EURASIAN GEOPHYTES

A REVIEW

Editor:
Sibel Day

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(Volume 2)

Eurasian Geophytes: A Review

Edited by

Sibel Day
Department of Field Crops
Faculty of Agriculture
Ankara University
Ankara, Türkiye

Frontiers in Horticulture

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FOREWORD

The book describes several geophytes, their characteristics, and their cultivation. Geophytes have been part of our daily lives since ancient times. They are used as ornamental plants, food, and medicine. The book covers the origin, distribution, morphology, and cultivation of geophytes. Pests and diseases are also described. The chapters are well structured, and several geophytes are described. This information will be useful in these changing climatic conditions.

I congratulate the editor, Dr. Sibel Day, and all the contributors of different chapters for bringing out this publication. I hope that the book will be of great use to students, researchers, scientists, and others interested in geophytes.

Nilgün Bayraktar
Department of Field Crops
Ankara University
Ankara, Türkiye

PREFACE

Geophytes are plants with underground organs that can survive, while their above-ground parts wither after the growing season. These botanical organisms, known for their specialized underground storage organs, display a wide variety of morphological adaptations essential for retaining nutrients, storing water, and surviving in diverse environmental conditions.

While our understanding of geophytes is slowly improving, especially in terms of the evolution of underground traits and the environmental factors affecting their distribution, heightened attention is needed for the scientific exploration of these taxa due to their economic and evolutionary significance.

In this book, we present a collection of 8 chapters written by experts in the field of geophytes. The information presented in this book demonstrates the features of geophytes, cultivation, some important families, and their importance.

I am extremely grateful to all our contributors for accepting the invitation to share their knowledge and research. Their expertise from diverse fields has been invaluable in composing the chapters, and their enduring editorial suggestions have helped to produce this project. I would also like to express my thanks to the Bentham team for their generous cooperation at every stage of the book production.

Sibel Day
Department of Field Crops
Faculty of Agriculture
Ankara University
Ankara, Türkiye

List of Contributors

Burak Tüzün	Department of Crop and Animal Production, Sivas Technical Sciences Vocational School, Sivas Cumhuriyet University, Sivas, Türkiye
Esra Uçar	Department of Crop and Animal Production, Sivas Technical Sciences Vocational School, Sivas Cumhuriyet University, Sivas, Türkiye
Ezgi Oguz	Department of Field Crops, Faculty of Agriculture, Ankara University, Ankara, Türkiye
Gülşen Güçlü	Department of Health Programmes, Health Services Vocational School, Sivas Cumhuriyet University, Sivas, Türkiye
Muhammet Cagri Oguz	Department of Field Crops, Faculty of Agriculture, Ankara University, Ankara, Türkiye
Mustafa Yildiz	Department of Field Crops, Faculty of Agriculture, Ankara University, Ankara, Türkiye
Nilüfer Koçak Şahin	Department of Field Crops, Faculty of Agriculture, Ankara University, Ankara, Türkiye
Sibel Day	Department of Field Crops, Faculty of Agriculture, Ankara University, Ankara, Türkiye

CHAPTER 1

An Overview of Geophytes: Features and Cultivation

Sibel Day[1,*]

[1] *Department of Field Crops, Faculty of Agriculture, Ankara University, Ankara, Türkiye*

Abstract: Geophytes, the specialised stems, are classified as true bulbs, onion bulbs, tubers, corms, and rhizomes. Their scientific exploration heightened attention due to their economic and evolutionary significance. Their morphology and cultivation methods show a wide diversity all over the world. Depending on species and genera, their environmental requirements show differences. Improving cultivation practices and conservation efforts for geophytes is important due to anthropogenic pressure. By recognizing the value of geophytes and implementing effective conservation measures, we can safeguard these botanical treasures for future generations.

Keywords: Bulbs, Corms, Morphology, Production methods, Tubers.

INTRODUCTION

Geophytes are biennial or perennial plants that have organs that can continue to live underground, even though their above-ground organs dry up and die after completing their development during the growing season. These specialised stems have the ability to store nutrients under the soil. The primary function of underground organs is to store nutrients and moisture for growth and to ensure the survival of the species. Geophytes are often referred to as bulbs. Researchers categorise them as true bulbs, onion bulbs, tubers, corms (bulb-like tubers), and rhizomes. However, the term 'bulb' is an appropriate label for all geophytes, regardless of whether they are bulbous, tuberous, or rhizomatous. Therefore, geophytes are commonly known as bulbous plants [1]. Bulbs can be a skin (*Tulipa* spp. and *Narcissus* spp., *etc*.) or without a skin (*Fritillaria* spp. and *Lilium* spp., *etc*.).

[*] **Corresponding author Sibel Day:** Department of Field Crops, Faculty of Agriculture, Ankara University, Ankara, Türkiye; E-mail: day@ankara.edu.tr

Geophytes, botanical organisms renowned for their possession of specialised underground storage organs, exhibit a rich diversity of morphological adaptations that are crucial for nutrient retention, water storage, and survival in varied environmental conditions.

While our understanding of geophytes is gradually advancing, particularly with regard to the evolution of underground traits [1 - 4] and the ecological determinants of their distribution [5 - 7], the scientific exploration of these taxa warrants heightened attention due to their economic and evolutionary significance.

So far, the focus of research on the evolution of geophytes has been mainly on specific taxonomic groups [1 - 3, 5, 8, 9] or geographical regions [6, 7, 10 - 14]. However, comprehensive studies examining the evolution of these traits on a global scale are lacking, hindering a holistic understanding of the evolutionary drivers of geophytism and the diversity of growth forms observed today.

GEOPHYTE MORPHOLOGY: ADAPTATIONS OF UNDERGROUND STORAGE ORGANS

Geophytes, plants with underground storage organs, exhibit diverse morphological adaptations that are essential for survival, growth, and ecological niche. These adaptations are evident in various aspects of their morphology, including storage organs, shoot systems, root systems, reproductive structures, and adaptations to environmental conditions. A comprehensive understanding of geophyte morphology is elucidated through botanical studies, contributing to broader insights into plant evolution, ecology, and horticulture.

Storage Organs

Storage organs such as bulbs, corms, tubers, rhizomes, and tuberous roots (Fig. **1**) are prominent features of geophyte morphology [15]. These organs serve as reservoirs of nutrients and water, facilitating survival during adverse conditions and supporting new growth [16]. The diversity of storage organs reflects the adaptive strategies of geophytes to different environmental niches and climatic conditions [17].

Bulbs

Bulbs, characterised by modified, underground stems covered by succulent scale leaves, have been extensively studied in the botanical literature [16]. The basal plate of bulbs serves as the point of root attachment, while the central axis facilitates shoot emergence, often shielded by protective scale leaves [15].

Notable geophytes associated with bulbs include species such as *Tulipa*, *Narcissus*, and *Lilium* [17].

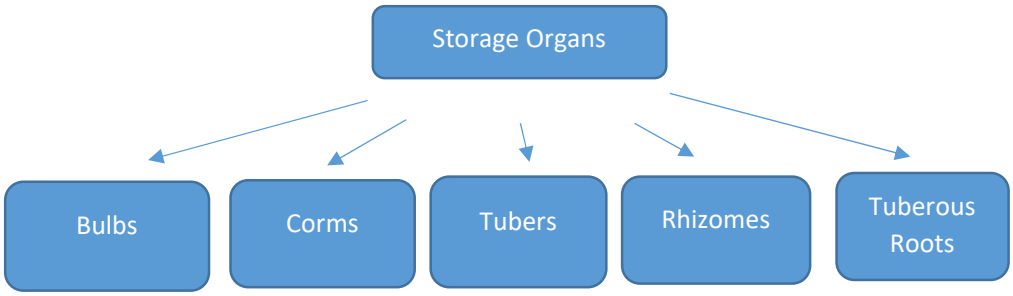

Fig. (1). Storage organs.

