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Cannabis sativa L.: ORIGIN, DISTRIBUTION, TAXONOMY AND BIOLOGY

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ABSTRACT. With a history dating back thousands of years, cannabis is one of the plants with the oldest relationships with people. Since ancient times, cannabis has been grown thanks to this tight connection. Cultivation studies have increased the distribution area of the plant but also caused the formation of different forms at the population level. Differences in population level caused the plant to be defined as a different species or subspecies taxon. Although cannabis has been defined as many different species and subspecies since its first description, today it is accepted as a single species. As a result of the cultivation studies, cannabis grown in different areas did not only show morphological differences but also differedin terms of phytochemical compound ratios, which led to the formation of medical and industrial cannabis definitions. The wide ecological tolerance limit has enabled cannabis to be cultivated and processed in many different regions, thus leading to multiple uses. Since hemp has been banned throughout history, it has not received the value it deserves today. Today, some nations are beginning to implement new laws in order to gain more from hemp, and the barriers to hemp production are starting to be taken down. The plant might be able to get more from this circumstance and the value it merits. Hemp has the potential to be a significant source of revenue for many nations with the correct legislation in place. *Cannabis sativa* is a versatile plant that goes by two common names: Industrial *Cannabis sativa* (also known as fiber type or hemp) and Medical *Cannabis sativa* (also known as marijuana type or marijuana). Herein, our goal isto review a study of the literature on its broad definition, geographic origin and distribution, taxonomic standing, and morphological characteristics.

Keywords: *Cannabis sativa*, *Cannabis* Taxonomy, Origin, Distribution, Morphology of *Cannabis*

Cannabis sativa L.: KÖKENİ, DAĞILIMI, TAKSONOMİSİ VE BİYOLOJİSİ

ÖZET. Kenevir binlerce yıllık tarihi ile insanlarla ilişkisi en eski olan bitkiler arasında yer almaktadır. Bu denli sıkı bir ilişki beraberinde eski tarihlerden itibaren kenevirin kültüre alınmasına olanak sağlamıştır. Kültüre alma çalışmaları beraberinde bitkinin dağılış alanını arttırmış bununla beraber populasyonlar düzeyinde farklı formların oluşmasına neden olmuştur. Populasyon düzeyindeki farklılıklar bitkinin farklı tür veya tür altı takson olarak tanımlanmasına neden olmuştur. Kenevir ilk tanımlanmasından günümüze kadar çok farklı tür ve tür altı takson şeklinde tanımlanmış olsa da günümüzde tek tür olarak kabul edilmektedir. Kültüre alma çalışmaları sonucu farklı alanlarda yetiştirilen kenevir sadece morfolojik farklılıklar göstermemiş aynı zamanda fitokimyasal bileşik oranları bakımından da farklılık göstermiş ve bu durum tıbbi ve endüstriyel kenevir tanımlarının oluşmasını sağlamıştır. Ekolojik tolerans sınırının geniş olması kenevirin çok farklı bölgelerde kültüre alınmasını ve işlenmesini sağlamış dolayısıyla birden

çok kullanımın oraya çıkmasına neden olmuştur. Kenevir tarihsel süreçte yasaklanmış olması nedeni ile günümüzde hak ettiği değeri alamamıştır. Günümüzde artık kenevirden daha fazla faydalanmak için bazı ülkeler yeni politikalar benimsemeye başlamış ve kenevir üretimi önündeki engeller kaldırılmaya başlanmıştır. Bu durum bitkiden daha fazla faydalanma imkanını ortaya çıkararak ve hak ettiği değeri kazanmasına olanak sağlayabilir. Doğru politikalar ile kenevir birçok ülke için önemli bir ekonomik gelir kapısı olabilir. Bu kapsamda buradaki amacımız, günümüzde iki yaygın adla bilinen *Cannabis sativa*'nın (Tıbbi *Cannabis sativa*/marijuana tip/marihuana ve diğeri ise endüstriyel *Cannabis sativa*/lif tipi kenevir/endüstriyel kenevir) çok amaçlı bir bitki olarak bitkisel üretim sistemlerindeki hak ettiği yerini alması için genel tanımı, orijin bölgesi ve yayılış, taksonomik durumu ve morfolojik özelliklerini hakkında bir literatür taraması yapmaktır.

Anahtar Kelimeler: *Cannabis sativa*, Kenevir Taksonomisi, Orijini, Dağılımı, Kenevirin Morfolojisi

INTRODUCTION

People have always had a deep relationship with their environment and have worked hard to understand it and gain greater benefits from it. He devised a number of systems to characterize various living and inanimate items in their environments as a result. The most intriguing aspect of the earth is its biodiversity. The initial questions that humanity tried to find solutions to naturally began with the richness of biodiversity. Despite the fact that biological diversity has always been a fascinating topic, the global species richness cannot be directly estimated because there have only been a few studies on the topic, and more are continuously being conducted. There are 8.7 million eukaryotic species on the planet, 2.2 million of which are found in the oceans, according to the methodology used by Mora et al. [1]. Plants are crucial to this complex biological ecology. As the main producers, a major source of food for many living things, and a natural habitat, plants are very significant. While some plant species only have one application, others have the potential for multiple applications. The *Cannabis* plant (*Cannabis sativa*) is one of the plant species that has this kind of potential for multiple uses. *C. sativa* is a 3 m tall annual herbaceous dicot angiosperm plant that belongs to the Rosales order, the Rosidae suborder, and the Cannabaceae family [2]. The *Cannabis* plant is one of the oldest crops in the world and is widely grown for its nutritional, industrial, medicinal, and psychotropic products. Depending on the amount of delta-9-tetrahydrocannabinol (D9-THC or THC), regulatory attitudes and terminology vary between nations. The *Cannabis* plant, the focus of this study, is a genus of plants in the Rosales order, which has roughly 260 genera and 7700 species in addition to nine distinct families of plants [3; 4; 5]. *C. sativa* is a species belonging to the Cannabaceae family, which includes 11 genera and 170 species [3; 4]. This review discusses the general definition, region of origin and distribution, taxonomic status, and morphological characteristics of *Cannabis sativa* with current sources in order to help cannabis take its rightful place in plant production systems.

