The American Journal of Agriculture and Biomedical Engineering
ISSN 2689-1018 Volume 08 - 2026

Biology And Significance Of Cannabis Sativa L.

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Received: 12 Mar 2026 | Received Revised Version: 11 Apr 2026 | Accepted: 24 Apr 2026 | Published: 18 May 2026

Volume 08 Issue 05 2026 | Crossref DOI: 10.37547/tajabe/Volume08Issue05-03

Abstract

This article examines the biological characteristics, morphology, karyotype, and legal status of Cannabis sativa L. in Uzbekistan. The structural and functional features of the root system, stem, leaves, flowers, fruits, and seeds are comprehensively described. Particular attention is given to cytogenetic characteristics, including the organization of metacentric and submetacentric chromosomes, nucleolar organizer regions, and the chromosomal mechanism of sex determination. Biological and morphological distinctions among Cannabis sativa, Cannabis indica, and Cannabis ruderalis are comparatively analyzed. In addition, the regulatory framework governing the cultivation and utilization of industrial cannabis in the Republic of Uzbekistan, together with international practices, is reviewed. The study emphasizes that modern genomic and biotechnological approaches considerably expand the potential applications of cannabis in medicine, industry, and agriculture.

Keywords: Cannabis sativa, biology, morphology, karyotype, industrial cannabis, tetrahydrocannabinol (THC), breeding, Uzbekistan.

Cite This Article: M.K. Mutalova. (2026). Biology And Significance Of Cannabis Sativa L. The American Journal of Agriculture and Biomedical Engineering, 8(05), 11–14. https://doi.org/10.37547/tajabe/Volume08Issue05-03

1. Introduction

Cannabis sativa L., a member of the Cannabaceae family, is among the oldest cultivated plant species utilized by humans for more than 10,000 years (Clarke and Merlin, 2013). Central Asia and China are regarded as the primary centers of origin of cannabis, as archaeological evidence confirms its ancient utilization in these regions (Russo et al., 2008). At present, cannabis is distributed across all continents and is cultivated under temperate, subtropical, and tropical climatic conditions.

Scientific interest in cannabis has increased substantially during recent decades due to the recognition of its pharmaceutical value and the rapid progress achieved in genomics and molecular biology (Sawler et al., 2015). Moreover, the plant possesses several complex biological characteristics, including dioecy, photoperiod sensitivity, and extensive diversity of secondary metabolites, making it an important model for botanical and genetic investigations.

Currently, the Laboratory of Population Genetics of Technical Crops at the Institute of Genetics and Experimental Plant Biology of the Academy of Sciences of Uzbekistan has initiated research on cannabis within the framework of the state-funded project entitled “Investigation of the Genetic Basis of Population Composition According to Morphological and Agronomic Traits in Technical Crops.”

TAXONOMY AND SYSTEMATICS

The genus Cannabis belongs to the family Cannabaceae

and comprises annual herbaceous plants widely recognized as fiber- and oil-producing crops. Central Asia is considered the center of origin of cannabis, and archaeological evidence indicates that it has been cultivated for fiber and oil production since the first millennium BCE (Clarke & Merlin, 2013). Today, cannabis is widely distributed across temperate, subtropical, and tropical regions worldwide.

Three closely related taxa are generally distinguished:

Cannabis sativa L. This species is primarily cultivated for fiber production in Russia, Belarus, Ukraine, Western Europe, and India. Wild populations occur throughout Mongolia, Afghanistan, Pakistan, India, and China. Plants are typically tall (up to 3–6 m), possess narrow leaves, and contain relatively low concentrations of tetrahydrocannabinol (THC).

Cannabis indica Lam. This species is cultivated mainly in Iran, Turkey, Syria, and neighboring Middle Eastern countries for oil extraction from seeds and for the production of hashish and marijuana from leaves, stems, and female inflorescences. Wild populations are widespread in Central Asia, Afghanistan, and Pakistan. Plants are shorter in stature (0.5–1.5 m), characterized by broader leaves and elevated THC content.

Cannabis ruderalis Janisch. This taxon commonly occurs as a weed in Central Asia, Western Siberia, and the Volga region. It is characterized by low stature, low cannabinoid content, and the ability to flower independently of photoperiod (autoflowering). Consequently, C. ruderalis is widely used in breeding programs as a donor of the autoflowering trait.

MORPHOLOGICAL CHARACTERISTICS

Root System: Cannabis possesses a well-developed taproot system that distinguishes it from many other annual crops. The primary root may penetrate 60–90 cm or deeper into the soil (Small, 2015). Lateral roots spread extensively within the upper soil layers, ensuring efficient nutrient absorption and anchorage. Root development is strongly influenced by soil texture, aeration, and moisture availability. Soil compaction or excessive waterlogging significantly impairs root respiration and negatively affects plant productivity.

Stem: The stem is erect, robust, and hollow internally, providing both flexibility and mechanical strength. Stem diameter ranges from 1 to 6 cm depending on genotype. Plants generally possess 7–8 internodes and exhibit relatively high requirements for warmth and moisture. The stem surface is covered with glandular trichomes secreting resinous essential oils that protect the plant against insects and desiccation. The outer stem tissues contain long and durable bast fibers of substantial industrial value. Plant height varies from 0.5 to 6 m, while the vegetation period ranges from 65 to 160 days according to cultivar characteristics.

