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MORPHOLOGICAL VARIABILITY OF *H.giganteus* L. AND *H.maximiliani* Sch. POPULATIONS

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SUMMARY

Morphological variability of two *Helianthus* species, *H.giganteus* and *H.maximiliani* (section *Divaricati*), was assessed at the Institute for Field and Vegetable Crops, Novi Sad. Fifteen populations of each species, with five plants per population, and thirty characters for each plant were analyzed. Three *H.giganteus* populations were found to differ morphologically in relation to the typical populations. Population 78 differed in the number of leaves per stem, length of involucral bracts and the length of ray flowers; population 2014 differed in leaf color and width and the angle between lateral veins and the midrib; population 2018 differed in stem color and the dentation of leaf margin. These populations originated from the western boundary of the distributional range of *H.giganteus* where species variability is high, representing specific adaptations that play an important role in the evolution of the species.

Key words: ***Helianthus giganteus, Helianthus maximiliani*, characteristic, morphology, cluster analysis, infraspecific variability**

INTRODUCTION

The systematics of the genus *Helianthus*

According to Takhtajan's phylogenetic system, the genus *Helianthus* belongs to the division *Magnoliophyta*, class *Magnoliopsida*, subclass *Asteridae*, order *Asterales*, family *Asteraceae* Dum. 1822 (*Compositae* Adans. 1763 Fam. 2:103 nom. cons.), (Takhtajan, 1987), subfamily *Asteroideae* (*Tubuliflorae* DC 1836 Prodr. 5: 8), tribe *Heliantheae* Cass. 1815 in Bull. Soc. philom. Paris 173 (Nyárády, 1964).

The genus *Helianthus* includes about 50 species classified into the four sections exclusively confined to North America. The two species investigated in the present study, *H.giganteus* L. 1753. Sp.Pl. 1: 905 and *H.maximiliani* Schrader 1835 Ind. Sem. Hort. Gotting., belong to the section *Divaricati* (Schiling and Heiser, 1981). Four *Helianthus* species, *H.annuus* 1753. Sp. Pl. 1: 904 (cultivated sunflower), *H.tuberosus* L. 1753. Sp. Pl. 1: 905 (Dozet *et al.*, 1993) (cultivated or adventive in ruderal vegetation), *H.pauciflorus* Nutt =*(rigidus)* (Cass.) Desf. 1829.

Cat. Pl. Horti Paris 3: 184, and *H.decapetalus* L. 1753. Sp. Pl.1: 905 (both adventive in ruderal vegetation) are present in the Yugoslav region. *H.pauciflorus = (rigidus)* and *H.decapetalus* are also ornamental plants (Boža, 1979; Merkulov and Boža, 1980). No interspecific forms of *H.giganteus* and *H.maximiliani* were recognized by Heiser (1969). In addition, taxa described in Heiser's earlier papers were treated as synonyms. Judging by the size of the autochthonous distribution ranges of the two species, it is difficult to assume that they are monotypic and that there are no morphological differences among populations. The specific adaptations to various microhabitat conditions can create differences in certain morphological features playing an important role in species evolution (Takhtajan, 1959). Since species populations had been obtained from North America and grown in a nursery in Yugoslavia for almost ten years, one may assume that observed morphological differences among populations of the same species are genetically controlled, therefore, they may deserve to be recognized as distinctive infraspecies taxa.

Our objective was to test the variability and taxonomic importance of 30 morphological characteristics of *Helianthus giganteus* and *H.maximiliani* populations cultivated under the same ecological conditions.

MATERIAL AND METHODS

Wild perennials species *Helianthus giganteus* and *Helianthus maximiliani* orginating in North America were analyzed. Fifteen *H.giganteus* populations (78, 1605, 1617, 1889, 1890, 1896, 1897, 2014, 2015, 2016, 2017, 2018, 2020, 2021, and 2029) and an equal number of populations of *H.maximiliani* (28, 30, 31, 32, 40, 41, 1645, 2007, 2098, 2100, 2115, 2214, 2219, 2226, and 2230) from various localities were evaluated. All populations were grown in wild species nursery of the Institute for Field and Vegetable Crops, Novi Sad, at Rimski Šančevi.

