OVERWINTERING OF SOME HARDY *IRIS* SPECIES IN AGROBOTANICAL GARDEN UASVM CLUJ-NAPOCA

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Abstract. In this study conducted in two winter seasons on eight *Iris* species of hardiness seven from Agrobotanical Garden UASVM Cluj-Napoca, by exploring the link between temperature and senescence it was shown that this factor affects differently the iris species in relation to leaf senescence onset and progression. It was observed that temperature variation from one studied overwintering interval to another seems to cause a stronger response in some semi-evergreen species *(I. pallida, I. orientalis).* Climatic data from last five winters suggests that hardy iris species that can withstand temperatures that reach -20°C and lower are best suited for Cluj County.

Keywords: dormancy, hardiness, rustic geophytes, leaf senescence.

INTRODUCTION

The genus *Iris* belongs to the *Asparagales* order of the flowering plants and the *Iridaceae* family (Meckenstock, 2005). Irises are rustic geophytes that can overwinter outdoors even in colder climates (Cantor and Pop, 2008), and the perennity of the plant is ensured by rhizomes in most species or bulbs in some (Cantor, 2003). The hardiness of the irises varies by species between H4 to H7. Thus, *Iris japonica* and *Iris hoogiana* can withstand mild winters with temperatures down to -5°C and -10°C, *Iris foetidissima* can withstand winter temperatures between -10 to -15°C, *Iris unguicularis* and *Iris germanica* are hardy in winters with temperatures that reach -15°C to -20°C, and *Iris sibirica,* like all H7 irises used in temperate continental gardens (like Romania) withstand winters that can register temperatures lower than -20°C (http://www.rhs.org.uk). Regarding the foliage, the irises are deciduous *(Iris sibirica, Iris pseudacorus, Iris chrysographes),* semi-deciduous *(Iris orientalis, Iris pallida)* or evergreen *(Iris foetidissima, Iris japonica, Iris germanica)* (http://www.rhs.org.uk). Leaves are flat and sword-shaped and in most species, each leaf is conjoined with the rhizome (Meckenstock, 2005).

On short, the life of the leaves follows several stages. Leaves initiate their life as leaf primordia. During their development and growth, they become photosynthetically active and accumulate nutrients. Leaves then enter the senescence stage, followed by their death (Wingler *et al.,* 2012). When it comes to natural senescence of leaves there can be identified two main types according to the plant species involved and based on the level at which it occurs. Thus, there is senescence at organismal and organ level. The first one is met in annual plants, when the senescence and death takes place at the level of the entire plant. By contrast, plant senescence at the organ level is manifested in changes in leaf color and the subsequent death of leaves in autumn for perennials and biennials (Hye *et al.*, 2013; Wingler *et al.,* 2012). Leaf senescence serves several important functions, one of which is preparation for winter. It is closely linked to dormancy of those organs which must survive the unfavorable period (Forbes and Watson, 1999). It was shown that nutrients that are degraded during leaf senescence are redistributed to be stored into other parts of the plant (like rhizomes). The nutrients stored in stems or roots are utilized later for the vegetative development next spring, since some vegetative meristem in perennial plants remains dormant for certain periods of time before restarting growth (Estiarte and Peñuelas, 2015; Girdhar, 2015; Hye *et al*., 2013; Rien, 1996). Climate is the main variable that controls leaf phenology (Botta *et al*., 2000), and different environmental changes are responsible for leaf senescence, but among the most well-known is temperature (Girdhar, 2015). Another well-known aspect is that photoperiod manifests a strict control on leaf senescence at latitudes where winters are severe while temperature gains importance in the regulation as winters become less severe (Estiarte and Peñuelas, 2015). However, besides these, it must be said that leaf senescence is controlled with multiple layers of regulation and is a highly complex mechanism since involves the collective functions of multiple genes and signaling pathways that integrate both age information and signals (either endogenous or exogenous) throughout the leaf lifespan. Leaf senescence can be considered an evolutionarily acquired developmental strategy and it is expected that plants that have evolved in different environments have different senescence physiology and regulatory modes (Hye *et al*., 2013).

Iris species with rhizomes usually are left over winter in the place they are planted outdoors but they can also be stored over winter and aspects reading both possibilities are presented.

