
	Seed production						■						
	Seed maturity							■					
	Dormancy								■	■	■	■	■

Results showed that the plant density of *S. hydrangea* L. decreased slowly with increasing the altitude, reaching the minimum value in the area with the

altitude of 2000 m and the maximum density of plant species was observed in Chaloo village (altitude of 1100 m) (Table 3). The same trend was also observed for the other measured vegetal factors of plant species. This indicated that the plant generally prefers the climate conditions with high temperature and high rainfall. Rooting depth was up to 50 cm in the soil. A lot of lateral roots occurred from the main root. The results showed that rooting depth of *S. hydrangea* L. in the loamy sand soils (Chaloo village, altitude of 1100 m and Langar village, altitude of 1700 m) was deeper than in the clay loamy soils (Sorkh–Geryeh village, altitude of 2000 m) (Table 3). Density and other measured vegetal factors of *S. hydrangea* L. decreased with decreasing the nutrient (OM, $CaCO_3$, P, K, Fe, Zn, Cu) content of the soil. The morphological characteristics of *S. hydrangea* L. (height and root depth) in the loamy sandy soils were greater than the clay loamy soils.

Table 3. Some vegetation characteristics of *S. hydrangea* L. in the study areas

	Habitat			
Characteristics	Chaloo (altitude 1100 m)	Langar (altitude 1700 m)	Sorkh-Geryeh (altitude 2000 m)	Sig
Density (No. $ha^{-1)}$	$27.00\times10^4\pm0.46^a$	$20.00\times10^4\pm0.42^a$	$10.11\times10^4\pm0.33^b$	0.00^{**}
Frequency	96.60^a	93.33^{ab}	90.00^b	0.05^*
Canopy cover (%)	27.00 ± 0.31^a	18.73 ± 0.24^b	16.30 ± 0.22^b	0.05^*
Height (cm)	50 ± 0.41^a	40 ± 0.22^{ab}	33 ± 0.18^b	0.03^*
Rooting depth (cm)	52 ± 0.40^a	41 ± 0.20^a	33 ± 0.17^b	0.00^{**}

Values (±SE) within a row followed by the different letter are significantly difference ($p<0.05$)
*and **=significant at the 0.05 and 0.01 probability level, respectively

Soil properties of habitats

General properties of soil samples collected from the natural habitats are given in Table 4. The habitats differed considerably in terms of chemistry (Table 4). The soil of habitats at the altitudes of 1100 m (Chaloo) and 1700 m (Langar) was characterized as loamy sand whereas in the altitude of 2000 m (Sorkh-Geryeh), the soil texture was clay loamy. The soil acidity in the habitats was near neutral (pH=7.86–7.87). The EC varied from 0.43 to 0.90 dS m^{-1} in the habitats indicating that *S. hydrangea* L. grows in the non-saline soils (Table 4).

The organic matter of soil of habitats varied from 1.01 - 3.00%. These soils are rich in terms of the organic matter. The calcium carbonate content of soils of *S. hydrangea* L. varied from 19–49%. It can be seen that this plant generally prefers the calcareous soils (Table 4). The soil of *S. hydrangea* L. was rich in terms of potassium. The soil was very poor in terms of micro-elements; however, in lower altitude (1100 m), the soil amount of micro and macro elements was more than higher altitudes.

Table 4. Characteristics of soil in the habitats of *S. hydrangea* L.

Soil properties	Habitat			
	Chaloo (altitude 1100 m)	Langar (altitude 1700 m)	Sorkh-Geryeh (altitude 2000 m)	Sig
EC_e (dS m^{-1})	0.68±0.00^{b}	0.90±0.00^{a}	0.43±0.00^{b}	0.05*
pH	7.86±0.10^{a}	7.70±0.10^{a}	7.87±0.20^{a}	0.24$^{n.s}$
OM (%)	3.00±0.03^{a}	1.20±0.00^{b}	1.01±0.00^{b}	0.05*
$CaCO_3$ (%)	49.00±2.50^{a}	42.00±2.07^{b}	19.00±1.13^{b}	0.00**
S.P (%)	42.01±2.00^{a}	48.00±2.40^{a}	60.00±2.53^{a}	0.00**
P (mg Kg^{-1})	11.50±0.73^{a}	4.80±0.12^{b}	7.30±0.24^{b}	0.01**
K (mg Kg^{-1})	509.00±21.60^{a}	224.00±7.44^{b}	278.00±5.78^{b}	0.00**
Mg (mg Kg^{-1})	216.00±6.42^{b}	349.01±8.09^{a}	426.00±18.76^{a}	0.00**
Fe (mg Kg^{-1})	7.40±0.11^{a}	3.50±0.03^{b}	3.90±0.01^{b}	0.01**
Mn (mg Kg^{-1})	3.70±0.01^{a}	3.60±0.04^{a}	8.50±0.23^{a}	0.00**
Zn (mg Kg^{-1})	1.50±0.01^{a}	1.30±0.00^{a}	1.20±0.01^{a}	0.07$^{n.s}$
Cu (mg Kg^{-1})	0.80±0.00^{a}	0.60±0.00^{a}	0.70±0.00^{a}	0.60$^{n.s}$
Silt (%)	19.00^{b}	20.00^{b}	39.00^{a}	0.05*
Sand (%)	78.00^{a}	77.00^{a}	28.00^{b}	0.05*
Clay (%)	3.00^{b}	3.00^{b}	32.00^{a}	0.01*
Texture	Loamy sand	Loamy sand	Clay loamy	-

