

## Integrated molecular and morphological characterization of *Daucus* in Tunisia

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**D***aucus carota* L. is a morphologically diverse species found throughout the Mediterranean regions and in many continents worldwide. Despite the genus *Daucus* has been described and revised several times, the taxonomy of *D. carota* L. remains difficult and unresolved. Among Mediterranean regions, Tunisia is considered a center of diversity for *Daucus* and many other crops because of the diverse ecosystems and climatic conditions. A collection of 160 *Daucus* accessions from Tunisia including cultivated carrot (*D. carota* subsp. *sativus*) and wild relatives were morphologically characterized using international descriptors and common taxonomic criteria. Fifty one *D. carota* accessions out of the whole collection were genotyped using Genotyping by sequencing (GBS) technology and compared to a worldwide collection. Morphological characterization showed that fruit characters were efficient to identify different species in the collection whereas leaves, stems, and flowers were required to distinguish among closely related *D. carota* subspecies. The purpose of the present study is to analyze the patterns of phenotypic diversity in a Tunisian *Daucus* collection in order to elucidate the interrelationship between the conserved accessions and to verify the suitability of morphological characterization for species and subspecies identification in our collection. Plant material and methodology: A total of 120 *Daucus* accessions including cultivated carrot (*D. carota* subsp. *sativus*) and wild relatives from different geographic and bioclimatic regions in Tunisia were surveyed and characterized morphologically using 30 qualitative parameters related to vegetative and reproductive parts of the plant. Quantification

of variability for each character was investigated using the standardized Shannon–Weaver diversity index ( $H'$ ). Diversity was established by multiple correspondence analysis and cluster analysis. Findings: The estimated  $H'$  index ranged from monomorphic for umbel type and position of involucre bracts on primary umbel to highly polymorphic for other traits. The highest (0.99) and the lowest (0.24)  $H'$  values were recorded for flowering pattern within plants and foliage coverage traits respectively. Multivariate analysis and cluster analysis permitted the subdivision of the *Daucus* collection into 9 distinct groups supporting traditional taxonomic treatments with a distinction of cultivated carrot from the closely related wild species. Conclusion: Morphological data provide considerable information that is useful to distinguish species and subspecies in the difficult *Daucus* genus. Our results serve as a basis for verification and possible reidentification of *Daucus* accessions in Tunisia and elsewhere.

GBS analysis based on Maximum Likelihood method showed a grouping of the accessions according to their geographic origin. Specifically all Tunisian wild *D. carota* members resolved in a same clade with the immediately adjacent western Libyan and mainland Italian. Comparison of the morphological and molecular results demonstrated concordance of grouping the taxa at specific level, but great discordance of grouping within taxa suggesting that while morphology is useful to group germplasm at the species level, GBS data are required to accurately make identifications at the subspecies level.

**Note :**