A Comprehensive Word "Cannabis"

Cannabis L. is the genus name for a group of plants that includes a variety of cultivars and hybrids that have historically been used to produce hemp and marijuana [6]. In a broad sense, the term "cannabis" refers to the cannabis plant, more specifically to the psychotropic compounds (drugs both legal and illicit), fiber products (plastics, textiles, and many types of construction materials), and edible seed products (now

dozens of processed foods) that are produced from the plant. In short, the term "cannabis" refers to all facets of the plant, particularly its by-products and applications [3]. For instance, cannabis is known as *C. sativa* L. in Latin. Cannabis is an abstract, general term that is frequently used as both a noun and an adjective. It is applicable to all cannabis preparations as well as the cannabis plant itself. To put it another way, the term 'cannabis' refers to goods (drugs and essential oils) made from or extracted from *C. sativa* and its cultivars. Marijuana and cannabis are frequently used interchangeably. There are a few slight differences, though. Both marijuana and hemp are regarded as species of the 170 various plant species collectively referred to as "cannabis" [8]. Cannabis seeds, dried flowers, leaves, and stems are combined to make marijuana, a cannabis product that also contains THC and CBD. In brief, *C. sativa* is known by two different names: marihuana (medical cannabis-marijuana type) and hemp (industrial *C. sativa*-fiber type). Industrial hemp is genetically distinct and can be identified by its use, chemical composition, and various production methods [9]. Although cereal and fiber cannabis types are generally referred to as "industrial cannabis" such plants must have a THC concentration of no more than 0.3 percent dry weight. *Cannabis* strains developed for their high THC concentration and psychotropic properties are referred to as medical cannabis. The high THC content of medicinal cannabis is primarily synthesized in the calyx and, to a lesser extent, in the trichomes of the leaves. THC levels have reportedly been found to be much higher than those of industrial hemp, averaging around 10% and even reaching 20% to 30% in some studies [10]. Cannabis is thought to have the potential to have a psychoactive effect or become intoxicating at levels of THC that are less than or equal to 1%. The line between industrial and medicalcannabis is set at less than 0.3 percent THC in accordance with the current lawsgoverning cannabis cultivation in the European Union and Canada [11]. In addition, according to some experts, industrial hemp has higher concentrations of CBD, a non- psychoactive component of *Cannabis*, which may lessen some of the effects of THC [12]. A high CBD/THC ratio is regarded as more indicative of a fiber-type plant than a drug-type plant. On how the CBD to THC ratio may impact those effects, there are still varying views.

Origin and Distribution of Cannabis sativa

One of the earliest domesticated plants, *C. sativa*, has been used for its fiber, hemp seeds, and psychoactive compounds since ancient times. Cannabis has a long history of use dating back approximately 12,000 years in human history and is generallysuggested to originate from Central Asia [Fig. 1.; 13]. It probably developed in ruderal areas of prehistoric hunters and gatherers. Although there are written records of its cultivation and use in many cultures, archaeobotanical evidence is based on pollen and seed analysis of the distribution of cannabis. The origin (gene center) of complex cannabis has been reported to be in Central and East Asia, with a wide distribution area extending from the Caspian and Himalayas to China and Siberia, despite the fact that it is not particularly healthy to do so [3; 14; 15]. (Fig. 1). Since ancient times, hemp has been grown for a variety of purposes, including as a source of fiber, seeds, and psychoactive phytochemicals [6]. Hemp is one of the oldest domesticated strains. The idea that *C. sativa* L. is a modern cannabis variety is supported by literature sources (Fig. 1) [13]. The majority of the spread originated in the Central Asian steppes, particularly in Mongolia and southern Siberia. Other sources, however, claim that it

may have originated in South Asia, Afghanistan, the Hindu Kush mountains, the Huang He River valley, or the South.

The biogeography of cannabis may have changed over time, partly as a result of the melting of the Pleistocene glaciers that provided it with protection [6]. In the Siberian Pazaryk tribes' Kurgan burial mounds dating to 3000 BC, burned cannabis seeds have been discovered [16]. Graves of Caucasian nobility interred around 2500 BCin Xinjiang and Siberia, such as the Yanghai Tombs in the Turpan Basin of East Turkistan, have reportedly contained significant amounts of mummified psychoactive *Cannabis sativa* but not the hemp-type variety [17; 18]. During the Aryan invasions between 2000 and 1000 BC, marijuana was probably brought to the South Asian peninsula [19].

The well-known narcotic soma, which was made popular by the Aryans and is extensively discussed in the Rig Veda, is thought by some to be cannabis [6]. In the sixth century AD, cannabis was brought to Southeast Asia. Both Thai kancha and Sanskrit ganja were referred to here by regional names like Vietnamese gai, Kambocyankanhch, and Lao kan xa [20]. Between 1400 and 2000 BC, hemp made its way to the Middle East, presumably as a result of broader Aryan immigration to the area [21]. Additionally, the Scythians produced cannabis for smoking, which they used in ceremonies and buried with them in their tombs [22]. They then transported it to Iran and Anatolia.

