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PREFACE

The production of cattle is severely hampered by a lack of feed, particularly during the dry season when the quality and quantity of grass on grazing pastures is inadequate in many dry countries. The annual feed shortages and nutritional inadequacies experienced during the dry season may be reduced by crop waste. In many nations, grain legume leftovers, often referred to as grain legume fodders, are stored and traded for use as feed during the dry season. However, the nutritional value and dry matter content of grain and legume feeds deteriorate as storage time increases.

Legumes have a higher nutritional value and intake when compared to grass for a number of reasons, including faster particle breakdown, quicker rumen digestion, more non-ammonium nitrogen reaching the small intestine, and higher energy utilization efficiency, though N utilization efficiency is lower. The breakdown and digestion of feed components in the rumen and gut do not follow a similar pattern. More specific information on the availability of nutrients to the animal is required on the rate of degradation of the various feed portions. The result of agricultural intensification was a decrease in soil fertility and an insufficient supply of high-quality feed for cattle. In an effort to meet the growing ruminant population's nutrient needs, cereals intercropped with fodder legumes are increasingly getting grown as a possible mitigating measure against intensification.

Breeding initiatives employing traditional and biotechnological techniques aim to increase nutritional value by, for example, enhancing the quality of the protein and adding condensed tannins to clovers and lucerne. Legumes are currently being bred to eliminate antiquality elements like bloat. In red clover and subclover, breeding to lessen oestrogenic effects has been successful. Improvements in breeding techniques, increased knowledge of the function of companion grasses, and improved tolerance to biotic and environmental stress are all contributing to improved legume consistency in mixtures.

Prof. Dr. Yaşar KARADAĞ
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CHAPTER I

ALFALFA (*Medicago sativa* L.)

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INTRODUCTION

Alfalfa's introduction to the New World begins with the emergence of a more historical reality. Colonists from Spain, England, and Germany added alfalfa seeds to available own seeds, and they researched and tested them in their old field areas. Colonists hope that these new attempts will bring success. Mexico, Chile, and Peru are perhaps the source of alfalfa brought to Southwestern America. Alfalfa seeds from ancient Mexico were produced in 1836 by Major Jacob in his field area of Colorado (Bolton 1962; Lesins ve Lesins 1979). Undoubtedly missionaries brought other seeds from Mexico to Texas, New Mexico, Arizona, and California.

Multiple harvests can be taken from grass and leguminous forage plants during the vegetation period. However, any forage crops can not reach the number of harvests and yields taken from alfalfa (Özkurt, 2018). Because the number of cutting is high, the yield of alfalfa is very high. Alfalfa has been known as the most produced species among forage crops all over the world. Some researchers suggest that although not yet certain the alfalfa cultivation area has been 35-45 million ha all over the World (Bouton 2001; Mielmann 2013; Böke, 2021).

Alfalfa History and Production Situation of Turkey

Considering the link between alfalfa culture and horse raising, it is also acceptable that Asian communities knew about alfalfa cultivation.

Thus, it is known that alfalfa was a valuable forage crop feeding of horses and other livestock animals in Anatolian Seljuk and the Ottoman Empire (Kır, 2010).

It is known that the Hittites living in Anatolia were interested in alfalfa cultivation and the name of the plant was "huncar" in the Hittites (Tarman, 1939). The inscriptions and cuneiform belonging to the Hittites dated 1400-1200 BC in the archaeological works in the Çorum-Alacahöyük region in Turkey show that the animals were feeding on alfalfa with high nutritional value during the winter months (Hanson,1972). Although there have been phonetic differences, alfalfa has been called "*Yonca*" in all Turkish dialects. "*Yond*" is mean "horse" in antic Turkish dialects. Philologists have accepted that the word of "alfalfa" derives from the word "Yond" (Tarman,1939). In Turkey, alfalfa is known as the Kayseri type that grows in Kayseri, which has the same name as itself.

Botanical Properties of Alfalfa

Alfalfa, an important leguminous plant, has been the most researched plant.

Most of the alfalfa species are annual, some alfalfa perennial and some species are semi-bush or form of bush (Heuser, 1931).

Taxonomy of Alfalfa

Kingdom	Plantae
Section	Magnoliophyta
Class	Magnoliopsida
Order	Fabales
Family	Fabaceae
Sub-family	Faboideae
Tribe	Trifoliae
Kind	*Medicago*
Species	*Medicago sativa* L.
Sub-species	M. *sativa* ssp. sativa
	M. *sativa* ssp. parviflora
	M. *sativa* ssp. gandiflora

There are some reasons why alfalfa is made so intensively both in the world and in Turkey. It is possible to array them as follows;

-Alfalfa can be harvested more than once in a vegetation period. Although the regions vary, alfalfa can be harvested 2-10 times.

-The alfalfa plant has high protein content (Avcıoğlu et al. 2009; Açıkgöz 2021).

-Alfalfa plant is a good source of vitamins. Especially it riches A, D, E, K, U, C, B1, B2, B6, B12 niasin, pantotenik acid, inositol, biotin and folic acid etc. a lot of vitamins. All the same, alfalfa includes phosphorus, calcium, potassium, sodium, chlorine, magnesium and copper, etc. lots of minerals (Putnam ve ark., 2001).

-Alfalfa can be grown in lots of different soil conditions, it increases soil yield since it is a leguminous plant. It contributes to decreasing erosions and straightening soil structure. Therfore alfalfa is one of the most important plant for sustainability and conservation agriculture.

-Due to the fact that the roots of the alfalfa grown very deep, it breaks the hard layers such as the footstone formed in the soil. It takes advantage of plant nutrients in the depths that other plants do not benefit from and carries them to the upper layers of the soil. In this way, it leaves a rich seed bed in nitrogen and organic matter for the plants that come after it, especially the plants with hairy roots (Açıkgöz, 2001; Avcıoğlu et al. 2009).

-Alfalfa has a wide variety of varieties that can grow even in very variable and extreme climatic conditions, from cold regions such as Siberia and Alaska, where winter temperatures reach -50 °C, to the death valley of California, where summer temperatures reach 60 °C (Manga et al. 1995; Açıkgöz, 2001).

Figure 1: Alfalfa leaf and flower

Root: Alfalfa has cylindrical taproots that can grown deep into the soil and have self-renewal features. In some regions, a dense root system was found at a depth of 40 m, sometimes 10 m, and generally 2-3 m. Its lateral roots are thin and few in number, but the main root can have a thickness of 2.0-2.5 cm.

Stems: Stems that develop upright from the buds in the root crown can be hairless, four-cornered, solid or hollow. Depending on the variety and ecology, it grows to an average of 60-70 cm. Young shoots are thin and soft, hardening with age. It has been reported that the stems with full inside have a higher feed value.

Leaves: Alfalfa leaf is made up of three leaflets. Leaflets can be in the form of long eggs, inverted spears or long inverted hearts. There are no spots on the leaves, they have dark and light green colors

Auricle: It is a pair, triangular lanceolate, with straight edges or toothed at the bottom.

Flowers: The flowers create a high panicle of 5-35 flowers. The sepals are half the length of the flower, the teeth of the calyx are triangular or lanceolate, half the length of the calyx. The flowers are usually violet, purple and rarely white.

Fruit: Spiral-shaped, 2-4 folded, 4-5 mm high, 3-9 mm in diameter, brown-yellow, hairy or bare, without spines; The veins emerging from the dorsal part form a network by branching in the form of an arc. It contains 2-7 seeds.

Seeds: Kidnbeaney, half kidney or boxing glove shape, 1.2-2.5 mm long, 1-1.5 mm wide, yellow, brown or greenish yellow, 1000 grains weight 2-3 grams.

Climate

Alfalfa is not extremely selective in terms of climate. Due to its widely genetic variation, it can adapt well to environmental conditions.

As a matter of fact, unique ecotypes have emerged in different regions of Turkey. For example, although the ecotypes in the Eastern Anatolia region late development due to the long winter season, the ecotype called of Kayseri alfalfa in the Central Anatolia region develops early and for a long time (Avcıoğlu et al. 2009).

Contrary to popular belief, alfalfa grows even in arid and non-irrigated areas (Undersander et al. 2011; Orloff et al. 2015).

It is accepted that it requires a temperature of 15-25 °C during the day and 10-20 °C at night for its optimum development (Açıkgöz 2001). In addition, it has been stated that it needs 850 °C (including day and night) in order to take a harvest (for one cutting) from alfalfa (Avcıoğlu et al. 2009).

Soils

Although alfalfa grows very well in loamy, sandy, lime-rich, irrigable, deep, well-drained, and adequately moist soils, it is not highly selective in terms of soil demand.

Since its roots go too deep, it is desirable that there are no obstacles such as sand, gravel and rocks in the soil profile (Tülücü, 2003). Another important issue is that the ground water should not be close to the surface.

If the water level is above 1.5-2.0 m, it seriously damages the plant growth. Alfalfa is sensitive to acidic soils and can not grow well (Hughes ve Metcalfe 1972; Murphy ve Johnson 1977; Hauptvogel 2003).

Optimum pH=6.8-7.3 for good alfalfa yield (Murphy ve Johnson 1977).

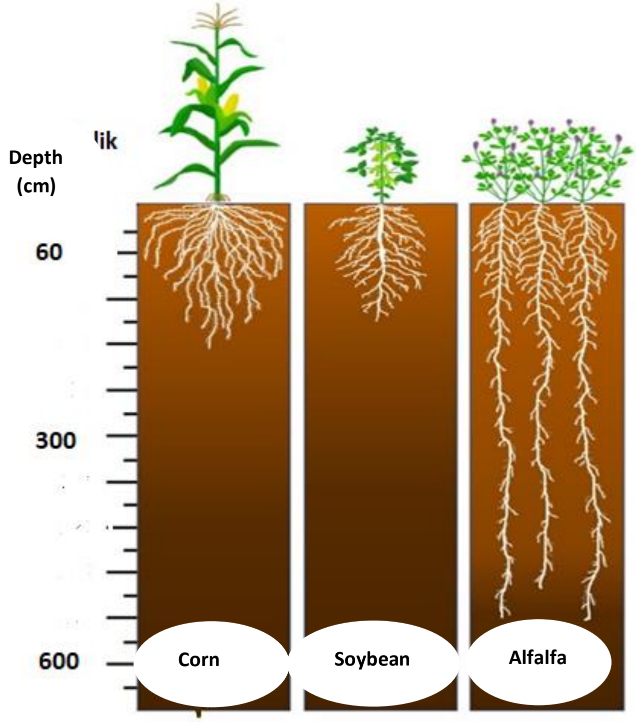


Figure 2: Root Depths of Corn, Soybean and Alfalfa (Anonim, 2022a)

Alfalfa Agriculture

The change in the cultivation area and production amount of alfalfa, the most important among forage crops in Turkey, in the last ten years is given in Table 1.

Tablo 1. Turkey Alfalfa Production Status (Anonim, 2022c)

Years	Sowing Area (ha)	Yield	Production Quantitiy (tons)
2011	558.552	2178	12.076.159
2012	674.183	1742	11.536.328
2013	628.641	2014	12.616.178
2014	692.305	1954	13.432.968
2015	662.045	2115	13.949.958
2016	650.110	2424	15.714.381
2017	659.431	2675	17.561.190
2018	635.105	2771	17.544.946
2019	641.212	2814	17.949.264
2020	662.888	2923	19.290.519

When Table 1 is examined although there are fluctuations in alfalfa cultivation areas, there is no sharp change.

Although there is not a very sharp increase in the amount of production in the first five years, there is a serious increase in the second five years.

Ultimately, the production amount, 12.0 million tons in 2011, reached 19.2 million tons in 2020. With this production amount and cultivation area, alfalfa is the most grown forage crop among forage crops.

On the other hand, The average alfalfa yield in Turkey has been on a continuous increase for the last ten years, except for a few years (Table 1).

While the average yields in some of our provinces are 5-6 thousand tons of herbage yield, Turkey's average is almost half of these yields.

There are a total of 104 alfalfa cultivars in Turkey, 73 registered and 31 licensed. Although the number of registered and licensed cultivars is quite high, Turkey's average yield is insufficient.

One of the most important reasons for this is that; although there are enough registered and production-allowed varieties, cultivation is not common.

Thus, especially in the Eastern Anatolia and Southeastern Anatolia Regions, the cultivation of more local ecotypes is proof of this. It is important to expand the production of suitable varieties according to the regions in increasing the yield of alfalfa in Turkey (Anonim 2022b).

The list of alfalfa varieties registered in Turkey is given in Table 2.

Table 2. Registered Alfalfa Varieties in Turkey (Anonymous, 2022b)

Variety	Registration Date		
Sazova Kır Yoncası	16.05.1964	N 525	10.04.2019
Elçi	18.05.1993	N 529	10.04.2019
Bilensoy 80	25.04.1984	N 586	10.04.2019
Sünter Yoncası	25.04.1984	N 656	10.04.2019
Kalender	30.04.2002	Alexis	10.04.2019
Savaş	30.04.2003	Banat VS	6.05.2020
Derby	12.04.2006	Zümrüt	6.05.2020
Emiliana	9.04.2007	Sahin	6.05.2020
Prosementi Bologna	7.04.2008	Blue Moon	6.05.2020
Alsancak	7.04.2008	Alphil	6.05.2020
Planet	8.04.2009	Galaxie	6.05.2020
Queen	13.04.2010	SW 6330	6.05.2020
Gea	12.04.2011	Tomris	6.05.2020
Verko	16.04.2012	Safkan	6.05.2020
Gözlü 1	16.04.2012	Frigos	6.05.2020
MA 225	16.04.2012	Timbale	6.05.2020
Mirna	16.04.2012	Defne	6.05.2020
Posavina	16.04.2012	Magnum 7	12.04.2021
Os 66	16.04.2012	Vanda	12.04.2021
Magnum V	16.04.2012	Creno	12.04.2021
Magna 601	16.04.2012	Classe	12.04.2021
CW 4696	16.04.2012	Central	12.04.2021
MA835	16.04.2012	Celsius	12.04.2021
Plato	16.04.2012	Vlasta	12.04.2021
Iside	8.04.2013	Pomposa	12.04.2021
Toros	8.04.2013	SHN	12.04.2021
Özpınar	8.04.2013	Riviera Vicentina	12.04.2021
Blue Ace	8.04.2013	SHN4	12.04.2021
Diane	7.04.2014	Palladiana	12.04.2021
Osjecka 99	10.04.2017	Beatrix	12.04.2021
Dimitra	10.04.2017	Daniela	12.04.2021
Ağstafa 1	10.04.2018	Sandra	12.04.2021
Abşeron	10.04.2018	Felicia	12.04.2021
Giulia	10.04.2018	Emily	12.04.2021
Azzurra	10.04.2019	Optimus	12.04.2021
Artemis	10.04.2019	Şahin 42	12.04.2021
Delta	10.04.2019		

Considering the winter dormancy issue of choosing the most suitable one for the region among these varieties, the yield and quality of the herbage yield and quantity will increase.

Preparation of Soil.

Since alfalfa seeds are a very small and perennial plant, soil preparation is one of the important issues affecting the yield of the plant in the following years.

Thus, it is desirable that the soil is processed very well and that there are no large and hard soil pieces.

It should be leveled with tools such as a plow, chisel, cultivator, and soil mill, suitable for the soil structure of the region, free from weeds, deeply plowed, and not ponding when irrigation is done.

Figure 3: Well Prepared Seed Bed

In heavy profile soils, recommended throwing 2-3 tons/da of burned farm manure. With this manuring, the formation of a duff layer on the surface of the soil can be prevented (Açıkgöz, 2001).

Sowing

Alfalfa can be planted in all seasons, taking into account the climatic conditions of the region, soil tempering, and irrigation facilities.

Taking into account the structure of the soil it is recommended to plant at a depth of 1-2 cm. If deep planting is done especially in heavy soils, emergence problems may occur. Thus, broadcast sowing is not recommended for the cultivation of alfalfa (Figure 3).

Figure 4: Brillon sowing machine (Anonymous, 2022d)

It has been reported that 15 cm row spacing and 2.5 kg/da seed should be used in row planting with a seeder (Özkurt and Karadağ 2020)..

Farmers in Turkey think that they will get more yield by using more seeds per unit area than necessary, but in dense planting, the plants enter into the competition, and rarity is observed in the field.

Irrigation

Although alfalfa is grown even in arid climates, irrigation is recommended for high efficiency because it responds very well to water.

The need for water varies depending on the region, the plant's physiological state, field conditions, groundwater, and irrigation method.

Alfalfa should be watered twice in every harvest, considering the region's climate structure and the alfalfa's condition.

This irrigation can 1 week before and after the cutting. When the plant needs water, the lower leaves turn yellow, while the upper leaves turn blue and greenish.

Weed Control

Since alfalfa is a perennial plant, the first year is accepted as the planting year, and then alfalfa cannot fully develop in its first year, it has difficulty combating weeds.

It is desirable that the alfalfa seeds planted are not certified or mixed with other species. Particular attention should be paid to small weed seeds such as clover seeds, which resemble alfalfa seeds.

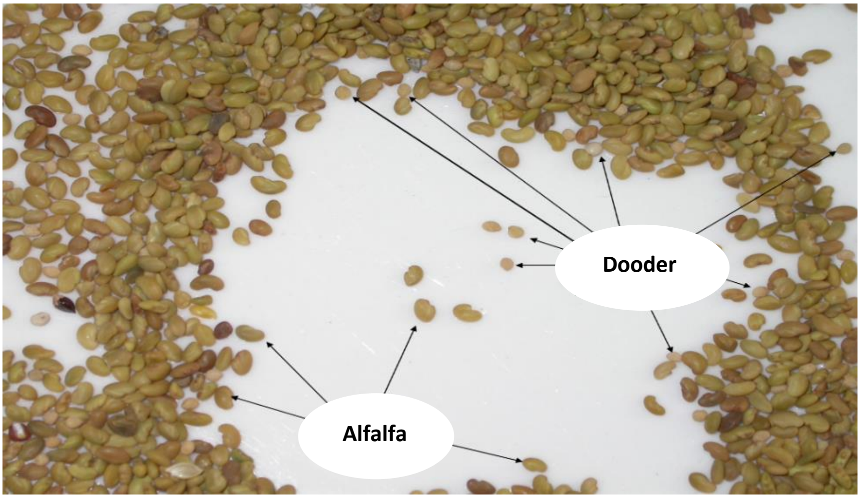


Figure 5: Alfalfa and dodder (Cuscuta spp.) seeds

Harvesting

For alfalfa to maintain its yield and quality for many years, it is necessary to be careful during the harvesting period and cutting height. Alfalfa shows different characteristics in terms of yield and quality in development stages (vegetative, budding, flowering, fruit setting) (Figure 6).

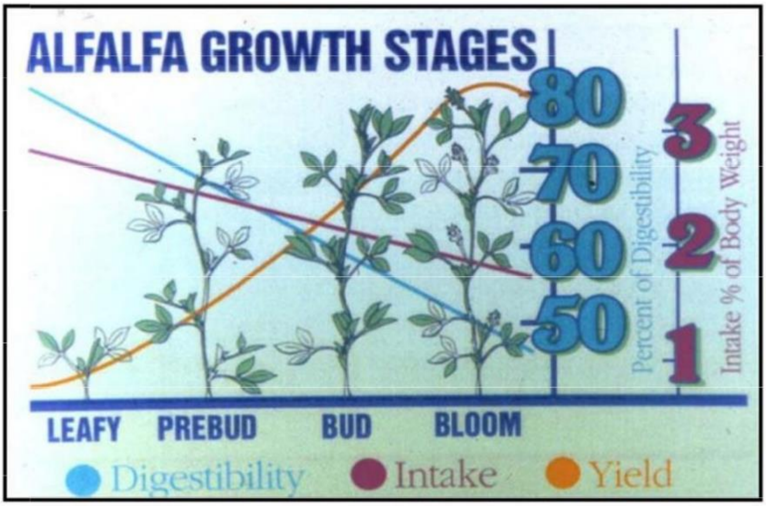
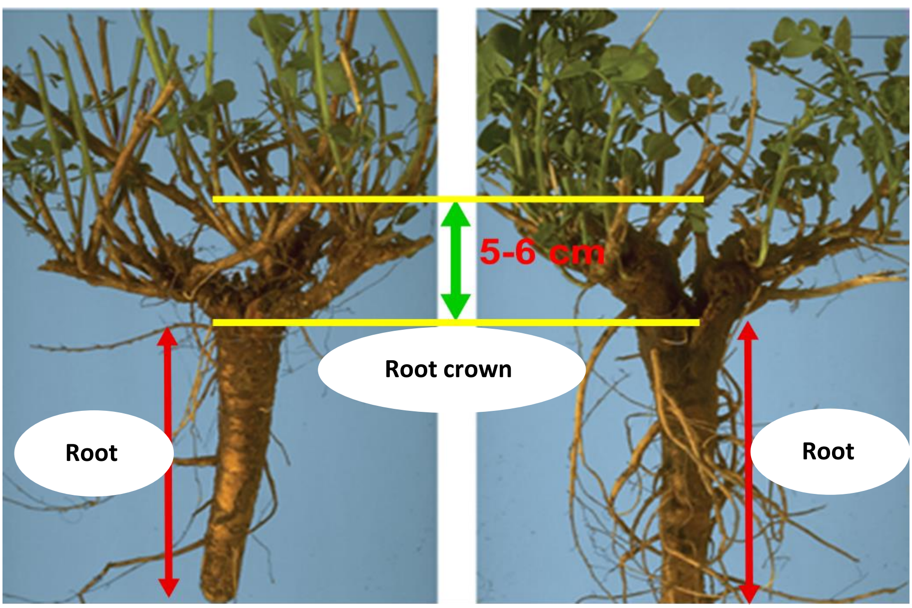


Figure 6: Maturity effects on forage y,ed and quality. (Garry Lacefield, University of Kentucky)

If the harvests are made too early, the alfalfa will be damaged and become rarefy because it cannot store enough nutrients (Açıkgöz, 2021). Considering the sustainable yield and quality characteristics of the herbage, it has been reported that the 10% flowering period is suitable (Açıkgöz, 2001:Avcıoğlu et al. 2009).

Also harvest height is one of the factors affecting the physiological functions of the alfalfa. New shoots have been develop from the buds in the root crown (Figure 6)

If the root crown is damaged, the plant does not develop by being damaged. While harvesting, it should be shaped from a height of at least 5 cm without damaging the root crown.



Resim 6: Alfalfa root and root crown

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CHAPTER II

BIRDSFOOT TREFOIL (*Lotus corniculatus* L.)

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1. INTRODUCTION

Efficient pastoral farming systems maintain or improve pasture production, crop growth and animal performance within the constraints of the socio-economic and biophysical environments. Efficient pastoral farming systems maintain or improve pasture production, crop growth and animal performance within the constraints of the socio-economic and biophysical environments. However, the use of some alternative legume forages that increase opportunities for better land use and animal production will be necessary to ensure the biological sustainability and performance of temperate regions, which regularly experience drought and global warming variability that may affect the seasonal and annual productivity and persistence of pasture legumes. In order to increase the present year-round sheep productivity in dryland farming conditions, it has been suggested that species of tap-rooted perennial legumes like *Lotus corniculatus* L. (birdsfoot trefoil) can be used.

Due to their high capacity for N2 fixation and ability to grow in soils with poor fertility, forage legumes are crucial to the productivity of cultivated pastures. Due to its high flavonoid content, *Lotus corniculatus*, a plant of significant agronomic importance in various parts of the world, is also of particular interest for more theoretical research.

Lotus corniculatus (birdsfoot trefoil), is a Eurasian perennial legume, popular in temperate climates for pasture or hay and silage production. Its ancestry is controversial (Grant & Small, 1996). In temperate parts of Europe, Asia Minor, North Africa, North and South America, Australia, and New Zealand, it can be found in both wild and naturalized populations. The genus *Lotus* is a sizable, polymorphic group with about 200 annual and perennial species that are found throughout the world (Steiner & De Los Santos, 2001). The *Lotus* genus's most significant and frequently cultivated plant is the bird's-foot trefoil (Diaz et al., 2005).

In South America, "birdsfoot trefoil" is a plant with exceptional agricultural value and widespread distribution (Diaz et al., 2005). Despite the species' origins in temperate regions of Europe and North Africa, cultivation has led to its global spread (Daz et al., 2005). Currently, *Lotus corniculatus*, which forms a symbiotic relationship with Mesorhizobium, is the most extensively used legume in pastures that have been sown in Uruguay (Sotelo et al., 2011). In the southern region of Brazil, ruminants eat *Lotus corniculatus* (*Fabaceae*), which is regarded as a fodder plant. This herb is also actually used to treat intestinal infection in these animals. *Lotus corniculatus* is commonly known as "Cornicho" in Brazil, as a plant fed to ruminants because it aids in ovulation, the absorption of vital amino acids, and the production of milk protein and lactose. This herb is also used as an important antihelmintic substance in these animals in sheep fed on birdsfoot trefoil (Dalmarco et al., 2010).

Figure 1. A *Lotus corniculatus* field (Picard, 2019)

Within the limitations of the socioeconomic and biophysical contexts, effective pastoral farming systems sustain or enhance pasture output, crop growth, and animal performance. However, the use of some alternative legume forages that increase opportunities for better land use and animal production will be necessary to ensure the biological sustainability and performance of temperate regions, which regularly experience drought and global warming variability that may affect the seasonal and annual productivity and persistence of pasture legumes. In comparison to perennial ryegrass (*Lolium perenne*)/white clover pasture, the use of tap-rooted perennial legume species like *Lotus corniculatus* L. has been proposed as a strategy to increase the present year-round sheep productivity in dryland agricultural conditions (Ramirez-Restrepo et al., 2005).

Birdsfoot trefoil increases milk yield of dairy cows (Woodward et al., 200). Other common fodder legumes, such alfalfa or white clover, cannot survive under flood conditions, whereas this warm-season legume species is adaptable to many different types of environmental stress (Striker et al., 2005). Other common forage legumes do not do well in acidic, infertile, or poorly drained soils, but this crop does (Steiner & De Los Santos, 2001). Lotus spp are nodulated by *Rhizobium loti* (van Rhijn et al., 1998).

Due to their exceptional capacity for symbiotic nitrogen fixation, legume crops play a significant role in the global nitrogen cycle and are commercially significant sources of protein and oil for human and animal use. In addition to being important for agriculture, legumes also create a wide range of advantageous secondary compounds, many of which have been shown to have health-promoting features including protecting against human diseases (Jian et al., 2009).

2. GENETICS & BIOLOGY

Although L. corniculatus is sometimes said to contain diploid populations, it generally seems to be tetraploid. This species is an allotetraploid, according to biochemical and genetic data (Grant & Small, 1996). The tetraploid species *Lotus corniculatus* is thought to have evolved as an autotetraploid of the closely related diploid species Lotus tenuis or Lotus alpinus, according to earlier investigations on the origins of this species. More recent research hypothesized that *L. alpinus* and *L. japonicus* might be related species. The study conducted by Ross & Jones, (1985) on tannin content, phenolic content, cyanide production, morphology, cytogenetics, Rhizobium specificity and self-incompatibility in the corniculatus group virtually excludes the possibility that *L. corniculatus* could have arisen through autopolyploidy of *L. tenuis* or *L. alpinus*, and suggests that *L. corniculatus* arose through hybridization of *L. alpinus* and/or *L. tenuis* (probably as female parent) with *L. uliginosus* (probably as male parent), followed by chromosome doubling in the hybrid.

Figure 2. *Lotus corniculatus* flower (Stanley & Raine, 2016)

It has been reported that L. corniculatus has either a disomic or a tetrasomic mode of inheritance (Fjellstrom et al., 2001). The species is a strictly entogamous, self-sterile Fabaceae that is frequently seen in urban and suburban regions (Pellissier et al., 2012).

3. FLAVONOIDS

With more than 6000 known structures, flavonoids constitute a sizable family of secondary plant metabolites that are present in many higher plants (Harborne and Baxter, 1999). Only derivatives of the two most prevalent subclasses, flavones and flavonols, have been found in *Lotus corniculatus* (Reynaud & Lussignol, 2005). Formononetin and biochanin A, two isoflavonoids, were also present in *Lotus corniculatus* at the budding and flowering stages, according to a study (Sarelli et al., 2003). These two phytoestrogens are present in too little of a concentration to have a negative impact on reproductive processes. Flavonol glycosides are particularly abundant in the plant seeds (5 monosides and 6 diosides). Kaempferol and quercetin are the two main flavonoids (found as glycosides) in the flower buds of the *Lotus corniculatus* plant (Jay and Ibrahim, 1986). In accordance with Ceruti et al. (1972), the amount and quality of solar radiation that individuals of the *Lotus corniculatus* get as a function of altitude are related to the upregulation of the flavonoid content.

In order to compare the reproductive effectiveness and wool growth of ewes grazing birdsfoot trefoil or perennial ryegrass (*Lolium perenne*)/white clover (*Trifolium repens*) pasture, a grazing experiment was carried out for 81 days (from 13 February to 4 May) in the late summer/autumn in New Zealand (referred to as pasture). The results showed that lotus grazing during mating improved the effectiveness of reproduction and clean wool production, with a contribution from the action of condensed tannins (Min et al., 2001).

Condensed tannins in *L. corniculatus* significantly reduced rumen protein degradability and ammonia production, while increasing the transit of , essential amino acid (52%) via the abomasum and their absorption (62%) from the small intestine, according to the study of Waghorn et al., (1987). Condensed tannins in birdsfoot trefoil boosted ovulation rate, lambing percentage, and wool growth throughout summer (Wang et al., 1996), without influencing voluntary feed intake (Ramrez-Restrepo et al., 2005), according to later sheep grazing trials.

4.MEDICINAL VALUES

The *Lotus corniculatus* is also valued for its therapeutic properties. The flowers have sedative and antispasmodic effects (Chiej, 1984). The root is febrifuge and carminative (Duke and Ayensu, 1985). A study by Rafiq et al. (2013) examined the anti-cancer properties of a lectin derived from *Lotus corniculatus* seeds. According to morphological analysis, *Lotus corniculatus* lectin-treated THP-1 cells revealed signs of apparent apoptosis like DNA fragmentation, the development of membrane-enclosed apoptotic bodies, and nuclear fragmentation. As shown by the wound healing assay, the lectin from *Lotus corniculatus* effectively blocks cell migration in a dose-dependent manner.

Figure. 3. *Lotus corniculatus* seeds (Echevarria et al., 2016)

The anti-inflammatory effects of the crude extract of *Lotus corniculatus* and its derived hexane (HEX), ethyl acetate (AcOEt), n-butanol (BuOH) and aqueous (Aq) fractions and isolated compounds kaempferitrin, oleanolic acid and β-sitosterol, in a mouse model of pleurisy induced by carrageenan were investigated. By inhibiting not only leukocytes and/or exudation but also pro-inflammatory enzymes and mediators such myeloperoxidase, adenosine-deaminase, and interleukin-1 beta, the crude extract of *L. corniculatus* demonstrated significant anti-inflammatory activity. It may be explained by the constituent's kaempferitrin, oleanolic acid, and beta-sitosterol (Koelzer et al., 2009).

5. ANTI-PARASITIC EFFECT

Traditionally, farmers have relied on the regular application of anthelmintics to manage helminth parasites, and this approach has shown to be quite cost-effective. Farmers are being required to look for other methods of parasite control due to a number of issues, including the rise of helminths resistant to pharmaceutical anthelmintics. Lambs grazing chicory (*Cichorium intybus*) and birdsfoot trefoil (*Lotus corniculatus*) have less helminth parasites than sheep feeding ryegrass/white clover (*Lolium perenne*/*Trifolium repens*) under UK environmental conditions. Overall findings support the hypothesis that alternative forages, subject to effective agronomic development and integration of these forages into whole farm systems, could play a beneficial role in the control of helminth infections in sheep (Marley et al., 2003).

