BIODICON
www.biodicon.com
ISSN 1308-5301 Print ; ISSN 1308-8084 Online

Biological Diversity and Conservation
Biyolojik Çeşitlilik ve Koruma
1 / 2 (2008) 91-104

Effects of different salt (NaCl), nitrate (KNO_3) and acid (HCl and H_2S0_4) concentrations on the germination of some *Hesperis* species seeds

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Abstract

Germination responses of 14 *Hesperis* species (*Hesperis aspera, H. bicuspidata, H. campicarpa, H. cappadocica, H. hedgei, H. laciniata, H. matronalis, H. pendula, H. persica, H. podocarpa, H. schischkinii, H. stellata, H. theophrasti* subsp. *sintensii, H. transcaucasica)* distributing naturally in Turkey were tested in this study at different salt (NaCl), nitrate (KNO_3) and acid (HCl, H_2SO_4) concentrations (Control, 0.5, 1, 2, 3%). Low salt concentration blocked seed germination of eight taxa (*Hesperis aspera, H. campicarpa, H. cappadocica, H. laciniata, H. pendula, H. persica, H. stellata, H. transcaucasica*) and also declined seed germination ratio and speed of the others. Although low potassium nitrate concentrations increased germination of all species except *H. hedgei*, its increasing concentrations decreased it. Hydrochloric acid (HCl) blocked germination percentage and speed completely of eight taxa (*Hesperis aspera, H. bicuspidata, H. campicarpa, H. cappadocica, H. hedgei, H. pendula, H. persica, H. theophrastii* subsp. *sintenisii*), while the other six species germinated in its low concentrations. Similarly, sulphuric acid (H_2SO_4) obstructed germination of all except two species, *H. podocarpa* and *H. transcaucasica* germinated in low H_2SO_4 concentration. Significant differences in sensitivity to salt, nitrate and acid were determined among the 14 *Hesperis* species ($p<0.05$).

Keywords: Conservation, Ecology, Hesperis, Germination, Turkey

1. Introduction

Physiological responses to various environmental stresses at different stages of their life cycle are an important aspect of explaining adaptation of plants to their habitats. Within this framework, germination is one of the most critical stages in the life cycle of plants and competition in their natural or secondary habitats transported by any vectors (Ungar, 1995; Escudero et al., 1997). In the same way, germination responses have a direct impact on a species' distribution and abundance, since it is a key element affecting population dynamics (Godi'nez-Alvarez et al., 1999; Valverde et al., 2004; Ramirez-Padilla and Valverde, 2005).

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Genus *Hesperis* L. (*Brassicaceae*) distributing on a wide area from Morocco to the Middle East is dense in especially Mediterranean and Irano-Turanian phytogeographic region and has nearly 60 species all over the World (Fournier, 1866; Tzvelev, 1959; Ball, 1993). In Turkey, 31 species and 4 subspecies belonging to the genus were recorded. Moreover, 18 *Hesperis* taxa are endemic and mostly distributes in the regions belonging to semi-arid and low-precipitation Mediterranean bioclimate layers (Cullen, 1965; 1988; Akman 1990). Considering the fact that Turkey has 35 natural *Hesperis* taxa of total 60 in the world, it can be thought that Turkey may be genetic differentiation center of the genus.

Some taxa belonging to genus *Hesperis* can cause economic lost in agricultural areas as weed and damage the natural ecosystem structure in their habitats which they were secondarily transported into by any vector because of their invasive characteristics (Hartman and Nelson, 2000). However, some of them have using potential in medical (as diaphoretic and diuretic) and parfumery sector (Baytop, 1999). Besides, some *Hesperis* taxa are in a risk category according to IUCN (2001) and considered in conservation programmes.

With the complexity and extensiveness of acid rains, a severe environmental problem in recent years, increased salinity and alkalinity are particularly threatening to Turkey's soils. So, identifying species resistance to acidity has gained a great amount of importance. Due to increased salinity problem, 0.6% of Turkey's land is no longer used for cultivation. Therefore, the risk of further salinification and consequent barrenness in currently fertile areas requires serious and urgent consideration. Salt-tolerance in plants may have a direct regulation to growth and it is well known that high salt concentrations inhibit seed germination (Yücel, 2000a). KNO_3, a growth-regulating and germination-stimulating substance, can both stimulate and inhibit seed germination in some species (Öztürk et al., 1984; Öztürk et al., 1993; Puppala and Fowler, 2002).

Some brief information about *Hesperis* species tested in terms of germination responses to different salt (NaCl), nitrate (KNO_3) and acid (HCl and H_2SO_4) concentrations is given below.

