HELIA, **16**, Nr. 18, p.p. 41-48 (1993)

GENETIC SIMILARITY OF THE JERUSALEM ARTICHOKE POPULATIONS (*Helianthus tuberosus* L.) COLLECTED IN MONTENEGRO

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SUMMARY

Sixty-three *Helianthus tuberosus* L. populations collected in Montenegro were analyzed for thirty-one morphological characteristics. The data obtained were grouped in two clusters, in accordance with their morphological characteristics which indicated obvious differences in origin. One of the clusters was further subdivided into groups which gathered populations collected in a close geographic proximity. It was concluded that the Jerusalem artichoke populations collected in Montenegro displayed a high interspecific variability which makes them valuable for breeding programs.

Key words: Sunflower, *Helianthus tuberosus* L., multivariate analysis, Montenegro.

INTRODUCTION

Helianthus tuberosus L. is a wild species which has been studied intensively on account of its resistance to diseases. Because of a high variability, this species may also serve for widening the genetic basis of the cultivated sunflower which, in turn, may increase heterotic effects during crossing.

At the time when an epiphytotic of *Diaporthe (Phomopsis) helianthi* Munt-Cvet. struck Yugoslavia, sources of resistance to the disease were found in some wild species (Ćuk, 1982). Of five thousand lines tested (Škorić, 1986), only four were highly tolerant to *Phomopsis*. Two of these had *Helianthus tuberosus* L. in their parentage. *Helianthus tuberosus* L. turned out a most prospective species for sunflower breeding for disease and pest resistance (Škorić and Vannozzi, 1984).

When the Yugoslav Bank of Plant Genes (BBGJ) was established in 1989, it included oil crops and, within them, the genus *Helianthus*. A plan of activities on the forming of the bank included a collecting trip for *Helianthus tuberosus* L. populations on the territory of Yugoslavia. In the period September 6-13, 1990, populations of this species were collected in Montenegro. This trip was a part of a larger research project.

The objective of this paper was to establish the variability present within the collected populations and to group the collected materials on the basis of a multivariate analysis of biological characteristics.

MATERIAL AND METHODS

Sixty-three *Helianthus tuberosus* L. populations were analyzed. Rhizomes of these populations were collected by Marinković and Dozet in 1990.

The collected material was hand sown in March 1991 at the quarantine plot of the experiment field of the Oil Crops Department of the Institute of Field and Vegetable Crops at Rimski Šančevi. Since the analyzed species is a noxious weed, the bed in which the samples were sown was lined with PVC foil to the depth of one meter in order to prevent the expansion of rhizomes and mixing of populations. Conventional cultural practices and irrigation were applied in the plot.

Helianthus tuberosus L. had been cultivated by American Indians before the arrival of Europeans. Together with *Helianthus annuus*, *H. tuberosus* is considered a cultivated species, although it also grows wild in central and eastern U.S. and Canada. In Yugoslavia, it is particularly frequent in the coastal part of the Adriatic sea, and it may be found in the continental part of Montenegro, southern Serbia, and the Vojvodina Province. Its chromosome number is 2n=102. It is an extremely variable species regarding the period of flowering since it flowers from August till October. Its rhizomes are exceedingly strong and the tubers well-developed. The latter contain a high portion of inulin-type sugars which are easily fermented into alcohol. The plant is one to three meters high and intensively branched. The leaves are opposite or alternate, oval to lanceolate, deeply serrated, with long petioles. Head diameter ranges from 2 to 8 cm, with 10-20 ray flowers which are about 4 cm long and 1.2 cm wide. The lanceolate bracts with characteristic pubescence either reach or exceed the rim of the upper side of the head. The seeds are 3-4 cm long.

The collected samples were analyzed for 31 morphological characteristics which are presented in Table 1.

Table 1 - The analyzed morphological characteristics of *Helianthus tuberosus* L.