6. PLANT PHYSIOLOGY & AGRONOMY

On *Lotus corniculatus,* each inflorescence typically loses around half of its developing fruits. Compared to random patterns of fruit abortion, natural patterns offruit abortion produce mature fruits that contain significantly more seeds. Additionally, these offspring have a higher chance of germination, are stronger as seedlings, and produce more offspring when they are adults. These findings show that *L. corniculatus* preferentially aborts those fruits that have the fewest seeds, improving the average quality of its offspring in the process (Stephenson & Winsor, 1986)

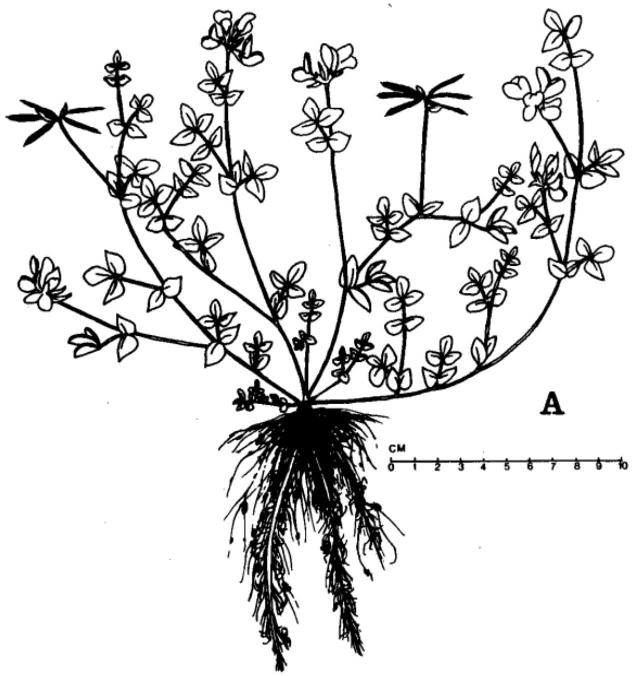

Figure. 4. *Lotus corniculatus* plant. Scale as shown (Turkington & Franko, 1980).

Lotus corniculatus is a valuable forage legume. Rhizomatous "*Lotus corniculatus*" germplasm from Morocco was discovered. Rhizomatous habit may increase persistence because new plants produced vegetatively by rhizomes could take the place of sick or dead plants. Because rhizomes are not mentioned in taxonomic descriptions of *L. corniculatus*, rhizome morphology in the Moroccan species is distinctive. The axillary buds on the basal sections of Moroccan L. corniculatus's shoots serve as the starting point for its rhizomes. The rhizome is made up of nodes and internodes, and each node has buds, scale leaves, and adventitious roots. The *L. corniculatus* rhizome is anatomically composed of six to seven principal vascular bundles, a big cortex, and a tiny pith. The cortex lacks endodermis and has starch-containing parenchyma cells. The aerial shoot of *L. corniculatus*, in contrast, contains nine to ten primary vascular bundles, a tiny cortex, and a big pith. The aerial shoot's concentric ring of vascular bundles is surrounded by an endodermoid layer, and the cortex's parenchyma cells have chloroplasts. Rhizomes and aerial shoots of *L. corniculatus* differ from one another morphologically and anatomically (Li & Beuselinck, 1996).

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CHAPTER III

HUNGARIAN VETCH (*Vicia pannonica* Crantz.)

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INTRODUCTION

It is known that there are 150 -210 species of vetch in the world. Vetch has its origin from Asia, Europe and especially Mediterranean countries. They are naturally found in a wide area from England to Japan. There are 59 species, 22 subspecies and 18 varieties in the genus *Vicia*, which is widely distributed in Turkey. Of these, 5 species and 3 subspecies are endemic (Davis, 1970; Gedik ve ark., 2013).

It is not known exactly when the cultivation of vetch, which was cultivated in the ancient world, began. However, the Vicia species cultivated for the first time are Vicia sativa and Vicia faba. Today, vetch is widely grown in Mediterranean countries, central and northern European countries, the former Soviet Union, the USA and the Middle East. The use of vetch with good forage yield and quality is due to their legume and annual characteristics.

The important vetch species distributed in the cool climate zone around the world are as follows. Among these, it is the common vetch that is grown the most both in our country and in other countries.

In addition, Hungarian vetch, hairy vetch, faba bean, narbonne vetch and bitter vetch are the species cultivated (Açıkgöz, 2001; Soya ve ark., 2004).

V. sativa: Common vetch
V.villosa: Hairy vetch
V.ervilia: Bitter vetch
V. pannonica: Hungarian vetch
V. faba: Faba bean
V. narbonensis: narbonne vetch
V. dasycarpa: Grazing vetch
V. villosa var. Glabrescens
V. cracca: Bird vetch
V. atropurpurea
V. grandiflora: Large-flowered vetch
V. lutea: Yellow vetch

Autumn planting of vetch in regions where winters are not severe spring planting is carried out in regions with harsh winters is done.

HUNGARIAN VETCH

Hungarian vetch grows naturally from southern and central Europe to the Caucasus and western Asia. It has been reported that the main gene source is Georgia, the second gene loss is Hungary (Enneking, 1997). It is found in many regions of our country as wild.Agriculture in our country began to spread after the 1970s. This plant has important features that make it widespread.

It is cold resistant. It can be planted in the winter. It is drought resistant. It can be grown in heavy and wet soils. Seed is easy to find. It is early. It comes to harvest quickly. The pod opening and seed shedding are low.

There are 2 subspecies of Hungarian vetch in use.

1. *Vicia pannonica* var. pannonica: It is a cold-resistant subspecies with yellowish-white seeds in the form of spherical and black flowers. It blooms late. The number of seeds in the pod is high and the seeds are small.

2. *Vicia pannonica* var. purpurescens: Flower color pink-violet seeds flat. It is suitable for temperate regions. It is early, the grass yield is a little higher and the seeds are larger. It is generally considered to be self-fertile. However, it can also be fertilized with foreign pollen by bees.

Chromosome number is 2n=12, rarely 2n=14 (Açıkgöz, 2021).

Hungarian vetch is an annual. Its body is 70-12 cm long, it is more enveloping than common vetch and hairy vetch. Since the plant is covered with fine hairs, it is seen in a dull gray green color. The leaves consist of 7-9 pairs of leaflets. The petiole has a weak leech. The leaflets are 10-25 mm long, 2-5 mm wide and oval or inverted egg-shaped. Auricles are small narrow pointed egg or arrow shaped. 1-4 of the flowers come out of the leaf axil together without a stem. Flower color is yellowish white or pink to yellowish white. Their pods are 2-3 cm long and 7-9 mm wide. It contains 3-6 seeds. The seeds are roundish and greenish-black in color. Thousand grain weight is 25-50 grams.

Hungarian vetch is not selective in terms of soil. It can be grown in almost any soil. The most important feature is that it can be grown in heavy, clayey and water-holding areas. Hungarian vetch can be planted both in summer and winter. Even in Eastern Anatolia, it is not damaged by the winter cold (Taş, 2015). For this reason, it should be grown in winter to reveal its advantages. Drought resistance is high. It can be grown even in arid conditions in the middle Anatolian region. Hungarian vetch is not successful in regions with very mild winters. Hungarian vetch should be planted in winter in all our regions. Summer plantings do not give successful results. In general, grain cultivation areas are also requested to enter the crop rotation. After the grain harvest, the seedbed preparation, which starts with stubble, is completed by passing a crowbar, rake and taper. Sowing should be done just before the onset of precipitation in autumn. This period is September-October for the eastern Anatolian region and November for our inner and western regions.

Based on soil analysis in fertilization, 4-5 kg/da N and 3-6 kg/da P2O5 should be applied in poor soils. The amount of nitrogen in seed production can be reduced to 2-3 kg/da. When it is grown plain, 8-10 kg of seeds per decare should be used with a wheat seeder. The hard seed feature is very low in its seeds, it germinates to a large extent. Row spacing should be 15-25 cm in sowing. If it is desired to produce seeds, it should be planted with 6-8 kg seeds and 20-30 cm row spacing in general. The average sowing depth is 4-5 cm.

The biggest problem of Hungarian vetch, as in other types of vetch, is the lying that occurs with the progress of development. Hungarian vetch successful with grains form mixtures (Açıkgöz, 2001; Avcıoğlu ve ark., 2009). For this reason, it is recommended to grow winter crops mixed with wheat and triticale. In this mixture, 60-70% (6-8 kg/da) Hungarian vetch and 30-40% (5-6 kg/da) grains should be present.

The most suitable time for Hungarian vetch grass production is the flowering phase. In general, the full bloom period is considered the most suitable cutting time. In mixed plantings with cereals, the flowering and milking period of the cereal and the flowering period of Hungarian vetch should be done. For silage production, it should be done during the milking period of the grain.

Grass yield obtained from pure Hungarian vetch or mixtures varies according to the soil and climate characteristics of the region and especially the amount and distribution of precipitation. Average hay yield is 700-800 kg/da. Seed production should be done when the pods at the bottom turn brown and mature and ready to open. Average seed yield is 70-100 kg/da.

RESULTS

Vetch is an important annual used in forage crop farming legumes. Hungarian vetch cultivation has been advancing in recent years. Hungarian vetch types while the number of varieties registered in Turkey is sufficient for production, however, the number of varieties varies by region and even by basin should be increased. Cultivation of vetch registered according to regions to increase the yield and thus to close the roughage deficit will contribute.

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CHAPTER IV

COWPEA (*Vigna unguiculata* L. walp.)

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1. INTRODUCTION

Cowpea (*Vigna unguiculata* L.), is an annual herbaceous legume grown for edible seeds or for use as animal feed. Prostrate types reach 80 cm heights, whereas climbing types might reach 2 meters. It has a strong root structure. One of the most common legumes grown outside of Africa is the cowpea, which is also grown in parts of Asia and America. Although cowpeas are mostly regarded as food, they are occasionally fed to animals. The vines and leaves of cowpeas, whether they are utilized fresh or preserved as hay or silage, are frequently used as forage for livestock. In Asia and Australia, cut-and-carry systems and cowpea pastures are firmly established. Yields of fresh fodder can be increased by cutting the plants two or three times in a season.

In warm to hot climates of Africa, Asia, and the Americas, cowpea (*Vigna unguiculata* L. Walp.) is an extensively adapted, stress-tolerant grain legume, vegetable, and fodder crop (Ehlers & Hall, 1997). This popular legume crop is grown mostly in Africa but is consumed worldwide by both humans and animals. Cowpea seeds, leaves, and green pods are also rich in protein, lipids, carbs, vitamins, dietary fibers, minerals, and vitamins.

The majority of the macro- and micronutrients found in cowpeas can be used as human food and as livestock feed. Cowpeas can tolerate water shortages. Additionally, it has antinutritional components that might interfere with the nutrition of non-ruminant animals and humans. To reduce or completely eliminate the detrimental effects of anti-nutritional components, numerous processing techniques are used. Cowpea seeds make up up to 30% of the diets of ruminants. For instance, raw cowpea seeds are part of the diet for ruminants, but they shouldn't be consumed by non-ruminants without preparation. Its hulls are a potential low-cost source of feed for poultry diets; starter and finisher rations may use up to 15% of this source. In addition to their nutritional advantages, cowpea leaves and green pods are used to prevent or treat a number of human ailments, such as measles, smallpox, adenitis, burns, and ulcers. Similar to how cowpea plant seeds are crucial for the treatment of several ailments, including astringent, antipyretic, and diuretic, Decoction or soup is used for issues with the liver and spleen, intestinal cramp, leucorrhoea, monthly irregularities, and urine expulsions. Additionally, up to 80% of the nitrogen in the soil may be fixed by cowpeas, reducing the need for and cost of nitrogen fertilizer. Usually, the livelihoods of less developed countries depend on cowpea plants and their byproducts for less expensive protein-based human and animal diets (Abebe & Alemayehu, 2022).

Fig. 1. *Vigna unguiculata* seeds (Zaheer et al., 2020) .

Cowpea is an important legume grown in the tropics where it constitutes a valuable source of protein. Certain biotic and abiotic stressors have a negative impact on its productivity (Boukar et al., 2019). A total of 6.2 million metric tons of cowpea are produced annually on an estimated 14.5 million ha of planted land around the world. Global cowpea production increased by 5% annually on average over the past three decades, with yearly area growth of 3.5% and yield growth of 1.5%, with area expansion accounting for 70% of the overall rise during this time (Boukar et al., 2016). Over 80% of African production is concentrated in West Africa, which also accounts for over 84 percent of the world's total production of cowpeas. Cowpea was grown on an estimated 12.3 million ha in Africa in 2014, with the majority of the production taking place on 10.6 million ha in West Africa, especially in Nigeria, Niger, Burkina Faso, Mali, and Senegal, according to FAOSTAT (2016) (Boukar et al., 2016).

2. THE PLANT

The herbaceous plant can be twining, erect, or prostate-shaped. The flowers can be blue, pink, yellow, purple, or other colors. When fully dried, the pods can be black, purple, or cream and can hang horizontally, vertically, or sideways. Up to 60 cm long pods have been observed (Jindla & Singh, 1970). The color of the seeds can range from white to black, mottle brown to purple, red, and brown. Cowpeas have four distinct grain coat textures: smooth, rough, wrinkled, and loose (Agbicodo et al., 2009). Different regions of the world have different preferences regarding grain coat texture. For instance, people in West Africa prefer cowpeas with large, white or brown grains and a rough grain coat, whereas those in East Africa prefer medium-sized, brown or red grains and a smooth grain coat. Black colors with different types of grain coat textures are favoured in some Latin American countries, especially Cuba and parts of the Caribbean (Obiegbuna et al., 2006). Rough grain coat is appreciated in West and Central Africa because it makes it simple to remove the grain coat, which is necessary for traditional culinary preparations (Singh & Ishiyaku, 2000). Due to its consistent expression and suitability for observation, grain coat color is regarded as one of the useful phenotypic markers in cowpea breeding (Xu et al., 2011).

3. GENETİCS, GENOMİCS AND BREEDİNG

Early maturing cowpea cultivars have been developed with acceptable grain quality and resistance a few significant diseases and pests, such as bacterial blight (*Xanthomonas campestris*), cowpea aphid-borne mosaic virus, cowpea aphid (*Aphis craccivora*), cowpea curculio (*Chalcodermus aeneus*), root-knot nematodes (Meloido Early cultivars can avoid drought and some pest infestations and can give marketable yield during growing season, and can be planted in a variety of cropping systems. Earlyness is essential in Africa and other regions. In the Sahel's severely dry and hot climate, new early maturing cultivars with unpredictable growth patterns have proven to be particularly productive. Breeding lines that can withstand high night temperatures and produce significantly more pods than other cultivars have been developed. An important current breeding goal is the development of cultivars with various resistances to biotic and abiotic stress factors. To promote drought adaptability, traits including earliness, delayed leaf senescence, and indeterminate growth habits are combined. In the future, it will be necessary to identify plants with high levels of resistance to significant insect pests including flower thrips (Megalurothrips *sjostedti*), maruca pod borer (*Maruca testulalis*), lygus (*Lygus hesperus*), and pod bugs (*Clavigralla tomentosicollis*). To develop cultivars with high levels of resistance to several of the main insect pests, it might be necessary to use genes from wild cowpeas, related Vigna species, or genetic engineering (Ehlers & Hall, 1997).

Fig. 2. Cowpea at a research station in United Arab Emirates (Rao & Shahid, 2011)

In order to better improve the crop, cowpea breeding programs have investigated the crop's qualitative and quantitative genetics in great detail. The development of cowpea genomic resources has been facilitated by a number of initiatives, including Tropical Legumes projects. Numerous illuminating markers were linked to quantitative trait loci (QTL) connected to favorable characteristics of cowpea. Utilizing existing genetic resources and current breeding technologies that will increase genetic gain when produced by sub-Saharan African farmers, cowpea genetic improvement initiatives aim to develop drought tolerant, phosphorus usage efficient, bacterial blight and virus resistance lines (Boukar et al., 2019).

Cowpea is grown mostly in tropical and subtropical areas, including Ethiopia. Ethiopians grow it largely for its edible seeds, pods, and leaves, which are fed to livestock and utilized as a source of revenue for households. Its production is carried out by using a variety of cropping strategies, such as sole cropping, intercropping, and mixed cropping. As a growing percentage of farm households produce cowpea on marginally fertile and infertile soils, the yield of the crop continually fall below its potential and the global averages. The overall low yield potential of cowpea is mainly attributed to limited attention by research and development programmes, severe attacks of pest complexes, low soil fertility, drought, poor management practices, marketing problems, and poor technology dissemination and popularization (Kebede & Bekeko, 2020).

4. ANİMAL FEED

The demand for and the price of vitamins, minerals, and proteins derived from animals have increased. Legume crop cowpea could improve the accessibility of human and animal feed as well as protein absorption to solve this issue (Chivenge et al., 2015). Because they are less expensive than beef, dairy products, shellfish, fish, meat, or chicken, cowpea seeds and leaves, for instance, are a good source of protein, vitamins, and minerals in less developed regions. This helps low-income farmers by preventing protein deficiency. Ripe or immature pods are consumed over most of Africa, especially during the "hungry period" (Dakora & Belane, 2019). In many dry and semi-arid regions, lower animal productivity is frequently associated with feed supplies that are less palatable and higher in protein. As a result, several tropical pulses with high yields, including cowpea, might be used as animal feed (Khare, 2008). They have a lot more potential as fodder because intercropping cowpea with other cereals (such utilizing maize) increases their protein content, dry matter digestibility, and soluble carbohydrate content (Uher et al., 2018). Cowpea fodder is high in protein and simple to digest for ruminants (Anele et al., 2011). A concentrate mixture's fiber intake, nitrogen percentage, rumen environment, and lamb growth were all improved by the addition of cowpea grains. As the primary source of protein in the concentrate mixture for a young lamb, cowpea grains can completely replace groundnut cake (Singh et al., 2006). (Tsigab et al., 2018) found that substituting up to 20% cowpea whole grain for broiler feed had no adverse effects on the chicks' growth rate.

Cowpea is the only high-quality legume hay that is readily accessible for use as animal feed in many parts of the world. It has been demonstrated that some cultivars are comparable to alfalfa in terms of digestibility and yield. Cowpea can be fed to animals as dry or green feed. Although cowpea grows well in a wide range of soil types and soil conditions, it flourishes in sandy loams with good drainage or sandy soil with a pH of 5.5 to 6.5. (Davis et al., 1991). Cowpea is a dual-purpose crop with the ability to control weed growth, improve soil quality, tolerate drought, and grow well in warm climates. It is a desirable and promising fodder plant in the usual tropical lowland climate. It is frequently grown in drier places and is typically more resistant to drought, high temperatures, and other biotic stresses than other agricultural plant species (Hall et al., 2018). (Atumo, 2018). After flowering, cowpeas can be utilized as feed by light grazing. Several buds that remain after defoliation allow the plant to regenerate for use as forage, hay, and silage. It can be combined with sorghum, maize, or molasses when used as silage to supply sugar for fermentation. Numerous cowpea cultivars have been grown side by side for both food and feed in some African nations. Cowpea is more nutrient-dense (CP% 20) than lablab and can supplement inadequate roughage feeds. Dual-purpose species are suitable for areas with unpredictable rainfall patterns and agro-pastoral farming systems. Most species tend to produce more herbage when the rain persists longer than usual. Since cowpea has a significant nutritional and health benefit to both humans and livestock, it is the most widely farmed, traded, and distributed food and feed crop. Varied *Vigna unguiculata* cultivars exhibit very different grain yields and dry matter yields (Agbogidi and Egho, 2012). With a maximum milk yield of 4.3 t/h, biomass yields in dry matter bases may support over 550 lactating Borana goats. The highest dry matter yield (10.6 t/ha) recorded for some accessions of Cow pea in Ethiopia. According to Ethiopia's ministry of agriculture, a recently released variety of forage cowpea has a dry matter yield of 11.4 t/ha, 7.8 branches per plant, and a low lignin content (Atumo, 2018).

Cowpea has the capacity to yield large amounts of quality dry matter. Cowpea forage yields under dry land environments have varied from 0.5 t DM/ha to over 4 t DM/ha under favorable conditions. The average production per season is 2 to 3 t DM/ha. In irrigated locations, yields of up to 8 t DM/ha have been reported (Mullen, 1999). Through intercropping, cowpea grows effectively in combination with cereal crops. In Africa, maize, sorghum, and millet are frequently interplanted with cowpea (Cook et al., 2005). With only a few cuts, farmers can harvest up to 0.4 t/ha of cowpea leaves without significantly reducing seed output. From a pure stand of cowpea, a potential yield of 4 t/ha of hay can be obtained with careful management. World average cowpea fodder yield is 0.5 t/ha (air-dried leafy stems) (Madamba et al., 2006).

In Asia and Australia, cut-and-carry systems and cowpea pastures are firmly established. Light grazing is necessary to protect the majority of the plant and minimize harm (Cook et al., 2005). If livestock enter the field before the cowpea plants are fully matured, the plants may be trampled. By trimming the plants twice or three times during the growing season, fresh fodder yields can be improved.

5. PHYTOCHEMİSTRY AND PHARMACOLOGY

Cowpea seeds have antimicrobial (Ashraduzzaman et al., 2016), antibacterial (Sandeep, 2014), antiparasitic (Souza et al., 2013), anti-atherosclerotic (Azizah et al., 2014), hepatoprotective (Zaheer et al., 2020), antisickling (Egba et al., 2012), antidiabetic (Tazin et al., 2014), antioxidant (Siddhuraju & Becker, 2007), thrombolytic (Hussain et al., 2016), hypoglycemic (Weththasinghe et al., 2014) properties. Cowpea leaves have antisickling (Mpiana et al., 2009), antimicrobial (Kritzinger et al., 2005), cardioprotective (Janeesh & Abraham, 2013), antidiabetic (Barnes et al., 2015) and Antiobesity (Nderitu et al., 2017) effects.

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CHAPTER V

COMMON GRASSPEA (*Lathyrus sativus* L.)

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INTRODUCTION

There are about 187 species related to the genus common grass pea (Lathyrus) and many subspecies concerned with these species. Among these species, there are both annual and perennial species (Allkin et al 1986).

The origin of common grass peas is not known exactly. The area stretching from the Western Mediterranean to Southwest Asia and Central Asia is considered to be the main origin. The earliest discoveries of the genus common grass pea go back to 4000-3500 BC in India and 3800-3200 BC in Western Asia (Davis, 1970; Genc and Sahin, 2001).

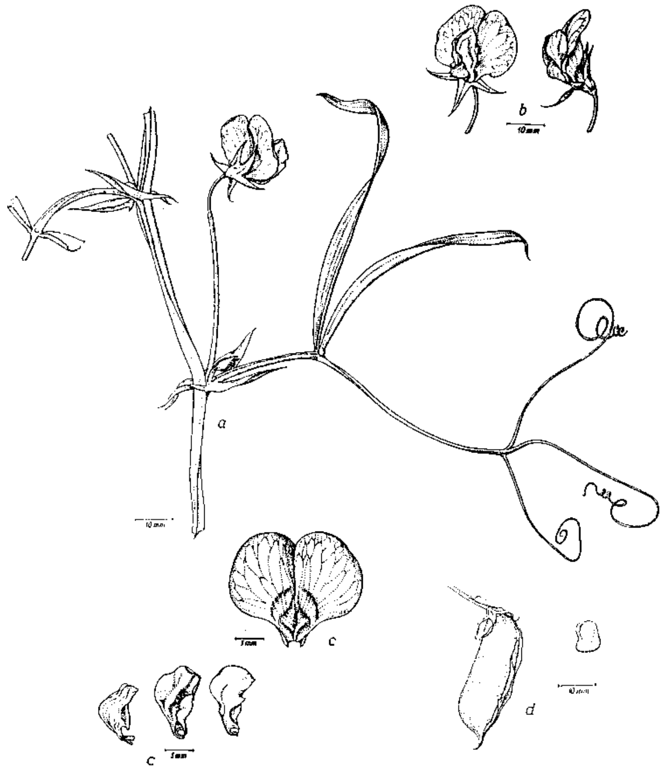
On the other hand, it is claimed that common grass pea has been used in human nutrition since the early neolithic age, and its cultivation was first started in the Balkans in 6000 BC. There are 58-61 species of common grass pea in Turkey, of which a few species are important from an agricultural aspect. The common grass pea is the most commonly cultivated species (Kislev, 1989; Muehlbauer and Tullu, 1997; Açıkgöz, 2021).

Common grass pea seeds were found in prehistoric settlements in Egypt, Troy, and Bosnia. It is thought that the ancient Egyptians obtained the common grass pea from the Black Sea region of Southeastern Anatolia, and from there passed it to Southern Europe. The common grass pea is the most commonly cultivated species all over the world. It is grown as a winter catch crop, especially in India, Bangladesh, and Pakistan. Common grass peas, which are cultivated in large areas in Ethiopia, are significant human food together with bean seeds. Some of the seeds are also used in animal nutrition (Sexana et al. 1993; Malek et al. 1995; Campbell, 1997; Muehlbauer and Tullu, 1997).

Description of Plant:

There are great differences in morphological characteristics between cultivars and genotypes in cultivated Lathyrus species. The common grass pea that annual leguminous plant has a well-developed root system. It is very resistant to drought with its deep-rooted root structures. It is climbing or semi-horizontal stems that can be 20-60 cm long and the stem is hairless. In green common grass pea plants, the stem is hollow, often very branched at the base (Tosun, 1974; Avcıoğlu et al. 2009; Açıkgöz, 2021).

Tendrils are highly branched, leaf-forming leaflets 0.5 cm wide and 1.0 cm long, typically lanceolate leaves. The leaflets are usually 5-7 strong and very thin parallel long nervate and bluish green in color.

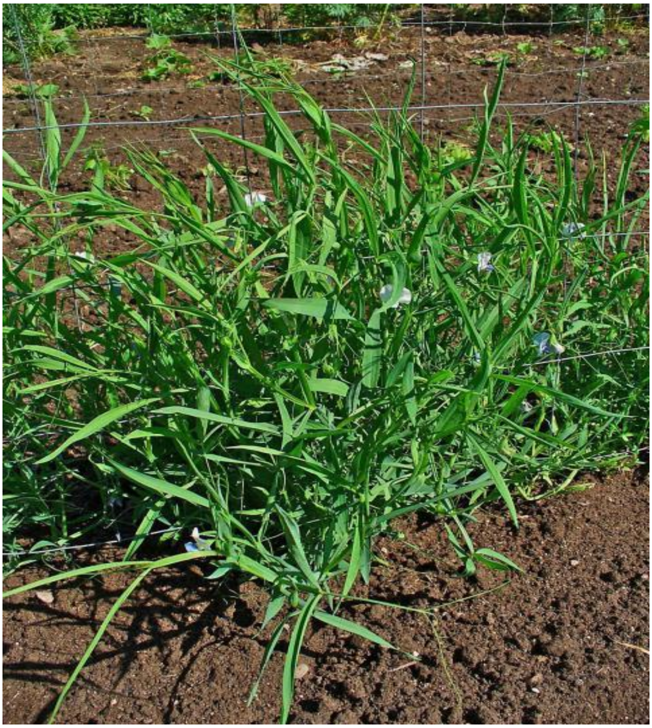


Lathyrus sativus L. (a) part of a flowering branch, (b) flower in front and side view, (c) dorsal petal (bottom), wings and keel (from right), (d) pod with seeds (drawing by R. Kilian in SchultzeMotel 1986, reprinted with permission of the Gustav Fischer Verlag, Berlin).

The stipules are almost as long as the petiole or half its length, semi-arrow and emarginated (Gençkan, 1992; Avcıoğlu and Soya 1990).

The flowers of the plant are 2 cm long, often single, rarely in pairs, in a scaly axillary bract, 5-6 cm long petiole. The color of the petals ranges from white to cream, blue and violet. Fruits are pod-shaped, 2-5 cm long. There are 3-7 seeds in the pods.

Seeds can be flat or mottled in white, brown, or yellow. The 1000-seed weight of grass peas varies between 70-150 g depending on genotype and growing conditions. Seeds can maintain their germination ability for up to 6 years under appropriate conditions. Although self-pollination is dominant in the plant, a very small amount of cross-pollination is also seen(Avcıoglu ve ark. 2009; Acıkgöz, 2021). Grass peas are leguminous species with wide adaptability. Grass peas have the ability to grow in very poor soils. It grows well in soils with pH between slightly acid and slightly alkaline. It can also grow in silty-loam and deep structured poorly drained soils. It is not tolerant to soil salinity. Grass pea species are not much resistant to drought (Tosun, 1974; Karadağ, 1999; Avcıoğlu et al. 2009; Açıkgöz, 2021).



It can be grown in barren fields of 250 mm annual precipitation for herbage and seed production without irrigation. Besides being tolerant of drought, grass peas are grown in high precipitation and ponding fields(Avcıoglu ve ark. 2009; Acıkgöz, 2021). Since grass peas have large and high vigor index seeds, it is not required a very well soil prepared. The planting of grass pea is more suitable in fall of temperate climatic regions, and early spring in summer of cool regions with harsh winters (Avcıoğlu et al. 2009; Tekele-Haimanot et al. 1990).

Since the grass pea is a leguminous forage plant, it does not need nitrogen fertilization. With sowing, 2-5 kg/da N and 5-10 kg/da P2O5 are sufficient for gass pea. It is preferred to row sowing in growing, row spacings must be 25-35 cm for seed feed productions. Sowing depth must be 4-6 cm in grass pea growing. The seeding rate changes to 10-20 kg/da according to seed size. Due to large seeds, sowing can be with a grain drill (Tosun, 1974;Avcıoglu ve ark. 2009; Acıkgöz, 2021). Grass pea can be grown in the mixture of cool climate cereals. Although common grass pea does not develop as accumbent as vetch, planting with a companion plant is more advantageous in producing greeen and dry hay, as it prevents the common grass pea from lodging.

Some studies have reported that 50%+50% common grass pea-triticale, and 25%+75% common grass pea-barley mixtures yield higher dry matter yields (1056 kg/da and 929 kg/da, respectively) compared to sole planting (Karadag ve Büyükburc, 2004 a; Karadag ve Büyükburc, 2004 b).

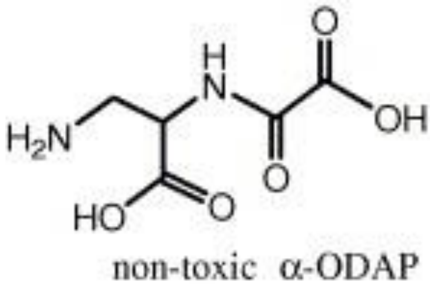
Sole planted common grass pea production is harvest time during the full bloom period. However green hay harvest time is can be delayed because the plants stays soft for a long time and late become rough. If the cereals are mixed with the sowing, they can be harvested when the grains reach the milk stage period. Common grass pea bloom period the beginning contains 24 %crude protein in dry matter (Abd El-Moneim et al. 1990; Acar et al. 1997; Klysha, 1990; Karadag and Büyükburc, 2003).

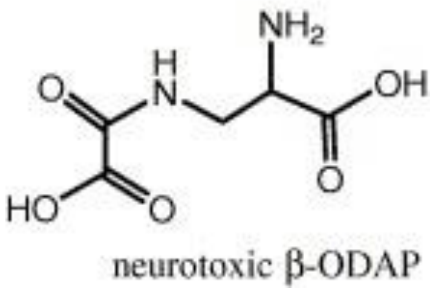
Common grass pea is not a very productive forage plant. Common grass pea productivity is very low, and dry hay yield changes 100-350 kg/da in Central Anatolia Region etc. But its yield can be 900 kg/da in Thrace and coast region, however, vary by soil conditions. Common grass pea seed yield is changing as far as climate factors such as sowing date, precipitation quantity, and especially the distribution of precipitation. Though common grass pea seed yield declines in summertime sowed and drought years, its seed yield can be high in winter sowed and plenty of precipitation (Balabanlı and Kara, 2003; Karadağ and Büyükburc, 2003; Karadag and İptas, 2007; Karadag, 2016; Sabancı et al. 2016).