Corms

The bulbous tuber (corm) is an enlarged body (basal plate) with scattered nodes and internodes. It is not shaped like onion scales. The basal plate is integrated with many shells and contains spreading root buds. In bulbous tubers, the storage organ is the basal plate. At the top of the bulbous stem is the apical shoot bud, which will later form the leaves and flower shoots. Corms, stout underground stems devoid of fleshy scale leaves, represent another prevalent form of storage organ in geophytes [18]. Surrounded by dry tunics, corms exhibit a solid interior with a centrally located growing point [19]. Botanical investigations have highlighted the significance of corms in species such as *Crocus, Gladiolus,* and *Crocosmia* [15].

Tubers

Tubers, characterised by enlarged underground stems that serve as reservoirs for energy reserves, have been extensively studied in the botanical literature [20]. Tubers, whether of stem or root in origin, have multiple eyes or buds for shoot emergence [21]. Well-known geophytes with tuberous storage organs include *dahlia*, *Solanum tuberosum,* and *cyclamen* [22].

Rhizomes

Rhizomes, horizontal underground stems that facilitate storage and vegetative propagation, have garnered significant attention in botanical research [23]. Rhizomes produce shoots and roots at nodes along their length, showcasing varied morphological adaptations [24]. Botanical studies have elucidated the role of rhizomes in geophytes such as *Iris, Zingiber officinale,* and *Asparagus officinalis* [25].

CHAPTER 2

Araceae

Gülşen Güçlü[1], Burak Tüzün[2,*] and **Esra Uçar[2]**

[1] *Department of Health Programmes, Health Services Vocational School, Sivas Cumhuriyet University, Sivas, Türkiye*

[2] *Department of Crop and Animal Production, Sivas Technical Sciences Vocational School, Sivas Cumhuriyet University, Sivas, Türkiye*

Abstract: The Araceae family comprises a diverse group of plants, the majority of which are found in tropical and subtropical regions. As of yet, 144 genera and 3,645 species have been identified. These plants often exhibit geophytic characteristics, with underground stems such as tubers and rhizomes.

The timing of flowering and fruiting varies among species and climates. Some species flower without leaves at the end of dry seasons, while others follow seasonal precipitation patterns. Although no Araceae species have been reported in true deserts, some, such as *Eminium spiculatum* subsp. *negevense*, are found in dry regions, demonstrating the family's adaptability. Despite the limited research conducted thus far, preliminary studies have indicated the potential anticancer properties of certain Araceae plants, including *Anthurium*, *Philodendron*, and *Dieffenbachia*. However, further research is necessary to confirm their efficacy and safety in cancer treatment.

The use of herbal medicine, which employs a variety of plant parts, has a long history in folk medicine. There is a growing interest in the biological effects of these plants. Phytochemicals derived from traditional medicinal plants, including those from the Araceae family, show promise in disease management, including cancer.

This chapter provides comprehensive information on the geophytic properties of plants in the Araceae family and their activity against cancer.

Keywords: Anticancer, Araceae, Breeding, Geophytes, *In silico* analyses.

INTRODUCTION

The Araceae family is a large family that includes plants with ground cover or climbing characteristics, mostly found in tropical and subtropical regions. There are 144 genera and 3,645 species reported so far [1 - 3]. The characteristic spathe

* **Corresponding author Burak Tüzün:** Department of Crop and Animal Production, Sivas Technical Sciences Vocational School, Sivas Cumhuriyet University, Sivas, Türkiye; E-mail: theburaktuzun@yahoo.com

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and spadix organs of the family member plants allow them to be easily distinguished in nature (Fig. **1**).

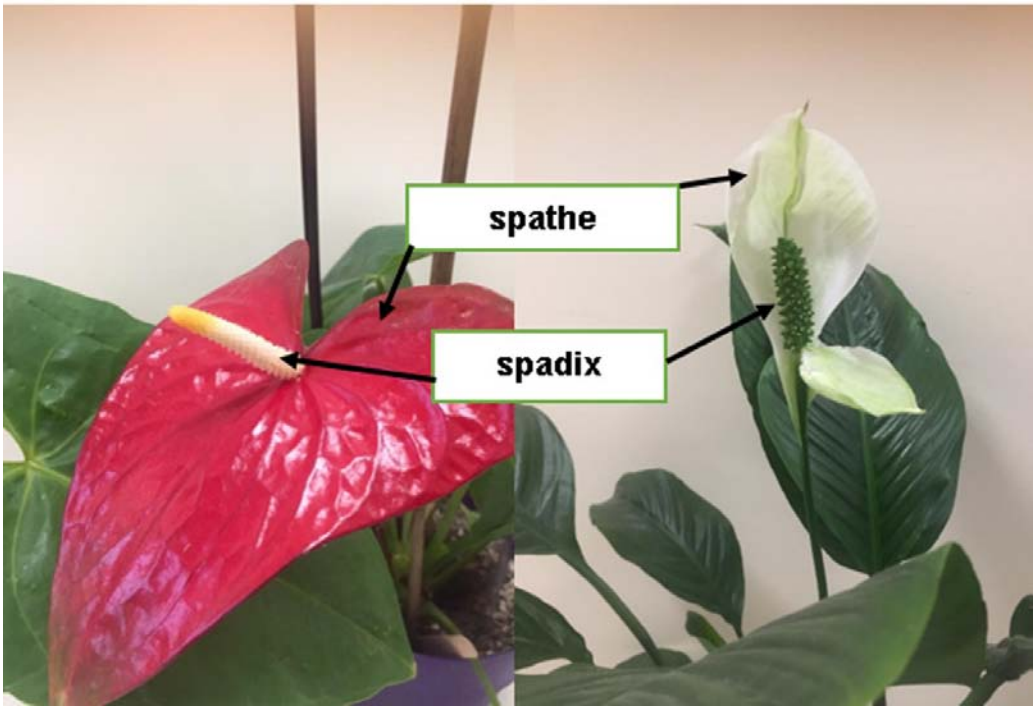

Fig. (1). Spathe and spadix organs in the Araceae family.

Araceae plants are commonly found in tropical humid regions. To a lesser extent, they also grow in temperate regions as halophytes or geophytes [4].

GEOPHYTES IN ARACEAE

Plants with underground stems, such as tubers and rhizomes, are classified as geophytes. In aroids, geophytic species are observed in arid regions or areas with intense winter seasons. However, there are also rainforest geophytes. Despite their climatic disparities, these species (*e.g.*, *Amorphophallus maculatus, Dracontium prancei, and Zomicarpella amazonica*) exhibit growth periodicity and dormancy.

