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The Catalogue of Key Plant Species in Semi-natural Grasslands

SMART STEP

Climate-Smart Steps in Grassland Management and Improvement

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AUTHORS

Grasses

Alopecurus pratensis L.	Wróbel, B., Paszkiewicz-Jasińska, A. & Stopa, W.
Anthoxanthum odoratum L.	Gassner-Speckmoser, K., Schaumberger, A., Klingler, A., Graiss, W. & Gaier, L.
Arrhenatherum elatius L.	Mandić V. & Ostojić Andrić D.
Briza media L.	Gassner-Speckmoser, K., Schaumberger, A., Klingler, A., Graiss, W. & Gaier, L.
Bromus inermis L.	Mandić V. & Ostojić Andrić D.
Cynodon dactylon L.	Mut, H., Mut, Z. & Burgu, L.
Cynosurus cristatus L.	Gassner-Speckmoser, K., Schaumberger, A., Klingler, A., Graiss, W. & Gaier, L.
Dactylis glomerata L.	Wróbel, B., Paszkiewicz-Jasińska, A. & Stopa, W.
Festuca arundinacea L.	Mandić V. & Ostojić Andrić D.
Festuca ovina L.	Mandić V. & Ostojić Andrić D.
Festuca pratensis Huds.	Mandić V. & Ostojić Andrić D.
Festuca rubra L.	Mandić V. & Ostojić Andrić D.
Lolium multiflorum Lam.	Mandić V. & Ostojić Andrić D.
Lolium perenne L.	Mut, H., Mut, Z. & Burgu, L.
Phalaris arundinacea L.	Wróbel, B., Paszkiewicz-Jasińska, A. & Stopa, W.
Trisetum flavescens (L.) P.Beauv	Wróbel, B., Paszkiewicz-Jasińska, A. & Stopa, W.

Legumes

Bituminaria bituminosa (L.) C.H. Stirt	Şahin, E.
Hymenocarpus circinnatus L.	Mut, H., Mut, Z. & Burgu, L.
Lotus corniculatus L.	Wróbel, B., Paszkiewicz-Jasińska, A. & Stopa, W.

Medicago lupulina L.	Gassner-Speckmoser, K., Schaumberger, A., Klingler, A., Graiss, W. & Gaier, L.
Medicago polymorpha L.	Galea-Gragera, F.A. & Llera, F.
Onobrychis sativa L.	Mut, H., Mut, Z. & Burgu, L.
Ornithopus compressus L.	Galea-Gragera, F.A. & Llera, F.
Trifolium cherleri L.	Galea-Gragera, F.A. & Llera, F.
Trifolium fragiferum L.	Ayan, İ
Trifolium meneghinianum Clem.	Kumbasar, F.
Trifolium pratense L.	Gassner-Speckmoser, K., Schaumberger, A., Klingler, A., Graiss, W. & Gaier, L.
Trifolium repens L.	Mut, H., Mut, Z. & Burgu, L.
Trifolium subterraneum subsp. Brachycalycinum	Galea-Gragera, F.A. & Llera, F.
Trifolium subterraneum subsp. subterraneum	Galea-Gragera, F.A. & Llera, F.
Herbs	
Achillea millefolium L.	Wróbel, B., Paszkiewicz-Jasińska, A. & Stopa, W.
Centaurea jacea L.	Gassner-Speckmoser, K., Schaumberger, A., Klingler, A., Graiss, W. & Gaier, L.
Cichorium intybus L.	Şahin, M.
Plantago lanceolata L.	Kumbasar, F.

Prepared by the above-mentioned authors in 2026 and edited by Gaier, L. and Temmel, M.

Table of Contents

Alopecurus pratensis L. - Meadow foxtail/field meadow foxtail 6

Anthoxanthum odoratum L. - Sweet Vernal Grass 10

Arrhenatherum elatius L. - False oat-grass 14

Briza media L. - Common Quaking Grass 19

Bromus inermis L. - Smooth brome grass 23

Cynodon dactylon L. – Bermuda Grass 28

Cynosurus cristatus L. - Crested Dog's-tail 33

Dactylis glomerata L. - Cocksfoot 37

Festuca arundinacea L. - Tall fescue 41

Festuca ovina L. - Sheep's-fescue 46

Festuca pratensis Huds. - Meadow fescue 51

Festuca rubra L. - Red fescue 56

Lolium perenne L. – Perennial ryegrass 61

Lolium multiflorum Lam. syn. Lolium italicum A. Braun - Italian ryegrass 66

Phalaris arundinacea L. - Reed canary grass 70

Trisetum flavescens (L.) P. Beauv. - Yellow oatgrass/golden oat grass 74

Bituminaria bituminosa (L.) C.H. Stirt.- Pitch trefoil, Arabian pea or Bitumen trefoil 78

Hymenocarpos circinnatus (L.) Savi – Disk Trefoil 86

Lotus corniculatus L. - Common bird's-foot trefoil 91

Medicago lupulina L. - Black medic, hop clover 95

Medicago polymorpha L. – Burr medic 99

Onobrychis sativa Lam. – Sainfoin 106

Ornithopus compressus L. – Yellow serradella 111

Trifolium cherleri L. – Cupped clover 119

Trifolium fragiferum L.- Strawberry clover 126

Trifolium meneghinianum Clem. – Gelemen Clover 134

Trifolium pratense L. - Red clover 139

Trifolium repens L. – White clover 142

Trifolium subterraneum L. subsp. brachycalycinum – Subterranean clover 147

Trifolium subterraneum L. subsp. subterraneum – Subterranean clover 154

Achillea millefolium L. - Yarrow 162

Centaurea jacea L. - Brown Knapweed 166

Cichorium intybus L. – Chicory 170

Plantago lanceolata L. - Ribwort plantain 176

List of Figures 182

Alopecurus pratensis L. - Meadow foxtail/field meadow foxtail

Systematics

Family: *Poaceae (grasses)*

Subfamily: *Pooideae*

Genus: *Alopecurus*

Botanical Description

Alopecurus pratensis L. (Meadow foxtail, Field meadow foxtail) is a perennial grass 30-150 cm tall. Generative shoots very often exceed 1 m in height. It has short underground runners, 4-5 cm long. The leaves are rolled up in a bud, flat and grooved, without spurs, up to 10 mm wide. The ligule is approx. 4 mm long and wide, evenly cut, short. The culm is straight, sometimes bent at the bottom. The leaf sheaths are open, smooth and adherent.

The inflorescence of this species is a panicle (spikelet-shaped and cylindrical) up to 15 cm long, which is pointed at the end. The spikelets are small (4-6 mm), hairy, set on short panicle branches, usually 4-10 on each. The glumes are partially fused and hairy. The lower glumes are awned. This species flowers from May to July (Włodarczyk, 1984).



Figure 1: Alopecurus pratensis L. - meadow foxtail © Institute of Technology and Life Sciences - National Research Institute

Distribution and Habitat

Meadow foxtail occurs in most European countries except Portugal, North Macedonia, Cyprus and Latvia. In Iceland, the species has been naturalised (Euro+Med (2006+)).

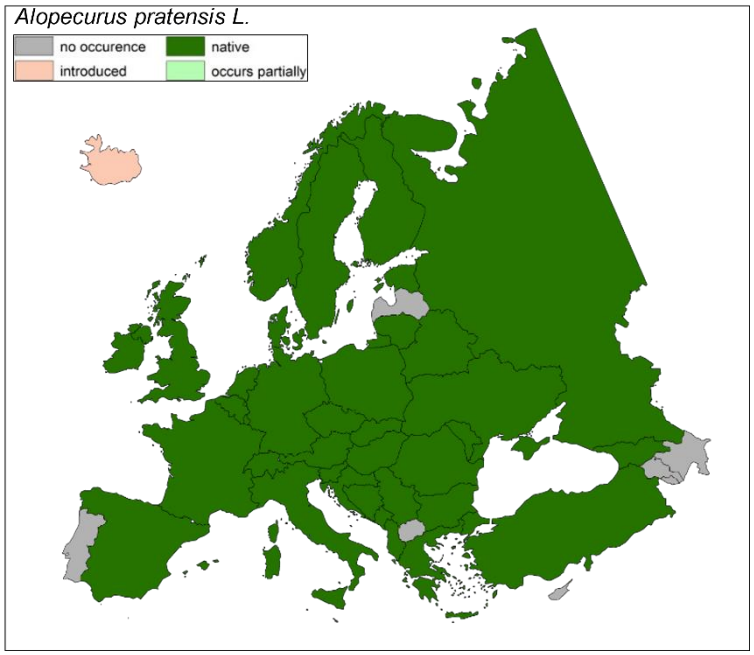


Figure 2:Distribution of Alopecurus pratensis L. in Europe.

This species occurs in fertile and moist grassland habitats. It prefers soils rich in nutrients. It thrives best in wetlands, periodically flooded or irrigated with sewage, where it forms characteristic meadows. Meadow grass occurs on mineral and organic soils in grassland. It is a grass that is very resistant to variable use. Resistant to frost, it can persist in the sward for a long time, even several years (Grzebisz et al., 2014).

Suitability for Agricultural Use

This species is a good source of valuable forage. Meadows with *Alopecurus pratensis L. grass* are often mowed 2-4 times a year, because meadow grass starts growing very early and progresses relatively quickly through the stages of development, and its generative shoots lignify quickly. It is often a highly competitive species, especially on soil fertilised with nitrogen fertilisers. The dry matter yield of meadows dominated by meadow foxtail often reaches around 10 t·ha-1 (Grzebisz et al., 2014). It forms hybrids with *A. aequalis*, *arundinaceus*, *geniculatus* and *myosuroides* (Rutkowski, 2008).

Infobox

Alopecurus pratensis L. (Meadow foxtail, Field meadow foxtail) is a perennial grass 30-150 cm tall. It has short underground runners, 4-5 cm long. The inflorescence of this species is a panicle up to 15 cm long. This species flowers from May to July. Meadow foxtail occurs in fertile and moist grassland habitats. It prefers soils rich in nutrients. It thrives best in wetlands, periodically flooded areas or areas irrigated with sewage. It is a good source of valuable forage. It is often a highly competitive species, especially on land fertilised with nitrogen fertilisers. The dry matter yield of meadows dominated by meadow foxtail often reaches around 10 t ha^{-1}.

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Anthoxanthum odoratum L. - Sweet Vernal Grass

Systematics

Family: Poaceae (grasses)

Subfamily: Pooideae

Tribe: *Poeae*

Genus: *Anthoxanthum*

Botanical Description

The plant reaches a height of 20 - 50 cm and is a tender grass with small, loose tufts (Wagner and Lauber 2001). The inflorescences are attached to branches rather than to the main axis of the asymmetrical inflorescence and there is more than one floret per spikelet. The leaf ligule is 2 - 7 mm long and hairy and the leaves are flat and hairy towards the base. Flowering time extends – depending on altitude – from April to July.

The fruit is a small caryopsis, usually ripening between May and August. Anthoxanthum odoratum seeds have awns that wind and unwind with changes in atmospheric humidity. The movement of seeds by this mechanism is not great, averaging 1.6 cm on dry soil and 1.3 cm on wet soil over a 5-day period, but it may give the seeds a slight advantage in reaching suitable germination sites (Schoenfeld and Chancellor 1983). *Anthoxanthum odoratum* roots are quite shallow, absorbing nutrients mainly from the upper 10 cm of soil (Berendse 1982). On fertilized soils, sweet vernal grass develops a dense surface root mat (Remison and Snaydon 1978).



Figure 3: Flowering Anthoxanthum odoratum (left) and seeds (right) ©AREC Raumberg-Gumpenstein

Distribution and Habitat

Sweet Vernal Grass is native to Europe and temperate parts of Asia. It has become widely naturalized and now has a circumpolar distribution in temperate regions.

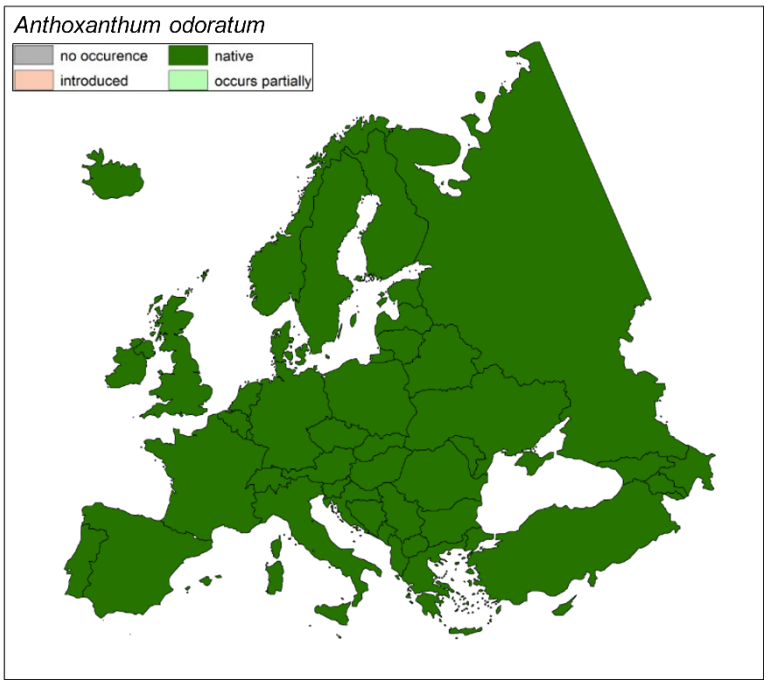


Figure 4: Distribution of Anthoxanthum odoratum L. in EuropeFigure 4: Distribution of Anthoxanthum odoratum L. in EuropeIt is a characteristic species of extensively to moderately used grasslands. It prefers limescale-free soils and acidic conditions (a low pH). The species inhabits almost all fresh to semi-dry, nutrient-poor to slightly nutrient-rich soils, with the exception of coarse rubble and rock. Its content of coumarin and benzoic acid contributes to a typical slightly vanilla-like smell of dried forage.4

Suitability for Agricultural Use

The fodder quality of *Anthoxanthum odoratum* is only moderate; however, due to its persistence, trampling tolerance, and tuft-forming growth, it contributes significantly to sward stability in extensive meadows. Under conditions of rising fertilization or more frequent cutting, A. odoratum tends to decline and may disappear from intensively managed grasslands.

Special ecological features

Anthoxanthum odoratum serves as fodder plant of various butterfly caterpillars.

Infobox

Anthoxanthum odoratum (Sweet Vernal Grass) is a perennial, tuft-forming grass of nutrient-poor to extensive grasslands and pastures. It reaches 20–50 cm in height and has narrow, flat leaves with a short ligule. The characteristic inflorescence is a 0.5–8 cm long asymmetrical panicle. The species is tolerant of trampling and grazing but reacts sensitively to frequent cutting, and is therefore primarily found in extensive, long-established permanent pastures. Agriculturally, it has only moderate fodder value but contributes to the acceptance of dried forages by a typical slightly vanilla-like smell of the dried plant in swards.

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Arrhenatherum elatius L. - False oat-grass

Systematics

Family: Poaceae (grasses)

Subfamily: Pooideae

Tribe: *Poeae*

Genus: *Arrhenatherum*

Botanical Description

A perennial plant that lives for 5–7 years or longer, it has a well-developed fibrous root system that penetrates deeply into the soil. This tall grass features a firm, smooth, upright stem 100–150 cm high. It forms tillers below the ground surface, creating a compact, clump-like turf with few leaves on the stem. The leaves are large, long (15–30 cm), and wide (0.4–1.2 cm), with sparse hairs and no auricles. The ligule is well developed, fringed, and blunt. The inflorescence is a long (over 30 cm), wide panicle. The spikelets contain two flowers: the upper is fertile, the lower is infertile, and the awn is knee-shaped and curved. The seed is yellow-gray, relatively large (8–9 mm long and 1.5–2.0 mm wide), elongated, enclosed by the lemmas and awn, and hairy at the base. There are 300–400 seeds in 1 g (Erić et al., 2016). False oat-grass is shown in Figure 5.



Figure 5: False oat-grass

Distribution and Habitat

False oat-grass is widespread throughout Europe, including Iceland, as well as in northern Africa, North America, and Australia, primarily in moderately warm and humid areas. It belongs to the sub-Central European floral element (Kojić, 1990). Distribution of *Arrhenatherum elatius* in Europe is shown in Figure 6.

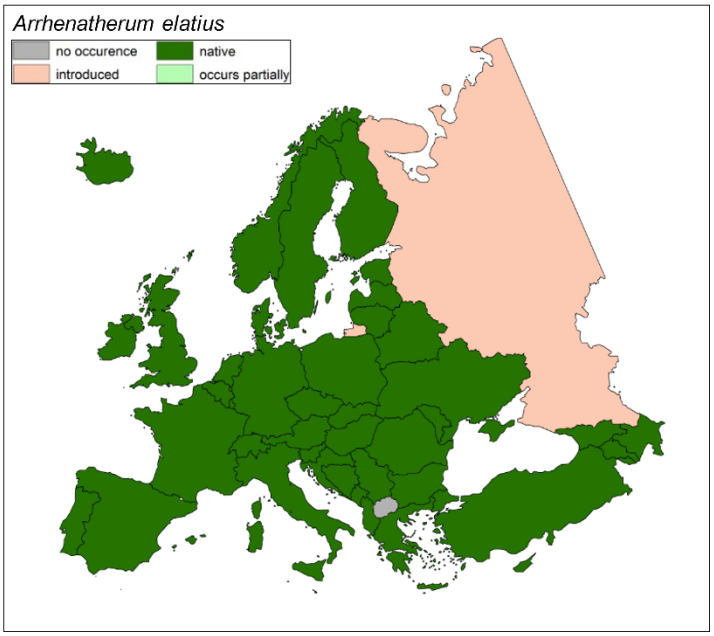


Figure 6: Distribution of Arrhenatherum elatius L. in Europe

This widely distributed species that forms the association *Arrhenatheretum elatioris* Br.-Bl. 1925 sensu lato in valley (plain) grasslands. Meadows of the association *Arrhenatheretum elatioris* are among the most valuable mesophilic meadows in Europe in terms of productivity and floristic composition. Populations of *Arrhenatherum elatius* from Serbia show significant morphological variability and yield potential (Sokolović et al., 2004). The species is most widespread up to 800 m above sea level but can also thrive in mountainous areas up to 2000 m above sea level.

It is highly competitive and resistant to drought and frost. It is best suited to deep, fertile, light to medium-heavy, calcareous, well-aerated soils with a low groundwater level. It is not suitable for peaty, wet, flooded, or acidic soils and is particularly sensitive to high groundwater levels. It responds very well to irrigation (Simić, 2019).

Suitability for Agricultural Use

False oat-grass is one of the earliest plants to appear in grasslands and regenerates quickly after mowing. It does not tolerate intensive grazing or trampling, so under such conditions it is gradually displaced from pastures. The quality index of this species is 8, classifying it as a more valuable meadow grass (Peeters and Dajić, 2006). The green fodder of this plant has a bitter taste due to the presence of amygdalin (Đukić et al., 2004), but when combined with other grassland species, this taste is mitigated and the fodder becomes acceptable for ruminants. It produces good yields of high quality on semi-natural and natural grasslands (Simić, 2019). However, after heading, it quickly loses its nutritional value and fodder quality. It is used in feed mixtures, for mowing and grazing, as well as for greening embankments, roads, and degraded areas, where it contributes to soil stabilization and erosion prevention. It is also used in decorative parks.

Special ecological features

Arrhenatheretum elatioris is an important habitat and food source for the caterpillars of many butterfly species, especially those in the families *Nymphalidae* (subfamily *Satyrinae*) and *Hesperiidae*.

Infobox

Arrhenatherum elatius is a perennial grass in the *Poaceae* family that forms a compact turf and grows up to 150 cm tall. It has a deep, fibrous root system and a well-developed panicle inflorescence. It belongs to the sub-Central European floral element. This species thrives in deep, fertile, well-aerated soils with a low groundwater level. It is the dominant species in valley meadows of the *Arrhenatheretum elatioris* association. Due to its early growth and high biomass production, it is important for mowing and hay production (quality index 8), but it does not tolerate grazing or trampling. After panicle formation, it quickly loses nutritional value.

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Briza media L. - Common Quaking Grass

Systematics

Family: Poaceae (grasses)

Subfamily: Pooideae

Tribe: *Poeae*

Genus: *Briza*

Botanical Description

Briza media has fine stems and distinctive hops-shaped green and purplish spikelets. The inflorescence is a loose, spreading panicle. The plant is a loosely tufted perennial with short rhizomes arising from vegetative shoots. The height reaches from 20 - 50 cm and the leaf cloth has a length of 0,5 - 1 mm (Deutsch, 2007).

The flowering time extends – depending on altitude – from May to July. As the spikelets hang on longs stem they easily shake in the wind and so Briza media is known as 'shaking grass' in some languages (Naturespot.com).

The fruit is a small caryopsis, usually ripening between July and September. Due to air between the caryopses and the husks, the fruits have a very low specific weight and can be dispersed by the wind like balloons. When wet, they can also be dispersed by animals and as rainwater runoff.



Figure 7: Flowering Common Quaking Grass (left) and seeds (right) © AREC Raumberg-Gumpenstein

Distribution and Habitat

The distribution range of *Briza media* extends from the Mediterranean to Scandinavia and from Ireland to Russia. It also extends beyond Turkey to the Caucasus, but is missing in Iceland, Latvia, Montenegro, Cyprus and North Macedonia and as well on the Balearic Islands, Sardiniaand the Aegean Islands.

It is a typical species of unimproved species-rich grassland, grazed calcareous grassland and pasture, old meadows and roadside verges. It´s common from valley areas to subalpine areas. It prefers moderately dry, well-drained soils with neutral to slightly acidic pH. It is an indicator of strong light demand. The species is low tolerant of trampling and grazing and is regarded as an indicator of long-established, low-fertility meadows.

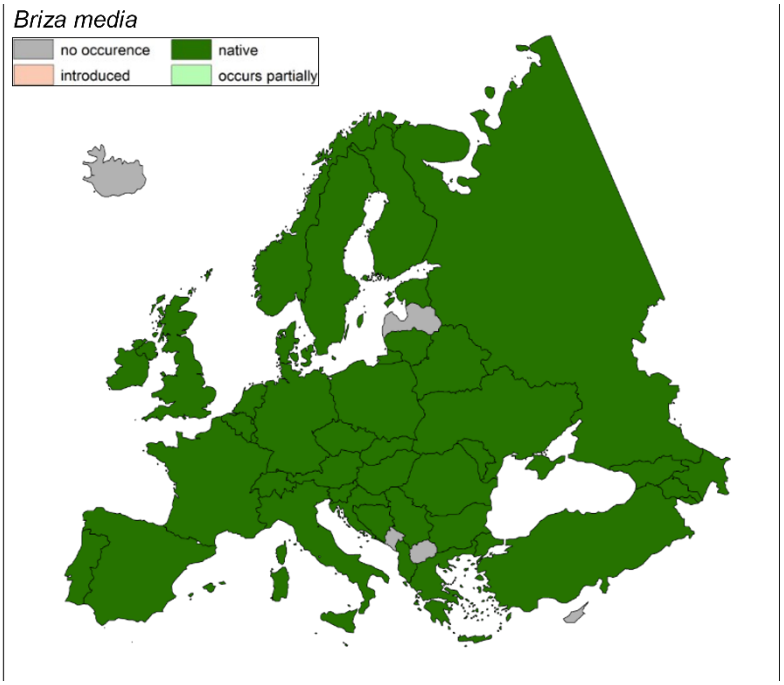


Figure 8: Distribution of Briza media L. in Europe

Suitability for Agricultural Use

The fodder quality and profitability of *Briza media* is only moderate; however, with its ecological value it is a typical species of high diversity extensive grassland.

Special ecological features

Briza media serves as feed and habitat for insects and caterpillars. Furthermore, it provides pollen for various animals.

Infobox

Briza media (Common Quaking Grass) is a perennial, tuft-forming grass of nutrient-poor to moderately nutrient-rich meadows, pastures, and calcareous grasslands. It typically reaches 20 - 50 cm in height and has narrow, flat leaves with a short ligule. The characteristic inflorescence consists of pendulous, heart-shaped spikelets on fine stalks that tremble in the wind, giving the species its common name. Briza media tolerates grazing and moderate cutting but is sensitive to intensive fertilisation and frequent mowing. It is therefore mainly found in extensively managed, species-rich grasslands. Agriculturally, it has low to moderate fodder

value, but is of high ecological importance as an indicator of traditional, low-input grassland management (Fischer et al., 2008).

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Bromus inermis L. - Smooth brome grass

Systematics

Family: Poaceae (grasses)

Subfamily: Pooideae

Tribe: *Poeae*

Genus: *Bromus*

Botanical Description

A long-lived, slow-growing perennial grass, it lives for 10–15 years or more. The root system is well-developed, branched, and penetrates deeply into the soil (up to 1 m), making it highly drought-resistant. About 60% of the root system's mass is located at a depth of up to 30 cm. It reproduces easily and renews itself vegetatively through underground rhizomes that develop in the topsoil at a depth of 10–20 cm. These rhizomes enable it to form a strong sod and a stable sward. The above-ground part of the plant is gray-green or light gray. It is a tall grass with a strong, upright stem 30–140 cm high, which is rough in the upper part. It is very resistant to lodging. The leaf is 8–15 cm long, about 8 mm wide, pointed at the tip, and may be bare or sparsely hairy. The ligule is narrow and crescent-shaped, and there is no auricle. The inflorescence is a large, long (up to 15 cm), branched panicle with very large, multi-flowered (4–7 flowers) spikelets. The seeds are grayish-yellow, large (9–12 mm long and 2–2.5 mm wide), lanceolate, with glumes, and have seven stripes, the middle of which is very prominent. There are 250–300 seeds per gram (Erić et al., 2016). Smooth brome grass is shown in Figure 9.



Figure 9: Smooth brome grass

Distribution and Habitat

Smooth brome grass is native to Europe and Asia. From Europe, it has spread to North America. Distribution of *Bromus inermis* in Europe is shown in Figure 10.

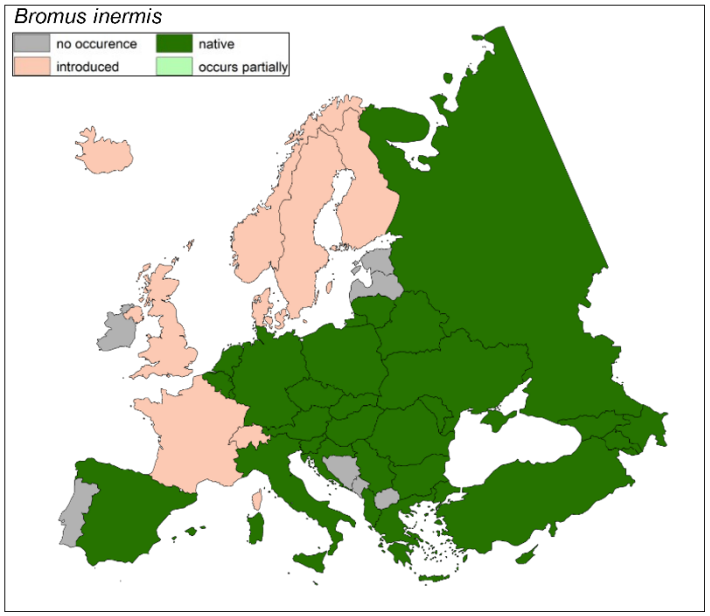


Figure 10: Distribution of Bromus inermis L. in Europe

Smooth brome grass occurs in grassland communities of lowland and hilly-mountain grasslands, up to 1000 m above sea level. In America, it occurs at elevations up to 3300 m above sea level (Vučković, 2004). Because of its good tolerance to drought and long-term, severe frosts, it is especially common in xerophilous areas. In Serbia, it is widespread on the edges of semi-xerophilous or xerophilous natural grasslands of the *Festucion vallesiaceae* family and in mesophilic grasslands belonging to the *Arrhenatheretalia* order (Sokolović et al., 2017). It also grows in sandy, dry habitats and along roads. This very resilient species occurs naturally on a variety of soils, including degraded, saline, acidic (pH 4.5), and alkaline soils. It is best suited to loose, light, sandy, well-drained soils with pH values of 6 to 7. It can withstand periodic flooding for up to seven weeks (Simić, 2019). It responds very well to irrigation.