Thirty traits were evaluated according to the International Board of Plant Genetic Resources (IBPGR) descriptors (IBPGR, 1985). These included: branching, type of branching, stem color, waxy stem coating, leaf shape, leaf color, leaf base, angle of lateral veins, leaf dentation, regularity of leaf dentation, head base, shape of ray flowers, bract shape, plant height, leaf number, leaf petiole length, leaf blade length, leaf blade width, receptacle diameter, achene number, number of ray flowers, length of ray flowers, length of disk flowers, length of corolla of disk flowers, bract length, bract width, pollen viability, percentage of fertilization in self-pollination, and in open-pollination. Pollen viability was determined after Alexander (1969).

The COSTAT statistical program was used to describe the variability of quantitative traits, descriptive statistics and variance analysis. All traits were analyzed by cluster analysis using the CLUSTER program modules of SYSTAT to produce dendrograms for the individual traits, traits groups, traits of the individual sunflower species and both species together.

RESULTS AND DISCUSSION

Within the species *H.giganteus*, a number of infraspecific taxa have been described (Farwell, 1916, 1927; Britton, 1898; Paettie, 1926; Long, 1954; Lakela, 1947). Heiser (1969) however, included these infraspecific taxa as synonyms. A review of these taxa, accompanied by original descriptions, is presented below in order to compare differential characteristics of population 78 with the characteristics used in describing the other *H.giganteus* populations.

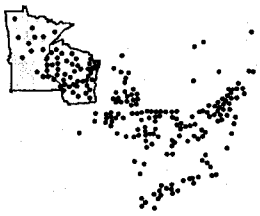

Figure 1: H.giganteus distribution area range (solid dots).

- ***Helianthus giganteus* L.** var. ***virgatus*** (Pers.) Farw. 1916, Mich. Acad. Sci. 17:180.

"Stem slender, simple, 4 feet or less high, terminated by a single head with one or two additional in the axils of as many of the uppermost leaves; leaves opposite, except the uppermost, very thin and delicate, lanceolate, coarsely serrate, green, nearly of the same hue of green on both faces; pubescence copious on the upper parts, much as in the species but *white* not rusty." (Farwell, 1916).

- ***Helianthus giganteus*** L. var. ***subtuberosus*** (Bourgeau) Britton, in Britt. & Brown, Ill . Fl. N. St. and Can. 3: 425, 1898.

"Fleshy roots, thick and edible. Leaves thick, more or less serrate, all or all but the upper ones distinctly petiolated, sometimes all opposite, 2½'-5' long, acuminate at the apex, mostly narrowed at the base, the petioles ciliate; heads not very numerous; bracts of the involucre lanceolate, acuminate, densely pubescent and white-ciliate, about 8" long; rays 1'-1¾' long." (Britton, 1898).

- ***Helianthus giganteus*** L. *var.* ***altissimus*** (L.) Farw. 1916, Rept. Mich. Acad. Sci. 17:180.

"Like the species but glabrous and glaucous on the stem, the branches and peduncles sparsely appressed hirsute; the tips of the chaff in this variety are not black as in the species." (Farwell, 1916).

- ***Helianthus giganteus*** L. var. ***oppositifolius*** Farw. 1916, Rept. Mich. Acad. Sci. 17:180.

"Stems three feet or under; leaves mainly opposite, some conduplicate, firm, narrowly lanceolate, acuminate at both ends, 4 or 5 inches long or less, bluish green, paler below; heads few, sometimes only one, when more, terminating axillary branches, forming a simple 3-6-flowered corymb; pubescence appressed, only on the uppermost parts." (Farwell, 1916).

- ***Helianthus giganteus*** L. var. ***resiniferus*** Farw. 1927, Amer. Midl. Nat. 10:218.