A considerable number of genera are found in more than one climatic regime. In *Stylochaeton*, the rainforest species *S. zenkeri* has evergreen, unthickened roots, and the flower state occurs with the leaves. Other species, for example, *S. natalensis*, grow in regions with a pronounced dry season and are dormant during this period. This species has thick, fleshy roots and usually flowers before or just after the leaves appear. Similarly, the genera *Amorphophallus* and *Dracontium*

exhibit considerable ecological diversity, occurring in rainforests or seasonally in green forests, deciduous forests, savannas, or grasslands (*A. abyssinicus* and *D. margaretae*).

Without leaves, geophytes from deciduous woods, savannas, or unique seasonal grasslands flower, usually at the end of the dry season after the first rains. The rainy season is when fruits and leaves develop.

Different species have different flowering and fruiting times depending on the climate. For instance, *Biarum ditschianum* (Türkiye) flowers in the spring after the end of the rainy season, while *Biarum davisii* (Crete and Türkiye) flowers early in the autumn, and fruit development continues all year long [5]. Native to the Mediterranean region, *Arum* species such as *A. dioscoridis* and *A. italicum* grow during the comparatively warm winter wet season, while *A. maculatum*, which is found further north, grows from spring to late summer and does not grow during the cold winter months [5]. *Arum* species native to the Mediterranean region (*e.g.*, *A. dioscoridis* and *A. italicum*) exhibit growth during the relatively warm winter wet season, whereas the more northerly *A. maculatum* demonstrates growth from spring to late summer and is dormant during the cold winter months [6].

No species of the Araceae family has been reported to occur in true deserts. However, *Eminium spiculatum* subsp. *negevense* has been observed to grow in the Najaf Desert [7]. However, some species are also known to grow in extremely dry areas. Examples of these species are *Arisaema* and *Sauromatum venosum* in the Arabian Peninsula and East Africa, *Arum* and *Eminium* in Central Asia, *Arum* and *Biarum* in North Africa and parts of Asia, and several *Stylochaeton* species in the African Sahel. These areas frequently have annual wet seasons during which the plants grow vegetatively, or they can be found in areas with subterranean water sources. Although it is more frequently found in savannas and evergreen forests, *Zamioculcas zamiifolia* is a succulent plant that can be found in settings with low moisture levels. It stores water in its thick petiole.

Morphogenesis and Flowering in Araceae Plants

Amorphophallus

Amorphophallus is an herbaceous perennial geophyte primarily distributed in Southeast Asia and Africa [8]. It is also a highly valuable economic crop, utilized across various industries such as food, pharmaceuticals, and chemicals, owing to the high content of glucomannan in its underground bulbs [9]. A notable characteristic of this genus is its morphology, characterized by a single leaf

CHAPTER 3

Amaryllidaceae Family

Sibel Day[1,*]

[1] *Department of Field Crops, Faculty of Agriculture, Ankara University, Ankara, Türkiye*

Abstract: The Amaryllidaceae family is significant, as it includes ornamental and medicinal species. The most common genera found in the Mediterranean are *Allium, Galanthus, Leucojum, Narcissus, Pancratium*, and *Sternbergia*. *Allium*, the largest genus in the Amaryllidaceae family, is distributed in the Mediterranean, Asia, Europe, and North America. The genus *Galanthus* comprises 19 species native to Europe and Asia. Both *Allium* and *Galanthus* are rich in alkaloids and are economically important worldwide. In conclusion, this chapter emphasises the importance of cultivating these species and their endemism rate in Türkiye.

Keywords: *Allium*, *Galanthus*, *Leucojum*, *Narcissus*, *Pancratium*, *Sternbergia*.

INTRODUCTION

The Amaryllidaceae family, commonly referred to as the Amaryllis family, is a diverse and economically significant group of flowering plants that includes numerous ornamental and medicinal species. This botanical family is known for its characteristic features, which include showy, trumpet-shaped flowers, typically with six petal-like tepals and a variety of growth habits. Amaryllidaceae is a taxonomically well-defined group of monocots encompassing over 75 genera and approximately 1600 species [1].

The Amaryllidaceae family is indeed present in the Mediterranean region, and it includes several genera and species that are native to or have naturalised in this area. Some of the notable genera within the Amaryllidaceae family found in the Mediterranean are *Allium, Galanthus, Leucojum, Narcissus, Pancratium*, and *Sternbergia*. *Allium* covers a wide variety of plants commonly known as onions, garlic, and chives. These genera are distributed across the Mediterranean region and are known for their culinary, medicinal, and ornamental uses [2].

[*] **Corresponding author Sibel Day:** Department of Field Crops, Faculty of Agriculture, Ankara University, Ankara, Türkiye; E-mail: day@ankara.edu.tr

The Amaryllidaceae family is of considerable economic and ecological importance. Many species within the family are cultivated for their ornamental value. Amaryllis (*Hippeastrum*), daffodils (*Narcissus*), and snowdrops (*Galanthus*) are popular garden plants prized for their striking flowers.

These plants have become horticultural staples. They are grown for both indoor and outdoor decoration. Medicinally, some members of the Amaryllidaceae family are used in traditional medicine. For example, the bulbs of plants like *Crinum* and *Galanthus* contain compounds with potential pharmaceutical applications, including the treatment of Alzheimer's disease, cancer, and neurodegenerative disorders. In addition, several species of Amaryllidaceae produce alkaloids with pesticidal properties [3].

More than 500 alkaloids have been identified and extracted from the Amaryllidaceae family of plants. The alkaloids of the Amaryllidaceae have been structurally classified into nine subgroups, namely lycorine, crinine, haemanthamine, narciclasine, galanthamine, tazettine, homolycorine, montanine, and norbelladine [4].

Ecologically, Amaryllidaceae plants play a role in various ecosystems as a food source for herbivores and pollinators. They can be important nectar sources for insects and are essential for the survival of specific pollinator species.

ALLIUM GENUS

Taxonomy and Properties

Regnum: Plantae

Divisio: Magnoliophyta

Subclassis: Magnoliidae

Familia: Amaryllidaceae

Genus: *Allium*

Allium is the largest genus in the family Amaryllidaceae, involving 1100 accepted taxa and distributed in the Mediterranean, Asia, Europe, and North America [5 - 8]. The Mediterranean region is one of the centres of species diversity of the genus *Allium*. This genus is rich in Türkiye and is represented by 255 taxa in Türkiye, of which 100 are endemic. The endemic taxa found in Türkiye are listed in Table **1**.

Table 1. Endemic taxa found in Türkiye [32].

