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Preliminary observations on winter-hardy *Agave* spp. in Hungarian rock garden

Szabó-Mohácsi, K.

Zoological and Botanical Garden, Budapest

Summary: In the recent three decades several winter-hardy succulent collections were established in Hungary. These collections belong to winter-hardy cacti and their companion plants the agaves too. The agaves are much more rare than cacti and only few species can tolerate Hungarian climate conditions without any guard. When selecting the species, winter-hardiness has to be considered which includes all factors in the winter period. Observations were performed for frost resistant or winter-hardy *Agave* species in private collections. The recent paper gives information on 7 species of *Agave* and try to help the determination of the plants outside in the ground.

Key words: *Agave*, winter-hardy, Hungarian collection

Introduction

Most people think about agaves like companion plants of cacti but few of them – with sharp and decorative features in unflowered conditions – are cast totally.

There are less determined succulent collectors, who keep large-size plants like agaves because of growing quickly, the claim to big place and to big physical load which means carrying the plant in and out depending on the season. So most of them look for another genus to collect or prefer those pigmy species which don't need carrying and place in the greenhouse because of their winter-hardiness under Hungarian conditions too.

The plants of the *Agave* genus (*Agavaceae*) are typically monocarpic: each rosette flowers only once and then dies because the inflorescence grows from the apical meristem. Some species then produce offsets or others die without being able to do so (*Benadom*, 2002).

Views on the generic delimitation of *Agave* and the number of its species have varied over the years. *Berger* (1915) recognised 274 species in subgenera *Manfreda*, *Littaea* and *Euagave*. *Breitung* (1968) recognized some 10 species in *Littaea* and *Euagave*. *Irish & Irish* (2000) estimate the number of species to be 200–250, while Thiede (2001) recognizes 210 species in subgenera *Littaea*, *Agave* and *Manfreda* (included in latter are the genera *Polianthes* and *Prochnyanthes*). *Mendosa* (2002) concluded that *Agave* genus (subgenera *Agave* and *Littaea*) consists of approximately 200 species, plus 47 intraspecific categories, giving a total of 247 taxa.

Agaves in general are plants of warm climates stretching through the American Southwest, Mexico, Central America and the Caribbean. A few species range into higher elevations and latitudes of Arizona, Utah, Nevada and Mexico, areas where subfreezing temperatures may routinely occur in winter (*Irish*, 2002). This situation, however, is complicated because high elevations in northern Arizona, where some highly cold tolerant agaves are native, experience very cold temperatures (-23 °C), while high elevations in southeastern Mexico are extremely moderate (-9 to -7 °C) (*Irish & Irish*, 2000). *Agave parryi* is a good example of this phenomenon. So the origin of the seeds and offsets of agaves is very important.

Breitung (1968) noticed more than 20 winter-hardy agaves in his reference. Debreczy characterised 23 species in his book: Winter-hardy cacti, agaves and yuccas (1976). To his impression several cactus collectors have been trying to grow and propagate winter-hardy cacti and agaves. However, the data in the literature can be misleading.

The temperature value indicates the frost-resistance of the particular species and does not tell much about its winter-hardiness. Winter hardiness is a genetically determined characteristic by which the plant can tolerate all the environmental factors (humidity, fluctuation of temperature, wind, snow-cover) during the winter season. As a consequence, frost-resistance means that the plant can survive certain low temperatures but it does not necessarily mean that the plant can survive through several winters (*Sabucco*, 1990).

The biggest problem in Hungary is the high precipitation and humidity of the fall and winter combined with the frost. Under Hungarian climate condition unfortunately only seven taxa can tolerate or can be called winter-hardy plant (*Mohácsi & Mohácsi-Szabó*, 2006).

Winter-hardy *Agave* spp. *(Agavaceae)* in Hungarian circumstances

Agave inaequidens ssp. inaequidens Koch 1860

Syn.: *Agave amoena* hort. *ex* Lemaire *ex* Jacobi (s.a.); incl. *Agave mescal* Koch (1865); incl. *Agave crenata* Jacobi (1866); incl. *Agave megalacantha* Hemsley (1880); incl.

Agave reginae hort. *ex* A. Berger (1912); incl. *Agave heterodon* hort. *ex* A. Berger (1915); incl. *Agave bourgaei* Trelease (1920).