Suitability for Agricultural Use

Smooth brome grass regenerates slowly after mowing. The optimal mowing time is when the panicle appears. It tolerates intensive grazing and trampling well. The quality index of this species is 5 (Peeters and Dajić, 2006), and it is considered a medium-quality grass. It has excellent palatability for ruminants (Vučković, 2004). After flowering, it loses nutritional

value and forage quality. Smooth brome grass is also used to prevent erosion and stabilize terrain, especially on dry and sandy soils, as well as in fodder mixtures. It is often included in mixtures for inter-row grassing in orchards and vineyards.

Special ecological features

Bromus inermis stabilizes soil and reduces erosion, helps preserve biodiversity, and provides shelter and food for many insects, birds, and small mammals.

Infobox

Smooth brome grass is a perennial species in the *Poaceae* family, with a lifespan of 10–15 years and stems reaching up to 140 cm in height. Its leaves are long (8–15 cm), broad (about 8 mm), with a short ligule and no auricles. The inflorescence is a branched panicle with 4–7 flowers per spike, and the seeds are large, lanceolate, with chaff and characteristic stripes. It is widespread in the grasslands of lowland and hilly-mountainous areas, especially along the edges of semi-xerophilous or xerophilous natural grasslands. It tolerates drought and frost well. It is considered a medium-quality grass.

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Cynodon dactylon L. – Bermuda Grass

Systematics

Family: Poaceae (grasses)

Subfamily: Chloridoideae

Tribe: *Cynodonteae*

Genus: *Cynodon*

Botanical Description

Cynodon dactylon L. is a perennial, upright-growing C4 grass species. It propagates by rhizomes and shoots (Nitu et al., 2019). Although it varies in different populations, rhizomes can be twice as wide as the shoots. Leaf blades are green to dull green, lance-shaped, with fine parallel veins on both surfaces, no midrib, and sparse but long hairs (Rosengurt et al., 1960)

Rhizomes show wide variation within the species and in some cases produce very few rhizomes, or no rhizomes under shady conditions. Stolons are also known to respond to light intensity and nutrient availability, therefore a large variation is observed in the length and number of stolons. Stolons, which are longer in low light intensity, are usually flat on the ground and can be easily buried, their morphology changes accordingly and they become indistinguishable from rhizomes (Dong & de Kroon, 1994).

Cynodon dactylon L. has longer leaves and internodes in less rainy and colder regions. Morphological characteristics such as height and internode length are significantly affected by the amount of available S and Ca in the soil and by pH (Wang et al., 2020). The inflorescence is a goosefoot-shaped spike. Spikes are arranged unilaterally on the spike axis (Manga et al.,

2002). The spikelets are approximately ¾ the length of the spikelet, sometimes slightly longer (Wu, 2010).



Figure 11: Cynodon dactylon L. ©Bilecik Şeyh Edebali University

Distribution and Habitat

Originally from Africa, *Cynodon dactylon* L. is naturally found in many parts of the world and is widely distributed in tropical, subtropical and temperate coastal regions (Taliaferro 1995).

It has been reported that the center of diversity of some species of *Cynodon dactylon* L. is the western region of Turkey, Iran, Afghanistan and Pakistan, which contains a wide variety of genes and genotypes (Harlan et al., 1970). Adapted to different soil and climate conditions, *Cynodon dactylon* L. is distributed on all continents and most oceanic islands between approximately 45° North and South latitudes (Wu, 2010). In Europe, it extends as far as approximately 53° North latitude, such as Yorkshire in England, Friesland in the Netherlands, Potsdam in Germany and southern Siberia (Harlan et al., 1969).

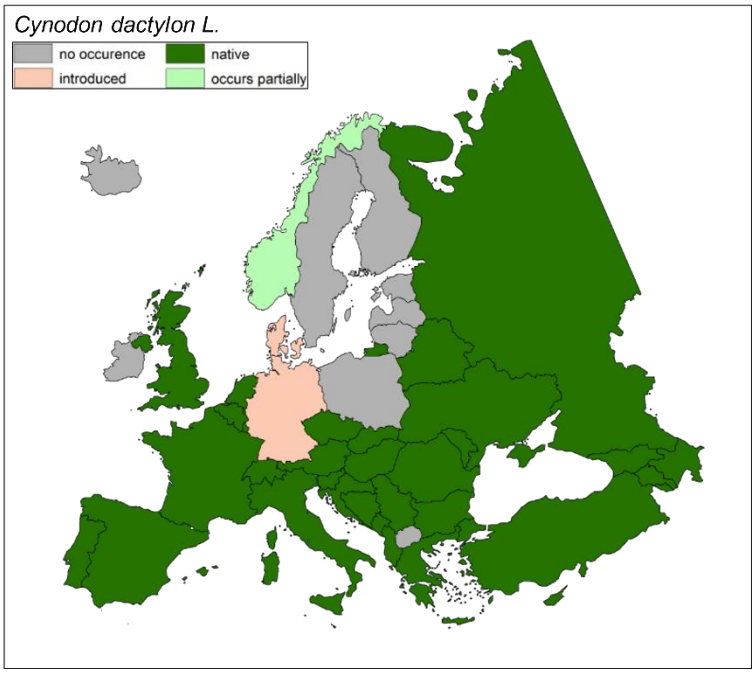


Figure 12: Distribution of Cynodon dactylon L. in Europe (http://www.europlusmed.org).

Suitability for Agricultural Use

Cynodon dactylon L. is classified among the species that proliferate in pasture areas. It has been determined that it is commonly found in pasture areas where long-term uncontrolled grazing takes place (Çınar et al., 2016). This is due to the species' resistance to grazing pressure and other stresses. In a study conducted to evaluate the use of horses in maintaining cultivated grass cover in central Italy, it was reported that very little dead grass accumulated during the summer in a pasture area heavily grazed and planted with a mixture of *Trifolium subterraneum brachycalycinum* + *Cynodon dactylon* (Pardini & Natali, 2005).

In a study conducted on 54 lines of Cynodon dactylon L., plant height ranged from 5.66 to 48.00 cm. Crude protein content ranged from 7.80% to 10.80%, ADF from 27.90% to 33.00%, and NDF from 62.40% to 70.10%. (Yılmaz et al., 2018).

Cynodon dactylon L. can be used in the establishment of resistant turf areas, greening of some problematic areas and erosion control measures.

Infobox

Cynodon dactylon L. is a perennial, upright-growing C4 grass species. It spreads by rhizomes and shoots. Although it varies in different populations, rhizomes can be twice as wide as the shoots. The leaf blades are green to dull green, lance-shaped, with fine parallel veins on both surfaces, and glabrous with no midrib.

Having adapted to different soil and climate conditions, *Cynodon dactylon* L. is distributed across all continents and between approximately 45° North and South latitudes, extending as far as 53° North latitude in Europe.

It is classified among the species that spread in pasture areas. It is commonly found in pasture areas with long-term uncontrolled grazing, due to its resistance to grazing pressure and other stresses.

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Cynosurus cristatus L. - Crested Dog's-tail

Systematics

Family: Poaceae (grasses)

Subfamily: Pooideae

Tribe: *Poeae*

Genus: *Cynosurus*

Botanical Description

Cynosurus cristatus is a perennial, tuft-forming grass of medium height. It reaches growth heights of about 15 - 60 cm and forms dense, fine-shooted tussocks with short rhizomes. The leaves are narrow, flat or slightly folded, 2 - 5 mm wide and medium to dark green (Lauber & Wagner, 2001). The upper surface is distinctly longitudinally striated, while the underside is smoother and often shiny. The leaf sheaths are hairless, tightly clasping, and completely fused. The youngest leaf is folded. The ligule is very short (0.5 - 2 mm), whitish-translucent or brownish, often raised at the tip with small lobes (Deutsch, 2007). The young vegetative shoots stand stiffly upright, giving the tussocks a compact appearance. The root system is rather shallow and spreads out more in width than in depth (Kutschera & Lichtenegger, 1982).

The inflorescence is a dense, 2 - 8 cm long false spike, resembling a simple spike. Typical features include the small spikelets arranged on one side, which give the inflorescence its characteristic "comb-like" appearance. The spikelets are very small (2 - 4 mm), usually contain only one fertile floret, and bear no or only very short awns. Flowering time extends – depending on altitude – from June to July. The fruit is a small caryopsis, usually ripening between July and September.

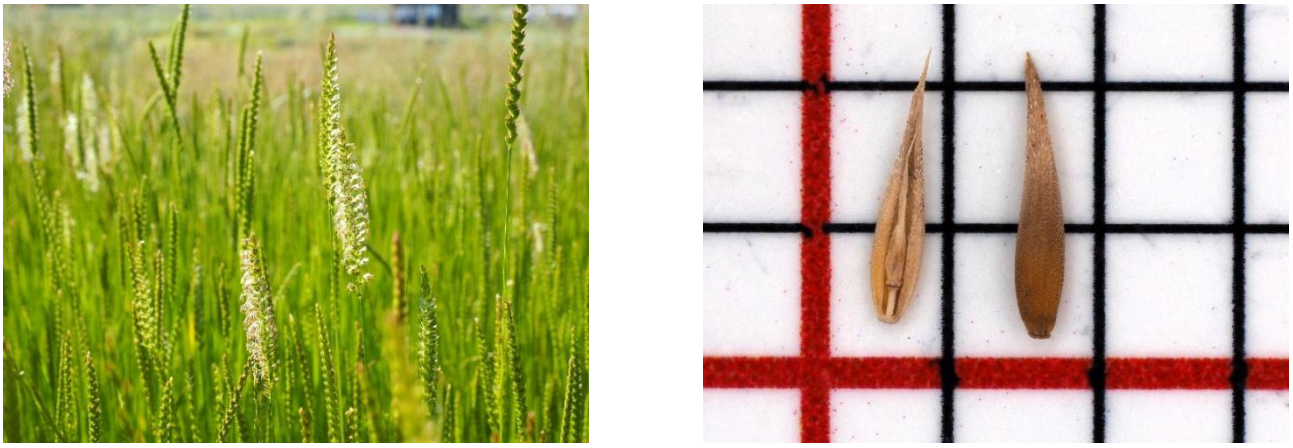


Figure 13: Flowering Crested Dog's-tail (left) and seeds (right) © AREC Raumberg-Gumpenstein

Distribution and Habitat

Crested Dog's-tail occurs in most parts of Europe, as well as in Southwest Asia extending to Iran and on the Azores. In Europe, it is present in almost all countries, missing only in Latvia and North Macedonia, and it has been introduced to Iceland. It has also been introduced to North America, Australia, and New Zealand.

It is a characteristic species of extensively to moderately used grasslands. It prefers moderately fresh to seasonally moist, nutrient-poor to moderately nutrient-rich sites on humus-rich, well-drained soils with neutral to slightly acidic pH. It is an indicator of loamy soils, fresh conditions, and strong light demand. The species is highly tolerant of trampling and grazing and is regarded as an indicator of long-established, low-fertility permanent grassland. In mountain regions it commonly occurs up to 1500 -1700 m, and sometimes even higher.

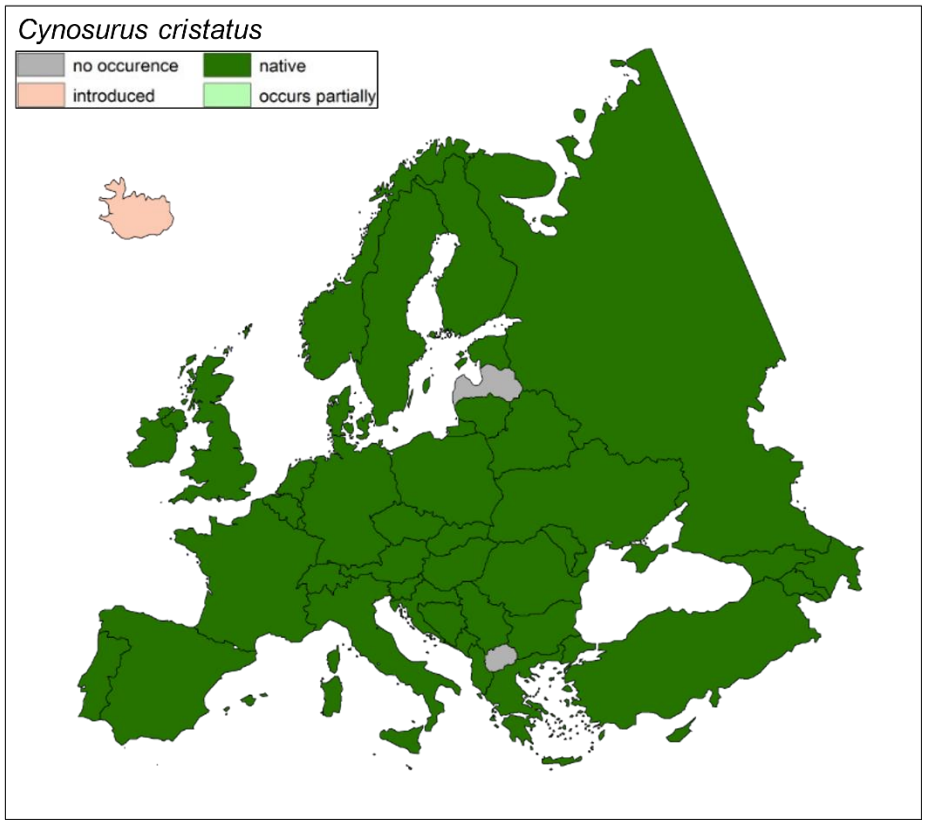


Figure 14: Distribution of Cynosurus cristatus L. in europe

Suitability for Agricultural Use

The fodder quality of Crested Dog's-tail is only moderate; however, due to its persistence, trampling tolerance, and tuft-forming growth, it contributes significantly to sward stability in extensive pastures. In higher altitudes, especially in mountain regions, it contributes to the long-term stability of swards. Because it is sensitive to frequent cutting, it is particularly suitable for low-intensity grazing systems. In such systems, it can be used as a substitute for the more winter-sensitive Perennial Ryegrass (*Lolium perenne*). However, it is not competitive enough in very intensively managed pastures.

Distinguishing Features from Similar Species

In the vegetative state, it can be difficult to distinguish from Perennial Ryegrass (*Lolium perenne*) at first glance. In contrast to ryegrass, the shoot base of *Cynosurus cristatus* is white

and often yellowish in the lower part, but never reddish-violet (Deutsch, 2007). In this area one can also clearly see the yellowish shoot buds. In addition Crested Dog's-tail completely lacks auricles, whereas Perennial Ryegrass has well-developed auricles.

Special ecological features

Crested Dog's-tail serves as caterpillar food for various butterflies.

Infobox

Cynosurus cristatus (Crested Dog's-tail) is a perennial, tuft-forming grass of nutrient-poor to extensive grasslands and pastures. It reaches 15 - 60 cm in height and has narrow, folded, distinctly striated leaves without auricles and a very short ligule. Young shoots stand stiffly upright. The characteristic inflorescence is a 5 - 10 cm long, comb-like false spike with very small spikelets arranged on one side. The species is tolerant of trampling and grazing but reacts sensitively to frequent cutting, and is therefore primarily found in extensive, long-established permanent pastures. Agriculturally, it has only moderate fodder value, but contributes strongly to sward stability—especially in higher altitudes.

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Dactylis glomerata L. - Cocksfoot

Systematics

Family: Poaceae (grasses)

Subfamily: Pooideae

Tribe: *Poeae*

Genus: *Dactylis*

Botanical Description

Dactylis glomerata L. (cocksfoot) is a perennial grass that forms clumps. It reaches a height of up to about 150 cm. The stem is straight, rough and strongly flattened. The leaves are flat, 4–10 mm wide and up to 50 cm long, usually rough, grey-green, matt, transversely wrinkled. The leaf sheaths are closed, flattened, rough and glabrous. The ligule is long (3–5 mm), white, pointed, sometimes frayed. This grass has a strongly developed root system (Grynia, 1995; Nawara, 2006).

The inflorescence is a straight, pyramidal, one-sided panicle 3-20 cm long. The spikelets are 5-8 mm long, 3-4-flowered, often red or purple. The spikelets are gathered in clusters at the ends of the branches. The glumes are 4–7 mm long and stiffly hairy on the back. The lower glume has a 1–2 mm long awn. The flowering period is from May to August (Nawara, 2006; Rutkowski, 2004).

The grain is ovoid, with a shallow, wide groove, and is reddish-brown in colour (Grynia, 1995).



Figure 15: Dactylis glomerata L. © Institute of Technology and Life Sciences - National Research Institute

Distribution and Habitat

Dactylis glomerata L. occurs throughout most of Europe and Asia, except for its southern and eastern extremities, and also on the northern fringes of Africa. *Dactylis glomerata* has been introduced to Australia, North and South America, and southern Africa. In some areas where it has been introduced, it has become an invasive species, especially in some areas of the eastern United States (*Dactylis glomerata* L., Plants of the World Online).

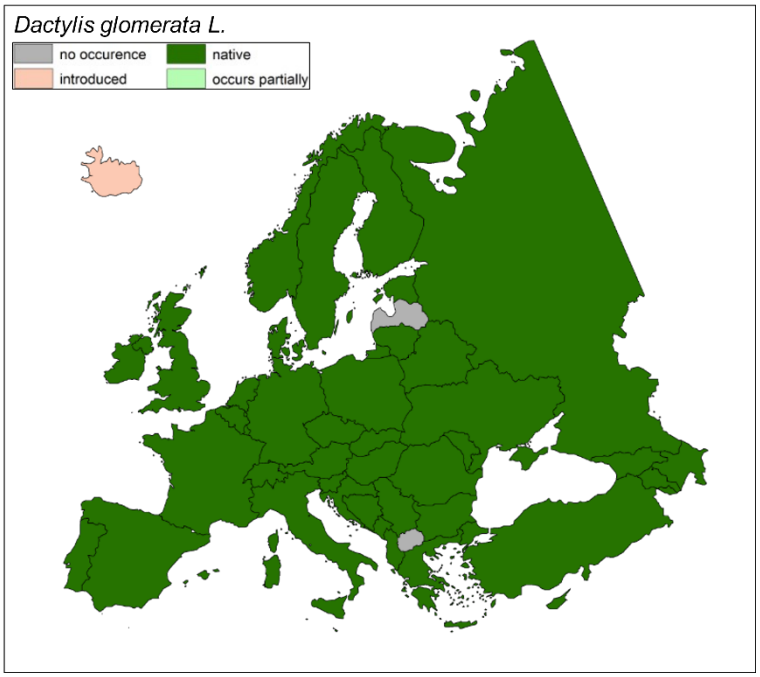


Figure 16: Distribution of Dactylis glomerata L. in Europe.

It is a species characteristic of fresh pastures, occurring in both meadows and pastures, and is also a species often cultivated in field mixtures. It prefers moderately moist sites on fertile soils rich in minerals (nutrients). It occurs on lighter, mineral soils and some soils of organic origin. It is an indicator of soils rich in nitrogen and potassium. It does not like high groundwater levels and excessive rainfall. It regrows quickly after mowing. This species is resistant to trampling. It is commonly found both in the lowlands and in the mountains up to the mountain pine (Pinus mugo Turra) (Nawara, 2006; Grynia, 1984).

Suitability for Agricultural Use

Dactylis glomerata L. is a grass of very good forage quality and yields well. It is suitable for mowing and grazing. It is a species of medium durability (5-8 years) and develops quite quickly after sowing. It should be mowed early (during the heading stage), as it quickly becomes woody and animals are reluctant to eat it (Grzebisz et al., 2014; Grynia, 1995).

Infobox

Dactylis glomerata L. (cocksfoot) is a perennial, nitrophilous, clump-forming grass found on fertile soils rich in nitrogen and potassium. It reaches a height of 30-150 cm and has

relatively broad, matt, transversely wrinkled leaves with a clearly marked midrib and a long sharp tip, without auricles, with a long ligule. Its characteristic inflorescence is a panicle with spikelets gathered in "cups". It is a universal grass, found in meadows and pastures, and can be grown in pure sowing or in forage mixtures. It has a very high feed value, yields well and is resistant to trampling.

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Festuca arundinacea L. - Tall fescue

Systematics

Family: Poaceae (grasses)

Subfamily: Pooideae

Tribe: *Poeae*

Genus: *Festuca*

Botanical Description

According to the Anglo-Saxon nomenclature, tall fescue belongs to the group of broad-leaved or tall fescues. It is a perennial species that lives for 8 to 10 years or longer. It has a well-developed, branched root system that permeates and binds the soil effectively, penetrating up to 120 cm deep. The main mass of the root system is located within the top 40 cm of soil. It has creeping rhizomes from which sterile shoots emerge, forming a semi-spreading and strong turf. The generative stem is upright and reaches up to 150 cm in height. The leaves are large, dark green, and rough, up to 30 cm long and 5–15 mm wide, with pronounced venation, straight to slightly funnel-shaped in cross section, and sharp to the touch. The auricles are well-developed and rough. The inflorescence is a large, drooping panicle, 20–40 cm long, very branched, with alternate branching and branches standing at an acute angle. The tips of the numerous large spikelets are reddish and may have short, sharp awns. The spikelets contain 4–7 flowers. The seeds are 6–8 mm long and 1.5–1.8 mm wide. There are 600–1,000 seeds per gram (Erić et al. 2016). Tall fescue is shown in Figure 17.



Figure 17: Tall fescue

Distribution and Habitat

Tall fescue is native to Europe and western Asia (Siberia) and has a wide distribution due to its high adaptability. It occurs in Europe up to 60 degrees north latitude, as well as in Russia, North Africa, America, and other temperate regions worldwide. Distribution of *Festuca arundinacea* in Europe is shown in Figure 18.

Tall fescue is a widespread species. In Serbia, it forms the Festucetum arundinaceae association in wet habitats. It grows along roads and canals, on stream banks and marshy meadows, but can also be found in drier habitats.

It is a very frost and drought-resistant species. In nature, it occurs on various soil types, including degraded and nutrient-poor soils, with pH values from 4.6 to 9.5, as well as poorly permeable and water-saturated soils. It is best suited to deep, medium-heavy, moist, and organic matter-rich soils, with an optimal pH value of 5.5 to 6.5. It can withstand periodic flooding for up to 60 days (Simić, 2019). It has a high competition index (Vučković, 2004).

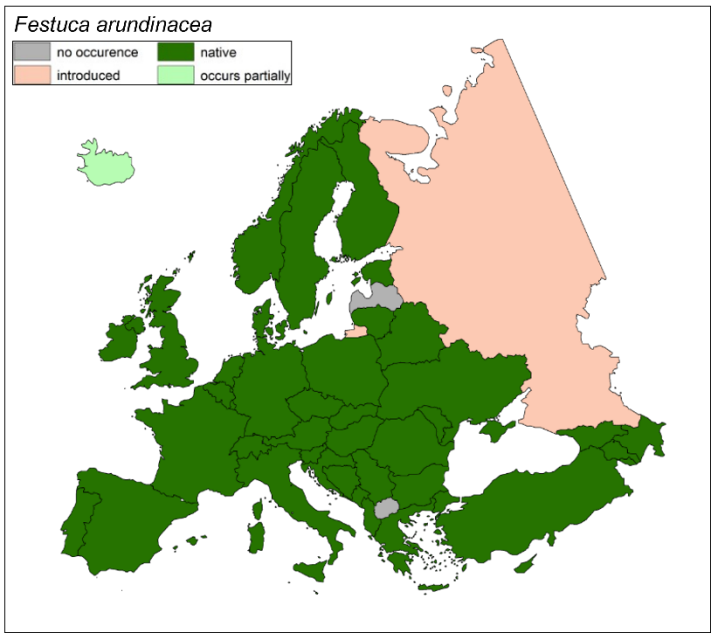


Figure 18: Distribution of Festuca arundinacea L. in Europe

Distinguishing Features from Similar Species

The seeds of tall fescue resemble those of meadow fescue but are darker and have a long, trapezoidal stalk. The distinct short awn differentiates them from meadow fescue seeds.

Suitability for Agricultural Use

Tall fescue is an early-maturing species with a short period of use in spring because it quickly transitions from the vegetative to the generative phase. Due to its good regeneration ability, it can be used for both mowing and grazing. The optimal time for mowing is at panicle emergence. It tolerates intensive grazing and trampling well. The quality index of this species is 4 (Peeters and Dajić, 2006). It has high genetic potential for yield (up to 18 t/ha of dry matter) and produces medium-quality forage (Đukić et al., 2004). It can be used to prevent erosion

and stabilize soil on slopes, in fodder mixtures, and for greening undeveloped or degraded areas, while dwarf varieties are used in decorative parks.

Special ecological features

Tall fescue stabilizes soil and reduces erosion, has a wide ecological amplitude, contributes to preserving biodiversity in grassland ecosystems, and provides refuge for many insects, birds, and small mammals. It is suitable for reclaiming and protecting degraded areas.

Infobox

Tall fescue is a perennial grass that grows up to 150 cm high, with a dense, branched root system reaching depths of up to 120 cm and creeping rhizomes. The leaves are up to 30 cm long and 5–15 mm wide. The inflorescence is a panicle 20–40 cm long, with 4–7 flowers per spikelet. Native to Europe and western Asia, it grows in both wet and dry habitats, including along canals and streams. It tolerates drought, frost, various soils, and periodic flooding. The forage is of medium quality (index 4). It is suitable for mowing and grazing. Tall fescue stabilizes soil, prevents erosion, and supports biodiversity.

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Festuca ovina L. - Sheep's-fescue

Systematics

Family: Poaceae (grasses)

Subfamily: Pooideae

Tribe: *Poeae*

Genus: *Festuca*

Botanical Description

According to the Anglo-Saxon nomenclature, sheep's-fescue belongs to the narrow-leaved or fine-leaved fescues. It is a perennial, low-growing grass with a shallow, fibrous root system that mainly develops in the 10–20 cm soil layer. It has short underground rhizomes and can form a semi-spreading turf (Vučković, 2004) or a compact, dense sward (Đukić et al., 2004). The stem is thin, erect or arched, gray-green, 20–60 cm high, with 2–3 nodes. The leaves are concentrated at the base, very narrow (thread-like or bristle-like), 0.4–1.1 mm wide, with a blunt tip and 5–7 nerves. The leaf sheath is dissected and smooth, entire at the base, and often covered with small, short hairs. The ligule is short. The inflorescence is a compact, erect panicle with alternate branching, linearly oblong or oblong-ovate, up to 12 cm long. The spikelets are green or purple, oblong or oblong-elliptic, 4–8 mm long, and have 3–8 flowers. The glumes are lanceolate and unequal, with the lower glume 1.5–3.0 mm long and the upper glume 2–4 mm long. The lemmas are awned. The flowering period is from May to July. The seeds are very similar to those of red fescue but are much smaller. The weight of 1000 seeds is 0.8 to 1.0 g. Sheep's-fescue is shown in Figure 19.



Figure 19: Sheep's-fescue

Distribution and Habitat

Sheep's-fescue has a wide distribution due to its high adaptability and low soil and nutritional requirements. It is found throughout Europe, extends to Antarctica, and is also present in Asia, Africa, North America, and Australia. Distribution of *Festuca ovina* in Europe is shown in Figure 20.

Sheep's-fescue is a widespread species both globally and in Serbia. It occurs in valley, hill-mountain, and mountain grasslands up to 2800 meters above sea level. It grows on sandy, rocky, and dry substrates, as well as in abandoned areas.

Compared to other fescue species, sheep's-fescue is distinguished by its exceptional resistance to drought, high temperatures, and grass diseases, and it also tolerates low temperatures well. In nature, it grows on various soil types, including sandy, rocky, and dry habitats, as well as marshes. It is particularly adapted to limited growth conditions. According to ecological indices, this species indicates moderately dry habitats, slightly acidic to neutral soils (pH 4.5–7.5), low nutrient levels, and habitats with higher light intensity. The ecological index for temperature also shows that the species is widespread in the montane region and the subalpine belt (Kojić, 1990). As an adaptive, competitive, hemicryptophytic species,

sheep's-fescue in the Agrostietum capillaris association, a typical meadow community of the Stara Planina Mountains in Serbia, increased its cover from 1980 to 2015, demonstrating its potential for dominance in grasslands.