Values (±SE) within a row followed by different letters are significantly different ($p<0.05$)
*, ** and ^{ns}=significant at 0.05 and 0.01 probability levels and non-significant, respectively

Discussion

Investigating the relationship between different plants with biotic and abiotic components which are in an ecosystem is usually a part of ecological studies. The results of studies help to improve our knowledge of each plant species (Jafari *et al*., 2013). The distribution, pattern and abundance of plant species have been related to three groups of factors: physical environmental variables, soil chemistry and anthropogenic disturbance (Enright *et al*., 2005).

The most common, unavoidable interaction occurring in the plant communities is the plant-environment interaction. External factors quantitatively affect the plant metabolic processes through their effects on plant development and growth rates. These factors can also trigger the abrupt activation of qualitative changes in secondary metabolite production (Lommen *et al*., 2008; Mahdavi *et al*., 2013). Although the relationships between plant and both soil properties and environmental factors have been well developed for some plants, a comparable understanding of how a variety of plant species in native rangelands may respond to soil properties and environmental factors is poorly developed (Rezaei, 2003; Masoodipour *et al*., 2014; Moradi *et al*., 2014).

The present study investigated some characteristics and autecological ones of *S. hydrangea* L. in Mazandaran province. It is important to know the factors that influence the plant characteristics, and their specific requirements for each particular case. The factors include: (a) physiological variations, (b) environmental conditions, (c) geographic variations, (d) genetic factors and evolution, and also (f) the amount of plant material/space and manual labor needs (Figueiredo *et al*., 2008).

In fact, these factors cause the establishment of different kinds of plant species in different habitats (Jafari *et al*., 2003) and they may be able to distinguish plant species from each other (Metaji and Zahedi–Amiri, 2006). It is interesting to note that all these things mix together (Mesdaghi, 2003) so that the differences in the plant species found for the same geographical origins are due to the differences in their natural habitats (Makhdoom, 2002).

Zhang and Dong (2010) in the study of relationships between environmental factors

and vegetation diversity in Lesi plateau of China observed that altitude, soil type, slope and aspect were important factors in Lesi zones' recovery and had the determinant roles in vegetation distribution. Also, Ebrahimi–Kebria (2002) showed that topographic factors had a considerable effect on the plant cover and diversity in Sefid-Ab of Haraz basin, Iran. Moradi and Ahmadipour (2006) in the investigation of morphology and soil roles in the plant vegetation in Vas sub watershed basin, Mazandaran, Iran reported that slope, aspect and altitude provides different conditions for the plant growth and expansion. Moradi *et al*. (2014) in a study in Kakan watershed located in Kohgelouye and Bouyerahmad province, Iran indicated that such edaphic factors as soil texture, organic carbon, total nitrogen and magnesium and such topographic features as slope, aspect and altitude play major roles in the plant establishment and distribution.

In the present study with respect to different topographic and climatic conditions across the study habitats, it can be concluded that altitude and soil properties were major determinants in the establishment and distribution of *S. hydrangea* L. Altitude has a vital role in the growth and production of plants in a variety of natural ecosystems and areas (Habibi *et al*., 2006; Haider *et al*., 2009; Mahdavi *et al*., 2013). It is one of the indirect environmental gradients which may have direct effects on environmental gradients such as climate and soil and directly affect the other factors including temperature through which plant species distribution will be also changed and the rangeland ecosystem structure will be revolutionized (Ebrahimi *et al*., 2015). So, increasing and decreasing the altitude level can change the temperature, relative humidity, wind speed, available water to the plant root and sunlight rates; hence, regarding the altitude level changes, ecophysiological reactions of plant will also change (Mahzooni–Kachapi *et al*., 2014).

The morphological characteristics of *S. hydrangea* L. were significantly different in the habitats with different conditions. As shown in the results of this study, the soils on which *S. hydrangea* L. grows have a pH value near neutral and these soils are non-saline and calcareous. A comparison of our data with those of other researchers reveals that other species of *Salvia* (e.g., *S. wiedemannii* Boiss., *S. kronenburgii* Rech. Fil. and *S. rosifolia* Sm.) distributed in the near region occupy the calcareous and non-saline soils (Kaya and Aksakal, 2007).