For the plants that winter outdoors, the usual autumn preparation for overwintering of irises includes trimming of leaves and applying mulch. While some sources are arguing against the cutting of leaves for winter of the established iris plants (White *et al*., 1997; Alvis, 2007), some sources underline the importance of good sanitation to ensure healthy plants for the next spring, by trimming the leaves and removing the them from the beds because spent iris leaves can be vector for leaf spot or iris borer eggs and to discourage herbivorous visitors (http://www.presbyirisgardens.org). Leaves can be either cut to the base or only the leaf tips can be cut off, depending on senescence setting. Trimming of leaves can be made in the fall when leaves start to turn yellow by reducing them at 15 cm (http://homeguides.com). The species with rhizomes that creep near the surface, like tall bearded types, are prone to having their rhizomes lifted from the ground in the winter by alternate freezing and thawing and the preventive measure is to secure them with rocks (White *et al*., 1997), or to bank soil around the exposed rhizome and roots when this happens during the winter months, but strictly avoiding to push them back (Gardens alive, 2014).

For storing the *Iris* rhizomes for winter there are several stages that need to be followed. After digging the rhizomes up from the planting beds, the leaves are trimmed back to about 7-10 cm long. Most often, the rhizomes are not washed to remove the dirt but instead are placed in the sun for a day or two until the iris rhizomes are dry to the touch. Only after that using a scrub brush, gently most dirt is brushed off. In case the rhizomes are washed they need to be left to dry well. The next step in preparing iris rhizomes for storage is to place them in a dark, dry place to further dry or as it is usually called to “cure” for a period of about 1-2 weeks. During this “cure” time they should be provided with plenty of air ventilation and the temperature should be 21°C. After the iris rhizomes, have cured, they are coated in sulfur powder or other anti-fungal powder. This will help prevent rot from setting in the rhizomes. The last step in storing iris rhizomes is to wrap each rhizome in a piece of paper or to introduce them in plastic bags with several holes, then place them in a box. Alternatively, the rhizomes can be packed in a box or container with some kind of dry material like sawdust or newspaper shreds. The boxes are stored in a cool, dry place at about 10°C. Every few weeks, the iris rhizomes are checked to make sure that rot has not set in. If the iris rhizomes start to rot, they will feel soft instead of firm, in this case the rotting iris rhizomes are discarded so that the fungus does not transfer to any other iris rhizomes in the box. If the rhizomes are acquired too close to winter they can be also kept in refrigerator (Rhoades, 2015; http://homeguides.com; http://www.thegardenhelper.com; http://www.gardenguides.com).

Until now, various authors reported that ageing and senescence in perennial plants had not been studied in detail (Girdhar, 2015). Thus, some recent authors (Hye *et al*., 2013) have pointed various issues to be researched in the future regarding this subject. For example, it is not known how the heterogeneity in dying cells is coordinated with the senescence of the entire leaf. Also, the mechanism that controls the relocation of nutrients from senescent leaves is another important aspect that has not been explored. Same authors suggest that it will be highly informative to perform comparative studies of different plants with a distinct senescence strategy since this will allow to later define the metabolic and physiological processes of senescence and their regulatory principles (Hye *et al*., 2013). Also, leaf senescence can provide revealing data used in bioclimatic models for assessing climatic changes, like in the studies of Wenquan *et al*. (2012).

First, studying how some *Iris* species behave in relation to temperatures in Cluj County, it might help in the selection of new *Iris* species and varieties for this area according to their hardiness, in order to enrich the garden assortment. Secondly, the information obtained could be used in improving the cultivation technology or settling more efficient wintering preparation techniques for irises in Cluj County. And not at last, the data obtained from the overwintering of iris, like senescence progression is important for the study of phenological stages of garden irises in Cluj County.

MATERIALS AND METHOD

The biological material used for this study was represented by 8 *Iris* species of hardiness “7”, meaning that these plants are hardy in the severest European continental climate (< -20) according to Royal Horticultural Society (www.rhs.org.uk).

The studied species planted in the Systematic Sector of the Agrobotanical Garden UASVM Cluj-Napoca, are: with deciduous foliage: *Iris setosa* Pallas, *Iris ensata* Thunberg, *Iris versicolor* Linneaus, *Iris missouriensis* Nuttal, *Iris sibirica* Linneaus, *Iris pseudacorus* Linneaus; with semi-deciduous foliage: *Iris orientalis* Miller, *Iris pallida* Lamarck. In order to make observations over senescence progression in different species no trimming and no mulch was applied to the studied plants in two non-consecutive winters (2013-2014 and 2015-2016). The observations concentrated on comparing the senescence progression rate throughout the winter months (December, January, February) in order to establish how fast, early or late the studied iris plants enter the dormancy stage in two different winters: 2013-2014 and 2015-2016, and how various deciduous iris species behave in the climatic conditions of Cluj County.