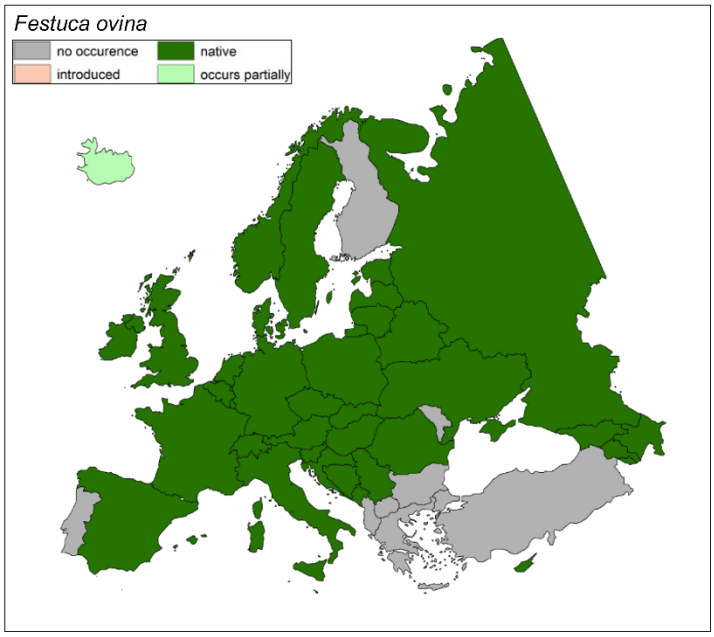


Figure 20: Distribution of Festuca ovina L. in Europe

Suitability for Agricultural Use

Sheep's-fescue is characterized by low yield and poor forage quality, resulting from its extremely xeromorphic structure. However, it is resistant to trampling and mowing. It is most often grazed by sheep. Grazing is recommended in early spring while the plant is in the vegetative phase. Due to its modest growth requirements, it is suitable for establishing poorly maintained grasslands and for areas with low fertility. The subspecies *F. ovina subsp. duriuscula* and *F. ovina subsp. tenuifolia* are often used to establish turf (Erić et al., 2016). Sheep's-fescue plays a significant role as a pioneer species in greening degraded soils, stabilizing surfaces, preventing erosion, and reclaiming grasslands.

Special ecological features

Sheep's-fescue plays an important role in soil stabilization and erosion reduction in dry, shallow, and rocky habitats. It has a wide ecological amplitude, allowing it to survive where most other grass species fail. In natural grasslands, it provides important habitat and food for many insects, especially butterfly larvae, and offers shelter for small invertebrates. It is also a key part of the diet for wild and domestic ruminants, thereby indirectly supporting the conservation of grassland biodiversity.

Infobox

Sheep's-fescue is a low perennial grass in the *Poaceae* family that most often forms compact turf. It has a shallow, dense, veined root system (10–20 cm) and narrow, thread-like or bristle-like leaves. The inflorescence is a compact panicle up to 12 cm long. The species is widely distributed in Europe and occurs in poor, dry, rocky habitats. It is characterized by exceptional resistance to drought, frost, and low soil fertility. It has a low yield and modest forage quality, but tolerates trampling and grazing well. It is important for soil stabilization, erosion prevention, reclamation of degraded areas, and preservation of grassland biodiversity.

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Festuca pratensis Huds. - Meadow fescue

Systematics

Family: *Poaceae (grasses)*

Subfamily: *Pooideae*

Tribe: *Poeae*

Genus: *Festuca*

Botanical Description

According to the Anglo-Saxon nomenclature, meadow fescue is classified among the broad-leaved, or tall, fescues. It is a perennial species that lives for 6 to 8 years or longer. It is characterized by a strongly developed, deeply penetrating, branched root system, which can penetrate up to 1.3 m deep. It forms short rhizomes and a loose turf. The stems are erect, smooth, and 30–120 cm tall. The leaves are dark green, lanceolate, shiny, mostly smooth and flat, 10–20 cm long and 3–5 mm wide. The leaf sheath is smooth and open with a short green ligule. The inflorescence is an oblong panicle, erect or slightly bent at the tip, up to 20 cm long, compact, and arranged on one side. The spikelets are yellow-green, sometimes with a purple hue, lanceolate or oblong, 9–11 mm long, and contain 7–8 flowers. The glumes are unequal; the upper, longer one is lanceolate and has three nerves, and the lower, shorter one has one nerve. The lemma is lanceolate, 6–7 mm long, without an awn, and sometimes streaked with purple. It flowers in June and July. The seeds are ovoid-oblong, 5–7 mm long and 1.2–1.6 mm wide. There are 500–600 seeds in 1 g (Erić et al., 2016). Meadow fescue is shown in Figure 21.



Figure 21: Meadow fescue (authors: A. Simić and V. Mandić)

Distribution and Habitat

Meadow fescue is widespread throughout Europe and temperate regions of Asia and has been introduced to North America. Figure 22 shows the species' distribution in Europe.

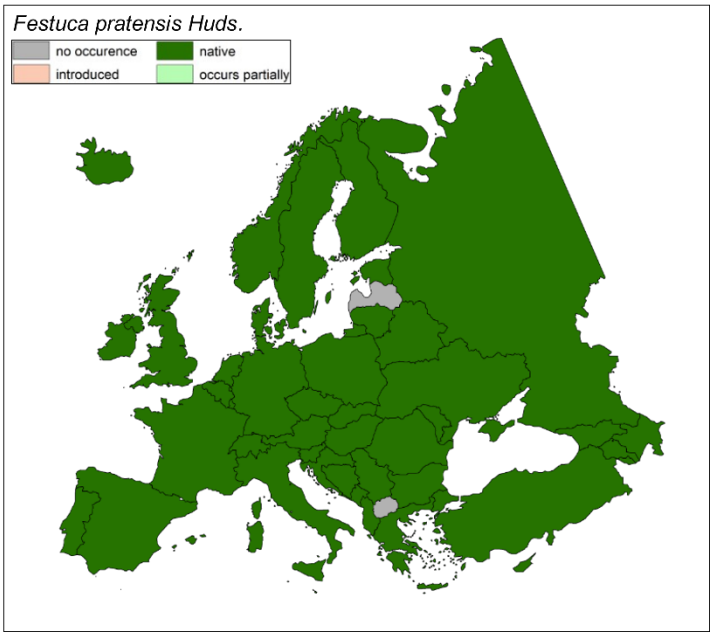


Figure 22: Distribution of Festuca pratensis Huds. in Europe

The species occurs in natural flora and in sown grasslands, where it plays a significant role in fodder production and the reclamation of degraded areas. Meadow fescue is found in diverse grassland ecosystems and is typical of valley and hill grasslands. In Serbia, it forms the grass association Festucetum pratensis, which dominates in moderately humid and wet habitats. It is also a characteristic species in the grass association Cynosuretum cristati and the anthropogenically altered association Arrhenatheretum elatioris (Sokolović et al., 2017). It often grows on abandoned land, embankments, and along roads and fields. The species is resistant to low temperatures and frost but is sensitive to drought and shade. In nature, it is most often found in humid, fresh, and wet habitats; however, it does not tolerate flooding. It can withstand submersion for up to 30 days. It responds well to irrigation and the application of mineral fertilizers, especially nitrogen, as important land improvement measures. It is best suited to fertile, deep, nutrient-rich soils with a heavier mechanical composition. On fertile and calcareous soils, it often becomes the dominant grassland species. Ecological indices indicate that this species is an indicator of soils with medium moisture, a slightly acidic to neutral reaction (pH 4.5–7.5), rich in nutrients, and habitats with higher light intensity (Kojić, 1990). However, it also occurs on more acidic soils, such as pseudogley, eutric-cambisol and ranker (Simić, 2019). The ecological index for temperature shows that it is widely distributed in the montane region and common in the subalpine zone.

Suitability for Agricultural Use

Meadow fescue produces a large amount of high-quality biomass, with a quality index of 10 (Peeters and Dajić, 2006). It is a highly valued forage species, suitable for use in pure grass stands and grass-legume mixtures, where it ensures high productivity, durability, and lawn stability. It is most often used for mowing, as it forms an upright above-ground mass with a uniform structure, allowing for easy and efficient mowing and the production of high-quality hay and silage. It is also suitable for grazing, as animals readily consume it due to its good digestibility, favorable chemical composition, and excellent taste. It is particularly important in the winter and early spring, as in mild winter conditions, it retains green mass for a long time and ensures continuity of grazing. During the growing season, it retains high quality for

an extended period, but after mowing, its nutritional value gradually decreases. In addition to its forage use, meadow fescue is also used for establishing lawns for special purposes (airports, racetracks, park areas), greening inter-row spaces in orchards and vineyards, landscaping neglected areas, and reseeding existing lawns. It is also important for soil stabilization and erosion prevention.

Special ecological features

Meadow fescue effectively stabilizes the soil surface layer, reduces erosion, and helps preserve soil structure and porosity, especially in wet valley and hill habitats. Its dense aboveground growth and well-developed underground biomass promote the accumulation of organic matter and support carbon sequestration processes in grassland ecosystems. Additionally, it enhances the stability of grass communities, increases biodiversity, and creates favorable microhabitats for many invertebrates, birds, and small mammals. Meadow fescue also aids in the reclamation of degraded areas, embankments, roadsides, and other anthropogenically altered habitats.

Infobox

Meadow fescue is a perennial, broad-leaved grass with a deep, branched root system, typical of wet valley and hill grasslands, where it forms the *Festucetum pratensis* association. It is also an important species in other grassland communities. Meadow fescue is widely distributed in Europe and temperate regions of Asia and has been introduced to North America. It produces a large amount of high-quality biomass (quality index 10) and is suitable for mowing, grazing, greening, and stabilizing degraded habitats. It is resistant to frost and low temperatures but does not tolerate drought or flooding. Meadow fescue is suitable for grass and grass-legume mixtures and contributes to the structure of grassland communities, biodiversity, and carbon sequestration.

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Festuca rubra L. - Red fescue

Systematics

Family: Poaceae (grasses)

Subfamily: Pooideae

Tribe: *Poeae*

Genus: *Festuca*

Botanical Description

According to the Anglo-Saxon nomenclature, red fescue belongs to the narrow-leaved or fine-leaved fescues. It is a perennial species that lives 7 to 10 years and is characterized by a highly branched, dense, fibrous root system. It forms a compact turf and may have dense, homogeneous rhizomes. The stems are intensely green, erect, stiff, smooth, and 20–100 cm tall. The leaves are bristle-like and twisted at the base, 0.4 to 1.2 mm in diameter, with 5 to 7 veins, while the leaves along the stem are straight, with 11 to 17 veins, and covered with hairs on the upper side. The leaf sheath is smooth and entire, and the ligule is smooth. The inflorescence is an erect or slightly pendulous panicle, 6–15 cm long, blue-violet or reddish, with branches that protrude during flowering. The spikelets are brown or pink-violet and contain 4 to 6 flowers. The glumes are unequal and lanceolate, while the lemmas are hairy with a short awn. It flowers for a long period, from June to October. The seeds are 6–8 mm long, 0.7–1 mm wide, white to slightly yellow, and sometimes purple or reddish. There are 850 to 960 seeds per gram (Erić et al., 2016). Red fescue is shown in Figure 23.



Figure 23: Red fescue

Distribution and Habitat

Red fescue has a wide distribution and belongs to the circumpolar floral element (Kojić, 1990), meaning it is naturally present throughout the northern hemisphere. It is found in Europe, Asia, North Africa, New Zealand, America, and other temperate regions. Distribution of *Festuca rubra* in Europe is shown in Figure 24.

Red fescue is a widespread species found both globally and in Serbia. It occurs in wild flora and in sown grasslands, where it is important for fodder and land reclamation. In Serbia, it forms the typical grass association *Festucetum rubrae*, which dominates hilly and mountainous grasslands.

This species tolerates low temperatures, frost, and drought well. In nature, it occurs in a variety of habitats, but most often in moist, fresh, and somewhat dry environments. Although it tolerates some drought and variations in moisture conditions, it does not thrive in permanently wet or submerged habitats for extended periods. The species has poor tolerance to saline soils (Erić et al., 2016). Ecological indices indicate that the species is an indicator of soils with medium moisture, slightly acidic to neutral pH (4.5–7.5), and moderate to moderately rich nutrient levels, as well as habitats with higher light intensity (Kojić, 1990). The

ecological index for temperature shows that it is widely distributed in the montane region and is common in the subalpine zone. Therefore, red fescue is adapted to temperate climates and cooler conditions but also has some tolerance to drought and low soil fertility, allowing it to survive in diverse grassland ecosystems. The species has low competitive ability (competition index 1) (Đukić et al., 2004).

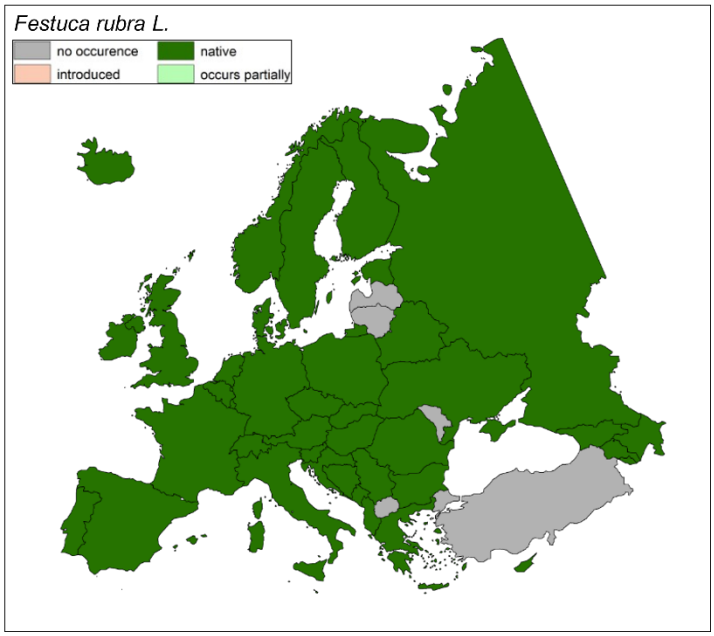


Figure 24: Distribution of Festuca rubra in Europe

Suitability for Agricultural Use

Red fescue is well-suited for use in grass and grass-legume mixtures, sports fields, and decorative lawns. It is often used to green inter-row spaces in orchards and vineyards, as well as for landscaping neglected areas and reseeding existing lawns. This species is also important as a pioneer plant in industrial areas and landfills, where it contributes to the initial stages of vegetation cover and soil stabilization. It tolerates intensive grazing and trampling well. Red fescue is most often used for grazing because it is palatable to animals. It is characterized by higher production in the spring, vigorous growth in autumn, and a favorable energy value of the forage (Simić, 2019). The quality index is 4 (Peeters and Dajić, 2006). Red fescue is not

suitable for hay production, as it has slower growth and a high density of ground leaves, resulting in lower yields and more difficult mowing.

Special ecological features

Red fescue effectively stabilizes the soil surface and reduces erosion, especially on slopes. It has a wide ecological range and longevity, making it important for reclaiming and greening degraded areas. In natural grasslands, it helps preserve community structure and stability and provides important habitat for many invertebrates and small animals.

Infobox

Red fescue is a perennial, narrow-leaved grass with a dense, fibrous root system and rhizomes that form a dense grass cover. It is naturally distributed throughout the temperate zone of the northern hemisphere and is common in Serbia, especially in hilly and mountain grasslands (association Festucetum rubrae). It tolerates frost, moderate drought, and poor soils well, but not long-term flooding or saline soils. It is suitable for grass and grass-legume mixtures, sports and decorative lawns, grazing, and for reclamation and soil protection from erosion due to its dense rhizome growth.

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Lolium perenne L. – Perennial ryegrass

Systematics

Family: Poaceae (grasses)

Subfamily: Pooideae

Tribe: *Poeae*

Genus: *Lolium*

Botanical Description

Perennial grass or English ryegrass is a perennial, long-lived grass forage plant. It has a very strong and dense fibrous root system. It firmly holds the upper layers of soil and is therefore very effective in erosion control and ground stabilization in sports fields. The plant height usually reaches up to 90 cm depending on growing conditions (Manga et al., 2003). The leaves are dark green, smooth, and have a very glossy underside and a matte upper surface (Beddows, 1967).



Figure 25: Lolium perenne L. seeds, plant habit, and inflorescence ©Bilecik Şeyh Edebali University

The leaf blade is 3-20 cm long and 2–5 mm wide (Açıkgöz, 2021). There are prominent parallel veins on the upper surface. In young shoots, the leaves are folded in the sheath The ligule is short, blunt and membranous. The auricles are small, narrow, and clasp the stem. The flower cluster is of the sparse spike type. The spikes are 5–30 cm long, slightly curved or erect. The spikelets are attached to the main axis by their narrow edges, and each spikelet contains

3–11 flowers (Baytekin et al., 2009). There is only one outer husk, and the outer husk is located on the side of the spikelet furthest from the axis. The seeds are generally awnless.

Distribution and Habitat

Lolium perenne L. is one of the most widely distributed and economically valuable forage and green field plants in the world. The plant's natural distribution area covers Europe (Figure 26), North Africa, and temperate Asia (Baytekin et al., 2009). It naturally grows in meadows and pastures, field edges, roadsides, riverbanks, and abandoned lands. It can be found in regions ranging from sea level to approximately 2000 meters in altitude (Davis, 1985). It particularly prefers nitrogen-rich, fertile, and heavy (clay-loam) soils. It performs best in soils with high soil moisture, good drainage, and high organic matter content (Şahin et al., 2022). Although it can grow in a wide range of pH between 5.0 and 8.0, it shows ideal development in slightly acidic or neutral soils with a pH of 6.0–7.0 (Polok, 2007). It is a cool and humid climate plant. It is sensitive to harsh winter cold and extreme summer drought. Growth begins around 6–7°C, reaches optimum levels between 20–25°C, and stops above 30°C. It prefers sunny areas; it has poor shade tolerance. Therefore, it is generally not preferred in under-tree mixtures. Root development is negatively affected in waterlogged soils and excessively saline areas.

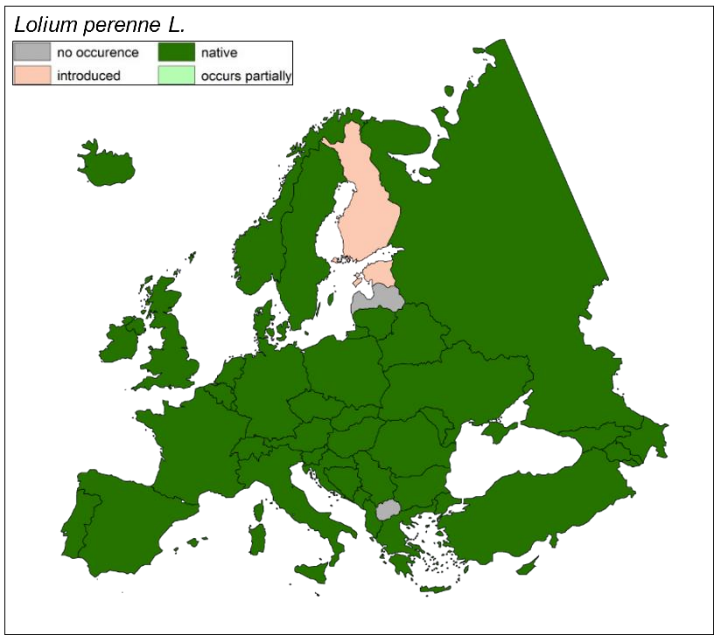


Figure 26: Distribution of Lolium perenne L. in Europe (http://www.europlusmed.org).

Suitability for Agricultural Use

Lolium perenne L. is an agriculturally important species due to its high nutritional value and its readily consumed nature by animals. Compared to other cool-season grasses, it is one of the species with the highest digestible dry matter and energy content (Hannaway, 1999). Because of its high sugar content (water-soluble carbohydrates), it is consumed with great appetite by cattle and small ruminants. This directly increases milk and meat yield. Due to its basal tillering and the proximity of its growing points to the soil surface, it is highly resistant to heavy grazing It is ideal for sheep pastures (Jung et al., 1996) It recovers very quickly after grazing or mowing. With irrigation and fertilization, it offers the possibility of numerous mowings throughout the season. Thanks to its high sugar content, it produces excellent quality silage. However, because its leaves are thin, it is more efficient to mix it with legumes (e.g., clover) rather than producing hay alone. Its seeds are large and germinate in a short time, such as 3–7 days, covering the area. With this feature, it acts as a gap filler and weed suppressant in pastures. Although the plant is perennial, its lifespan can be shortened by

extreme summer drought or very harsh winters. Therefore, overseeding may be necessary at certain intervals in pastures. It has low drought tolerance. Severe drying occurs in the parts of the plant located in the upper layers of the soil during the summer months (Jupp & Newman, 1987). Regular rainfall or irrigation is essential for economically viable agricultural production. Fungi found in some natural varieties can cause some neurological disorders in animals (Beddows, 1967). This risk has been minimized in improved modern varieties.

Distinguishing Features from Similar Species

In perennial ryegrass (Lolium perenne L.), the leaves of young shoots are folded within the sheath. This feature is one of the most important differences between perennial ryegrass and annual ryegrass, as annual ryegrass has rolled leaves in the shoot. Perennial ryegrass seeds are generally awnless, whereas annual ryegrass seeds are usually awned. Perennial ryegrass is generally shorter than annual ryegrass.

Infobox

Lolium perenne L. is a perennial, long-lived grass forage plant. It has a very strong and dense fibrous root system. It is one of the most widely distributed and economically valuable forage and green field plants in the world. Due to its tillering from below and the proximity of its growing points to the soil surface, it is resistant to heavy grazing.

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Lolium multiflorum Lam. *syn. Lolium italicum* A. Braun - Italian ryegrass

Systematics

Family: *Poaceae (grasses)*

Subfamily: *Pooideae*

Tribe: *Poeae*

Genus: *Lolium*

Botanical Description

Italian ryegrass is a tall grass adapted to temperate climates, with very rapid growth and a lifespan of 1 to 2 years, rarely 3 years. It is characterized by a well-developed, branched, and fibrous root system that penetrates up to 1 m deep and forms a compact turf. The stem is upright, tender, elastic, and dark green, rough at the base, up to 150 cm high, and about 5 mm in diameter. The leaves are large, linear-lanceolate, light green, up to 25 cm long and about 1 cm wide; rough on the upper side and smooth and shiny on the lower side. The leaf sheath is open and covers the entire internode, and in the lower leaves, it has a reddish color. The inflorescence is a large, drooping, complex spike up to 40 cm long, with 35–40 alternately arranged and directly attached spikelets, each 8–30 mm long. Spikelets contain 10–20 fertile flowers and have a short, silky awn, often brownish-red in color. The seeds are gray-yellow, covered with glumes, elongated-lanceolate, and about 6 mm long. Flowering occurs from May to July. There are 450–500 seeds in 1 g (Erić et al., 2016). Italian ryegrass is shown in Figure 27.



Figure 27: Italian ryegrass (authors: N. Micić and A. Simić)

Distribution and Habitat

Italian ryegrass belongs to the sub-Mediterranean flora (Kojić, 1990). The species is widespread in Western, Southern, and Central Europe, the Caucasus, North Africa, Asia Minor, and Syria, and has been introduced to North America. In Europe, Italian ryegrass is the most important forage grass species, covering 12 million ha, out of a total of 52 million ha under grass (Humphreys et al., 2010). The distribution of the species in Europe is shown in Figure 28.

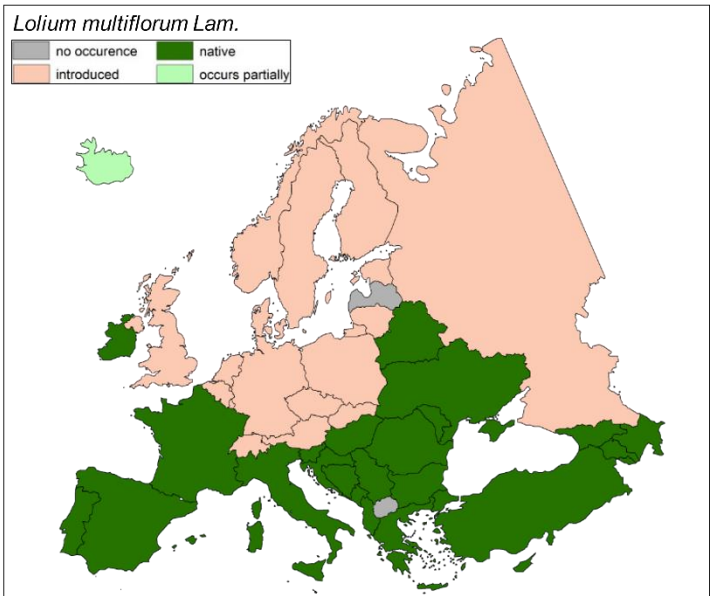


Figure 28: Distribution Lolium multiflorum Lam. in Europe

The species occurs in natural, anthropogenic, and neglected grasslands, as well as in gardens and along roads. In nature, it is found on moist lowland grasslands. It grows on various soil types, but alluvial deposits and semigley are most suitable. The most favorable conditions are fertile, deep, and moderately moist soils with a lighter mechanical composition. It is sensitive to low temperatures and frost but responds well to irrigation and the application of mineral fertilizers, especially nitrogen fertilizers. Ecological indices indicate that this species is an indicator of soils with medium moisture, a slightly acidic to neutral reaction (pH 4.5–7.5), rich in nutrients, and habitats with higher light intensity (Kojić, 1990). However, it can also occur on more acidic soils, pseudogley, and eutric-cambisol (Simić, 2019). The ecological index for temperature shows that it is widely distributed in lower, valley areas.

Suitability for Agricultural Use

Italian ryegrass produces a large amount of high-quality biomass. It is considered the highest quality and most digestible animal feed, with high energy content and excellent palatability for ruminants (Ertekin et al., 2022). Its quality index is 10 (Peeters and Dajić, 2006). It is a highly valued forage species, used in both pure grass stands and grass-legume mixtures. It is most often used for mowing and does not tolerate trampling. In addition to its forage use, it is also used for greening unimproved abandoned areas, soil stabilization, and erosion prevention.

Special ecological features

Italian ryegrass can improve soil health, reduce erosion by increasing soil aggregate stability, support carbon sequestration in grass ecosystems through the production of large amounts of organic matter, enhance the stability of grass communities, and increase biodiversity. It also promotes the formation of favorable microhabitats for many animals, influencing species diversity and density.

Infobox

Italian ryegrass is a tall grass that is typically annual or biennial, and rarely triennial, widely distributed in the temperate climates of Europe. It belongs to the sub-Mediterranean flora and is a characteristic species of wet lowland grasslands. The species is distinguished by its deep, branched root system and its production of large amounts of high-quality biomass (quality index 10) with excellent palatability for animals. Italian ryegrass is used more for mowing than for grazing because it does not tolerate trampling. It is sensitive to low temperatures and frost. It is suitable for grass and grass-legume mixtures and contributes to the structure of grass communities, biodiversity, and carbon sequestration.

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Phalaris arundinacea L. - Reed canary grass

Systematics

Family: Poaceae (grasses)

Subfamily: Pooideae

Genus: *Phalaris*

Botanical Description

Phalaris arundinacea L. (Reed canary grass) is a perennial grass growing to a height of 150-200 cm, erect, with numerous, branched and thick runners. Leaf blades are long (up to 40 cm) and broad (up to 15-20 mm). The leaves are rolled up in a bud, without auricles, rough on top, indistinctly grooved, grey-green. The leaf ligule is strongly torn, up to 5 mm long. The leaf sheaths are bare and usually rough (Nawara, 2006; Włodarczyk, 1984).

The inflorescence is a panicle up to 10-20 cm long, plume-like clustered before and after flowering. Widely spread, pale green, reddish or white-violet during flowering. Spikelets are single-flowered, 3-5 mm long, gathered in loose clusters. There are four apparent glumes. The two lower ones are lanceolate, pointed, 5-6 mm long. The two upper ones are brush-like, hairy, 3-4 mm long, grey-brown. The flowering period lasts from June to July (Nawara, 2006; Włodarczyk, 1984).

The fruit of *Phalaris arundinacea* is a caryopsis shielded by coriaceous pallets. It is about 5 mm long and it has a short sharp brown tip, containing a single seed (Ghica and Samfira, 2011).



Figure 29: Phalaris arundinacea L. - Reed canary grass © Institute of Technology and Life Sciences - National Research Institute

Distribution and Habitat

Phalaris arundinacea L. is a species native to most European countries (except Latvia and North Macedonia) and also to the African continent in Algeria. The species has been introduced in Egypt and Iceland (Euro+Med (2006+)).