Leaves: Cannabis leaves represent one of the most diagnostically important morphological traits of the species. Leaves are arranged oppositely or alternately along the stem and exhibit a palmately compound structure. Each leaf usually consists of 7–9 lanceolate leaflets, although the number may vary from 3 to 13. Leaflets are deeply serrated and covered with trichomes on both surfaces. These glandular trichomes synthesize and accumulate cannabinoids and terpenoids. Considerable variation exists among subspecies and cultivars: indica forms typically possess broader and darker leaves, whereas sativa forms exhibit narrower and elongated leaflets.

Flowers: Cannabis is predominantly a dioecious species in which male and female flowers develop on separate plants. Inflorescences are racemose; female flowers form compact clusters within leaf axils, whereas male flowers are located terminally on lateral branches. Flowering generally lasts 15–25 days, and male flowers usually open 4–7 days earlier than female flowers, thereby reducing the probability of self-pollination.

Male flowers are yellowish-green and consist of five tepals and five stamens. Following pollination, male plants rapidly senesce and die.

Female flowers are small and green, possessing two elongated stigmas. After pollination, female plants substantially increase cannabinoid accumulation and remain physiologically active until seed maturation.

Fruits and Seeds: Botanically, the fruit of cannabis is an achene, commonly referred to as a seed. The fruit is smooth, one-seeded, and frequently exhibits reticulate surface ornamentation, with a diameter of 2–5 mm. The weight of 1,000 seeds ranges from 10 to 26 g depending on genotype.

Seeds display high tolerance to low temperatures: germination begins at 1–2°C, active seedling emergence occurs at 8–10°C, and seedlings can withstand frosts down to –5 or –6°C. Optimal growth temperature ranges between 19 and 25°C.

Seeds contain 25–35% oil and 20–25% protein and possess nutritionally valuable omega-3 and omega-6 fatty acids in an approximately optimal 3:1 ratio. Under favorable storage conditions, seed viability may be maintained for 3–5 years.

KARYOTYPE CHARACTERISTICS

Metaphase cells derived from root tips of both male and female plants contain numerous polyploid cells. Cannabis chromosomes are relatively small, ranging from 2.6 to 3.8 μm in length, and not all chromosomes can be clearly distinguished according to size and centromere position (Divashuk et al., 2014).

The autosomal complement consists of eight pairs of metacentric chromosomes and one pair of submetacentric chromosomes carrying nucleolar organizer regions (NORs) and satellites. According to chromosome length and arm ratio, chromosomes are arranged as pairs 1–9.

The haploid karyotypic formula of C. sativa is:

Male plants: 8m + 1sm(SAT) + X_m/Y_m, Female plants: 8m + 1sm(SAT) + X_m

These findings confirm that C. sativa possesses an XY chromosomal sex-determination system.

INDUSTRIAL AND MEDICINAL IMPORTANCE

Cannabis fibers are localized within the stem bark and are characterized by high durability, coarse texture, and water resistance. Stem tissues may contain up to 27% fiber, which is utilized for the production of coarse textiles, ropes, sacks, and industrial materials.

Seeds contain approximately 30–35% oil and 18–23% protein. Cannabis oil is extensively used in confectionery production, food processing, paint and varnish industries, and soap manufacturing. Seed cake serves as valuable livestock feed.

The crop exhibits particularly high water demand during budding and flowering stages. For fiber production, cannabis is cultivated in dense stands, whereas wider row spacing is employed for seed production. Fiber harvesting is performed during the flowering stage, followed by retting, drying, and fiber extraction.

INTERNATIONAL EXPERIENCE AND LEGAL REGULATION

Currently, industrial cannabis is cultivated and processed for industrial purposes in more than 40 countries worldwide. China, France, Canada, Australia, and Chile are among the leading producers and processors of industrial cannabis.

Different countries regulate allowable tetrahydrocannabinol (THC) concentrations as follows:

Country	Permissible THC Content
China, Czech Republic	up to 0.3%
Italy, Hungary, Sweden, Belgium	up to 0.2%
Russian Federation	up to 0.1%
Uzbekistan	up to 0.2%

In the Republic of Uzbekistan, the Resolution of the Cabinet of Ministers dated December 7, 2020, established regulatory measures governing the cultivation and utilization of cannabis for industrial purposes unrelated to narcotic or psychotropic substance production. According to this regulation, cannabis-derived products containing THC concentrations exceeding 0.2% are subject to confiscation and destruction in accordance with established legal procedures.

CONCLUSION

The biology of Cannabis sativa L. is highly complex and multifaceted. Its distinctive morphological features, sophisticated physiological processes, dioecious reproductive system, photoperiod sensitivity, and broad ecological adaptability make cannabis an invaluable model for botanical, genetic, and pharmacological research.

The integration of modern genomic and biotechnological approaches provides new opportunities for a deeper understanding of cannabis biology and for expanding its applications in medicine, industry, and agriculture. Future investigations focusing on cytogenetics, molecular breeding, and metabolomic profiling will contribute significantly to the development of high-value industrial

and medicinal cannabis cultivars.

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