RESULTS AND DISCUSSION

One of the most important factors of natural leaf senescence is temperature (Girdhar, 2015; Estiarte and Peñuelas, 2015). Thus, in this study it was researched the link between temperature and leaf senescence and in Figure 1 can be observed the lowest temperatures in each of the two seasons when observations on leaf senescence rate were conducted in the months of December, January and February. November temperatures are important for determining a possible influence of colder or warmer late autumn temperatures on senescence stage registered at the beginning of winter dormancy (December). It is mentioned that Romania is situated in transitional temperate-continental climate (Philander, 2012) but the correlation between precipitation and solar activity gives Cluj-Napoca climate an oceanic character (Criveanu, 2001).

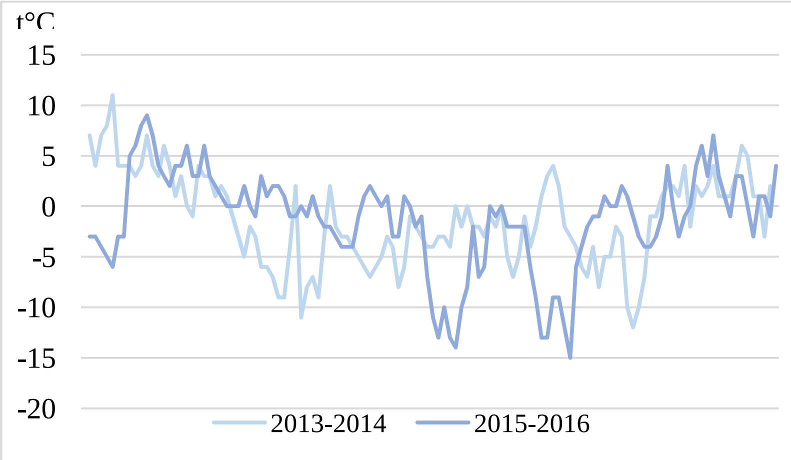

Fig. 1. Lowest temperatures in two seasons for the months: Nov., Dec., Jan., Feb. in Cluj-Napoca (source: https://www.wunderground.com/history/)

In the Figures 2 and 3, it can be observed the senescence progression of two semi-evergreen species *(I. orientalis and I. pallida)* and six deciduous species studied (*Iris setosa, Iris ensata, Iris versicolor, Iris missouriensis, Iris sibirica, Iris pseudacorus).* It can be noted immediately that both the semi-evergreen and the deciduous species studied were overall presenting more green foliage at the debut of December 2013 compared with December 2015. When comparing these charts (Fig. 2, Fig. 3) with temperatures from Figure 1, it can be observed that November debut of 2015 was colder with freezing temperatures while in 2013 only towards the end of November temperatures begun to drop and eventually to plunge under 0°C. Further in 2013, the temperatures maintained their cooling trend from the end of November throughout most part of December. Because of this, by January 2014 the colder end of November and most of December caused the senescence to accelerate and thus it can be observed in Table 1, the difference between average senescence in the two seasons was not as large for January as it was for December.

Table 1

Average leaf senescence of eight hardy *Iris* species in two winters

Season / Month	December (average %)	January (average %)	February (average %)
Winter of 2013-2014	60.00	78.75	86.25
Winter of 2015-2016	81.62	85.62	91.87

The fact that a milder late autumn for the most part caused an overall slower onset of senescence determined in December of 2013 compared with 2015 comes as no surprise, since some authors report that in general climatic warming will obviously delay leaf senescence (Estiarte and Peñuelas, 2015). But since the temperatures decreased more abruptly from end of November and throughout most part of December 2013, senescence advanced by January, once more accentuating the strong influence of temperatures on the senescence onset and progression for the iris leaves.