1	*Allium alpinarii* Özhatay & Kollmann	Endemic
2	*Allium anatolicum* Özhatay & B.Mathew	Endemic
3	*Allium antalyense* Eren, Çinbilgel &Parolly	Endemic
4	*Allium armenum* Boiss. & Kotschy	Endemic
5	*Allium armerioides* Boiss.	Endemic
6	*Allium arzusense* Eker & Koyuncu	Endemic
7	*Allium asperiflorum* Miscz.	Endemic
8	*Allium balansae* Boiss.	Endemic
9	*Allium baytopiorum* Kollmann & Özhatay	Endemic
10	*Allium brevicaule* Boiss. & Balansa	Endemic
11	*Allium cappadocicum* Boiss.	Endemic
12	*Allium circinatum subsp. evae* R.M.Burton	Endemic
13	*Allium colchicifolium* Boiss.	Endemic
14	*Allium czelghauricum* Bordz.	Endemic
15	*Allium deciduum subsp. deciduum*	Endemic
16	*Allium djimilense* Boiss. ex Regel	Endemic
17	*Allium eginense* Freyn	Endemic
18	*Allium elmaliense* Deniz & Sümbül	Endemic
19	*Allium enginii* Özhatay & B.Mathew	Endemic
20	*Allium ertugrulii* Demir. & Uysal	Endemic
21	*Allium fethiyense* Özhatay & B.Mathew	Endemic
22	*Allium flavum subsp. flavum var. minus* Boiss.	Endemic
23	*Allium flavum subsp. tauricum var. pilosum* Kollman & Koyuncu	Endemic
24	*Allium gayi* Boiss.	Endemic
25	*Allium glumaceum* Boiss. & Hausskn.	Endemic
26	*Allium goekyigitii* Ekim, H.Duman & Güner	Endemic
27	*Allium gorumsense* (*Regel*) Boiss.	Endemic
28	*Allium huber-morathii* Kollmann, Özhatay & Koyuncu	Endemic
29	*Allium ilgazense* Özhatay	Endemic
30	*Allium isauricum* Hub.-Mor. & Wendelbo dağ	Endemic
31	*Allium junceum subsp. tridentatum* Kollmann, Özhatay & Koyuncu	Endemic
32	*Allium karamanoglui* Koyuncu & Kollmann	Endemic
33	*Allium kastambulense* Kollmann	Endemic
34	*Allium koenigianum* Grossh.	Endemic

CHAPTER 4

Colchicaceae

Nilüfer Koçak Şahin[1,*]

[1] *Department of Field Crops, Faculty of Agriculture, Ankara University, Ankara, Türkiye*

Abstract: Colchicaceae is a family of angiosperm plants with 16 genera and 161 accepted species, widely distributed in temperate and Mediterranean climates. It has a basal leaf aggregation, reproducing by corms or rhizomes, parallel vein leaves, sessile, petiolate, lamina with stomata, and mesophyll cells with calcium oxalate crystals. *Colchicum* spp. is a non-cyanogenic plant with toxic alkaloids that are active against gout, have anti-inflammatory and anti-cancer properties, and are used in folk medicines. Corms of all species are nutritive due to low alkaloids and high starch/carbohydrates. Colchicine is a pseudocrocus that is biosynthetically extracted through condensation of tyrosine and phenylalanine to a phenethylisoquinoline precursor. Gloriosa is a perennial climbing tuberous herb that grows in tropical, sub-tropical areas and Himalayan foothills. It is used to extract colchicine and to treat cancer neuralgic pains, rheumatism, and other diseases. It is also used in horticulture as a cut and garden flower. Chapter 4 reviews the taxonomy of two species and the general characteristics of the plants in this family.

Keywords: Angiosperm plants, *Colchicum*, *Gloriosa*.

INTRODUCTION

Colchicaceae are a family of angiosperm plants containing 16 genera (Table **1**), 161 accepted species in the genus *Colchicum,* and 11 species in the genus *Gloriosa* (Table **2**) [1 - 5]. The genera *Gloriosa* and *Colchicum* (Çiğdemgiller in Turkish, Sorenjan in Persian, Urdu, and Baluchi) are the two most important groups of plants in this family. This chapter will discuss the Colchicaceae family as a whole, including multiplication agronomy of the genera *Colchicum* and *Gloriosa* spp.

Distribution and Habitat

This family is widely distributed in almost all areas of the world with a temperate or Mediterranean type of climate or pockets in the tropical areas of New Zealand,

* **Corresponding author Nilüfer Koçak Şahin:** Department of Field Crops, Faculty of Agriculture, Ankara University, Ankara, Türkiye; E-mail: nkocak@ankara.edu.tr

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Australia, Africa, Asia, Europe, and North America, with several common seasonal similarities with rain in winter (Figs. **1** and **2**) [2, 8 - 10].

Table 1. Genera of *Colchicaceae* (Desai C. (2016)) [6].

No.	Latin name	English name
1	*Androcymbium*	(Men in a Boat)
2	*Anguillaria*	(Anguillaria)
3	*Burchardia*	(Milkmaids)
4	*Camptorrhiza*	(Camptorrhiza)
5	*Colchicum*	(Naked Lady)
6	*Disporum*	(Fairy Bells)
7	*Gloriosa*	(Glory Lily)
8	*Iphigenia*	(Iphigenia)
9	*Kuntheria*	(Kuntheria)
10	*Littonia*	(Climbing Lily)
11	*Merendera*	(Merendera)
12	*Neodregea*	(Neodregea)
13	*Ornithoglossum*	(Bird's Tongue)
14	*Sandersonia*	(Christmas Bells)
15	*Uvularia*	(Bellwort)
16	*Wurmbea*	(Early Nancy)

Table 2. A list of accepted species in the genus *Colchicum* spp. (Source: https://www.worldfloraonline.org/ accessed date: 20.12.2023) [7].

No.	Species
1	*C. zahnii* Heldr.
2	*C. worsonense* (U.Müll.-Doblies & D.Müll.-Doblies) J.C.Manning & Vinn.
3	*C. woronowii* Bokeriya
4	*C. walteri* (Pedrola, Membrives & J.M.Monts.) J.C.Manning & Vinn.
5	*C. wendelboi* K.Perss.
6	*C. volutare* (Burch.) J.C.Manning & Vinn.
7	*C. villosum* (U.Müll.-Doblies & D.Müll.-Doblies) J.C.Manning & Vinn.
8	*C. variegatum* L.
9	*C. varians* (Freyn & Bornm.) Dyer
10	*C. vanjaarsveldii* (U.Müll.-Doblies, Hähnl., U.U.Müll.-Doblies & D.Müll.-Doblies) J.C.Manning & Vinn.

(Table 2) cont.....

No.	Species
11	*C. undulatum* (U.Müll.-Doblies & D.Müll.-Doblies) J.C.Manning & Vinn.
12	*C. umbrosum* Steven
13	*C. tuviae* Feinbrun
14	*C. turcicum* Janka
15	*C. tunicatum* Feinbrun
16	*C. tulakii* Giannakis, Tsiftsis & Elefth
17	*C. troodi* Kotschy
18	*C. triphyllum* Kunze
19	*C. trigynum* (Steven ex Adams) Stearn
20	*C. szovitsii* Fisch. & C.A.Mey.
21	*C. swazicum* (U.Müll.-Doblies & D.Müll.-Doblies) J.C.Manning & Vinn.
22	*C. striatum* (Hochst. ex A.Rich.) J.C.Manning & Vinn.
23	*C. stirtonii* (U.Müll.-Doblies, Raus, Weiglin & D.Müll.-Doblies) J.C.Manning & Vinn.
24	*C. stevenii* Kunth
25	*C. speciosum* Steven
26	*C. soboliferum* (C.A.Mey.) Stef.
27	*C. sieheanum* Hausskn. ex Stef.
28	*C. sfikasianum* Kit Tan & Iatroú
29	*C. serpentinum* Woronow ex Miscz.
30	*C. schimperianum* (Hochst.) C.Archer
31	*C. schimperi* Janka ex Stef.
32	*C. scabromarginatum* (Schltr. & K.Krause) J.C.Manning & Vinn.
33	*C. roseum* (Engl.) J.C.Manning & Vinn.C. sanguicolle K.Perss.
34	*C. robustum* (Bunge) Stef.
35	*C. ritchii* R.Br.
36	*C. rechingeri* (Greuter) J.C.Manning & Vinn.
37	*C. rausii* K.Perss.
38	*C. raddeanum* (Regel) K.Perss.
39	*C. pusillum* Sieber
40	*C. pulchellum* K.Perss.
41	*C. psammophilum* (Svent.) J.C.Manning & Vinn
42	*C. praeirroratum* (U.Müll.-Doblies & D.Müll.-Doblies) J.C.Manning & Vinn.
43	*C. polyphyllum* Boiss. & Heldr.
44	*C. poeltianum* (U.Müll.-Doblies & D.Müll.-Doblies) J.C.Manning & Vinn.