Hesperis aspera Fourn.; stems are erect up to 20 cm in length, with very small and lilac flowers, an endemic plant for Turkey, *Hesperis bicuspidata* (Willd.) Poiret; stems are (15) 20–35 cm in length, erect, flowers are whitish lilac to deep violet, siliquae slender and torulose; the plant grows over 1300–2800 m, on rocky slopes, a perennial herb. A widespread taxa in Turkey, *Hesperis campicarpa* Boiss.; stems are branched, flowers are greens to brownish pink, a perennial herb. It grows over 850–1900 m, on rocks and cliffs. An endemic plant for Turkey in CD risk category, *Hesperis cappadocica* Fourn.; stems are branched from the base, flowers are pinkish-mauve, it grows over 1200-1600 m, on screes, sandy slopes. A biennial herb, an endemic plant for Turkey in LC risk category, *Hesperis hedgei* P.H. Davis & Kit Tan; stems are approximately 50 cm in length, herbaceous, erect, flowers are lavender. It grows over 1050 m and in basaltic clay fallow fields. It is probably biennial, an Irano-Turanian element, an also endemic plant for Turkey in the EN risk category, *Hesperis laciniata* All.; it is with yellow or rarely pinkish yellow flowers, siliquae subcompressed, grown on slopes, a biennial herb, *Hesperis matronalis* L.; stems are up to 100 cm in length, tall, erect siliquae asperous. It grows over 1000–2100 m, on slopes and in meadows, a biennial or rarely a perennial herb. This species has also urinativing, sweating effects and causes to tear down mucus (Baytop, 1999), *Hesperis pendula* DC.; stems are branched, with greenish-yellow flowers, siliquae terete. The plant grows on fields, gulleys, rocks, usually on limestone, and over 850-2400 m, and it is a perennial plant, *Hesperis persica* Boiss.; stems are erect, flowers are purple to brownish, and it is a biennial or perennial herb, *Hesperis podocarpa* Boiss.; stems are up to 40 cm in length, little branched, flowers are deep violet, siliquae erect. It is a perennial and an endemic plant, *Hesperis schischkinii* Tzvelev.; stems are erect, up to 30 cm in length, with reddish violet flowers, siliquae terete, obscurely torulose. The plant grows over 1600–2000 m, on igneous slopes and fields. It is a biennial herb and an endemic plant for Turkey in NT risk category, *Hesperis stellata* Dvořàk; stems are 30–50 cm in length, flowers are deep rose purple or violet. It grows over 2440 m and on rocky slopes. It is perennial plant. This species is an Irano-Turanian element and also endemic plant for Turkey in EN risk category, *Hesperis theophrasti* Borbàs subsp. *sintenisii* Dvořàk; stems are 40–48 cm in length, erect, and siliquae torulose, perennial. It grows on marble rocks. It is an East Mediterranean element and an endemic subspecies for Turkey in DD risk category, *Hesperis transcaucasica* Tzvelev.; stems are tall, erect, the upper stem leaves sessile and amplexicaule, with lilac flowers. It grows over 1700–2250 m, and on rocky slopes, in fields and gullies (Cullen, 1965; 1988; IUCN, 2001), (Figure 1).

It is obvious that determination of the ecophysiological characteristics of the plant taxa, especially endemic and/or in any risk categories is very important for conservation of the biological diversity. No information is available about the ecophysiological characteristics of the genus *Hesperis*. The aim of this study is, therefore, to determine the effects of different concentrations of salt (NaCl), nitrate (KNO_3) and acid (HCl, H_2SO_4) on the germination of 14 *Hesperis* taxa distributing naturally in Turkey.

2. Materials and methods

After determined natural distribution areas of 14 *Hesperis* species in Turkey, seed samples were collected from their natural habitats (Table 1, Figure 1). Plant samples were also taken as herbarium materials, identified and vouchers were kept in the Herbarium of Kırıkkale University (ANADOLU), Faculty of Science and Arts, Department of Biology (Cullen, 1965; 1988).

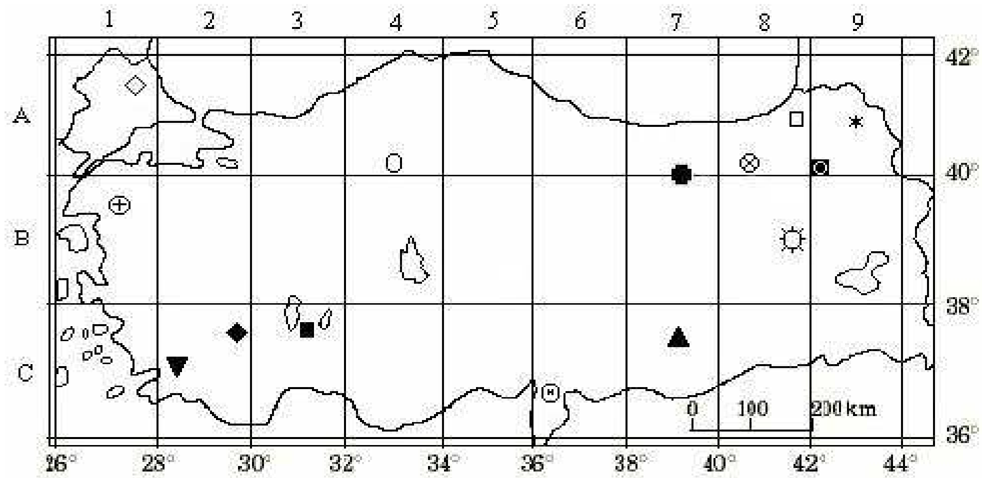

Figure 1. Seed collection localities (in Turkey)