Although it varies by region common grass pea seed yield in Turkey's Ecological conditions vary 75-450 kg/da. Common grass pea can produce pretty much dry hay in its seed production. Its dry hay yield changes from 250-550 kg/da. Common grass pea that very valuable for livestock feeding contains a high crude protein rate. Common grass pea seed contains high crude protein rate than other leguminous forage plants. Its seeds crude protein rate are contains usually at 25%, and its rate can be as high as 30%. In addition to this must be a careful evaluation of consumption in seed feeding (Fırıncıoglu et al.

1996; Kendir, 1996; Yilmaz et al. 1999; Bayram et al. 2004; Bucak, 2009; Basaran et al. 2010; Kökten et al. 2011; Arslan, 2017; Uysal et al. 2018;

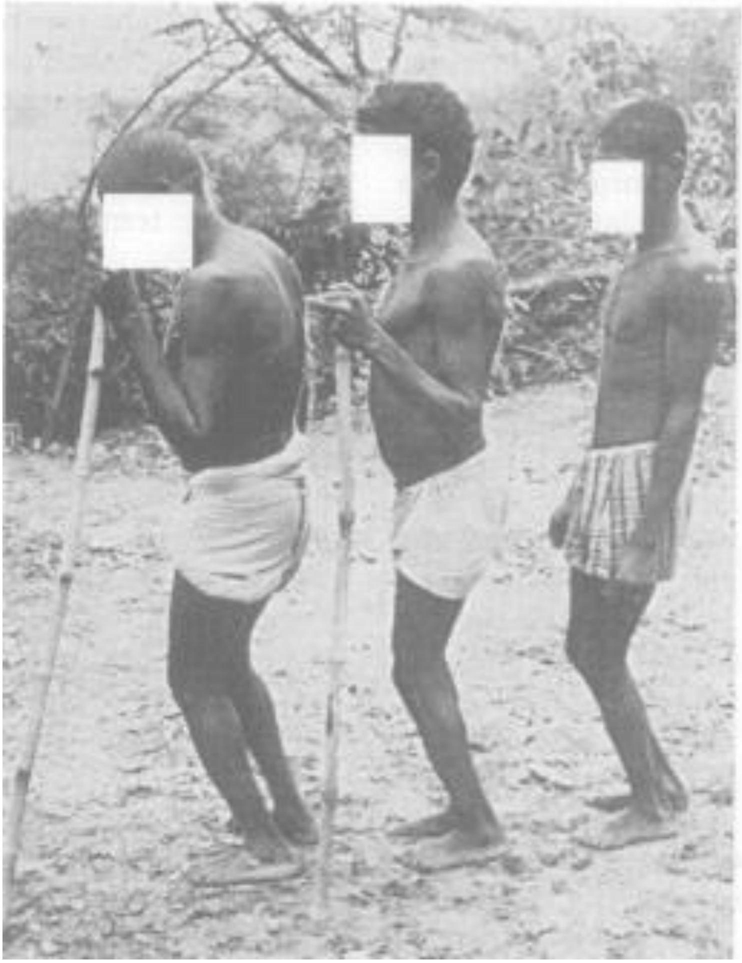
Because common grass pea seed contains chemicals that create livestock feeding adverse impacts such as amylase, chymotrypsin, trypsin inhibitors, lectin, tannins, and different oligosaccharides. But in common grass pea seeds, the greatest problem is that they contain notably beta-N oxalyL-alpha-beta-diaminopropionic acid (ODAP) and some neurotoxins (Basaran et al. 2007; Hanbury et al. 2000).





Connection situations of Non-toxic and neurotoxic ODAP (Yan et al. 2006)

These toxins come across in every common grass pea species. Though ODAP is spread to all of the plant's tissue, the highest amount of its contained in embryos and cotyledons. The density of ODAP is very low in plant vegetative organs. All living creatures which consume common grass pea emerge poisonous a disease called lathyrism (Larry et al. 1995; Basaran et al. 2013; Onar et al. 2014).



Patients with lathyrism.

In this disease, a number of disorders are seen such as gait disturbances, degeneration of the spinal cord and nervous system, and muscle stroke. If consumption continues, deaths take place. Lathyrism at times is a problem in Etiyopia, Pakistan, Bangladeshi and India where common grass pea is consumption of a human diet. Common grass pea is main dish of poor human being in this country.

ODAP contains may be decreased with wetting, blanching or stewing of seeds at 90%. Also Lathyrism hazard is decreased common grass pea seeds consumption with cereals. Lathyrism is a problem also to livestock with feeding common grass pea seeds. Especially poisoning may be occur in livestock animal that feeding common grass pea seed at a long time. Although ruminant animals are affected less, poultry is more affected. Studies in recently, it has been found that low ODAP contents common grass pes seeds, highly included in poultry and sheep rations, do not adversely affect growth and yield. Some studies in Turkey, it has been found that similar results (Basaran and Acar, 2013; Açıkgöz, 2021).

Common grass pea is ambitiously consume as green or dry hay by sheeps. Besides it is may consume by other livestock animals. However, it should not consume animals such as horses and donkeys.

Spotted and dark colored seeds have high Lathyrin content and have a toxic effect when fed uncontrolled (Granati, 2003; Avcıoğlu et al. 2009).

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CHAPTER VI

BITTER VETCH (*Vicia ervilia* L.)

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SCIENTIFIC CLASSIFICATION

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Rosids
Order:	Fabales
Family:	Fabaceae
Subfamily:	Faboideae
Tribe:	Fabeae
Genus:	*Vicia*
Species:	V. ervilia
Binomial name:	*Vicia ervilia* (L.) Willd.

ORIGIN AND HISTORY

Vicia, which is spread all over the world with approximately 160 species, is a member and part of the Legumes (*Leguminosae*) family, which has 750 genera and 19,400 species (Zohary and Hopf, 2000; Hoover *et al.*, 2010; Bryant and Hughes, 2011). The genus Vicia is known as bitter vetch and besides English names, it has also taken local names in different countries. Some of these names are gavdaneh (Persian), kersannah (Arabic), yero (Spanish), rovi (Greek), and vetch (Turkish) (Anonymous, 2010).

Table 1. List of vetch species common cultivated in world

Scientific Name	**Common Name**
Vicia sativa	Common Vetch
Vicia ervilia (L.) Willd.	Bitter Vetch
Vicia villosa	Hairy Vetch
Vicia pannonica Crantz.	Hungarian Vetch
Vicia narbonensis	Narbonne Vetch
Vicia benghalensis	Purple Vetch
Vicia caroliniana	Wood Vetch
Vicia cracca	Tufted Vetch
Vicia faba	Broad Bean
Vicia grandiflora	Large Yellow Vetch
Vicia hirsuta	Tiny Vetch
Vicia hybrida	Hairy-yellow Vetch
Vicia sepium	Hedge Vetch
Vicia tetrasperma	Lentil Vetch
Vicia villosa ssp. varia	Winter Vetch

There are many cultivated and wild types in the world. Most of the species included in the Vicia genus, which are widely grown today, are annuals. The vetch species listed in Table 1 are commonly grown worldwide (Anonymous, 2022 a).

Vicia ervilia (L.) Willd, also called the bitter vetch or ervil is a native species of plants in the temperate areas of the Northern hemisphere and also found in Mediterranean, Europe, North Africa and Western Asia regions (Frison and Serwinski, 1995). Human begins started to benefit from vetch about 9500 years ago. The wild vetch species was restricted to an area covering Anatolia and northern Iraq, where Syria and Lebanon extend southward through the Anti-Lebanon Mountains. Traces of the earliest domesticated specimens, thought to date from the 7th and 6th millennium BC, have been found in various archaeological excavations in Turkey, (Zohary *et al.*, 2012).

As seen in the Figure 1. *Vicia ervilia* L. native to the countries like Afghanistan, Albania, Bulgaria, Cyprus, East Aegean islands Egypt, France, Iran, Iraq, Italy, Kazakhstan, Kirgizstan, Lebanon-Syria, North Caucasus, Portugal, Tadzhikistan, Trans-Caucasus, Turkey, Turkmenistan, Uzbekistan and Yugoslavia. It was introduced later on to some other countries such as Algeria, Austria, Baltic States, Belarus, Canary Is., Central Russian, Czechoslovakia, Germany, Great Britain, Greece, Kenya, Crimea, Libya, Madeira, Morocco, Palestine, Sardegna, Switzerland, Tunisia and Ukraine.

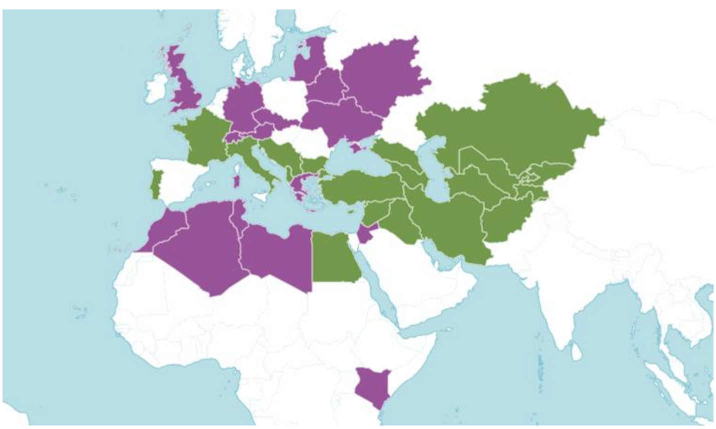

Figure 1. Distribution of *Vicia ervilia* (L.) Willd in the Word (Anonymous, 2022b). Photo: https://powo.science.kew.org

Native Introduced

Bitter wetch is defined as conscious plants in terms of herbaceous structure and ecological demands. Therefore, they have an important place in field agriculture (Samarah et al., 2003; Mokhtari and Kızılşimşek, 2019). There are a total of 59 species, 8 of which are endemic, in the genus Vicia in Turkey. It is also stated that there are 85 taxon in the genus Vicia in Turkey (Maxted, 1995). The chromosome number of the species is similar in cultured and wild genotypes (2n=14), and the two gene pools can be interbred. (Ladizinsky and Van Oss, 1984). Bitter vetch, which was originally grown for human nutrition, soon became more important than other legumes, and began to be used as a fodder plant after animals were domesticated. The plants species was cultivated by many Mediterranean countries until early 20th century, however, it has become unpopular over the years hence substituted for higher efficiency products (Townsend and Guest, 1974). Since vetch group plants are annual, they are generally not preferred next to plants such as alfalfa (*Medicago sativa*), sainfoin (*Onobrychis sativa*), red clover (*Trifolium pratense*), clover (*Lotus corniculatus*) used in the improvement of meadow-pasture lands (Altin *et al.*, 2005).Today they are primarily grown as fodder and cover crop.

MORPHOLOGICAL CHARACTERISTICS OF BITTER VETCH

Bitter vetch is a deep rooted plant. However, how deep the roots go depends on various site factors, such as soil type and availability of water. In areas with suitable soil structure, its roots reach a depth of more than 100 cm. The root structure is dense and can go down to the lower layers of the soil. Better vetch is a persuasive plant and can be grown economically in areas where other crops cannot be grown (Sadeghi *et al.*, 2009; Arabestani *et al.*, 2013). As in the other butterfly plant group, vetch is an indicator plant for nitrogen-poor soils and can spread more than other plants because they produce their own nitrogen sources thanks to the bacteria in their nodules. Hence, the ecological role of *Vicia ervilia* as home to nitrogen-fixing bacteria (*Rhizobium leguminosarum*) is capable of fixing free nitrogen from the air. It has the ability to survive even in poor and nitrogen deficient soils. Rhizobium bacteria lead a symbiotic life and as a result of this, rhizobium bacteria that settle in the nodules consume the sugar produced as a result of photosynthesis and in return provide nitrogen to the plant. Thus, vetch can be found in lawns, settle in beds as unwanted weeds and spread rapidly. Regular lawn fertilization, especially in green areas, ensures that the lawn becomes more competitive and the vetch disappears again. Unwanted vetch seeds in the beds can be manually removed before sprinkling (Handi, 1982; Nadal *et al.*, 2012).

The plant height of bitter vetch usually rises up to 30-50 cm, and can grow up to 70 cm in suitable conditions. The stem of the bitter vetch is usually angular or sometimes rounded. Bitter vetch are slender-stemmed filigree plants that often creep and climb. The body is hollow and has a vetch-like recumbent feature. Therefore, it can be mixed with upright growing.

Ligaments support compound leaves with narrow leaflets. Its leaves are oppositely compound, and the tip of the leaf axis is very short, resulting in a thorn-like slug and purple bloom. Bitter vetch leaves are mutually compound and their number varies between 8-15 pairs. The auricles in bitter vetch are half-moon shaped, their edges are toothed and their number is higher than in vetch types. The leaves are 10–20 mm long and 1.5 mm wide. Bitter vetch flowers are in sparse clusters. The plant has 1-4 small flowers of red-purple color in the seat of each leaf. The flowers are hermaphrodite (have both male and female organs) and are self-pollinating. Pollination is done with the support of insects.

Figure 2. *Vicia ervilia* (L.) Willd plant. (Pansesco, 2021)

Figure 3. *Vicia ervilia* (L.) Willd Flower (Basbag, 2019)

Figure 4. *Vicia ervilia* (L.) Willd Flower and leaf (Basbag, 2019)

Bitter vetch fruit is pod-shaped and resembling a distinctly gnarled bean. The grains are arranged in the form of pods with narrowing between them. The plant species contain 2-5 tetrahedral seeds in each pod, and each node having up to 5 pods. The sections where the seeds are found are swollen and look like a string of pearls. A major constrain of the ervil during seed production is pod shattering. Pod shattering leads to seed losses when seed harvesting is delayed, however, early harvest of the seeds disturbs seed germination and dormancy.Modern vetch genotypes are characterized by rapid germination and the absence of unbroken pods. The seedlings establish very quickly after sowing seeds (Kernick, 1978; Enneking, 1995; Esteban, 1996; Abd El Moneim and Saxena, 1997; Nadal *et al*., 2012).

Bitter vetch seeds are mottled or solid in colour (red or brown) and tetrahedral, round or angular. Its size is 3.5-5.5 mm in diameter. The seeds have different anti-nutritional factors and highly toxic amino acids. The main aglycones contained in *Vicia ervilia* seed are polyphenol, luteolin, kaempferol, apigenin, canavanin and quercetin (Enneking, 1995; Esteban, 1996; Nadal *et al.*, 2012; Vioque *et al.*, 2020). It seems to play an important role in the prevention of parasitic weeds (Barbour *et al.*, 2001).

Figure 5. *Vicia ervilia* (L.) Willd pods (Basbag, 2019)

Figure 6. *Vicia ervilia* (L.) Willd seeds (Anonymous, 2015)

CLIMATE DEMANDS

Bitter vetch is a short-lived annual species and can be used for both grain and fodder production. It can grow in the shallowest soils and adapt to drought, hot and cold weather. It can withstand frosts down to -6 °C in winter. Therefore, it can better grow in summer or winter forms (Abd El Moneim, 1993). It can also be grown in both irrigated and non-irrigated conditions (Samarah *et al.*, 2003). Due to the low water requirement, it is possible to grow it in regions where precipitation is low or in the semi-desert climate with 250-350 mm of annual precipitation. It can easily grow from full sun to partial shade and harvest does not cause much trouble to the farmers (Enneking and Francis, 2007).Yields of up to 2 t/ha can be achieved in low-input, low-precipitation environments.

SOIL REQUIREMENTS

It adapts to calcareous soils in terms of soil. However, the ideal soil pH is between 6.2 and 7.2, well-drained loamy soils with high moisture content. It can thrive and grow even in heavy soils as long as there is no flooding. Bitter vetch can also be grown in very shallow, low fertile soils. They show high resistance to low temperatures and allow them to be grown in regions where other legumes such as peas cannot grow due to cold (Serin and Tan, 2001; Larbi *et al.*, 2011).

NUTRITIVE VALUE

Since the stems of bitter vetch are thin and leafy, they have high nutritional value. The purpose of cultivation is generally cover crops, green grass, hay, silage, seeds, grazing, hay production and green manure production. It is also suitable for early grazing (Mohamed, 1997; Samarah *et al.*, 2003). While it is grown in the coastal areas and consumed as fresh grass in winter, it is grown and used as dry grass in other regions in summer. Since its grains are rich in protein and energy, it is used as concentrate feed. *Vicia ervilia*, which has many advantages in terms of agriculture, increases feed quality and reduces production costs thanks to its high crude protein content, especially in animal nutrition. Bitter vetch contains approximately 26% crude protein in the seed, 15% crude protein in the hay, 1.6% fat, 61.2% carbohydrates, 5.9% crude fiber and 3.7% ash (Sadeghi *et al.*, 2009; Arabestani *et al.*, 2013, Fernandez-Figares *et al*. (1995). Bitter vetch seeds contain two essential amino acids such as glutamic acid (18.13 g/kg) and aspartic acid (9.47 g/kg). (Kim *et al.*, 2015; Yuksel and Ozcelik, 2015, Dong *et al.*, 2016). Despite the high amount of crude protein in their tissues, they do not cause bloating in animals (Serin *et al.*, 1996). The use of bitter vetch is generally not recommended in poultry farming because it contains the toxin gamma-glutamyl betacyanolalanine (GBC). This toxin reduces the growth rates and feed intake of poultry, while negatively affecting the metabolism of laying hens. It can also reduce the growth rate and feed intake of pigs if vetch is included in more than 20-25% of their diet, although this will also vary depending on the variety. GBC is also known to cause favism, a fatal hemolytic disease in humans (Sadeghi et al., 2004, 2009).

L-CANAVANINE CONTENT

One of the important factors in the underdevelopment and neglect of bitter vetch cultivation is that it contains substances that are not suitable for nutrition. Although some microorganisms in the rumen destroy these substances, they have been found to have some undesirable metabolic effects in monogastric animals. It has adverse effects due to the presence of certain phytochemicals, including L-Canavanine, lectins, protease inhibitors and tannins (Enneking, 1995). However, special attention is drawn to the possible role of L-Canavanin in the observed toxic effects. It has been found to exhibit potent anti-metabolite properties in organisms ranging from prokaryotes to L-Canavanin, all animals to viruses (Shqueir *et al.*, 1989). The most important toxic amino acid contained in the burdock is expressed as L-Canavanine (Berger *et al.*, 2003). The non-protein amino acid L-Canavanin (2-amino-

4(guanidinoxy) butanoic acid) is a potent arginine antimetabolite stored as a chemical barrier against disease and harmful effects by many legume plants. They turn to newly synthesized proteins that lead to the development of non-functional proteins.(Rosenthal, 1977). The toxic effect is intense, especially in chickens, which are monogastric animals. It is reported that the seed content of bitter vetch has an average of 0.76 mg/kg L-Canavanin. - (Sadeghi *et al.*, 2004). To improve the nutritional quality of vetch grains and ensure their safe use in poultry, it is important to eliminate or reduce toxic substances. The various processing methods tried have led various outcomes on boosting the nutritional value of the ervil. For instance, the method of heat treatment is claimed to be effective in inactivating protease inhibito, trypsin and lectins. (Alonso *et al.*, 2001). Since L-Canavanin remains quite stable at relatively high temperatures, positive results could not be obtained with heat treatments, but studies are continuing on its solubility in water, acid and alkaline solvents (Siddhurajua *et al.*, 2002).

CULTIVATION

Since bitter vetch is not a winter-hardy plant, it is planted in the spring. It would be appropriate to plow the field to be planted in autumn, to clear weeds in the spring and to have a disc harrow to work the soil well. If necessary, a roller should be passed from the field in order to sow in a tight seed bed. Row spacing should be 20 cm in vetch planting with seeder. 8-10 kg/da of seeds should be used per decare. Sowing depth should be 4-6 cm. During sowing, the row spacing and on-row should be carefully adjusted. If this issue is not taken care of, the plant is prevented from getting enough air and not be affected by diseases. Seeds can be sown either with spreaders or seeders. There are advantages such as seed emergence at the same time, providing the most suitable living space for a plant, easy maintenance, the same planting depth and the same ripening time in sowing with seeder. If there are large clods in the field after planting bitter vetch, the base should be pulled and crushed and the soil surface should be smoothed. If clods continue after this process, the roller should be pulled to ensure full contact of the seed with the soil and the soil surface should be compacted.

IRRIGATION

In regions with sufficient rainfall, bitter vetch can be grown without irrigation. However, in order to get a better yield, a good irrigation should be done at the appropriate time and in the appropriate amount. The main purpose of bitter vetch irrigation is to increase the water to be given to the field capacity at the effective root depth of the plant. The effective root zone depth is 80% of the depth that the plant can absorb the water in the soil. The area where bitter vetch roots can go deep and take usable water from the soil is very important. If there is a decrease in humidity in this region, various problems may arise in the plant. When irrigating, the number of irrigation and the amount of water to be given should be determined by considering all these conditions.

HARVEST

The condition of the pods should be observed when harvesting bitter vetch for grain. Harvest should be entered when the lower pods turn yellow and always done early in the morning. Otherwise the stems can become brittle in the heat which makes harvest difficult to pluck. The seed yield of bitter vetch plant is 80-100 kg per decare. In addition, 1000 kg of vetch straw is obtained per decare. Bitter vetch is the most common harmful legume seed beetle (Bruchus). These insects reduce the feed value of the grain. For this, field spraying, storage and seed spraying should be done when the bitter vetch plant is in flower.

If bitter vetch is grown for grass, the harvest is done by hand because its plant does not grow much. In order to obtain green grass, bitter vetch harvest is done at the stage of 25% flowering. Harvesting for hay or silage can be done until the full grain filling period of the first pods. When the bitter vetch plant is grown in anhydrous conditions, 700-800 kg of green grass is taken per decare. As a result of drying, this figure corresponds to approximately 100-130 kg of dry grass. Delaying the harvest of bitter vetch causes quality loss and form difficulties in the plant. Harvested bitter vetch plants should be dried and threshed with threshing machines.

BITTER VETCH DRYING FOR FODDER

Bitter vetch plant should be dried in the field or in rainy regions, on stands. The harvested vetch plant is left to dry in the field for one day. Then it is turned into a barrel with acrobat rakes and allowed to continue to dry. It is necessary to pay attention to drying in bitter vetch grass. If over-drying is done, leaf loss will be high. On the otherhand, if drying is done less, heating, rotting and molding occur. The fodders that have been turned into bales should be stored by stacking them properly in warehouses that will protect the product similar to the alfalfa plant, of sufficient size, especially not to receive rain, and where the necessary safety measures have been taken.

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CHAPTER VII

HAIRY VETCH (*Vicia villosa* Roth.)

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INTRODUCTION

Vicia villosa Roth. is from legumes (*Fabaceae*) family and is an annual or biennial herb of the vetch genus (*Vicia* L.) (ITIS, 2022; Gençkan, 1983). *Vicia villosa* is a legume fodder plant known as “hairy vetch”, “fodder vetch” or “winter vetch”. Hairy vetch was first grown in the mid-19th century in Germany/Europa (Hanelt, 2001). Although the homeland of hairy vetch is Asia, it naturally spreads in almost all of Europe (USDA, 2022). It is distributed in Central and Southern Europe, Central and Southern Russia, Crimea and Southwest Asia. It grows almost everywhere in Türkiye. It is found in habitats such as roadsides, rocky areas, fields, shorelines, and wetlands (Temel et al., 2021).

Herbal Properties

Hairy vetch is a taproot plant. Its body grows horizontally, but its climbing stem allows it to grow upright by clinging to support plants (Çakmakçı and Aydınoğlu, 2009). The climbing stem can be 30–60 cm long in general, and sometimes up to 150 cm (Özdemir et al., 2021). The stem and leaves are covered with soft woolly hairs, hence the name "hairy vetch". The leaves are in the form of reciprocally combined leaves and end with a leech. On the leaves, between 6 and 10 pairs of leaflets are arranged opposite the stem. The auricles in the part where the leaves are attached to the stem are pointed. Hairy vetch flowers emerge from the leaf axils and are cluster shaped. The flowers, which are blue, violet or red-violet-violet, are 15-20 mm long and 3-30 unilaterally merge to the flower axis to form a cluster (Soya et al., 2004). Flower colors can sometimes be white or yellow. Flowers bloom in March-July. Hairy vetch pods are bean-shaped and hairless. There are 4–8 seeds in the light brown pods. The seeds are 3-5 mm long and black or brown in color.

Figure 1. *Vicia villosa* Roth.
Reference: Anonymous, 2022

Climate and Soil Demand

The most distinctive feature of hairy vetch in terms of climate demands is that it is resistant to winter cold and drought thanks to its advanced branched root system. Hairy vetch can be planted from late summer to the first half of autumn, depending on the harvest of summer-grown plants. However, it should not be delayed in planting in climatic regions with harsh winter months (Coşkun and Çaçan, 2019). As a matter of fact, winter damage was detected in hairy vetch in Turkey-Erzurum ecological conditions, and the mortality rate was found to vary between 0 and 42% (Tahtacıoğlu et al., 1996). Although it is a winter-hardy plant, the appropriate germination temperature is 15–23 ^{o}C, and the appropriate temperature requirement for root development in the early period is 20–25 ^{o}C (Mosjidis and Zhang 1995). Hairy vetch shows optimum growth and development in the spring, when the soil temperature is 10 ^{o}C and the air temperature is 20 ^{o}C (Teasdale et. al. 2004).

Hairy vetch does not have much selectivity in terms of soil demand. However, it grows better in light and sandy soils. It cannot grow well in moist, heavy, and water-retaining soils (Özdemir et al., 2021). The pH requirement of hairy vetch is between 6-7.5 and it is moderately sensitive to soil acidity (Çakmakçı and Aydınoğlu, 2009).

Planting, Care and Harvest

The row spacing of the hairy vetch varies according to the production purpose. It should be planted with a row spacing of 15-20 cm for hay production and a row spacing of 25-30 cm for seed production (Çakmakçı and Aydınoğlu, 2009). In cases where the hairy vetch is grown in arid conditions, the row spacing should be increased to 30–40 cm (Açıkgöz, 2001). The sowing depth should be 3–4 cm. The amount of seed in hairy vetch should be 8–12 kg da^{-1} for hay production and 6–8 kg da^{-1} for seed production.

Since vetch species have creeping structures, a lying problem arises in lean planting. In this case, the parts of the plant that come into contact with the ground rot, which makes harvesting difficult and lead to a decrease in hay yield and quality. For this reason, it is recommended that such forage crops grown for hay be cultivated with a plant with a holding feature, especially cereals. When cultivated in a mixture with cereals, a feed rich in protein and carbohydrates will be obtained (Elçi, 1976).

Since hairy vetch develops horizontally, it must be planted with a support plant to prevent lodging when cultivated for hay production. Barley, oat, rye, or triticale are generally preferred as support plants. In cases where vetch is to be cultivated as a mixture with cereals, the ratios of the species in the mixture are of great importance. In regions with a mild winter season, vetch completes its development quickly and suppresses cereals. Therefore, the vetch laying condition occurs, the harvest becomes difficult. In regions with cold and dry winter season, cereals develop better and suppress vetch. Under these conditions, the dry matter yield of the hay is high, and the protein yield is low (Anlarsal and Yağbasanlar, 1996). It is recommended to plant 5-6 kg da^{-1} hairy vetch and 5-6 kg da^{-1} cereal seeds in mixed plantings (Soya et al., 1997).

In the field where hairy vetch will be cultivated, if the vetch or pea species with good nodules have not been grown recently, the seeds should be inoculated with suitable *Rhizobium* bacteria in order to fix nitrogen in the soil. Hairy vetch seeds should be inoculated with *Rhizobium leguminosarum* biovar *viceae* bacteria in order to get more yield from hairy vetch and fix nitrogen in the soil (Mothapo et al., 2013).

Nitrogen fertilization is generally not needed when hairy vetch is cultivated lean. The type and amount of fertilizer vary depending on the results of the soil analysis to be made. In general, hairy vetch fertilization should be done to provide 4-5 kg/da P_2O_5 and 12 kg/da K_2O. In cases where the hairy vetch is mixed with cereals, nitrogen fertilization should be done to provide 4 kg of N per decare (Soya et al., 1997).

Hairy vetch for green herbage should be harvested during the flowering period. When the vetch is grown in a mixture with cereals, the harvest should be done in the milk stage of the cereals in order to obtain a high yield and quality (Akbay Tohumcu, 2021). Flowering in hairy vetch is from bottom to top. For this reason, the maturation of seeds also occurs at different times. When the pods in the lower nodes are mature, the upper pods are not yet at the harvest stage. For this reason, seed production in hairy vetch is very difficult. Seed harvesting should be done when most of the hairy vetch pods turn yellow or brown starting from the lower nodes (Çakmakçı and Aydınoğlu, 2009). The point to be considered here is to harvest without cracking the pods. Otherwise, seeds will be poured from cracked pods, and yield loss will result.

Areas of Use of Hairy Vetch

Hairy vetch has many usage areas, such as hay production, seed production, green manure, erosion control, weed control, and a winter cover crop (Büyükburç and Karadağ, 2003; Caporali et. al., 2004; Seo et al., 2005; Choi and Daimon, 2008).

Hairy vetch can be used as green hay and dry hay, or by adding different plants to silage. Hairy vetch, a legume forage crop, is an important source of vegetable protein and has an important role in improving feed quality. For this reason, it is an important legume forage crop in terms of animal nutrition. Hairy vetch is planted as a mixture with cereals as well as lean cultivation. Thus, it is possible to obtain animal feed with high yield and quality. As a matter of fact, many researchers have reported an increase in yield and quality of legumes when they are grown as a mixture (Kır, 2014; Gülümser et al., 2017; Akbay Tohumcu, 2021).

In studies examining the yield characteristics of hairy vetch, the hay yield was determined as 702.9 kg da^{-1} (Açıkgöz and Çelik, 1986); 310-358 (Tahtacıoğlu et al., 1996); 200-250 kg da $^{-1}$ (Açkgöz, 2001); 589 kg da1 (Güzeloğulları and Albayrak, 2016); and 757.5 kg da1 (Seydoşolu et al., 2016). The seed yield of hairy vetch is 100-150 kg/da. In very good conditions, this value can reach up to 300 kg (Manga et al., 2003).

Hairy vetch is used as a cover crop or green manure in many countries to prevent erosion, increase the organic matter content of the soil, and enrich the soil in terms of nitrogen. For this purpose, after the hairy vetch is included in the crop rotation system, a soil enriched with nitrogen and organic matter is left for the plant to be cultivated. One of the important features of legumes is that they form a symbiotic relationship with Rhizobium bacteria and free-living nitrogen fixing bacterias from the air to the soil. Thus, it ensures that the nitrogen fixed in the soil in mixed plantings is used by grasses or plants from different families. In a study in which they examined the yield characteristics of some legume forage crops for green manure in the vineyard, researchers found that hairy vetch fixed nitrogen at 15.3 kg da-1 (Geren et al., 2010).

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CHAPTER VIII

WHITE CLOVER (*Trifolium repens* L.)

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INTRODUCTION

Red clover (*Trifolium pratense* L.), a perennial forage legume, is one of the most important forages due to its high protein content, nutritional value for ruminants and high rate of biological nitrogen fixation (Thilakarathna et al., 2017; Demirkol, 2022). Additionally, it allows increased soil fertility, reduced soil erosion (Hunt et al., 2019) and suppressed weeds (McKenna et al., 2018). In terms of production area and seed yield, red clover ranks second forage legume crop in the world, following alfalfa (Boller et al., 2010).

After the 1960s, the introduction of low-cost experiment of synthetic nitrogen fertilizers largely contributed to the decrease in red clover production. Because N fertilizer production requires a significant amount of energy and contributes to both climate change and the eutrophication of lakes and streams due to N leaching, this trend has reversed in recent years. As a result of the comeback of more sustainable agriculture, red clover is once again becoming increasingly significant.(Ravagnani et al., 2012).