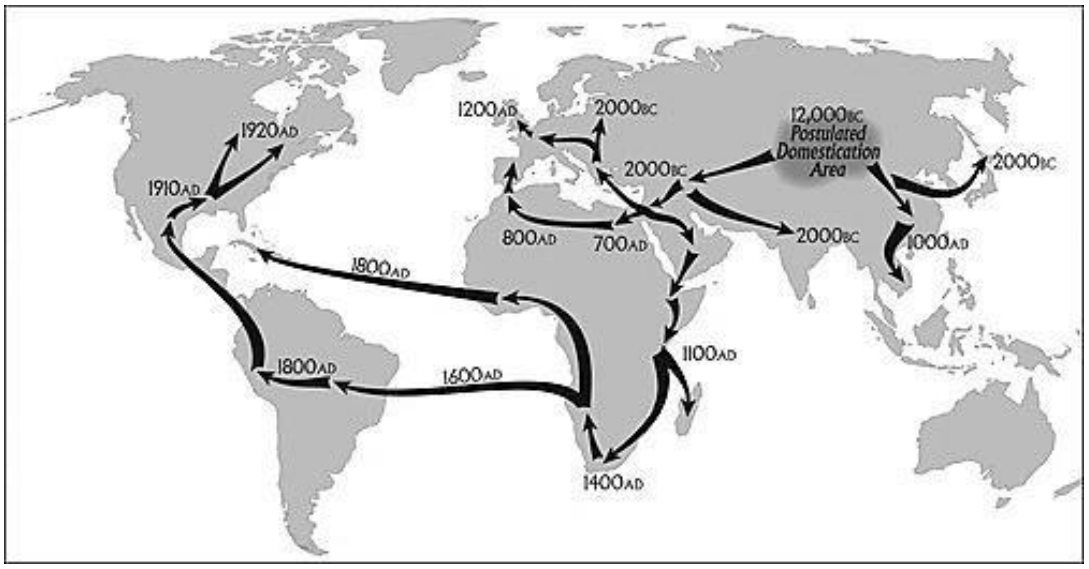

Fig 1. Historical/geographical distribution of *C. sativa* [13].

Hemp was presumably brought by the Scythians into Ukraine and southeast Russia, where they had long-term settlements. Cannabis was first introduced to Eastern Europe by Aryan traders and warriors circa 3000 BC [6]. Cannabis was commonly farmed during the late Saxon and Norman eras, and medieval cannabis seeds have been discovered in York, Norwich, Gloucester, Norfolk, and Scotland [23]. It was brought to England with the Anglo-Saxon invasions of the fifth century AD. From the Middle East, Eastern Europe, or both, cannabis spread to the Greco-Roman world [24].

Cannabis likely entered East Africa through Egypt and Ethiopia, where Arab traders transported it. In the 13th century, marijuana was utilized in Ethiopia [25], where it most likely arrived via trade routes in the Red Sea. Early Christians in Europe's Mediterranean coastal nations were the first to cultivate it, and it later expanded throughout the rest of Europe during the Middle Ages. It was grown in North America a century after it was grown in Chile in the 1500s [26]. Cannabis was not just once but multiple times introduced to Latin America in the 16th century [27], becoming a crucial component of the renowned Colombian Drug Exchange [28].

Russians met the demand for cannabis in Europe; therefore, the British crown looked for alternative sources to lessen its reliance on Russian imports. Everyone in the empire with sixty acres or more of land was mandated to cultivate marijuana by Queen Elizabeth's decree in 1563 or face a fine [29]. For this reason, farmers in the Virginian colony of Jamestown were compelled to plant cannabis; past US presidents George Washington and Thomas Jefferson also had cannabis gardens on their lands. *C. sativa* is almost entirely grown for its fibers in Europe and northern Asia, but in southern Asia, it is utilized as a recreational, cultural, and spiritual medicine. It is generally agreed that the ancestors of *C. sativa* originated in temperate central, western, or perhaps eastern Asia [29; 30; 31].

In a 2021 study comparing the genomes of 110 samples of cannabis from around the world, it was found that *C. sativa* was first domesticated in the East Asian region during the early Neolithic and that all cannabis and pharmaceutical varieties are now ancestrally represented by native plants and native breeds in China. It was stated that it left the pool [32]. In line with this view, the differences in the phytochemical content of the cannabis samples collected from different areas caused them to be defined asdifferent taxa.

To put it briefly, it is largely accepted that *C. sativa* originated in temperate, central, or western Asia, and maybe eastern Asia, and that it expanded to other areas of the world as a result of knowledge of the advantages associated with the plant's many sections [31; 33]. In short, it is assumed that the industrial and medicinal varieties of cannabis were historically selected in different geographical centers. Fig. 1. illustrates how *C. sativa* expanded to other continents over the course of several thousand (1000) years under varied social and political circumstances. As a result of scientific studies, it is known that cannabis production in Anatolia has been occurring since 1500 BC [34; 35]. As a result of the excavations carried out in the Dundar Tepe mound in Samsun, a tool used in rope making was found, which was made from the lumbar vertebrae of a dolphin from the Hittite period [15; 36]. This situation shows us that hemp cultivation has been done in Anatolia since 1500 BC [15; 35]. In the Ottoman Empire, cannabis was commonly used, though less so by Turks than by Arabs [37]. For instance, wine and hashish are mentioned in the epic poem Benk u Bde from the sixteenth century. Similar to Amsterdam, which is now in the Netherlands, marijuana cigarette shops were documented in Istanbul during the height of the empire in the 16th century.

The natural distribution of cannabis in Turkey has been identified as being in Çanakkale, Istanbul, Kırklareli, Tekirdağ, and Burdur, according to the Flora of Turkey. The 'List of Plants of Turkey," established in 2012, indicates that the distribution region is in the sections of Çatalca and Kocaeli (Fig. 2). In some recent studies on cannabis, different and incorrect spellings are reported, such as the plant's families Cannabinaceae and Cannabiaceae. In scientific sources such as Flora of Turkey, International Plant

Name Index (IPNI), www.theplantlist.org [38], and https:// Bizimbitkiler.org.tr [39], it has been clearly stated that the correct name of the family is Cannabaceae.