(□ *Hesperis. aspera*; ■ *H. bicuspidata*; ○ *H. campicarpa*; ● *H. cappadocica*; ▲ *H. hedgei*; ▼ *H. laciniata*; ◊ *H. matronalis*; ♦ *H. pendula*; ☼ *H. persica*; Θ H. podocarpa; ◙ *H. schischkinii*; ⊗ *H. stellata*; ⊕ *H. theophrasti* subsp. s*intenisii*; ∗ *H. transcaucasica*)

Weight of 1000 dry seeds was determined after the seeds gathered (Table 2). The germination experiments were carried out in plant growth chambers (MLR–350 Model Sony, Japan). During the experiments, a constant temperature (25 ^{0}C ± 1) and a white light source (daily photo-period of 8 hours light, 16 hours darkness) were used.

Experiments were carried out in petri dishes (9 cm diameter lined with discs of filter paper) containing filter paper. A hundred seeds were used in each petri, with four replicates for each series and concentrations (4x100) (Willan, 1985). During the germination period, treatments were applied to each experiment series in the same way at the same time. Six main series (NaCl, H_2SO_4, KNO_3, HCl, Dark Medium and Control groups) were prepared for each taxon. During these experiments, 0.5%, 1%, 2% and 3% solutions of NaCl, H_2SO_4, KNO_3 and HCl were used. For the control group, pure distilled water was used. Seeds were considered as germinated when the radicle touched the seed bed.

Germination speed is as much important as seed germination percentage. So, germination speed was calculated for each series of experiments according to Yücel (2000a). For the statistical evaluation of all data acquired at the end of the germination experiments, *SPSS 10.0 (Statistics Package for the Social Science)* package program was used and *ANOVA Scheffe-F test* was applied.

Threatened categories are proposed for endemic and rare *Hesperis* taxa according to IUCN risk categories (IUCN, 2001). The following abbreviations were used: EN, Endangered, CD, Conservation dependent, NT, Near threatened, LC, Least concern, DD, Data Deficient.

3. Results

3.1. Effects of Different Dark-light Periods on the Germination Percentage and Speed

Light encouraged the germination percentage of *Hesperis bicuspidata*, whereas it inhibited the germination of *H. campicarpa, H. laciniata, H. matronalis, H. pendula, H. podocarpa* and *H. theophrasti.* Results showed that these species germinated higher in dark than in light. It was found that relationship between light and germination ratio of

Table 1. Seed collection localities of *Hesperis* species (in Turkey)

Species name	Locality name	Altitude (m)	Herbarium No
Hesperis aspera (E)	Artvin, Ardanuç, Karlı Village	860	5537
Hesperis bicuspidata	Isparta, Şarkikaraağaç, Çiçek Mountain	1750	5025
Hesperis campicarpa (E)	Ankara, Kızılcahamam-Gerede 15 km	1090	5814
Hesperis cappadocica (E)	Gümüşhane, Kelkit-Erzincan 14-27 km	1680	5549
Hesperis hedgei (E)	Urfa, Siverek, Karacadağ Village	1100	5511
Hesperis laciniata	Muğla, Gökova-Marmaris 5 km	500	4641
Hesperis matronalis	Kırklareli, Pınarhisar, Ataköy	160	5485
Hesperis pendula	Burdur, Dirmil-Korkuteli, Karaçulla	1850	5497
Hesperis persica	Muş, Muş-Bulanık 18 km	1400	5512
Hesperis podocarpa (E)	Hatay, Hassa, Dedemli Village, Köremez	1300	5747
Hesperis schischkinii (E)	Erzurum, Horasan-Erzurum 4 km	1580	5535
Hesperis stellata (E)	Bayburt, Bayburt-Aşkale, Kop Mountain	2400	5013
Hesperis theophrasti subsp. *sintenisii* (E)	Balıkesir, Edremit-Kalkım 27 km	360	5827
Hesperis transcaucasica	Ardahan, Göle, Sürügüden-Karlıyazı	2000	5004

(E): Endemic

Table 2. Weight of 1000 dry seeds of each *Hesperis* species (E: Endemic)

Species	Weight of 1000 dry seed grain (gr)
Hesperis aspera (E)	1,36
Hesperis bicuspidate	1,95
Hesperis campicarpa (E)	2,85
Hesperis cappadocica (E)	2,65
Hesperis hedgei (E)	3,86
Hesperis laciniata	5,43
Hesperis matronalis	1,13
Hesperis pendula	2,13
Hesperis persica	3,25
Hesperis podocarpa (E)	2,60
Hesperis schischkinii (E)	2,66
Hesperis stellata (E)	2,12
Hesperis theophrasti subsp. *sintenisii* (E)	1,15
Hesperis transcaucasica	1,97

H. aspera, H. cappadocica, H. hedgei, H. persica, H. schischkinii, H. stellata and *H. transcaucasica* was statistically insignificant ($p<0.05$), (Table 3). Light inhibited the germination speed of *H. campicarpa, H. cappadocica, H. matronalis, H. pendula, H. podocarpa, H. theophrasti* subsp. *sintenisii* and *H. transcaucasica*. Effect of light on the germination speed was not significant statistically for *H. aspera, H. bicuspidata, H. hedgei, H. laciniata, H. persica, H. schischkinii, H. stellata* ($p<0.05$).