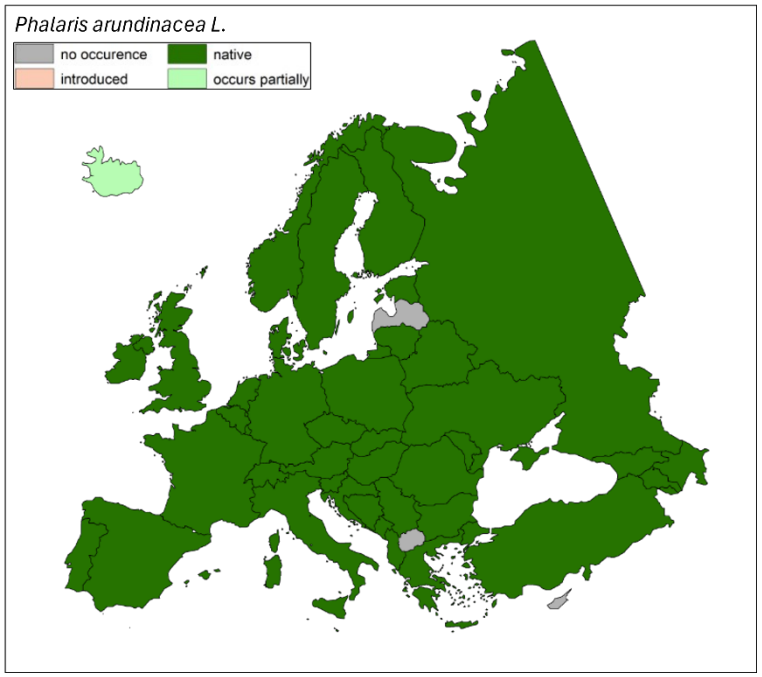


Figure 30: Distribution of Phalaris arundinacea L. in Europe

It is common in lowlands and less common in lower mountain areas. It occurs mainly on fertile, calcium-rich, moist organic soils, along the banks of stagnant and slow-flowing

waters. It thrives in flooded habitats and those irrigated with sewage. It does not like rolling and compacted soils. It is a species resistant to drought, frost and shade (Grzebisz et al., 2014; Nawara, 2006). In many places, it is considered an invasive species. In wetlands, it inhibits the growth of native vegetation and reduces biodiversity, and once established, it is difficult to eliminate. Phalaris arundinacea L. form dense monocultures that spread radially. (Apfelbaum and Sams, 1997; Batze and Sharitz, 2006).

Suitability for Agricultural Use

Phalaris arundinacea L. has average forage value. It is mainly suitable for cutting because it cannot tolerate grazing and trampling. It must be mowed before heading. To ensure both yield and quality of forage, the grass should be harvested three times per annum. Reed canary grass meadows are characterised by high yield. The dry matter yield from meadows dominated by *Phalaris arundinacea* L. can reach 14-16 t·ha-1. When harvested at the right time, the green fodder has a favourable chemical composition and high nutritional value. (Grzebisz et al., 2014; Nawara, 2006; Ghica and Samfira, 2011). This species also has high energy potential due to its high yield (Grzelak, 2009).

Infobox

Phalaris arundinacea L. (Reed canary grass) is a perennial grass growing up to 150-200 cm in height. This species is common in lowlands, less frequently in lower mountain areas. It occurs mainly on fertile, moist organic soils. It has long and wide leaf blades. The leaves are curled in a bud. The inflorescence is a widely spread panicle, pale green or reddish during flowering. *Phalaris arundinacea* L. is a species native to most European countries. Reed canary grass has average forage value. It is mainly suitable for mowing because it cannot tolerate grazing and trampling. The flowering period lasts from June to July.

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Trisetum flavescens (L.) P. Beauv. - Yellow oatgrass/golden oat grass

Systematics

Family: Poaceae (grasses)

Subfamily: Pooideae

Genus: *Trisetum*

Botanical Description

Trisetum flavescens L. (Yellow oatgrass, golden oat grass) is a loose-tufted perennial grass 30-120 cm tall, with short underground runners. The leaf blades are delicate and densely hairy. The culm is erect, 40-80 cm tall, covered with short hairs below the nodes. The highest node is located halfway along the culm. The leaf blades are flat, up to 12 cm long and 2-5 mm wide, delicate, densely hairy, narrowly pointed. The ligule is collared, finely serrated, 1-2 mm long. The leaf sheaths are open, sometimes sparsely hairy, usually smooth.

The inflorescence is a spreading panicle, 5-20 cm long, erect, clustered before flowering, spikelets golden-shiny, 5-8 mm long, lemma bent at the bend, twisted halfway. The lower glume is single-veined, with two teeth at the top, the upper glume is three-veined. The spikelet usually has two to four awns, 3-7 mm long. The flowering period lasts from May to September (Nawara, 2006; Włodarczyk, 1984).



Figure 31: Trisetum flavescens L. - Yellow oatgrass © Institute of Technology and Life Sciences - National Research Institute

Distribution and Habitat

This species is native to most European countries. It has been introduced to northern countries such as Sweden, Norway and Finland. However, it does not occur in Latvia, Iceland, Cyprus and Bosnia and Herzegovina (Euro+Med (2006+)). *Trisetum flavescens* L. is a valuable forage grass for meadows located on fertile mineral soils, rich in calcium, with moderate moisture and good structure. It appears on lowland grasslands but is a typical meadow grass for sites located at altitudes above 600 m above sea level. It prefers warm, sunny sites. It can withstand short periods of flooding (Grzebisz et al., 2014).

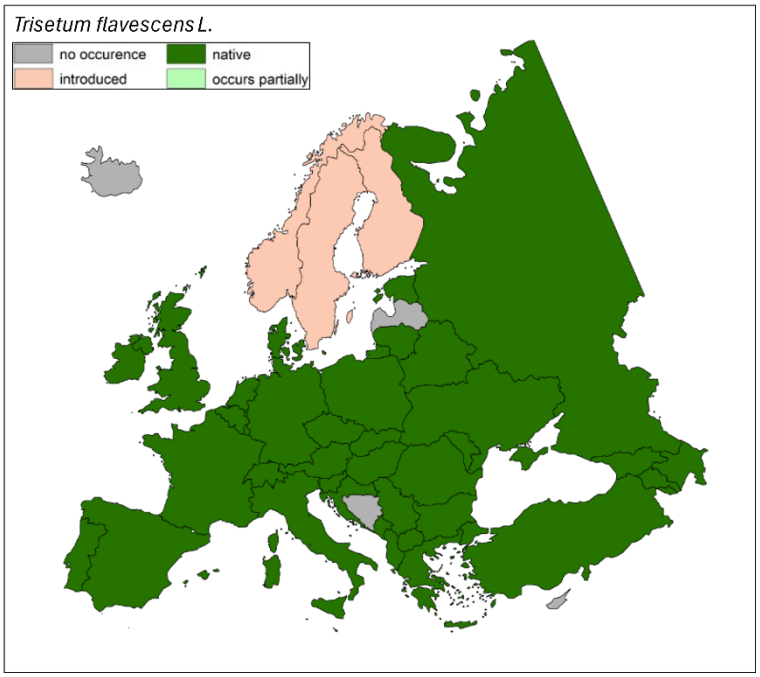


Figure 32: Distribution of Trisetum flavescens L. in Europe.

Suitability for Agricultural Use

A species with high forage value. It contains an optimal amount of total protein, but little carbohydrates. It is also characterised by a high calcium content, often exceeding the optimal level in animal nutrition. When grazing animals are fed exclusively and continuously on grass with more than 40% yellow oatgrass excessive calcium deposition in the animal's soft tissues (calcinosis) may occur. It is very sensitive to grazing and does not tolerate low mowing well. Yield approx. 4-12 $t \cdot ha^{-1}$.

Infobox

Trisetum flavescens L. is a perennial loose-tufted grass 30-120 cm tall with short underground runners. The leaf blades are delicate and densely hairy. The inflorescence is a spreading panicle, 5-20 cm long. This species is native to most European countries. It was introduced to the north in the Scandinavian countries. Yellow oatgrass is a valuable forage grass for meadows located on fertile mineral soils with moderate moisture and good structure. It prefers warm, sunny locations. It can withstand short periods of flooding. It is a

species of high forage value, very sensitive to grazing and does not tolerate low mowing well. The flowering period lasts from May to September.

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Bituminaria bituminosa (L.) C.H. Stirt.- Pitch trefoil, Arabian pea or Bitumen trefoil

Systematics

Family: Fabaceae (legumes)

Sub-Family: Faboideae (Papilionoideae)

Tribe: *Psoraleae*

Genus: *Bituminaria*

Botanical Description

Bituminaria bituminosa is a perennial, hemicryptophytic legume that may exhibit herbaceous to semi-woody characteristics depending on environmental conditions (Gutman et al., 2000). Its leaves are typically trifoliolate and described as 'subdigitately trifoliolate,' with the central leaflet petiole being longer than the laterals. Leaflets are pubescent on the abaxial surface, lanceolate or oval, and the number of leaves per plant ranges from 50 to 596 (Gülümser et al., 2010).

The flowers are purple–violet, terminally positioned, and arranged in a capitate inflorescence borne on a long peduncle. Flowering begins in May and continues at low intensity throughout the year. The species is self-pollinating and has a chromosome number of 2n = 20 (Pazos-Navarro et al., 2011).

The fruit is a small, generally indehiscent pod showing morphological variation within the species (Carruggio et al., 2020). Each flower produces a single seed, with a thousand-seed weight of 25–33 g (Gülümser et al., 2010). The seeds are large and have a beak-like structure

at the tip. The pronounced hard-seed dormancy can be substantially reduced through mechanical scarification or chemical pre-treatments (Beard et al., 2014).



Figure 33: Bituminaria bituminosa general appearance and plant parts (Sources: Anonymous, 2026a; Doğan, 2023; Gedikoğlu, 2026; Anonymous, 2026b, respectively).

Distribution and Habitat

The natural distribution of *Bituminaria bituminosa* (L.) C.H.Stirt. extends across the Macaronesian Islands (particularly the Canary Islands), Southern Europe, the Balkans, Anatolia, the Caucasus, and the Mediterranean coastal belt of North Africa (Royal Botanic Gardens Kew, 2026). The species is especially common in Spain, Italy, Greece, Türkiye, Cyprus, as well as Morocco, Algeria, and Tunisia. In the Macaronesian archipelagos (Canary Islands, Madeira), populations show pronounced genetic and morphological differentiation, and it has been reported that B. bituminosa var. albomarginata—known as tedera—originated from these insular populations (Real, 2023).

The species is naturally distributed across a range of habitats within the Mediterranean climate zone, including semi-arid to arid rangelands, maquis clearings, roadsides, and rocky–calcareous slopes, demonstrating strong adaptation to these environments (Royal Botanic Gardens, Kew, 2026).

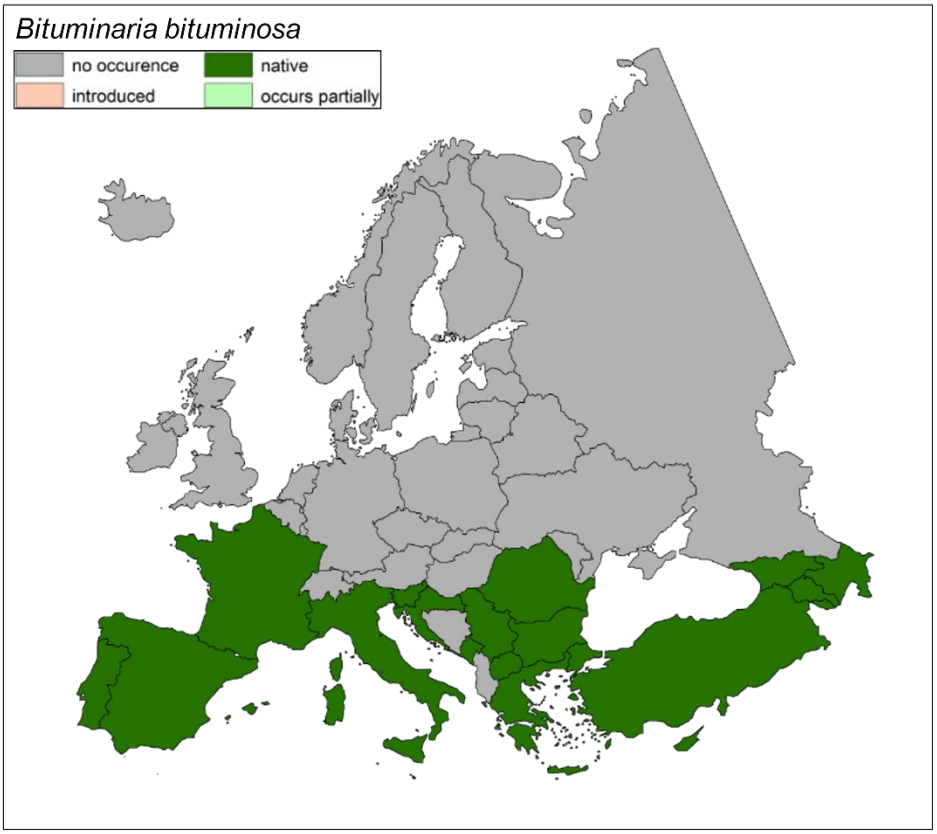


Figure 34: Distribution of Bituminaria bituminosa (L.) C.H. Stir. in Europe

Bituminaria bituminosa is a perennial legume naturally distributed across the Mediterranean biogeographic region, exhibiting strong adaptation to hot, dry, and semi-arid climatic conditions. The species demonstrates high ecological tolerance in stressful habitats, including rocky and calcareous slopes, stony terrain, maquis–garrigue openings, roadsides, rangelands, and nutrient-poor soils with low organic matter (Sternberg et al., 2006).

The species is considered an important forage plant in natural and semi-natural rangelands, as it retains green biomass longer than many competing species during drought periods (Sternberg et al., 2006). Adaptation trials conducted in the Mediterranean have further demonstrated that it maintains high survival and regrowth capacity even in arid regions receiving 250–450 mm of annual rainfall (Real, 2023; Fernández-Habas et al., 2025).

The species occurs between 0 and 1500 m elevation and shows no strict soil specificity; however, it prefers well-drained sandy, gravelly, and calcareous soils (GRIN-Global, 2026). Owing to its high drought tolerance, it can grow successfully even in low-fertility and degraded

soils. Its deep root system enables effective use of groundwater, contributing to the reduction of secondary salinity and the prevention of soil erosion (Beard et al., 2014). Its ability to grow in stressful environments such as roadsides, areas with topsoil loss, and forested habitats—together with its tolerance to a wide pH range (4.7–8.5) and its capacity to persist in calcareous, nitrogen-poor soils through biological nitrogen fixation—demonstrates the species' high ecological adaptability.

Bituminaria bituminosa is a perennial legume adapted to the Mediterranean climate, characterized by cool–wet winters and hot–dry summers. Its most distinctive trait is the ability to maintain green biomass for extended periods despite summer drought (Acar & Kaymak, 2020). The species exhibits moderate cold tolerance and produces seeds capable of germinating across a wide temperature range. Limited leaf shedding during summer–autumn and high water-use efficiency further contribute to its success in arid regions (Real, 2022).

A three-year study conducted on the Iberian Peninsula demonstrated that the tedera variety exhibited earlier phenological development and remained green throughout the summer, even under 24% reduced rainfall and competitive conditions (Fernández-Habas et al., 2025).

To reduce establishment risks, early sowing after the first autumn rains is recommended. A sowing depth of approximately 2 cm ensures optimal emergence. Under suitable conditions, some genotypes can produce 3–4 cuts per year.

Suitability for agricultural use

Bituminaria bituminosa is considered a valuable forage species for agricultural production and rangeland management in Mediterranean environments due to its high drought tolerance, ability to provide green biomass during critical periods, and long-lived perennial growth habit. Although Türkiye is one of the species' natural centers of distribution, research on its use in dry rangelands has increased only in recent years. The var. albomarginata form has gained prominence in breeding programs in Australia and the Mediterranean region, where registered cultivars have been developed (Real, 2023). Multi-

location trials have shown that tedera can markedly reduce forage scarcity by maintaining green biomass during summer–autumn, even in semi-arid regions receiving 250–450 mm of annual rainfall (Real, 2012; Fernández-Habas et al., 2024). This performance is associated with its deep root system and high water-use efficiency (Real, 2023). Key agronomic traits include a grazing-tolerant leaf–stem ratio, approximately 60% digestibility, and a crude protein content of 14–22% (Real, 2023). Although forage quality declines with advancing maturity, the reduction in leaf protein content remains limited (Acar et al., 2016). Its perennial growth habit, biological nitrogen fixation, and low input requirements make the species suitable for long-term rangeland management. Adaptation to calcareous and low-organic-matter soils broadens its potential use, while the presence of furocoumarins necessitates careful planning of grazing strategies (Walker et al., 2012).

Infobox

Bituminaria bituminosa is a perennial legume well adapted to the Mediterranean climate, characterized by high drought tolerance and the ability to maintain green foliage even during prolonged summer dryness due to its deep root system. Its limited leaf shedding contributes to the preservation of hay quality. The species is distributed across a broad geographical range and can grow successfully even in stressful habitats. Its ability to tolerate a wide pH range further enhances its ecological flexibility.

With a crude protein content of 14–22% and consistently high digestibility throughout the year, B. bituminosa provides green forage during summer–autumn in semi-arid regions, making it valuable for sustainable forage production. However, grazing should be managed carefully due to the presence of furocoumarins.

Overall, B. bituminosa holds strong potential as an alternative forage species in Mediterranean environments owing to its drought resistance, low input requirements, and adaptability to harsh and resource-poor soils.

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Hymenocarpos circinnatus (L.) Savi – Disk Trefoil

Systematics

Family: Fabaceae (legumes)

Subfamily: Faboideae

Tribe: *Loteae*

Genus: *Hymenocarpos*

Botanical Description

Hymenocarpos circinnatus (L.) Savi is an annual plant from the legume family, usually growing to 10 to 35 cm in height. It is sparsely hairy. It grows laterally but can also exhibit vertical growth, especially under competition (First et al., 2025). The leaves, branches, and stem are whitish-green. Internodes are 3-6 cm. The lower leaves are simple, while the upper leaves have two or three pairs of leaflets. The terminal leaflet is much larger than the lateral leaflets. The flowers are yellow-orange, umbrella-shaped. The plant has an average of 2 to 6 flowers. The calyx is stiffly hairy and toothed, much longer than the tube. The corolla is 5 to 7 mm long and yellow to orange (Turki et al., 2019).



Figure 35: Hymenocarpos circinnatus (L.) Savi (Photo: Ziarnek, 2017; CC BY-SA 4.0).

Hymenocarpos circinnatus (L.) Savi is a legume species with a high dormancy and its fruit containing two seeds (Tielbörger. & Petrü, 2010)]. The fruit is single-chambered; 2–2.5 cm long; 0.6–0.8 cm wide; 0.25 cm thick; It is a structure that is 2–9 times longer than its width. It is brown, tan or gray and purple in color and has a smooth surface texture. Its seeds are 1–3 mm long; 2–2.5 mm wide; 1 mm thick, asymmetrical; kidney-shaped, flattened and have a smooth surface (ITP, 2003).

Distribution and Habitat

It is limited to Old World regions in the Mediterranean, and some taxa extend to northern Europe, the Atlantic Islands, and northeastern Africa (Allan & Porter, 2000). It is mostly found in herbaceous plant communities together with other species. Its relatively large biomass gives it an advantage in plant communities. The fact that it has large seeds can also be interpreted as a defense mechanism against environmental risks. This, together with seed dormancy, allows it to survive in bad years at the expense of reduced reproductive success in good years (Petrů & Tielbörger, 2008). Although more common at lower altitudes, it has been observed up to 1500 meters. The plant flowers from March to May (Anon, 2008)

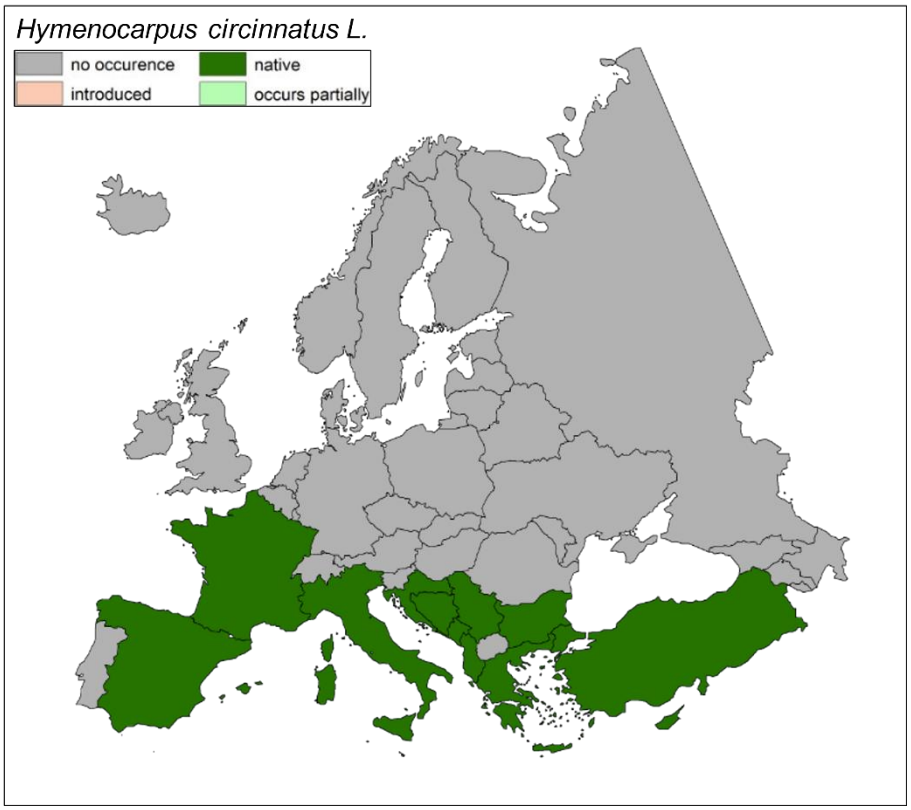


Figure 36: Distribution of Hymenocarpos circinnatus (L.) Savi in Europe (http://www.europlusmed.org).

Suitability for Agricultural Use

In the study conducted by Kara et al. (2024), it was reported that *Hymenocarpos circinnatus* (L.) Savi plants have 12.54% ash, 87.46% organic matter, 50.73% organic carbon, 19.50 C/N ratio and are rich in inorganic compounds such as Ca, Mg, K, Mn, Zn, Cu, Fe. Başaran et al. (2006) determined that the plant height varies between 40 – 55 cm, the protein content is 15% and the crude ash content is 13%. It is known that the species has seed dormancy and the germination rate varies between 5-20% (Petrů& Tielbörger, 2008).

Infobox

Hymenocarpos circinnatus (L.) Savi is an annual plant in the legume family, usually growing to a height of 10 to 35 cm. It is sparsely hairy. It grows laterally but can also exhibit vertical growth, especially under competition. Its flowers are yellow-orange, and its stems and

leaves are whitish-green. Widespread around the Mediterranean, some taxa of *Hymenocarpos circinnatus* (L.) Savi extend to northern Europe, the Atlantic Islands, and northeastern Africa. In these regions, it is mostly found in herbaceous plant communities together with other species.

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Lotus corniculatus L. - Common bird's-foot trefoil

Systematics

Family: *Fabaceae (legumes)*

Subfamily: *Faboideae*

Genus: *Lotus*

Botanical Description

Lotus corniculatus L. (Common bird's-foot trefoil) is a perennial herbaceous plant. It reaches a height of 10 to 40 cm, sometimes more when supported by other plants (up to 60 cm). The stem is highly branched, solid or with a narrow channel and thick walls. The leaves are odd-pinnate, almost sessile, five-leafed. The three upper leaves are obovate or oblong-oval in shape, the two lower ones are smaller and obliquely ovate. There are no stipules or tendrils. The root system is taproot, strongly developed, reaching a depth of 1.5 m (Nawara, 2006; Rutkowski, 2008).

The inflorescence is an umbel with 3-8 flowers. The flowers are 10-15 mm long, yellow to orange in colour, gathered on a fairly long stem and located at its top. The flower buds are tinged with red on the outside. The five green sepals are fused into a tube around the base of the petals. The flowering period lasts from June to September. It is pollinated by insects, most often by bees (Grynia, 1995; Nawara, 2006; Rutkowski, 2008).

The fruit is an elongated legume, 2-3 cm long, protruding from the stem. As it ripens, it twists into a spiral, which allows Lotus corniculatus L. to self-seed (Nawara, 2006).



Figure 37: Lotus corniculatus L. © Institute of Technology and Life Sciences - National Research Institute

Distribution and Habitat

Lotus corniculatus L. is a species with a wide distribution range. It originates from Europe, Asia and North Africa, and has also spread to North and South America, Australia and

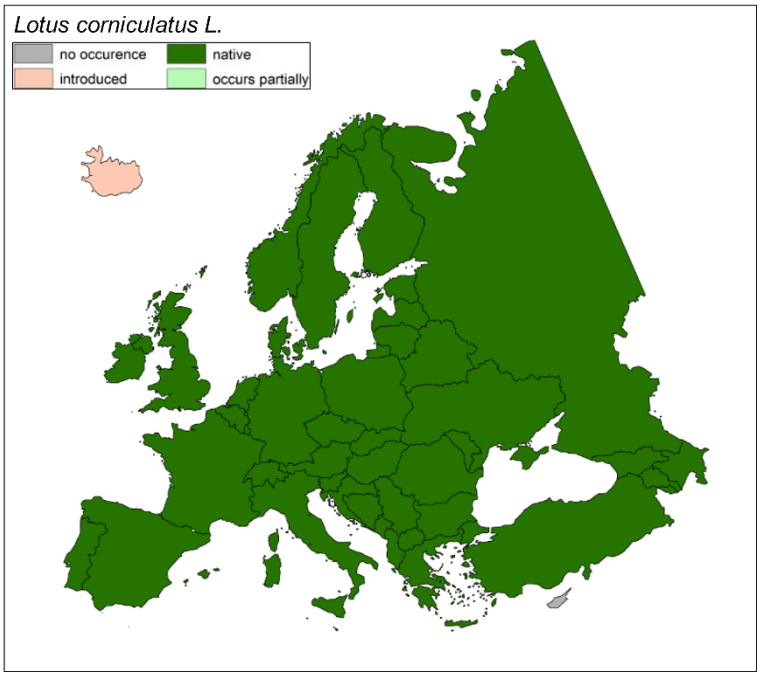


Figure 38: Distribution of Lotus corniculatus L. in Europe.

New Zealand. It is also cultivated in many countries around the world (Germplasm Resources Information Network).

It is a species found in moderately moist and dry meadows and pastures. It regrows well after mowing and tolerates trampling and grazing. It is most commonly found on sandy soils. It is adapted to nutrient-poor habitats with lower pH levels. It does not like shade. It is commonly found in lowlands and mountains up to the alpine zone (Grynia, 1995; Nawara, 2002).

Suitability for Agricultural Use

Lotus corniculatus L. is a valuable species with good nutritional value. It is characterised by a favourable chemical composition of basic nutrients and high digestibility, but it is less palatable than other legumes due to its bitter taste. It is used in mixtures for permanent meadows and pastures, although in small quantities. Animals are reluctant to eat it when fresh. The bitter taste disappears during drying. Milk obtained from cows fed with this plant contains significant amounts of vitamins A and E. This plant does not cause flatulence in cattle because its chemical composition, mainly in the leaves, contains condensed tannins. These compounds slow down the digestive processes in the rumen, preventing the release of large amounts of gas. Tannins also enable animals to make better use of protein. Tannins also have a deworming effect and prevent the occurrence of nematodes in the digestive tract of ruminants.

Lotus corniculatus is an important food plant for the caterpillars of various butterflies. (Thomas et al., 1999).

Infobox

Lotus corniculatus L. (Common bird's-foot trefoil) is a perennial herb with a stem 10-40 cm long (sometimes longer), spreading or erect, solid or with a narrow channel inside. The pinnate leaves consist of five parts. The yellow flowers form an umbel, consisting of 3-8 flowers, located at the top of the stem. After flowering, it develops into 2-3 cm long fruits that protrude from the stem, resembling “claws”. The species is adapted to nutrient-poor habitats

and occurs in meadows and pastures. It is used in agriculture as a forage plant. It is resistant to drought, grazing and trampling. It is also used in mixtures, but in small quantities due. When fresh, it is not very popular with animals due to its bitter taste, which disappears when dried. It produces fairly high yields of delicate hay (Grynia, 1995; Nawara, 2006; Rutkowski, 2008).

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Medicago lupulina L. - Black medic, hop clover

Systematics

Family: Fabaceae (legumes)

Subfamily: Faboideae

Tribe: *Farboideae*

Genus: *Medicago*

Botanical Description

Medicago lupulina is herbaceous biennial plant in the genus *Medicago*. It reaches growth heights of about 10 - 60 cm and has three-lobed leaves with a pointed tip on the central leaflet. At the beginning of growth the fine hairy stems often lie flat and erect later. The flowers are yellow and are collected in dense flower heads with up to 50 small flowers. The flowering period starts in May until October.

