Chapter 1
Hemp (*Cannabis sativa* L.)-Taxonomy, Distribution and Uses

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Abstract *Cannabis sativa* L. (Family: Cannabaceae) is reported as one of the oldest cultivated crops for various purposes such as food, medicine and fiber. It is believed to be originated in central Asia around northwest Himalayas and has spread around the world. It is documented to be used as medicine in India and China for almost six thousand years. However, due to the presence of psychoactive tetrahydrocannabinol (THC) compounds such as (-)-*trans*-$\triangle^9$-tetrahydrocannabinol ($\triangle^9$-THC) and (-)-*trans*-$\triangle^8$-tetrahydrocannabinol ($\triangle^8$-THC), its cultivation and use is restricted/regulated in many countries. On the other hand, cannabidiol (CBD) oil is gaining a lot of attention in recent years for various medicinal purposes such as the treatment of chronic pain and opioid dependence. Apart from the highly disputed medicinal purposes, hemp seeds are used as food and nutritional products in various cultures around the world. Similarly, the oil obtained from the seeds is used as edible oil and other purposes. One of the main industrial use is the production of high-quality fiber from the stem bark used in textiles, clothing, papers, building materials and biofuel. This chapter covers the history, taxonomy, distribution and current uses and future potentials of hemp as sustainable agricultural crop.

Keywords *Cannabis sativa* · Hemp · Tetrahydrocannabinol · Cannabidiol · Fiber · CBD oil

1.1 Introduction

Cannabis sativa L. (Family: Cannabaceae) (Fig. 1.1) is reported as one of the oldest cultivated crops for various purposes such as food, medicine and fiber (Hillig 2005; Żuk-Gołaszewska and Gołaszewski 2018). It is an annual herb of about 2 m in height and propagated by seeds (Fig. 1.2). It is believed to be originated in central Asia around northwest Himalayas and has spread around the world. It has been reported

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T. Belwal and N. C. Belwal (eds.), *Revolutionizing the Potential of Hemp and Its Products in Changing the Global Economy*,
https://doi.org/10.1007/978-3-031-05144-9_1

Fig. 1.1 Photographs of *Cannabis sativa* plant (Photos by Basu Dev Neupane, Nepal)

Fig. 1.2 Photographs of fruits and seeds of *Cannabis sativa* (Photos by Basu Dev Neupane and Prakash Poudel, Nepal)

to be used in India and China for almost six thousand years as medicine (Hillig 2005; Liu et al. 2017). It was later introduced to Europe around 3500 years ago and to Africa around 2000 years ago by nomadic tribes and traders from Central Asia (Hillig 2005). It is highly regarded as an important medicinal plant in many countries (Watanabe et al. 2005).

Due to wide spread use of various parts of the plant, it had become one of the significant crops in the ancient times. Leaves are used as traditional medicines in many Asian countries for the treatment of diarrhea, dysentery, wounds, etc. However, due to the presence of psychoactive tetrahydrocannabinol (THC) compounds such as (-)-*trans*-$\triangle^9$-tetrahydrocannabinol ($\triangle^9$-THC) and (-)-*trans*-$\triangle^8$-tetrahydrocannabinol ($\triangle^8$-THC) (Fig. 1.3), its cultivation and use are restricted/regulated in many countries. Some varieties of *C. sativa* having low content of THC are cultivated to obtain cannabidiol (CBD) oil from leaves and flowers rich in (-)-*trans*-cannabidiol, hemp seed oil from the seeds and fiber from the stem bark. Such low THC-content and high