Description of red clover

Red clover grows in areas that can be irrigated or having uniformly high precipitation in temperate regions (McKenna et al., 2018). It is widely cultivated in all European countries and North America (Açıkgöz, 2001). The use of forage legumes to increase soil fertility in rotation with cereal crops has increased interest due to worries about the potential environmental effects of mineral fertilizers (McKenna et al., 2018). Dhamala et al. (2017) reported that red clover is more effective at nitrogen fixation than alfalfa and white clover plants. The red clover is a popular forage plant as a result of all these advantages. One of the disadvantages of red clover is its overall low persistence. Red clover also has a drawback of being susceptible to abiotic stress conditions such as salinity and drought (Herrmann et al., 2008; Asci, 2011; Vaseva et al., 2011). Limited red clover is cultivated as hay, but it is a common plant of pasture forage when mixed with perennial grasses. Compared to alfalfa, red clover has stronger seedling vigor and frequently better establishment, but lower long-term yields, a higher risk of winter damage, and less overall persistence (Ortega, Parra, & Quiroz, 2014; Catalano et al., 2019; Zarza et al., 2020).

Ecological requirements of red clover

Red clover grows well on clay loam soils that are nearly neutral acidity (6-7 pH) and well drained, while it cannot be successfully grown on sandy, salty and gravelly soils (Açıkgöz, 2001). Red clover needs uniform precipitation (min 700 mm in a year) and moderate temperatures because the several studies reported that red clover plants has sensitivity against drought and high temperatures (Açıkgöz, 2001; Staniak, 2019).

Cultivation of red clover

Red clover can be planted as a monoculture or in combination with other perennial grasses to increase fertility (McKenna et al., 2018). It has been reported that when red clover is grown with perennial grasses such as timothy, meadow fescue, tall fescue, and perennial ryegrass, it has a good relationship in the form of yield, quality, and pasture sustainability (Açıkgöz, 2001). Red clover can also be cultivated in a combine with other legumes, such as lucerne and sainfoin (McKenna et al., 2018).

Genetic resources of red clover

Red clover is thought to have originated in Eastern regions of the Mediterranean, especially in Anatolia where the greatest diversity is found by several researchers (Açıkgöz, 2001; Büyükkartal, 2003). These genetic studies indicated that red clover plants showed high variation between populations using molecular markers (Dias et al., 2008; Jones et al., 2020; Osterman et al., 2022).

Red clover is naturally diploid. In addition, it has synthetic autotetraploid cultivars (Sattler et al., 2016). Tetraploid cultivars have lower fertility than diploid types, which is likely a result of both multivalent formation and less pollination (Annicchiarico et al., 2015). Due to the red clover's long history of breeding and relatively high divergence between cultivated and wild forms, local landraces are more crucial than for white clover. Wild populations are less productive than native species in areas that are suitable to agricultural growth, but they tend to be more persistent and can produce higher yields (Isobe et al., 2014; Annicchiarico et al., 2015).

Forage yield in red clover

In response to various environmental conditions, red clover has a very varied ability of morphology and yield (Amdahl et al., 2017). Red clover has yield losses in warm climates regions. In temperate and rainy climates, red clover showes its optimum yield efficiency. It was determined that in these areas red clover produced 7 500-10 000 kg ha^{-1} of hay yield (Açıkgöz, 2001).

Red clover has a persistence problem, therefore, improved persistence is an important breeding goal in red clover studies (Ergon & Bakken, 2022). Wild populations are more persistent than landraces, but because they also have lower forage yield potential, their genetic resources have not been fully utilized (Annicchiarico et al., 2015).

Seed yield in red clover

Red clover has a low seed yield despite having a large genetic variety for seed yield selection. There are little research on seed production in red clover, despite the reality particularly in tetraploid ones, have limitation on seed production (They produce in general 200-400 kg seed ha^{-1}, that means 20-50% less seed production than diploid ones (Amdahl et al., 2016; Vleugels et al., 2019)).

Red clover flowers are self-incompatible (Vleugels et al., 2021). Therefore, flowers need foreign pollen. Red clover flowers are not attractive to honey bees. The presence of more attractive flowers in the environment causes very little pollination of qred clover flowers (Açıkgöz, 2001).

The tetraploid red clover plants have weaker seed yield than diploid ones. Weak ovule fertility and lower pollination is a key factor in low seed production in tetraploid varieties than in diploid ones (Büyükkartal, 2008; Annicchiarico et al., 2015).

Forage quality in red clover

The optimum cutting time of meadow clover is between the beginning and full flowering. Delays in cutting time do not cause major quality losses compared with alfalfa, due to late-ligninated form of red clover (Dewhurst et al., 2009). For this reason, red clover produces high-quality grass over a prolonged cutting time (Açıkgöz, 2001). According to a study, the hay yield in red clover included 18–19% crude protein rate, 41-44% ADF rate, and 51–54% NDF rate (Alay et al, 2017). The studies showed that red clover increases the amount of crude protein and polyunsaturated fatty acids in the final product such as meat and milk, when it is fed to ruminants (Vleugels et al., 2019). In addition to crude protein, ADF and NDF values, secondary plant metabolites are the main subject of current research aimed at enhancing forage quality (Hart et al, 2016; Harlow et al., 2020; Muñoz et al., 2021).

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Ruminants may have adverse effects from extensive grazing on alone red clover. Therefore, researchers suggest to culture red clover with timothy, meadow fescue, tall fescue, and perennial ryegrass (Açıkgöz, 2001).

Tolerance to biotic stresses in red clover

Several studies revealed that *Fusarium oxysporum* is a major pathogen of red clover (Šišić et al., 2018; Jambagi et al., 2022). In addition to Fusarium, biotic stress studies in red clover focused on developing varieties resistant to nematodes (*Meloidogyne* spp.) and other fungi that reduce forage yield and quality (Guo et al., 2016; Naydenova & Aleksieva, 2017; Dobosz & Krawczyk, 2021).

Tolerance to abiotic stresses in red clovers

Despite red clover's advantages, it has the disadvantage of being sensitive to a wide range of abiotic stressors, such as drought, salinity, and nutrient limitations. Therefore, one of the main objectives of forage breeders has been the development of red clover cultivars with improved forage quality and biomass productivity under abiotic stress conditions. (Demirkol, 2022).

The studies showed that red clover is more tolerant against drought stress than white clover, owing to its strong taproot from the primary seedling root (Roberts et al., 2017). It is believed that the use of deep-rooted legume plants such as red clover in grassland combinations instead of white clover, will grow in popularity as future climate conditions with higher drought stress (Jing et al, 2021).

Variety selection in red clover

Depending on cutting time, red clover plants are divided into two groups: 1) Late varieties (late flowering varieties having one cut), 2) Early varieties (Early flowering varieties having 2-4 cuts). Late varieties are more tolerant against cold climates than early varieties. They are longer-lived varieties, while early varieties usually live for two years (Açıkgöz, 2001). It has been reported that late varieties may also store more reserves in their root system, that may also be significant from an agronomic perspective (McKenna et al., 2018). Because single cut red clover does not flower in the seeding year, using it as a cover crop lowers the chance of undesired volunteers reseeding the following crop. (Gaudin et al., 2013).

In addition, red clovers are divided into two group as diploid and tetraploid, depending on their chromosome number. Tetraploids have larger leaves, larger flowers, and larger seeds than diploids, and often have more hay yield than diploid ones, but have lower fertility (Açıkgöz, 2001; Annicchiarico et al., 2015).

Genetics and breeding in red clover

Breeding methods in red clover, an obligate outcrossing species with a high level of gametophytic self-incompatibility, depend on open pollinated populations such as mass, phenotypic or polycross selections. These techniques have improved agronomic factors such as forage yield, winter hardiness, and disease tolerance, but have had less success increasing seed production (Annicchiarico et al., 2015; Vleugels et al., 2019).

In red clover, the main breeding objectives have focused on persistence and high forage yield. However, the seed yield in red clover has been declining during the past few decades. The researchers suggested that the reasons might be the pollination problems and the introduction of tetraploid red clover (Jing et al., 2021).

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CHAPTER IX

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CHAPTER X

VETCH CULTIVATION

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1.VETCH (VICIA) GENUS

It is known that there are about 150 species belonging to the vetch genus that have spread to various parts of the world and can grow. The species in the genus in question are single-year-old and are one of the most cultivated plants among legume fodder crops. Almost all of the vetch species cultivated are native plants of Asia and Europe, especially the Mediterranean region. Although the date when vetch species were cultured is not exactly known, the species that were cultured for the first time were ordinary vetch and pod (Figure 1) and other vetch species were later cultured (Açıkgöz 2001). Turkey is very rich in vetch species. It has been determined that approximately 59 vetch species spread to all regions of Turkey grow (Davis, 1970).

Many vetch species are thin-stemmed, abundant leaves, tasty and nutritious species and are used in a wide range of areas from humid regions where continental climate prevails to arid regions from semi-tropical climate zone (Miklas ve ark., 1987). Although species characteristics are so abundant and rich, some species are of great importance in terms of agriculture (Açıkgöz 2001; Soya et al. 2004) .

The most widely grown of these species are Common vetch and Hungarian vetch.

Good grass yield is obtained when all vetch species are planted lean or together with cereals. While vetch is planted in autumn in regions where winters are not harsh, spring cultivation is carried out in regions with harsh winters. Although vetch grasses vary according to the time of form, they have a crude protein ratio between 12-20% (Açıkgöz 2001).

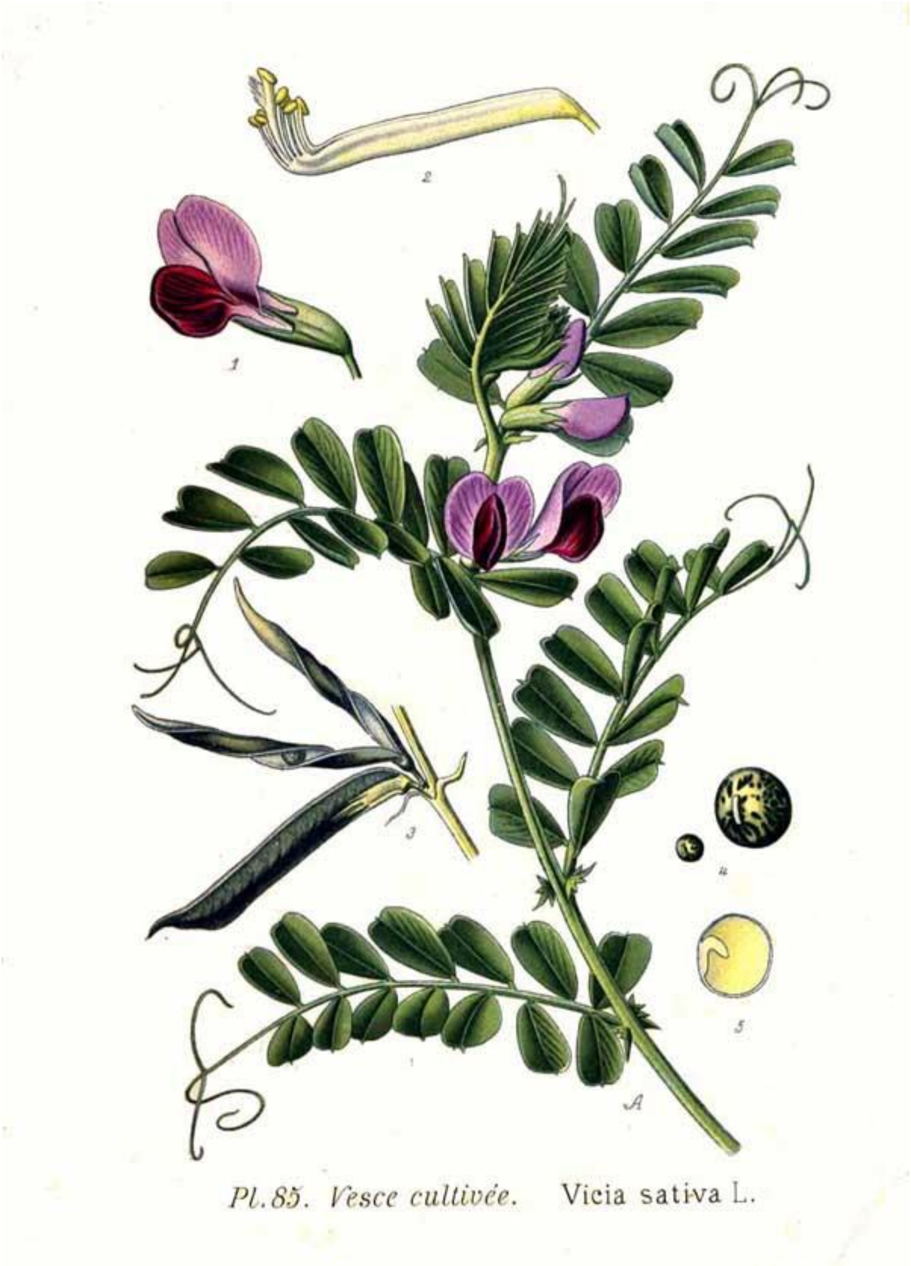

Figure 1: Overview of the pod plant (Anonymous, 2022a)

2. COMMON VETCH (*Vicia sativa* L.):

It is one of the most grown fodder plants in our country. Although it is grown so much, the fact that it is known as "Ordinary vetch" in its name and in most places should not make the value of this fodder plant ordinary. Common vetch, which is used in the diet of all types of animals, is nutritious and tasty. Common vetch seeds, which have a protein content of over 20% in their grains, are also broken and used in rations. Due to the high protein content, it was also used as human food in some regions during the famine years. Vetches are plants that do not tire the soil too much in general (Kabakov, 1960). On the contrary, the root residues of the harvested plants increase the organic matter of the soil (Seydoşoğlu, 2014). As a matter of fact, the fact that it is a single year and legume ensures that it is one of the most suitable plants that can be used as green fertilizer. In our country, where arid and semi-arid climate generally prevails, the grain-fallow cultivation system is applied at the beginning of the most applied systems. Vetches are the leading plants that can be used to ensure that the fallow soils are not empty and to evaluate the soil well. Vetches can be grown lean on their own or in mixtures with grains such as barley, oats and triticale (Gülcan et. al. 1988). In places with an annual rainfall of 400 mm or more and in the bottom lands, widespread vetch cultivation offers a great opportunity for feed production (Açıkgöz 2001; Envoy 2005; Avcıoğlu et al. 2009).

Common vetch grows naturally in our country and, accordingly, shows a great wealth of species. The common vetch, which is known to have been cultivated since ancient times, was found in excavations belonging to 5860-5600 BC in Çatalhöyük, 7500-6500 BC in Çayönün and 7000 BC in Hacılar (Açıkgöz 2001; Bogaard et al. 2013).

2.1 Common Vetch Herbal Properties

Common vetch is an important leguminous fodder plant that has a thin, non-penetrating main root and a large amount of side roots. The stems of the common vetch are thin, soft and slightly pubescent. The cross section of the stems is four-cornered and hollow. Almost all types of vetch develop upright in the first stages and then lie down. While the plant can grow up to 40-50 cm in barren, it grows up to 100 cm in waterable places (Miller ve Hoveland 1995). The leaves are inverted egg-shaped, with 3-7 pairs of leaflets collected on the leaf axis. The leaf axis ends with a leech. The auricles are cocky-shaped, and the edges are toothed. There is also a pronounced black spot under almost all of the auricles. Especially the shape of the auricle and the black dots under it are important in the diagnosis of diffuse vetch. The flowers are located together with 1-3 flowers on short saplings protruding from the leaf seats. The color of the petals is usually violet and purple. The fruit of the common vetch is a pod, 3-6 cm long, bean-shaped yellow brown color. There are 2-10 seeds in the pod. The color of the seeds varies from dark yellow to brown and black, and the weight of 1000 grains varies from 40-120 g (Yücel et. al 2014). The place where the seeds are attached to the pod (hilum) is thin, long and whitish in color (Tosun 1974; Acikgoz 2001; Envoy 2005; Avcioglu et al. 2009).

Figure 2: Common Vetch Overview (Anonymous, 2022c)

3.SOIL AND CLIMATE REQUESTS

Common vetch can grow on almost any soil. However, higher yields are obtained in fertile soils with deep profile, clay, loamy and rich in organic matter. Light, sandy soils may not be satisfactory in terms of yield. This situation can be corrected by fertilizing.

It can grow naturally in semi-arid regions with 300-500 mm of rainfall. Satisfactory yields are obtained in humid and cool places. Although it is highly drought-resistant, seed and grass yields are considerably reduced in very arid areas. Although some varieties provide resistance to cold, they are damaged below 0 ^{o}C. Quality roughage can be obtained by planting vetch in the bottom plots, where the annual rainfall is 400 mm and more (Açıkgöz 1991; Avcioglu et al. 2009;).

4.SOWING AND MAINTENANCE

The land where vetch will be planted should be processed with tillage tools such as dips, plows, diskaros, etc. so that there are no large pieces of soil. Widespread vetch cultivation should be carried out in autumn in coastal and transitional climate zones where the winter is not cold, and in spring in places with heavier winter. It can be planted as a second crop in coastal areas, depending on ecological conditions. If it is suitable for non-heavy light structure cultivation, it can be planted without the need for tillage (Avcıoğlu et al. 2009).

Since common vetch seeds are close to grains in size, they can be easily sown with grain drills (Templeton et. al. 1976). In some regions, sowing is carried out by sprinkling sowing. However, it is recommended not to be preferred because there will be excess seed loss with this sowing method. For grass production in both arid and irrigated lands, the distance between the rows of common vetch should be adjusted to be 15-40 cm (Rudoman, 1972). The sowing norm should be calculated as 10-12 kg/da, this rate should be reduced to 8-10 kg/da in grain production and the inter-row distance should be increased to 30-50 cm (Avcıoğlu et al. 2009; Açıkgöz 2021). Thanks to the fact that its seeds are not very small, it can be sown to a depth of 3-4 cm (Permeti, 1968). As in other vetch species, since the first development is vertical and then sloping development is seen in common vetch, rotting is seen in the parts close to the soil due to lying in the plants. To eliminate this problem, vetch species are often planted mixed with cereals such as barley, oats, triticale. In this way, it is wrapped by clinging to the leeches at the ends of the leaves and the grains that develop upright. Thus, since it will be easier for the sun's rays to reach the soil, soil moisture decreases, so the decay in the vetch is reduced. In addition, mixed plantings create a balanced and high-quality roughage for animals. As a matter of fact, in addition to the protein richness of legumes, wheat fruits are rich in carbohydrates.

Legume fodder plant common vetch brings plenty of nitrogen to the soil with the tubers in the roots. In plots where vetch and peas have not been grown for a long time, it is necessary to graft the seeds with bacterial culture (Yolcu 2011). However, the fact that vetch species are naturally found almost everywhere in our country does not make it mandatory to vaccinate bacteria in October. Vetches do not need much nitrogen, thanks to the bacteria in their roots. Therefore, it is sufficient to give 1-3 kg / da of nitrogen with planting. In addition, giving 8-10 kg/da of phosphorus in phosphorus-poor and irrigable areas will increase the yield (Açıkgöz 1991; Avcıoğlu et al. 2009).

5. HARVEST

Very high quality grass is obtained from vetches mowed in the early period in pure plantings. However, dry matter yield is at low levels. Although dry grass yield increases with the delay of harvesting, there are no serious losses in quality (Nelson et. al. 1994). For this reason, the appropriate form time of the vetch produced for grass purposes can be made in a wide range from flowering to the period when all the pods are full (Açıkgöz 2001; Avcioglu ver et al. 2009).

Vetch flowers are self-fertilizing during the bud period and do not need any pollinators. As a result of overdrying of the pods, cracking occurs and seed losses increase. Attention should be paid to this in determining the time of seed harvesting. In large areas, seed harvesting can be done during the period when 3-4 pods on the lower side are completely yellowed. Since vetch develops horizontally, harvesting with the harvester is difficult and increases crop loss. For this reason, the harvested plants are dried in the field in the form of barrels for a few days and then blended with patosis (Avcıoğlu et al. 2009; Anlarsal 2009; Açıkgöz 2021).

6. HUNGARIAN VETCH

Hungarian vetch is a type of vetch that is resistant to cold and drought. It is one of the fodder plants that are best adapted to winter in Central Anatolian conditions. Due to its semi-flat development, it can be grown lean or can create successful mixtures with cereals. Hungarian vetch production in our country is a rapidly increasing vetch species. It appears in a slightly gray color, as the plant is covered with thin hairs. Hungarian vetch can grow up to 60-80 cm in length. The flower stem of the Hungarian vetch, which develops slightly more upright than the common frique, is shorter and varies according to the varieties, but the petals can be white-cream or purple in color. The pods of the plant are 2-3 cm tall and have 3-6 pods in them. Its seeds are of color, which can vary from light brown to black, and the weight of 1000 grains is in the range of 25-50 g. There are speckles similar to quail eggs on the plant seeds (Açıkgöz 2001; Avcioglu et al. 2009; Balabanli 2009).

Figure 3: Hungarian Vetch Plant View (Anonymous, 2022d)

Hungarian vetch (Figure 4), which has very good winter resistance, is able to withstand very low temperatures, especially under snow cover. Although it is not selective in terms of soil, it is an important feature that it grows in heavy, clayey and water-holding lands (Budak et. Al. 1997). Hungarian vetch, which has better winter and cold resistance than common vetch and downy vetch, can be easily grown for winter in all regions. Summer plantings do not give successful results due to the possible vernalization need of the seeds (Açıkgöz, 2001). If Hungarian vetch without the need for a large amount of fertilizer is to be grown in poor soils, it will be sufficient to give 2-3 kg / da nitrogen and 5-10 kg / da phosphorus (Çakmakçı et. al 2002). Thanks to its large seeds, it can be planted as deep as 3-5 cm and makes a good exit with its high germination ability. In the studies carried out in our country, 8-12 kg / da seed in grass production and 6-8 kg / da seed in seed production should be used and the row interval should not exceed 50 cm. As with other vetch species, Hungarian vetch successfully mixes with grains (Açıkgöz 2001; Envoy 2005; Avcıoğlu et al. 2009).

In general, Hungarian vetch, which is grown for the purpose of grass production, is considered to be the optimal harvest time full flowering. In mixed plantings, the harvest time is usually determined by the grains, and the spike period of the grains is the optimal harvest time. Since it develops more upright than ordinary vetch, plants can be easily harvested with a harvester in seed production. On average, 100 kg/da seed yield can be considered as a satisfactory yield under Turkish conditions. Seed harvesting is done during the period when all the pods are ripe (Açıkgöz 1991; Avcıoğlu et al. 2009).

7. HAIRY VETCH

Hairy vetch, which is a type of vetch that is widely cultivated in some countries, is a working plant in our country and there are many registered vetch varieties. Its production in our country is quite limited against the potential to be grown in continental climates with an annual rainfall of 400 mm and above. The hairy vetch, which is taller than the common vetch, has all its organs, especially young shoots, covered with hairs (Figure 5). Its flowers are lined up on one side of the long flower stalk that protrudes from the leaf seats, and their color is violet-purple and sometimes white. Each inflorescence contains 5-20 flowers. After the fertilization of the flowers, pods are formed and there are 4-8 seeds in each pod. Seeds with a round and black color weigh 1000 grains of 20-30 g. The plant, which is normally 50-100 cm tall, can grow up to 2 m in some cases (Açıkgöz 2001; Çakmakçı and Aydınoğlu 2009).

Figure 4: Overview of Hairy Vetch (Anonymous, 2022f)

Hairy vetch, which has a high ability to gain nitrogen and organic matter into the soil, is a good cover and green manure plant. It is considered one of the most cold-resistant species among vetch species. Although it is not very selective in terms of soil demand, it develops better on sandy and light soils. The shaggy vetch, which is moderately resistant to salinity, is more tolerant than alfalfa and tripuli species in weakly acidic soils. According to the varieties, there is a hard seed dormancy ranging from 10-70% in the seeds (Açıkgöz 2021). There are 5 registered feathered vetch varieties in Turkey (Table 3).

Cultivation can be done like common vetch, 4-8 kg/da of seeds and 30-50 cm row are sufficient for grass and seed in barren. The first exit may not be uniform in varieties with a high rate of hard seed dormancy of the downy vetch with a sowing depth of 2-4 cm. But most of the seeds germinate until spring, forming seedlings. As with other vetch species, feathered vetch can be successfully grown in sowing mixed with grains (Tosun 1974; Açıkgöz 2021).

As in the case of Hungarian vetch, the optimal form time for grass in feathered vetch is the period of full flowering. Since the feathered vetch lies easily, it is a great advantage to plant the grains mixed together in preventing both the losses caused by rotting and the losses that occur in the harvest. The role of bees is great, since the flowers of common vetch are a good source of nectar and pollen in seed production (Somerville, 2012). The rate of seed pouring is not as much as common vetch. In feathered vetch, as in Hungarian vetch, seed harvesting can be done with harvesters after the seeds have ripened.

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CHAPTER XI

LUPINE (*Lupinus* L.)

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INTRODUCTION

Lupins are annual or perennial herbaceous plants, as well as being in the form of shrubs or small trees. It is one of the legumes that have been accepted to have nearly 300 species in recent years. 90% of these plants are of the new World origin and have spread over a wide area as far as Argentina and Chile. Açıkgöz (2021) reported that about 12 species of lupine can grow naturally around the Mediterranean and some species in East Africa. Although white lupine is the oldest cultivated species, its origin is unknown, but it was assumed to have been originated all around the Mediterranean, yellow lupine wild forms belonged to Morocco, Algeria, Tunisia and the Iberian Peninsula and spread throughout the Mediterranean, blue lupine originated around the Aegean and Andean lupine originated in the Andes Mountains in South America. Lupine seeds contain 30-40% crude protein and 5-10% oil (Prusinski, 2017). It is used as green manure and forage plant and its seeds are also used in human and animal nutrition (Baytop, 1994). It was stated that when lupine was added to the ration at a rate of 50% in poultry nutrition, the feed conversion coefficient increased (Yıldız and Yazgan, 2000). Lupine, which is generally used as animal feed, is also consumed as an appetizer in a few provinces such as Konya and Antalya (Akıl and Okant, 2020). In our country, lupine is known as lupine, lupin, andean lupin, white lupin, tarwi, tick bean, lupinus, and commonly as lupin bean (Yorgancılar, 1996; Hakkı et al., 2007).

In the world, lupine cultivation area is 1.049 million ha and grain production is around 1.32 million tons. The largest producing countries are Australia (798,629 t), followed by the Russian Federation (166,271 t), Poland (145,690 t), Morocco (56,282 t) and Chile (45,606 t) (FAO, 2019). Today, blue lupine accounts for 80% of its production. Davis (1970) reported that there are 5 species of the lupinus varieties in the flora of Turkey. In our country, *Lupinus albus* and *Lupinus angustifolius* species are found naturally mostly in our coastal zone. According to our recent information, only *Lupinus albus* (white lupine) species is cultivated in Isparta, Konya, Burdur and Antalya provinces under different names such as Andean lupine, white lupin, tarwi, tick bean, lupinus, and commonly as lupin bean (Yorgancılar, 1996; Hakkı et al., 2007). In Turkey, it is cultivated in a total area of 25,796 da, with a production of 128 t and 88% of the production is performed in Konya province (TUIK, 2021).

Lupines are used for seed production, grass production, silage production, green manure and soil improvement and *Lupinus polphllus*, *Lupinus perennis* and *Lupinus arboreus* species are used as ornamental plants. Lupine plant, which contains alkaloids such as lupanin, spartein and anagyrine, also has an important place in the pharmaceutical industry (Kayserilioğlu, 1990). In addition, although it is used as an alternative to soybean as a raw material in products such as bread, biscuits, cakes, pasta, candy, soybean sauce, high quality vegetable oil with high antioxidant content, gluten-free flour, alternative products to milk and as an appetite in the world, it is used as an appetite in Turkey and it is benefited from the alkaloids (Mülayim and Acar, 2008). Since lupine is sensitive to calcareous soils, it is cultivated in the Lakes Region (Akşehir, Beyşehir, Eğridir and Doğanhisar), which has low lime content. Therefore, the cultivation of this plant is limited and the majority of the Turkish population does not know this plant. Lupine, which has 2-3 times more protein than cereals, is also a rich source of vitamins, minerals, calcium and iron. Although soybean ranks first in terms of vegetable protein production, in case the amount of production and yield is increased, lupin can compete with soybean with its high protein content (28% in green grass and 47.6% in grain) (Sator, 1983; Akıl, 2019).

Status in the systematics

Lupine has herbaceous annual or shrubby perennial species in the Lupinus species of the subfamily Papilioniodeae. It is divided into two main groups as old and new world species. Old World species are about 12 herbaceous plants. The cultivated (*Lupinus albus L.*), yellow lupine (*Lupinus luteus L.*), blue lupine (*Lupinus angustifolius L.*) are included in this group. New World *Lupinus* species are very numerous and complex (Gladstones et al., 1984; Wolko et al., 2011). Individuals differing in the number of chromosomes can be found between and within the *Lupinus* species. The chromosome numbers of species vary from 2n=32 to 2n=96. Wolko et al. (2011) reported that it can generally be considered as Lupinus albus (2n=50), Lupinus luteus (2n=52), Lupinus angustifolius (2n=40) and Lupinus mutabilis (2n=52).

Description of the plant

Lupine species cultivated as a legume forage plant are annual or perennial plants. In lupine species, there is a strong taproot that can go down to 1-2 m and underdeveloped lateral roots, and there are species that can grow up to 300-100 cm under normal conditions, sometimes up to 150-200 cm. The stems become woody towards ripening. Leaflets, ranging from 5 to 15 depending on the species, are joined at the end of a long petiole in the form of palm (radial). The color of the petals varies according to the species. White lupine flowers can be white, pink, light blue, or dark blue in *graecus* varieties. Yellow lupine flowers are typically yellow, rarely white.

Blue lupine flowers are usually blue, while cultivated varieties in Australia are white. Andean lupine flowers are mostly purple blue, rarely pink or white. After pollination of the flowers, 5-15 cm long, flat, yellow, brown and black pods are formed. Each pod contains 2-7 seeds. The seeds are generally flat and the hilum is very prominent. Depending on the species and cultivars, the seeds can be white to gray and brown, smooth or spotted. Thousand grain weights can vary between 110-350 g in white lupine, 30-240 g in blue lupine, 50-150 g in yellow lupine and 80-280 g in Andean lupine. Blue lupine is self-fertilized. Foreign fertilization rate is low. White lupine and yellow lupine are self-fertilized. Andean lupine is fertilized by foreign flower powder (Gustafssin and Gadd, 2009).

Soil and climate requirements

Lupins generally like coarse, well-drained, neutral or slightly acidic soils. Iron chlorosis and diseases are common in very heavy, poorly drained and basic soils. White lupine has a very wide adaptation. It grows well in light or medium textured, fertile and acid soils. Soils with a pH lower than 6.5 are ideal. It tolerates salinity quite well. It is not recommended for cultivation in the northern regions of Europe as it is latish. A humid and cool climate after planting and a clear and sunny climate during the fruit formation period are ideal for lupins. High relative humidity during the first development periods accelerates development. In case of low relative humidity, fruit does not set or yield decreases. Most Mediterranean region varieties are long day plants and react to vernalization. In general, lupines are not sensitive to cold. Blue lupine is very resistant to cold. Some wild types have been determined to survive down to -16°C. High temperatures and drought disrupt flower fertilization and reduce seed yield. When all lupine species are exposed to drought stress during flowering, fertilization and fruit setting are disrupted.