The upper surface is bald to matted. The leaflets are clasping, and completely fused. The young vegetative shoots stand in a rosette-like growth habit and are often hairy.

The thin spindle-shaped taproot reaches until medium depth and are colonized by bacteria on small nodules. This bacteria is only present on clover species (legumes) and so they are able to use atmospheric nitrogen (N_2) for nutrition.

The fruit is a very small (1,4 - 2,2 mm long, 1,1 - 1,5 mm wide) kidney shaped yellowish green seed, some fine hair may be present on the legume. It is usually ripening between June and September.



Figure 39: Flowering Medicago lupulina (left) and seeds (right) © AREC Raumberg-Gumpenstein

Distribution and Habitat

Medicago lupulina originated from the Mediterranean Basin, central and southern Europe as well as Africa (Ecocrop, 2017). It has been introduced to Moldova.

Medicago lupulina is found in lawns, pastures, cultivated fields, roadsides, disturbed areas (Darbyshire 2003). Black medic can grow from sea level up to an altitude of 2900 m in East Africa and up to 3600 m in the Himalayas (Ecocrop, 2017).

It grows in places where mean annual temperature is between 5.7°C and 22.5°C and annual rainfall is about 500-800 mm. However, it is tolerant of a much broader annual range of rainfall: 310 - 1710 mm (Duke, 1981). Black medick is undemanding in terms of soil type and produces the best yields on calcareous marl and loess soils.

Suitability for Agricultural Use

Like other medics, black medic yields a high amount of biomass and is an N-fixing legume. These traits are valuable in long rotations of forages and cash crops as well as in mixtures for cover cropping (Sanders et al., 2011). Black medic is palatable to livestock and has fair forage value.

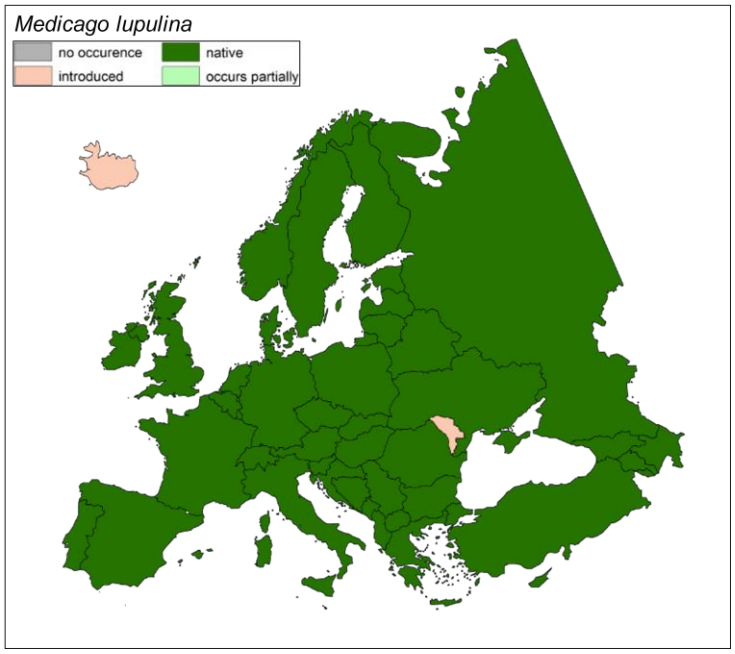


Figure 40: Distribution of Medicago lupulina L. İn Europe

It mixes well with grasses and clovers to make good quality forage (Duke, 1981). It is used to preserve soil moisture and prevent weed development thanks to its quick spring regrowth. In Austria, it has been referred to as a soil stabilizer of highway borders (Hanelt et al., 2001). Its resistance to biting and trampling when used as autumn pasture is particularly noteworthy (LfL, 2025).

Special ecological features

Medicago lupulina serves as source of nectar for wildbees and butterflies. Caterpillars of Polyommatus spp. feed on the leaves.

Infobox

Medicago lupulina originated from the Mediterranean Basin, central and southern Europe as well as Africa (Ecocrop, 2017). It has been introduced to Moldau. It reaches growth heights of about 10 - 60 cm and has a leaves three parted leaves with a pointed tip on the middle leaf. These traits are valuable in long rotations of forages and cash crops as well as in mixtures for cover cropping. Black medic is palatable to livestock and has fair forage value. It

also mixes well with grasses or other clovers to make good quality forage. It is used to preserve soil moisture and prevent weed development thanks to its quick spring regrowth. It has been referred to as a soil stabilizer of highway borders. Its resistance to biting and trampling when used as autumn pasture is particularly noteworthy.

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Medicago polymorpha L. – Burr medic

Systematics

Family: Fabaceae (legumes)

Subfamily: Faboideae

Tribe: *Trifolieae* (Small & Jomphe, 1989)

Genus: *Medicago*

Synonyms: *Medicago hispida* Gaertn., Medicago nigra (L.) Krock., Medicago denticulata Willd., Medicago apiculata Willd., Medicago polycarpa Willd. ex Godr. (Sales & Hedge, 2000)

Botanical Description

Medicago polymorpha is a winter-growing annual herbaceous legume (therophyte) characteristic of Mediterranean annual grasslands and agro-pastoral mosaics (Sales & Hedge, 2000; CABI, 2013).

Growth habit: plants are prostrate to ascending, with stems typically 10–50(–60) cm, branched from the base; shoots are usually glabrous or sparsely hairy (Sales & Hedge, 2000).

Leaves: Alternate, stipulate and trifoliolate; the central leaflet is distinctly petiolulate. Leaflets are obovate to obcordate with serration mainly on the upper third. Deeply laciniate stipules are a stable, field-useful character for identification (Sales & Hedge, 2000). In the CICYTEX selection ‘Aroche’, plants are described as vigorous, with comparatively large obovate leaflets and conspicuous white speckling, a selection trait within managed material (Galea-Gragera & Llera, 2025).

Flowers: axillary racemes bearing usually 2–8 small yellow papilionaceous flowers (~3–4.5 mm) (Sales & Hedge, 2000).

Fruits (seeds): the diagnostic fruit is an indehiscent spiralled pod ("bur") with about 1.5–6 lax coils, generally discoid to subcylindrical and commonly bearing hooked marginal spines (Sales & Hedge, 2000). Seeds are reniform, smooth, yellow to brown, typically ≈2.5–3.5 mm (Sales & Hedge, 2000). In the cultivar 'Aroche', the glomerules are spiny, the thousand-seed weight is 4.51 g, and hardseededness exceeds 80%, supporting persistence through a durable soil seed bank (Galea-Gragera & Llera, 2025).



Figure 41: Medicago polymorpha L. var. aroche. From left to right: trifoliolate leaves, yellow flowers, and a mature coiled spiny pod ("burr").

Distribution and Habitat

Medicago polymorpha is native to the circum-Mediterranean region and has become widely naturalised in temperate and Mediterranean-type regions worldwide (CABI, 2013; European and Mediterranean Plant Protection Organization (EPPO)). In Europe, Euro+Med PlantBase reports it across the Mediterranean region and as introduced/naturalised further north (Euro+Med PlantBase, 2006). Point occurrences and downloadable records are available through GBIF (GBIF Secretariat, 2026). In the Iberian Peninsula it is frequent in annual pastures, fallows, field margins and road verges, including dehesa-type silvopastoral systems (Sales & Hedge, 2000; González et al., 2009). It typically occurs on well-drained soils ranging from neutral to alkaline, though it tolerates moderate acidity (pH > 5.5) better than *M. truncatula*, depending on the ecotype and management (CABI, 2013).

Figure 42 (Euro-Mediterranean distribution) and Figure 43 (georeferenced occurrence records) can be used together to combine chorological coverage with point-based evidence (Euro+Med PlantBase, 2006; GBIF Secretariat, 2026).

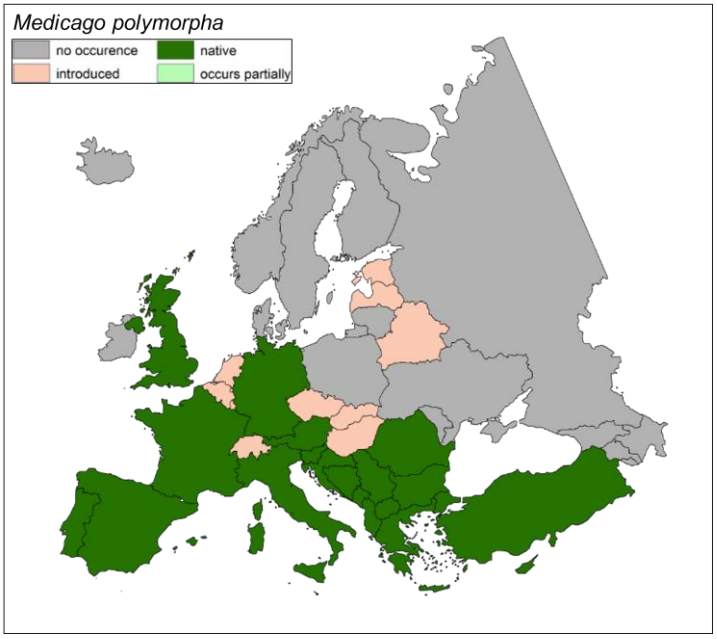


Figure 42: Euro-Mediterranean distribution of Medicago polymorpha L.

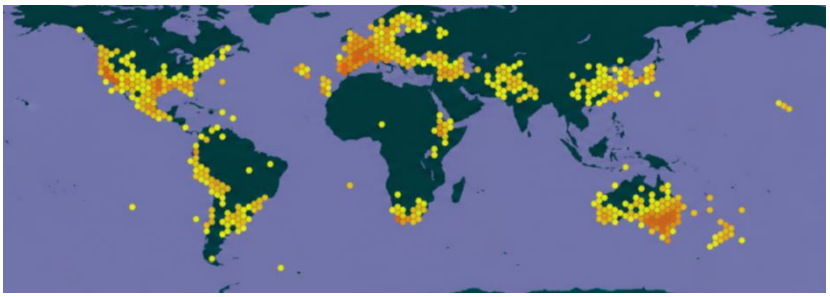


Figure 43: Global occurrence records of Medicago polymorpha L.

Suitability for Agricultural Use

Medicago polymorpha is a key self-reseeding annual legume in Mediterranean low-input grazing systems ("ley farming"), valued for winter–spring growth, grazing tolerance and nitrogen contribution through symbiosis (Porqueddu & González, 2006). Productivity varies

with rainfall and genotype; Mediterranean evaluations typically report rainfed yields of 0.5–3.5 t DM·ha^{-1}, occasionally higher in well-adapted accessions (Ovalle et al., 1997). In the CICYTEX selection 'Aroche', traits of agronomic interest include strongly spiny burs, high thousand-seed weight, and a very high proportion of hard seeds (>80%), which supports robust regeneration after summer and contributes to persistence under extensive grazing (Galea-Gragera & Llera, 2025).

Forage and seed quality: analytical results from the CICYTEX collection indicate forage crude protein ranges between 11–13.5% with moderate fibre levels (Llera et al., 2022), while seeds can exceed ~39% crude protein (Llera et al., 2023), supporting both spring forage value and a protein-rich summer seed resource in extensive systems.

Additional Uses and Constraints: Burr medic is also used as a winter cover crop in Mediterranean vineyards, improving ground cover and reducing erosion while avoiding summer water competition due to its short cycle (Porqueddu, 2000). However, grazing management must address two main constraints: (i) hooked burs can contaminate wool in strongly spined types; and (ii) the risk of ewe infertility caused by high phytoestrogen levels, particularly when pastures are infected by Phoma medicaginis or aphids. Therefore, pasture health should be monitored prior to mating (Barbetti et al., 2020; Omidvari et al., 2022).

Distinguishing Features from Similar Species

Field identification relies on fruit and leaf traits (Sales & Hedge, 2000):

Vs. *Medicago arabica*: easily distinguished by a dark anthocyanin spot in the leaflet centre and multicellular hairs on stems; *M. polymorpha* lacks spots and is glabrescent.

Vs. *Medicago truncatula*: fruits are cylindrical (barrel-shaped) with thick, adpressed spines; *M. polymorpha* burs are discoid to sub-cylindrical with thinner, hooked spines.

Special ecological features

Persistence Strategy: it relies on high hardseededness as a bet-hedging mechanism against false autumn breaks, maintaining a durable soil seed bank (Norman et al., 1998).

Edaphic Adaptation & Rooting: *M. Polymorpha* is sensitive to acidity (requiring pH > 5.5). However, in suitable soils, its roots can penetrate over 100 cm, allowing access to subsoil moisture unavailable to shallower-rooted clovers (Moreno Cruz & Gallardo Martínez, 1983).

Biotic Stress Response: fungal infection (e.g., Phoma) triggers the synthesis of coumestrol as a defense mechanism. While beneficial for the plant, these induced phytoestrogens pose a fertility risk to herbivores (Omidvari et al., 2022).

Infobox

Medicago polymorpha L. is a prostrate annual legume native to the Mediterranean, identified by its deeply laciniate stipules and spiny spiralled burs. Adapted to neutral-alkaline soils (pH > 5.5), it is intolerant of waterlogging, yet its deep root system (>100 cm) ensures drought survival. Grazing management should consider wool contamination by burs. Fungal stress (Phoma) can raise phytoestrogens to levels that risk reducing ewe fertility.

The CICYTEX variety 'Aroche' is noted for its white-marked leaflets and excellent winter production. It ensures persistence via large seeds with high hardseededness (>80%). While green forage quality is moderate, its seed bank provides a premium protein reserve (~39%) for summer grazing.

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Onobrychis sativa Lam. – Sainfoin

Systematics

Family: *Fabaceae (legumes)*

Subfamily: *Faboideae*

Tribe: *Hedysareae*

Genus: *Onobrychis*

Botanical Description

Sainfoin is a perennial, long-lived legume forage plant. Its upright, hollow stem grows to approximately 100–120 cm in height. Ten to thirty stems can emerge from a crown (Açıkgöz, 2021). The stem is reddish-brown in color and covered with hairs. The leaves are compound, containing 5–10 pairs of oppositely arranged, inverted egg-shaped leaflets along the leaf axis, with a single leaflet at the tip of the leaf axis (Collins et al., 2018). The lower surface of the leaflets is slightly hairy and the margins are smooth. The stipules are small, triangular, and pointed. Sainfoin has a deep taproot system with several main roots and numerous fine lateral roots bearing most of the rhizobial nodules (Frame, 2019).

It usually has darker red veins on a pink or light red background (Figure 44). The flower structure is largely cross-pollinated and is an excellent nectar source for honeybees. Sainfoin generally starts in late April and ends in late July (Davis, 1970).

The fruit is a small, flattened pod with a single seed and a semi-circular shape. The edge of the fruit shell is spiny in a protruding manner. The seed is bean-shaped and dark brown in color. It may contain hard seeds and the thousand seed weight is 17 - 32 g (Açıkgöz, 2021)



Figure 44: Onobrychis sativa Lam. (left) and seeds (right) ©Bilecik Şeyh Edebali University

Distribution and Habitat

The origin of Onobrychis spp. is Central and Southwest Asia and the Anatolian plateau. Cultivated forms spread from the 16th century onwards to Central Europe (especially to the regions of France and Germany with calcareous soils), then to North America and other temperate zone regions. In Turkey, it is widespread in almost every region (especially Central, Eastern and Southeastern Anatolia) (Frame, 2019). It can survive in a very wide range of altitudes from sea level to the borders of the alpine zone (2796 m) (Figure 45).

In the natural flora, sainfoin usually forms communities on sunny slopes, steppes, roadsides and open areas with limestone cliffs. It adapts to a wide range of soil and climate conditions, from arid regions with more than 330 mm of annual rainfall to irrigated soils. Its deep taproot system increases the plant's physiological resistance to water stress (Elçi, 2006) It prefers calcareous soils, but also grows in moderately acidic and alkaline soils, intolerant of

very acidic soils and prolonged waterlogging. It performs best in deep, well-drained calcareous soils with a pH level of 6.0 and above (Frame, 2019).

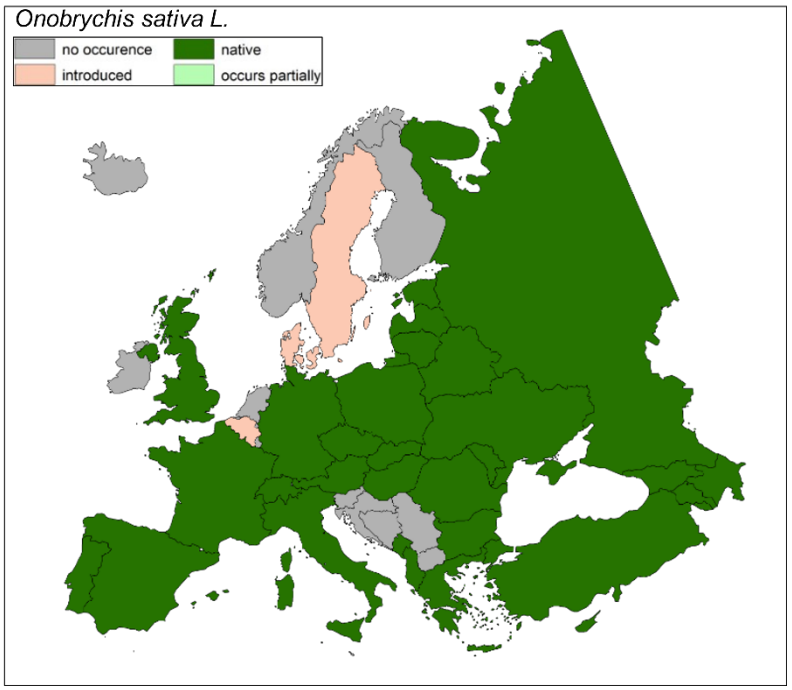


Figure 45: Distribution of Onobrychis spp. in Europe (http://www.europlusmed.org).

Suitability for Agricultural Use

Sainfoin is an important legume plant with approximately 16-25% crude protein in its hay and 35-37% in its seeds. The biggest advantage of sainfoin from an agricultural point of view is that it does not cause bloating when consumed fresh by ruminant animals. The condensed tannins in the plant prevent the excessively rapid breakdown of proteins in rumen fluid and prevent foam formation (Açıkgöz, 2021). This makes sainfoin one of the safest legumes for direct grazing in pastures. It forms compatible mixtures with many cool-season plants such as meadow fescue and dogtail. Dry hay yield can vary between 7 and 15 tons per hectare depending on growing conditions (Frame, 2019).

Sainfoin is also an important plant for beekeeping. Because its flowering period starts earlier than other legumes and its flowers have an attractive scent, it is among the plants preferred by bees for honey, pollen and nectar production.

Stand longevity can be improved by allowing plants to flower and set seed periodically, for example every 2–3 years, to promote natural reseeding. Sainfoin should not be mown or grazed before the early flowering stage, as early or severe defoliation can reduce plant reserves and weaken regrowth. (Collins et al., 2018). One of the main problems of sainfoin is rootworm. The larvae of insects called Bembecia scopigera and Sphenoptera carceli develop in the roots of the plant and feed by creating galleries, which causes the plants to die. The fact that the larvae live in the root collar of the plant and in the soil also makes chemical control difficult (Gül & ve Tan, 2024)

Infobox

Sainfoin (*Onobrychis sativa* Lam.) is a perennial legume forage plant native to Anatolia and Central Asia, reaching up to 120 cm in height with its erect stem. Possessing a deep taproot system, it thrives in a wide altitude range, up to 2796 meters above sea level, particularly on sunny slopes and in calcareous soils. Its pink-red veined flowers bloom between April and July, providing a rich nectar source for honeybees. A key feature that makes sainfoin unique from an agricultural perspective is its ability to prevent bloating in animals and allow for safe grazing thanks to its condensed tannins. Its dry hay contains 16-25% crude protein, while its seeds contain 35-37%. It can be cultivated in arid regions receiving more than 330 mm of annual rainfall.

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Ornithopus compressus L. – Yellow serradella

Systematics

Family: Fabaceae (legumes)

Subfamily: Faboideae

Tribe: *Loteae*

Genus: *Ornithopus*

Synonyms: *Ornithopodium compressum* (L.) All., *Coronilla compressa* (L.) E.H.L. Krause

Botanical Description

Ornithopus compressus is a winter-growing annual herbaceous legume (therophyte) characteristic of oligotrophic Mediterranean grasslands on acidic, sandy soils (Talavera & Arista, 1999; Galea-Gragera & Llera, 2025b).

Growth Habit: prostrate to ascending, often forming mats or rosettes; stems slender, usually 10–50(–75) cm, branched from the base (Talavera & Arista, 1999). A diagnostic trait is the indumentum: the entire plant is densely villous with short whitish hairs (Figure 46) (Talavera & Arista, 1999). In the CICYTEX cultivar ‘Mazagón’, the growth habit is described as semi-upright to upright, with good winter vigor (Galea-Gragera & Llera, 2025).

Leaves: alternate, imparipinnate (to ~10–12 cm), with 8–18 pairs of small oblong–elliptic leaflets (3–8 × 2–4 mm), hairy on both surfaces (Talavera & Arista, 1999).

Flowers: axillary umbels on long peduncles with 2–5 bright yellow papilionaceous flowers (6–8 mm). A key taxonomic character is the pinnate leafy bract immediately subtending the umbel, equalling or exceeding the flowers (Talavera & Arista, 1999).

Fruits (seeds): a laterally compressed, curved lomentum (18–42 mm) ending in a hooked “bird’s claw” beak; it breaks into indehiscent one-seeded segments at maturity (Talavera & Arista, 1999; Ovalle et al., 2006). Seeds are ~2 mm, yellowish to reddish-brown (Ovalle et al., 2006). In ‘Mazagón’, thousand-seed weight (TSW) is 4.72 g and hardseededness is ~65%, supporting persistence via a durable soil seed bank (Galea-Gragera & Llera, 2025).



Figure 46: Ornithopus compressus L. From left to right: imparipinnate leaves, flowers, and developing curved, laterally compressed pods (“bird’s foot”).

Distribution and Habitat

The species is native to the circum-Mediterranean region and Macaronesia, extending eastward into SW Asia (Euro+Med PlantBase, 2006-). It is widely naturalised in other Mediterranean-type climates, particularly southern Australia and Chile, where it has been adopted as a strategic annual pasture legume (Ovalle et al., 2006). Ecologically, it is calcifuge and favours open habitats (grasslands, field edges and vineyards) on deep, well-drained acidic sands or sandy loams, typically pH ~4.0–6.5, under low fertility where acidity can constrain more demanding legumes (Ovalle et al., 2006; Galea-Gragera & Llera, 2025). Global occurrence records provide point-based evidence of this broad distribution within those edaphic constraints (GBIF Secretariat, 2026).

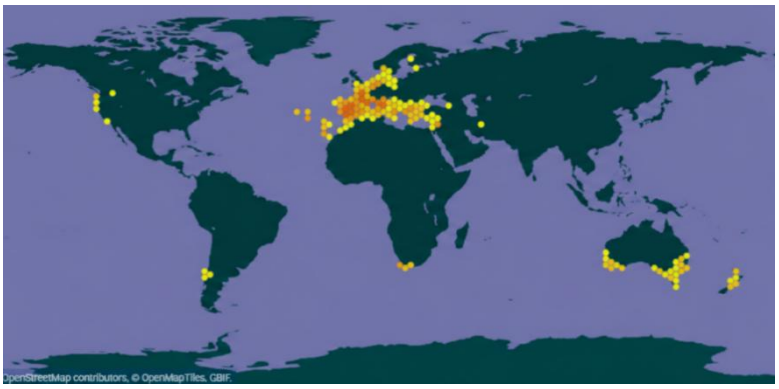


Figure 47: Global occurrence records of Ornithopus compressus L.

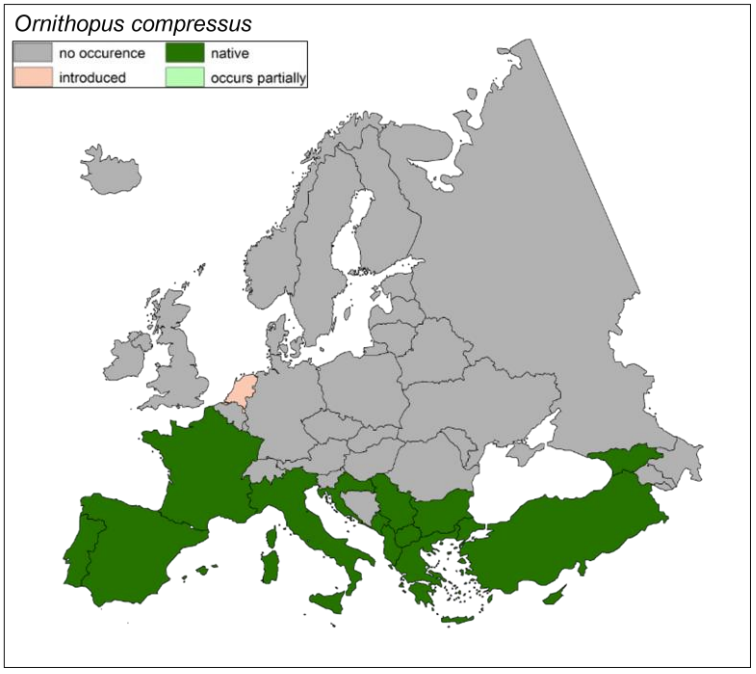


Figure 48: Euro-Mediterranean distribution of Ornithopus compressus L.

Suitability for Agricultural Use

Ornithopus compressus is valued as a self-reseeding annual forage legume for low-input systems on marginal acidic soils (Ovalle et al., 2006).

Nutritional quality: in the dehesa pasture-species classification, *O. compressus* forage is ranked as “First Class” based on quality indices (including RFV and crude protein) (Llera et

al., 2022). Seed analysis of the cultivar ‘Mazagón’ highlights a protein- and energy-rich summer reserve (37.19% crude protein; 7.53% crude fat) (Llera et al., 2023), supporting its role as a “protein bank” when green forage declines in summer.

Production and seasonal fit: as a winter-growing annual, it can extend grazing resources into late winter–spring on poor acidic sands (Ovalle et al., 2006). In Mediterranean-climate evaluations, it has shown good biomass potential in favourable years and contributes to ground cover, reducing erosion risks typical of bare sandy soils (Ovalle et al., 2006).

Added-value functions: inoculation with fungal endophytes (e.g., Byssochlamys spectabilis) has increased biomass (up to 42%) while affecting nutritive value and mineral accumulation (Santamaría et al., 2017). In degraded soils, its association with organic amendments (sewage sludge) has improved aggregate stability and supported structural remediation (Sandoval et al., 2011).

Persistence and regeneration: in ‘Mazagón’, hardseededness (~65%) contributes to a multi-year soil seed bank that buffers recruitment against “false breaks” in autumn rainfall (Galea-Gragera & Llera, 2025; Revell et al., 1999). Hard seeds can soften gradually depending on burial depth and seasonal conditions, stabilising re-establishment across years (Revell et al., 1999).

Constraints and management: it is sensitive to waterlogging, with significant reductions in root growth under hypoxia, so it should be used on well-drained sites (Ovalle et al., 2006; Kidd et al., 2020). Recent syntheses also highlight low bloat risk and low oestrogenic activity in serradellas, supporting safe grazing use in mixed pastures (Goward et al., 2025).

Distinguishing Features from Similar Species

Vs. *Ornithopus sativus*: pink/white flowers, less hairy, straight moniliform pods; O. compressus has yellow flowers, is densely villous, and has curved laterally compressed pods (Talavera & Arista, 1999).

Vs. *Ornithopus pinnatus*: glabrous, cylindrical pods, lacks the leafy bract; O. compressus retains the leafy bract (Talavera & Arista, 1999).

Special ecological features

Phosphorus Efficiency: comparative trials indicate lower phosphate requirements than wheat or subterranean clover to reach maximum yields, making serradellas suitable for low-input, P-limited sands (Paynter, 1990). A recent review reinforces their potential to diversify pasture systems on acidic soils with reduced fertiliser dependence (Goward et al., 2025).

Symbiosis: unlike many annual clovers, O. compressus forms specific symbioses with slow-growing Bradyrhizobium strains that can perform in acid soils (Tiwari et al., 2015). This specificity is agronomically relevant because effective nodulation is a frequent bottleneck in acidic environments.