Distribution: Mexico (Jalisco, Hidalgo, Michoacan, Mexico, D.F., Morelos, Puebla). The primary habitat is the pine forestedslopes between 1850-2480 m, also characterized by oaks and other hardwoods. Annual rainfall averages about 1000 mm, the mountain slopes are generally well timbered and agaves are restricted to the more open rocky slope (*Gentry*, 1982). Plants medium to large, single, short-stemmed, openly spreading; mostly 75–150 x 11–21 cm, leaves variable broadly or narrowly lanceolate to oblanceolate, ascending to outcurving, thick-fleshy, light green to yellow green, rarely faintly glaucous, the margin undulate to repand and crenate; teeth dimorphic, straight or variously curved, castaneous to dark brown, spine stout. Buds and tepals reddish purple, opening yellow (*Gentry*, 1982).

This species had decorated in the rock-garden in Érd (Hungary) for long time, but in 1999 the motherplant died when the temperature fell below -23 °C. However, its offsets (5 cm high) survived also that winter without any demages (*Mohácsi &Mohácsi-Szabó*, 2006).

Rüdiger Mattern (1997) mentioned this species with its -18 °C frost tolerant.

Agave utahensis ssp. utahensis Engelmann 1871

Syn.: *Agave haynaldii* var. *utahensis* (Engelmann) A. Terracciano (1885); *Agave utahensis* var. *utahensis; Agave newberryi* Engelmann (1875); *Agave scaphoidea* Greenman & Roush (1929); *Agave utahensis* var. *scaphoidea* (Greenman & Roush) M. E. Jones (1930); *Agave utahensis* var. *nevadensis* Engelmann *ex* Greenman & Roush (1929); *Agave nevadensis* (Engelmann *ex* Greenman & Roush) Hester (1943); *Agave utahensis* var. *discreta* M. E. Jones (1930); *Agave eborispina* Hester (1943); *Agave utahensis* var. *eborispina* (Hester) Breitung (1960); *Agave utahensis* fa. *nuda* hort. *ex* E. & B. Lamb (1978).

Distribution: USA (California, Utah, Nevada, Arizona).

A fairly small species which often forms large clumps. The plant has 70-80 lanceolate, rigid leaves, plane to concave above, convex below, mostly 15–30 x 1,5–3 cm, light green or yellowish green. The terminal spine is rounded, 2–4 cm long, the light grey teeth occur along the margin of the leaves apart 1–2,5 cm. The inflorescence is spicate, racemose or paniele, 2–4 m tall (*Gentry*, 1982).

This species is planted in some rock garden in Hungary more or less succes, but it can be seen only its vegetative dwarf forms which are in the ground (*Mohácsi & Mohácsi-Szabó*, 2006).

Agave utahensis ssp. kaibabensis (McKelvey) Gentry 1982.

Syn.: *Agave kaibabensis* McKelvey (1949); *Agave utahensis* var. *kaibabensis* (McKelvey) Breitung (1960).

Distributon: USA (North- Arizona)

The difference from ssp. *utahensis* is that the plant is robust, rozetta is bigger than former subspecies, usually single. In old age the plant forms trunk. The leaves are 30–50 x 3–5 cm, light, bright green, the teeth are (2-)3–5 mm long, apart 2–4 cm. The terminal spine is strong, 2–4 cm long. The inflorescence is 3,5–5 m tall, the flowers are similar to ssp. *utahensis*, but bigger.

Variety *nevadensis* and *eborispina* are accepted by Gentry as synonim of *A. utahensis* ssp. *utahensis*. According to him the varieties are transitional forms between the two in southwestern Utah and perhaps elsewhere (*Gentry*, 1982). All varieties and forms appear to be sensitive to wet-cold conditions (*Irish*, 2002). However in Hungary these plants are the best winter-hardy agave and more collectors noted that this species is living for years without any seriously demages (*Mohácsi & Mohácsi-Szabó*, 2006).

Agave havardiana Trelease, 1912.

Distribution: USA (Texas, southeastern New-Mexico), Mexico (Chihuahua, Coahuila).

The symmetrical rozette is usually solitary or with very few offsets, 40–61 x 51–79 cm. The leaves are a glaucous gray to dull green, occasionally yellowish, very thick at the base, rigid, and wide at the middle of the leaf, tapering to a sharp tip (*Irish & Irish*, 2000). The teeth are spaced 2.5–5 cm apart. The terminal spine is stout, dark brown aging to grey, 2,5–5 cm long, and decurrent sometimes as a continuous border. The inflorescence is a panicle 2–5 m tall (*Irish & Irish*, 2000).