Planting and maintenance

Lupins can be cultivated for many different purposes such as seed or grass production, silage, green manuring or grazing. Depending on the region and purpose, it can be grown as a main crop or a second crop after winter crops. There is no lupine variety that has been reclaimed, registrated or authorized for production in Turkey. For white lupine production, the white lupine population grown in Konya and the Lakes Region can be used. White lupins grown in Konya and neighboring provinces in Turkey are generally cultivated in fallow areas as summer crops. White lupine is planted between April 15 and May 10 in the regions with an altitude of 1400-1500 m in Konya province (Mülayım and Semerciöz. 1992; Mülayım and Acar, 2008). In a study conducted in Şanlıurfa, November 30 was recommended as the ideal date for winter intercropping (Akıl, 2019). No special soil preparation is required for lupine cultivation. The weed-free, hard and smooth planting bed is sufficient for lupins. Lupine, which is a legume, are not given too much nitrogen fertilizer. Lupines are known as plants that fix abundant nitrogen in the soil. However, sufficient and effective special lupine bacteria (*Rhizobium lupini* = *Bradyrhizobium lupine*) must be present in the soil. Some lupine species are sensitive to phosphorus deficiency. It is sufficient to give 5-10 kg/da P_20_5 in phosphorus-poor soils. Potassium fertilizers can be given to sandy soils. The optimum plant density and planting rate of lupins vary according to the varieties, climatic conditions of the region, soil structure and cultivation method. In general, in arid conditions, wide row spacing gives more yield than narrow row spacing. Under arid conditions, no significant yield difference was observed between 15 and 60 cm row spacing and 30 cm row spacing was recommended (Bhardwaj et al., 2004). The cultivation of lupine species has not been studied much in our country. In many studies, lupine plantings were made with 20-40 cm row spacing and successful results were obtained (Okuyucu, et al., 2004; Orak and Tuna, 1994; Orak and Nizam, 2003; Akıl, 2019). In Turkey, white lupine sowing in narrow areas is done manually or by spreading with fertilizer spreading machines. The distributed lupine seeds are buried in the soil with a light disc harrow and then pressed down with a slide. Depending on the 1000 grain weight of the variety, planting rates of 15-20 kg da^{-1} for white lupine, kg da^{-1} for yellow and blue lupine and 5 kg da^{-1} for Andean lupine can be applied. Large seeded lupine seeds should be planted in a humid soil depth for good emergence. The recommended sowing depth is 5-5 cm.

Use as a green manure plant

Lupins are green manure plants that are especially suitable for sandy and poor areas. For green fertilizing, alkaloid varieties that are more resistant to environmental conditions, diseases and pests are recommended. In Australia, blue lupine varieties with high alkaloids are widely used for green fertilizing. Yellow lupine is widely used as a green manure crop in Central and Northern Europe, especially in Poland and Germany. In studies conducted in these regions, Wolko et al. (2011) reported that lupine species bound varying amounts of N to the soil ranging from 18-35 kg ha^{-1}.

Seed production

Lupins are resistant to heeling. They are suitable for harvesting from the east since pod cracking is not common and pods are usually located on the upper parts of the plants. Flowering starts on the main stem and continues on the side branches for 10-15 days. Therefore, uniform seed ripening is not seen in indeterminate varieties. If the whole plant is expected to dry naturally, pod dropping and pod cracking events and consequently seed losses may occur. Therefore, harvesting should be started without delay when the plants reach harvest ripening. In many countries, seed harvesting of lupins is done directly by combine harvesters. In Konya region, since uniform ripening is not observed, the harvested plants are left to dry in bundles and the green plants are expected to mature. When the plants are completely dry, the grains are separated from the stalks to be threshed with a thresher.

White lupine yields are 50-150 kg ha^{-1} in arid areas of the USA and 300-400 kg ha^{-1} in irrigated areas (Bhardwaj et al., 2004). In Turkey, very few studies were conducted on seed yields of lupine species. The yield of white lupine planted in summer in Thrace was 126 kg da^{-1} and the yield of white lupine planted in winter in the same region was 200-250 kg da^{-1} (Orak and Tuna, 1994; Orak and Nizam, 2003). In the studies conducted in Ödemiş and Bayındır plains, yields of up to 232 kg da^{-1} from white lupin, 271 kg da^{-1} from blue lupin and 150 kg da^{-1} from yellow lupin were obtained (Reader, et al., 2004). In Konya region, white lupine seed yields varied between 9-95 kg da^{-1} and it was obtained more yields from local variety (Özkaynak et al., 1994). In another study conducted in Şanlıurfa region, seed yield varied between 84-213 kg ha^{-1} (Akıl, 2019). As seen from these studies, lupine seed yields varied greatly in our country according to years, soil and climate conditions. Lupine seeds are very rich in protein and oil. Although analyzes give different results, in general, the lowest (25-55%) crude protein content is found in blue lupine seeds and the highest (40-50%) in Andean lupine seeds. Lupine seeds are important animal foods in many countries and are included in concentrated feed mixtures. Alkaloids in lupine seeds are soluble in water. In alkaloid seeds, alkaloids can be easily washed out by processes such as wetting, washing or boiling. Throughout history, the negative effects of alkaloids have been eliminated by these simple processes. In many regions of our country, boiled white lupine seeds are safely consumed as appetites under the name of lupin bean.

Alkaloids

As in most legume seeds, lupine seeds also contain various alkaloids. Although there are about 10 alkaloids in lupine seeds, the most abundant alkaloids are spartein and lupanin. In general, the highest alkaloid content was found in white lupine and the lowest in yellow lupine. Total alkaloid content in normal lupine plants varied between 0.01% and 4% depending on species, plant organs and cultivation conditions. The alkaloid content in seeds is much higher than in other plant organs (Prusinski, 2017). These alkaloids available in lupine seeds caused bitterness, low palatability and decreased feed value, as well as muscle contractions, breathing difficulties, vomiting and sometimes death in animals (Zdunczyk et al., 1998). It is accepted that the total alkaloid content of this plant should be below 0.02% for safe consumption by humans and animals (Prusinski, 2017; Resta et al., 2008). The seeds of improved sweet varieties do not adversely affect animals, and although they have high digestibility rates, sweet varieties are more sensitive to environmental conditions than alkaloid varieties.

Conclusion and suggestion

It has been observed that lupine, which is a local delicacy, is a competitor to soybean with its mineral content and 25-55% high protein and 8-9% fat ratio in addition to this rich content and has the potential to supply a significant part of the mineral substances that should be taken daily. Due to its potentials to be consumed as an appetite of its fruits, to be an important animal feed with its abundant leaves and high amount and quality protein, to grow some species as pharmaceutical or cosmetic plants, to use its seeds in dietary products, and to use the bitter water filtered during the sweetening of the seeds as a medicine for insecticides within the scope of biological control, it has been an option to develop and expand the cultivation of lupine in Turkey and the region through reclamation.

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CHAPTER XII

FORAGE PEA (*Pisum sativum* spp. *arvense* L.)

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INTRODUCTION

Pea species are of old world origin. Pea species are naturally found in a wide area in Europe, extending to the Mediterranean environment, Asia Minor and Central Asia (Açıkgöz, 2001). Forage pea, which has a high nutritional value and is delicious, is an annual legume forage plant. It is grown in almost every part of our country (Karayel and Bozoğlu, 2012). It is grown for its grain or grass. The herb is delicious and has high nutritional value. It has a high level of protein in its grains. It can be mixed with roughage after crushing. However, grain-pea mixes are suitable for grazing (Açıkgöz, 2001). Seeds of forage pea grown in Europe are used as protein feed in the feed industry. Because its seeds contain crude protein in amounts ranging from 20% to 30%. Similarly, the dried grass of the forage pea contains around 20% crude protein if it is shaped in the appropriate period. Pea grains are a quality and nutritious protein source for animals. Forage pea, which use both dry grass and green grains as feed, can also be used as green forage plant and green manure to increase nitrogen in pastures. (Özkaynak, 1980; Açıkgöz, 2001).

Figure 1. A general view from forage pea (URL 1)

Almost all of the forage pea grown in Europe are varieties with white flowers and yellow or green seeds (Açıkgöz, 2001).

Production data of the last 5 years of forage pea production are given in Table 1.

Table 1. Forage pea production data for the years 2017-2021

Years	Sown area (da)	Yield (kg da^{-1})	Produce amount (ton)
2017	69.595	2.003	139.366
2018	104.377	2.019	210.706
2019	146.090	1.944	283.928
2020	243.191	1.862	452.776
2021	268.212	1.814	486.233

Kaynak TÜİK, 2022

When Table 1 is examined;

Forage pea cultivation area in Turkey was 69 thousand decares in 2017. Especially in 2020, the production area has doubled compared to the previous year. In 2021, the production area increased by approximately 4 times to 268 thousand decares.

The average yield per decare is 2 tons in 2017 and 2018. However, the yield per decare decreased to 1.8 tons in 2019, 2020 and 2021.

The production amount was 139 thousand tons in 2017. It was 210 thousand tons in 2018, 283 thousand tons in 2019 and 452 thousand tons in 2020 with an increase of 60%. Due to the increase in production areas, it increased to 486 thousand tons in 2021.

When Table 1 is evaluated; Although the yield per decare has decreased in recent years, there has been a serious increase in production areas. For this reason, the increase in forage pea production in Turkey has continued every year.

Important Properties of Forage Pea

- Forage pea have high grass yield.
- Forage pea has a delicious and high quality herb. In addition to 20-30% crude protein in its grass, it has mineral substance and vitamin content at levels to meet the needs of animals.
- There are no toxic substances in the herb. Therefore, it is safe for consumption by animals.
- Forage pea is a good crop rotation plant.
- Forage pea seeds with high protein content can be used as concentrate feed in animal nutrition.

- Forage pea is a plant species that can be used in green fertilization with its suitable features such as being early and creating abundant green parts.
- Forage pea is a good mix plant that can be planted mixed with cereal types.
- The large size of the forage pea seeds does not require a very precise seedbed preparation.
- The absence of dormancy in the seeds ensures easy germination and a uniform emergence.

Plant Taxonomy and Morphology

Peas are collected under the species *Pisum sativum*. As a subspecies of this species, *Pisum sativum* ssp. *sativum* (fodder pea) ve *pisum sativum* ssp. *arvanse* L. Poir (forage pea) is located (Bilgili ?)

Pea, which is an annual plant, has thin stems and is covered with a light waxy layer and exceeds 1 m in height in suitable regions. The leaves are broad and branching, the flower color is mostly white, the fruit is typical bean-shaped. Seed color ranges from light yellow to green to brown. 1000 grain weight is 100-300 g (Açıkgöz, 2001).

Figure 2. Morphological structure of forage pea (URL 2)

Soil and Climate Requirements

Forage pea is an annual legume forage crop with wide adaptability. Although there is no special soil requirement, it performs better in soils with loamy texture, rich in organic matter, neutral in terms of soil reaction (pH: 6.5 -7.0) (Gul et al., 2005).

Forage pea is actually a cool climate plant. It grows well in places with an annual precipitation of 500-1000 mm. It is not very durable in the ear. Withstands light to moderate frosts well (Açıkgöz, 2001). In our country, winter takes place in October, November and December. It is considered suitable for summer planting in February-March.

Forage Pea Farming

Since the seeds of forage pea are large enough, they do not need a special soil preparation. Soil preparation for widely cultivated products such as wheat, barley and lentils is also suitable and sufficient for forage pea (Sayar, 2021).

Since forage pea is a legume plant, it can be cultivated both purely and mixed with grains. In pure sowing, the seed to be planted per decare is calculated as 100 seeds per square meter. For this reason, the amount of seed to be planted per decare in pure sowing can vary between 12-20 kg da^{-1} depending on the seed size of the variety to be used. If forage Pea is to be planted mixed with grains, 8-12 kg da^{-1} of forage pea seeds and 5-7 kg da^{-1} of grain (barley, triticale) seeds should be used. The sowing depth is 5-6 cm, the row spacing is 20-25 cm, but the row spacing should be 30-40 cm in sowing for seed purposes (Sayar, 2021). With sowing, 5-10 kg da^{-1} of P_2O_5 should be given in soils that can be irrigated with 2-5 kg da^{-1} of N and that are poor in phosphorus. In coastal areas, forage pea planted in autumn do not need irrigation. However, irrigation contributes significantly to yield in arid regions.

In suitable climatic conditions, seedlings are seen in rows 1-2 weeks after planting. Weed control is important after emergence. For this reason, the field should be prepared very well or herbicide should be used after planting.

Different diseases and pests are seen in peas. Among the fungal diseases, those that cause significant damage to forage pea are listed as *Erysiphe pisi, Peronospora pisi, Fusarium oxysporum sp. Pytium ultimum*. In addition, pea mosaic virus, *Pseudomonas pisi* bacteria cause significant damage to peas (Lewis and Matthews, 1985).

Grass and Seed Production

The most suitable cutting time for grass production is the period when the first fruits begin to develop. The forage pea harvested during this period can be given to animals as green, or dried and used in winter (Açıkgöz, 2001). Researches have been carried out in different ecological conditions by many researchers for the purpose of forage pea grass production. In the study carried out with 6 different annual legume forage plants in Antalya ecological conditions between 2000-2002, it was reported that the green grass yield was

1219 kg /da and the dry grass yield was 317 kg da^{-1} (Çeçen et al., 2005). In the two-year study carried out on forage pea lines in the field conditions of the Harran Plain in Şanlıurfa; It has been reported that an average of 457 kg da^{-1} dry grass and 2178 kg da^{-1} green grass yield were obtained (Çil et al., 2007). They evaluated pea genotypes with two semi-leaves and four normal leaves at eight different locations during the 2001-2002 and 2002-2003 growth periods. The average green grass yield of the pea genotypes was 2660.5 kg da^{-1} and the highest yield was obtained from the variety with normal leaves (Bilgili et al., 2010). In the study carried out to determine the yield and quality characteristics of some forage pea genotypes in Isparta in 2012, it was determined that the green grass yield was between 907-1109 kg da^{-1} and the dry grass yield was between 221-281 kg da^{-1} (Ömeroğlu, 2016). In the study carried out in Çanakkale ecological conditions, it was reported that the highest yield of green grass 2695.5 kg da^{-1} and dry grass 430.65 kg da^{-1} for Töre variety. (Çınar, 2017). In the study carried out to determine suitable forage pea varieties and planting times in Ağrı-Eleşkirt conditions, they reported that the green grass yield was between 1026-2053 kg da^{-1} and the hay yield was between 204-398 kg da^{-1} (Temel and Yazıcı, 2021).

The most suitable harvest time for seed production should be harvested when most of the fruits of the plant are fully ripe and turn yellow. A lot of research has been done on seed production. The average grain yield was determined as 140 kg da^{-1} in a study using two semi-leaf and five normal-leaved pea genotypes in Bursa between 1997-2001 (Uzun et al., 2005). In the study conducted on the forage pea plant in Bursa ecological conditions, it was determined that the seed yield was between 352.4-378.3 kg da^{-1} (Bilgili et al., 2010). In a study conducted between 2004-2005 to determine the grain yield and yield components of some forage pea cultivars in Bursa Mustafakemalpaşa ecological conditions in early spring, it was determined that the grain yield was between 96.83-149.00 kg da^{-1} (Öz and Karasu, 2010). In the study they carried out to determine the agricultural characteristics between 20 lines and 3 varieties of forage pea in Konya in 2015, the highest grain yield was determined as 272.7 kg da^{-1}, and the lowest grain yield was 123.8 kg da^{-1} (Ceyhan and Avcı, 2015). In a study carried out to determine the yield and quality characteristics of some forage pea genotypes in Isparta in 2012, the grain yield was determined between 113.7-205 kg da^{-1} (Ömeroğlu, 2016). In the study carried out to determine the morphological characterization of the local pea genotypes grown in Giresun in the 2012-2013 growing season, the grain yield was calculated as 92.25-143.45 kg da^{-1} (Kılınç, 2017).

Quality and Evaluation of Forage Pea

It is grown for forage pea grass and grain, which is an annual legume plant. The protein rate in the grain is around 30-35%, and it is successfully used in the nutrition of all farm animals by being mixed with roughage after crushing. In addition to these, pea-grain mixtures are also suitable for grazing. There are many studies on the quality of forage pea. It has been reported that the protein rate in the seed of Perla forage pea variety, which is resistant to drought and cold, is between 25-28% (Ranalli et al., 1998). In the study conducted in Ankara conditions, it was reported that the crude protein ratio varied between 16-19% (Timurağaoğlu et al., 2004). A study was conducted to determine the effect of three different harvest times (flowering onset, full flowering and seed filling) of pea varieties with different leaf forms on feed yield and quality in 2010-2011 in Isparta. According to the results of the study, the highest crude protein yield was found to be 44.20 kg da^{-1} (Türk and Albayrak, 2012). It was reported that the protein ratio was calculated between 19.86-28.12% in the study conducted in Ordu ecological conditions (Kılınç, 2017). In the study carried out to determine the nutritional values of the seeds and cuts of 4 different forage pea varieties in 6 different sowing times, including winter and summer in Iğdır ecological conditions, seed crude protein ratios were reported to vary between 21.46% and 24.67%. (Keskin et al., 2021)

Forage pea planted as pure or mixed can also be used for grazing as a pasture plant. However, due to the risk of swelling, it should be planted mixed with grains. It is a good green manure for peas like other legumes. Like all legumes, forage pea have nitrogen fixing properties.

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CHAPTER XIII

FENUGREEK (*Trigonella foenum-graecum* L.)

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INTRODUCTION

The legume family, which is the largest family of flowering plants, is one of the most important plant communities in terms of economy (Dall'Agnol et al., 2021). In terms of forage crops, it includes the most valuable species (Özyazıcı et al., 2021). Apart from forage plants of the legume family, it can also be used in many fields such as medicinal and aromatic, human nutrition, industry, drug making, pharmacology, and pesticides. Especially leguminous plants; in field agriculture, they come to the fore with their biological nitrogen fixation capacity and the use of atmospheric nitrogen, thus increasing the yield and quality of the product that comes after them.

Fenugreek (*Trigonella foenum-graecum* L.), one of the plants belonging to the Fabaceae family; Its yellowish-white triangular flowers mean 'small triangle' (Hilles and Mahmood, 2021) in Latin and 'triangle' (Mandal and DebMandal, 2016; Zandi et al., 2017) in Greek, describing triangular flowers. In addition, 'foenum-graecum', which indicates that it was used as a forage plant in the past, literally means 'Greek straw' (Basu et al., 2019). The fenugreek plant, which is mentioned as one of the oldest medicinal plants in history; It is mentioned that it was used for mummification on Egyptian papyrus as early as 1500 BC (Hilles and Mahmood, 2021; Singh et al., 2022). In Egyptian, Greek and Indian civilizations, fenugreek has been one of the most important herbs used in traditional medicine and human health (Kandhare et al., 2015; Abdel-Wahab and Abdel-Wahab, 2021).

Fenugreek depending on climatic conditions; Cultivated all over the world, including India, North Africa, Southeast Asia, Europe, Russia, Middle East, China, Pakistan, Iran, Türkiye, Morocco, Greece, Afghanistan, Australia, Canada, Argentina and the USA (Figure 1). While India produces the most fenugreek in the world, it does not contribute much to the global fenugreek trade as it is the country that consumes the most (Petropoulos, 2002; Mandal and DebMandal, 2016; Ouzir et al., 2016; Zandi et al., 2017; Varghese et al., 2019; Belkadi et al., 2022).

Fenugreek it is a dicotyledonous, self-pollinating, drought and high temperature resistant, one-year legume plant that grows well in temperate climates and can be planted in winter (Kevseroğlu and Özyazıcı 1997; Kızıl and Arslan 2003; Agha et al., 2022; Aqeel et al., 2022). It is also highly sensitive to abiotic stress factors such as salinity, heavy metals and UV radiations (Naeem et al., 2020; Faizy et al., 2022). *T. foenum-graecum* stands out as a product with potential in terms of being able to grow in marginal lands and adapting to various climatic zones, and to be introduced to different agricultural systems (Ahmad et al., 2016). Fenugreek plant in many countries such as Iran; It is grown in arid and semi-arid regions where drought and soil salinity pose a significant threat. Unlike other legumes, fenugreek is highly tolerant of salinity (Saxena et al., 2017).

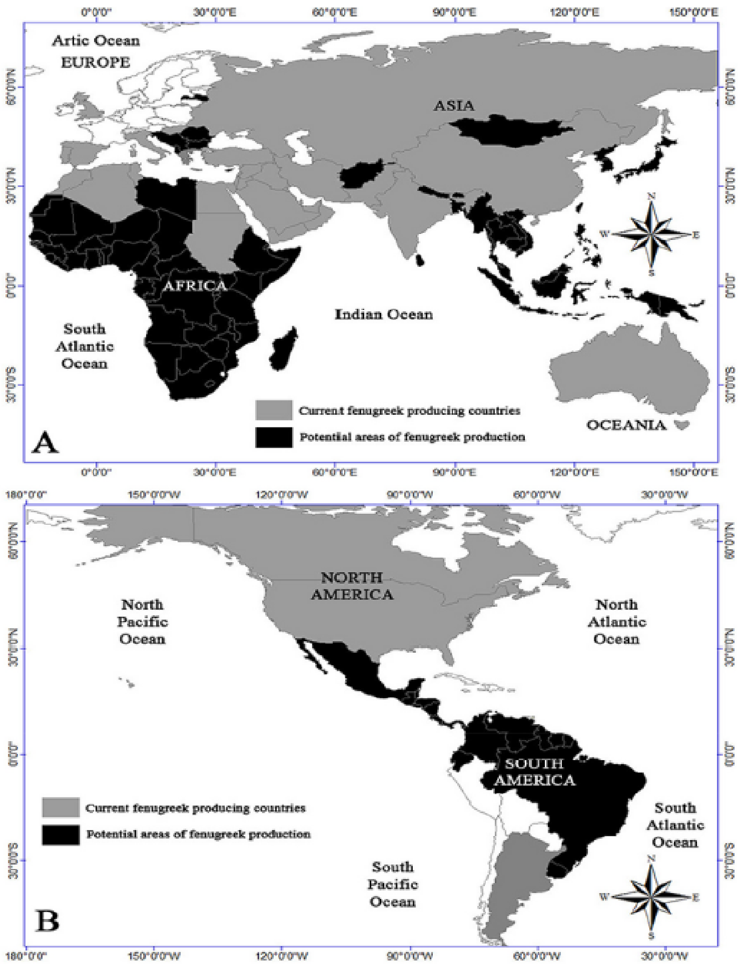

Figure 1. Worldwide distribution of *Trigonella foenum-graecum* (Zandi et al., 2017)

In fenugreek herbage and seeds; Many, including fiber, phospholipids, glycolipids, oleic acid, linolenic acid, linoleic acid, choline, vitamins, nicotinic acid, niacin, alkaloids, flavonoids, saponins, amino acids, tannins, certain steroidal glycosides, protein, minerals, polysaccharide, triterpenoid, and coumarin Contains elements and metabolites (Mehrafarin et al., 2010; Yadav et al., 2011; Talapatra and Talapatra, 2015; Ahmad et al., 2016; Megias et al., 2016; Grela et al., 2017; Aasim et al., 2018).

In studies conducted in many regions of Türkiye, it has been revealed that the need for roughage is determined according to animal existence and that quality roughage is not met in almost all of the studies carried out in the region (Balabanlı and Bıçakçı, 2015; Turan et al., 2015; Balabanlı and Bıçakçı, 2016; Bıçakçı and Açıkbaş, 2018). Fenugreek is thought to be one of the alternative products that can be included in the production pattern as a forage plant in Turkey in meeting the need for quality roughage. Since it is a legume plant, it can fix nitrogen to the soil with the help of Rhizobium bacteria, it is nutritious and delicious for ruminant animals, and this plant stands out as a forage plant despite its many uses.

HERBAL PROPERTIES

Fenugreek (*T. foenum-graecum* L.) is an annual plant with taproot. There is a large amount of nodosity on the roots and the effective bacterial species is *Rhizobium meliloti*. The average height of the plant varies between 30-60 cm, the stems are hairy at the beginning of the development period and then show a hairless structure. They are very similar to alfalfa in terms of leaf characteristics and the leaf is in the form of a compound leaf consisting of three leaflets. The leaflets are generally 10-40 mm long. The flowers are 3-18 mm long, the flowers are papillonic and white to yellow. The pods are thin, curved, pointed and 6-11 cm long. There are 10-20 seeds in the pods, 5 mm long, oblong or square, hard and golden yellow in color (Figure 2). 1000 grain weight of seeds is 18-20 g (Gençkan, 1983; Köroğlu, 1985; Petropoulos, 2006; Acharya et al., 2008; Moradi and Moradi, 2013; Żuk-Gołaszewska ve Wierzbowska, 2017; Singh et al., 2022).

Fenugreek leaves contain 7 different saponins known as graecunins. These compounds are glycosides of diosgenin. In leaves; It contains 86.1% moisture, 4.4% protein, 0.9% fat, 1.5% minerals, 1.1% fiber and 6% carbohydrates. Mineral and vitamin contents; calcium, iron, phosphorus, carotene, thiamine, riboflavin, niacin and vitamin C (Singh et al., 2022). Fenugreek seeds contain 27% protein, 7-10% fixed oil, nitrogenous compounds, 1% alkaloids (trigonellin) and flavonoids (Gruenwald et al., 2004).

Figure 2. Plant and seed view of fenugreek

CLIMATE, SOIL REQUEST AND CULTURAL PROCESSES OF FENUGREEK

Fenugreek is an annual cool season legume forage crop. It is a winter plant and requires low temperature for its growth. It is resistant to winter frosts, drought and high temperature. There is no soil selectivity. its best development; It does well in well-drained, low-lime, loamy soils. Fenugreek grown by seed is grown by row planting method and soil preparation is important for emergence. The pH of the soil should be between 5.3 and 8.2. As the sowing norm, it should be 2-4 kg/da in seed production, 5-8 kg/da in grass production and it should be done at a depth of 2-4 cm with 20-40 cm distance between rows. The plant can be harvested after 120-150 days. Plants should be harvested during flowering for grass production. Delayed harvest leads to pod burst and seed loss. The expected yield of fenugreek seeds is 0.5-3.8 t/ha. Although fenugreek seeds can be stored for more than 10 years without any treatment, they have been reported to be susceptible to fungal pathogens, sometimes called Cercospora leaf spot (Hakyemez and Bilgili, 2009; Snehlata and Payal, 2012; Açıkgöz, 2021).

USAGE AREAS OF FENUGREEK

Evaluation as Forage Crop

Fenugreek seeds are mostly used in the diet of cattle, horses and pigs due to the glycoside called coumarin (cumarin), and it is recommended to add 25-30 g per day to the rations of these animals. It has been reported that fenugreek can be considered as an alternative forage plant in ruminant feeding due to its nutritional content close to alfalfa, and it also increases appetite in ruminant animals and encourages feed consumption (Acharya et al., 2006; Zandi et al., 2010; Basu and Prasad, 2011). Thus, fenugreek is reported to promote muscle growth and increase carcass weight in cattle (Acharya et al., 2008). Fenugreek seeds; It has been stated that it has effects on blood composition, wool, meat and milk production in sheep, goat and cattle nutrition (Ibrahim, 2019). Fenugreek seeds also increase milk production and body weight in goats and sheep (Alamer and Basiouni, 2005; Hassan et al., 2012).

Fenugreek is a good source of protein in animal nutrition. It is also defined as a high quality feed because it does not cause swelling in ruminant animals and contains substances that promote animal growth such as diosgenin (Mir et al., 1998; Baldemir and İlgün, 2015).

In studies with fenugreek plant; plant height 64.60-121.23 cm (Özel et al., 2008; Mamatha et al., 2017; Özyazıcı, 2020; Güzel and Özyazıcı, 2021), dry matter rate 91.53% (Özçelik and Şahin, 2018), crude protein (CP) ratio 10.4-25.8 %, crude oil 1.60-6.53%, crude ash 3.26%, crude fiber 6.28-28.07%, acid detergent fiber (ADF) ratio 32.80-34.30%, neutral detergent fiber (NDF) ratio 35.15-36.53% (Kochhar et al., 2006; Özçelik and Şahin, 2018). In a study examining the plant height and forage yield of fenugreek in different form stages; mean plant height values before flowering (May), after flowering (June) and harvest time (July) were 30.1, 36.1 and 40.1 cm, respectively; Forage yields have been reported as 724.1, 883.2 and 472.8 kg/da (Özçelik and Şahin, 2018). It has been determined in the studies that the seed yield of fenugreek is between 91-245 kg/da (Sharma and Bhati, 1987; Deo and Kothari, 2002; Güzel and Özyazıcı, 2021).

In order to evaluate the fenugreek plant as a silage, a study was conducted with different grasses (rye and oats) as a mixture at different rates. In the study, the best results were obtained from a mixture of 25% oat + 75% fenugreek. Dry matter, pH, CP, ADF, NDF and relative feed value of silages varied between 15.67-34.33%, 5.06-5.79%, 6.01-18.17%, 32.03-48.90%, 40.07-74.53% and 63.41-148.48%, respectively (Özyazıcı et al., 2022).

Fenugreek is used in different rotation systems to improve soil properties and as a green manure plant (Gökçe and Efe, 2016). At the same time, it can be used as an intermediate product and because it is a legume plant, it can increase the production of the next grain crop (Layek et al., 2018; Bitarafan et al., 2019; Toukabri et al., 2021) and can also be used in weed control (Abbes et al., 2019).

Medicinal-Aromatic and Other Usage Areas

Fenugreek has been used in various traditional medicines for thousands of years. The use of fenugreek in traditional medicine; Mentioned in Islamic scripture, Ayurveda, Iranian traditional medicine system, Latin, Arabic, Chinese and Korean pharmacopoeias (Bahmani et al., 2016). In traditional medicine, fenugreek is used as an infusion, water and alcohol extracts, etc. for different purposes. It is used for the preparation of skin problems, especially as an antidepressant, for the treatment of gastrointestinal disorders and eye diseases (Wannes and Tounsi, 2020). The seeds and leaves of the fenugreek plant are rich in flavonoids, saponins and alkaloids (Singh et al.,, 2020). Flavonoids are natural compounds found in many vegetables, fruits, and beverages and are known for their antioxidant, anti-cancer, antibacterial, hepatoprotective, and other health-promoting properties (Akimoto et al., 2017). Elements and metabolites contained in fenugreek have many medicinal properties such as irritant, digestive, antipyretic, cholesterol and blood sugar lowering, hypotensive, antioxidant, antiviral, galactagogue, laxative, antimicrobial and tumor treatment (Hornok, 1992; Abdelgani et al., 1998; Haber and Keonavong, 2013; Yadav and Baquer, 2014; Goyal et al., 2016; Zameer et al., 2017; Nateqi and Mirghazanfari, 2018; Varghese et al., 2019). The bitterness of fenugreek seeds is due to the presence of oil, steroidal saponins and alkaloids. It also contains trace elements such as Ca, Cu, Fe, Zn, K, Mg, P, Na and Mn, vitamins (A, B1, C), sitosterol, n-alkanes, sesquiterpenes and cholesterol (Zandi et al., 2017). In addition, they contain large amounts of carbohydrates (mucilage fiber, galactomannan) and free amino acids (4-hydroxy isoleucine, arginine, lysine and histidine) (Snehlata and Payal, 2012).

Fenugreek, which is a multi-purpose product; industry, beverage, cosmetics, spices, flavoring different syrups, condiment, nutraceutical, pharmaceutical and functional food industries used in the production of steroids and other hormones (Semalty et al., 2009; Snehlata and Payal, 2012; Razavi et al., 2021; Belkadi et al., 2022). It is also used to produce edible products, pesticides and perfumes in different countries (Hilles and Mahmood, 2021). In addition, fenugreek seeds and leaves are used in dishes in the Indian subcontinent (Beyzi and Gunes 2021), especially fresh leaves and stems to make "methi ka saag", India's most famous winter food (Wani and Kumar, 2018). In Africa, it is widely used in bread making and its green leaves are used to make curry powder or paste (Liu et al., 2012).