CHAPTER 5

Iridaceae Family

Sibel Day[1,*]

[1] *Department of Field Crops, Faculty of Agriculture, Ankara University, Ankara, Türkiye*

Abstract: The *Iridaceae* family, with 92 genera, is distributed globally, and the family is more common in the southern hemisphere. The main genera are *gladiolus, iris, sisyrinchium, crocus, romulea, geissorhiza, babiana,* and *hesperantha*. These genera are important for phytochemical extracts and ornamental value. The *Crocus* and *Gladiolus* are mentioned in this chapter. *Crocus* is a genus of plants that grows naturally in a variety of environments. Türkiye has the largest diversity of *Crocus*, with more than 80 different species, but they can also be found in regions ranging from Western Europe and North Western Africa to Western China. *Gladiolus* is currently one of the most significant bulbous ornamental flowers in the world. There are 11 taxa of *Gladiolus* found in Türkiye. Most of the taxa prevailing in nature are in danger of extinction. Identification of these taxa and their cultivation and protection are important for the genetic pool. This chapter underlines the cultivation of *Crocus sativus* and *Gladiolus* cultivation.

Keywords: *Crocus*, Cultivation, Diseases, *Gladiolus*, Morphology, Pests, Saffron.

INTRODUCTION

Iridaceae is a family of plants that includes 92 genera and 1800 species [1]. It belongs to the monocot order Asparagales, and its plants are found in tropical and temperate regions worldwide. The greatest diversity of *Iridaceae* can be found in sub-Saharan Africa, followed by South America, Europe, and temperate regions of Asia [2]. Horticulturally, *Iridaceae* is considered one of the most important plant families. *Crocus* and *Iris* are common in the floral diversity of Eurasia and North America, while *Gladiolus* and *Morea* are major genera of the flora found in Sub-Saharan countries [3]. Though *Iridaceae* plants are distributed globally, the family is more common in the southern hemisphere [4].

The main genera are *gladiolus, iris, sisyrinchium, crocus, romulea, geissorhiza*, *babiana,* and *hesperantha* [5].

* **Corresponding author Sibel Day:** Department of Field Crops, Faculty of Agriculture, Ankara University, Ankara, Türkiye; E-mail:day@ankara.edu.tr

Leaves are usually narrow and sword-shaped, arranged in a two-ranked manner. They can be cylindrical or parallel to the stem. The inflorescences are diverse and range from terminal spikes to groups of flowers arranged in panicles or spikes. Usually, two bracts that resemble spathes subtend these inflorescences [6].

Leaves are typically narrow, ensiform (sword-shaped), and often arranged in a distichous (two-ranked) fashion. They may be unifacial (with the leaf plane parallel to the stem) or terete (cylindrical). Inflorescences are diverse, ranging from terminal spikes to solitary flowers or clusters of flowers arranged in spikes or panicles. These inflorescences are often subtended by two spathe-like bracts [6].

The *Iridaceae* family consists of four subfamilies: Isophysidoideae, Iridoideae, Aristeoideae (also known as Nivenioideae), and Crocoideae (also referred to as Ixioideae). Subfamilies are differentiated based on floral morphology, such as flower arrangement, presence or absence of spathe-like bracts, and ovary position [7].

Members of the Iridaceae family have a worldwide distribution, with a particular concentration of diversity in southern Africa.

Many species in the family, including irises, gladioli, freesias, and crocuses, are important as ornamental plants. This chapter includes two genera: *Crocus* and *Gladiolus*.

CROCUS

Crocus is a genus of plants that grows naturally in a variety of environments, such as scrub, meadows, and woodland. Türkiye is rich in crocus, with over 80 species. However, they can also be found in regions ranging from western Europe and northwest Africa to western China. The diversity found in Türkiye is given in Table **1** with 154 taxa (53 taxa given in Table **1** are endemic). Apart from the triploid *Crocus sativus*, all members of *Crocus* are diploid. *Crocus sativus* is only vegetatively reproduced by corms. Cultivated all over the world, it is the best-known species of the genus. *Crocus sativus* is best known for producing the spice saffron, but other species in the genus have medicinal, food, and ornamental uses [8].

A comprehensive literature review identified 16 *Crocus* species with ethnobotanical and ethnomedicinal uses, largely from Asia and Europe.

Table 1. Crocus taxa prevailing in Türkiye.

-	Taxa	Endemism
1	*C. abantensis* T.Baytop & B.Mathew	endemic
2	*C. abracteolus*	-
3	*C. adamioides*	-
4	*C. adanensis* T.Baytop & B.Mathew	endemic
5	*C. aerius* Herb.	endemic
6	*C. akdagensis*	-
7	*C. akkayaensis*	-
8	*C. ancyrensis* (Herb.) Maw	endemic
9	*C. ancyrensis* subsp. *guneri*	-
10	*C. antalyensioides*	-
11	*C. antalyensis* B.Mathew	-
12	*C. antalyensis* subsp. *antalyensis* B.Mathew	endemic
13	*C. antalyensis* subsp. *gemicii* Şık & Erol	endemic
14	*C. antalyensis* subsp. *striatus* Erol & Koçyiğit	endemic
15	*C. antherotes*	-
16	*C. arizelus*	-
17	*C. asumaniae* B.Mathew & T.Baytop	endemic
18	*C. babadagensis*	-
19	*C. baytopiorum* B.Mathew	endemic
20	*C. berytius*	-
21	*C. bifloriformis*	-
22	*C. biflorus* Mill.	-
23	*C. biflorus* subsp. *adamii* (Gay) B.Mathew	-
24	*C. biflorus* subsp. *albocoronatus* Kernd.	endemic
25	*C. biflorus* subsp. *artvinensis* (Philippov) B.Mathew	endemic
26	*C. biflorus* subsp. *atrospermus* Kernd. & Pasche	endemic
27	*C. biflorus* subsp. *biflorus* Mill.	-
28	*C. biflorus* subsp. *caelestis* Kernd. & Pasche	endemic
29	*C. biflorus* subsp. *caricus* Kernd. & Pasche	endemic
30	*C. biflorus* subsp. *crewei* (Hook.f.) B.Mathew	-
31	*C. biflorus* subsp. *fibroannulatus* Kernd. & Pasche	endemic
32	*C. biflorus* subsp. *ionopharynx* Kernd. & Pasche	endemic
33	*C. biflorus* subsp. *isauricus* (Siehe ex Bowles) B.Mathew	endemic

CHAPTER 6

Liliaceae Family

Sibel Day[1,*]

[1] *Department of Field Crops, Faculty of Agriculture, Ankara University, Ankara, Türkiye*

Abstract: Liliacea family consists of 15 genera, which are distributed in the Northern Hemisphere and Eurasia. *Fritillaria* and Tulip are the most famous genera known all over the world. *Fritillaria* and Tulipa are the most common ornamental plants. *Fritillaria* is also valued for its chemical components and is used in conventional medicine. Protection of the wild genus of Fritillaria and Tulip is important for new germplasm against some of the important pests and diseases of these plants. *Fritillaria* and Tulip cultivation, especially *fritillaria* cultivation and its development, is important to prevent collection from nature. In this chapter, their taxa in Türkiye, as well as their importance and cultivation, are discussed.