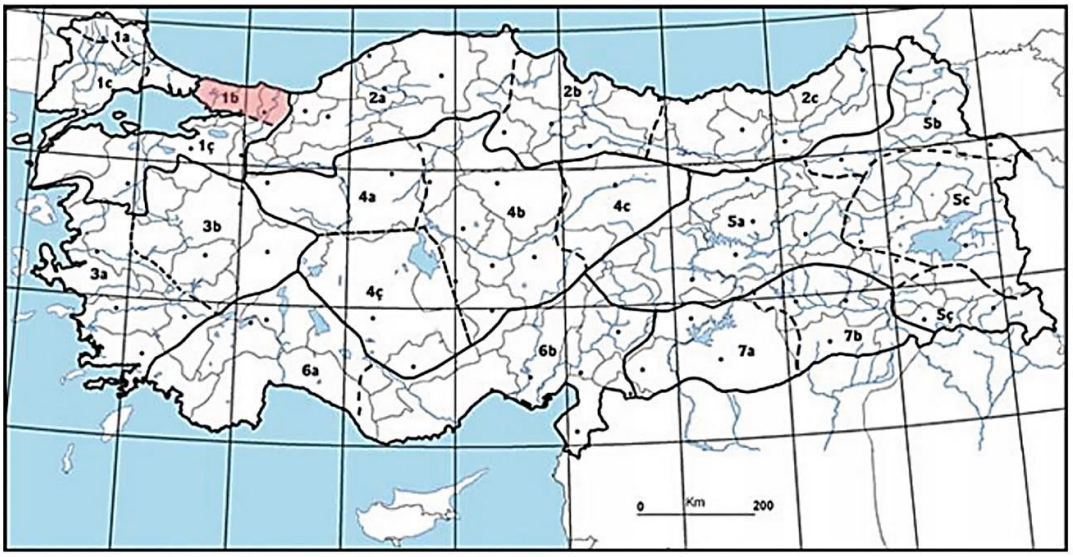

Fig 2. Natural distribution area of *C. sativa* in Turkey [39].

The Systematics of Cannabis

The classification of cannabis in science has gone through several stages in a systematic progression because each plant expresses sex differently and temperature also has a significant impact on phenotypic traits [40]. There are many names for the cannabis plant, but only one of them is currently recognized as a genuine species name, according to literature reviews (Table 1). The cannabis plant shows morphological changes in response to the ecological conditions of the region where it grows, but it has been suggested that these differences are essentially variations [3]. *C. sativa*, an annual herb in the Cannabinoidaceae family, is thought to have originated in central or western Asia, as well as possibly in eastern Asia or India. Looking at the recorded history, it has been determined that it has been used by people for different purposes (food, fiber, and medicine) at different times. Medical cannabis appears to have been discovered in India for therapeutic reasons as early as 900 BC, despite being thought to be a native of Central Asia.

The plant is frequently used for the same tasks, even if it goes by different names in various societies. Carl Linnaeus first classified cannabis in the genus *Cannabis*and family Cannabaceae in 1753 [41; 42; 43; 44].

Table 1. *Scientific names used for the cannabis (Cannabis L.) plant from past to present (www.theplantlist.org, May 10, 2019 [3].*

No.	***Scientific Name***	***Status***
1.	*Cannabis americana Pharm. ex Wehmer*	*Synonymous*

2.	*Cannabis erratica Siev.*	*Synonymous*
3.	*Cannabis faetens Gilib.*	*Synonymous*
4.	*Cannabis foetens Gilib.*	*Synonymous*
5.	*Cannabis generalis E.H.L.Krause*	*Synonymous*
6.	*Cannabis gigantea Crevost*	*Synonymous*
7.	*Cannabis chinensis Delile*	*Synonymous*
8.	*Cannabis intersita Soják*	*Synonymous*
9.	*Cannabis indica Lam.*	*Synonymous*
10.	*Cannabis × intersita Soják*	*Synonymous*
11.	*Cannabis indica var. kafiristanica Vavilov*	*Synonymous*
12.	*Cannabis indica f. afghanica (Vavilov) Vavilov*	*Synonymous*
13.	*Cannabis macrosperma Stokes*	*Synonymous*
14.	*Cannabis sativa var. indica (Lam.) Wehmer*	*Synonymous*
15.	*Cannabis lupulus Scop.*	*Synonymous*
16.	*Cannabis kafiristanica (Vavilov) Chrtek*	*Synonymous*
17.	*Cannabis ruderalis Janisch.*	*Synonymous*
18.	*Cannabis sativa var. macrosperma (Stokes) Asch. & Graebn.*	*Synonymous*
19.	*Cannabis sativa f. chinensis (Delile) A.DC.*	*Synonymous*
20.	*Cannabis sativa f. afghanica Vavilov*	*Synonymous*
21.	*Cannabis sativa f. pedemontana A.DC.*	*Synonymous*
22.	*Cannabis sativa subsp. indica (Lam.) E.Small & Cronquist*	*Synonymous*
23.	*Cannabis sativa subsp. intersita (Soják) Soják*	*Synonymous*
24.	*Cannabis sativa var. ruderalis Janisch.*	*Synonymous*
25.	*Cannabis sativa var. kafiristanica (Vavilov) E.Small & Cronquist*	*Synonymous*
26.	*Cannabis sativa var. monoica Hol.*	*Synonymous*
27.	*Cannabis sativa var. gigantea (Delile ex Vilm.) Alef.*	*Synonymous*
28.	*Cannabis sativa var. kif A.DC.*	*Synonymous*
29.	*Cannabis sativa var. indica (Lam.) E. Small &*	*Synonymous*

	Cronquist	
30.	*Cannabis sativa var. spontanea Vavilov*	*Synonymous*
31.	*Cannabis sativa var. ruderalis (Janisch.) S.Z.Liou*	*Synonymous*
32.	*Cannabis sativa var. praecox Serebr.*	*Synonymous*
33.	*Cannabis sativa var. sativa*	*Synonymous*
34.	*Cannabis sativa var. vulgaris Alef.*	*Synonymous*
35.	***Cannabis sativa L.***	***Valid name***

Cannabis, Humulus, and eight other genera (*Celtis, Pteroceltis, Aphananthe, Chaetachme, Gironniera, Lozanella, Trema,* and *Parasponia*) that were previously categorized as members of the Celtidaceae family have been moved to the Cannabaceae family [45]. In the 18th century, Carolus Linnæus developed the taxonomic nomenclature system, and, as a result of scientific definitions, the genus Cannabis was defined as three different species (*C. sativa* by C Linnæus in 1753, *C. indica* by JB Lamarck in 1785, and *C. rubralis* by DE Janischewsky in 1924). These taxonomic classifications were made by considering mostly classical taxonomy (physical, morphological, chemical, and geographical data). For this reason, it is still not clear whether the genus *Cannabis* consists of a single species or more than one species or subspecies.