Irish (2002) collected opinions about this species and many reporters noted problems with this species regardless of temperature during an unusually wet year. In Hungary, László Sándor kept *A. havardiana* in his garden for more than 15 years, where it beared -30 °C in the coldest winter (*Sándor*, 1996).

Agave parryi var. parryi Engelmann 1875

Syn.: *Agave parryi* ssp. *parryi, Agave scabra* ssp. *scabra, Agave americana* var. *latifolia* Torrey (1859), *Agave scabra* Salm-Dyck (1859), *Agave wislizeni* Engelmann (1875), *Agave marcusii* De Smet (1876), *Agave noah* Nickels (1894), *Agave applanata* var. *parryi* (Engelmann) Mulford (1896), *Agave chihuahuana* Trelease (1911), *Agave patonii* Trelease (1911), *Agave marcusea* hort. *ex* Trelease (1912), *Agave marensii* hort. *ex* Trelease (1912), *Agave parrayi* hort. *ex* Trelease (1912), *Agave parreyi* hort. *ex* Trelease (1912), *Agave paryi* hort. *ex* Trelease (1912), *Agave payrii* hort. *ex* Trelease (1912).

Distribution: USA (southeastern Arizona; southwestern New Mexico), Mexico (Chihuahua and Durango); at elevations from 460–2400 m in open rocky slopes.

The rosette is stemless, rounded, (35-) 40–60 x 60–75 cm, richly sprouting. Per rosette there are 100–160, rigid, thick leaves, (18-) 25–50 x (4,5-)8–12 cm (*Berger*, 1988). They are light gray to light blue-green and have a straight or very slightly undulate margin from which arise variably sized red-brown teeth. The terminal spine is stout, flat, brown, and long decurrent.

There are three very distinct varieties of this species. *Agave parryi* var. *couesii* (Engelmann *ex* Trelease) Kearney and Peebles 1939 is much smaller than the type with a leaf shape somewhat between the more lanceolate form of var. *huachucensis* and the extremely obovate form of var. *truncata* (*Irish & Irish*, 2000).

Agave parryi var. *couesii* is founded in the northwest border of the distribution of the species so it probably can be winter-hardy under Hungarian climate conditions.

Agave neomexicana Wooton and Standley 1913

Syn.: *Agave parryi* var. *neomexicana* (Wooton and Standley) McKechnie (1949); *Agave parryi* ssp. *neomexicana* (Wooton and Standley) B. Ullrich (1992).

Distribution: USA (NewMexico and Southwest-Texas montains), Mexico (Coahuila?)

Agave neomexicana is small to medium-sized species with rosettes averanging 25–40 cm tall and 30–39 cm wide. Plants form numerous offsets, making very compact rosettes. Leaves are slender, lanceolate, concave above and convex below. Strong teeth occur along the margin, and the horny margin commonly is discontinuous. The terminal spine is 2.5–3.2 cm long, rounded, and decurrent to the one or more teeth. The inflorescence is a panicle 2.4–3.4 m tall. The flowers are re din bud and yellow when open (*Irish and Irish*, 2000).

Agave virginica Linné 1753.

Syn.: *Manfreda virginica* (Linne) *Salisbury ex Rose, Polianthes virginica* (Linne) *Shinner, Agave lata* Shinners (1951), *Polianthes lata* (Shinners) Shinners (1966), *Manfreda virginica* ssp. *lata* (Linne) O'Kennon & al. (1999), *Agave pallida* Salisbury (1796), *Agave virginica* var. *tigrina* Engelmann (1875), *Manfreda tigrina* (Engelmann) Small *ex* Rose (1903), *Manfreda virginica* var. *tigrina* (Engelmann) Rose (1903), *Agave virginica* fa. *tigrina* (Engelmann) Palmer & Steyermark (1935), *Agave tigrina* (Engelmann) Cory (1936), *Polianthes virginica* fa. *tigrina* (Engelmann) Shinners (1966), *Allibertia intermedia* Marion (1882), *Agave alibertii* Bake (1883).

Distribution: southeastern USA.