"The lower surfaces of the leaves are copiously covered with large, yellow, resinous globules." (Farwell, 1927).

- ***Helianthus giganteus*** L. var. ***microcephalus*** (Peattie, 1926), Amer. Midl. Nat. 10:131.

"Foliis vix 1.5 cm latis, integris vel sparse sinuatis, inferne pallidis; caulis tenuis; capibitus parvulis; pedunculis tenubius, bracteis brevioribus; radiis brevioribus, tenuioribus." (Peattie, 1926).

- ***Helianthus giganteus*** L. ssp. ***alienus*** (Watson) Long.1954, Rhod. 56:201.

"Leaves with petioles, commonly 0.8-1.2 cm long; undersurfaces usually with rather abundant, spreading hairs; phyllaries short-ciliate, surfaces generally short pubescent." (Long, 1954).

- ***Helianthus giganteus*** L. var. ***verticillatus*** Farw. 1927. Amer. Midl. Nat. 10:219.

"The leaves on the upper part of the stem are arranged in whorls." (Farwell, 1927).

- ***Helianthus giganteus*** L. var. ***subtuberosus*** *f.* ***verticillatus,*** Lak.1947, Rhod. 49:21.

"Foliis caulinis medianis verticillatis." (Lakela, 1947).

Most of the characteristics mentioned above were used in analyzing the populations in our study. Population 78 of *H.giganteus* originating from the western edge of its distributional range differs from other *H.giganteus* populations in number of leaves, bract length, and length of ray flowers. Numerical values for these characteristics were closer to those of *H.maximiliani* (Table 1).

Table 1: Number of leaves, bract length, and ray flower length for population 78 of *H.giganteus* and *H.maximiliani*

Population or species	Leaf number			Bract length			Ray flower length		
	Min	Max	X	Min	Max	X	Min	Max	X
					cm				
78	33	47	39	1.09	1.24	1.16	3.22	3.57	3.43
H.giganteus	33	179	69	1.04	2.38	1.58	1.30	3.98	2.52
H.maximiliani	24	63	40	0.74	1.98	1.35	2.53	4.57	3.31

Minimum, maximum, and mean.

A dendrogram of all analyzed traits showed that *H.giganteus* populations 78 and 2018 were separated forming a single group (Figure 2). A separate position for population 2018 is due to its differences in taxonomically less important characters like stem color, and in part leaf margin dentation.

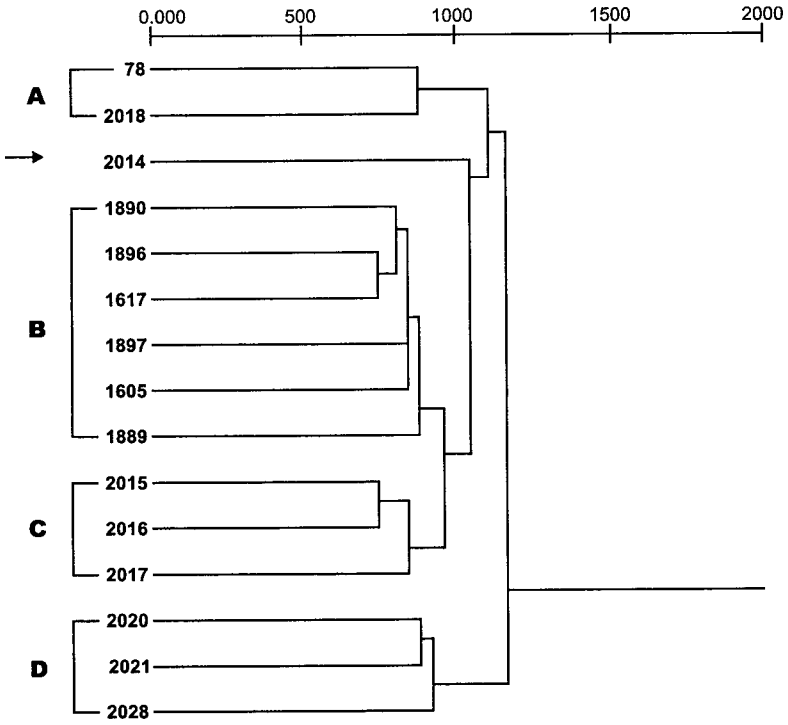

Figure 2: United dendrogram of H.giganteus populations.