Cannabis has been classified as a monotypic genus with a single species, *C. sativa*, based on the enormous variation of quantitative features and the limitless capacity of cannabis plants to cross [46]. As the psychoactive capacity of the plant is reflected by a legal limit when cultivating cannabis, it has recently been reported that classification into species and varieties is dependent on the THC content of the plant [47]. Weakly intoxicating (THC < 0.3%) *C. sativa* ssp. *sativa* (var. sativa) and naturalized herbaceous or wild cannabis (var. *spontanea*), while strongly intoxicating (THC > 0.3%) *C. sativa* ssp. *indica* includes domesticated (var. *indica*) and wild (var. *kafiristanica*) species [48]. However, recently developed studies of genome sequencing and bioinformatics have resulted in more accurate species-level taxonomic assignments. According to recent studies, it has been reported that the genus *Cannabis* has moved away from the previous multi-species framework and points to the genus *Cannabis*, which consists of a wide variety of monotypic species [49]. In this context, the current systematics of hemp are as follows [3; 50]:

Kingdom **: Plantae**
Subkingdom : Tracheobionta
Superdivision : Spermatophyta
Division : Magnoliophyta
Class : Magnoliopsida
Ordo : Rosales
Family : Cannabaceae
Genus : *Cannabis*
Species : *sativa*
Binominal nomenclature **: *Cannabis sativa* L.**

The cannabis plant, which resembles a herbaceous plant in general (Fig. 3), varies in terms of cannabinoid/terpene concentration, appearance, geographic origin, and odor. It is grown for both medical and industrial purposes [51].

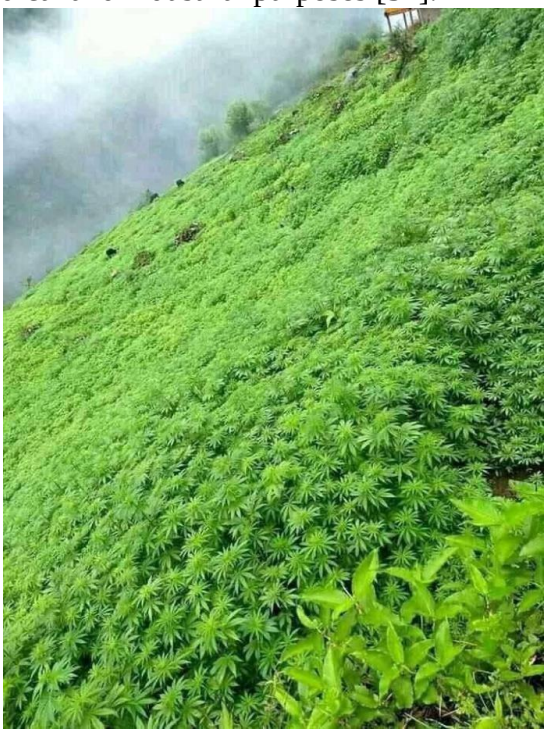

Fig. 3. *Wild form of C. sativa growing in the Himalayan region [51].*

These two varieties differ according to their morphological characteristics, such as stem length, branching shape, leaflets, and flower structures [52]. Understanding the advantages associated with various plant components led to the domestication of cannabis. The plant has several advantages, particularly as a source of fiber [33] and the spread of the plant to other continents due to its pleasing properties. However, according to recent detailed studies, the main reason for the differences between these two populations is ecological factors, and the differences shown by these plants are variations of the same species under different ecological factors [3]. In this case, these plants can be called different ecotypes of the same species.

The Morphology of C. sativa

C. sativa is obligate cross-pollinator because it produces male and female inflorescences on separate plants (dioecious). All medical cannabis (marijuana) plants used for commercial production are genetically female; male plants are eliminated since they have a negative impact on seed output and flower quality [53; 54]. Cannabis, an annual plant, carries out all its biological activities in the same vegetation period, from seed to germination and all stages until it passes back to seed. The morphological structure of male and female plants of *C. sativa* is shown in Fig. 4. [55]. Although the differences between male and female cannabis may seem insignificant in general, it is extremely important to know this distinction in the plants produced. This distinction canonly be made after planting and the growth of the plant. The male plant can be

identified in 2-6 weeks by having larger and thicker stalks. The buds of male and female individuals are different. In male individuals, small nodes replace buds. Where the stem meets the branches, there are flat, round nodes that indicate that the plant is male. Since female individuals are responsible for the formation of fruit or the flowering and growth of buds, their number of leaves is higher [56].