3.2. Effects of Different Salt (NaCl) Concentrations on the Germination Percentage and Germination Speed

Salt inhibited the germination of eight species completely at low concentrations, wheras it decreased the germination ratio of six species. All salt concentrations blocked the germination of eight species completely (*Hesperis aspera, H. campicarpa, H. cappadocica, H. laciniata, H. pendula, H. persica, H. stellata* and *H. transcaucasica*) and decreased the germination percentage and speed of six species (*H. bicuspidata, H. hedgei, H. matronalis, H. podocarpa, H. schischkinii* and *H. theophrasti*), (Table 4).

Low salt concentration (0.5%) decreased the germination percentage of *H. bicuspidata, H. hedgei, H. podocarpa, H. theophrasti* whereas its effect on germination percentage of *H. matronalis* and *H. schischkinii* was found statistically insignificant ($p<0.05$), (Figure 2). However, this concentration increased the germination speed of *H. matronalis, H. podocarpa* and decreased the germination speed of *H. theophrasti* while its effect on germination speed of *H. bicuspidata, H. hedgei* and *H. schischkinii* was found statistically insignificant ($p<0.05$), (Figure 3).

1% salt solution increased the germination speed of *H. bicuspidata, H. podocarpa* and *H. theophrasti*. Its effect on the germination percentage of *H. matronalis* was significant statistically; even though it caused the germination of the others to be inhibited completely. This concentration increased the germination speed of *H. podocarpa*, decreased of *H. matronalis and H. theophrasti*, and its effect on *H. bicuspidata* was insignificant.

All salt concentrations tested during the study (0.5–3%) decreased germination of *H. podocarpa* and these results were found significant ($p<0.05$). *H. podocarpa* was also the only species which could germinate at all salt concentrations.

3.3. Effects of Different Potassium Nitrate (KNO_3) Concentrations on the Germination Percentage and Germination Speed

Low KNO_3 concentration (0.5%) encouraged the germination of *H. aspera, H. bicuspidata, H. matronalis, H. pendula* and *H. podocarpa*, but decreased the germination of *H. campicarpa, H. laciniata, H. persica, H. stellata, H. theophrasti* subsp. *sintenisii, H. transcaucasica*. Effects of this concentration on *H. cappadocica* and *H. schischkinii* were insignificant ($p<0.05$), (Figure 4, 5).

1% KNO_3 concentration encouraged the germination percentage of *H. matronalis, H. pendula, H. podocarpa;* decreased the germination of *H. bicuspidata, H. campicarpa, H. persica, H. stellata, H. theophrasti, H. transcaucasica* and inhibited the germination of *H. aspera, H. cappadocica, H. laciniata, H. schischkinii* completely. This concentration decreased the germination speed of *H. pendula, H. persica, H. stellata, H. theophrasti, H. transcaucasica*, and encouraged germination speed of *H. matronalis, H. podocarpa*. The effect on *H. bicuspidata* and *H. campicarpa* was found insignificant ($p<0.05$).

Table 3. Effect of dark versus light on germination percentage (%) and germination speed

Species	Dark/Light **	Germination percentage (%)	Germination speed
Hesperis aspera	Dark	4 a*	9 a
	Light	9 a	11 a
Hesperis bicuspidata	Dark	19 c	12 a
	Light	44 g	9 a
Hesperis campicarpa	Dark	22 e	18 c
	Light	18 b	9 a
Hesperis cappadocica	Dark	5 a	17 b
	Light	7 a	9 a
Hesperis hedgei	Dark	7 a	7 a*
	Light	15 a	9 a
Hesperis laciniata	Dark	41 g	8 a
	Light	26 f	8 a
Hesperis matronalis	Dark	19 c	24 h
	Light	6 a	15 a
Hesperis pendula	Dark	41 g	20 d
	Light	4 a	17 b
Hesperis persica	Dark	91 i	10 a
	Light	84 i	13 a
Hesperis podocarpa	Dark	49 g	21 e
	Light	24 f	16 a
Hesperis schischkinii	Dark	11 a	13 a
	Light	9 a	10 a
Hesperis stellata	Dark	67 h	16 a
	Light	65 h	14 a
Hesperis theophrasti subsp. *sintenisii*	Dark	21 d	22 f
	Light	16 a	20 d
Hesperis transcaucasica	Dark	47 g	25 i
	Light	44 g	23 g

* Within each column, means with the same letter are not significantly different (p=0,05); ANOVA Scheffe–F test.