1. Leaf size (very small=1, small=2, intermediate=5, large=7, very large=9)
2. Plant height (dwarf=1, very short=2, short=3, short to intermediate=4, intermediate=5, intermediate to tall=6, tall=7, tall to very tall=8, very tall=9)
3. Uniformity of flowering (extreme variability=1, intermediate=5, absolute uniformity=9)
4. Head inclination (0°=1, 45°=2, 90°=3, 135°=4, 180°=5, 225°=6)
5. Head size (small=3, intermediate=5, large=7)
6. Head shape (concave=1, flat=2, convex=3, shapeless=4)
7. Branching (absent=0, present=1)
8. Branching type (basal=1, apical=2, full branching with main head=3, full branching without main head=4)
9. Leaf shape (oval=1, lanceolate=2, triangular=3, cordate=4, round=5)
10. Leaf color (light green=1, green=5, dark green=7)
11. Anthocyanin in leaves (absent=0, present=1)
12. Leaf glossiness (absent=0, present=1)
13. Leaf margin (entire=3, intermediate=5, dentate=7)
14. Shape of leaf cross section (concave=3, flat=5, convex=7)

15. Leaf base (acute=1, deltoid=3, cordate=5, auriculate=7)
16. Angle of lateral nerves of the leaf (acute=3, right or almost right=5, obtuse=7)
17. Height of leaf tip in relation to the petiole (very short=1, short=3, intermediate=5, high=7, very high=9)
18. Petiole (absent=0, very short=1, intermediate=5, very long=9)
19. Pubescence of stem tip (very low=1, low=3, intermediate=5, high=7, very high=9)
20. Length of internode (short=3, intermediate=5, long=7)
21. Bud openness before flowering (closed=0, open=1)
22. Length of bracts on the bud (cm=0, 1-2cm=1, 2cm=2)
23. Pubescence of bracts (absent=0, sparse=3, intermediate=5, thick=7)
24. Bract shape (convergent=1, parallel edges=2, round=3, undulate=4)
25. Bract size (small=2, intermediate=5, large=7)
26. Length of bract tip (short=3, intermediate=5, long=7)
27. Number of ray flowers (0-10=3, 11-16=1, >16=2)
28. Shape of ray flowers (elongated=1, oval=2, round=3)
29. Color of ray flowers (ivory=1, pale yellow=2, yellow=3, orange=4, purple=5, red=6, multicolored=7)
30. Disk color (yellow=1, red=2, purple=3)
31. Anthocyanin on the stigma (very low=1, low=3, intermediate=5, high=7, very high=9)

Observations and assessments were made at the stage of full flowering (over 75% of plants in flower), in accordance with the IBPGR Sunflower Descriptor (1985).

The analyzed samples consisted of four plants per population. The results obtained were processed by the multivariate analysis, which is used for classifying and grouping

Figure 1. Natural population of Helianthus tuberosus L.

Figure 2. Populations of Helianthus tuberosus L. in quarantine plot

genotypes according to variability. Analytical precision is increased by introducing a large number of qualitative and quantitative parameters, which is enabled by the method of hierarchical cluster analysis. This method is used for testing genetic similarities and differences between populations of different or unknown origin.

Data processing and the construction of dendograms were done using SYSTAT statistical program (1986).

RESULTS

On the basis of the analysis of the 31 characteristics of the 63 *Helianthus tuberosus* populations, a dendogram was made which is presented in Table 4.

Two clusters are visible in the dendogram.

Population no. 25 forms a separate group. It was collected seven meters from the shoreline, at the altitude of 3-4 meters. This population was introduced during the World War II. Its local name is "kartofel".

The second cluster is divided in four subclusters. Populations no. 3, 5, and 60 form separate groups. These were collected in the valley of the Zeta River, at the altitude of about 400 meters. Their origin is unknown and they are not used for any specific purpose.

Figure 3. Helianthus tuberosus L.