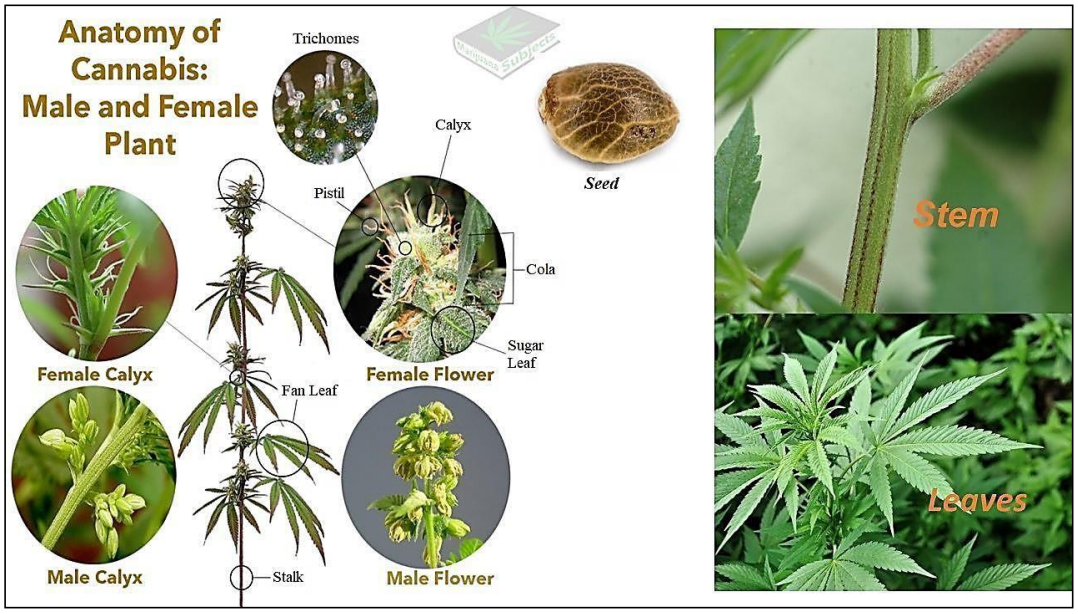

Fig. 4. *Morphological structure of male and female cannabis plants [55].*

Root

Roots, which provide water and nutrients from the soil, are the only plant parts that do not contain psychoactive substances [57]. The root system has a strong taproot that goes deep into the soil, giving it small lateral roots. It is an annual herb growing upright, 1-3 m tall, with a trunk structure covered with lightly branched green-grayish trichomes. Its main stem develops vertically from the root. When the primary root of cannabis, which has a pile root structure, is examined, the epidermis is composed of single-row cells, and the hypodermis layer is just below it. After the cortex, which covers a large area, there is a single-layered endodermis and a pericycle consisting of more than one cell row [58].

Stem/Stalk

The cannabis plant shoot system consists of three regions: **[1] Cola;** The part where most of the buds grow and bloom is called, **[2] The middle part;** It is where some buds, stems, and many sugar leaves are found. The buds in this part are smaller than the buds of the cola and **[3] the base part**; it contains a large amount of fan leaves and very few buds [57]. Industrial hemp varieties are longer than medicinal varieties. The cannabis stem has lateral branches with different morphological regions. It is the primary vascular pathway that naturally carries water and minerals to other tissues by vascular bundles arranged in a ring-shaped formation from the stem roots. It develops from the central stem, called the secondary growth node. Branching occurs in pairs fromnodes on both sides of the stem [3]. Under the epidermis layer, which is in the

outermost part of the stem, there is hypodermis consisting of single cells, endodermis, and chlorenchyma consisting of several cell rows. Some researchers, in the cross- section they took from the cannabis stem, found that the circular and angular xylem is approximately 30-100 microns in diameter, and the thick and lignified xylem fibers are arranged radially [59].

The hypocotyl part is initially round, then four- and six-sided. Although the inner part of the trunk close to the ground is woody, the upper parts are filled with essence and then turn into a hollow shape [34]. The formation of this gap in the stem structure of cannabis occurs with cambium activity. Initially, the center of very young stems is covered with a "core" consisting of undifferentiated cells, but a cavity forms in the middle of the stem because the development of the woody xylem originating from the cambium and towards the center of the stem causes the core to degenerate [29].

Leaves

Leaves are palmate, spirally arranged, with 5-7 leaflets (leaflets 3–7 cm, rarely 11 cm long), with numerous pointed stipules at the base of long, thin petioles, linear-lanceolate, tapering at both ends, and sharply serrated margins [60]. These elliptical leaves usually consist of five leaflets, and the middle leaflet is longer than the others. The number of leaflets in the cultured samples can be up to nine, depending on the growing conditions [3; 61]. The palmate compound leaves of industrial hemp have 5–11leaflets (typically 7-9). The initial pair of leaves on cannabis seedlings are one-foliolate, whereas the second and third pairs are three- and five-foliolate, respectively [61].

Undoubtedly, one of the most characteristic features of a cannabis plant is the palmate-shaped fan leaves emerging from a single point on the petiole (Fig. 4.) [5]. Fan leaves are protruding leaves that appear along the stem, where intense photosynthesis takes place for the entire plant. Most cultivars commonly have five individual fanleaves, sometimes seven or even nine (in industrial cannabis). In the iconic image of a cannabis leaf, the lowest pair of backward leaves are called "spurs" or "Fan leaves" [62]. The leaves, which have a rough appearance, are generally used for medicine, spice, and tea purposes. Since it grows from more than three leaflets that emerge from a single point on the petiole, the leaf blade (also known as the lamina) has compound leaves. The initial pair of symmetrically paired compound leaves on the stalk often only have one lobe [62]. The ecological settings and cultivars in which they are cultivated, however, have a significant impact on the size, number, and shape of the leaves. The upper and bottom epidermal layers of the cannabis leaf have been described as being single-layered when the cross-sections of the leaf are studied [63]. The upper epidermis is said to contain distinctive cystolith hairs with a broad base, and the epidermal cells are said to have wavy anticline walls on the surface. On the surface of the lower epidermis, there are a lot of secretory and cover hairs, as has been expressed. Stomata are believed to be more numerous on the underside of leaves than on the upper surface. Sponge and palisade parenchyma have been said to make up the mesophyll layer [3; 58; 63].

Flower

Cannabis plants are diclinal and sexually dioecious (Fig. 4). Depending on the type of sex, the blooms can form spike-like or branching clusters. Spike-like or branching clusters form in the pistillate plant, but in the staminate plant, branched

clusters form [52]. A small female flower's ovary, styli, and two lengthy stigmatic branches make up the structure. The pollen-receiving portion of the stigmatic branches is made up of the tiny tongues on the stigmas, which serve as landing pads for pollen grains. The structure of the female flower, which consists of an entirely juvenile perianth and a green bract that completely encircles the ovary, is extremely straightforward.