Agave virginica ssp. *virginica* is a small species rarely more than 46 cm tall. It has numerous soft, fleshy leaves and a true winter dormancy in temperate areas wherein the entire plant dies away to return in warm weather. Plants can multiply rapidly from rhizomes or from buds at leaf axils (*Irish & Irish*, 2000). There are 6–10 leaves in a rozette, the leaves are lanceolate or spatulate, very sharp but not pricky, 15–45 cm long with a width of 2–5 cm, concave, dark green often with a red stripes, rarely spotted (*Berger,* 1988). It is easily recognised by its slender, green flowers with upstanding lobes and style which is shorter than a filament (*Verhoek-Williams*, 1975).

Spreading of the winter-hardy agaves

Among the 7 winter-hardy agaves (in Hungarian climate condition) 5 taxa are native in northwest USA (*Figure 1*), one (*Agave virginica*) (*Figure 2)* is native in southeast USA, and the last one (*Agave inaequidens* ssp. *inaequidens)* is native in Mexico (Jalisco, Hidalgo, Michoacan, Mexico, D.F., Morelos, Puebla).

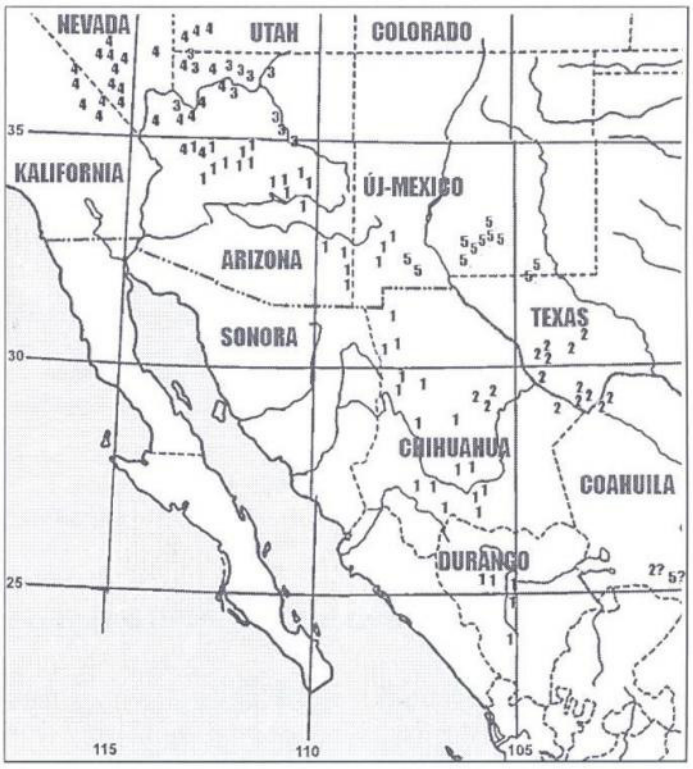

Figure 1 Distribution of the evergreen winter-hardy agaves in the USA. 1–2 var. *parryi* and var. *couesii*; 3. *utahensis* ssp. *kaibabensis;* 4. *utahensis* ssp. *nevadensis*; 5. *neomexicana*; 6. *havardiana*

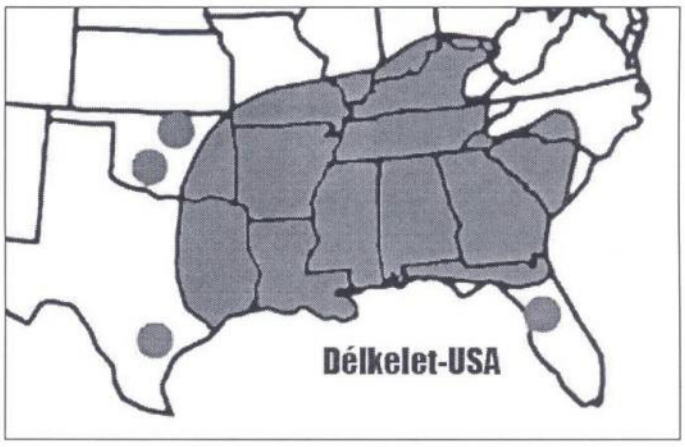

Figure 2 Distribution of the deciduous winter-hardy agave, *Agave virginica* in the USA.