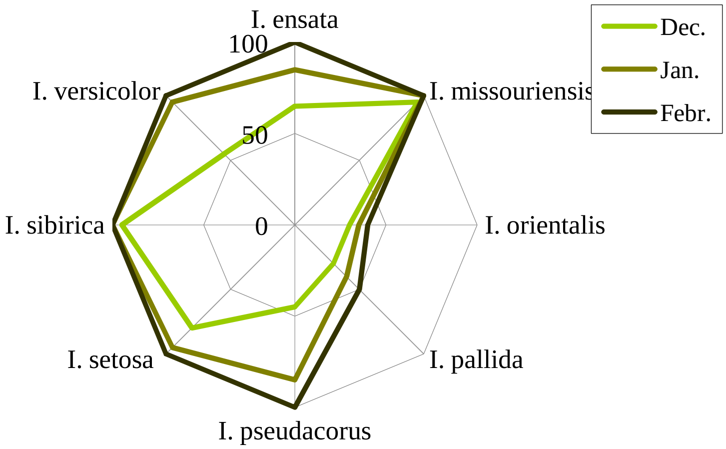

Fig. 2. Senescence progression (%) for *Iris* leaves during winter of 2013-2014

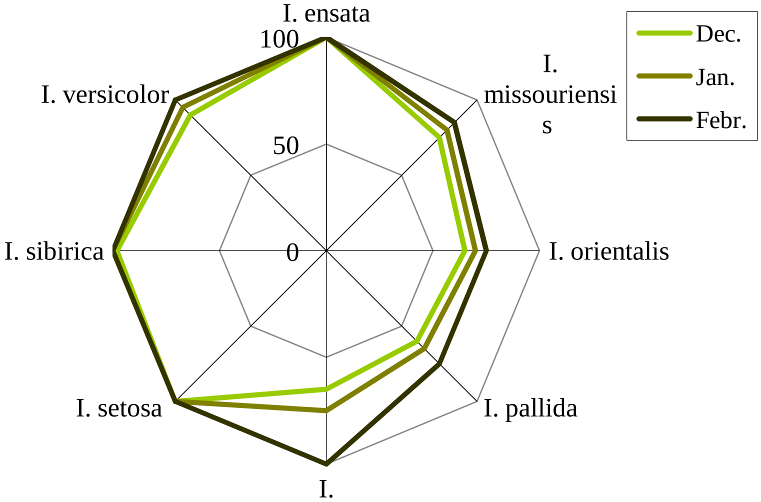

Fig. 3. Senescence progression (%) for *Iris* leaves during winter of 2015-2016

The leaves of the deciduous species were on average more dry in December 2015 with 5 out of 6 species studied with leaves dry more than 70%, compared with December 2013 when 3 species *(I. ensata, I. versicolor, I. pseudacorus)* presented leaves under 70% dry (Fig. 2, Fig. 3). Furthermore, the following species with deciduous foliage: *Iris setosa, Iris versicolor, Iris sibirica, Iris pseudacorus* in both winters presented leaves dry over 90% at the middle of winter dormancy (January), and over 95% dry until the end of dormancy (February) (Fig. 2, Fig. 3). For *Iris versicolor* and *Iris pseudacorus* in the winter of 2013-2014, the foliage drying progression was slower in December compared to the other deciduous species but dried completely until the end of the dormancy. In the winter of 2015-2016, *Iris pseudacorus* and *Iris missouriensis* presented a slower progression of senescence in December, but only *Iris pseudacorus* leaves completely dried until the end of dormancy, while *Iris missouriensis* still presented 15% green parts at the end of dormancy.

It can also be observed that two semi-evergreen species *(Iris pallida, Iris orientalis)* that in the winter of 2013-2014 had 50% or more green leaves up until the end of winter, in the winter of 2015-2016 were dry more than 50% throughout the winter (Fig. 2, Fig. 3). It can be the case that semi-evergreen species *Iris pallida* and *Iris orientalis* are stronger influenced by temperatures (possibly including a colder late autumn), since it was shown when comparing senescence progression throughout the winter months (Fig. 2, 3) with temperatures (Fig. 1) that they can exhibit some striking senescence differences from one winter season to another. Compared to the semi-evergreen species, considering the deciduous iris species, it can be observed in Figures 2 and 3 that *Iris ensata, Iris versicolor, Iris sibirica, Iris setosa* and *Iris pseudacorus*, were consistently presenting their leaves completely dry in February in both winter seasons. From the deciduous species studied, only two species in the first season *(Iris pseudacorus, Iris versicolor)* and joined by another in the second season studied *(Iris missouriensis)* presented a somehow delayed or slower onset of senescence in the first two months of winter compared to the other deciduous species studied. This slower onset seems to remain more consistent particularly for *Iris pseudacorus* from the deciduous species, when analyzing the data. These results seem once more to be in accordance with literature that shows that although temperature is the main factor controlling the leaf senescence, it does so at varying degrees depending on the species (Estiarte and Peñuelas, 2015).

The implications of these results and observations have a practical dimension. Thus, it is proposed that winter preparation and trimming of iris leaves could be set different and eventually specifically addressed for certain species. Because it is important to allow the *Iris* foliage to remain on the plant as long as it remains green (http://homeguides.com) and since it was shown in this study that various semi-evergreen and deciduous species behave differently it is proposed that:

- The semi-evergreen species *Iris pallida* and *Iris orientalis* to be left untrimmed or to be trimmed less severely in autumn having only the upper part of the leaves removed.
- Some deciduous species with a slow senescence onset in winter like *Iris pseudacorus*, *Iris versicolor* and eventually also *Iris missouriensis,* could have their leaves trimmed lower down than the semi-evergreen species in autumn.
- A series of deciduous species with fast onset of senescence like *Iris sibirica* and *Iris ensata* could be trimmed closer to the base in autumn.