H.giganteus population 2014 is also distinguished from the remaining populations due to its deviations in leaf color and width and angle of lateral venation vs. main vein.

A comparative united dendrogram of all populations of *H.giganteus* and *H.maximiliani* clearly showed that *H.giganteus* populations 78, 2014, and 2018 were more closely related to *H.maximiliani* populations (Figure 3).

Population 78 significantly deviated from the other *H.giganteus* populations in the characteristics mentioned above (number of leaves, bract length and ray flower length), which may be considered as taxonomically significant.

Only in the description of the taxon *H.giganteus* var. *microcephalus* (Paettie, 1926) described earlier are involucral leaves "bractei brevioribus" mentioned. Taking into consideration its small heads, shorter bracts are expected.

The environmental-ecological conditions at the Rimski Šančevi locality differ from the original habitats, but were the same for all populations analyzed in this study.

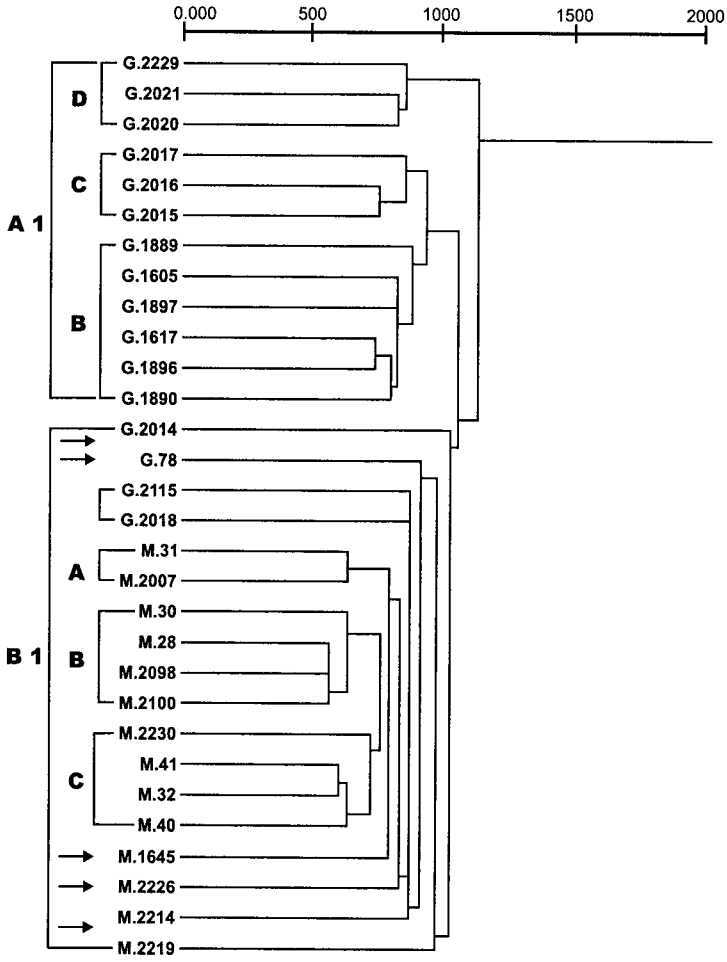

Figure 3: United dendrogram of H.giganteus and H.maximiliani population traits.

Separation of populations 78, 2014 and 2018 from other *H.giganteus* populations sympatric with approaching *H.maximiliani* populations may be explained by the higher variability of the peripheral populations within the species distributional range (Mayr, 1970). Populations 2014 and 2018 originated from Wisconsin, and population 78 from Minnesota, from the westernmost part of the distributional range of the species (Figure 1 - Solid dots in the shaded area).