****** 8 hour light-16 hour darkness photo period.

Table 4. Effect of NaCl concentration on germination percentage (%) and germination speed

Species	Concentration (NaCl-%)	Germination percentage (%)	Germination speed
Hesperis bicuspidata	0,5	11 b	9 a
	1	3 a	7 a*
	Control	44 e	9 a
Hesperis hedgei	0,5	8 a	8 a
	Control	15 c	9 a
Hesperis matronalis	0,5	2 a	17 e
	1	1 a*	14 b
	Control	6 a	15 c
Hesperis podocarpa	0,5	10 b	17 e
	1	8 a	16 d
	2	5 a	11 a
	3	4 a	10 a
	Control	24 d	18 g
Hesperis schischkinii	0,5	1 a	11 a
	Control	9 a	10 a
Hesperis theophrasti subsp. *sintenisii*	0,5	10 b	18 g
	1	6 a	11 a
	Control	16 c	20 h

* Within each column, means with the same letter are not significantly different (p=0,05); ANOVA Scheffe–F test.

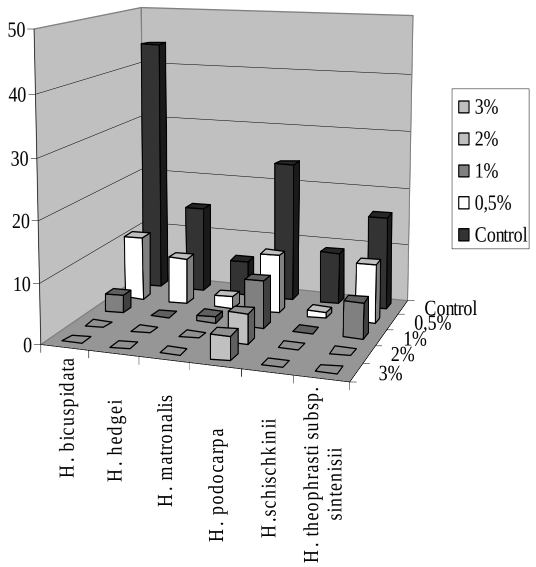

Figure 2. Effects of NaCl on the germination percentage

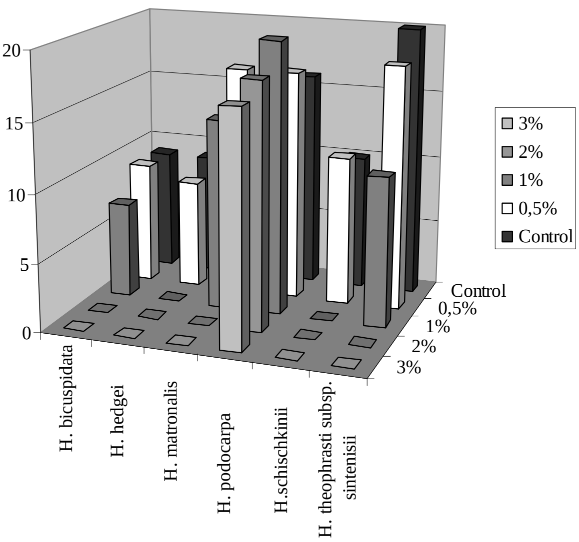

Figure 3. Effects of NaCl on the germination speed

2% KNO_3 encouraged the germination percentage of *H. matronalis*, decreased the germination of *H. persica, H. podocarpa*, *H. stellata, H. transcaucasica*; but, the effect on *H. pendula* was not significant statistically (p<0.05). This solution increased the germination speed of *H. podocarpa*, and decreased the germination of *H. matronalis*, *H. pendula, H. persica, H. stellata* and *H. transcaucasica.*

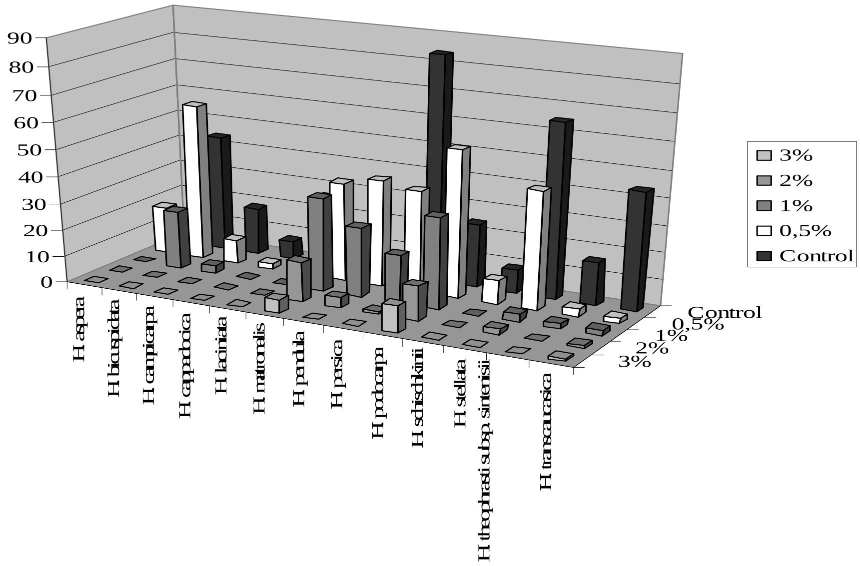

Figure 4. Effects of KNO_3 on the germination percentage

3% KNO_3 was effective on the germination speed and percentage of all species except *H. matronalis*. This concentration decreased the germination speed and percentage of *H. podocarpa*, *H. transcaucasica*, and it also inhibited the germination completely of the rest (*H. aspera, H. bicuspidata, H. campicarpa, H. cappadocica, H. hedgei, H. laciniata, H. pendula, H. persica, H. schischkinii, H. stellata, H. theophrasti*). *H. transcaucasica* attracts attention as the most resistant species to the KNO_3 among the 14 species. All KNO_3 concentrations inhibited the germination of *Hesperis hedgei* completely (Table 5).

