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Comparative Evaluation of *Pyrus* Species to Identify Possible Resources of Interest in Pear Breeding

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Abstract: Pear is one of the most important fruit species grown in the temperate zones of the globe. Besides fruit production, pear species are highly valued in forestry and agroforestry systems; in landscaping, as ornamental features; as fruits of ecological value, and in other areas. The *Pyrus* species, obtained from a gene bank, were evaluated for the different morphological traits of the trees, leaves, flowers, and fruits, as well as their responses to attacks from principal diseases and pests. Phenotypic data were examined using correlation and multivariate analyses, and a dendrogram of morphological traits was completed via molecular investigations at the DNA level using the RAPD markers. The findings revealed the complexities of the phenotypic and genetic connections among *Pyrus* species, as well as the difficulty in establishing phylogenetic relationships among pear species. The findings also demonstrated that the wide variability between species with different geographical origins, and their multiple peculiarities of interest, represents a cornerstone as the source of genes of great utility for pear breeding or for utilizing trees for different edible crops and for silvocultural, landscape, or ecological purposes.

Keywords: diseases and pests; gene bank; genetic diversity; genetic relations; morphological diversity; phenotypic correlations; phenotypic traits; tree growth

1. Introduction

Pear (*Pyrus* genre) is one of the oldest and most important economically fruit crops in the temperate zone [1] after apples (*Malus domestica* L.) and before peaches (*Prunus persica* L.) [2,3]. Besides being a significant global source of food, pears have multiple health benefits, including protection against cancer, type 2 diabetes, osteoporosis, inflammatory and acne disorders, skin infections, and so on [4–6]. They also contribute to the reduction in triglycerides and the detoxification of the body [7], the regulation of folic acid levels during pregnancy, and the prevention of congenital abnormalities in newborns [8]. The varied genetic traits of different *Pyrus* species make them useful for various purposes [9], and each part of the tree has multiple uses and medicinal properties [10–14].

Traditionally, people used the bark (rhytidome) and leaves of pears to heal wounds, a property attributed to arbutin [15]. Arbutin is also used in cosmetics, due to its skin-whitening property [16]. Pear wood is very durable, homogeneous, heavy, hard, elastic, light, and is easy to bend and to process [17]. It is one of the more expensive materials used to make high-quality woodwind instruments [16]. In addition, the species of the genus *Pyrus* can also be used for ornamental purposes, for example, in parks and various green spaces and landscapes [18–20]. Trees contribute to enhancing the landscape, eliminate monotony in flatness and color, mask city noise, lower air pollution, support a variety of living organisms, promote and maintain biodiversity, provide a variety of rest and relaxation possibilities, and lessen the negative effects on humans' psychological well-being [21–24].

The identification and description of *Pyrus* species were based for a long time on the traditional morphological characteristics of trees, leaves, flowers, and fruits [25], which in recent decades were supplemented with detailed molecular studies. The genus *Pyrus* comprises only woody plants, most commonly medium-sized trees, and only a few shrubby species [26]. The stem of the tree is straight and well-embedded in the ground. In general, the leaves are simple, arranged alternately, with a length between 2–12 cm and 3–5 cm wide, while petioles are stipulate and have whole or serrated limb edges [27]. Some species have glossy green leaves, whereas others are silvery and densely tomentose, and while most are deciduous, one or two Southeast Asian species show sempervirescent leaves [27]. The tree blooms in April–May, and the flowers are grouped in corymb-type inflorescences from 5 to 20 flowers [28]. The fruits are pomes that often have a pyriform shape and contain sclereids in the pulp. Fruits measure 1–4 cm in diameter in wild species and up to 18 cm long and 8 cm wide in some cultivated forms. The shape of the fruit varies from an elongated pyriform, in the case of European pear species (with a dense, consistent texture that is soft (butter/beurré pears) and juicy when ripe), to a round shape, in the case of Asian pear species, with porous, harder, and firm textures that do not change after harvest [27,29].

At least 22 known species of the genus *Pyrus* exist across the globe, and over 5000 different pear varieties have been described [30,31]. However, it is extremely probable that this number is much higher. In accordance with Hedrick et al. [26], more than 3000 distinct cultivars of the European pear (*P. communis*) were reported before 1921. It is obvious that since then, in over 100 years, modern breeding has produced numerous new cultivars. Excluding European pears, Teng [32] demonstrated that more than 3000 different cultivars of *P. ussuriensis*, *P. pyrifolia*, and *P. singkangensis* have been documented in China. These sources alone reflect a number of at least 6000 cultivars, roughly equally divided between European and Asian pears. The differences between the genotypes and phenotypes of European and Asian species are also reflected in the taste and other organoleptic characteristics of the cultivars and in consumer preferences for European and Asian varieties in Europe, America, Australia, and New Zealand and in Asia, respectively.

Even if there is a significant demand for these 'luxury' fruits, pear production is frequently influenced by the sensitivity of the cultivars to stress factors, especially attacks from diseases and pests [33]. These biotic stressors affect tree development, yield capacity, and fruit quality. Chemicals used to control diseases and pests are expensive and do not always have the desired efficiency. Furthermore, their effects and consequences are detrimental to the environment as well as human and animal health [34–37]. With an increased demand for ecological products in the fruit market and among consumers, pear breeding, similarly to other fruit or agricultural species, aims to develop and promote cultivars that are resistant or tolerant to stress factors [38,39].

Although there are thousands of pear varieties in the world today, and pear breeding is a traditional activity with notable results, many varieties have deficiencies, such as poor resistance to diseases and pests; fruiting alternation; poor fruit quality, including a reduced nutritional value or a low content of useful substances; sensitivity to handling and transport; poor fruit preservation, etc. [29,39]. Although the diversity of cultivars appears to be broad, only a small number of cultivars are widely distributed and cultivated on a large scale. As a result, it is estimated that only approximately ten cultivars comprise 90%

of the world's pear production [27]. In addition, many varieties have a common origin, deriving from common or related parents, which causes a narrowing of genetic variability among pear varieties and, at the same time, results in an increase in the degree of genetic vulnerability of the cultivated species [33].

At present, humanity is facing new challenges, such as global population growth (which has surpassed 8 billion people), climate change, soil erosion and desertification, aridity, salinization, and the appearance of new pathogenic and pest agents alongside an increase in their virulence and resistance to phytosanitary products used to protect orchards, etc. [40]. All of this contributes to growing concerns about the availability of human food resources, including fresh fruits and those necessary for industrialization, as well as compliance with the requirements of sustainable agriculture and the ecological environment [41].

In this regard, the availability of diverse pear varieties that are resistant to diseases and pests is essential for successful production. The identification of genes that provide resistance to disease and insect attacks is an important objective for breeding programs in order to enhance the genetic basis of cultivated pears. Such sources can also be represented by wild *Pyrus* species, although, when utilized in interspecific hybridizations with different varieties, they have the disadvantage of the extremely difficult and time-consuming recovery of the valuable recurrent parent's phenotype [29]. Another issue with species of spontaneous flora is the considerable decrease in the population sizes of wild *Pyrus* species because of the sixth mass extinction [42]. Consequently, the collection and preservation of *Pyrus* species in germplasm pools, as well as their assessment for possible use in pear breeding, are highly desirable goals. As a result, in the current study, certain wild pear species were tested for a set of phenotypic characteristics of interest related to the morphological peculiarities of their trees, leaves, flowers and fruits and their response to diseases and pest attacks, as well as molecular analysis to identify the genetic diversity among them.

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