Fenugreek, with its sharp aromatic properties (Perry, 1980), is widely used in the production of pastrami (dried meat, canned meat) and breakfast sauces in Türkiye (Altuntaş et al., 2005). It is the main component of the mixture coated on the pastrami and protects the pastrami from the effects of external microorganisms (Akgül,1993; Küçük and Gürbüz, 1999; Develi Işıklı and Karababa, 2005). Fenugreek seed flour, which is one of the additives in the composition of fenugreek, has an adhesive property and also gives flavor and aroma to the pastrami by acting as a cover (Kök, 2003).

Fenugreek is not just an all-purpose medicinal herb by extraction of phenolic compounds for use in the pharmacological field (Xalxo and Keshavkant, 2020). It has also been the subject of research in phytoremediation (Zayneb et al., 2015; Kaur, 2016).

CONCLUSION

Fenugreek, which has an important potential as a medicinal and aromatic plant; It is used extensively in many sectors such as spice, traditional and today's medicine, beverage, industry, pastrami and fragrance. In addition to all these areas of use, it also takes its place as an alternative forage plant.

Fenugreek is an annual, cool season legume plant resistant to winter frosts, drought and high temperatures; It can be used as a forage plant and fodder with its features such as high protein content of its grass and seeds, being a legume plant and being able to fix nitrogen in the soil, increasing the appetite of ruminant animals, not causing swelling in animals, improving soil properties in crop rotation systems, being used as silage and being used as a green manure plant. stands out. Fenugreek, with its many features as a forage plant, should be included more in the production pattern of forage crops in field agriculture and it should be used in the nutrition of ruminant animals from both herbage and seeds.

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CHAPTER XIV

BERSEEM (*Trifolium alexandrinum* L.)

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INTRODUCTION

Clovers are important forage crops in the legume family and are grown in the temperate climate zone (Williams et al., 2019). There are 242 species in the genus *Trifolium*, 16 of which are economically grown and all are cultivated as forage crop (Zohary and Heller, 1984). Berseem (*Trifolium alexandrinum* L.), which is among the clovers, was brought to India from Egypt in 1904 and cultivated and dispersed to other parts of the world from here (Das Gupta, 1943; Akram et al., 2022). Berseem is an important winter legume fodder plant cultivated in Egypt, India, Pakistan, Australia, Afghanistan, Southern Europe, the USA (California), Turkey, and South Africa (Knight, 1985; Hazra, 1995; Roy et al., 2005; Akram et al., 2022; Mahesha et al., 2022).

Berseem is grown intensively especially in Egypt, India, and Pakistan due to its high nutritional properties. Compared to other forage crops grown in these countries; It is called the “king of forage crops” due to its green, succulent leaves and stems and for its rapid regeneration power. Berseem is an important food source in the nutrition of ruminant animals, with a long season of green fodder harvest from November to May with multiple cuttings (2-8 times) (Jabbar et al., 2022; Mahesha et al., 2022; Yadav et al., 2022). In addition to these features, it also stands out with its milk-increasing aspect in dairy cattle (Pathak et al., 2015; Praveen et al., 2022).

Since it is directly related to the consumption of quality feed by animals to obtain healthy animal products (Balabanlı and Bıçakçı, 2015; Bıçakçı and Açıkbaş, 2018), berseem is an important plant in terms of its nutritional values and not having a negative effect on the health of animals. It is also a popular feed due to its rich mineral content, high digestibility, not causing bloating in ruminant animals, taste, high protein content, and potential to increase soil fertility (Laghari et al., 2000; Kaushal et al., 2003; Hackney et al., 2007; Daneshnia et al., 2016; Garg et al., 2016; Roy et al., 2019; Khanduri et al., 2021). In addition, it improves the soil structure and prepares the soil for the upcoming seasons due to its strong nitrogen fixation ability (Akram et al., 2022). Berseem stands out with its good adaptability, ability to fix nitrogen to the soil up to 200 kg N/ha per year (Giambalvo et al., 2011).

HERBAL PROPERTIES

Berseem has a thick taproot with roots that can go down to 75-100 cm. It has slightly hairy, upright growing, hollow, and branching stems. Its leaves consist of 3 leaflets, yellowish-green in color and slightly hairy, and are similar to common clover leaves. It has a soft stem and abundant leaves. The auricles of the plant are generally grayish-white in color and are quite large (2-3 cm). Tubular-lanceolate auricles have smooth margins and green veins on the surface. In the first forms, there is a flower structure that can be necked up to 30-120 cm, the flowers are yellow-white and 40-100 flowers form the inflorescence. Berseem berries are egg-shaped and matte, and wrinkled fruits are yellowish-brown. Seeds are contained in pods and as a single seed. The colors of the seeds vary between white, violet, and purple. The 1000-grain weight of the seeds varies from around 3.5 g in uniform and 2.8 g in polymorphous (Soya, 2009; Açıkgöz, 2021).

CLIMATE AND SOIL REQUIREMENTS

Berseem, as an annual species, requires an optimum temperature of 18-25 ^{o}C for successful growth and development, and its growth is adversely affected when the temperature drops to 6-8 ^{o}C (Nand et al., 2018). Although it does not seem to pose any problem in terms of plant development when the air temperatures rise to 35 °C in India and Pakistan, which are the most cultivated places, the development of the plants is reported to slow down. In addition, it is highly tolerant to light salinity, short-term ponding, and shade (Açıkgöz, 2021).

Although berseem has thin lateral roots, it forms a strong root system in clay-loam soils and has a large number of tubers in its roots. It can grow well in all soils except light sandy soils and provides good growth in areas with annual precipitation above 400 mm or with sufficient irrigation conditions. On the other hand, it is reported to have a very low yield in areas with precipitation below 300-400 mm (Soya, 2009; Açıkgöz, 2021; Praveen et al., 2022).

The mineral content of the soils in which berseem is grown also has an important effect on the maximum yield. According to the reports, phosphorus fertilizers have an important on root and nodule development in legume plants. In addition, the presence of macronutrients such as potassium at the desired level can have a positive effect on plant growth, thus providing more stable feed production (Özyazıcı et al., 2021).

CULTURAL TREATMENTS IN BERSEEM CULTIVATION

Some of the factors contributing to the successful cultivation of the plant and seed reproduction are sowing time, sowing method, appropriate seed rate, fertilization, first and last cutting date, the status of pollinators, and disease and pest management.

Accurate and timely implementation of cultural practices in forage crop production is also of great importance. In this sense, planting time is one of the most important factors affecting the yield and quality of the forage obtained (Özyazıcı et al., 2019). Winter-grown berseem is grown in the September-November period in Turkey conditions (Açıkgöz, 2021), and in places where intensive cultivation is made such as Pakistan and India, mid-October (2nd and 3rd weeks of sowing) sowing (Jabbar et al., 2022; Praveen et al., 2022) is the most suitable planting time. The optimum temperature range for sowing is 20-25 ^{o}C, which has an important role in ensuring a good output (Praveen et al., 2022).

In terms of sowing norm and frequency, 2-2.5 kg/da seed is sufficient for a properly prepared seedbed of berseem (Açıkgöz, 2021). Although the nutrient content of hay in forage crops can vary significantly according to the row spacing (Alatürk et al., 2021), it is recommended to plant in 15-25 cm row spacing for forage production (Açıkgöz, 2021). The 40-60 cm row spacing for seed production is important in obtaining the most appropriate seed yield (Açıkgöz, 2021). In addition, row spacing in sowing varies according to grass or seed production.

The feed efficiency, which is increased by applying chemical fertilizers, can be sufficient for crop growth even in small amounts due to the high nutrient content of the fertilizers (Nand et al., 2018). Berseem needs sufficient free-form phosphorus for better nodulation (Akram et al., 2022). In general, legumes need more potassium and phosphorus than grains, as they can meet the nitrogen requirement for plant growth due to biological nitrogen-fixing bacteria (Ayub et al., 2012). Phosphorus and potassium fertilization directly contribute to the quality and quantity of forage and seeds (Beena et al., 2011; Akram et al., 2022). Paying attention to the application of the fertilizer types and amounts recommended in the soil analysis of the nutrients that are deficient in the first planting year (Özyazıcı and Açıkbaş, 2021) is one of the important factors for good plant growth and high yield in berseem.

Feeds with different quality ranges are obtained according to the forming stage of the forage plants. In this sense, the development period of the plant/harvest time is among the most important parameters affecting the feed quality (Özyazıcı and Açıkbaş, 2019; Açıkbaş, 2022). The most suitable cutting period for berseem is the flowering period. (Açıkgöz, 2021).

IMPORTANCE AND USAGE AREAS OF THE BERSEEM

Berseem can be used as forage and hay, silage, green manure plant, phytoremediation plant, weed control, and pasture plant due to its features such as taste and nutritional values, providing green fodder for a long time, not causing bloating in animals, and being able to be harvested more than once.

It is reported that berseem has a forage yield of 70-80 t/ha (Muhammad et al., 2014; Praveen et al., 2022), crude protein (CP) rate of 15.8-26.7 % (Muhammad et al., 2014; Yadav et al., 2015; Devi and Satpal, 2019; Praveen et al., 2022; Yadav et al., 2022), crude fiber ratio of 14.9-28.3% (Devi and Satpal, 2019; Yadav et al., 2022), total digestible nutrients (TDN) between % 60-70 (Muhammad et al., 2014; Gondal et al., 2021; Yadav et al., 2022), acid detergent fiber (ADF) ratio of 35-38% (Praveen et al., 2022), and neutral detergent fiber (NDF) ratio of 42-49% (Praveen et al., 2022). In addition to these studies, it has been stated that the calcium (Ca) content varies between 1.40-2.58%, the phosphorus content between 0.1-3.0% (Frame, 2005; Devi and Satpal, 2019), the nitrogen content varies between 2.52-4.25% and meets a significant part of the needs in the nutrition of animals (Devi and Satpal, 2019).

In a study in which 5 varieties (Carmel, Lito, Castalia, Pinias, and Meteor) of berseem were evaluated in Ankara, Turkey, yield variation was examined according to the order of the forms. According to the results, as the average of the forms and years, the natural plant height was between 58.57, 39.31, and 33.15, forage yield was 1695.93, 791.75, and 183.31 kg/da, hay yield was 406.83, 189.97 and 43.99 kg/da, CP ratio was 19.16%, 18.68%, and 18.87%, and CP yield was reported as 78.05, 35.89 and 9.20 kg/da (Hakyemez and Sancak, 2005). In another study conducted with 10 varieties of berseem at Ayub Agricultural Research Institute in Faisalabad, Pakistan; plant height was 58.40-64.07 cm, the number of siblings was 102-150, the number of leaves per brother was 9.80-12.60 and forage yield was between 78.22-91.78 t/ha (Naeem et al., 2006). Akram et al. (2022), evaluated the effects of phosphorus (P) (40, 60, and 80 kg/ha) and potassium (K) (0, 15, 30, and 45 kg/ha) doses on the development of berseem. Accordingly, the highest values were found where P and K were used together. In 60-30 kg/ha application; plant height was 76 cm, the number of seeds per capsule was 46, 1000-seed weight was 1.77 g, forage yield was 82 t/ha and seed yield was 617 kg/ha.

Due to the high water content in the fleshy stems, berseem is not ideal for feeding as hay. Berseem straw alone is not suitable for silage due to leaf fall from dry plants. However, ensiling may be considered when used with berseem grains (Praveen et al., 2022). In the evaluation of berseem as silage, Shaug et al. (2000) state that high-quality silage can be obtained when mixed with 20% ground corn. In addition, it is possible to make silage with berseem with 5% molasses (Gaafar et al., 2011). When the grazing performance of the berseem was evaluated, it was reported that the plant was damaged, and therefore did not perform well under grazing, since the animals grazing on the pasture especially preferred the top-growing buds first. When grazing on irrigated pastures is intended, it should start before the plants become too steep and berseem in the grazing area should be grazed to a height of 5-6 cm, with a rest period of approximately 30-40 days between grazing periods (Hackney et al., 2007).

Heavy metals are one of the main pollutants that affect plants and animals around the world. Food and forage crops grown in metal-contaminated soils can pose a serious risk to human and animal health and lead to the accumulation of large amounts of heavy metals (Rattan et al., 2005; Kulhari et al., 2013; Ahmadi et al., 2019; Rahimi et al., 2019; Erman et al., 2022). In this context, one of the positive features of the berseem plant is the use for phytoremediation of heavy metals, namely cadmium (Cd), lead (Pb), Copper (Cu), and zinc (Zn), due to its multi-sectional structure, short lifespan and high biomass production (Ali et al., 2012). It was determined that the chromium (Cr), Cu, Cd, and cobalt (Co) elements were above the limit value (1) in the samples collected from the Alexandria clover grown in an area with intensive agriculture practiced in India. It has been concluded that berseem is not safe for animal consumption in such contaminated areas (Bhatti et al., 2016).

Berseem can be planted as a mixture with wheatgrass, and also helps to prevent weed growth, especially when planted in a mixture with oats or ryegrass. Grains continue to grow again after they are harvested and take shape (Clark, 2008). It has also been reported to aid weed control in rice-wheat crop rotation through continuous cuttings (Dass et al., 2016).

Since Berseem is an N-fixing legume plant in the soil, it may require rhizobium inoculation outside its native area (Hackney et al., 2007), especially as a winter plant, it helps to prevent erosion by covering the soil as a ground cover. Berseem can also be used as green manure and it can be planted together with corn, soybean, and oat. It was reported that berseem increased the corn yield in rotation by 10% and fixed 43 kg N/ha to the soil (Ghaffarzadeh, 1997).

CONCLUSION

The sustainable agriculture system is at risk due to increasing ecological deterioration such as global warming, drought, and salinity. In particular, it should be emphasized that leguminous plants such as Berseem, which have biological nitrogen fixation capacity, are used more and have an important place in the nutrition of ruminant animals, as well as in the improvement and preservation of soils. Berseem; it stands out in forage crops with its high biomass production, high protein content, multi-forming possibilities and long-term supply of green fodder. In countries with suitable ecological conditions, fodder crops should be added to the production pattern and should play an important role in feeding the animals with quality roughage by making more cultivation place in the places where they are produced.

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CHAPTER XV

SAINFOIN (*Onobrychis sativa*.)

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INTRODUCTION

Sainfoin is a native plant of the temperate climate areas of Central and Southern Europe and Asia. It has been produced as a meadow, pasture and fodder crop for years in Mediterranean countries, Central Europe and England (Tosun, 1971). Sainfoin was imported to North America in the 1900s, and different varieties were developed with subsequent breeding studies, and then spread to the western states of America and Canada and started to be produced there (Tosun, 1971; Richards and Edwards, 1988; Welsh et al., 2003).

Sainfoin is a plant that can grow in chalky, arid and arid regions. For this reason, it has a very important place in the planning of crop rotation in many climatic and soil conditions where water is a problem. However, the ratio of nitrogen-free core materials, crude oil and crude protein of sainfoin is quite high, and the ratio of lignin, which adversely affects digestion, is quite low (Serin and Tan 2001). For this reason, the swelling problem seen in alfalfa is absent in sainfoin. Because the sainfoin begins to develop early in the spring, it provides forage for animals before other pasture crops reach grazing maturity (Stevens and Monsen 2004).

Sainfoin can grow very well in different ecological conditions of Turkey, especially in arid and watery conditions. Sainfoin is also used as a forage plant, pasture plant and bee pasture plant in Turkey (Elçi et al., 1987). It is cultivated especially in the Eastern Anatolian Regions of Turkey. Elçi et al., (1987) reported that the sainfoin alone has the power and potential to meet the needs of meadow, pasture and fodder in our country.

Although sainfoin is one of the important soil improvement plants, it is an important forage plant and a good bee plant. As in many countries, it is known as a forage plant, not as a bee plant in Turkey. Although it is generally desired to be produced as a forage plant by sainfoin growers, it is also of great importance as a honey plant or bee plant (Dubbs, 1968).

In the production of sainfoin seeds, honey bees and wasps play an important role in pollinating the sainfoin. It is necessary to focus on this issue for the development of sainfoin seeds (Özbek and Hayat, 2003).

1. DESCRIPTION AND MORPHOLOGY OF SAINFOIN PLANT

The first studies on the genus *Onobrychis* started with Linnaus in 1753. In 1754, Miller collected *Onobrychis* species, which Linnaus gave in *Hedysarum* genus, under *Onobrychis* genus and named this genus for the first time (Aktoklu, 1995; Büyükaşık, 2002). In 1872, Boissier gave the first extensive information about the genus *Onobrychis* in his work called "Flora Orientalis". Handel-Mazzetti (1909, 1910) made the first detailed study of the breed after Boissier. Handel-Mazzetti made the first type of identification key.

Afterwards, Sirjaev focused on diognastic characters and the distribution of species in his work "*Onobrychis* Generis Revisio Critica" and gave only brief descriptions of endemic and newly described species (Aktoklu 1995, Büyükaşık 2002). Grossheim conducted studies on the species belonging to the *Onobrychi*s and *Hymenobrychis* sections in the Caucasus in 1926 and 1929 and defined new species in Turkey. Later, 7 new species were published from Turkey by Huber-Morath (1982), Kit-Tan and Songer (1986), Duman and Vural (1990) (Aktoklu 1995, Büyükaşık 2002). The most comprehensive revision study of these studies in Turkey was done by Aktoklu (1995).

In this study, it was reported that there are 52 sainfoin species (60 taxa) in Turkey. Subgenus Taxa and Diagnostic Keys According to Davis (1970-88), subgenus taxa and diagnostic keys are as follows;

The genus is represented by two sub-genus in Turkey.

1. Subgenus *Onobrychis*; flowers are usually pink, rarely cream or white; fruit almost sessile.

subgenus *Onobrychi*s;

Section 1. Dendobrychis; plant perennial, semi-bush, spiny, fins longer than calyx; ovary with 1 ovule.

Section 2. Lophobrychis; herbaceous annuals, fins approximately as long as calyx; ovary with 1-2 (-3) ovules.

Section 3. *Onobrychis*; herbaceous perennials, fins usually long, sometimes short, from the calyx. Ovary with 1 ovule. The fruit has no distinct stem or junction.

2. Sisyrosema subgenus; flowers are yellow, rarely cream or white; fruit with prominent stem.

Sisyrosema subgenus;

Section 4. *Heliobrychis*; perennial, rarely annual herbaceous. Fins usually equal to calyx, sometimes long; ovary with 1(-2) ovules; fruit stalked, curved junction, up to 4 mm cetose spines.

Section 5. *Hymenobrychis*; herbaceous perennials, fins equal to calyx or short; ovary usually with 2(-1) ovules; The fruit-stem junction is curved, wide and flat-edged, the margin varies from two rows of toothed to full-edged.

According to his revision study in Aktoklu (1995), there are 52 species and 60 taxa under the 5 sections mentioned in Turkey. According to Aktoklu

(1995), the sainfoin genus is defined as follows. Annual or perennial herbs, rarely thorny shrubs. Stem usually lignified at the base or with thick underground stems, usually curved and with distinct light green stripes, simple hairy or glabrous. Auricles free or fused, usually membranous and marginally ciliated. The leaflets of the leaves are solitary, usually the base with a long petiole, the upper with a short petiole or rarely sessile, the leaflets entire-edged, rounded to lanceolate-oblong, apex ending with a hard tip or a small hard tip. Inflorescence axial, panicle. Bracts membranous, persistent, bracteoles 2, membranous, filamentous, usually on sepal tube, rarely on peduncle. Calyx leaf bell-shaped, lower part of tube bulging outward, teeth unequal, usually lanceolate-suddenly narrowed or lanceolate abruptly narrowed. Petal pink, lilac, yellow, cream or white, often with dark purple veins; flagella circular, inverted ovate, elliptical or oblong-elliptic, sometimes dorsal, with soft bristly hairs; fins usually shorter than sepals, rarely long, auricular, petiolate; keel short or equal to the flagella, rarely longer. Male organs diadelph. Ovary with 1-2(-3) ovules, sessile, sometimes very short petiolate, at least at the tip with soft bristly hairs, rarely glabrous. Fruit with 1(-2) seeds, does not open when dry, usually slightly circular, soft bristly hairy or glabrous, rarely thin long soft hairy, densely fluffy or woolly, consists of 2 rows of comb-like surface disc in the middle and margins of varying width, disc and margin smooth They range from spiny or hook-shaped with 5 teeth to scaly or full-edged. Seeds 1(-2) pieces, kidney or oblong.

Characteristics are the first criteria to be considered in the identification of species. These morphological characters have some advantages and disadvantages (Parmaksız, 2004).

Advantages of morphological characters;

-They are usually dominant. It is used to distinguish a dominant gene from a recessive gene.

- They are very few in number. There are several in each cross.
- Each locus has 2 alleles.
- Analysis is very easy.
- They are easily determined by an observation in the mapping population.

Disadvantages of morphological characters;

- They cannot identify heterozygotes.
- It may have been caused by mutations.
- They are affected by environmental factors.

- They are subject to epistatic or pleiotropic effects.

There are very few studies to reveal the morphological structures and agricultural characteristics of sainfoin species in the world. Studies in the world and in Turkey have generally been conducted to examine the morphological characteristics of sainfoin species with agricultural importance.

2. CLASSIFICATION AND TAXONOMY OF SAINFOIN

The homeland of the sainfoin is Asia and Europe. Around 160 species of sainfoin are known in the world. Wild sainfoins are spread over a wide area from the Baltic Sea to the Mediterranean, Asia Minor and Siberia. It has been concentrated and diversified especially in the Anatolian-Iran-Caucasus triangle. Of these regions, 32 (60.4%) of 53 species in Iran, 27 (51.9%) of 52 species in Turkey and 21 (53.4%) of 39 species in the Caucasus are endemic (Avcı, 2010). In line with these data, it is revealed that Turkey is one of the important development centers for this breed (Aktoklu 1995).

Although 160 species of sainfoin (*Onobrychis*) are known in the world, only 3 species of sainfoin are agriculturally important. These species are;

1. Common Sainfoin (*Onobrychis sativa* Lam. Syn.: *O.viciifolia* Scop.)
2. Anatolian Sainfoin (*Onobrychis arenaria* Kit. Ex. Wild. D.C.)
3. Caucasian Sainfoin (*Onobrychis trans*caucasica Gross H.).

The most important sainfoin species in our country are; *Onobrychis arenaria*, *Onobrychis hypargyrea*, *Onobrychis teurneforti*, *Onobrychis montana*, *Onobrychis cornuta* and *Onobrychis cana*. The most common and cultivated is *Onobrychis sativa* (culture sainfoin). These species are;

1. *Onobrychis montana* **(**Mountain S.)

2. *Onobrychis hypargyrea* (Donkey S.)

3. *Onobrychis cana* (Anatolia S.)

4. *Onobrychi***s** *oxyodonto* (Threaded S.)

5. *Onobrychis teurneforti* (Hairy S.)

6. *Onobrychis argyrea* (Lunar S.)

7. *Onobrychis cornuta* (Horned S.)

8.*Onobrychis* venosa (Cyprus S.)

3. PLANT PROPERTIES OF SAINFOIN

The sainfoin can develop upright, horizontally or semi-upright. The body is 30-60 cm high, the upper parts are hollow at the base. The face of the body is striated, slightly hairy and round in cross section. The trunk branches from the crown with numerous stems. Under normal conditions, 10-30, sometimes up to 60 stems can come out of a crown. The trunk develops in the form of rosettes in the early spring and autumn periods. Plants whose stems grow upright grow up to 140 cm in watery conditions and lie in places.

Plant properties of sainfoin

The sainfoin can develop upright, horizontally or semi-upright. The body is 30-60 cm high, the upper parts are hollow at the base. The face of the body is striated, slightly hairy and round in cross section. The trunk branches from the crown with numerous stems. Under normal conditions, 10-30, sometimes up to 60 stems can come out of a crown. The trunk develops in the

form of rosettes in the early spring and autumn periods. Plants whose stems grow upright grow up to 140 cm in watery conditions and lie in places.

Plants that grow upright in arid conditions can grow up to 100-120 cm. The hollow upper parts of the base of the sainfoin body are filled (Açıkgöz 2001).

Sainfoin leaf; It consists of 5-14 pairs of oval-shaped (egg-shaped) leaflets arranged opposite each other on a leaf axis and 1 leaflet at the end of this axis. The number of compound leaves is odd. Leaf length varies between 10-25 cm. Leaflets are smooth, 2-3 cm long and 0.5-1 cm wide. The upper part of the leaflets is bare or slightly hairy, and the lower part is hairy. The auricles formed at the junction of the leaf with the stem are triangular and membranous. Auricles are greenish red in the young plant period and brown in the ripening period (Welsh et al 2003).

The sainfoin flowers are conical at the end of the long stem of the plant, fragrant, and pinkish red in the form of frequent clusters. Bee visitation is absolutely necessary for pollination in the sainfoin. The stigma (stigma) and male organs (anther) in the boat come out with the weight of the bee that has been placed on the flower, and they regain their original form when the bee leaves. The fact that the stigma is longer than the male organs makes self-pollination almost impossible and makes cross-pollination obligatory. On the other hand, the 2–3 mm depth of the calyx tube makes it easier for many bee species to collect pollen and nectar from sainfoin flowers. The flowers open during the day, especially in the morning, and flowering in the cluster occurs from the bottom up. The flowering period lasts about 2-3 weeks. Flowering starts from the base of the panicle and takes 2-3 weeks to open up to the top, a flower that has opened can maintain its normal state for a day. Bogoyavlenskii (1955) states that up to 50% of the flowers in a cluster can set seeds. It was determined years ago that the sainfoin is self-infertile, that seed setting in flowers depends on crosspollination, and that pollination is carried out by bees (Knuth, 1906–1909).

From each flower comes a fruit containing a seed. Foreign fertilization occurs to a large extent in the sainfoin. Self-fertilization rate is between 0-37%. The sainfoin, which has abundant nectar in its flowers, is frequently visited by pollinator insects such as honey bees, as it has an attractive feature. Sainfoin honey is among the highest quality honeys (Ebeling et al., 2008).

The fruit of the sainfoin is a small semicircular pod with only one seed inside and toothed in the shape of a cock's comb. The top of the fruit has clear veins in the form of a net. The fruit is 5-8 mm long and 4-6 mm wide. Among the wild sainfoin species, it is also possible to come across those with 2 seeds in a fruit. The seeds are kidney-shaped and the surface is smooth. Their color can be dark green olive, brown and close to black. Its pod-shaped fruits are single-seeded. It has a strong tap root.

4. IMPORTANCE AND USAGE AREAS OF SAINFOIN

One of the most suitable forage crops to be grown in arid and calcareous marginal areas is sainfoin. It is possible to grow it even in infertile construction excavation soil. Because of its similar grass quality, sainfoin is often compared to alfalfa in forage crops sources. It is more productive than alfalfa in unirrigated or barren areas. It is one of the leading perennial legumes forage crops to be taken for crop rotation in dry agricultural areas. Even in the most suitable soil, the sainfoin can give a maximum of 2-3 forms. Although its yield increases significantly in irrigated rich soils, it is much less productive than alfalfa under the same conditions (Baldridge and Lohmiller 1990). When grown in irrigated conditions, excessive tillering and grading occur in plants, and because the trunk is hollow, it lies to a large extent. Pests that cause significant losses to the above-ground parts, such as the trefoil proboscis (*Hyperapostkci*) seen on clover, are also absent in the sainfoin. Sainfoin seeds can also be used as compound feed when necessary. Since its seeds contain 36-38% protein, it can be used directly as animal feed. Sainfoin is richer than alfalfa in terms of mineral matter, crude oil and crude protein ratio, while it is relatively behind in terms of crude fiber and ash. Lignin, which negatively affects digestion, is less in sainfoin than in alfalfa (Stevens and Monsen 2004). Sainfoin is among the plants with good salinity tolerance.

Usage Areas

-Use alone and in the production of fodder mixed with grasses:

Sainfoin; It is usually grown alone for hay production in barren conditions. Approximately 250-350 kg of dry grass is taken from the sainfoin under arid conditions, and 600-900 kg of dry grass is taken under wet conditions. The sainfoin can also be grown mixed with a grassy plant such as weed or awnless bromine.

In places where the sainfoin has a long development period, the seed can be taken first and then left to the growing grass.

-Using in the renewal of pastures:

Provided that it is not heavy and continuous, it is the first plant that comes to mind in the pasture facility. Because Sainfoin;

It grows in arid conditions, its grass is delicious, it does not swell, it develops early in the spring. For these reasons, Sainfoin is a good pasture plant. It is possible to see the sainfoin in many high altitude natural pastures in our country. Due to its nutritional value and resistance to arid conditions, sainfoin is mostly preferred as a source of legumes in artificial pasture facilities (Rochon et al., 2004). Sainfoin does not swell. With this feature, animals can be grazed directly on artificial and natural pastures. Especially sheep prefer sainfoin grazing to other forage plants. Sainfoin fodder has healing properties against stomach nematodes that harm lambs.

-Using in soil improvement:

It grows easily in sainfoin, poor, stony and calcareous lands and aerates and processes the soil with its deep roots. It helps soil formation by breaking down rocks due to its strong root system.

Sainfoin increases the organic matter of the soil (Porqueddu et al. 2000). Since sainfoin is also a legume plant, it adds nitrogen to the soil. Sainfoin is a more important plant than clover in soil improvement. Because; The sainfoin leaves 1800 kg/da and clover 470 kg/da root parts. The amount of nitrogen that it leaves to the soil with its roots and symbiotic way is 46.5 kg/da.

-Using in erosion control:

It is an ideal plant for erosion control in sloping areas. It is possible to control water and wind erosion in barren areas, especially by planting sainfoin plants that grow horizontally (Xu et al. 2006).

-Use in honey production:

Sainfoin is a good nectar plant. It contains plenty of nectar and is rich in sucrose, glucose and fructose. The flowers of the sainfoin are strikingly colored and large.

Inflorescences form at the top, bees can easily reach. As in clover, there is no throwing phenomenon in its flowers. Sainfoin is a good source of honey extract. Honey bees generally prefer sainfoin plots over clover and sainfoin plots planted side by side (Avcıoğlu, 1977). The honey of bees that prefer sainfoin as a source of honey extract is fertile and has a distinctive pleasant flavoring.

-Using in crop rotation systems:

Sainfoin is a very preferred plant in crop rotation systems because it can add nitrogen to the soil, can grow in arid conditions, correct the physical properties of the soil with its roots, its roots have a high cation exchange capacity, and it is a very suitable pre-plant in arid and poor areas.

5. CULTIVATION OF SAINFOIN

Climate and Soil Requirements:

The temperate climate zone and moderately humid regions are the most suitable places for sainfoin cultivation (Frame, 2005). After completing the seedling period, it is resistant to cold. It has a very high drought resistance and can be grown without irrigation in 300 mm precipitation belt. In humid regions with high annual precipitation and frequently irrigated lands, its lifespan is short due to root and root collar diseases.

The sainfoin is not a very selective plant in terms of soil demand. It can easily grow in poor, barren and calcareous soils. It likes light, calcareous soils, makes good use of soils with plenty of lime and deep groundwater levels. It can even grow on stony-rocky lands, provided that there are cracks that allow its roots to function. Its resistance to salinity is good, but it does not like acidic and wet soils. Sainfoin was grown and the highest grass yield and leafiness were determined at neutral pH (6.9) (Sorkun, 1995). It has been determined that the tannin ratio in the grass increases, which adversely affects the nutritional value, especially when grown on acid soils (Cash and Ditterline 1996).

Cultivation of the Sainfoin:

Although sainfoin can be grown on irrigated lands, it is actually a plant of barren lands that cannot be irrigated. Weed yields increase in irrigated conditions, but it does not respond well to irrigation as it does not regrow well like alfalfa. Planting time of sainfoin depends on climatic conditions as in many legumes. It can be planted in autumn in temperate climates. The most reliable planting time in cold winter regions is spring, as it is damaged by severe cold during the seedling period. Spring planting should be done as early as possible. Since the germination of seeds can take place at different temperatures, it is not necessary to wait for the soil temperature to rise too much in sowing. Since the seedlings develop slowly, the plants should complete their root development until the summer droughts begin.