Keywords: Cultivation, *Fritillaria*, *Fritillaria imperialis*, Morphology, Tulip.

INTRODUCTION

Liliaceae was initially presented to the scientific community by Antoine Laurent de Jussieu in 1789. The families known as Liriaceae, Tulipaceae, Erythroniaceae, and Fritillariaceae are considered synonyms of Liliaceae [1, 2].

The Liliaceae family consists of 15 genera and 635 species in the Northern Hemisphere and temperate Eurasia. The genera of the family include *Amana*, *Calochortus, Cardiocrinum, Clintonia, Erytronium, Fritillaria, Gagea, Lilium, Medeola, Notholirion, Prosartes, Scoliopus, Streptopus, Tricyrtis*, and *Tulipa* [3].

In Türkiye, the Liliaceae family is used in ethnomedicine for treating abdominal pain, including in infants, as well as abscesses, edema, halitosis, headaches, menstrual pain, rheumatism, skin firming, toothaches, and wounds [4 - 12]. This chapter includes the properties and cultivation of *Fritillaria* and *Tulipa*.

[*] **Corresponding author Sibel Day:** Department of Field Crops, Faculty of Agriculture, Ankara University, Ankara, Türkiye; E-mail: day@ankara.edu.tr

FRITILLARIA

There are 148 accepted species of *Fritillaria* that have been reported. According to reports, the genetic diversity center of the *Fritillaria* genus is located in Iran, where subgenera from central Asia, the Mediterranean, and the Caucasus meet [13]. The genus consists of species that are native to Cyprus, Iran, and Southern Türkiye [14]. The highest number of *Fritillaria* taxa have been reported in Türkiye, with 19 of them being endemic and a total of 46 taxa (Table **1**). Iran has 18 endemic taxa. China, Greece, California, and India have reported 30, 24, 18, and 6 taxa, respectively [15].

Table 1. *Fritillaria* species in Türkiye [22] (www.bizimbitkiler.org.tr.).

1	*Fritillaria ozdemir-elmasii* Yıldırım & Tekşen	Endemic
2	*Fritillaria acmopetala* Boiss.	-
3	*Fritillaria alburyana* Rix	Endemic
4	*Fritillaria alfredae* Post	-
5	*Fritillaria alfredae* subsp. *glaucoviridis* (Turrill) Rix	Endemic
6	*Fritillaria alfredae* subsp. *platyptera* (Sam. ex Rech.f.) Rix	-
7	*Fritillaria assyriaca* Baker	-
8	*Fritillaria assyriaca* subsp. *assyriaca* Baker	-
9	*Fritillaria assyriaca* subsp. *melananthera* Rix	Endemic
10	*Fritillaria aurea* Schott	Endemic
11	*Fritillaria baskilensis* Behcet	Endemic
12	*Fritillaria bithynica* Baker	-
13	*Fritillaria byfieldii* N.Özhatay & Rix	Endemic
14	*Fritillaria carica* Rix	-
15	*Fritillaria caucasica* Adam	-
16	*Fritillaria crassifolia* Boiss. & A. Huet	-
17	*Fritillaria crassifolia* subsp. *crassifolia* Boiss. & A. Huet	Endemic
18	*Fritillaria hakkarensis* (Rix) Tekşen	-
19	*Fritillaria crassifolia* subsp. *kurdica* (Boiss. & Noë) Rix	-
20	*Fritillaria elwesii* Boiss.	-
21	*Fritillaria fleischeriana* Steud. & Hochst. ex Schult. & Schult.f.	Endemic
22	*Fritillaria forbesii* Baker	-
23	*Fritillaria frankiorum* R.Wallis & R.B.Wallis	-
24	*Fritillaria amana* (Rix) Tekşen	-
25	*Fritillaria imperialis* L.	-

(Table 1) cont.....

26	*Fritillaria kittaniae* Sorger	Endemic
27	*Fritillaria latakiensis* Rix	-
28	*Fritillaria latifolia* Willd.	-
29	*Fritillaria michailovskyi* Fomin	Endemic
30	*Fritillaria milasense* Tekşen & Aytaç	Endemic
31	*Fritillaria minima* Rix	Endemic
32	*Fritillaria minuta* Boiss. & Noë	-
33	*Fritillaria mughlae* Tekşen & Aytaç	Endemic
34	*Fritillaria persica* L.	-
35	*Fritillaria pinardii* Boiss.	-
36	*Fritillaria pontica* Wahlenb.	-
37	*Fritillaria serpenticola* (Rix) Tekşen & Aytaç	Endemic
38	*Fritillaria enginiana* (Byfield & Özhatay) Tekşen	Endemic
39	*Fritillaria sibthorpiana* (Sm.) Baker	-
40	*Fritillaria straussii* Bornm.	-
41	*Fritillaria stribrnyi* Velen.	-
42	*Fritillaria uva-vulpis* Rix	-
43	*Fritillaria viridiflora* Post	-
44	*Fritillaria whittallii* Baker	Endemic
45	*Fritillaria wendelboi* (Rix) Tekşen	Endemic
46	*Fritillaria asumaniae* R.Wallis, R.B.Wallis & Özhatay	Endemic

Fritillaria is a significant genus in the Liliaceae family and is valued for its chemical components employed in conventional medicine by various societies, including Türkiye [16], Southeast Asia [17], China, Pakistan, and Japan [18]. The genus is also commonly used in therapeutic plants [19] and floriculture [20]. Moreover, *Fritillaria* is widely consumed globally as both a food source and medication; Native Americans use roasted bulbs of certain species as food. The dried bulbs of certain *Fritillaria* species are used in traditional Turkish, Chinese, and Japanese medicine to treat various ailments, including asthma. Additionally, the bulbs of the plant are employed in traditional medicine to mitigate pain, reduce phlegm, lower fever, relieve coughs, and facilitate detoxification. However, the slow-growing nature of *Fritillaria* plants results in minimal annual growth and medicinal yield, with seed germination to flowering taking as long as 4-5 years. In Türkiye, the combination of *Fritillaria* germplasm resources, habitat degradation, and animal and human intervention has resulted in the overexploitation and severe endangerment of wild *Fritillaria* resources. The collection and destruction of this species are prohibited and are updated annually

CHAPTER 7

Orchidaceae

Ezgi Oguz[1], Muhammet Cagri Oguz[1,*] and **Mustafa Yildiz[1]**

[1] *Department of Field Crops, Faculty of Agriculture, Ankara University, Ankara, Türkiye*

Abstract: The Orchidaceae family is the world's largest family of flowering plants. Species belonging to the Orchidaceae family have great economic importance as ornamental plants and food raw materials. Orchid species grow naturally in Türkiye. Orchid tubers attract great attention, especially in sahlep production. Collecting orchid tubers from nature for sahlep production causes the extinction of the species. For this reason, it is of great importance to increase knowledge and awareness about the cultivation of sahlep orchids. In this section, information is given about the characteristics of orchid species and the species distributed in Türkiye.

Keywords: Orchidaceae, Orchid, Sahlep, Tuber, Vanilla.