The ovary matures 2-3 days after the male flowers, and is encircled by a green perigonal leaf in the flowers. Contrarily, the male flower has five tepals (sepals and petals are identical), and the five weak, drooping filaments of the stamens are either pale or greenish in hue [29]. The pistillate blooms resemble popcorn in appearance, are hairy and sticky, and have a greenish-yellow tint. Trichomes, which have many hairs, cover the flowers [64]. When a female plant is pollinated, the calyx effectively develops and the ovary takes shape. Female plants blossom lavishly. The calyx turns into a small seed incubator [5]. *Cannabis* plants can have racemous, cymous, or paniculate inflorescences, which express how the flowers are arranged on the stalk [65; 66; 67; 68].

Male individuals, whose main task is to produce pollen, have a very high rate of fulfilling this task. A single bloom has the capacity to produce about 350,000 pollen grains [69; 29]. After three days, cannabis pollen starts to rapidly lose viability; however, some pollen can last for up to a week [70; 29]. Unwanted seed formation results from spontaneous hermaphrodite inflorescences that are accompanied by the development of female flower anthers; the mechanism causing this is not entirely known [53]. In addition, female cannabis flowers are rich in acidic cannabinoids, including Δ9-tetrahydrocannabinolic acid (THCa) and cannabidiolic acid (CBDa) [54].

Small and Cronquist [46] set a threshold for distinguishing between industrial cannabis and medicinal cannabis forms based on the relative dry-weight concentration of THC in the female inflorescences of the plant. Plants that accumulated Δ9-THC levels above 0.3% were considered medicinal cannabis, and plants containing levels below this threshold are considered industrial cannabis in North America. In the European Union, this threshold value is accepted as 0.2% [71; 72]. *C. sativa* is a dioecious plant; however, some of its individuals can be monoecious. The male and female plants in cannabis are separate plants. Male plants have andrekeum in their blooms, while female plants have guinekeum [73].

Pollination

The pollination of the cannabis plant is carried out by the wind (an anemophily) [74]. *C. sativa* subsp. *sativa* var. *spontanea* Vavilov has the potential to be day-neutral, but the majority of cannabis strains are typically short-day plants [75]. While cannabis plants require around 12 hours of darkness to flower, flowering is hampered by longer days. Photoperiodic fluctuations can be controlled if the plant is grown in a protected environment [76; 77]. Cannabis pollen has been noted to travel more than 300 kilometers in the wind [78]. Cannabis pollen is an important allergen for some people, so its presence is often observed. A study carried out in August in the Midwest of the United States (where marijuana cultivation is not permitted but wild cannabis is common) noted that cannabis pollen represented 36% of the total airborne pollen count [79]. However, in a similar study conducted in Texas, it was reported that the pollen count was lower [80]. An isolation distance of approximately 5 km is typically advised for the production of purebred seeds due to the remarkable pollen dispersal of cannabis, which is more than the advised distance for nearly all other crops [81]. Pollen is present

on most of the earth, at least in modest amounts, as a result of widespread clandestine cultivation [29].

Fruit

Cannabis fruit is an achene-type fruit and has an ellipsoid shape [82]. It is greenish-brown with reticulate veining on the surface. Achenes contain a single seed and are also confused as seeds due to their hard shell. The fruit is small, smooth, light brown-gray in color, and completely filled with seeds. The ovary contains a thin-walled,ellipsoid, slightly flattened, smooth, approximately 2–5 mm long, usually brownish and mottled, hard-shelled seed (Fig. 4.) [3]. The seeds are green-gray in color and oval- shaped, 2–5 mm long and 3-3.5 mm wide, and the weight of 1000 seeds is between 20 and 25 g [15].

Glandular Trichomas "Pharmaceutical Factories of Plants"

Plants generally tend to regulate defense by distributing secondary metabolites to tissues. This important and functional tissue in hemp is the female flower. The flowering stage of high-performing cannabis varieties allows cannabinoid-containing structures to form dense trichomes (Fig. 5.). On the aerial parts of many plant species, there are very small epidermal hairy outgrowths called "trichomes", which are generally thought to be protective against diseases and pests [7]. In higher plants, glandular trichomes are morphologically represented in three different ways: bulbous, hairy, and capitate types (53). Bulbous, peltate, and capitate types have been previously described in *C. sativa* [83].

Briosi and Tognini [84] published the first comprehensive study on the cannabis plant, which has an abundance of glandular hairs, in the literature. Important sources of terpenes and cannabinoids are glandular capitate trichomes, which are generated in the bract tissues of female *C. sativa* inflorescences with high THC levels [85]. Although glandular hairs, which are more common in female cannabis plants, are mainly associated with flower structures, these hairs are sometimes found on the young plant stem and lower epidermis of leaves [29]. Glandular trichomes develop during thecannabis flowering period. While the flowers mature, resulting in an overall increase in numbers over time, there are also different developmental stages observed at any given time. In the later phases of flowering (6–8 weeks), the bulk of trichomes change into a stalked-capitate type [85]. The produced substances not only support plants as preservatives but also provide benefits for humans as natural pesticides, food additives, perfumes, and pharmaceuticals [86].

The plant produces cannabinoids, a distinct class of terpene-phenolic chemicals. There are 120 phytocannabinoids out of the 565 cannabis components that have been identified from *C. sativa* to date [7]. THC and CBD, which are mostly found in *C. sativa*'s flowers and leaves, are two of the cannabinoids that are often the most prevalentsecondary metabolites in the plant [52]. Female flower bracts contain the majority of cannabinoids in their trichomes [87]. Cannabinoids are present in small quantities in the plant's seed, seed oil, and pollen and at much lower concentrations in the root, shoot, and leaf tissues. In light of recent findings about the therapeutic effects of cannabis and cannabinoids, as well as their potential applications in the treatment of a number of serious illnesses, including depression, neuralgia, glaucoma, Alzheimer's, multiple

sclerosis, and the alleviation of symptoms of HIV/AIDS and cancer, the quest for a deeper understanding of the systematic, biological, chemistry, and medicinal properties of this plant has gained momentum [7].