Care should be taken to ensure that the seed bed is well prepared when planting sainfoin. The seed bed should be straightened, pressed and their clods broken. Soils that are not well prepared and lumpy in barren lands lose their moisture in a short time and plantings fail. Since seedling development is slow, the seed bed should be free of weeds. Since the sainfoin seed is large, a very sensitive seeder is not needed and sowing can be done with a grain seeder. Planting depth in the sainfoin is around 2.5-5.0 cm depending on the soil type. The sainfoin can be planted alone or mixed with grasses. Grassroots weeds (*Agropyron cristatum* Gaertn L.), awnless bromine (*Bromus inermis* Leyss.) and bluegrass (*Agropyron intermedium* Hoşt Beauv.), which are suitable for cultivation in arid conditions, are suitable for mixing with sainfoin.

The seed used for sowing is actually the pod of the sainfoin. Since the fruit shell does not open when the sainfoin is mature, it is very difficult to separate the pod from the seed. Since there is one seed in each fruit, there is not much harm in planting with shells. Breading the sainfoin crust is safer. Because the seeds without shell germinate immediately with a little precipitation. If the precipitation does not continue, alatav problem arises. Most of the germinated seeds wither and die before they become seedlings. However, shelled seeds cannot germinate unless there is sufficient rainfall or moisture. If there is enough moisture in the soil to pass the fruit peel and germinate the seed, germination and development will continue even if the rainfall is stopped. Moreover, it is more practical to plant as fruit, since removing the fruit peel from the sainfoin requires an additional expense.

The amount of seeds to be sown per decare varies according to the purpose of the facility. Under ideal conditions, 2.5 kg of shelled seeds per decare is sufficient to have 10 plants per m2 in grass production (Gintzburger et al., 1990).

However, it is beneficial to keep the sowing rate higher considering the seed germination rate will not be 100% and the land losses will be considered. 8-10 kg/da of seed is sufficient for sowing with a seeder in a well-prepared seed bed. This amount can be increased to 10-12 kg in places where the seed bed is not well prepared and the land is stony and gravelly. The sainfoin is a barren plant. For this reason, it is generally recommended to keep the row spacing wide. In general, 25-50 cm row spacing is recommended (Altın and Tuna 1996).

Fertilizing the Sainfoin:

Although sainfoin can grow in poor soils, the nutrients needed must be given as fertilizer in order to get high yields. Nitrogen fertilizer should be given to the sainfoin, which is a legume plant, only in the first year, until the bacteria in its roots become active. Since sainfoin is usually grown in arid, it does not react much to high doses of fertilization.

3-4 kg N/da should be applied in October, good nodule formation should be achieved and nitrogen should not be given during the maintenance years. It is stated that 5-10 kg of phosphorus should be applied to the sainfoin according to the phosphorus situation in the soil and the precipitation regime of the region. It also responds well to K and Ca applications in soils where sainfoin nutrients are insufficient. The need for these elements is higher, especially in highly shaped sainfoin types (Jahns and Shipka, 2004).

Fodder Production in Sainfoin:

The shapes made in the sainfoin at different maturity stages affect the hay yield and the chemical structure of the grass. Crude protein and crude ash ratios decrease rapidly as maturation progresses, while the ratios of crude cellulose and nitrogen-free core materials generally increase. The maximum amount of dry matter, crude protein, crude ash, crude oil and digestible dry matter per decare is taken in the first flower stage. Therefore, the most suitable form time for grass is the beginning of flowering. Fodder yield is around 300-700 kg/da according to soil and climatic conditions. The highest grass production takes place in the year following planting and gradually decreases in the following years.

Seed Production in Sainfoin:

Sainfoin can be grown in both arid and irrigated conditions for seed production. The amount of seeds to be planted per decare should be around 8 -

10 kg. As in grass production, nitrogen fertilizer should be given in the seed production of sainfoin only in the first year and on a limited basis. Researchers mostly focused on phosphorus doses in sainfoin, which is a legume plant. In conditions where the vegetation period is suitable, sainfoin varieties that give more than one form can be used. In this way, it is possible to buy more than one product in a year. Usually in these cases a weed and a seed crop are taken. Like clover, clover and white clover, sainfoin is a foreign pollinating plant. Honey bees frequently visit sainfoin flowers. The reasons for this are; sainfoin flowers are formed on the upper parts of the plant, they are large and in striking colors, they are rich in honey essence and pollen, and there is no natural tripping mechanism. The fruit setting rate remains very low in flowers that are not visited by insects (Özbek, 1996).

Harvest time is very difficult to determine in sainfoin, since not all fruits ripen at the same time. First, the fruits at the bottom of the cluster ripen, and this ripening continues over time to the upper parts of the cluster. When the fruits in the upper part of the cluster ripen, the lower ones begin to fall. Therefore, the best harvest time for seed in the sainfoin is when the fruits on the underside of the cluster turn dark brown. Average seed yield in sainfoin is 70-80 kg/da.

Combating Weeds, Diseases and Pests in Sainfoin:

Weed Control in Sainfoin:

In order for the plant to be successful in the sainfoin, it is necessary to fight weeds in the seedling stage. In plants where row planting is done, this struggle is usually carried out mechanically, cleaning can be done in the first year without allowing one-year weeds to form seeds. Weed problem is not seen much in the 2nd and 3rd years of the plant, but due to the sparseness of the sainfoin in the following years, weeds increase again. The herbicides developed by the world chemical industry are still insufficient for sainfoin.

Disease Control in Sainfoin:

Some diseases that damage the sainfoin are as follows:

Sclerotinia trifoliorum (root, crown and stem rot),

Fusarium solani (root rot),

Verticillium alboatrum (pallor),

*Ramularia ono*brychidis (sainfoin leaf spot),

Septoria orobina (leaf spot),

Pleospora hebarium (round spot),

Aschochyta onobrychidis (stem and leaf spot).

Pest Control in Sainfoin:

The most important problem of sainfoin in Turkey in recent years is rootworms. The sainfoin, which has a lifespan of 5-6 years under normal conditions, is partially damaged at the end of the 2nd year in agricultural areas and completely towards the end of the 3rd year. The cause of this death is the larvae of the insects *Sphenoptera carceli* and *Bembesia scopigera*, which damage the developed sainfoin roots. It is not practical and economical to spray the soil under field conditions. At this stage; It is possible to change the sainfoin planting areas continuously with crop rotation and to remove and destroy the wilted plants seen in the fields in spring with their roots. Hopeful results could not be obtained in breeding studies against insect damage.

6. BREEDING OF SAGA PLANTS

For centuries, the sainfoin plant has adapted to various environmental conditions such as different temperatures, precipitation, drought, salinity, diseases and pests in the regions where it grows. Therefore, it is very rich in gene diversity (Hart, 2001). Today's breeding programs now focus on the importance of genetic diversity. These wild sainfoin species, which show a wide variety, are used in sainfoin breeding studies.

In addition to increasing the yield and quality, it is aimed to develop new varieties that are resistant to environmental pressures such as diseases, pests, drought and salinity, suitable for new agricultural techniques and new demands of the consumer. Increasing the level of genetic diversity is essential for the success of breeding programs.

The sainfoin, which is normally pollinated with foreign pollen, has 2n=28 chromosomes. The most important breeding goals are to increase yield and longevity. Bees play a major role in pollination and fertilization of sainfoin flowers. Since the flower color is attractive, sainfoin is a plant that attracts the attention of bees and visits a lot. For this reason, as foreign fertilization will increase, it is natural for new sainfoin types to be formed and genetic variation to increase.

7. CONCLUSION

Sainfoin is an important forage plant, It is more productive than clover and clover in barren soils, It is very resistant to winter and drought, Its grass has high nutritional value, It does not swell in animals, It is resistant to pests such as clover beetle, It grows in calcareous soils with its deep roots, it absorbs nutrients easily, Very good it is a nectar plant. Many studies on sainfoin show that the plant has a great importance in meeting the nutritional needs of both animals and bees.

Since sainfoin is a native plant of our country, it is a very valuable bee plant, as well as being an important forage plant that has adapted to ecological conditions very well and can grow in wet and barren areas. Since it is a perennial plant, it directly and indirectly prevents soil erosion when planted on sloping lands.

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CHAPTER XVI

BEANS (*Vicia faba* L. *minor*)

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1. INTRODUCTION

Beans (*Vicia faba* L.), also known as broad bean, field bean and horse bean, are cool season grain legumes or 'pulses'. It belongs to the subfamily *Faboideae*, the tribe *Fabeae* (Cubero, 2011).

The plant is grown mainly as a staple food for humans and animal feed. It is grown alternately with cereals to add N to the soil and provide disease breaks, this is the most common use. As with other legumes, there is an interest in planting the legume with cereals to reduce N fertilizer application and help control diseases to which legume crops are prone. A very small portion is grown as a horticultural crop and harvested for fresh seeds or pods for human consumption. Non-nutritive factors limiting the value of faba grain for livestock feed are eliminated by cooking before human consumption. (Mínguez & Rubiales, 2021).

Broad bean (*Vicia faba* L.) is a cool climate legume that originated in the Middle East in prehistoric times and has traditionally been used as the main protein source for human and animal nutrition (Multari et al., 2015).

The genetic variability of the species is very high and is usually defined based on differences in seed weight, shape and size. Broad bean has four subspecies (Table 1):

1. large-seeded broad beans ***V. faba* sp. *faba* var. *major***, (broad beans) its very flat seeds weigh more than 1 g and are developed in the Southern Mediterranean regions and China;

2. *V. faba* sp. *faba* var. *equina* (horse beans, field beans) its flattened seeds have a medium seed size of 0.6–1 g and were developed in the Middle East and North Africa;

3. The ellipsoidal shaped seeds of **V. *faba* sp. *faba* var. *minor*** (tic beans) found in the Ethiopian highlands, Sudan and Northern Europe are between 0.3–0.6 g;

4. Growing in Central Asia, ***V. faba* sp. *paucijuga*** is a rare species, probably close to the wild hypothetical form (Duc et al., 2011; Muratova, 1931; Cubero & Nadal, 2004).

Size of broad bean grain is an important feature in determining the market and consumption pattern. Large-seeded varieties (pods) are commonly used for food as a fresh green vegetable or (hulled) dried seeds. Varieties with small to medium seeds are mostly used as animal feed (Crepon et al., 2010).

Table 1: Characterization of beans and pods of broad beans

Botanical Group	Seed Weight and Shape	Pod Characteristics
Major	SW≥1 g Very plate	Small to large (from 2 to 10 seeds)
Equina	0,6<SW<1 g Plate	Plate, thick, nondehiscent pods *Equina* 0,6<SW<1 g Plate Medium size, 3–5 seeds Plate
Minor	0,3<SW<0,6 g Cylindrical to rounded form	Small with 3–4 seeds, cylindrical form
Paucijuga	0,2<SW<0,3 g Rounded to elliptical form	Very small, dehiscent or nondehiscent types

Reference: Duc et al., 2011; Muratova, 1931; Cubero & Nadal, 2004; Fouad et al., 2013)

Although seed size is a constantly variable feature, it is important in terms of meeting market and farmer needs. Large-seeded varieties are commonly preferred for food use as a fresh green vegetable or dried in many cultures. Small-seeded varieties are preferred in the pigeon feed market and in high latitudes, such as the Scandinavian region and the Canadian province of Saskatchewan, as they dry out easily after harvest. The most common varieties, used mainly as animal feed in European cultures and as dried legumes in Western Asia and North Africa, have medium-sized seeds. Breeding progress for yield tends to be fastest in this medium class, perhaps due to the balance between high seedling strength from relatively large seeds and high reproduction rate from relatively small seeds (Duc et al., 2015).

2. ORIGIN AND DISTRIBUTION

Forage broad bean, also called animal broad bean, has been grown in France, Italy, England, all Mediterranean countries, Japan, Iran, USA, equator, Mexico and especially China as a very common forage plant in the world since the beginning of the 20th century (Anonim, 2008).

Archaeological findings at Tell El-Kerkh in northwestern Syria indicate that broad bean domestication began in the late 10th millennium BC (Tanno & Willcox, 2006). In addition, Caracuta et al. (2016) found that 14,000-year-old specimens discovered in the Mount Carmel region are the lost ancestor of the broad bean. It then followed different routes of human migration (Cubero & Nadal, 2004): (1) the European route crossed Anatolia, Greece, followed the Danube Valley to Central Europe and then the rest of the continent; (2) following the African Mediterranean coast westwards to the west of the

Mediterranean Sea (the Maghreb and the Iberian Peninsula); (3) extending south from lower Egypt and Mesopotamia, reaching Abyssinia. The broad bean in India may have come from Mesopotamia or Abyssinia via the Sabean route; and (4) finally crossing the Caucasus from the Near East to reach the Eurasian plains (Cubero, 1974). China was probably reached in the first millennium AD, as the local varieties of Chinese faba are only the main type. It was taken to America in the 16th century, and to South Africa and Australia in the 18th century (Mínguez & Rubiales, 2021).

The diversity center area includes Iraq, Iran, Georgia, Armenia, Azerbaijan, Syria and Turkey (Maxted, 1995). The medium type was found in both Portugal and Spain in the Iberian Peninsula and in Central Europe 5,000 years ago. Larger flattened types were not known 1500 years ego (Ladizinsky, 1998).

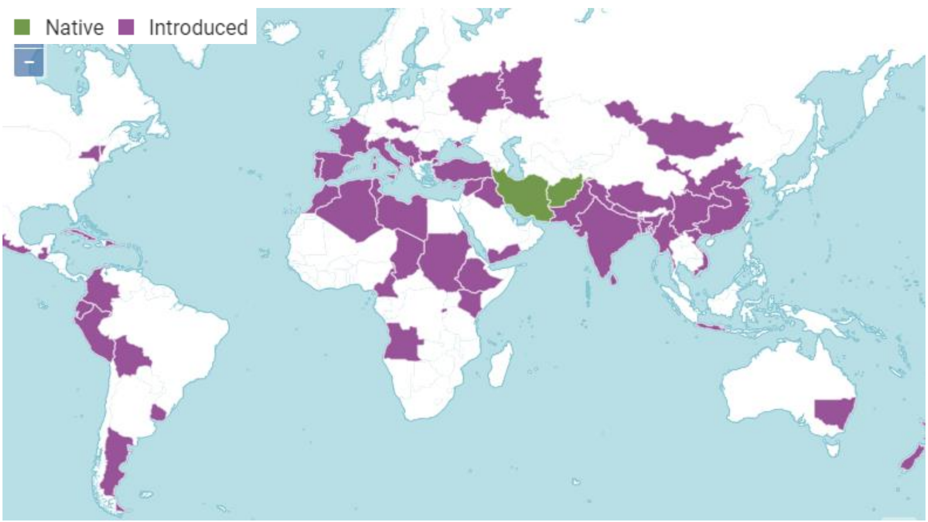

Figure 1. Distribution of *Vicia faba* in the world
Anonymous, 2022

3. DESCRIPTION OF THE PLANT

Broad bean is an annual cool season legume plant. The stems are erect, hollow, unbranched, hairless and have an indeterminate growth habit. Its height varies between 15 and 200 cm. The cross-section of the handle is square with protruding corners (Bond et al., 1985; Duc et al., 2015; Geren et al., 2009).

The pod has a plentifully branched taproot at the top, which can go down to 1.5 meters deep into the soil. In general, about 60% of the roots are located in the upper 0.15–0.20 m of the soil (Husain et al., 1990; Rengasamy & Reid, 1993; Manschadi et al., 1998; Sau & Mínguez, 2000). Nitrogen-fixing nodules containing rhizobia form on both taproot and lateral roots (Bond et al., 1985; Geren et al., 2009). Root characteristics are very variable and greatly influenced by tillage practices (Zhao et al., 2018; Maalouf et al., 2015; Munoz-Romero et al., 2011; Sau & Minguez, 2000; Turpin et al., 2002). It has been noted that root growth ceases during the flowering period or at the beginning of the pod filling period (Sprent et al., 1977; Husain et al., 1990).

Leaf consists of 2 to 6 leaflets, rather large, oval, thick, bright greenish-blue, smooth margins and glabrous, arranged oppositely but irregularly along a long axis. The end of the leaf axis results in a needle-shaped formation (Bond et al., 1985; Geren et al., 2009).

The flowers typically have a papilloed structure. Flowers emerging from the leaf axil are 2-3 cm long, in short stalked clusters (1-10 pieces). Their color can be white, purple, or violet. wing petals have black spots (Nayak et al., 2015; Bond et al., 1985; Geren et al., 2009).

Seed weight ranges from 0.2 to 2.5 g. The seeds are oblong to broadly oval with a prominent hilum at the end; their color can be yellow, green, brown, black or purple and sometimes even the seeds are mottled (Figure 2) (Maalouf et al., 2013).

The pods are straight or slightly curved, leathery at maturity, with brown-black veins and wrinkled. The length of the pod is 5-8 cm. It contains 2-5 round seeds in different colors from white and green to brown-violet and black. Seeds can maintain their vitality for 5-6 years (Geren et al., 2009).

Chromosome number is 2n=12. It is largely self-fertile. However, pollination rate may increase with foreign pollen according to the surrounding art population. In broad bean cultivation, foreign pollination rate varies between 1-63% according to genotype, environment and years (Çelik, 1980). Therefore, placing honeybee hives in bean fields increases pollination rate and seed yield with foreign pollen (Somerville, 1994).

Figure 2. General view of Vicia faba
Reference: R. Karaman.

3. CLIMATE AND SOIL REQUIREMENTS

Forage broad bean, which does not require much heat, prefers cool and humid climates. For a good yield, it requires the temperature to be between 15-25°C during the vegetation period. Minimum, optimum and maximum growth temperatures for broad bean are 3°C, 27°C and 35°C (Boote et al., 2002). It can withstand temperatures as low as -5°C. The vegetation period varies between 120-190 days. It needs a total temperature of 634°C until the flowering period and 1300°C until the grain maturity period. During the growing season, 400-600 mm of precipitation is sufficient. The yield is significantly reduced in aquaculture at altitudes exceeding 500 m. It cannot withstand drought for long, and its yield decreases depending on the duration and severity of the drought. Drought accelerates flower shedding. It suffers a lot from excessive moisture and stagnant water (Açıkgöz, 2021; Geren et al., 2009). It is more resistant to cold compared to cowpea, beans and peas (Vural et al., 2000).

Deep and loamy soils rich in nutrients also give successful results. Although it provides its best development between 6.5-7.2 pH degrees, it can also be grown in soils with a pH of 8. Light sandy soils can be made well-suited for pods when they are supplemented with nutrients and adequate water is available (Geren et al., 2009).

Broad beans; grows best in fine-textured soils but tolerates almost any soil type (Jensen et al., 2010). The ideal soil pH for broad bean cultivation is ≥7 (Köpke and Nemecek, 2010).

Although the broad bean is a large-seeded species, a good seed bed should be prepared. In the regions where winter sowing will be made, the seed bed should be prepared in October and November. Sowing can be done from October to December. In the regions where summer planting will be made, the soil should be prepared in autumn. Summer sowing can be done from March to the end of April, depending on the regions. Winter plantings are superior in terms of plant growth and yield (Bozoğlu & Gülümser, 1994; Pekşen & Gülümser, 2007; Tosun et al., 1984).

4. BREEDING

The seeds of the plant can be planted by scattering or sowing in rows, or it can be planted by hand-seeding the furrows opened with a hoe. Spreading is not recommended as it makes planting, maintenance and harvesting difficult. Generally, 50-60 plants per m^2 is sufficient for a desired yield. For this, in row plantings; The distance between rows should be 35-40 cm, and the distance on rows should be 4-5 cm. The planting depth of the broad bean, which has the largest seeds among the field crops, is greater than that of many plants. Depending on the grain size and soil texture, the most suitable planting depth is 5-8 cm. Pressing the soil after planting increases the germination and emergence rate. For row plantings, 150-200 kg of seeds per hectare, and 250-300 kg for scatter plantings should be used (Açıkgöz, 2021; Geren et al., 2009).

Sıkça (1994) investigated the effects of different planting times (6 and 19 November) and plant density (25 and 30 plants/m^2) on yield and yield components of Sakız and Eresen-87 cultivars in Bursa conditions. According to the results of the study, the best results were obtained at the beginning of November and at the density of 30 plants/m^2.

Seeds can be sprayed with some organic mercury chemicals against some diseases and pests. The best germination temperatures of seeds are 20-25°C that require a minimum temperature of 3-4°C for their germination. Seeds can germinate in 6-9 days at these temperatures, and in 15-18 days at 8°C. Since the seeds are large, it is desirable to have more than 90% purity and more than 90% germination power (Geren et al., 2009).

Drought stress, which may occur especially during flowering and post-flowering periods, increases flower and fruit drop and reduces yield (Geren et al. 2009).

Faba bean is susceptible to a variety of foliar fungal diseases

(Chocolate spot, Botrytis fabae; Ascochyta blight, Ascochyta fabae; Cercospora leaf spot, Cercospora zonata; Downy mildew, Peronospora viciae; Rust, Uromyces viciae-fabae) that may require fungicide treatment for control (Stoddard et al., 2010; Sillero et al., 2010).

Parasitic weeds (*Orobanche* and *Phelipanche* spp.) are the main constraints that can lead to significant reductions in area and productivity (Gressel et al., 2004; Abang et al., 2007; Maalouf et al., 2011).

In addition to parasitic weeds, annual weeds are a major barrier to legume production in North Africa and Western Asia. The broad bean is a slow-growing crop in the early stages and is prone to weed competition, which can reduce legume yields by 25-40% (Pandey et al., 1998).

In dry years, broad bean aphid (*Aphis fabae*) and green aphid (*Macrosiphum flounder*) cause great damage. In addition, *Bruchus granariuinn*, which is a seed pest, lays its eggs in the ovary during the flowering period, and the larvae eat the seed from the inside, causing huge financial losses (Day ve ark, 1979).

Harvest time for the grain product is the period when the pods in the lower parts of the plant turn brown and black. During harvest, the stems may be green in general. During this period, the moisture content in the grain is between 15-17%. Since there is no cracking in the pods in the feeder pods, there is no problem such as shedding grains. However, in cases where the harvest is delayed, it is necessary to be careful with machine harvesting. Harvest should be done early in the morning in order to minimize the opening of pods due to mechanical vibration. In our country, harvesting is generally done by hand plucking or mowing with a sickle. After the product harvested in this way is dried in the field for a few days, it is passed through the threshing machines and the seeds and chaff are separated. Grain yield, which can be up to 5000 kg ha^{-1} under suitable conditions, generally varies between 2500-3500 kg ha^{-1}. In addition to this product, 300-400 kg ha^{-1} of broad bean straw is obtained (Geren et al., 2009). It should not be forgotten that not only the yield amount but also the feed quality is important (Özyazıcı et al., 2020) and it is a remarkable feature of the broad bean that both the feed efficiency and feed quality are high.

Under favorable conditions, the broad bean constitutes the most productive genus in the legume family. It can provide good green fodder if the plant is mowed after completion of flowering when it is just starting to grow its lower pods. On average, 3 tons ha^{-1} of green grass can be obtained (Janezar, 1983; Avcıoğlu et al., 1999).

5. AREAS OF USE

Bean grain, green and dry grass, bean residues, straw and bean silage can be used as animal feed. The green grass yield of the broad bean is quite high. However, due to the thick and fleshy stem and leaves, the grass dries out late. Dried tissues also turn black. For this reason, broad bean grass is not suitable to be evaluated as dry grass. In addition, it can be used as a green manure plant because it has a very green component. Although fodder broad bean is a very good precursor for cereals, especially wheat and maize, it is not self-bearing. For this reason, it should take at least four years to plant in the same field. Due to the nematode danger, it should not be grown after other forage plants that are members of the legume family (Açıkgöz, 2021; Geisler, 1987).

It can be grown purely due to its vertical development. It is recommended to mow during full bloom and fruit formation periods. During this period, the dry matter rate is as low as 15-20%. In the studies carried out in the Izmir region, where the broad bean is grown in winter, the green grass yield can reach 30-50 tons ha^{-1}, and in Adana 90 tons ha^{-1}. In Erzurum, where summer planting is done, the yield is 15-20 tons ha^{-1} (Cevheri & Avcıoğlu 2004; Geren & Alan 2005; Alan & Geren 2006; Kuşvuran et al., 2014).

Forage broad beans, whose main production purpose is to use their grains as fodder, can also be used to meet the green fodder requirement of ruminant animals by mowing before or during flowering in some cases. Green forage of faba bean can adversely affect the taste of milk when fed to dairy cows just before milking. When the green bean grass is dried, its stems become very hard and lose its feed value. If the plant is cut, dried and shredded while it is young, it is consumed more willingly by animals (Geren et al., 2009).

The most important feature of the broad bean is its crude protein content, which reaches 30% in some varieties. However, the digestibility and biological value of the protein are low due to the tannins, lectins, glycosides and some inhibitory substances found in the grains. It is poor in amino acids such as threonine and sulfur-containing methionine and cystin, but rich in lysine. Vit-C and Yit-D coverage is trace amount (Geren et al., 2009).

It is considered as one of the most important legumes in the world due to its superior nutritional values such as proteins, carbohydrates, B group vitamins and minerals (Crépon et al., 2010). Proteins and minerals are needed for the healthy growth, development, reproduction and yield of animals (Özyazıcı & Açıkbaş, 2019).

Manga et al. (1995) stated that broad bean seeds can be used in human and animal nutrition because they are rich in protein, carbohydrates and mineral substances. The researchers also found that there are differences in morphological and seed characteristics among the broad bean varieties in Turkey, their plant height is 40-200 cm, the number of seeds in the pod is 2-5, the seed yield is 1000-4000 kg ha^{-1}, and the thousand-seed weight is between 350-800 g. They also stated that the crude protein ratios can reach up to 25% and they added that the plant height increases in warm and rainy climates.

Broad beans are often used as a protein source in balanced food rations to feed pigs, poultry and cattle. Currently, soybean is the largest protein integrator of the animal diet, but it is always more difficult to find soybean products on the market that do not contain genetically modified organisms. In organic agriculture, the use of GMO products in animal nutrition is not allowed (EC Regulation 1804/99). The ban on animal proteins has led to an increased demand for alternative protein sources in Europe, where peas (*Pisum sativum* L.), broad beans (*Vicia faba* L.) and lupine (*Lupinus* spp.) are the most used (Brenes et al., 2002).

Bean seeds have a high content of starch (about 30%) and protein (20-28%) and other compounds (tannins, proteinase inhibitors, glycosides) that can adversely affect animal digestion and limit the absorption of other compounds, especially in monogastric animals (Minakowski et al., 1996; Pusztai et al., 2004). Of these, glycosides and tannins are the most harmful in terms of nutrition because divicine and isouramil, that is, active derivatives of vicine and convicine, are known to cause hemolytic anemia called favism, while tannins inhibit the absorption of nutrients (Gulewicz et al., 2004). Heat treatment can improve the nutritional quality of this raw material by removing or eliminating some of the anti-nutritional factors responsible for chick weight reduction, feed efficiency and retention of dry matter, protein and crude fiber (Diaz et al., 2006; Ward et al., 1977).

Due to the remarkable progress in plant breeding, the level of secondary plant metabolites in the pod has been significantly reduced; for example, bean varieties with zero tannin have been developed (Duc et al., 1999). In addition, processing procedures (e.g. groats and micronisation) have been developed to alter the starch structure to eliminate or neutralize non-nutritive substances in the pod and improve the nutritive value of seeds for poultry (Lacassagne et al., 1988; Igbasan & Guenter, 1997).

Grain legumes have aroused great interest as low-input crops, alternating with grains for their capacity to improve soil fertility, and as alternative protein sources after the BSE (Bovine Spongiform Encephalopathy) crisis (EC Regulation. n. 1259/1999) (Di Paolo et al. 2015).

190-320 kg ha^{-1} of nitrogen is stored in the above-ground part of the broad bean plant, which uses the free nitrogen of the air, and it can be added to the soil by green manuring or used as animal feed (Heinzmann, 1981). Moreover, broad beans contribute to soil organic carbon in soils (Özyazıcı ve Açıkbaş, 2021).

The broad bean lives in a symbiotic state with the rhizobium bacteria and thus binds the free nitrogen in the atmosphere to the soil (Uçar, 2019). It is also reported that the legume has the highest nitrogen fixation rate in the soil among legumes. (Erincik, 2010; Yıldırım & Özaslan Parlak, 2016). It improves soil physical properties and reduces disease, pest and weed competition (Senaratne & Hardarson, 1988; Chalk, 1998; Jensen et al., 2010). As many researchers have reported, with the introduction of leguminous forage crops into crop rotation, the need for fertilizer use will decrease, the crop yield will increase, and the animal husbandry will be more economical by providing cheap roughage (Açıkgöz, 2021; Avcıoğlu, 2009; Yolcu & Tan, 2008; Bıçakçı & Açıkbaş, 2018; Turan et al., 2015; Özyazıcı ve Açıkbaş, 2021).

It was determined that the soil gained 270 kg ha-1 nitrogen with bean green manuring in Australia (Matthews & Marcellos, 2003).

It has been determined that more than 250 kg of nitrogen can be gained per hectare if the broad bean is used as green manure in İzmir conditions (Geren & Alan, 2005).

Broad bean grass can be considered as silage. However, the low dry matter content and water-soluble carbohydrate content in the broad bean is a problem in silage production. Because it contains a lot of water, cutting should be delayed until the lower pods and leaves begin to turn slightly black. In the forms made in this period, the dry matter rate is 20% and the crude protein rate is about 15%. It must be withered before being ensiled. Broad bean for a good silage production; triticale should be grown in a mixture with grains such as wheat and barley (Açıkgöz, 2021; Ingalls et al., 1979; McKnight & MacLeod, 1977).

It is reported that the plant height is 40-150 cm, the yield is between 8-18 tons ha^{-1}, and the crude protein ratio in the seed reaches 24.5% (Sağlamtimur et al. 1990). Broad bean varieties with unlimited growth can be sized between

50-200 cm depending on environmental conditions. The number of lateral branches varies between 1-6 pieces/plant, and the crude protein ratio varies between 20-41% (Sepetoğlu, 1992). In a study carried out in Bornova conditions between 1995-1996, it was determined that the plant height of the broad bean was 89-110 cm, the yield yield was 21-30 tons ha^{-1}, and the dry matter ratio varied between 18-21% (Özkayahan & Avcıoğlu, 1997). Between 2001 and 2003, in an experiment in which the broad bean variety named "Sevilla" was used in Bornova conditions, the plant height was 82-95 cm, the yield was 18.6-35 tons ha^{-1}, dry matter, crude protein and ash ratios were 27%-13%, respectively. It has been reported to vary between 14% (Cevheri ve Avcıoğlu, 2004). Dry broad beans contain 20-36% protein, green beans contain 5-7% protein (Vural ve ark, 2000). In a study conducted in Bornova conditions between 1995-1996, it was determined that the plant height of the broad bean varied between 89-110 cm, the weight of a thousand grains was 294-343 g, the weight of hectoliter was 81-83 kg, and the seed yield varied between 91-144 kg/da (Özkayahan & Avcıoğlu,1997). Plant height in the pod varies between 20-200 cm depending on the variety and climatic conditions. According to the cultivars, the number of stems in the plant is 2-6, the number of pods in each cluster is 1-9, the number of seeds in the pod is 3-4, the weight of a thousand grains varies between 180-2670 g (Şehirali, 1988; Sepetoğlu, 1992).

6. CONCLUSION

Bean grain, green and dry grass, bean residues, straw and silage can be used as animal feed. Since broad beans are rich in protein, carbohydrates and minerals, they are grown as a staple food for humans and animals. However, it also contains secondary metabolites that adversely affect digestion in monogastric animals.

Like other legumes, thanks to the rhizobium bacteria in its roots, it can fix nitrogen in the soil in large amounts. In fact, it is the plant with the highest nitrogen fixation rate to the soil among legumes. When it is planted in a mixture with cereals, the need for nitrogen fertilizer to be used decreases and the protein ratio of the grass to be obtained will increase significantly.