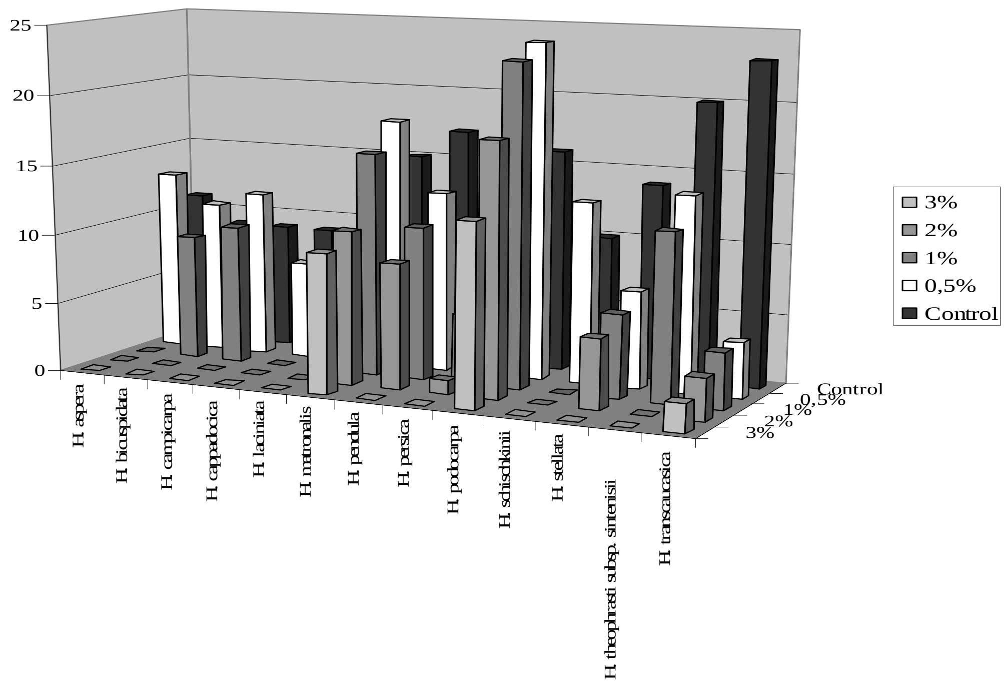

Figure 5. Effects of KNO_3 on the germination speed

3.4. Effects of Different Hydrochloride Acid (HCl) Concentrations on the Germination Percentage and Germination Speed

HCl concentrations (0.5-3%) applied during the study inhibited the germination of *Hesperis aspera, H. bicuspidata, H. cappadocica, H. campicarpa, H. hedgei, H. pendula, H. persica and H. theophrasti* completely. However, it decreased the germination percentage of *H. laciniata, H. podocarpa, H. stellata, H. transcaucasica*. Effect of 0.5% hydrochloride acid on the germination percentage was insignificant for *H. matronalis* and *H. schischkinii* ($p<0.05$), (Figure 6).

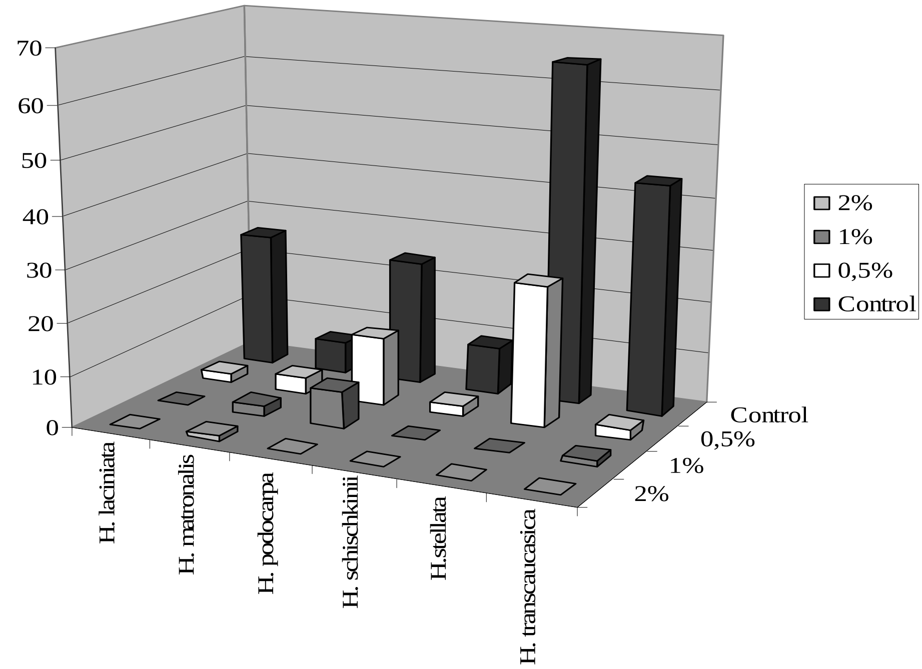

Figure 6. Effects of HCl on the germination percentage

0.5% HCl decreased the germination speed of *H. podocarpa, H. stellata and H. transcaucasica.* Its effect on the germination speed was insignificant for *H. laciniata, H. matronalis* and *H. schischkinii* (Figure 7). All species tested in this study did not germinate in the solution of 2-3 % concentrations of hydrochloride acid (Table 6). Only *H. matronalis, H. podocarpa* and *H. transcaucasica* germinated in 1% HCl concentration.

