Tagetes (Asteraceae)

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The genus *Tagetes*, which includes plants known as ‘marigolds’, belongs to the Asteraceae family and contains more than 50 cultivated and wild species. Marigolds are native to America, but several species are naturalised in Africa, Asia, and Europe. Plants of the genus *Tagetes* are amongst the most widespread garden flowers worldwide. Marigolds are popular amongst gardeners due to their easy cultivation, wide adaptability, low demands for ecological and technological factors, and flower production throughout the year.

seed characteristics germination percentage phenological stages morphological traits phylogenetic relationships

1. Introduction

The genus *Tagetes*, which includes plants known as ‘marigolds’, belongs to the Asteraceae family and contains more than 50 cultivated and wild species. Marigolds are native to America, but several species are naturalised in Africa, Asia, and Europe [1][2]. Plants of the genus *Tagetes* are amongst the most widespread garden flowers worldwide. Marigolds are popular amongst gardeners due to their easy cultivation, wide adaptability, low demands for ecological and technological factors, and flower production throughout the year [3].

As ornamental plants, marigolds have several advantages through which they have become particularly appreciated and widely cultivated in the world. These include: their suitability for a large type of cultivation, i.e., for bedding, edges, and pots, but also as cut flowers, bouquets, different floral arrangements, and other applications recognised in social or even religious life; long flowering period extending throughout the summer and fall; easy reproduction by seeds; and the great diversity of varieties within several species of *Tagetes* [3][4][5]. Furthermore, due to their multiple utilities, the short production period of decorative and marketable flowers, a broad spectrum of attractive colour palettes, shapes, and sizes of flowers, and also plant habits, marigolds have become one of the preferred species of many amateur and commercial flower growers [6].

As a crop species, with a short period necessary for cultivation, marigolds can be grown in a multi-crop system, rotated with other crops, or as a mixed crop. In the latest case, cultivated on the borders with other plants can assure beneficial effects in organic agriculture management [7], mainly in the production of important horticultural species, e.g., tomatoes [4]. Due to their bactericidal, nematicidal, fungicide and insecticide action, *Tagetes* species can be used in organic agriculture, especially in the culture of vegetables. Thiophenes, alkaloids, polyacetylenes,

fatty acids, flavonoids and terpenes compounds present in *Tagetes* confer antimicrobial and nematicidal effects, which may be of interest in organic farming. The use of natural or biological origin pesticides has the advantages of low toxicity, efficient control, and reduced cost. In addition, these products do not promote resistance to pests and diseases in agricultural crops [7]. Highlighting the role and importance of *Tagetes* plants in Mexican culture, Tapia-Vázquez et al. [8] note their widespread use as an antioxidant, medicine, food pigment, flavouring, perfume, resin, ornamental and insecticide. Biocidal extracts from roots, stems, leaves, inflorescences, or from the whole plant allow wide use in agriculture as a nematicide, larvicide, attractant or insecticide and as a fertilizer [4][9]. *Tagetes* can be used in crop rotation and, in pest control, can be applied as organic manure to plants or as aqueous extracts and powders [8]. The variation in *Tagetes* cultivars belonging to different species allows the identification of genotypes with resistance or tolerance to saline and drought stresses and other adverse conditions [4][10][11].

2. Application

Marigolds are widely used for industrial and medicinal purposes and also as natural dyes and insecticides or herbicides [4][12][13][14][15]. Due to their importance as medicinal plants in health care and herbal preparations, marigolds are cultivated and produced at an industrial scale, particularly in developing countries from the Far East. In addition, marigolds have received increasing attention in scientific research because of their multiple uses and their phytochemistry and bioactivity importance [6][16]. However, marigolds are extremely appreciated as annual ornamental plants, *Tagetes patula L., T. erecta L.* and *T. tenuifolia Cav.* being amongst the best known and most widespread. In addition to their value as ornamental plants, these three species have diverse and extremely numerous uses and properties, making them very interesting species to be used in marigold breeding works [17].

The species *T. patula* is native to the highlands of Mexico and Argentina but is now widespread throughout the world, known as the French marigold. The date of its introduction into Europe is uncertain, but it was first reported in France around 1880 [18]. The species is also well acclimatised in Romania, where it is widely cultivated in gardens and green spaces. The plants of this species are small, about 40 cm, and have strong branches and elongated leaves (dark green), with pinnate compositions. Their floral heads are small, with thick peduncles, and the flowers are usually hermaphroditic, yellow, orange or a combination of colours. Flowering takes place gradually, starting in July and extending until September.

Tagetes erecta originates from Mexico and was first introduced to Europe in Spain in the 16th century [19][20]. It is known as the African marigold, Aztec marigold, American marigold, or big marigold. The species is well known in Romania. In Mexico, the species can reach up to 1.5 m or more, but the average of the most commonly used varieties is 60–80 cm [21]. Excessive growth often complicates its growth in pots. For this reason, new commercial varieties have a height of only about 25–38 cm [21]. The stems are glabrous or pubescent with green branches and numerous long ribs. The leaves are pinnately compounded. It blooms from July to October. The flower heads are large, with a diameter of 4–7 cm, comprising many individual flowers, usually orange in colour [21]. *Tagetes* erecta has multiple uses as an ornamental plant in decorating green spaces and various floral arrangements and garlands; it is planted in crops as an insect repellent and has use in pharmacy and medicine, industry, and so forth [22]. African marigold meal and extracts are used in poultry feed to colour the skin, meat (fat) and egg yolks and as

colourants in a wide variety of food products [23]. Yellow-orange flowers are sources of great interest in the extraction of natural oils and pigments. Lutein is extracted from flowers, the main pigment used to produce the colour orange, T. erecta being the main source of this pigment for commercial uses [20]. The species can be used as natural air filters or sinks to alleviate air pollution [24]; it also has a strong invasive potential [20] and, from cultivated gardens, can easily migrate into spontaneous flora and spread freely, Romania being recorded as being invaded by the alien flora [25].

The origin of T. tenuifolia is found in America, and it occurs from Mexico throughout Central America to central Colombia [26]; compared to the two previous species, it is less common. It is known as signet marigold, golden marigold or lemon marigold. It has smaller dark green compound leaves and smaller, yellow, orange, golden or multicoloured floral heads. It gradually blooms from June to October [27][28].

Marigold seeds are usually sown directly in the field [29]. The optimal sowing period varies depending on the geographical area. In Romania, this period corresponds to mid-April. Seed germination is influenced by various environmental factors, especially soil temperature and humidity, as well as watering frequency and water quality used. Seed quality is paramount in marigolds to achieve rapid and uniform seedling emergence, avoid gaps in the field and ensure uniform field culture [30].

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