The fourth subcluster is again divided in seven sub-subclusters. One of them gathers populations no. 10, 15, 36, 45, 58, and 63. Populations no. 10, 45, and 63, collected in Ulcinj, Krupac, and Danilovgrad, respectively, prefer small altitude and the proximity of running water. Populations no. 36 and 58 were collected in the vicinity of Nikšić, as volunteers in a garden. Population no. 15 was collected in the vicinity of Budva.

The remaining 53 populations comprise a separate group. Obviously, they are close and derived from the same origin. Sixteen populations form separate subclusters.

Populations no. 2, 6, and 55 form a separate group. Population no. 2 was collected in the vicinity of Podgorica, population no. 6 between Podgorica and Ulcinj, population no. 55 in the vicinity of Nikšić. The second population was introduced from Australia some ten years ago, the third population was transferred from Podgorica. Their common origin is evident.

Populations 33, 41, 46, 47, and 54 form a separate subcluster. Population no. 33 was collected near the coast (Igalo), the other populations in the vicinity of Podgorica.

Population 4, 20, 23, 29, 30, and 32 form a separate subcluster. All of them were collected near the coast, at low altitudes, and it seems that they were introduced about forty years ago.

Population no. 1, collected in the vicinity of Podgorica and brought from Belgrade, is close to population no. 39, collected in a garden near Nikšić and brought there with a truckload of earth for ground levelling.

Populations no. 1 and 2, in spite of a proximity of the collection sites, seem to have completely different origins. The former was brought from Belgrade, the latter probably from Australia. Also, populations 5 and 6 obviously belong to distant clusters although their collection sites were only a few kilometers away from each other and although they have the same local name (Russian potato).

DISCUSSION

The analyzed population were grouped in two clusters, in accordance with the differences established between them in morphological characteristics and origin. In further analysis, one of the clusters was divided into subclusters which mostly gather populations collected over a small geographic distance. The only exception was population no. 33 which was collected in Igalo and grouped with populations from the vicinity of Podgorica.

In some cases, populations collected in sites several hundred meters apart had to be grouped in distant subclusters. For example, population 2, which probably draws origin from Australia, was collected near population 1 which had been brought from Belgrade. Populations 5 and 6, although they share the same local name, are not of the same origin. The origin of the former population was not established and it was grouped in a separate subcluster; the latter population was introduced from Australia about ten years ago. This illustrates the different ways of dispersal of this species.

Most of the collected populations were introduced during and after the World War II, mostly from overseas countries. First they served as food and feed, or decorative and medicinal plants, and later on they turned into weeds. They spread from one garden to another or with the earth for ground levelling. Most populations were found near rivers, lakes, springs, or in gardens, i.e., in places with

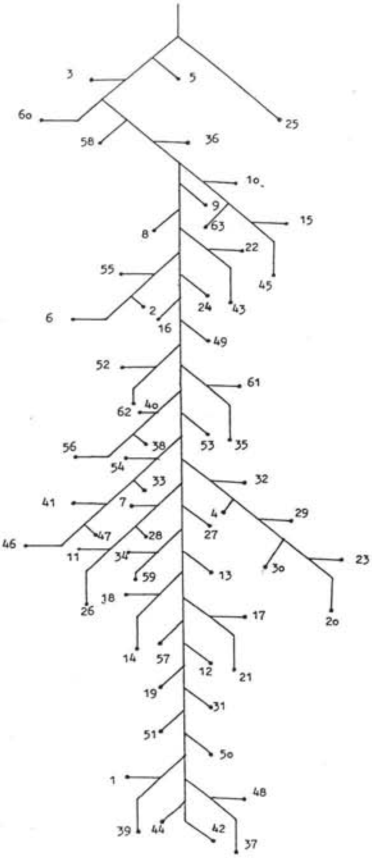

Figure 4. The similarity between different population of Helianthus tuberosus L. which have been collected in Montenegro, based on thirty one morphological traits.