It is interesting to note that in comparison of three habitats, density, canopy cover, height and rooting depth of *S. hydrangea* L. were more in Chaloo habitat (lower altitude) where the nutrient (OM, $CaCO_3$, P, K, Fe, Zn, Cu) content of soil was higher. Generally, it can be concluded that in addition to altitude, the soil influences the growth of *S. hydrangea* L. Marked variations in the growth of *S. hydrangea* L. from various areas have been reported. In an investigation of the effects of environmental factors on the distribution of *S. hydrangea* L. in Kerman province (Iran), Saber–Amoli *et al*. (2008) reported that the plant generally prefers the clay sandy soils and was dominant in the altitude of 1850 m with the mean annual precipitation of 250 mm and mean temperature of 15°C. Also, *S. hydrangea* L. growing in Yazd province, Iran has been reported to prefer the sandy clay soils and was more abundant in the altitude of 2147 m with the mean annual precipitation of 308 mm and mean temperature of 16 ^{0}C (Zarezadeh *et al*., 2007).

Conclusion

Very few ecological studies have been conducted on *S. hydrangea* L. in Iran used in pharmaceutical, ornamental, and tea industries. Results showed that all the measured vegetal factors of *S. hydrangea* L. decreased slowly with increasing the altitude, reaching the minimum value in the area with higher altitude. Results

indicated that *S. hydrangea* L. generally prefers the climate conditions with high temperature and high rainfall. Rooting depth of *S. hydrangea* L. in the loamy sand soils was deeper than the clay loamy soils. The morphological characteristics of *S. hydrangea* L. in the loamy sand soils were greater than the clay loamy soils. General properties of soil showed that the habitats of *S. hydrangea* L. differed considerably in terms of chemistry. *S. hydrangea* L. grows in the non-saline soils and prefers the calcareous soils. Hence, we can conclude that at lower altitudes, there are more optimal conditions for this plant domestication and harvest. Considering the effect of various environmental factors, further studies of *S. hydrangea* L. from different locations in Iran are necessary to ascertain its environmental requirements.

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برخی ویژگی‌های آت اکولوژی گیاه دارویی *Salvia hydrangea* L. در استان مازندران

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چکیده. مطالعه گیاهان تحت شرایط محیطی منجر به درک نیازهای فیزیکی و شیمیایی آنها برای رشد و تولید مثل می‌شود. این موضوع باعث افزایش شناخت از محل رشد گیاهان می‌گردد. مطالعه حاضر در سال ۱۳۹۴ به‌منظور بررسی بعضی خصوصیات آت اکولوژی *Salvia hydrangea* L. که یکی از گونه‌های بومی استان مازندران است، انجام شد. ارزیابی گیاه در رویشگاه‌ها، در طول ترانسکت (۱۰۰ متر) و در سطح پلات (۴ مترمربع) با استفاده از روش تصادفی-سیستماتیک در مراحل فنولوژیکی انجام شد. در ابتدا، رویشگاه‌ها (ارتفاعات ۱۱۰۰، ۱۷۰۰، ۲۰۰۰ متر) مشخص گردید و سپس خصوصیات اقلیمی و برخی خصوصیات خاک رویشگاه‌ها تعیین شد. همچنین مراحل فنولوژیکی، تراکم، تاج پوشش، ارتفاع گیاه و سیستم ریشه گیاه مطالعه شد. نتایج نشان داد در ارتفاعات پایین رشد گیاه در اواسط اسفند شروع می‌گردد و تا زمان گلدهی در اواخر اردیبهشت ادامه می‌یابد. درحالی‌که، در ارتفاعات بالاتر رشد گیاه در ابتدای فروردین ماه شروع می‌شود و تا اواخر تیرماه ادامه دارد. متوسط بارندگی و درجه حرارت رویشگاه‌ها به‌ترتیب از ۵۴۰-۳۸۳ میلی‌متر و ۲۴-۲۱ درجه سلسیوس تغییر داشت. نتایج نشان داد که تراکم گیاه و تاج پوشش با افزایش ارتفاع کاهش داشت و کمترین مقدار مربوط به ارتفاع ۲۰۰۰ متر بود. ریشه‌دوانی گیاه در خاک‌های لومی شنی عمیق‌تر از خاک‌های لومی رسی بود. تراکم و دیگر خصوصیات گیاه با کاهش مواد غذایی خاک در ارتفاعات بالا کاهش داشت. خاک‌های لومی شنی و لومی رسی رویشگاه‌ها دارای اسیدیته تقریبا خنثی بودند و قابلیت هدایت الکتریکی دامنه تغییرات ۰/۰۹ تا ۰/۴۳ دسی‌زیمنس بر متر داشت. به‌طور کلی نتایج حاکی از آن بود گیاه مورد مطالعه شرایط اقلیمی با دما و بارش بالا را ترجیح می‌دهد و در ارتفاعات پایین‌تر با عناصر غذایی بیشتر، شرایط رشد بهینه برای *S. hydrangea* L. به‌عنوان یک گیاه دارویی وجود دارد.

کلمات کلیدی: آت اکولوژی، فاکتورهای اکولوژیکی، فنولوژی، *Salvia hydrangea* L.