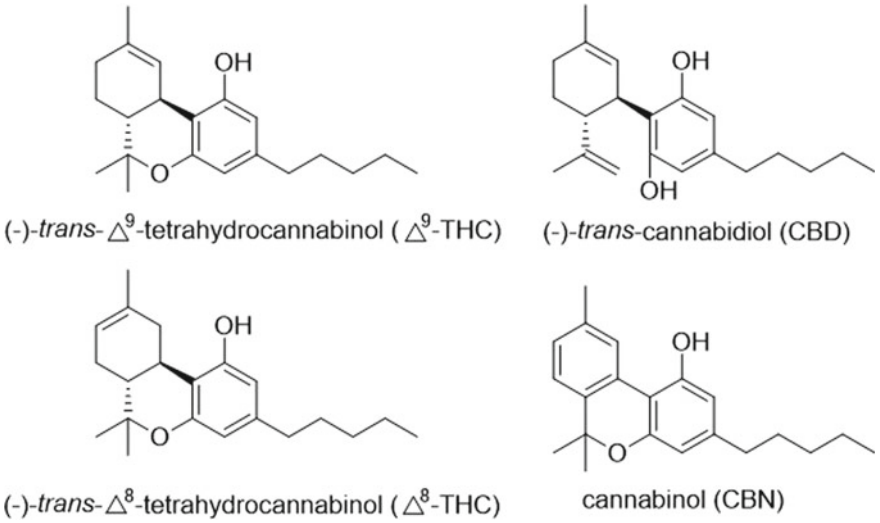

Fig. 1.3 Chemical structures of main compounds of *Cannabis sativa*

CBD content varieties usually cultivated for production of fiber are commonly known as hemp and those with high THC contents are known as marijuana (Hazekamp 2018). CBD oil is gaining a lot of attention in recent years for various medicinal purposes chronic pain and opioid dependence, however researchers have been cautious about their standardization and regulation as the contents in marketed products vary from one product to another (Hazekamp 2018; VanDolah et al. 2019). The Controlled Substances Act (CSA) of 1971 had restricted the cultivation and sell of *C. sativa* in USA. However, the Agricultural Act of 2014 allowed higher education institutions and State Department of Agriculture for the growing or cultivation of industrial hemp, i.e. *C. sativa* plants parts with no more than 0.3% of $\triangle^9$-THC content on dry weight basis, for the research purposes (VanDolah et al. 2019). Cultivation of hemp is restricted by law in many other countries and few regions/countries have their own regulation for the content of THC. For example, in Canada, it is allowed to contain up to 3% of THC. The European Union allows up to 0.2% and Switzerland allows up to 1% of THC content (Hazekamp 2018).

Small (2015) has reported an interesting summary of *C. sativa* use, domestication and cultivation by humans. Along with human utilization, it has been evolved as one of the most useful and controversial plant species (Small 2015; Cerino et al. 2021). Hundreds of vernacular names have been used for *C. sativa* such as weed, hemp, marijuana, *Ganja*, *Bhang*, etc. As explained earlier, hemp is the name commonly used for the cultivar grown for obtaining the fiber having low contents of THC and marijuana is the common name for the cultivar used for euphoric and therapeutic properties having high contents of THC (Small 2015; Cerino et al. 2021). Hempseed is the common name for the seeds used to obtain oil for various purposes.

Apart from the highly disputed medicinal purposes, hemp seeds are used as food and nutritional products in various cultures around the world (Manandhar 2002; Cerino et al. 2021). Similarly, the oil obtained from the seeds is used as edible oil and for other purposes. One of the main industrial use is the production of high-quality fiber from the stem bark used in textiles, clothing, papers, building materials and biofuel (Adesina et al. 2020).

1.2 Taxonomy

The taxonomy of *C. sativa* is disputed as some authors consider it as a monotypic and others as polytypic one. Carl Linnaeus first named *Cannabis sativa* L. as monotypic genus. Later, other species were assigned such as *C. indica* was assigned for a specimen collected from India and *C. ruderalis* was assigned for a specimen from Russia (Pollio 2016). After 1970s, there have been many publications which assign *Cannabis* as monospecific or polyspecific genus (Pollio 2016; Cerino et al. 2021). While some authors argued that *C. indica* to be a variety of *C. sativa*, Schultes et al. described it as a separate species (Schultes et al. 1974). Later in 1976, based on the fruit morphology analysis and contents of THC, Small and Cronquist proposed that *Cannabis* is actually a monospecific genus with two subspecies i.e. (i) *C. sativa* subsp. *indica* and (ii) *C. sativa* subsp. *sativa* and four varieties i.e. (i) *C. sativa* L. subsp. *sativa* var. *sativa*, (ii) *C. sativa* L. subsp. *sativa* var. *spontanea* Vavilov; (iii) *C. sativa* L. subsp. *indica* Small and Cronquist var. *indica* (Lam) Wehmer and (iv) *C. sativa* L. subsp. *indica* Small and Cronquist var. *kafiristanica* (Vavilov) Small and Cronquist (Small and Cronquist 1976). Later in 2005, Hillig proposed that *Cannabis* is a polytypic genus with three species *C. sativa*, *C. indica* and *C. ruderalis* and seven putative taxa based on genetic analysis of the 157 samples collected from various geographical regions around the world (Hillig 2005).

However, many authors have also commonly mentioned two varieties of *C. sativa* i.e. *C. sativa* var. *sativa* commonly known as industrial cannabis/industrial hemp and *C. sativa* var. *indica* commonly known as medicinal cannabis or medicinal marijuana (Żuk-Gołaszewska and Gołaszewski 2018). Some other publications also refer them as subspecies not varieties i.e. *C. sativa* subsp. *sativa* (hemp) and *C. sativa* subsp. *indica* (marijuana) (Lim et al. 2021). Thus, the taxonomy of *C. sativa* has been always a topic of discussion among researchers due to its high market value and regulatory factors.

1.3 Global Dispersal, Distribution and Cultivation

Although the indigenous range is believed to be Central Asia, the northwest Himalayas and possibly China (Hillig 2005), *C. sativa* is widespread all around the world specially in temperate zones. It is cultivated and naturalized in most temperate

and tropical areas of the world between 200 and 2700 m (Watanabe et al. 2005). Worldwide distribution map of *C. sativa* is presented in Fig. 1.4. (GBIF 2021).