The bean, which is not selective in terms of soil and climate demands, has high nutritional value and yield ability. Considering these values, if the ratio of secondary metabolites, which adversely affect digestion, can be reduced or reset through improvement, a huge gain will be achieved.

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CHAPTER XVII

NARBON VETCH (*Vicia narbonensis* L.)

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1. HISTORY AND DISTRTIBUTION OF NARBON VETCH

The spread of *Vicia narbonensis* (Narbon bean, moor's pea or narbon vetch) as a cereal crop is closely related to the cultivation and domestication of the broad bean (*Vicia faba*). Due to the superficial similarities between the two, as well as the frequent availability of narbon bean in broad bean fields, it was probably domesticated and placed as a secondary crop in the bean's shade (Enneking & Maxted, 1995). *Vicia narbonensis* naturally spread over the region stretching from Central Europe to Asia Minor. It is found naturally in all regions of Turkey except Northeast Anatolia. The center of origin of the Narbon Vetch plant, currently cultivated in the Mediterranean and Central European countries, is likely to be North-West Asia, where the highest variety of *Vicia narbonensis* can be found. It is a member of the Vetch-like tribe (*Vicieae*), a subgenus of the vetch genus, and an annual vetch similar to broad bean (*Vicia faba* L.) in appearance (Avcıoğlu et al. 2009; Elçi, 2005; Schäfer, 1973; Maxted et al, 1991).

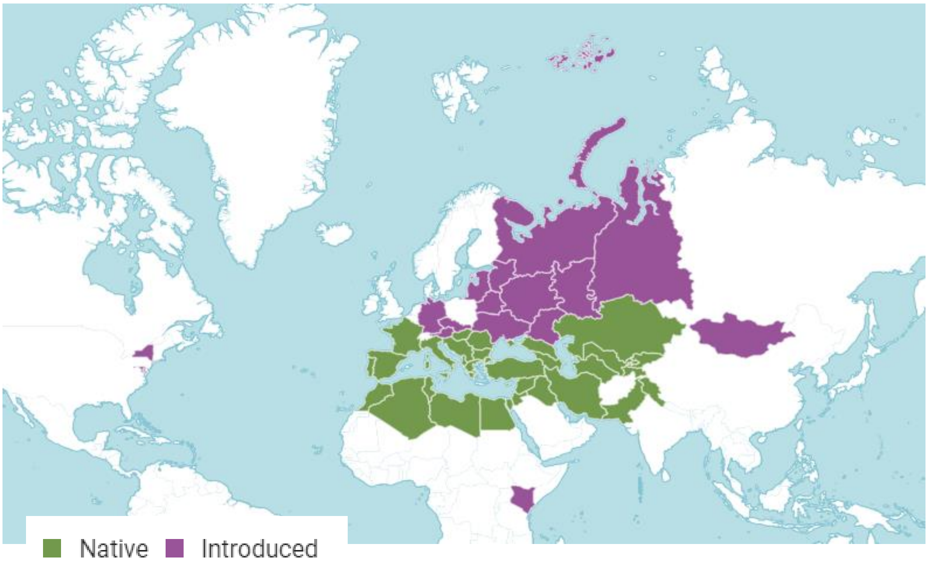

Figure 1. Distribution of *Vicia narbonensis* in the world
Reference: Anonymous, 2022

The seeds of *Vicia narbonensis* were probably transported, like other vetch, along with the traded grain, from Turkey and the eastern Mediterranean to Italy, the Iberian Peninsula, and North Africa. They also spread through grazing animals and seed-eating birds (Enneking & Maxted, 1995). Chassagne (1957) reported that *Vicia narbonensis* has been known in Puy-de-Dôme since the 18th century and can be found on abandoned slopes. The cultivated variety Vicia narbonensis var. narbonensis was first recorded in 1925. It was probably identified with forage cereals from the Black Sea region during the First World War (Enneking & Maxted, 1995). According to Chassagne (1957), pigeons are fond of this rarely grown plant and help it spread.

It is difficult to distinguish *Vicia narbonensis* from *Vicia faba* in the archaeological record unless it has pods (Zohary & Hopf, 1988). Therefore, we have no clear indication of its earliest cultivation or domestication. The earliest evidence of broad bean cultivation has been found in Jericho and dates back to 5000 BC. The oldest finds from the Iberian Peninsula can be dated back to 3000 BC (Enneking & Maxted, 1995).

The large size of Broad bean seeds has evolved relatively recently, because in all archaeological finds from ancient settlements the seeds are not as large as they are today. A find made in Iraq dating to AD 1000 is the first archaeological record of larger seeds. The seed size of the large-seeded varieties of *Vicia narbonensis* is close to that of the small-seeded *Vicia faba*. Therefore, *Vicia narbonensis*, whose plant structure is also similar to bean, can be considered a imitation of this crop (Enneking & Maxted, 1995).

2. DESCRIPTION OF THE PLANT

Vicia narbonensis is known as a species with high seedling strength, resistant to drought and cold, resistant to many diseases and aphids (Açıkgöz, 2021). As trials conducted in Syria, Iraq, Cyprus, Turkey, France and Australia have shown, high grain yield (1.5-5.1 t/ha) can be obtained from *Vicia narbonensis* without irrigation in Mediterranean type winter conditions (250-550 mm/year) (Enneking & Maxted, 1995).

It contains 15-20% crude protein in straw and 20-25% in seeds. However, there are compounds that give plant tissues and seeds a bad taste and odor. Therefore, its grass and seeds are not very palatable for animals. Boiled or roasted vetch seeds are consumed as human food since the bad odor and taste disappear (Açıkgöz, 2021).

While Canbolat & Bayram (2007) reported that the protein content in the *Vicia narbonensis* seed is 24%, Larbi et al. (2010) determined this rate as 31.8%.

Turan et al. (2018) in their research to determine the phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg) contents of genotypes of some vetch species; reported that the P ratio of the narbon vetch genotypes varied between 0.28-0.33%, the K ratio between 2.59-3.09%, the Ca ratio between 0.76-1.16% and the Mg ratio between 0.35-0.44%.

It is one of the largest species in terms of plant and seed among legumes forage crops. Plants grow 30-40 cm in arid conditions and 70-100 cm in winter planting and humid areas. It is an annual legume with thick, angular, hairy and upright growing stems (Ecocrop, 2013; Bryant et al., 2011). Since the stem of the vetch plant is woody, it is the most resistant vetch type against lodging, and therefore it can be grown alone without the need for mixtures (İptaş and Yılmaz, 1999). The root system is well developed. The leaves are two foliolates born in pairs with elliptical to oval leaflets 20-50 mm long x 20-30 mm wide. The flowers are papillonous, purple or white, and 40 flowers are born in axillary racemes. The fruit is a dehiscent capsule containing several smooth seeds, usually 5.5-6 mm wide and brown in color (Figure 2) (Ecocrop, 2013; Bryant et al., 2011; Hyppa, 2000; Açıkgöz, 2021).

There are 3 subspecies of Narbon vetch:

Vicia narbonensis subsp. integrifolia: The plant with flat leaves is almost hairless. Pods are dull, matt and twisted. It is the first cultured form.

Vicia narbonensis subsp. serratifolia: The leaflets and auricles of this form, which has saw-toothed leaves, are also saw-toothed. The pods contain small spiny hairs. The stem is coarser and branched than *Vicia narbonensis* subsp integrifolia. It is a subspecies with very limited cultivation.

Vicia narbonensis subsp. Intermedia: Densely hairy and low stature. The pods of this form, whose leaflets are toothed and auricles notched, are shiny and flat. It is a common wild form in the Mediterranean Region (Soya et al, 2004).

Figure 2. General view of Narbon vetch
Reference: S. Açıkbaş

3. CLIMATE AND SOIL REQUIREMENTS

Narbon vetch, which can be grown in any soil, likes deep, loamy and calcareous soils. Narbon vetch, which is similar to common vetch in terms of climate demand, is a forage plant that withstands winter and drought very well. It can be grown in regions with an annual precipitation of up to 350 mm. However, good yields cannot be obtained in very arid or excessively rainy regions. Among the vetch species, vetch with high winter resistance requires more warmth and less moisture than broad bean (*Vicia faba* L.) (Açıkgöz, 2021; Elçi, 2005).

Narbon vetch is known to have the potential to grow in areas where water is scarce. As a matter of fact, studies have been carried out in Australia and Syria (ICARDA) to improve this feature of narbon vetch (Francis et al., 2000; Ahmed et al., 2000).

In initial trials in Western Australia, species used in breeding programs showed slower growth than *Vicia faba*. However, the final yields were noted to be comparable to those obtained with *Vicia faba*. Vicia faba better in wet conditions; *Vicia narbonensis* better in dry conditions (Siddique et al., 1996).

In addition to high drought tolerance, improvements desired through breeding programs include faster growth (Siddique et al., 1999), higher seed yield (Francis et al., 2000), higher seed protein content (Rolletschek et al., 2004), higher content of essential amino acids in seed protein (Muntz et al., 1998), greater resistance to diseases and parasitism of *Orobanche* species (Sillero et al., 2005; Nadal et al., 2007; Ahmed et al., 2000).

Due to its drought and cold resistance, pest resistance and high seed yield, *Vicia narbonensis* is well suited for growing as a grain legume in dry areas. Available information indicates that this crop is particularly suitable for ruminant livestock production and shows significant promise for arable farming in regions with Mediterranean climates (Enneking & Maxted, 1995).

4. BREEDING

One of the most important factors affecting productivity in crop production is the number of plants that the soil can feed in the area where cultivation will be carried out (Özyiğit, 2018). The amount of seed to be sown per hectare for vetch recommended to be planted in autumn in temperate regions is 150-200 kg. It is recommended that the spacing between rows be 15-25 cm in sowing for grass production. It is stated that the distance between rows of 30-40 cm will be appropriate for sowing for seeds (Avcıoğlu et al., 2009; Özyiğit, 2018). Appropriate planting depth is 5-6 cm. With sowing, 20-30 kg ha^{-1} of nitrogen and 70 kg ha^{-1} of phosphorus fertilizer per hectare affect the yield considerably (Avcıoğlu et al., 2009).

Özyiğit (2018) reported that he got the highest grain yield from 150 kg ha^{-1} application in his research to determine the most suitable planting norm for the plant vetch (*Vicia narbonensis* L.) in Antalya coastal conditions.

The most suitable harvest time for green grass production is the full bloom phase. The most suitable harvest time for seed production is the period when the lower pods mature and darken (Açıkgöz, 2021; Avcıoğlu et al., 2009).

5. AREAS OF USAGE

It can be used in green fertilization due to being a voluminous plant, high green grass yield, forming many nodules in the roots and high nitrogen fixation ability (Özyazıcı & Manga, 2000; Avcıoğlu et al., 2009; Açıkbaş & Özyazıcı, 2021; El-Bok et al., 2017). As a matter of fact, it is stated by many researchers that legume forage crops and improve the physical and chemical properties of soils due to high green grass yield and provide nitrogen fixation (Hanay et al., 1998; Adak et al., 1998; Eser et al., 1998; Latif et al., 1992; Feiziene et al., 2016; Özyazıcı & Açıkbaş, 2021).

Green grass amount of 30 tons ha^{-1} was produced from the vetch grown in the Samsun Çarşamba plain for the winter. After this product was buried in the ground for green fertilization, a yield increase of 50% was achieved in corn planted and 35% in sunflower (Özyazıcı & Manga 2020). The benefit provided by burying the whole part of the plant or the stubble cover is equivalent to nitrogen fertilization at 100-200 kg ha^{-1} (Özyazıcı & Manga, 1998).

Acar et al. (1994) obtained 354 kg/da straw and 55 kg/ha crude protein yield from Narbon vetch (*Vicia narbonensis* L.), 248 kg/da straw and 55 kg/ha yield from common vetch (*Vicia sativa* L.) in the reseach conducted in Samsun ecological conditions.

Sefa (1984) determined the average yield of maize planted after common vetch and narbon vetch as 900.0 and 903.1 kg/da, respectively, in the green manuring application in which all parts of common vetch and narbon vetch are buried. They report that the increases compared to the control were 21.0% and 21.5%.

Özyazıcı & Manga (2000) reported that by growing common vetch and vetch between existing rotation pairs, fertilizer costs could be reduced and erosion could be prevented, as a result of the study they carried out in order to determine the feed and green manure values of legume forage crops that can be grown as a winter intermediate product in the irrigated conditions of Çarşamba plain (Table 1). Some characteristics of the corn plant planted after green manuring in this experiment are shown in Table 2.

Table 1. Feed value and yield of some leguminous forage crops

Plant	Green grass yield (kg ha^{-1})	Hay yield (kg ha^{-1})	Crude protein yield (kg ha^{-1})	Carbon/Nitrogen
Maize+Green manuring+Maize				
Vicia narbonensis	31000	3584	816	12.7
Vicia sativa	27617	2985	759	11
Lathyrus sativus	14958	1864	338	16.1
Maize+Green manuring+Sunflower				
Vicia narbonensis	31667	3609	807	13.1
Vicia sativa	2845	2869	705	11.3
Lathyrus sativus	1640	2027	346	17.1

Özyazıcı & Manga (2000)

It can be cultivated for the purpose of green grass production. However, the stems and leaves do not dry well and turn black due to their coarse texture. Therefore, it is better to consume it as green or add it to silage (Açıkgöz, 2021).

Table 2. Some characteristics of corn plant planted after green manuring

Plant of green manuring	Plant height (cm)	Cob length (cm)	Number of grains on the cob (grain/cob)	Thousand grain weight (g)	Crude protein ratio (%)	Grain yield (kg/da)
Vicia narbonensis	209.8	20.0	630.5	336.1	11.57	974.2
Vicia sativa	214.8	20.0	654.0	327.8	11.83	963.3
Lathyrus sativus	204.1	19.2	632.2	321.7	10.62	873.5
Control	178.8	14.5	428	285.3	10.32	800.0

Özyazıcı & Manga (2000)

Çakmakçı & Çeçen (1999) investigated the forage yield of some annual legume forage crops in Antalya and reported that they obtained the highest values from *Lathyrus sativus* and *Vicia narbonensis* (Table 3).

Table 3. Graz yields of some annual legume forage crops

Plants	*Lathyrus sativus*	*Vicia narbonensis*	*Trigonelle foenum*	*Vicia sativa*	*Vicia ervilia*	*Vicia villosa*	*Pisum arvense*	*Trifolium resupinatum*	*Trifolium alexandrinum*
Average dry matter yield (kg ha^{-1})	4043	3595	3175	2864	2725	2463	2270	2150	1565

Çakmakçı & Çeçen (1999)

Çakmakçı et al. (1999) investigated the grain and hay yields of *Vicia sativa*, *Vicia villosa*, *Vicia narbonensis* and *Vicia ervilia* in Antalya ecological conditions and determined that the species with the highest grain and hay yield was big vetch (Table 4).

Table 4. Grain and hay yield of some annual legume forage crops

	Vicia narbonensis	*Vicia sativa*	*Vicia villosa*	*Vicia ervilia*
Grain yield (kg ha^{-1})	3848	1908	778	2074
Hay yield (kg ha^{-1})	7114	5566	5368	6775

Çakmakçı et al. (1999)

Çeçen et al. (2005) in their study in which they examined the grass and grain yield of 6 different annual legume forage plants, reported that the highest values in terms of forage yield were obtained from *Trifolium resupinatum*, and the highest values in terms of grain yield were obtained from *Vicia narbonensis* and *Lathyrus sativus* (Table 5).

Table 5. Greengrass, hay and grain yields of some annual legume forage crops

	Vicia sativa	*Vicia narbonensis*	*Vicia villosa*	*Trifolium resupinatum*	Pisum arvense	Lathyrus sativus
Grass yield (kg ha^{-1})	3006	3806	6114	8403	1219	3144
Hay yield (kg ha^{-1})	561	585	992	1250	317	505
Grain yield (kg ha^{-1})	371	535	103	36	350	513

Çeçen et al. (2005)

Sabancı et al. (1998) investigated the grass and seed yields of 15 narbon vetch lines in Menemen conditions and found that the average biological yield was 1305 kg/da, the average straw yield was 873 kg/da and the average grain yield was 415 kg/da. In a similar study on menemen, Sabancı et al. (1996) reached a biological yield of 1760 kg/da in narbon vetch.

Kurt et al. (2022), in their study on the chemical content, digestibility and feed value of many legume forage plants, reported that narbon vetch is one of the leading plants in terms of crude protein ratio, raw ash, ADF and NDF ratios (Table 6).

Table 6. Data on digestibility and feed value of some forage legumes

	Dry matter (%)	Organic matter (%)	Crude protein ratio (%)	Crude ash (%)	Crude oil ratio (%)	ADF (%)	NDF (%)
Vicia narbonensis	93.79	88.28	24.72	11.71	3.77	23.63	37.98
Medicago sativa	94.93	93.65	17.17	6.34	3.91	33.25	47.43
Onobrychis viciifolia	92.21	94.58	17.15	5.41	3.17	32.82	43.09
Vicia sativa	94.15	90.44	21.49	9.55	2.38	26.53	40.28

Kurt et al. (2022)

Özyazıcı & Açıkbaş (2019) conducted a study to determine the effect of different levels of phosphorus doses on grass and seed yield in vetch (*Vicia narbonensis* L.); The highest green grass yield (2765.3 kg/da), hay yield (488.9 kg/da) and seed yield (237.6 kg/da) were determined at 9 kg/da fertilizer dose. The lowest values in all parameters were determined in the control plots without phosphorus fertilizer application (Table 7).

Table 7. The effect of different levels of phosphorus doses on grass and seed yield in narbon vetch (*Vicia narbonensis* L.)

	Control	30 kg ha^{-1} P	60 kg ha^{-1} P	90 kg ha^{-1} P	120 kg ha^{-1} P
Green forage yield (kg ha^{-1})	19764	21875	24125	27653	23542
Grain yield (kg ha^{-1})	1618	1975	2097	2376	2210

Özyazıcı & Açıkbaş (2019)

It can be evaluated by making silage, but if silage is preferred, it is recommended to mix it with grains. Grain ratio should be high for a good silage (Altınok, 2002).

The grains are crushed and used in animal nutrition. It has a high yield potential compared to many other plants in terms of grain yield (Çeçen et al., 2005). However, it is not preferred by animals due to some alkaloids in it. These substances have a negative effect even in low levels in poultry rations (Eason et al., 1990).

Abd El-Moneim (1992) reported that the average crude protein ratio of narbon vetch grains was 28.6% and that of dry grass was 9.02% in the study they conducted on the yield of 9 vetch lines under dry farming conditions. He also stated that the average seed yield was 1.27 t ha^{-1}.

One of the advantages of narbon beans is its high sulfur amino acid content, which is an important factor when considering the use of legumes in the diet. However, this is also a disadvantage because most of the cysteine occurs in the form of g-L-glutamyl-S-ethenyl-L-cysteine, which gives it a very unpleasant aftertaste. Royo et al. (2007) proposes both chemical and genetic strategies to deal with this problem and concludes that the previously "highly vilified and underrated narbon bean" now has great potential (Upadhyaya et al., 2007).

It is resistant to parasitic weeds such as *Orobranche crenata*, mainly phytoparasitic nematodes (*Pratylenchus* spp., *Meloidogyne* spp., *Ditylenchus dipsaci*), fungal diseases caused by *Aschocyta* spp. and *Botrytis* spp., as well as insects and viruses (Enneking & Maxted, 1995). It has great potential with this feature. If the resistance genes can be detected and transferred to the cultivated plants, it can make a great economic contribution.

6. CONCLUSION

Big vetch is known as a species with high seedling strength, resistant to drought and cold, resistant to many diseases and aphids. It is one of the largest species in terms of plant and seed among legumes forage crops. It is important in terms of animal husbandry due to the high grain yield and crude protein content of the grains.

It can be used in green manure because of being a voluminous plant, high green grass yield, forming many nodules in its roots and high nitrogen fixation ability. It can be cultivated for the purpose of green grass production. However, the stems and leaves do not dry well and turn black due to their coarse texture. For this reason, it is more correct to consume it as green or add it to silage. It can be evaluated by making silage, but if silage is preferred, it is recommended to mix it with cereals. Cereal ratio should be high for a good silage.

The grains are crushed and used in animal nutrition. It has a high yield potential compared to many other plants in terms of grain yield. However, it is not preferred by animals due to some alkaloids in it.

In the light of this information, it seems possible to benefit from vetch in many ways. However, the alkaloids in its grains are a factor limiting its use in livestock. It is thought that if the alkaloid ratio in the grains can be reduced or destroyed with the improvement studies that are developed today, it can make a great contribution to animal husbandry in terms of economy.

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CHAPTER XVIII

STRESS FACTORS IN SOYBEANS

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Soybean

It is known that soybean (Glycine max L.), whose history dates back 5000 years, was first seen in the lands of East Asia (Öner, 2006). Soy, which is defined as a sacred plant, wonderful plant and god plant in Far East countries and China, has created an important source of food and livelihood for the people living in these regions.

It was first reported to be recorded in the United States in 1765 (Hymowitz and Harlan, 1983). In the decade from 1929 to 1939, the soybean production area quadrupled. Soybean, which was originally grown as a fodder crop, started to be grown for its seeds after 1941 and exceeded all cultivated areas in terms of area (Probst and Judd, 1973). Between 1950 and 1979, it reached 28.9 million hectares of cultivation area with a steady increase, and this record increase was not exceeded until 1998 (Specht et al., 2014). In the next period, the harvested area remained stable in the range of 29 to 31 million hectares.

The reasons why soybean is a widely used forage leguminous crop are its use as human food, animal feed (grain feed, pulp, forage) due to its high protein (37-39%) and edible oil (18-20%) content, biofuel production and nitrogen addition to the soil can be counted (Valliyodan et al., 2017). 34.68% of oilseed production in the world in 2018 belongs to soybean, and it is the sixth in the list of the most produced plants in the world (FAO, 2019). According to 2022 data, world soybean cultivation area is 126,951,517 ha and production is 353,463,735 million tons. The top 10 producing countries are America, Brazil, Argentina, China, India, Paraguay, Canada, Bolivia, Ukraine and Russia (FAO 2022). According to the data of our country for 2021; Soybean cultivation area is reported as 438,917 da and soybean production as 182 thousand tons (TUIK, 2021). According to the 2025 Agricultural projections of the United States Department of Agriculture (USDA), it is estimated that the use of soybean meal will increase by 20% and the use of soybean oil by 30% in world soybean trade. (Wescot and Hansen, 2016).

Soybean is also a plant that increases soil fertility by binding the free nitrogen in the air to the soil (Deshmukh et al., 2014). Apart from consumption, it is estimated that soybean oil will be used as a fuel source in the future, and studies on this are ongoing (Candeia et al. 2009). In addition, it is estimated that the current food production will need to double by 2050 due to the increasing population (Ray et al., 2013). Therefore, the effects of stress factors such as salt, drought, flood, heat, cold, frost and heavy metals that suppress soybean yield should be taken into account (Deshmukh et al., 2014).

Abiotic Stresses

Abiotic stress is one of the main factors limiting and negatively affecting crop yield (Chebrolu et al., 2016; Clarke et al., 2013). The fact that abiotic environmental factors come to the level of stress and it changes from species to species makes it difficult to define the concept of stress (Korkmaz and Durz, 2017). Understanding the response and tolerance of plants to abiotic stress is very important and challenging in plant studies (Hirayama and Shinoza, 2010). Because the response and response of plants to stress is highly variable depending on the intensity, type and duration of stress (Kosová et al., 2011). The environment and situation that creates stress for a plant in biological conditions can provide optimum conditions for a different plant (Kireçci and Yürekli, 2019). The most practical definition of biological stress can be defined as adverse conditions that suppress normal development, function and formation in biological systems such as plants (Jones and Jones 1989; Gaspar et al., 2002; Jaleel et al., 2009). As a matter of fact, abiotic stresses such as salinity, drought, extreme temperatures and heavy metal contamination are threats that cause disruption of agricultural activities and pollution of the environment. Abiotic stress is the primary cause of crop yield loss worldwide, and it is reported that it reduces the average yield of crops with the highest yields by more than 50% (Wang et al., 2004). It is known that soybean is adversely affected by abiotic stresses, especially in the seedling period, and drought, flood, salt and heavy metals are the leading stresses.

This study was prepared as a summary of the literature studies investigating the effects of some abiotic stress factors on soybean.

Drought and Salt Stress

Among the various abiotic stresses, salinity, drought and temperature suppressor stresses are at the forefront and negatively affect growth due to water loss in the tissues of crop species including soybean (Feng et al., 2020). Gradual decrease in precipitation levels increases the amount of moisture in arid and semi-arid areas due to the increase in temperature, leading to drought and salt stress, with plants deficient in water and nutrients (Mahajan and Tuteja, 2005; Al-karaki, 2006; Porcel et al., 2012).

Salt Stress

The increase in soil salinity has become an important environmental problem today, negatively affecting crop production worldwide (Jiang, et al., 2013). It has been reported that more than 800 million hectares of terrestrial area worldwide are affected by salt stress. The affected area corresponds to 6% of the world's terrestrial areas (Munns, 2005). Of the 150 million hectares cultivated under dry conditions, 32 million hectares are threatened by secondary salinity at varying degrees. 45 million hectares of 230 million hectares of irrigable land is cultivated under salinity conditions (Munns, 2002). It is estimated that this situation negatively affects product yield, decreases its quality and causes economic losses as a result of all these (Mahajan, and Tuteja, 2005).

Salt stress causes many changes at the macro, cellular and molecular levels of plants. Salinity affects the water and ion contents of plant cells and suppresses their transport to the leaves. In addition, it disrupts the chloroplast structure, suppresses photosynthesis and other biosynthesis reactions and the synthesis of antioxidant enzymes (Yılmaz et al., 2011).

Soybean is an important food and oil crop in many countries where or will experience salinity stress (El Sabagh et al., 2015). Studies show that soybean is sensitive to salty soils and its yield decreases (Lauchli, 1984; Phang et al., 2008). Its growth is greatly suppressed and there is a serious decrease in its yield (Katerji et al., 2003). Considering that more and more agricultural lands will be exposed to salt stress, it has been reported that breeding studies of soybean varieties with high tolerance to this stress are very important (Lee et al., 2009). The number and functionality of nodules in the root structure, which are the nutritional sources of the plant, are negatively affected by salt stress, reducing the effectiveness of nitrogen fixation (Singleton and Bohlool, 1984; Delgado et al., 1994; Elsheikh and Wood, 1995). It also prevents the beginning of the symbiosis process by negatively affecting the deformation of the tuber hair structures in the nodes (Duzan et al., 2004). The effect of alkaline salts on plants is not the same as neutral salts on plants. Alkaline salts, which are more harmful than neutral salts, cause changes in soil pH (Yang et al., 2012). Alkaline salt stress has a more negative effect on the growth and development of soybean than neutral salt stress on photosynthetic activity damage (Jiao et al., 2018; Li et al., 2017; Zhang et al., 2016).

Drought Stress

It has been reported that soybean has a high water requirement during the seedling period and is more sensitive to drought than other legumes (Feng et al., 2020). Drought stress is the most adverse effect on plant growth in soybean and reduces crop yields (Sullivan and Teramura, 1990). The frequency of extreme weather events, including changes in climatic conditions, high temperatures, changing and decreasing precipitation patterns, and drought conditions frequently encountered in all agricultural areas, is increasing. This situation is estimated to cause significant damage to crop production, yield and global food security. The effects of extreme heat, floods and drought, which are the result of climate change, have caused significant reductions in crop production and yield in the last 30-40 years (Boyer, 2013; Lesk et al. 2016). According to the National Aeronautics and Space Administration (NASA) weather modeling methods, a 30% increase in the incidence of heavy precipitation is predicted by 2030 (Rosenzweig et al., 2002). Although a gradual increase in yield has been observed today, researchers have observed that due to climate change, corn (Zea mays), wheat (Triticum aestivum), rice (Oryza sativa) and soybean (Glycine max) predict yield reductions for crops with a high cultivation area (Iizumi et al. 2013; Lobell et al., 2014; Rosenzweig et al., 2014)). Yield losses of 40% are observed in soybean due to drought, and the fact that these losses occur in various periods (vegetative, generative) of the plant affects the plant more due to water loss (Specht et al. 1999). Drought stress in soybean during the vegetative period causes curling and falling of leaves. This leads to leaf loss and yield reduction. In the seedling period, the fall of flowers and shells increases in soybeans, causing the formation of small pods with fewer, smaller and more wrinkled seeds than normal (Boyer, 1983). When the plant is under drought stress, it slows down the growth rate of plants and enables more carbohydrates to be stored in order to maintain metabolic balance (Feng et al., 2020). Organic osmolytes such as glycine and proline become active and accumulate at high rates in the face of environmental stresses such as salinity and drought in soybeans (Ashraf and Foolad, 2007; Das et al., 2017).

Heavy Metal Stress

Soil is one of the most important components of the environment that creates ecosystems (Feng et al., 2020). Along with the rapid population growth in recent years, industrial wastes, gases from the exhausts of motor vehicles, mining activities, volcanic eruptions, excessive fertilizers and pesticides used in agriculture and urban wastes cause metal accumulation in the soil (Stresty and Madhava Rao, 1999). Cobalt, zinc, manganese, copper, nickel and molybdenum from heavy metals reaching the ecosphere are known as essential metals for plant growth. Aluminum, arsenic, vanadium, mercury, lead, cadmium and selenium are non-essential toxic metals. Even though it is absolutely necessary for plant development, when the accumulation of heavy metals in plant tissues and organs increases, it negatively affects the development and growth of vegetative and generative organs of plants (Gür et al., 2004). Due to these toxic effects, heavy metals negatively affect many physiological events in plants such as transpiration, stomatal movements, water uptake, germination, photosynthesis, enzyme activity and protein synthesis (Kennedy and Gonsalves, 1987). The response and tolerance of plants when faced with environmental stress depends on many factors. The type of plant, the type of stress, the duration of exposure to stress and the structure of the tissue or organ exposed to stress are some of them (Gür et al., 2004). For this reason, many studies should be carried out to know the response of plants to these stress conditions, their tolerance level and the adaptation mechanisms they have developed. In order to know the tolerance limits of plants against heavy metal stress, the type and amount of various metals in plants, their usefulness to the plant, the severity and type of damage caused by toxicity, as well as the formation process of the damage should be considered as a whole. Knowing these features is very important for the development and vitality of plants (Paschke et al., 2005).

most heavy metal stresses such as Pb, Hg and Cr; reduces the photosynthesis, respiration or transpiration capacity of soybean (Bazzaz et al., 1974; Ma and Li, 1999). It has been reported that as chromium contamination in the soil increases, soybeans grow more slowly, proline levels accumulate at a high rate and prevent water absorption and accumulation in the plant (Ganesh et al. 2009). Mo is one of the essential micronutrients for plant and animal growth and development (Feng et al., 2020). It has been reported that protein, vitamin C and amino acid contents in soybean seeds decrease significantly under excessive Mo stress (Peng and Yuai, 2003). It has also been reported that soybean root structure is significantly affected by heavy metal contamination (Feng et al., 2020).

CONCLUSION

There are many factors affecting the tolerance of soybean to abiotic stresses, and more research is needed to understand this complex structure. Abiotic stresses such as extreme temperature, drought, salinity and heavy metals greatly suppress crop yield and development. Most current research deals with one of the abiotic stresses, but in field conditions it is often the case that multiple stresses affect the plant. In addition, different reactions are observed between different parts or varieties of soybean even under the same stress factor, and the entire metabolic system of plants consists of a complex structure that is constantly changing (Ahsan et al., 2012). The response of plants under stress is a complex complex structure, and the molecular mechanism governing this response needs to be elucidated in depth with various analytical methods and numerous studies to be conducted (Feng et al., 2020)

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