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Introductory Chapter: Characterization and Breeding of *Brassica* Germplasm

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1. Introduction

The genus *Brassica* L. belonging to the family Brassicaceae has a vital role in agriculture and populations health [1]. It comprises several species, including major oilseed and vegetable crops of promising agronomic traits [2–5]. *Brassica* species are vital resources of vegetable oil, vegetables, and condiments [6]. *Brassica napus*, *B. rapa*, *B. juncea*, and *B. carinata* provide approximately 12% of the vegetable oil supply worldwide [3, 7]. The oil is utilized for human consumption or as a biofuel or renewable resource in the petrochemical industry. *B. oleracea* comprises a large storage capacity for nutrients and provides a large range of unique cole and cabbage crops used for human consumption [1, 3]. The seed of *Brassica nigra* is used as a condiment mustard. Furthermore, *Brassica* species are vital sources of potassium; dietary fiber; vitamins A, C, and E; phenolics; and other health-enhancing factors [3, 6, 8]. Brassicaceae contains glucosinolates which are broken down to isothiocyanates known to mitigate tumor development and resist a range of heart diseases and human cancers [2, 3, 9]. The plants comprising high amount of glucosinolate may be further utilized as a potential genetic source for breeding [10]. *Brassica* vegetables inhibit major diseases such as Alzheimer's, and some of the functional declines associated with aging [3, 9].

Brassica secondary products have antibacterial, antioxidant, and antiviral effects as well as inducing the immune system and regulating steroid metabolism [2, 3, 9]. Various fungal, bacterial, viral, and insect and pest pathogens, including *Plasmodiophora brassicae* (clubroot), *Peronospora parasitica* (downy mildew), *Ophiosphaerella korrae* (ring spot), *Leptosphaeria maculans* (blackleg), *Fusarium oxysporum* (yellows or fusarium wilt), *Xanthomonas campestris* (black rot),

Brevicoryne brassicae (aphids), *Prodenia* spp. (cut worms), *Pieris rapae* (cabbage worms), and *Delia radicum* (cabbage root fly) infect *Brassica* and crucifers causing harmful diseases and damage [3, 11]. The utilization of pesticides to control these devastated diseases is harmful for human and environment. The issue has led to searching for alternative resources to control these diseases. To close this gap, disease-resistant *Brassica* varieties would be developed in future breeding programs in order to improve their conservation and agricultural production [3]. Hence, attention has been paid to wild *Brassica* genetic resources (repositories of resistance genes) to identify the genes conferring resistance and good agronomic traits including oil content [2, 3, 12–14]. Due to the strong self-incompatibility system, most *Brassica* crops are outbreeders with a high degree of heterozygosity in natural populations and open-pollinated crops [3, 9]. Better methods for characterizing those germplasm collections have also been developed to improve strategies for their biodiversity conservation and utilization in varietal improvement.

2. Genetic characterization of *Brassica* germplasm

Genetic diversity is defined as the variation of individual genotypes within and among species and is the raw material permitting species to adjust to a changing world [2, 3]. Knowledge of the amount and distribution of genetic variability within a species is important for establishing efficient conservation and breeding practices [3], whereas it provides plant breeders with options to develop, through selection and breeding, new and more productive crops that are resistant to diseases and pests and adapted to changing environments. It also provides information for domestication and designing sampling protocols [3]. Therefore, assessing genetic diversity is also essential for providing information for domestication, propagation, and breeding programs as well as conservation of plant genetic resources. Different techniques and markers have been successfully used for characterizing *Brassica* genetic resources [3]. These techniques include morphological, cytological, biochemical, and molecular markers. Physiological, biochemical, and molecular genetic techniques have also successfully applied in different plant species [15–31]. This work highlights the current knowledge of the application of physiological and genetic markers in the genus *Brassica* L. in order to understand its biology, diversity, conservation, and breeding as a basis for further research to develop disease-resistant and more productive crops. Breeding technologies and resistance to abiotic stresses in *Brassica* species are also discussed.

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