In any case, it seems justifiable to raise a question whether the species *H.giganteus* and *H.maximiliani*, are monotypical in their entire distributional range, as claimed by Heiser (1969), or, perhaps, Britton (1898), Farwell (1916, 1927), Peattie (1926) and Labela (1947) were taxonomically justified to separate infraspecific taxa (varieties or forms).

Further investigations are needed including similar analyses of the populations in their natural habitats or analyses of the same traits of new generations produced from seed in the wild species collection at the Institute of Field and Vegetable Crops, Rimski Šančevi. Modern molecular genetic methods (RAPD, RFLP, etc.) should be used for defining the new infraspecific taxon.

CONCLUSIONS

Analyzing 30 characteristics of 15 populations each of *H.giganteus* and *H.maximiliani*, we concluded that the three populations of *H.giganteus* are closer to the populations of *H.maximiliani*.

The Wisconsin *H.giganteus* population 2014 (western edge of its distributional range) may be distinguished from the remaining populations by its leaf blade width and angle of lateral veins, while the Wisconsin population 2018 was distinguished by stem color and in part by the dentation of the leaf margin. In our opinion, these traits are taxonomically less important.

The Minnesota *H.giganteus* population 78 (also western edge of the species distributional range) is closer to *H.maximiliani* populations in number of leaves, involucral bract length, and length of ray flowers. Deviations of these traits from those of other *H.giganteus* populations are statistically significant.

Deviations of *H.giganteus* populations 78, 2014, and 2018 from others may be explained by higher trait variability of plants occurring at the periphery of their distributional range.

Higher variability may be due to special adaptations that are important in species evolution.

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VARIABILIDAD MORFOLÓGICA DE LAS POBLACIONES *H.giganteus* L. Y *H.maximiliani* Sch.

RESUMEN

La variabilidad morfológica de dos especies del género *Helianthus*, *H.giganteus* y *H.maximiliani* (sección *Divaricati*), ha sido estudiada en el Instituto Cientifico para el cultivo del campo y de verduras en Novi Sad. Fueron analizadas quince poblaciones de cada especie, cinco plantas por población y treinta caracteristicas por planta. Tres poblaciones de *H.giganteus* se diferenciaban morfológicamente de las poblaciones tipicas. La población 78 se distinguia por el número de hojas al tallo, la largura de brácteas involucradas y flores lingüiformes; la población 2014 se distinguia por el color y la anchura de hoja y por el ángulo entre el nervio central y los nervios laterales de hoja; la población 2018 se distinguia por el color de tallo y el tipo de dentado al borde de hoja. Estas poblaciones provienen de la área situada al limite occidental de extensión de la especie *H.giganteus*, donde la alta variabilidad de especie representa la adaptación especifica que tiene un papel importante en la evolución de esa especie.

VARIABILITÉ MORPHOLOGIQUE DES POPULATIONS *H.giganteus* L. ET *H.maximiliani* Sch.

RÉSUMÉ

La variabilité morphologique de deux espèces de la famille *Helianthus*, *H.giganteus* et *H.maximiliani* (section *Divaricati*) a été observée à l'Institut scientifique d'Agriculture et d'Horticulture de Novi Sad. Quinze populations de chaque espèce, cinq plantes par population et trente caractéristiques par plante ont été analysées. On a constaté que trois populations de *H.giganteus* avaient une morphologie différente de celle des populations typiques. La population 78 était différente par le nombre de feuilles sur la tige, la longueur des involucres et la longueur des fleurs linguiformes; la population 2014 était différente par la couleur et la largeur des feuilles et par l'angle entre la nervure centrale et la nervure latérale de la feuille; la population 2018 était différente par la couleur de la tige et le type de dentelure de la feuille. Ces populations sont originaires de la région qui se trouve à la limite occidentale du domaine de distribution de l'*H.giganteus* où une grande variabilité est signe d'une adaptation spécifique jouant un rôle important dans l'évolution de l'espèce.