3.5. Effects of Different Sulphuric Acid (H_2SO_4) Concentrations on Germination Percentage and Germination Speed

It is known that even low H_2SO_4 concentrations inhibit the germination of the plants (Yücel, 2000a; b; c). In this study, it was determined that germination of 12 species of total 14 (*Hesperis aspera, H. bicuspidata, H. campicarpa, H. cappadocica, H. hedgei, H. laciniata, H. matronalis, H. pendula, H. persica, H. schischkinii, H. stellata* and *H. theophrasti)* was completely blocked. Other two species (*H. podocarpa* and *H. transcaucasica*) germinated in only 0.5% H_2SO_4 (Table 7). In this concentration, germination percentage and speed of these species decreased. The result was found statistically significant ($p<0.05$), (Figure 8, 9).

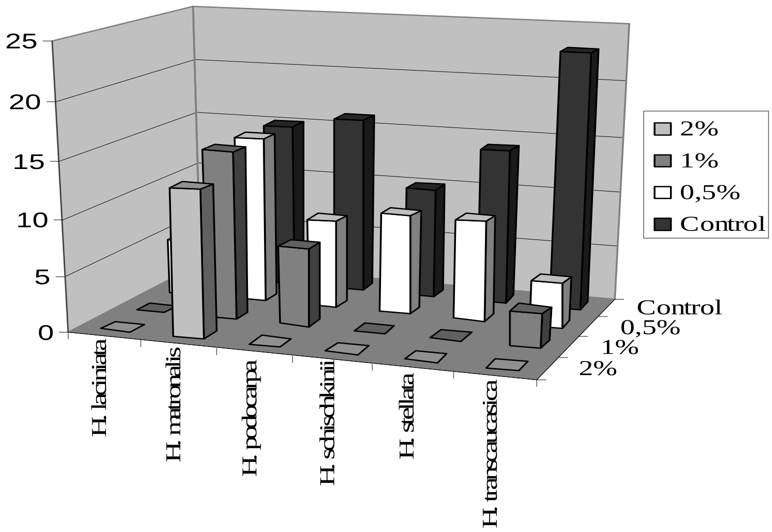

Figure 7. Effects of HCl on the germination speed

4. Conclusions and discussion

Seeds are the most important reproductive part responsible from distribution, aggregation and abundance of plant populations (Barrera and Nobel, 2003). Several factors like light, salinity, acidity that regulate seed germination interact in the soil interface (Ungar, 1995; Khan et al., 2000). Most seeds are located near the soil surface where salt and acid concentration changes because of rain and continuous evaporation of soil water (Ungar, 1991), especially in semi-arid environments (Godi'nez-Alvarez et al., 1999; Valverde et al., 2004).

The fact that light and illumination period has a great effect on germination is well known (Smith, 1986). They encourage (Yücel, 1996a) or inhibit (Probert et al., 1986; Yücel, 1996b) the germination of some species. Light period is also effective on the germination of some *Hesperis* taxa. However, it is seen that *Hesperis* taxa could tolerate the light effects more than the chemicals applied during the experiments.

Tolerance to salinity during germination period is critical for establishment of plants growing in saline soil of arid regions (Ungar, 1995; El-Keblawy and Al-Rawai, 2005). It has reported that low salt concentration is not effective on the germination of most species (Öztürk et al., 1993; Yücel, 2000a) whereas it inhibits the germination of certain species completely when it is in high concentration (Yücel, 2000b; Khan and Gulzar, 2003). Considering the results, it can be seen that increasing salinity due to natural and/or antropogenic reasons and environmental changes related to salinity can have limited effects on distribution of the populations.

KNO_3, a growth-regulating and germination-stimulating substance, can both stimulate seed germination in some species (Öztürk et al., 1984; Öztürk et al., 1994; Puppala and Fowler, 2002) and also inhibit (Yücel, 1996b).

KNO_3 concentration series among the parameters applied during the experiments have the less negative effect on the seed germination. However, increasing concentrations could block or decrease the germination of some *Hesperis* taxa.