Infobox

Ornithopus compressus is a winter-growing annual legume with dense villous hairs, bright yellow flowers subtended by a leafy bract, and curved, laterally compressed segmented pods ending in a hooked “bird’s claw”. Best adapted to deep, well-drained acidic sandy soils of low fertility; widely used as a self-reseeding pasture legume in low-input systems. The CICYTEX cultivar ‘Mazagón’ shows good winter vigour, a thousand-seed weight of 4.72 g and a high proportion of hard seeds, approximately 65%, supporting persistence and providing a summer protein reserve, with around 37% crude protein and 7.5% crude fat in the seed.

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Trifolium cherleri L. – Cupped clover

Systematics

Family: Fabaceae (legumes)

Subfamily: Faboideae

Tribe: *Trifolieae*

Genus: *Trifolium*

Synonyms: *Trifolium sphaerocephalum* Desf., *Trifolium involucratum* Lam., *Trifolium phlebocalyx* Fenzl ex Tchich., *Trifolium obvallatum* Moench (Zohary & Heller, 1984).

Botanical Description

Trifolium cherleri is a winter-growing annual herbaceous legume (therophyte) typical of Mediterranean dry grasslands. It is readily recognized by sessile flower heads enclosed within a protective stipular “cup” (involucre) formed by the upper leaves (Muñoz Rodríguez et al., 2000).

Growth Habit: stems 3–30 cm, slender, densely patent-pilose, prostrate to ascending (Muñoz Rodríguez et al., 2000). The CICYTEX variety ‘Sao Bento’ is markedly creeping (prostrate) and highly pubescent, favourable for ground cover in low-input, drought-prone sites (Galea-Gragera & Llera, 2025).

Leaves: alternate, stipulate, trifoliolate; leaflets small (to ~15 × 9 mm), obovate–obcordate, subsessile, pubescent on both surfaces (Muñoz Rodríguez et al., 2000). In ‘Sao Bento’, leaflets are typically uniform green without conspicuous dark central markings (Galea-Gragera & Llera, 2025).

Flowers: dense hemispherical heads (~12.5–24 mm), sessile within the stipular cup. Calyx tube with ~20–30 parallel veins is diagnostic (Muñoz Rodríguez et al., 2000). Corolla colour varies from white to pinkish in wild material; ‘Sao Bento’ shows white flowers (Galea-Gragera & Llera, 2025a).

Fruits (seeds): one-seeded legume enclosed by persistent calyx. In ‘Sao Bento’, TSW ~2.49 g and hardseededness ~61% (Galea-Gragera & Llera, 2025a), supporting physical dormancy and soil seed-bank persistence (Norman et al., 1998).



Figure 49: Trifolium cherleri L. From left to right: trifoliolate leaf, flowering head, and developed flower head

Distribution and Habitat

Trifolium cherleri is native to the circum-Mediterranean region, extending from Macaronesia through southern Europe and North Africa to West Asia (Galea-Gragera & Llera, 2025b). It is a highly rustic therophyte typical of open annual grasslands and low-input agro-pastoral mosaics, frequently associated with acidic to moderately acidic, nutrient-poor substrates, often of siliceous nature, where competitive perennial forage species are limited (Muñoz Rodríguez et al., 2000; Galea-Gragera & Llera, 2025b).

The CICYTEX accession/variety ‘Sao Bento’ is associated with strongly acidic conditions (pH 4.5–5.5) and clay-sandy soils according to passport data (Scoppola et al., 2018), consistent with its use potential in marginal low-input environments (Galea-Gragera & Llera, 2025a).

Figures 50 and 51 illustrate the distribution range. Figure 50 (Euro-Mediterranean distribution) and Figure 51 (georeferenced occurrence records) can be used together to combine chorological coverage with point-based evidence (Euro+Med PlantBase, 2006; GBIF Secretariat, 2026).

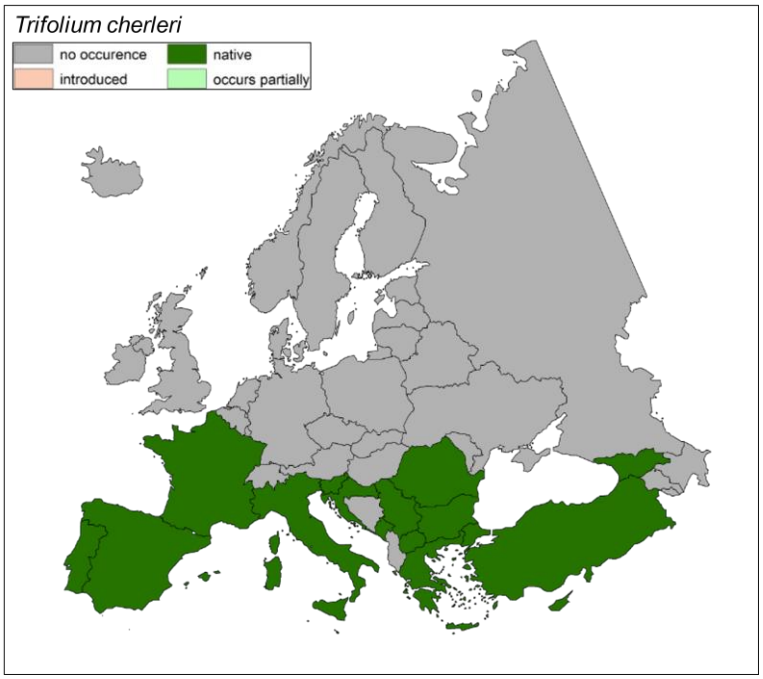


Figure 50: Euro-Mediterranean distribution of Trifolium cherleri L.



Figure 51: Global occurrence records of Trifolium cherleri L.

Suitability for Agricultural Use

Trifolium cherleri is a self-reseeding annual forage legume valued for rehabilitating marginal, acidic, and sandy soils.

Forage: In dehesa pasture assessments, crude protein around 13.36% and relatively high fibre (NDF ~48.88%) suggest best use in mixtures rather than as a sole legume (Llera et al., 2022).

Functional value: A study reported that T. cherleri had a good content of total antioxidants, including non-enzymatic antioxidants, suggesting added functional value beyond basic nutritive parameters (Robles Cruz et al., 2017).

Seed quality: seeds can act as a strategic summer feed resource in Mediterranean systems where green biomass collapses after spring. CICYTEX analyses report ~35.63% crude protein, ~4.46% crude fat and low crude fibre (~10.17%), supporting high digestibility during the dry season (Llera et al., 2023).

Distinguishing Features from Similar Species

Distinguished from other hairy annual clovers (e.g., *T. hirtum, T. striatum, T. scabrum*) by sessile heads enclosed in a stipular "cup" plus a calyx tube with ~20–30 veins (Muñoz Rodríguez et al., 2000; Zohary & Heller, 1984). 'Sao Bento' also shows a creeping habit and white flowers (Galea-Gragera & Llera, 2025a).

Special ecological features

Hardseededness (~61% in 'Sao Bento' (Galea-Gragera & Llera, 2025a)) is a bet-hedging strategy that maintains a persistent soil seed bank, buffering establishment against "false breaks" (Norman et al., 1998). As a Trifolium, it contributes to soil fertility via nitrogen fixation; rhizobial symbionts in Mediterranean systems include Rhizobium leguminosarum (Villadas et al., 2017). Global-change sensitivity: Biomass and nutritive quality can be affected by elevated tropospheric ozone and nitrogen deposition (Sanz et al., 2014).

Infobox

Trifolium cherleri is a winter-growing annual Mediterranean clover distinguished by hairy stems and sessile flower heads enclosed in a leafy stipular "cup". The CICYTEX selection 'Sao Bento' is creeping and highly pubescent, adapted to strongly acidic, nutrient-poor siliceous soils (passport pH 4.5–5.5). It provides moderate winter forage (~13% crude protein) and a protein-rich summer seed reserve (~35.6% crude protein; ~4.5% crude fat), with high hardseededness (~61%) supporting persistence through a durable soil seed bank.

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Trifolium fragiferum L.- Strawberry clover

Systematics

Family: Fabaceae (legumes)

Subfamily: Faboideae

Tribe: *Trifolieae*

Genus: *Trifolium*

Botanical Description

Strawberry clover (*Trifolium fragiferum* L.) is a perennial, long-lived legume forage species with a prostrate, stoloniferous growth habit. The stems form stolons 30–40 cm long, and in addition to a primary taproot, secondary roots develop from stolon nodes, allowing the plant to spread widely (Forde et al., 1981; Frame, 2005). Leaves consist of three rounded leaflets, 5–15 mm in length, with equal petiolules; some ecotypes show faint crescent- or pale green V-shaped markings, while others lack distinct markings. Leaflet margins are finely serrated, and stipules are large, reddish, ovate, and pointed (Zohary & Heller, 1984; Frame, 2005).

Flowers are dirty white to pinkish and borne on peduncles 10–20 cm long, exceeding the leaf petioles. The inflorescences are spherical, and after fertilization the swollen calyx forms a reticulate pattern. Mature flower heads exceed 2.4 cm in diameter, are pink, and resemble a strawberry (Elçi, 2005). The fruit is compound, with two-seeded pods; seeds are 1.2–1.6 mm long, light to reddish brown in color, and have a thousand-seed weight of approximately 0.9 g (Manga et al., 2003; Frame, 2005; Figure 52).



Figure 52: Trifolium fragiferum L.: (a) whole plant; (b) leaf; (c) primary taproot with secondary roots including nodules; (d) stolon rooting at nodes with daughter plantlets; (e) flower head cross-pollinated by a honeybee; (f) seed. Source: Smith et al. (2023).

Distribution and Habitat

Strawberry clover (*Trifolium fragiferum* L.) is native to Europe, other Mediterranean regions, and Western–Central Asia, and has also been recorded in Ethiopia (Zohary & Heller, 1984). This distribution is supported by passport data from 480 geo-referenced wild populations, including information on climate, altitude, and soil characteristics (Genesys, 2022). Outside its native range, the species has been introduced to Australia, New Zealand, and the western United States; in Australia, the widely used cultivar ‘Palestine’ was introduced

in 1929 from Zimbabwe and originated from an Israeli ecotype (Barnard, 1972; Townsend, 1985; Frame, 2005).

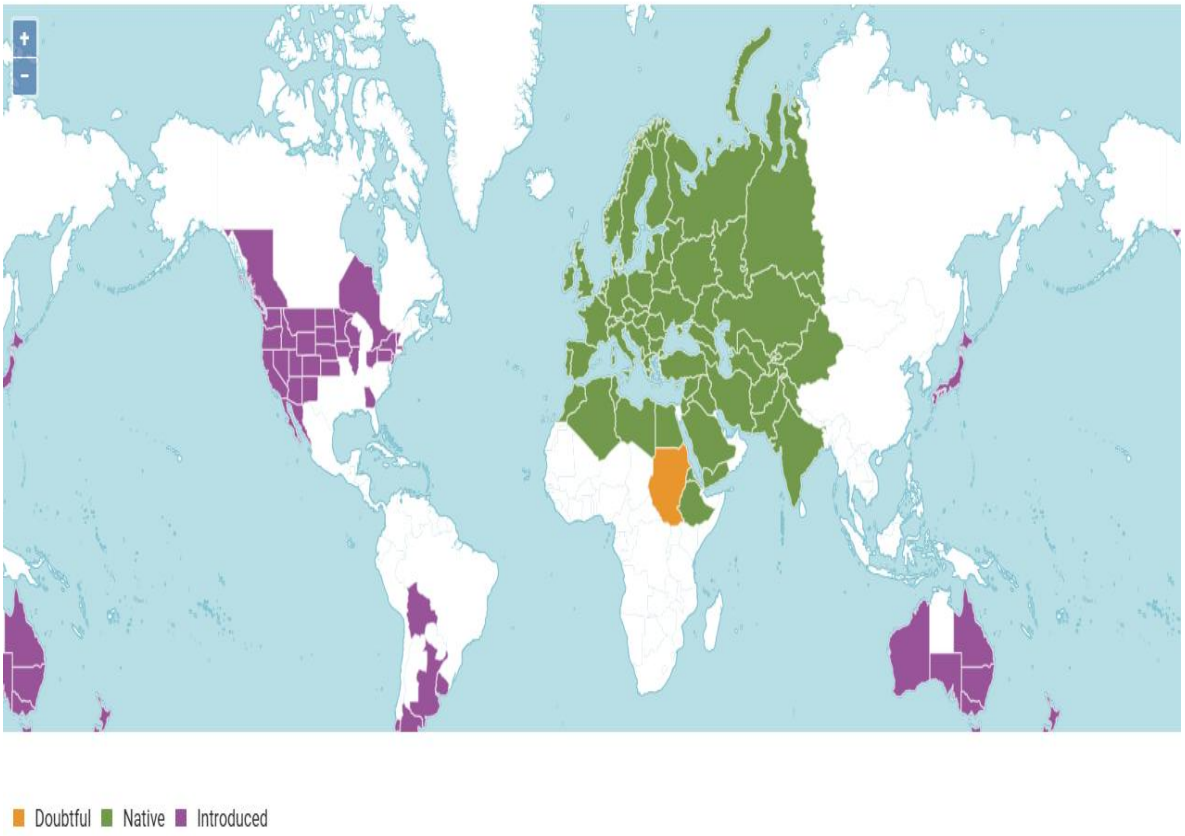


Figure 53: Global distribution map of Trifolium fragiferum L. (Source: Mifsud, 2002).

Strawberry clover (*Trifolium fragiferum* L.) is primarily a temperate species but can also adapt to warm and moderately dry environments. It shows optimal growth under cool, moist, and highland conditions and has high winter hardiness. The species is well adapted to moist, saline, and alkaline soils, tolerates poor drainage and flooding for up to two months, and maintains growth on heavy soils, wet meadows, coastal grasslands, and lowland pastures (Davis, 1970; Gençkan, 1983; Manga et al., 2003; Açıkgöz, 2021).

Compared with white clover, strawberry clover exhibits higher salinity tolerance and better adaptation to coastal saline environments, although dry matter yield may decrease by about 50% at 21 dS m^{-1} salinity (Can et al., 2013; Duminš et al., 2021). Its tolerance to waterlogging is associated with strong adventitious and lateral root development, whereas

seedlings are sensitive to soil acidity (Pires et al., 1992; Rogers & West, 1993; Rogers et al., 2009). Strawberry clover also shows greater drought tolerance than white clover, responds well to summer rainfall, recovers rapidly after drought, and forms an effective symbiosis with Rhizobium leguminosarum bv. trifolii (Dear et al., 2003; Drew et al., 2012; Nichols et al., 2008; Milne, 2011).

Suitability for Agricultural Use

Strawberry clover is a pasture species with high forage value, with crude protein content ranging from 13% to 26% depending on maturity and environmental conditions (Smith et al., 2023). Although it is less tolerant of heavy grazing than white clover, its strong regrowth capacity and high palatability make it suitable for moist pasture systems.

The species can be grown on saline soils requiring continuous ground cover under controlled grazing. Its persistence is ensured by stolons and seedling recruitment from shed seeds, supporting long-term stand survival (Manga et al., 2003). Strawberry clover contains very low levels of phytoestrogens and does not accumulate high concentrations of estrogenic isoflavones (Francis et al., 1967).

Strawberry clover readily forms mixtures with grass species and contributes to pasture sustainability. Its spreading growth habit reduces soil surface temperatures during summer and improves the persistence of companion species in mixed swards (Hayes et al., 2021). It can be grown with perennial ryegrass (*Lolium perenne*), Kentucky bluegrass (*Poa pratensis*), and red fescue (*Festuca rubra* L.), and is also beneficial in alfalfa (*Medicago sativa* L.) stands affected by periodic waterlogging (Dear et al., 2010).

The flowering period may extend from mid-spring to autumn under favourable conditions, and the flowers are visited by honeybees (Dodd & Orr, 1995; Forde et al., 1981; Somerville, 2019). Strawberry clover provides effective ground cover and is used in turf and turfgrass mixtures, including the cultivar ‘Fresa,’ as well as a cover crop in vineyards and orchards for weed control (Baltensperger et al., 1982; Baltensperger & Gaussoin, 1984).

Distinguishing Features from Similar Species

The most distinctive botanical feature of strawberry clover is the pronounced swelling of the calyx after flowering, forming a fleshy, spherical, strawberry-like structure. This characteristic allows *T. fragiferum* to be readily distinguished from other Trifolium species under field conditions.

Special Ecological Features

Infobox

Strawberry clover (*Trifolium fragiferum* L.) is a perennial, long-lived legume forage species with high palatability and continuous growth, making it an important pasture plant. Its crude protein content ranges from 13% to 26%. The species is highly tolerant of salinity and is well adapted to heavy soils, wet meadows, coastal grasslands, and lowland pastures, where it can grow throughout the year. Strawberry clover provides effective ground cover and is used in turf and turfgrass mixtures, as well as a cover crop in vineyards and orchards for weed control.

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Trifolium meneghinianum Clem. – Gelemen Clover

Systematics

Family: Fabaceae (legumes)

Sub-Family: Faboideae

Tribe: *Trifolieae*

Genus: *Trifolium*

Botanical Description

Gelemen clover (*Trifolium meneghinianum* Clem.) is an annual herbaceous legume species naturally occurring in the Black Sea Region of Türkiye. Morphological observations carried out on plants growing under natural conditions indicated that the average plant height was 69.34 cm (Tokluoğlu and Tekeli, 1982). The species develops a taproot system, with an average root length of 23.51 cm (*Okumuş*, 1990).

Leaves are trifoliolate, and the number of leaves per plant ranges between 3 and 5. Inflorescences are characteristic of the genus Trifolium, forming compact flower heads. Each inflorescence contains approximately 85–100 flowers. The flowers exhibit typical papilionaceous morphology. Flowering and reproductive development were observed under natural field conditions (*Okumuş*, 1990).

The fruit is a legume. Seeds are small, and seed retention was reported to be 99%. The thousand-seed weight was determined to be approximately 0.645 g. Dry matter content of the plant was measured as 19.7%, crude protein content as 13.35%, and crude ash content as 8.6% (*Okumuş*, 1990).



Figure 54: Gelemen clover seeds and plant habit (Source: Çankaya et al., 2022).

Distribution and Habitat

Trifolium meneghinianum is native to the Eastern Mediterranean and Western Asia and is considered an endemic or near-endemic species to Anatolia and its surrounding regions. In Türkiye, the species is naturally distributed mainly in the Black Sea Region, particularly in and around the Samsun–Gelemen plain, as well as in parts of Central Anatolia (Çankaya et al., 2022).

The species typically occurs in natural and semi-natural grasslands, meadows, pasturelands, field margins, and lightly disturbed habitats. It is generally found at low to medium altitudes, ranging from sea level up to approximately 1200 m. Gelemen clover prefers fertile, well-drained soils but can also tolerate moderately heavy alluvial soils common in coastal plains (Williams and Nichols, 2010).

Climatically, the species is well adapted to temperate and semi-humid environments. It benefits from adequate spring precipitation and shows good tolerance to cool winter conditions, which supports its persistence and regular regeneration in natural grassland systems.

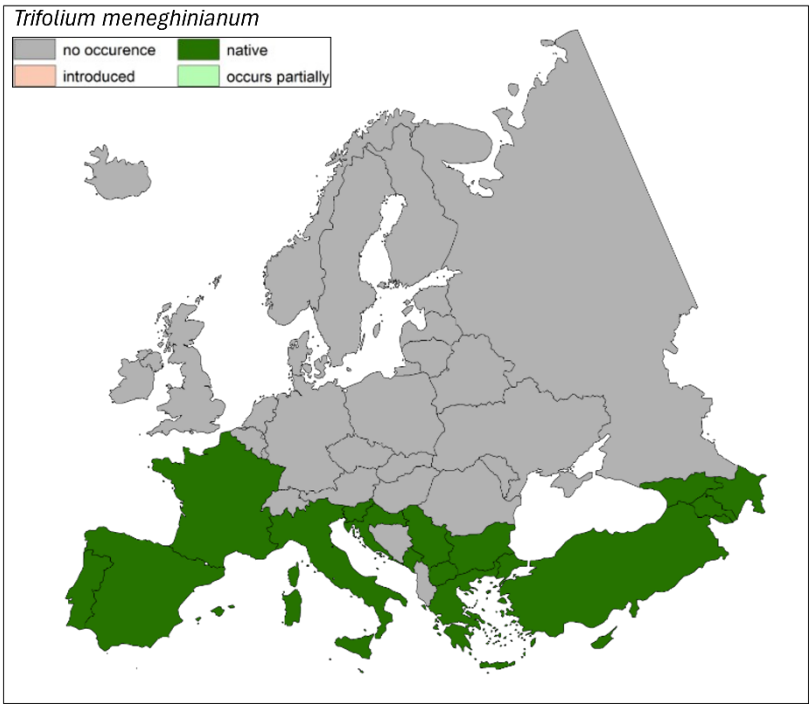


Figure 55: Distribution of Trifolium meneghinianum Clem. in Europe

Suitability for Agricultural Use

Trifolium meneghinianum Clem. is a naturally occurring clover species with practical importance for forage production in lowland grassland systems. The species shows early growth and the ability to establish under a wide range of soil conditions, allowing it to contribute to forage availability at an early stage of the growing season (Başaran et al., 2006).

The species exhibits a prostrate to erect growth habit, with main stem length ranging from 40 to 110 cm. Due to its high seed production capacity, T. meneghinianum is able to maintain stable populations under natural conditions (Başaran et al., 2006).

In lowland areas, naturally growing stands of Gelemen clover are commonly harvested by farmers and utilized as roughage. This practice demonstrates that the species is already used as a forage resource within natural and semi-natural grassland systems (Başaran et al., 2006).

Distinguishing Features from Similar Species

Trifolium meneghinianum Clem. (Gelemen clover) can be distinguished from other clover species occurring in natural grasslands by a combination of growth habit, stem length, flower colour, and seed production capacity. According to field observations, the species exhibits a prostrate to erect growth form, whereas some other Trifolium species show predominantly prostrate or strictly erect growth habits.

The flowers of *T. meneghinianum* are white in colour, which differentiates it from several commonly associated clover species such as *Trifolium pratense* L., characterized by pink flowers, and *Trifolium repens* L., which generally shows a creeping growth habit. The main stem length of *T. meneghinianum* ranges from 40 to 110 cm, placing it among the relatively taller clover species present in natural vegetation (Çankaya et al., 2022).

In addition, Gelemen clover is characterized by early growth and a high seed production capacity. This feature distinguishes it from some other clover species occurring in the same habitats and contributes to its persistence and frequent occurrence in lowland grassland areas (Başaran et al., 2006).

Special Ecological Features

Trifolium meneghinianum Clem. is characterized by early growth and the ability to establish under a wide range of soil conditions. This ecological flexibility allows the species to occur naturally in different habitats, particularly in lowland areas (Başaran et al., 2006).

The species exhibits a prostrate to erect growth habit, which enables it to adapt to varying environmental conditions within natural grassland vegetation. One of the notable ecological features of Gelemen clover is its high seed production capacity, which supports its persistence and widespread occurrence under natural conditions (Başaran et al., 2006).

Due to these characteristics, *T. meneghinianum* is frequently encountered in natural and semi-natural grasslands, where it maintains stable populations without cultivation (Başaran et al., 2006).

Infobox

Gelemen clover (*Trifolium meneghinianum* Clem.) is an annual clover species naturally occurring in grassland ecosystems. The species exhibits a prostrate to erect growth habit, with main stem length ranging from 40 to 110 cm. Flowers are white in colour, and the species is characterized by early growth and a high seed production capacity.

Gelemen clover contains moderate crude protein levels (16.23%) and is commonly utilized as roughage in lowland areas where naturally growing stands are harvested by farmers. Owing to its adaptability to different soil conditions and stable persistence under natural conditions, T. meneghinianum represents an important forage component of natural and semi-natural grassland systems.

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Trifolium pratense L. - Red clover

Systematics

Family: *Fabaceae (legumes)*

Subfamily: *Faboideae*

Tribe: *Trifolieae*

Genus: *Trifolium*

Botanical Description

The legume reaches a height of 15 - 45 cm and the entire plant is slightly hairy with typical trifoliate leaves. The leaflets are sessile, ovate and often marked with a light-colored "angle" on the upper surface. The inflorescences are light to dark red flower heads, the single flowers are tubular formed. The fruit is a very small (2 - 3 mm long, 1,1 - 1,5 mm wide) kidney formed yellowish to reddish seed. It has an upright growth habit and no runners for vegetative propagation. The taproots of *Trifolium pratense* are deep and help to withstand dry periods. Furthermore Red clover lives in symbiosis with rhizobia bacteria and can fix up atmospheric nitrogen from the air for yield formation (Krautzer et al., 2017).



Figure 56: Flowering Trifolium pratense (left), its habit in an reseeded meadow (middle) and seeds ©AREC Raumberg-Gumpenstein

Distribution and Habitat

The red clover is native to Europe and its introduced to Iceland. In less intensive grassland there are wild types, breeding varieties are used and distributed in intensively used meadows and leys. It grows in non-alpine and non-saline Grasslands, Alpine-subalpine and arctic grassland. It prefers deep, humus-rich soils or mineral soils with pH values of 5.5 or higher. It is a characteristic species of intensively used meadows and leys due to it's high fodder value

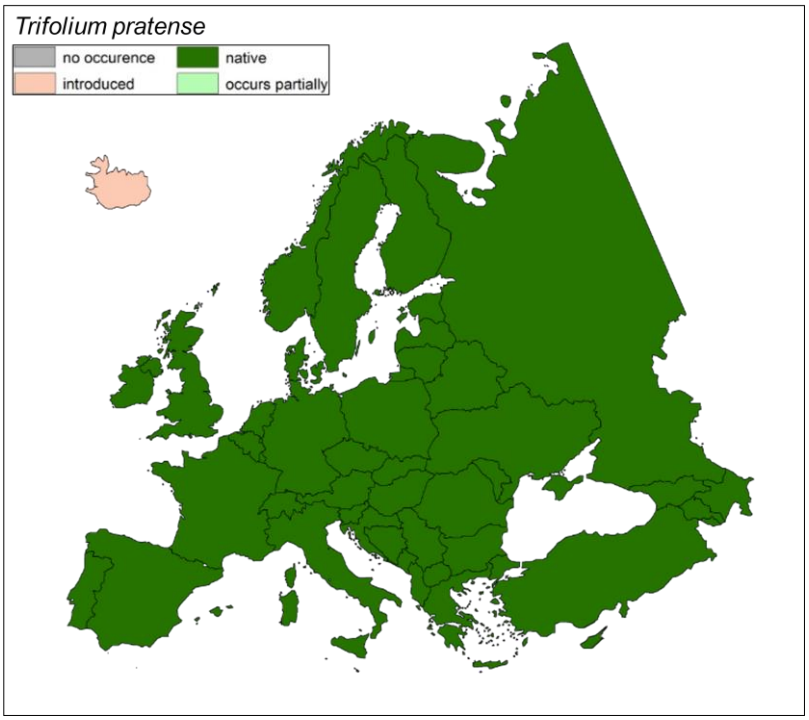


Figure 57: Distribution of Trifolium pratense L. in Europe

Suitability for Agricultural Use

Agriculturally, it has a high fodder value and provides protein for livestock nutrition. Among forage legumes, it is the second most important worldwide after alfalfa. Red clover, especially in forage mixtures, delivers high yields with excellent forage quality. Subspecies of red clover occur naturally in permanent meadows that are used no more than two to three times a year and reach seed maturity at least once annually (Krautzer et al., 2017).

It it best suitable for ensiling and, when young, as green fodder. At field drying there it is prone to crumbling losses of its high in protein leaves (EAGFF, 2026).

Special ecological features

Trifolium pratense serves as fodder plant of bumblebees and for caterpillars of Lycaenidae butterflies.

Infobox

Subspecies of red clover occurs naturally in permanent meadows that are used no more than two to three times a year and reach seed maturity at least once annually. Agriculturally, it has a high fodder value and provides protein for livestock feeding. It is tolerant against frequent cutting - up to five cuts. It it particularly suitable for ensiling and, when young, as green fodder. At field drying there it is prone to crumbling losses of its high in protein leaves.