INTRODUCTION

The Orchidaceae family consists of approximately 1,000 genera and more than 35,000 plant species worldwide and is the world's largest family of flowering plants [1]. Although the Orchidaceae species is distributed in many regions of the world, it is especially dense in humid and tropical regions.

Species of the family have great economic importance as ornamental plants and food raw materials. Plant materials are collected from nature or cultivated for different uses. Orchid flowers are in high demand as ornamental plants and are widely cultured commercially. Especially *Cypripedium* (lady's slipper), *Epidendrum* (green fly orchid), *Habenaria* (fringe orchid), *Oncidium* (butterfly orchid), *Vanda*, *Vanilla*, and *Odontoglossum* (lady orchid) attract great attention due to the color and structure of their flowers. Besides, the tubers of the *Orchis* species are used to produce sahlep. Sahlep is used as a thickening and flavoring agent in ice creams and beverages. Sahlep orchids are in danger due to their intense and uncontrolled collection from nature. Vanilla (*Vanilla planifolia*) cultivation is of great importance in countries in the Western Hemisphere.

* **Corresponding author Muhammet Cagri Oguz:** Department of Field Crops, Faculty of Agriculture, Ankara University, Ankara, Türkiye; E-mail: m.cagrioguz@gmail.com

Sibel Day (Ed.)

Vanilla is an important product used to add flavor to foods. *V. pompona* and *V. tahitensis* are widely grown for vanilla production. Additionally, leaves of *Calanthe veratrifolia* are used as dye raw materials. Besides, the tubers of *Habenaria susannae* and *Orchis latifolia* are used as food in many regions [2]. Although Orchidaceae species are perennial, they are non-woody plants. Some species are ivy-like. The species of the family include terrestrial, epiphyte, detritus, vine, rhizomes, or tuberous plants. They have annual rhizomes in terrestrial forms and perennial rhizomes in epiphytic species and roots that have turned into pseudo bulbs. While some species bear nutrient-storing tubers, some species have tape roots. The tape roots can benefit from oxygen and moisture in the air. In Orchidaceae species, strong branches form the primary shoot [3]. Branching occurs when one branch develops more strongly than the other. Weaker branches arise laterally and have a bifurcation pattern. This type of branching pattern is called sympodial (sympodialis). On the other hand, some species are plants with monopodial (monopodialis) growth habits. They grow upwards from a single point. Every year, they add leaves to the top, and the trunk grows accordingly. This type of growth is common in orchid genera. Monopodial growing species often develop green roots that hang down in long curtains and are used as additional photosynthetic organs. They have fleshy leaves that are effective in adapting to drought. The stem is generally leafy. They have simple, alternate, sometimes opposite or whorled, usually fleshy, linear to oval leaves covering the base, sometimes reduced to achlorophyllous scales. Leaves may have bract-like sheathed scales. The leaves are rarely hairy. Many species have layers of dead cells called velamen to protect them from water loss and hot conditions. The flowers of Orchidaceae species are usually single, rarely unilateral or bilateral [4]. Some flowers have a bracted structure, erect, symmetrical, with or without a stem. They generally have an epigynous ovary structure. The flowers are in single or double rows, in different numbers, joined together or in a column. The ovary is inferior and has one or rarely three segments. The seed capsule is numerous and small. The plant has three stigmas, and all or only two lateral ones are fertile. The fruit is in capsule form. The seeds are numerous, small, and distinctly winged. Especially in orchids, rostellum functions to encourage foreign pollination if the plant cannot self-fertilize. Rostellum is a tongue-shaped structure that exists between the anther and the pistil tube. If the plant is not pollinated, the rostellum dries out, and the flower can self-pollinate. This structure is one of the protection mechanisms developed by the plant for the continuation of the generation. Orchids are pollinated by bees, butterflies, moths, and insects such as weevils and grain borers [5]. Plants have different floral and scent characteristics to attract insects. Some orchid flowers resemble insects (*Phalaenopsis*, moth orchids), while others are perceived by insects as food or enemies. After the pollinator insect receives the orchid pollen, the pollen is released when it visits another

orchid of the same species [6, 7]. Orchidaceae family species have been divided into five subfamilies based on recent studies [8]: Apostasioideae (two genera, *Neuwiedia* and *Apostasia*), Cypripedioideae (five genera: *Cypripedium*, *Mexipedium*, *Paphiopedilum*, *Phragmipedium,* and *Selenenedium*), Epidendroideae (has 15,000 species in 576 genera), Orchidoideae (7 tribes and 3,630 species; has 2 subclades with tribes *Orchideae* and *Diseaethen;* the other has tribes *Cranichideae*, *Chloraeeae,* and *Diurideae*), and Vanilloideae (15 genera and about 180 species: Pogonieae (77 species) also Vanilleae (with 172 species).

Apostasioideae

Apostasioideae has 15 species and two genera, *Neuwiedia* and *Apostasia* [8]. It is naturally grown in Sri Lanka, India, Nepal, Thailand, Vietnam, Cambodia, southern China, Japan, Malaysia, Indonesia, the Philippines, New Guinea, and northern Australia.

The genus *Neuwiedia* is a primitive terrestrial orchid distributed in the shade habitats of China, Asia, and some Pacific Islands. They are rhizomatous plants with long leaves. They have white and yellow flowers hanging on a branchless upright stem. Although the species of both genera have primitive features, they could be sibling genera to other orchid families [9]. *Apostasia* is commonly called lawn orchids [10]. They are grass-like evergreen plants. They have a star-like structure consisting of small yellow and white flowers on a branched flower stalk. They are naturally distributed in humid regions of China, India, Sri Lanka, and Southeast Asia.

Species of the Apostasioideae family are generally terrestrial plants. It is in the shape of a flake with leaves. The roots are partly stilt-like. It also has rhizomes and can bear capillary roots. The stem structure is upright, simple and with ascending branches. The leaf structure is spiral-shaped. They have leaves of different shapes, from oblong to oval, often curled. Although the leaves are hairless or slightly hairy, they can be herbaceous and slightly thick. The flowers of the Apostasioideae family species are generally bracted, leafy, glabrous, or slightly hairy. The flowers are in cluster form. The clusters with upright, simple, and branched stems bear colorful flowers. Each flower is located at the end of a short or long stem [11].

The flower stalk (pedicel) and the ovary are cylindrical or elliptical. The sepals are similar to each other. The flower parts are attached to the expanded flower receptacle of the stem. The flower basin narrows towards the base. It acts as a thick, fleshy, protruding spine on the outside. Apostasioid orchids have 3 stamens (except Cypripedioideae). However, other orchid subfamilies are single stamens

CHAPTER 8

Zingiberaceae

Muhammet Cagri Oguz[1,*], **Ezgi Oguz**[1] and **Mustafa Yildiz**[1]

[1] *Department of Field Crops, Faculty of Agriculture, Ankara University, Ankara, Türkiye*

Abstract: The Zingiberaceae family has many economically important genera. This family contains agriculturally important spices and medicinal plants. Turmeric, ginger, galangal, and cardamom are among the medicinal and aromatic plants that attract great interest worldwide. Although the Zingiberaceae family has different genera, they have similar structures botanically. There are minor distinctive differences between the species. Differences in flowers, leaves, stems, fruits, and active ingredients are important in distinguishing the species from each other. The most important common feature in the Zingiberaceae family is the rhizome root structure. Especially rhizomes, which are both propagation material and harvest products of cultivated species, have high starch content. Rhizomes are offered to the market as fresh, dried, ground, and oil solutions. This chapter includes botanical and agricultural information about some Zingiberaceae genera that have attracted great attention in recent years.