Another aspect that could be raised into attention is hardiness. When reviewing the climate data for Cluj-Napoca since 2011, it was observed that lowest temperatures recorded were -19°C in 2011, -23°C in 2012, -12°C in 2013, -18°C in 2014, -18°C in 2015 and at the beginning of 2016 the lowest temperature was -15°C (https://www.wunderground.com/history/). It can be observed also from Figure 1, that although during the studied seasons the lowest winter temperatures did not reached nor plunged under -20°C, it did in some previous years (like 2012), but does not seem to occur very frequent lately. Thus, the *Iris* species of hardiness six and seven remain the recommended ones for Cluj County, that according to Royal Horticultural Society can withstand temperatures up or respectively below -20°C (http://www.rhs.co.uk). However, hardiness five species could be tested in the future but perhaps preventively coupled with mulching for more protection from potential frost damage.

In the end, it can be said that in Cluj County the leaves of various *Iris* species undergo senescence at a different rate (Fig. 2, Fig. 3, Fig. 4). At the beginning of winter in some years (2013) irises have on average more green foliage than in others (2015). This was caused most likely by the fact that in some years late autumn presents mostly positive temperatures, like it was observed in 2013, when in the first part of November for example, the lowest temperatures of the day were between 3 and 11°C, while in other years the debut of November came with freezing temperatures (2015) causing an earlier onset of leaf senescence.

a

b

Fig. 4. Senescence progression over winter for three *Iris* species in Agrobotanical Garden: a - Beginning of dormancy 2015 *(Iris sibirica, Iris pallida, Iris orientalis)*
b - Middle of dormancy 2016 *(Iris sibirica, Iris pallida, Iris orientalis)*

The results of this study confirmed that one of the most important factors of natural leaf senescence is temperature (Girdhar, 2015; Estiarte and Peñuelas, 2015). However, the stronger response in some species compared to others when it comes to leaf senescence in relation to temperature variations from one winter season to another could be explained when considering the origin of those species. For example, *Iris sibirica* originary from northern temperate continental Eurasia (White *et al.,* 1997), might respond stronger to photoperiod, while *Iris pallida* a species from Dalmatian coast (White *et al.,* 1997), is responding stronger to temperatures regarding onset of dormancy and leaf senescence. This could be explained by the fact that different leaf senescence strategies can be met in plants according to the environments they evolved in (Hye *et al*., 2013). In this way it could be easily understood why photoperiod manifests a prime role in leaf senescence for species that evolved at latitudes where winters are more severe while temperature might have a prime importance in the leaf senescence regulation for plants that evolved in regions where winters are less severe (Estiarte and Peñuelas, 2015). All these clearly relate to the fact that *Iris sibirica* does not present major differences in leaf senescence onset from one dormancy season to another in Cluj County despite temperature variations observed during studied periods, while *Iris pallida* presents evident differences.

It was also observed that not trimming the leaves of the studied irises did not visibly affected the sprouting and flowering in the spring (including for the tall bearded with rhizomes creeping near the surface) and by mid-March all irises presented new shoots. Probably the iris leaves that are not trimmed (especially for the herbaceous species) protects the rhizome over the course of winter.

CONCLUSIONS

During their lifespan, plant leaves transition through a series of developmental, physiological and metabolic changes that culminate in senescence and death. From the factors that influence leaf senescence this study explored the link between temperatures and senescence in some hardy iris species in two winters. By following the senescence progression throughout the winter months, it was shown that in Cluj County the leaves of various *Iris* species undergo senescence at a different rate. When comparing the senescence rates with temperatures it was confirmed that indeed temperature is an important factor involved in the leaf senescence, but the influence seems stronger in the case of certain *Iris* species like *Iris orientalis*, *Iris pallida*, *Iris pseudacorus*, *Iris versicolor*, compared to others like *Iris sibirica* and *Iris setosa*.

Hardiness is one of the most important aspects to keep in consideration when choosing or caring various irises in temperate or northern gardens. It appears that for the temperate continental climate of Cluj County Romania, irises of hardiness 6 and 7 that can withstand temperatures up to -20°C and lower might be best suited.

The absence of mulching did not seem to influence much the hardy irises over winter, since all the studied species entered vegetative stage until mid-March after both studied winter intervals.

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