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Trifolium repens L. – White clover

Systematics

Family: *Fabaceae (legumes)*

Subfamily: *Faboideae*

Tribe: *Trifolieae*

Genus: *Trifolium*

Botanical Description

Trifolium repens L. is a perennial, long-lived legume forage plant. Growing prostrate, the plant reaches a height of 20-40 cm, and a single plant can cover an area of 1 m in diameter with stolons. The leaves are compound leaves consisting of 3 leaflets. The leaflet stalks are equal. The leaflets are 2-3 cm in size, round or slightly oval, and have serrated edges (Kuo et al., 2024). A V-shaped white spot is present on the leaflets (Figure 58). The leaves are generally smooth and glossy dark green. The stipules are small, triangular, whitish in color, with smooth edges and pointed tips. It has a taproot that does not penetrate very deeply. However, the root system of the plant varies considerably, from forms with a large taproot containing a small number of lateral roots to forms without a large taproot but with a high proportion of lateral roots (Caradus, 1977).



Figure 58: Trifolium repens L. leaves (left), flowers, and seeds (right) ©Bilecik Şeyh Edebali University

The inflorescence is a globose head borne on a long peduncle. 40-100 flowers are attached to the end of a long stalk emerging from the leaf axils by pedicels. The flowers are quite small, the petals are usually white, sometimes light pink. The pollinated flowers in the clusters turn downwards (Figure 58). White clovers usually start flowering in early spring (March-April) and can continue until early autumn (September-October) (Davis, 1970).

The fruit is quite small. It contains 2-6 seeds (Açıkgöz, 2021). The seeds are heart-shaped, bright yellow or red in color. The color darkens in older seeds. They may contain hard seeds and the thousand seed weight is about 0.5-0.6 g (Açıkgöz, 2021).

Distribution and Habitat

The white clover is native to Europe and the Near East. It is a native species throughout almost all of Europe. It is found naturally in every country from the northernmost part of the continent (Scandinavia) to the southernmost (Mediterranean islands). It is only believed to have been introduced to some extreme northern regions, such as Iceland, by human intervention (Figure 59).

With its wide distribution and high nutritional quality, white clover is a perennial legume forage plant found in both natural and artificial grasslands (Ek et al., 2021). Although it is a highly adaptable plant, white clover shows its best development in heavy and medium-heavy soils. It prefers loamy, clay-loamy and well-drained soils (Özyazıcı, et al., 2021). Due to its low water-holding capacity in sandy soils, and because its roots are superficial (concentrated at a depth of 0-20 cm), it quickly becomes subject to drought stress (Demirkol, 2022). It is one of the most resistant legume species to areas with high groundwater levels (Collins et al., 2018). It is reported to be much more tolerant to short-term flooding and poorly drained soils than common alfalfa (Medicago sativa) (Açıkgöz, 2021). The optimal pH range for both mineral uptake by the plant and the activity of Rhizobium trifolii bacteria in its roots is stated to be 6.0 to 7.0 (neutral or slightly acidic) (Collins et al., 2018). White clover is moderately sensitive to soil salinity. Increased soil salinity negatively affects stolon elongation and leaflet size by creating osmotic stress (Vălușescu et al., 2022). It is quite tolerant to cold.

White clover has found its habitat above 900 m in England, 2220 m in the Alps, 6000 m in the Himalayas, 1800 m in Hawaii and 2200 m in Australia. It is widespread in the mountains of the Mediterranean region, but is only found in the plains in particularly humid places (Burdon, 1983)

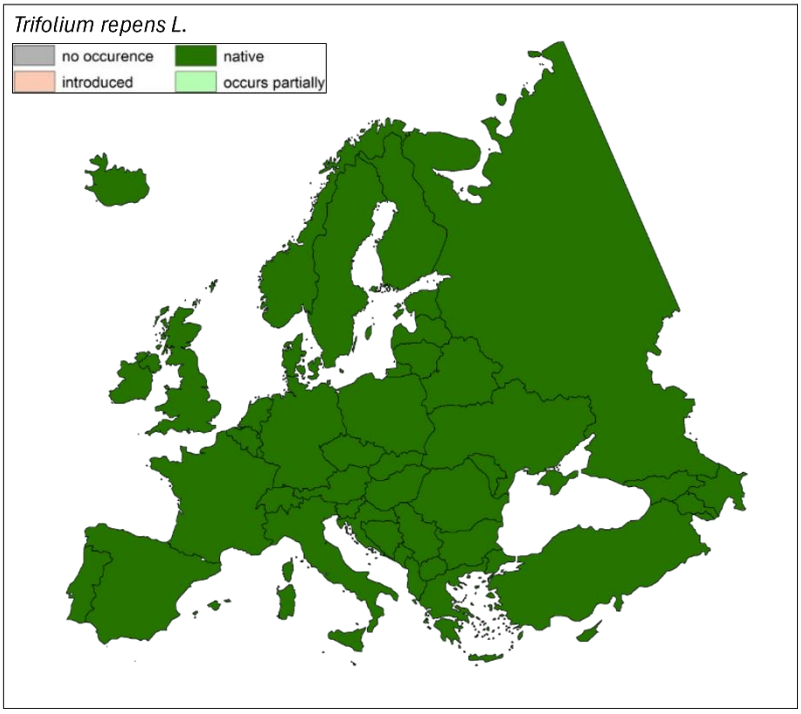


Figure 59: Distribution of Trifolium repens L. in Europe (http://www.europlusmed.org).

Suitability for Agricultural Use

White clover is one of the forage plants with the highest protein content and digestibility In forage, crude protein can reach approximately 20% of dry matter, although this value varies depending on phenological stage, growing conditions and management (Açıkgöz, 2021). Furthermore, its low fiber content and high soluble carbohydrate content make it readily consumed by animals. Unlike many other legumes, it largely retains its digestibility even during the flowering period. The main agricultural advantage that distinguishes white

clover from many other legumes is its stoloniferous growth habit. Thanks to its stolons, the growing points remain close to the soil surface and often escape direct damage during grazing, allowing the plant to regenerate rapidly when sufficient moisture is available. White clover is therefore particularly valuable in moist pastures, temperate grasslands, irrigated swards, or systems with adequate soil moisture, where it shows high tolerance to grazing and trampling. However, its persistence may be limited in extensive Mediterranean rainfed systems, such as dehesa-type pastures, due to summer drought and its relatively shallow root system (Frame, 2019). This feature also meets the nitrogen needs of the grasses it grows with (Açıkgöz, 2021). It usually grows in perfect harmony with grasses such as Kentucky Bluegrass (*Poa pratensis*) or perennial ryegrass (Lolium perenne). These mixtures also reduce the risk of bloating that may occur in animals. They develop rapidly in the spring months (Manga et al., 2003). They continue to grow in the summer months when the yield of cereals decreases (if there is sufficient soil moisture) and fill the "summer gap" in pastures.

Infobox

White clover is a perennial legume forage plant native to Europe and the Near East, capable of covering an area of 1 m in diameter on the soil surface and reaching a height of 20-40 cm thanks to its stoloniferous growth habit. Ecologically adaptable, this species can be found up to 6000 m above sea level. Its stolonous structure makes it resistant to grazing and trampling, and it is particularly important in sustainable pasture management when mixed with grasses.

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Trifolium subterraneum L. *subsp. brachycalycinum* – Subterranean clover

Systematics

Family: Fabaceae (legumes)

Subfamily: Faboideae

Tribe: *Trifolieae*

Genus: *Trifolium* L. (Muñoz Rodríguez, 2000; Zohary & Heller, 1984)

Species: *Trifolium subterraneum* L. (Muñoz Rodríguez, 2000; Zohary & Heller, 1984)

Subspecies: *Trifolium subterraneum* L. subsp. *brachycalycinum* (Zohary & Heller, 1984)

Synonyms: *Trifolium brachycalycinum* (Katzn. & Morley) Katzn.; *T. subterraneum* subsp. *oxaloides* Nyman (Muñoz Rodríguez, 2000)

Botanical Description

Winter-growing annual legume with a geocarpic “crack-seeking” strategy (passive burr placement) adapted to cracking clays or stony soils (Katznelson & Morley, 1965).

Growth Habit: prostrate, mat-forming annual arising from a central crown, with long runners commonly reaching 30–90 cm. The defining diagnostic trait is peduncle behaviour after flowering: subsp. brachycalycinum develops long, slender, sinuous peduncles that trail across the soil surface and place burrs into cracks or beneath stones (“passive burial”), unlike subsp. subterraneum, which uses short, rigid peduncles for active soil penetration (Zohary & Heller, 1984; Katznelson & Morley, 1965).

Leaves: alternate and trifoliolate; leaflets typically larger than in other subspecies, obcordate to cuneate, often with a relatively high leaf-to-stem ratio (Abdi et al., 2020). In CICYTEX varieties, `Valmoreno´ displays large leaflets with a pale green central band and slight anthocyanin spotting, whereas `Nuraghe´ presents deep-green leaflets with a pale central band and anthocyanin pigmentation on both surfaces (Galea-Gragera & Llera, 2025a).

Flowers: axillary racemes bearing 3–8 small white to creamy-pink flowers. The calyx tube is typically pale or green and usually lacks the red pigmentation band commonly observed in subsp. subterraneum (Katznelson & Morley, 1965). Flowering in CICYTEX materials is mid-to-late (late March to May), reflecting adaptation to longer growing seasons (Galea-Gragera & Llera, 2025a).

Fruits (seeds): during burr development, peduncles do not force burrs into the soil but lodge them into protected microsites (Ghamkhar et al., 2015). Seeds are dark (black to purplish-black), relatively large and slightly flattened (Llera & Galea-Gragera, 2026). CICYTEX reports Thousand Seed Weight values of 7.69 g in 'Valmoreno' and 6.63 g in 'Nuraghe'. Hardseededness levels (~30–35% in 'Valmoreno'; ~22% in 'Nuraghe') contribute to persistence under variable autumn rainfall (Galea-Gragera & Llera, 2025a; Llera & Galea-Gragera, 2026).



Figure 60:Trifolium subterraneum subsp. brachycalycinum. From left to right: trifoliolate leaves, pinkish papilionaceous flower, and developed geocarpic burr.

Distribution and Habitat

Native to the Mediterranean basin and West Asia (Zohary & Heller, 1984). This subspecies occupies a distinct edaphic niche, thriving on well-drained but heavy-textured soils, particularly neutral to alkaline cracking clays and stony ground where active burr penetration is mechanically constrained (Ghamkhar et al., 2015; Pastor, 1993).

It tolerates higher pH levels (up to approximately 8.5), where subsp. subterraneum is frequently penalised by iron chlorosis (Gildersleeve et al., 1988). Agronomically, it is recommended for sites with high water-holding capacity and/or relatively high rainfall (>600 mm for certain cultivars), provided drainage prevents prolonged winter ponding, as persistent waterlogging favours subsp. yanninicum (Enkhbat et al., 2021).

Regarding the distribution maps, Figure 61 (Euro-Mediterranean distribution) provides curated chorology for T. subterraneum at species level (Euro+Med PlantBase, 2006-). A subspecies-level occurrence map, used for other taxa in this work, is not available for T. subterraneum subsp. brachycalycinum in the consulted occurrence database.

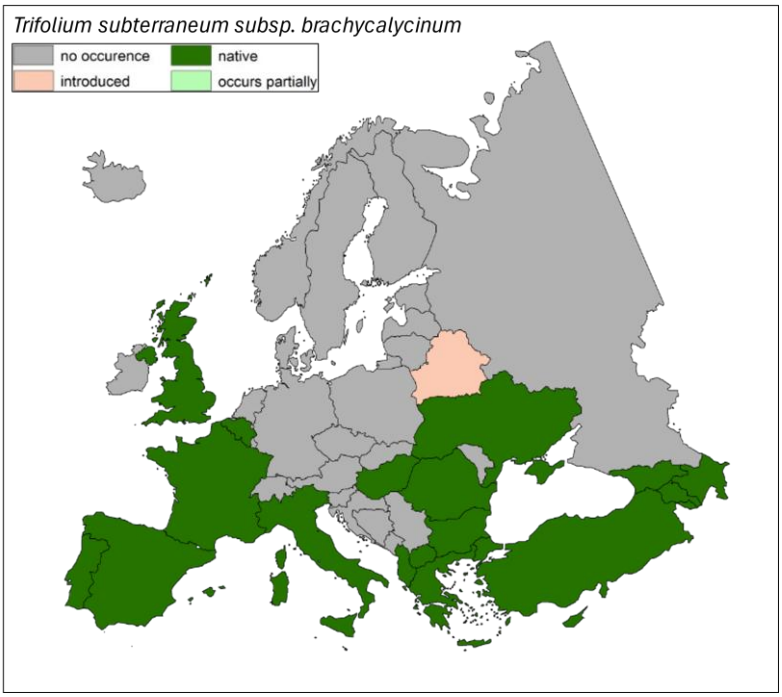


Figure 61: Euro-Mediterranean distribution of Trifolium subterraneum L.

Suitability for Agricultural Use

A strategic self-regenerating forage legume for low-input grazing systems on neutral to alkaline clay soils where other annual clovers may fail due to edaphic constraints (Llera & Galea-Gragera, 2026).

Forage Quality: in dehesa pasture assessments, it ranks among the highest-quality pasture legumes ("First" class; RFV ~139), with crude protein around 10.8% during vegetative stages (Llera et al., 2022). It is typically used in mixtures with compatible grasses and annual legumes.

Seed quality: Seeds act as a high-protein summer reserve (~38% crude protein; ~3% crude fat) for grazing livestock, providing a valuable nutritional supplement during the dry season (Llera et al., 2023).

Genetic resources: CICYTEX maintains characterised materials including 'Valmoreno' and 'Nuraghe', both vigorous and mid-to-late flowering, adapted to deep neutral–alkaline clays with high water retention. 'Nuraghe' is noted for low oestrogenic activity in sheep systems (Galea-Gragera & Llera, 2025a). Their hardseededness buffers recruitment against autumn "false breaks" and supports multi-year persistence under grazing (Norman et al., 1998).

Distinguishing Features from Similar Subspecies

Burial mechanism: passive "crack-seeking" (long, sinuous peduncles) vs. active burial in subsp. subterraneum (Katznelson & Morley, 1965).

Soil fit: specialist for neutral–alkaline cracking clays; tolerant of high pH conditions where subsp. subterraneum suffers iron chlorosis. Subsp. yanninicum remains the specialist for seasonally waterlogged sites (Ghamkhar et al., 2015; Gildersleeve et al., 1988).

Morphology: calyx tube typically pale/green without red banding; seeds dark and relatively large (Abdi et al., 2020; Galea-Gragera & Llera, 2025a).

Special ecological features

"Crack-seeking" geocarpy is an evolutionary adaptation to hard-setting soils where active burial is mechanically difficult. By lodging burrs into fissures or protected microsites, the plant reduces seed loss to grazing and buffers seeds against extreme summer surface temperatures (Zohary & Heller, 1984; Katznelson & Morley, 1965).

As a pasture legume, it contributes significantly to ecosystem nitrogen cycling through symbiotic fixation. Reported contributions in grazed systems commonly range from ~25 to over 150 kg N ha^{-1} depending on management and environmental conditions (Peoples & Baldock, 2001; Unkovich et al., 1996).

Infobox

Winter-growing annual subclover defined by passive burr placement into soil cracks. Best adapted to neutral–alkaline clayey soils (pH 6.0–8.5) with good moisture retention. Rated "First" quality in dehesa systems (RFV ~139) and provides a high-protein summer seed reserve (~38% crude protein). CICYTEX varieties 'Valmoreno' (TSW 7.69 g; 30–35% hardseededness) and 'Nuraghe' (TSW 6.63 g; ~22% hardseededness) exemplify adaptation and persistence in improved Mediterranean pastures.

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Trifolium subterraneum L. *subsp. subterraneum* – Subterranean clover

Systematics

Family: Fabaceae (legumes)

Subfamily: Faboideae

Tribe: *Trifolieae*

Genus: *Trifolium* L. (Muñoz Rodríguez, 2000; Zohary & Heller, 1984)

Species: *Trifolium subterraneum* L. (Muñoz Rodríguez, 2000; Zohary & Heller, 1984)

Subspecies: *Trifolium subterraneum* L. subsp. *subterraneum* (Zohary & Heller, 1984)

Synonyms (species-level): *Calycomorphum subterraneum* (L.) C. Presl; *Trifolium subterraneum* var. *genuinum* Rouy (POWO, 2024)

Botanical Description

Winter-growing annual legume combining grazing tolerance with geocarpy (burr burial).

Growth Habit: prostrate, mat-forming plant with many runners from a central crown; runners generally do not root at the nodes. Stems, petioles and leaflets are typically hairy (pubescent), helping to distinguish it from the usually glabrous subsp. *yanninicum* (Abdi et al., 2020; Katznelson & Morley, 1965).

Leaves: alternate, trifoliolate; leaflets obcordate to obovate and often marked (crescents/bands/anthocyanin), with cultivar-specific patterns used for identification (Abdi et al., 2020; Galea-Gragera & Llera, 2025a; Nichols et al., 2013). In CICYTEX varieties, ‘Areces’ commonly shows a pale central mark with two white arms and anthocyanin speckling, whereas `Cubillana´ concentrates anthocyanin mainly on the midrib (Galea-Gragera & Llera, 2025a).

Flowers: small axillary racemes (typically 2–5 fertile flowers). Flowering time (maturity type) depends on genotype × environment responses, notably vernalization and photoperiod

(Goward et al., 2023; Nichols et al., 2013). ‘Cubillana’ is very early (late February) and ‘Areces’ mid-season (mid-March) (Galea-Gragera & Llera, 2025a).

Fruits (seeds): as burrs develop, peduncles bend downwards and thicken, actively pushing burrs into the soil (active burial), protecting seeds from grazing and summer heat (Galea-Gragera & Llera, 2025a; Katznelson & Morley, 1965). Seeds are dark and relatively large (TSW typically ~6–9 g, cultivar-dependent) (Galea-Gragera & Llera, 2025a). CICYTEX reports TSW 6.65 g (‘Areces’) and 6.48 g (‘Cubillana’); both have black spherical seeds and high hardseededness (35–40% and >35%), supporting a persistent seed bank and reducing losses after “false breaks” (Galea-Gragera & Llera, 2025a; Norman et al., 1998).



Figure 62: Trifolium subterraneum subsp. subterraneum. From left to right: trifoliolate leaves, white papilionaceous flower, and developing geocarpic burr.

Distribution and Habitat

Native to the Mediterranean basin and West Europe, and widely cultivated/naturalised in Mediterranean-climate regions (Ghamkhar et al., 2015). In SW Iberian dehesa-type systems, it dominates where soils are not strongly calcareous and prolonged winter waterlogging is limited (Llera & Galea-Gragera, 2026).

Ecological Niche: often considered a rainfall “generalist” in Mediterranean pastures (commonly >375 mm yr^{-1}), but soil-selective. Best performance is on well-drained, moderately acidic to neutral soils (approx. pH 5.0–7.0) with sandy-loam to loam textures, where soil mechanical resistance does not constrain active burial (Ghamkhar et al., 2015; Nichols et al., 2013).

Limitations: more sensitive to prolonged winter waterlogging than subsp. *yanninicum*, with clear subspecies differences in tolerance and recovery under hypoxia (Enkhbat et al., 2021). Frequently penalised on alkaline/calcareous soils by iron-deficiency chlorosis (relative to subsp. *brachycalycinum*) (Gildersleeve et al., 1988; Llera & Galea-Gragera, 2026).

Figure 63 and Figure 64 illustrate the distribution range. Figure 63 (Euro+Med PlantBase, 2006–) provides curated chorology for T. *subterraneum* at species level. Figure 64 provides georeferenced occurrence records specifically for T. *subterraneum* subsp. *subterraneum* (GBIF Secretariat, 2026).

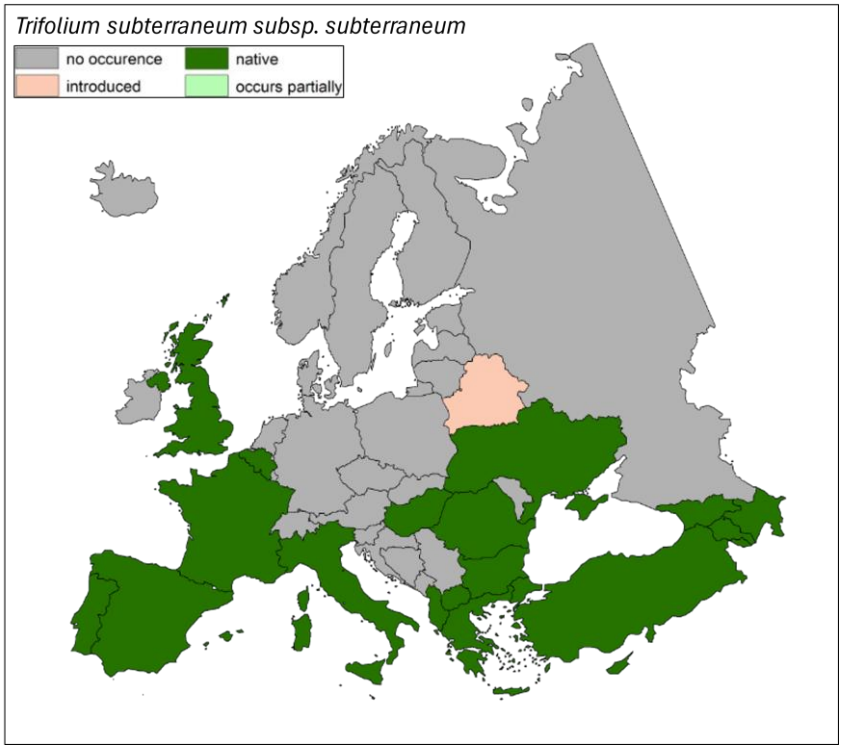


Figure 63: Euro-Mediterranean distribution of Trifolium subterraneum L.



Figure 64: Global occurrence records of Trifolium subterraneum subsp. subterraneum.

Suitability for Agricultural Use

Key self-reseeding legume for low-input Mediterranean grazing systems, combining high winter–spring forage with reliable regeneration via active burial (Llera & Galea-Gragera, 2026).

Forage quality: Dehesa assessments classify it as “First Class” (RFV ~135) with crude protein around 13% in vegetative stages; its prostrate habit improves grazing tolerance and ground cover (Llera et al., 2022).

Seed quality (summer feed): the burrs and seeds produced at the end of the growing cycle may constitute a protein- and energy-rich summer reserve for livestock, especially when green forage availability declines. CICYTEX analyses of ‘Areces’ report 35.44% crude protein and 11.92% crude fat (Llera et al., 2023). Hardseededness (≈35–40%) supports a multi-year seed bank and buffers establishment against variable autumn rainfall (Galea-Gragera & Llera, 2025a; Norman et al., 1998).

Genetic resources and varietal fit: ‘Areces’ (mid-season; vigorous; marked leaves) is suited to medium rainfall zones, whereas ‘Cubillana’ (very early; cold-tolerant; semi-upright/slender) fits lower rainfall areas and shorter springs (Galea-Gragera & Llera, 2025a).

Distinguishing Features from Similar Subspecies

Correct subspecies choice is essential; soil mismatch is a frequent cause of establishment failure (Llera & Galea-Gragera, 2026).

Burial mechanism: active burial via short, robust peduncles, which performs best on softer soil surfaces (Abdi et al., 2020). In contrast, subsp. *brachycalycinum* uses long, fine, sinuous peduncles to lodge burrs in cracks or under stones, a strategy known as passive burial (Katznelson & Morley, 1965)

Soil fit: prefers acidic–neutral, well-drained soils; commonly reduced on calcareous soils (chlorosis) and under persistent winter waterlogging (where *yanninicum* is favoured) (Ghamkhar et al., 2015; Llera & Galea-Gragera, 2026).

Morphology: plants are typically hairy; the calyx often shows a red band (commonly pale/green in subsp. *brachycalycinum*) (Abdi et al., 2020; Nichols et al., 2013).

Seeds: colour is usually black to purplish-black, contrasting with the cream/amber/yellowish seeds typical of subsp. *yanninicum* (Galea-Gragera & Llera, 2025a; Llera & Galea-Gragera, 2026).

Special ecological features

Survival relies on geocarpy plus hardseededness.

Geocarpy: Active burial provides physical protection against grazing predation, extreme summer surface temperatures and fire, improving interannual persistence under Mediterranean grazing regimes (Llera & Galea-Gragera, 2026).

Hardseededness: Physical dormancy reduces germination after sporadic summer/early autumn rain (“false breaks”), preserving the seed bank until reliable autumn rains; responses vary with genotype, burial depth and soil conditions (Norman et al., 1998; Nichols et al., 2025; Taylor, 2005).

Infobox

Winter-growing annual subclover with a prostrate, mat-forming habit and typically hairy stems and leaves. Defined by active burr burial via short, rigid peduncles, enabling strong self-regeneration under grazing. Best on well-drained, acidic to neutral soils (approx. pH 5.0–7.0). Provides “First Class” winter–spring forage (~13% crude protein; RFV ~135) and a high-value summer seed reserve. CICYTEX varieties ‘Areces’ (TSW 6.65 g; 35–40% hardseededness) and ‘Cubillana’ (TSW 6.48 g; >35%) illustrate persistence in improved dehesa pastures.

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Achillea millefolium L. - Yarrow

Systematics

Family: Asteraceae

Subfamily: Asteroideae

Tribe: *Anthemideae*

Genus: *Achillea*

Botanical Description

Achillea millefolium L. (Yarrow) is a perennial herbaceous plant with an erect or ascending stem, 20-80 cm tall and up to 3 mm thick, densely leafy, furrowed. It sometimes forms small clumps, spreading by means of rhizomes and underground stolons. It forms numerous ground-level rosettes of leaves, from which inflorescence stems grow. The plant is green, sparsely hairy or glabrous. The stem is usually sparsely branched or unbranched at the bottom, densely leafy. The leaves long and fernlike, divided bipinnately or tripinnately, the leaf blade is lanceolate, reaching up to 4 cm in width in basal leaves and usually 1 to 2 cm in stem leaves. The leaves are green, slightly pointed, glabrous or sparsely hairy on the upper surface and more hairy on the lower surface, with equal segments (Nawara, 2006; Rutkowski, 2008; Włodarczyk, 1984).

The flowers are gathered in flat umbels at the ends of stiff, erect shoots. The flower are ligulate and tubular flowers. The marginal flowers are ligulate, numbering 4 to 6, most often white, sometimes pink or red. The inner flowers are tubular, yellow-white. This species blooms from May to September, sometimes until October, and in warm climates from April to June (Nawara, 2006; Rutkowski, 2008). The flowers are insect-pollinated by, butterflies, bees and beetles.

The fruit is a flattened achene, 1.5–2 mm long, narrowly winged (Nawara 2006, Rutkowski, 2008; Mowszowicz, 1986). The fruits are dispersed by wind or animals (Mowszowicz, 1986).



Figure 65: Achillea millefolium L. © Institute of Technology and Life Sciences - National Research Institute

Distribution and Habitat

Achillea millefolium L. originates from the temperate regions of the northern hemisphere and is found in Europe, Asia (and the Himalaya in the south) and North America. It was introduced as fodder for livestock in New Zealand and Australia, where it is a common weed. This species also grows in southern Africa and South America (Achillea millefolium L., Plants of the World Online).

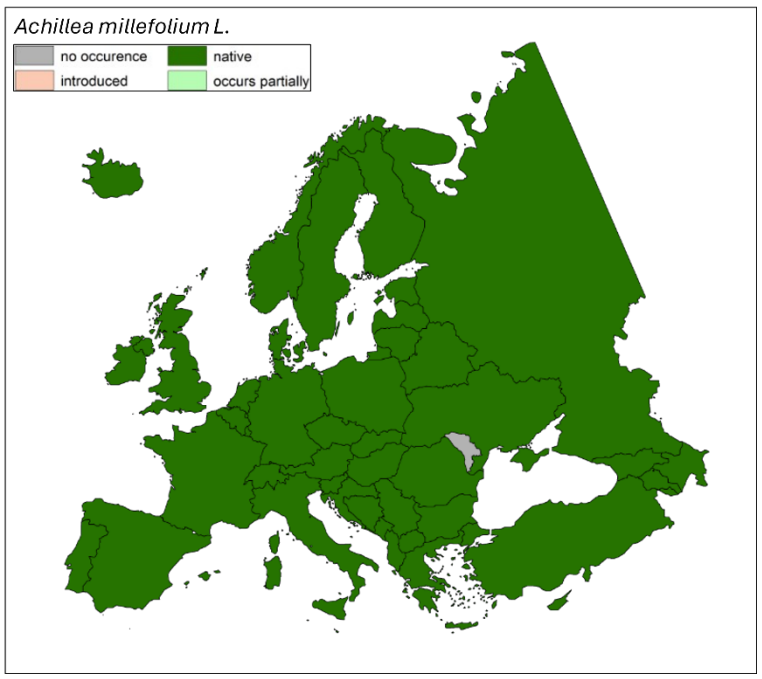


Figure 66: Distribution of Achillea millefolium L. in Europe.