Keywords: Cardamom, Ginger, Galangal, Turmeric, Zingiberaceae .

INTRODUCTION

Zingiberaceae is a large plant family consisting of approximately 1600 species and 50 genera [1]. Species of the Zingiberaceae family are naturally distributed in the tropical regions of the Southern and Northern Hemispheres [2]. The Zingiberaceae family is of great importance with its wide use as an ornamental plant and medicinal and aromatic properties. *Costaceae* is the closest relative of the Zingiberaceae family [3]. Important species belonging to the Zingiberaceae family include ginger (*Zingiber officinale*), turmeric (*Curcuma longa*), galangal (*Alpinia officinarum*), and cardamom (*Elettaria cardamomum*). Some species, such as *Alpinia* and *Hedychium,* are cultivated as ornamental plants. Ornamental plants include shell gingers, siam or summer tulip (*Curcuma alismatifolia*), ginger lily (*Hedychium spicatum*), *Kaempferia*, torch ginger (*Etlingera elatior*), *Renealmia*, and ginger (*Zingiber*). Especially the rhizomes of *Zingiber officinale* (ginger) and *Curcuma species* (turmeric) are the most consumed important spices in the world market.

* **Corresponding author Muhammet Cagri Oguz:** Department of Field Crops, Faculty of Agriculture, Ankara University, Ankara, Türkiye; E-mail: m.cagrioguz@gmail.com

Sibel Day (Ed.)

The seeds of the *Elettaria cardamomum* and *Aframomum* species plant are of great importance as spices and pharmaceutical compounds. Different plant parts of *Aframomum*, *Alpinia*, *Amomum,* and *Kaempferia* species are used as flavorings in meals. *Hedychium* and *Alpinia galanga* can be used in the perfume industry, and *Curcuma* is used as a coloring agent. *Globba* species, *Curcuma*, *Hedychium*, *Alpinia,* and *Etlingera* genera are cultivated as ornamental plants in tropical and subtropical regions. Besides important features, the Zingiberaceae family contains essential oils. Essential oils containing a wide variety of organic compounds, such as phenylpropanoids, are synthesized in *Zingiber* and *Curcuma* species. The most well-known compound, "curcumin", is found in *Alpinia*, *Curcuma,* and *Zingiber*. In addition, they contain aromatic acids, flavonoids, diterpenes, triterpenes, beta-carotene, lycopene, anthocyanins, and tannins.

General Characteristics of Zingiberaceae Plants

The Zingiberaceae family plants have pseudo-erect stems formed by leaf sheaths. In these species, the main stem stops growing after side branches grow. The main stem develops weaker than the side branches and creates a bifurcated branching pattern (sympodial). This development is generally seen in the Zingiberaceae family. Upright and large shoots are pseudo-stems consisting of arrowroots. The actual stem of the plant is short and thin. Flowers occur at the ends of branched leafy pseudo stems. *Etlingera* and *Alpinia* genera's pseudo stems can grow up to 8 meters in tropical regions.

Zingiberaceae has a few species that have flowers and leaves located on separate shoots. In tropical areas covered with dense vegetation, the plant height is tall and the flowers are close to the ground, while the flowers of plants in open areas are located at the ends of the stems. The leaves under the shoots on the stem are scattered and tufted. Although Zingiberaceae varies according to species, some species are ligule, elliptical, linear or broadly elliptical, hairy or hairless, open or curled leaf, with or without petioles. Petioles are of varying lengths. *Zingiber* is short, fleshy, and plump. Leaf sheaths are usually open, but closed leaf sheaths have also been found in *Roscoea* and *Cautleya* [4]. Blades vary in size; the largest usually develops in the middle of the shoot. They are elliptical in shape, rarely broadly elliptical or linear. Especially in *Alpinieae*, the blades are asymmetrical. During growth, one half of the blade rolls completely around the other [5].

Zingiberaceae flower structure is generally epigyne. The flower tray is sunken inward, and the female organ is located in the sunken part, while the other organs are located on the top. Male and female organs are located in the same plant. The flowers are variable axis (zygomorphic). The calyces are green covering leaves located outside the corolla (crown) and shaped tubular in the flower. The shape

and size of the corolla varies depending on the breed. Corolla has three lobes and a tubular shape. The blooming is usually such that the main axis grows indistinctly. Although it resembles a raceme in appearance, the branches have a definite growth and form the actual raceme (thyrse) [6]. The flowers are arranged in two close rows, each corresponding to a leaf-like formation. Besides, flowers are usually modest and sometimes brightly colored. However, flowering may vary among genera and species. In some genera, the inflorescence is dense and the bracts are tightly overlapped. This type of flower has specialized leaves combined with reproductive structures. This structure, called bracts, is mostly different from green leaves. Bracts can be large, small, and in different colors, shapes, and textures.

In some genera of the Zingiberaceae family, bracts can be extremely large. In these cases, leafy appendages can develop. *Camptandra* and *Pyrgophyllum* are example genera with this condition. In *Curcuma* and *Zingiber* species, bracts form sac-shaped water-holding structures. For this reason, the resulting flower clusters develop continuously embedded in watery mucilage. In *Zingiber*, the development and formation of fruits take place in this viscous liquid substance [7].

The Zingiberaceae family generally has longitudinally opened and inward anthers. Although the lower ovary always appears to have three eyes in the early stages of development, a single ovary actually forms. The division of the pollen main cell is sequential, and the maturing pollen is always binucleated. In the Zingiberaceae family, embryo-sac development is of the polygonum type, and endosperm development is helobial. First, a cell wall forms between two nuclei in the formation of the helobial endosperm. Then, the endosperm develops, with one half extending through the cellular pattern and the other half encompassing the nuclear pattern [8].

The Zingiberaceae family fruit consists of a dry or sometimes fleshy capsule. It can be opened loculicidalally with three valves from top to bottom. The fruit consists of two or more carpels. Although the opening locations of the fruit are important in systematics, they are used to distinguish species [9]. Ripe fruits show a loculicidal opening from the back of each carpel from top to bottom. The number of seeds varies. Seeds are round or nearly round in shape. Seeds of various structures have flat and linear embryo structures that contain starch, are large, and contain abundant perisperm. The seeds are usually compounded in Hedychieae and Zingibereae. Alpinieae seeds, simple small grains with diameters less than 2.5 mm, are formed. While the seeds of Alpinieae do not contain starch, in other species, the perisperm contains large amounts of starch. As a general feature, hypogeal germination is dominant in Zingiberaceae. During germination, cotyledons or storage organs remain underground. The pulumula is pushed

SUBJECT INDEX

Sibel Day

Dr. Sibel Day is a Professor at the Department of Field Crops, Faculty of Agriculture, Ankara University. She received a Ph.D. in Applied Sciences in 2011 from Ankara University. In 2013, she did postdoctoral research at Leibniz University Hannover. She is an expert on the cultivation of industrial crops, particularly in oilseeds and medicinal plants. She is involved in many collaborative research projects. She is a full professor at Ankara University, where she supervises research activities in the field of industrial crops cultivation and breeding and teaches bachelor's and master's students. She is the author/ co-author of more than 45 papers in international refereed journals.