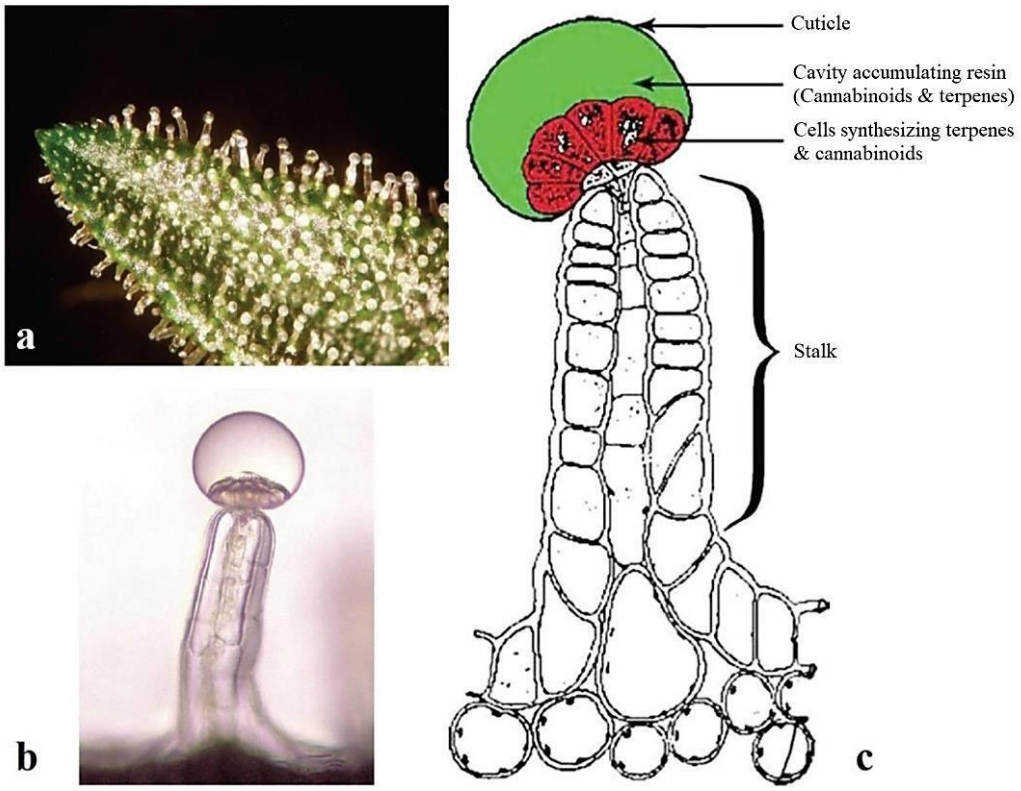

Fig. 5. a. *Development of trichomes on the bract tissues of inflorescences;* ***b.*** *the capitate stalked trichome;* ***c.*** *a longitudinal section of a trichome (modified from Small [29]).*

RESULTS and FUTURE PROSPECTS

Numerous studies have been conducted on the cannabis plant over the years. It has been grown in various regions of the earth since antiquity for use in various or related contexts. However, due to the fact that they looked different depending on the ecological conditions of the regions where they were cultivated, they were named in different ways. Ecological factors are important factors that can cause significant differences in the vegetative organs of plants. Vegetative characteristics like plantheight, leaf size, and pubescence may significantly shift in populations of the same species residing in regions with varied ecological variables. The underlying causes of this issue come from research on plant culture and the growing of plants in various ecologies. The cannabis plant, which has been cultivated for thousands of years and has a variety of applications, inexorably exhibits distinct morphological structures, according to the studies reported. Plants were first cultivated, and then these cultivated plants were moved to different regions, which resulted in the escape of cultured life to

natural life in each region, the emergence of intermediate forms between culture and natural forms, and the appearance of populations that diverge from one another at particular rates. These distinctions are regarded as variants if they do not appear in the more conserved and easily recognizable generative elements. In other words, these modifications just suggest that definition of the species should be broadened rather than resulting in the formation of a new species or subspecies taxon. For the reasons we have stated, although the cannabis plant is expressed as medical cannabis and industrial cannabis, they are the same species scientifically, and its scientific name, *C. sativa* L., is the only accepted name. All of the species and subspecies names given to this plant at different times are now accepted as synonyms for *C. sativa*. To summarize, *C. sativa* is considered to be monotypic (occurring as a single species), but debate continues regarding its polytypic nature (33). Although cannabis was among the banned cultivation products in the past due to its different uses and being natural, many countries have lifted this ban due to the excess of positive usage areas and the spread of their culture. In addition to its medicinal use, the fact that each part of it, from its root toits flower or seed, has more than one use in many fields of industry, makes this plant important in terms of its economic return. The production of pharmaceutical products such as CBD oil, which is not harmful to health, in many industries, and especially the production of hemp, is an important feature of this species that should be emphasized. This plant belongs to the cosmopolitan group, i.e., it has non-specific habitat requirements and high competitive power and can be grown in many parts of the world. For the reasons we have stated, we think that especially developing countries will havea great advantage in focusing on the culture of this plant and bringing it into their economies as an economic income source.

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Contributions of Authors
Mehmet Fidan: Visualization, conceptualization, writing—original draft preparation, writing—review and editing, final manuscript reading
Veysel Süzerer: Visualization, writing—original draft preparation, writing—review and editing, final manuscript reading
Ahmet Onay: Review and editing, supervision, final manuscript reading

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