It is a perennial plant found in meadows, grasslands and pastures (including mountain pastures). It grows in moderately moist and even moderately dry locations in sunny areas. It tolerates drought well. It prefers soils rich in nitrogen compounds (Nawara, 2006; Mowszowicz, 1986).

Suitability for Agricultural Use

Achillea millefolium L. is an important component of grassland vegetation and is eagerly eaten by animals. In the past, this species was sown as an addition to pasture mixtures. It contains a lot of essential oils, which give the feed a special aroma. These oils have dietary properties, stimulating appetite and accelerating digestion. In addition, this species contains bioactive substances (including saponins, tannins, flavonoids and inulin) that have a positive effect on animal health, including anti-inflammatory and antiseptic properties. A small amount in hay (2-5%) improves the taste of the feed. However, when eaten in larger quantities and over a longer period of time, it is toxic (Grynia, 1995; Grzebisz e.al., 2014).

Infobox

Achillea millefolium L. is a perennial herb with a highly variable appearance and hairiness, 20-80 cm tall, with underground runners. It occurs in meadows, grasslands and pastures, in sunny locations. It is characterised by an erect single stem, densely leafy, with 2-3 pinnate leaves and an umbel inflorescence. The ligulate flowers are usually white, less often pink or red. It is a medicinal plant. In the past, this species was sown as an addition to pasture mixtures, giving the fodder a special aroma and taste. It is eagerly eaten by animals and contains numerous compounds that stimulate better metabolism and blood circulation, but when eaten in large quantities and over a long period of time, it can have an adverse effect on animal health.

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Centaurea jacea L. - Brown Knapweed

Systematics

Family: Asteraceae

Subfamily: Carduoideae

Tribe: *Cynareae*

Genus: *Centaurea*

Botanical Description

Centaurea jacea is herbaceous perennial plant in the genus Centaurea and is native to dry meadows and open woodland throughout Europe, extending to West Siberia and Caucasus.

It reaches growth heights of about 20 - 100 cm and has a straight erect, single or branched rough stem The basal leaves form a rosette; stem leaves are ovate to lanceolate, often pinnately lobed, petioled. The flower heads consist of tubular violet-purple florets. It is collected in flower heads, that are 1-2 cm long and egg-shaped.

The marginal florets are larger, more showy, and generally sterile or neutral, whereas the inner florets are hermaphroditic and fertile. The stamens push the anthers upward under the touch of an insect, making it easier for them to carry pollen.

Centaurea jacea develops a relatively deep taproot system that spreads primarily downward rather than laterally, providing good anchorage and drought tolerance (Kutschera & Lichtenegger, 1982). Flowering time extends – depending on altitude – from June to September.

The fruit of *Centaurea jacea* is a small, shiny, yellowish achene measuring approximately 3 mm in length. It bears a brown appendage that can easily attach to the fur of passing animals, aiding seed dispersal. Fruits typically ripen between June and September.



Figure 67: Flowering Centaurea jacea (left), basket with und violet-purple inflorescence (middle) and seeds (right) © AREC Raumberg-Gumpenstein

Distribution and Habitat

Brown Knapweed (*Centaurea jacea*) occurs throughout most of Europe. It is present in nearly all European countries, with the exception of the Balearic Islands, Sardinia, Cyprus and the Aegean Islands. In Europe, it is present in almost all countries, except the Balearic Islands, Sardinia, Cyprus and the Aegean Islands. It is casual in Great Britain, Ireland and Iceland.

Centaurea jacea is a characteristic species of extensively to moderately managed grasslands. It thrives in dry to moderately moist meadows, pastures, and open woodland edges, particularly on nutrient-poor soils.

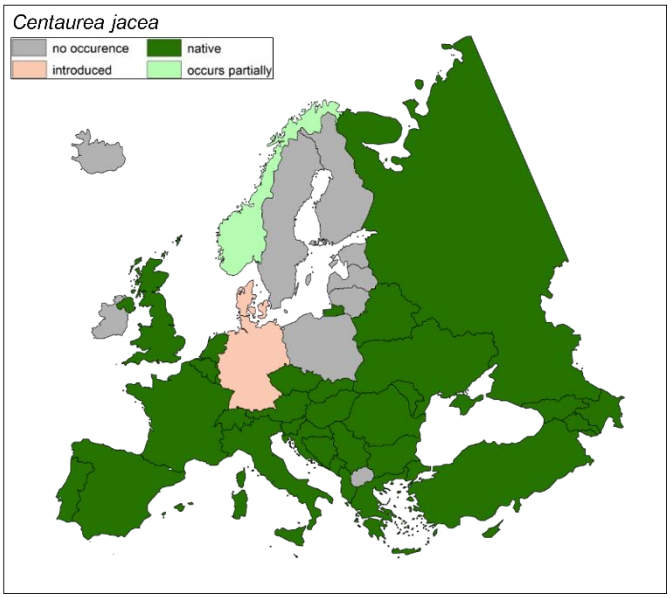


Figure 68: Distribution of Centaurea jacea L. in Europe

Suitability for Agricultural Use

The fodder quality of Brown Knapweed is considered low. The plant contains tannins, and its stems have a high fiber content, reducing acceptance and digestibility for livestock. With higher amount of nitrogen fertilisation and intensification of grassland management the proportion of *Centaurea jacea* in grassland areas decreases (Seithe, 2016).

Distinguishing Features from Similar Species

In the vegetative state, it can be difficult to distinguish from *Centaurea scabiosa* at first glance. However, unlike *C. scabiosa*, the rosette and stem leaves of *C. jacea* are not deeply feathered. Instead, they are narrow to lanceolate in shape (Spohn et al., 2015).

Special ecological features

Centaurea jacea is an important source of nectar and pollen for a wide range of pollinators, including bees and numerous butterfly species. As a long-flowering perennial, it contributes significantly to the ecological value and biodiversity of species-rich grasslands.

Infobox

Centaurea jacea is herbaceous perennial plant in the genus *Centaurea* and is native to dry meadows and open woodland throughout Europe, extending to West Siberia and Caucasus. It reaches growth heights of about 20 - 100 cm and has a straight erect, single or branched rough stem. The fodder quality of Brown Knapweed is considered low. The plant contains tannins, and its stems have a high fiber content, reducing acceptance and digestibility for livestock.

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Cichorium intybus L. – Chicory

Systematics

Family: Asteraceae

Subfamily: Cichorioideae

Tribe: *Cichorieae* (syn. *Lactuceae*)

Genus: *Cichorium*

Botanical Description

Chicory (*Cichorium intybus* L.) is a perennial diploid species (2n = 18). During its first year, the plant primarily develops its taproot system, while in the second and subsequent years it produces upright stems, inflorescences, and seeds (Figure 69).



Figure 69: The life cycle of chicory during the first 18 months following spring sowing (Source: Australian Dairy Plan, n.d.).

Root: Wild chicory typically develops a dominant taproot 45–210 cm long with lateral roots 10–20 cm in length (Reaume, 2010). Cultivated types usually form a single taproot longer than 100 cm, with an effective rooting depth of 80–90 cm (Figure 70a). This deep and strong root system allows chicory to grow well even in heavy soils and contributes to its high drought tolerance (Durham & Hancock, 2010).

Leaves: Chicory bears alternately arranged stem leaves and basal rosette leaves. Upper stem leaves have short-winged petioles, whereas lower stem leaves are larger and tapering. Rosette leaves are lanceolate with a thick, hairy midrib, showing deeply serrated margins in wild forms and smoother margins in cultivated types (Figure 70b). The species overwinters in the rosette stage and produces flowering stems that may exceed 1 m in spring (Reaume, 2010; Anonymous, n.d.).



a b

Figure 70: Leaf morphology of chicory (Cichorium intybus L.) (a: wild type; b: 'Commander') (Source: Can et al., 2020).

Flowers: Chicory flowers are usually blue, occasionally pink or white, and are borne on sessile or very short peduncles that open mainly in the morning. Each head contains 5–6 outer and 8 inner bracts and consists entirely of 11–21 ray florets, with no disk florets. The ovary is white and glabrous, the stamens have blue filaments with white pollen, and the pistil has two recurved stigmatic branches (Figure 71). Flowers mature into fruit within 6–7 weeks, and a plant typically produces around 227 flowers, with pollination largely carried out by honeybees Figure 71: Floral structure of chicory (Cichorium intybus L.) (Source: Can et al., 2020).Figure

71: Floral structure of chicory (Cichorium intybus L.) (Source: Can et al., 2020).(Clapham et al., 2001; Reaume, 2010; Anonymous, n.d.).



Figure 71. Floral structure of chicory (Cichorium intybus L.), source: (Can et. al, 2020)71

Distribution and Habitat

Chicory belongs to the tribe Cichorieae within the family Asteraceae, one of the largest and most diverse plant families, comprising approximately 32,000 species and 1,900 genera, making it one of the largest and most diverse plant families worldwide. The species is native



Figure 72: Fruit structure of chicory (Cichorium intybus L.) (Source: Can et al., 2020).Figure 72: Fruit structure of chicory (Cichorium intybus L.) (Source: Can et al., 2020).Fruit: Chicory produces an achene-type fruit, each containing a single seed. The seeds are dark brown and measure approximately 2.2–2.8 mm in length, 1–1.5 mm in width, and 0.7–1 mm in thickness. At the point of attachment to the corolla, 28–45 small hairs are present (Reaume, 2010; Anonymous, n.d.). The thousand-seed weight ranges from 1.3 to 1.7 g (Figure 72).72

to Europe, Central Russia, Central and Western Asia, and North Africa, but has subsequently been introduced and naturalized across many temperate and semi-arid regions of the world (Figure 73).

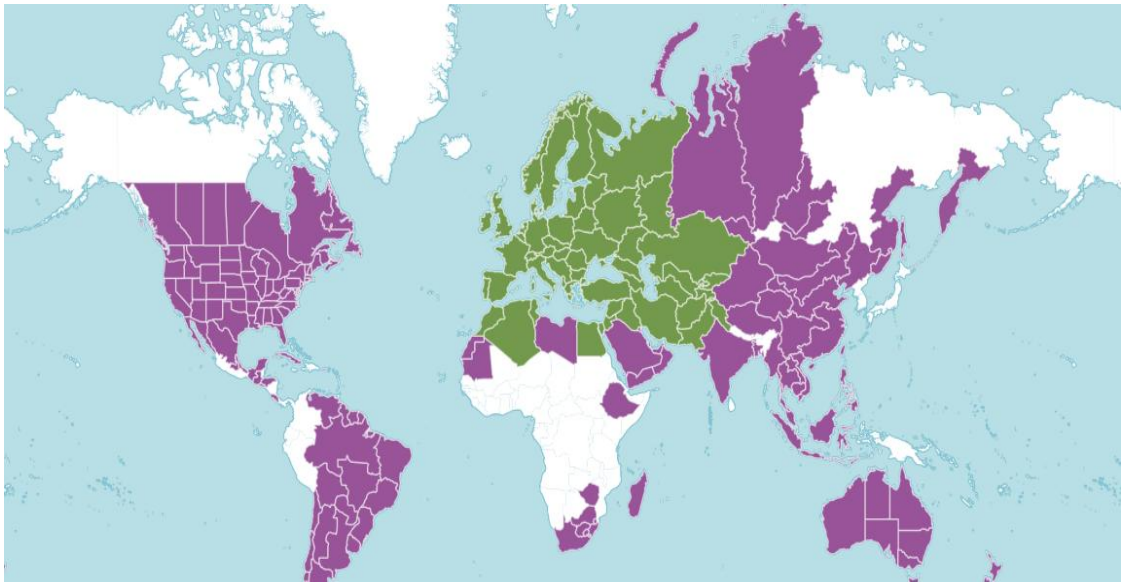


Figure 73: Global distribution of chicory (Cichorium intybus L.), showing native regions in green and introduced regions in purple (Source: Royal Botanic Gardens, Kew, 2026).

Suitability for Agricultural Use

Chicory is well suited for agricultural use due to its high digestibility, rich mineral composition, drought tolerance, and strong palatability (Barry, 1998; Athanasiadou et al., 2007). It provides high-quality forage during summer when many species enter dormancy and is effectively used in pasture mixtures, hay, silage, and grazing systems. In rotational grazing, chicory maintains superior nutritive value and extends the period of quality feed availability, integrating successfully with white clover, red clover, birdsfoot trefoil, perennial ryegrass, and plantain. Its moderate tannin and phenolic contents can reduce bloat risk and help suppress internal parasites (Athanasiadou et al., 2007; Peña-Espinoza et al., 2020). Animals grazing chicory often show higher liveweight gains, indicating that it is a valuable and sustainable forage option, particularly in Mediterranean-type environments.

Distinguishing Features from Similar Species

Chicory is readily distinguished from related and similar species by several key traits. Within the genus *Cichorium*, it differs from *C. endivia* through its short pappus, perennial growth habit, and self-incompatibility, along with its broader distribution and phenotypic diversity. Compared with other Asteraceae such as dandelion, chicory has bright blue ligulate

florets that open in the morning, alternately arranged stem leaves with a hairy midrib, and a deep perennial taproot (Kiers, 2000). These features make *C. intybus* easily identifiable in pasture and natural habitats.

Special Ecological Features

Chicory possesses a deep taproot that provides strong drought tolerance and enables growth when many pasture species are dormant (Barry, 1998; Athanasiadou et al., 2007). Its erect growth form reduces soil contact and limits parasite contamination, while phenolic compounds further suppress internal parasites in grazing animals (Peña-Espinoza et al., 2020). The species also maintains high-quality forage during warm, dry periods, enhancing pasture resilience in temperate and Mediterranean environments.

Infobox

Cichorium intybus L. (chicory) is a perennial diploid species native to Europe and Western Asia, now widely naturalized in temperate and semi-arid regions. It has a deep taproot, blue ligulate florets, and lanceolate rosette leaves, and produces single-seeded achenes. Chicory is highly digestible, mineral-rich, drought-tolerant, and maintains quality forage during summer, making it valuable for grazing, hay, silage, and pasture mixtures. Its tannins and phenolic compounds may reduce bloat risk and parasite burden, supporting animal performance in pasture systems.

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Plantago lanceolata L. - Ribwort plantain

Systematics

Family: Plantaginaceae

Subfamily: Plantaginoideae

Tribe: *Plantagineae*

Genus: *Plantago*

Botanical Description

Ribwort plantain (*Plantago lanceolata* L.) is a perennial herbaceous species that develops in a rosette growth form and is of considerable importance in grassland and forage systems due to its distinctive morphological and ecological traits. During the seedling stage, the plant initially forms a dominant taproot system. Owing to its strong and deep-penetrating root system, *P. lanceolata* exhibits a high tolerance to drought stress; in particular, the taproot has been reported to reach depths of up to 1 m during the second and third years of growth (Lubenov, 1985; Abate et al., 2022). Plant height generally ranges from 20 to 80 cm, and the leaves are narrow, elongated, and lanceolate in shape, bearing 3–5 distinct parallel veins. The leaves are short-petioled and either glabrous or sparsely pubescent (Pol et al., 2021). The inflorescence consists of a dense spike with closely packed flowers, which is borne on a leafless scape ranging from 10 to 40 cm in length. Pollination occurs predominantly by wind, and each spike is capable of producing up to approximately 200 seeds. The fruit is a capsule measuring

3–4 mm in length and typically contains 1–3 seeds. Seed colour varies from black to yellowish-brown or dark brown, and the thousand-seed weight ranges between 1.0 and 1.5 g.



Figure 74: Ribwort plantain seeds and plant habit (Sources: Canadian Food Inspection Agency, 2017; IDseed, n.d.).

Distribution and Habitat

Plantago lanceolata L. is a perennial herbaceous species whose native range is considered to encompass Europe and parts of Western Asia. Although the exact centre of origin remains uncertain, the species is generally regarded as indigenous to temperate Europe and adjacent regions of Asia. Owing to its long history of anthropogenic dispersal and remarkable ecological adaptability, *P. lanceolata* has become a cosmopolitan species, currently distributed throughout most temperate regions of the world.

Plantago lanceolata exhibits a broad altitudinal range, occurring from sea level up to approximately 2500 m above sea level, reflecting its high tolerance to diverse climatic and edaphic conditions. The species is commonly found in meadows, permanent pastures, road verges, field margins, fallow lands, and other disturbed or managed habitats.

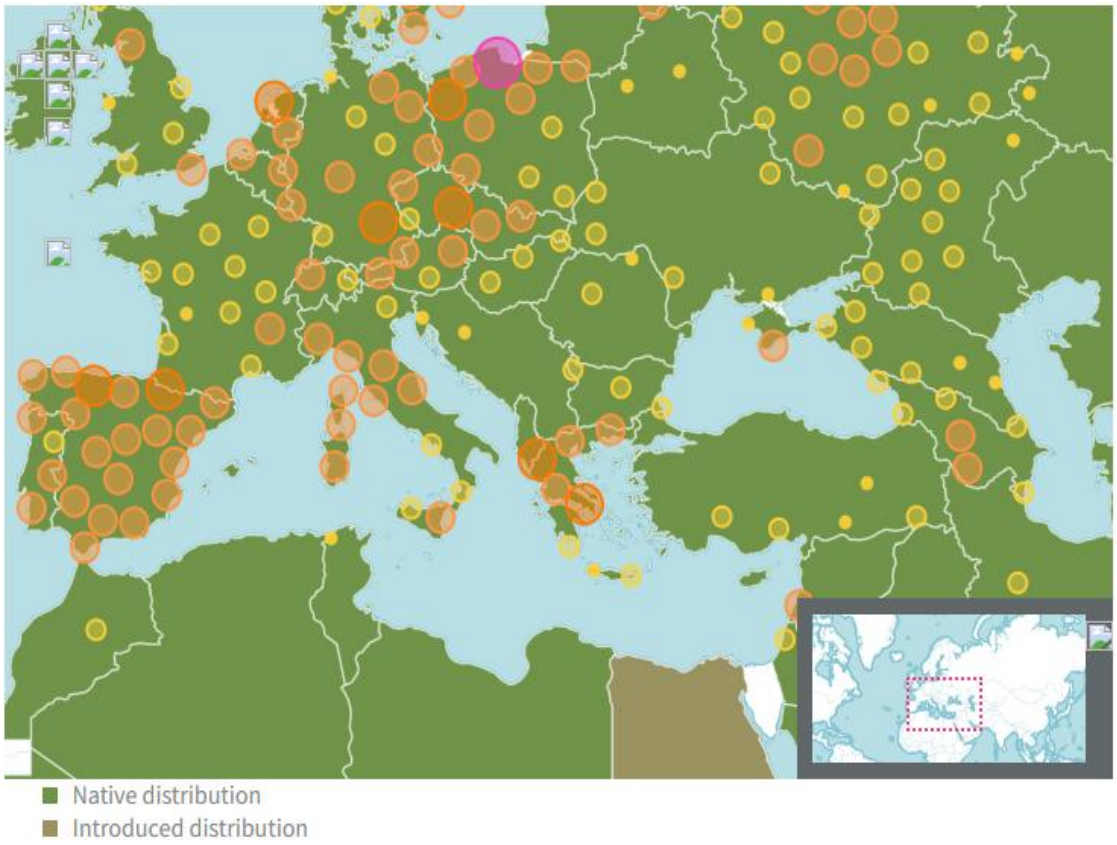


Figure 75: Distribution of Plantago lanceolata L. in Europe (Source: Brazilian Flora 2020 Project, 2014).

Optimal growth is generally observed on well-drained, moderately fertile soils with slightly acidic to neutral pH (approximately 5.5–7.5). While the species shows moderate resistance to drought, prolonged waterlogging and poorly drained conditions can negatively affect its persistence (Mook et al., 1989).

Climatically, *P. lanceolata* is well adapted to temperate and semi-humid environments. It exhibits notable cold tolerance, surviving winter periods in a vegetative rosette state, and maintains growth activity during cooler seasons when moisture is sufficient (Sagar and Harper, 1964; Stewart, 1996).

Suitability for Agricultural Use

Plantago lanceolata L. is a valuable forage species in natural and improved grasslands due to its nutritive value, grazing tolerance and ecological adaptability. In fresh forage, it may

contain approximately 15–25% dry matter. Its nutritive quality is higher at the vegetative and flowering stages, when fibre content is lower and digestibility and palatability for ruminants are higher, whereas it decreases at the early seed stage due to increased structural carbohydrates and reduced crude protein (Kara et al., 2018).

Its rosette growth form and deep taproot system provide strong resistance to grazing and trampling, while also enhancing tolerance to periodic drought stress (Sagar and Harper, 1964).

In addition to its agronomic performance, the species contains bioactive secondary metabolites that may support animal health and contribute to reduced enteric methane emissions. Overall, P. lanceolata is well suited for inclusion in diverse, low-input, and climate-resilient pasture systems, particularly when managed in combination with grasses and legumes (Pain et al., 2015).

Distinguishing Features from Similar Species

Plantago lanceolata L. can be readily distinguished from other *Plantago* species by its narrow, lanceolate leaves arranged in a basal rosette and bearing 3–7 prominent parallel veins. In contrast to *Plantago major* L., which has broad, ovate leaves with long petioles, P. lanceolata possesses sessile to short-petiolate leaves with a distinctly elongated shape (Davis, 1978; Tutin et al., 1976).

Unlike *Plantago media* L., which typically has wider, softly pubescent leaves and shorter, more robust spikes, *P. lanceolata* exhibits narrower, usually glabrous leaves and more elongated inflorescences.

Special Ecological Features

Plantago lanceolata L. is a grazing- and trampling-tolerant grassland species. Its basal rosette growth form allows the plant to maintain vitality and regrow even under intensive grazing conditions (Wilson et al., 2020).

The species possesses a deep taproot system, which enables access to subsoil moisture during dry periods and enhances tolerance to temporary drought stress. This trait

contributes to its persistence in environments characterized by seasonal water limitation (Mook et al., 1989; Stewart, 1996).

Infobox

Ribwort plantain (*Plantago lanceolata* L.) is a perennial herbaceous grassland species native to Europe and Western Asia and now widely distributed across temperate regions. The species exhibits a basal rosette growth form with narrow, lanceolate leaves characterized by prominent parallel venation. Its deep taproot system confers relative tolerance to drought stress and enables persistence under intensive grazing and trampling.

P. lanceolata is recognized as a valuable forage species for ruminant production due to its high digestibility and moderate to high crude protein content. In addition, the presence of bioactive secondary metabolites contributes to functional roles in animal nutrition and grassland ecosystem processes.

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List of Figures

Figure 1: Alopecurus pratensis L. - meadow foxtail 7

Figure 2: Distribution of Alopecurus pratensis L. in Europe. 8

Figure 3: Flowering Anthoxanthum odoratum (left) and seeds (right) 11

Figure 4: Distribution of Anthoxanthum odoratum L. in Europe 12

Figure 5: False oat-grass 15

Figure 6: Distribution of Arrhenatherum elatius L. in Europe 15

Figure 7: Flowering Common Quaking Grass (left) and seeds (right) 20

Figure 8: Distribution of Briza media L. in Europe 21

Figure 9: Smooth brome grass 24

Figure 10: Distribution of Bromus inermis L. in Europe 25

Figure 11: Cynodon dactylon L. 29

Figure 12: Distribution of Cynodon dactylon L. in Europe. 30

Figure 13: Flowering Crested Dog's-tail (left) and seeds (right) 34

Figure 14: Distribution of Cynosurus cristatus L. in europe 35

Figure 15: Dactylis glomerata L. 38

Figure 16: Distribution of Dactylis glomerata L. in Europe. 39

Figure 17: Tall fescue 42

Figure 18: Distribution of Festuca arundinacea L. in Europe 43

Figure 19: Sheep's-fescue 47

Figure 20: Distribution of Festuca ovina L. in Europe 48

Figure 21: Meadow fescue 52

Figure 22: Distribution of Festuca pratensis Huds. in Europe 52

Figure 23: Red fescue 57

Figure 24: Distribution of Festuca rubra in Europe 58

Figure 25: Lolium perenne L. seeds, plant habit, and inflorescence 61

Figure 26: Distribution of Lolium perenne L. in Europe 63

Figure 27: Italian ryegrass..... 67

Figure 28: Distribution Lolium multiflorum Lam. in Europe 67

Figure 29: Phalaris arundinacea L. - Reed canary grass 71

Figure 30: Distribution of Phalaris arundinacea L. in Europe..... 71

Figure 31: Trisetum flavescens L. - Yellow oatgrass 75

Figure 32: Distribution of Trisetum flavescens L. in Europe. 76

Figure 33: Bituminaria bituminosa general appearance and plant parts. 79

Figure 34: Distribution of Bituminaria bituminosa (L.) C.H. Stir. in Europe 80

Figure 35: Hymenocarpos circinnatus (L.) Savi..... 86

Figure 36: Distribution of Hymenocarpos circinnatus (L.) Savi in Europe..... 88

Figure 37: Lotus corniculatus L. 92

Figure 38: Distribution of Lotus corniculatus L. in Europe. 92

Figure 39: Flowering Medicago lupulina (left) and seeds (right) 96

Figure 40: Distribution of Medicago lupulina L. İn Europe..... 97

Figure 41: Medicago polymorpha L. var. aroche. From left to right: trifoliolate leaves, yellow flowers, and a mature coiled spiny pod (“burr”). 100

Figure 42: Euro-Mediterranean distribution of Medicago polymorpha L. 101

Figure 43: Global occurrence records of Medicago polymorpha L. 101

Figure 44: Onobrychis sativa Lam. (left) and seeds (right) 107

Figure 45: Distribution of Onobrychis spp. in Europe 108

Figure 46: Ornithopus compressus L. From left to right: imparipinnate leaves, flowers, and developing curved, laterally compressed pods (“bird’s foot”). 112

Figure 47: Global occurrence records of Ornithopus compressus L. 113

Figure 48: Euro-Mediterranean distribution of Ornithopus compressus L..... 113

Figure 49: Trifolium cherleri L. From left to right: trifoliolate leaf, flowering head, and developed flower head 120

Figure 50: Euro-Mediterranean distribution of Trifolium cherleri L. 121

Figure 51: Global occurrence records of Trifolium cherleri L..... 121

Figure 52: Trifolium fragiferum L.: (a) whole plant; (b) leaf; (c) primary taproot with secondary roots including nodules; (d) stolon rooting at nodes with daughter plantlets; (e) flower head cross-pollinated by a honeybee; (f) seed..... 127

Figure 53: Global distribution map of Trifolium fragiferum L.. 128

Figure 54: Gelemen clover seeds and plant habit. 135

Figure 55: Distribution of Trifolium meneghinianum Clem. in Europe 136

Figure 56: Flowering Trifolium pratense (left), its habit in an reseeded meadow (middle) and seeds 139

Figure 57: Distribution of Trifolium pratense L. in Europe..... 140

Figure 58: Trifolium repens L. leaves (left), flowers, and seeds (right)..... 142

Figure 59: Distribution of Trifolium repens L. in Europe (..... 144

Figure 60:Trifolium subterraneum subsp. brachycalycinum. From left to right: trifoliolate leaves, pinkish papilionaceous flower, and developed geocarpic burr. 148

Figure 61: Euro-Mediterranean distribution of Trifolium subterraneum L. 149

Figure 62: Trifolium subterraneum subsp. subterraneum. From left to right: trifoliolate leaves, white papilionaceous flower, and developing geocarpic burr..... 155

Figure 63: Euro-Mediterranean distribution of Trifolium subterraneum L. 156

Figure 64: Global occurrence records of Trifolium subterraneum subsp. subterraneum. 157

Figure 65: Achillea millefolium L. 163

Figure 66: Distribution of Achillea millefolium L. in Europe. 164

Figure 67: Flowering Centaurea jacea (left), basket with und violet-purple inflorescence (middle) and seeds (right) 167

Figure 68: Distribution of Centaurea jacea L. in Europe 168

Figure 69: The life cycle of chicory during the first 18 months following spring sowing 170

Figure 70: Leaf morphology of chicory (Cichorium intybus L.) (a: wild type; b: 'Commander')..... 171

Figure 71: Floral structure of chicory (Cichorium intybus L.) 172

Figure 72: Fruit structure of chicory (Cichorium intybus L.) 172

Figure 73: Global distribution of chicory (Cichorium intybus L.), showing native regions in green and introduced regions in purple..... 173

Figure 74: Ribwort plantain seeds and plant habit 177

Figure 75: Distribution of Plantago lanceolata L. in Europe..... 178

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