Table 5. Effects of KNO_3 concentrations on germination percentage (%) and germination speed

Species	Concentration (KNO_3-%)	Germination percentage (%)	Germination speed
Hesperis aspera	0,5	18 e	13 d
	Control	9 a	11 b
Hesperis bicuspidata	0,5	59 l	11 b
	1	22 f	9 a
	Control	44 k	9 a
Hesperis campicarpa	0,5	9 a	12 c
	1	3 a	10 a
	Control	18 e	9 a
Hesperis cappadocica	0,5	2 a	7 a
	Control	7 a	9 a
Hesperis laciniata	0,5	4 a	5 a
	Control	26 h	8 a
Hesperis matronalis	0,5	37 k	18 j
	1	35 j	16 g
	2	15 c	11 c
	3	5 a	10 a
	Control	6 a	15 f
Hesperis pendula	0,5	40 k	13 d
	1	26 h	11 b
	2	4 a	9 a
	Control	4 a	17 h
Hesperis persica	0,5	38 k	7 a
	1	18 e	5 a
	2	1 a*	1 a*
	Control	84 m	13 d
Hesperis podocarpa	0,5	55 l	24 l
	1	34 i	23 k
	2	13 b	18 i
	3	10 a	13 d
	Control	24 g	16 g
Hesperis schischkinii	0,5	9 a	13 c
	Control	9 a	10 a
Table 5 continued…			
Hesperis stellata	0,5	44 k	7 a
	1	3 a	6 a
	2	2 a	5 a
	Control	65 l	14 e
Hesperis theophrasti subsp. *sintenisii*	0,5	3 a	14 f
	1	2 a	12 c
	Control	16 d	20 k
Hesperis transcaucasica	0,5	2 a	4 a
	1	2 a	4 a
	2	1 a	3 a
	3	1 a	2 a
	Control	44 k	23 k

* Within each column, means with the same letter are not significantly different (p=0,05); ANOVA Scheffe–F test.

As a result of urbanization and industrialization, acid rains have become an important environmental problem in recent years (Evans, 1982). Because of these factors, a large number of species face with the danger of extinction. So, identifying species resistance to acidity has gained a great amount of important. In this study, it is obvious that increasing acidity inhibits or decreases the seed germination of *Hesperis* taxa.

Table 6. Effect of HCl concentration on germination percentage (%) and germination speed

Species	Concentration (HCl-%)	Germination percentage (%)	Germination speed
Hesperis laciniata	0,5	2 a	5 a
	Control	26 d	8 a
Hesperis matronalis	0,5	3 a	15 c
	1	2 a	15 c
	2	1 a*	13 b
	Control	6 a	15 c
Hesperis podocarpa	0,5	13 b	8 a
	1	7 a	7 a
	Control	24 c	16 d
Hesperis schischkinii	0,5	2 a	9 a
	Control	9 a	10 a
Hesperis stellata	0,5	27 d	9 a
	Control	65 f	14 b
Hesperis transcaucasica	0,5	2 a	4 a
	1	1 a	3 a*
	Control	44 e	23 f

* Within each column, means with the same letter are not significantly different (p=0,05); ANOVA Scheffe–F test.

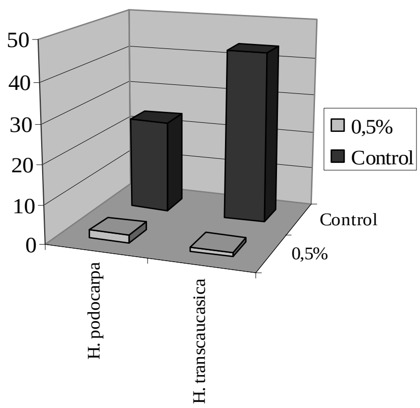

Figure 8. Effects of H_2SO_4 on the germination percentage

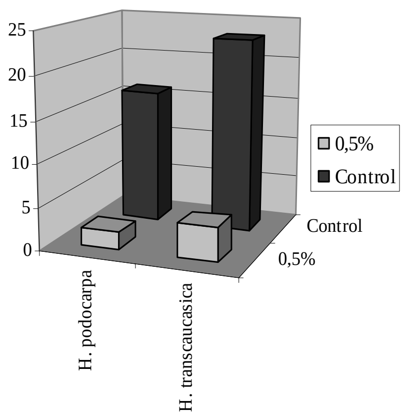

Figure 9. Effects of H_2SO_4 on the germination speed

Table 7. Effect of H_2SO_4 concentration on germination percentage (%) and germination speed

Species	Concentration (H_2SO_4-%)	Germination percentage (%)	Germination speed
Hesperis podocarpa	0,5	2 a	2 a*
	Control	24 b	16 b
Hesperis transcaucasica	0,5	1 a*	4 a
	Control	44 c	23 c

* Within each column, means with the same letter are not significantly different (p=0,05); ANOVA Scheffe–F test.

In all 14 *Hesperis* taxa, *H. matronalis* showed a wider tolerance spectrum to light and chemicals applied during the experiments. This is probably the reason of invasive characteristic of the plant. This species has also using potential medically because of having urinativing, sweating effects and causing to tear down mucus (Baytop, 1999). As a result, *Hesperis* species are sensitive to NaCl, KNO_3, HCl and H_2SO_4. It is thought that the information about the ecophysiological characteristics of *Hesperis* taxa will serve as a database to improve effective conservation strategies related to the species in a risk category, to control the populations of invasive ones and to cultivate the economically important species.

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(Received for publication 12 November 2008)