Determination of winter-hardy agaves in Hungary

The determination was prepared about those species, which can tolerate 23 °C subzero. The data concern fully developed plants. The circumstances of keeping can

influence the quality of individual. Before taking a decision we have to summerize all the different data for the determination. The character of the influorescence was not taken into consideration because of the unflowered conditions in Hungary. Among Hungarian collections there is no freqvent flowering of agave.

1. Succulenct leaves with terminal spine 2
1. Leaves without terminal spine, semi succulent soft, fleshy leave die away to return in the warm weather . . . . . *virginica*
2. Leaves maximum 5 cm broad 3
2. Leaves minimum 5 cm broad 4
3. Leaves 3 – 5 cm broad and 30 – 50 cm long (rarely the leaves of *A parryi* var. *parryi* can be 4,5 cm broad) *utahensis* ssp. . . . . *kaibabensis*
3. Leaves 1,5 – 3 cm broad and 15 – 30 cm long *utahensis* ssp. . . . . *utahensis*
4. Leaves indented, warted 5
4. Many offsets with long rhizomes form big spreading group, leaves non warted 6
5. Terminal spine non decurrent, brodest leaf int he middle. . . *inaequidens*
5. Mostly single. Leaves ovate-acuminate, broadest at clasping base teeth numerous, larger, straight toward leaf apex, the others reflexed . . . . . *havardiana*
6. Large rozette with many leaves, terminal spine 1,5 – 3 cm . . . . . *parryi*
6. Leaves lanceaolate ending into the spine, 20 – 45 cm long, terminal spine subulate, 3 – 5 cm long . . . . . *neomexicana*

The winter-hardy agaves in Hungarian collection

In Hungary there are two cactus sociaties, more groups and about 500 cactus collectors all over the country. The collectors found a collection consist of a specialized group of succulent plant, one genus or one type of succulence or collect everything which is pleased. There are less than 10 collectors keep only agaves and similarly there are fewer rock garden where growing winter-hardy agave without any protection. In *Table 1*, there are listed cactus collectors with growing agave species and conditions of keeping. The table is based upon collection of facts namely more than 400 questionaries would be posted and the collectors gave information about winter-hardy and frost resistant cacti and agaves; and own experience as well. The last 5 years I visited several succulent collections.

Table 1 Winter-hardy Agave species in Hungary

Note: decorated value 1 – when the plant is not growing but regressing year by year; 2 – intensity of the grow is average; 3 – growing of the plant is spectacular; the species marked bold lettering are flowered.

Site of agave collections	Species	Age of the plants	Deco-ration value
	A. havardiana,	4	2
1 Mátraterenye	***A. neomexicana***	18	3
2 Budakeszi	***A. virginica***	5	3
	A. utahensis ssp. *utahensis,*	3	1
3 Veszprém	*A. utahensis* ssp. *kaibabensis*	5	1
	A. parryi	20	3
	A. havardiana	3	3
4 Balatonalmádi	*A. utahensis* ssp. *utahensis*	3	1
5 Budapest	*A. utahensis* ssp. *kaibabensis*	4	3
	A. inaequidens ssp. *inaequidens*	7	3
	A. utahensis ssp. *kaibabensis*	7	3
	A. utahensis ssp. *utahensis*	3	1
	A. virginica	2	3
6 Érd	*A. parryi*	2	1
	A. havardiana	4	1
	A. utahensis ssp. *kaibabensis*	5	3
	A. utahensis ssp. *utahensis*	5	2
	A. neomexicana	4	3
7 Szigetszentmiklós	*A. parryi*	4	5
8 Szeged	*A. parryi*	2	5

Conclusions

Two years ago as an experiment there was built a rock garden in our area and in the ground we did not mix any organic substances and higrofil matters. So the moisture is running through easier. The plants absorb the water guickly after the rain and the superfluous moisture does not remain around the roots of the plants. It seems this soil has favorable effect to the developing of the plants and its winter-hardiness. On the other side it is good for maintenance working like weeding, too.

To experiences of several collectors those agaves kept under folia were protected against moisture in winter period developed much more intensive and had less damage on the leaves. Other plants without any protection showed the biggest problem after warming up in spring the frost returned, and the soil became wet. The mud splashed on the sprouts by the rain can have negative affect serving favorable conditions for fungal and bacterial attack.

Purchase of these species is complicated. To my opinion those individuals can be kept outside in the garden originating from offsets of a long period winter-hardy plants of collectors. In absence of these sprouts the own winter-hardy agave collection can be built up with long time experiences and full of failures.

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