Figure 5. The distribution of populations of Helianthus tuberosus L. in Montenegro.

an abundance of water. Obviously, the analyzed species does not tolerate arid conditions. The finds on the sea shores indicate a high tolerance of some populations of this species to salinity.

Because of a high level of intraspecific variability, the Jerusalem artichoke populations from Montenegro may find application in breeding programs. It is necessary to further study other characteristics of this species, such as the content and type of inulin, presence of genes for resistance to dominant pathogens, and cytogenetic parameters.

The cluster method, a complex mathematical procedure, is widely applicable in biological, taxonomic, and ecological studies, either for determination of genetic similarities and differences between populations of the spontaneous flora (Singh and Jain, 1971), cultivated plants (Veronessi and Facinelli, 1988), or for establishment of genetic diversity between breeding material and natural populations aimed at gaining information about the origin of the former (Moran and Bell, 1987). Murphy et al. (1986) used the cluster analysis to analyze the coefficient of parentage of the American hard red wheats.

This statistical method, besides the applicability in the studies of the degree of variability (Aliaga-Morelli et al., 1987), may be a useful tool for classifying samples in different plant collections, even when data on the origin of the entries are not available (Peeters and Martinelli, 1989).

The hierarchical cluster analysis, which is used for the assessment of mutual relations of samples defined by various parameters, has several advantages over the other cluster methods. First of all, it allows a combining of quantitative and qualitative data, i.e., it allows all available data on a given sample to be considered. Secondly, it gives equal treatment to all individuals analyzed, unlike most of the multivariate techniques which are based on variations present in groups of individuals. Finally, the method is capable of handling a large number of attributes, which is far beyond the capacity of the conventional method.

CONCLUSION

Out of 81 *Helianthus tuberosus* populations collected in Montenegro, 63 were statistically processed. Valuable data were provided by local farmers about the origin, uses, and time of introduction of the collected populations. The results of the cluster analysis go in favor of the hypothesis that there were two major paths of *H. tuberosus* introduction to and distribution in Montenegro. One leads from north towards Podgorica and the valley of the Zeta River, the other from marine ports, along the coast, and inland. The cluster analysis was found a useful tool for differentiating the populations on the basis of their morphological characteristics and origin. The results obtained indicate a relatively high variability among the *H. tuberosus* populations in Montenegro, which may be used in breeding programs to widen the genetic basis of the cultivated sunflower.

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POBLACIÓN (*Helianthus tuberosus L.*) **COLECCIONADA EN MONTENEGRO**

RESUMEN

Sesenta y tres poblaciones de *Helianthus tuberosus* coleccionadas en Montenegro fueron analizadas para treinta y una caracteristicas morfológicas. Los datos obtenidos se agruparon en dos "clusters" de acuerdo con sus caracteristicas morfológicas que indicaban diferencias obvias de origen. Uno de los cluster fue posteriormente subdividido en grupos que clasificaron las poblaciones coleccionadas de acuerdo con proximidad geográfica. Se concluyó que las poblaciones alcaohofa de Jerusalén coleccionadas en Montenegro mostraron una alta variabilidad interespecifica que las hace valiosas para programas de mejora.

SIMILITUDES GÉNÉTIQUES DE POPULATIONS DE TOPINAMBOUR (*Helianthus tuberosus* L.) **COLLECTÉES DANS LE MONTÉNÉGRO**

RÉSUMÉ

Soixante trois populations d'*Helianthus tuberosus* L. collectés dans le Monténégro ont été étudiées par le biais de trente et un caractères morphologiques. Les résultats obtenus ont été regroupés en deux clusters selon leurs caractéristiques morphologiques, indiquant des différences évidentes quant à leurs originoe. Un des clusters a été par la suite subdivisé regroupant des populations collectées dans des lieux géographiquement proches. Nous en avons conclu que les populations de topinabour collectées dans le Monténégro représontent une forte variabilité interspécifique les rendant très intéressantes pour des programmes de sélection.