For at least 6000 years, *C. sativa* has been transported and cultivated in various parts of the world by humans and thus is widespread out of its original range (Small 2015; Liu et al. 2017) which is also supported by many archaeological discoveries. In historic times, it was cultivated mainly as the source of fiber, oil, paper and clothing. It was cultivated widely in Europe in between sixteenth and eighteenth century (Żuk-Gołaszewska and Gołaszewski 2018). Both wild and cultivated varieties grow in open and sunny areas however few wild ones were also found to be growing in shaded places (Small and Cronquist 1976; Small 2015). Several factors such as phenotypic plasticity and resistance to insect damage may have resulted into widespread distribution of *C. sativa* (Small 2015). However at current times, due to strict regulation on the cultivation and use, the permitted verieties for cultivation, their cultivation condition and utilization depend upon these countries' legal frameworks.

According to Adesina et al. (2020), it is now legal to cultivate hemp in 46 states in USA and it is cultivated for scientific or commercial purposes in at least 46 states. Various researchers are now focusing their studies to understand the optimal cultivation conditions for cultivation of hemp to obtain high quality fiber and products for food, nutritional and other purposes.

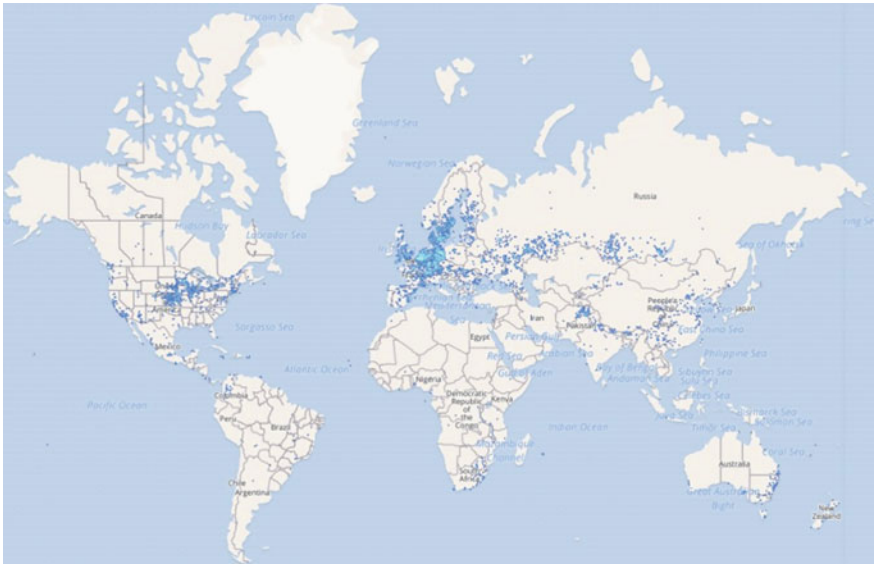

Fig. 1.4 Global distribution of *Cannabis sativa* (GBIF 2021)

1.4 Uses

Hemp has been reported to be used in China and India for almost six thousand years as medicine (Hillig 2005; Liu et al. 2017) and its various uses has made it one of the significant crops in the ancient times. Various plant parts of hemp are used for diverse purposes from food and medicine to fibers which are discussed in detail in following subsections.

1.4.1 Use as Traditional Medicine, Food, Cosmetics and Others

Cannabis sativa has long history of being used as traditional medicine in various countries. Mainly seeds were used in traditional medicines in China by mixing with other herbs to treat constipation (Liu et al. 2017). In Ayurveda, the dried leaves, known as *Vijaya*, are used in many traditional formulations. It is locally known as *Ganja* or *Bhang* in Nepal and the seeds are roasted and used to make pickle. People also chew roasted seeds. Paste of leaves is applied in cuts and wounds. Juice of the leaves is reported to be used in the treatment of diarrhea and dysentery. Leaves are mixed with animal feed to treat diarrhea and dysentery in animals. Leaves are also used as anthelmintic (Manandhar 2002). Leaf juice is used to stop bleeding from cuts and the paste of inflorescence is used to get relief from stomach pain and diarrhea. Resinous exudations of the stem, young leaves and flower buds is used to treat headache, cough, asthma and pain (Watanabe et al. 2005). In Japan, leaves were traditionally used for their pain-relieving properties, however, its use is prohibited now under the law. The seeds known as *Masinin* are used in the treatment of constipation and cough. Seeds are also one of the important ingredients included in a traditional Kampo formulation *Mashiningan* and a famous spice known as *Sichi-mi-togarashi* (Mitsuhasi et al. 1988). Hemp seeds are also used widely in China as food where roasted ones are still sold in markets. They are used as snack and by making porridge along with the edible seed oil (Liu et al. 2017).

Hemp seeds contain about 28–35% oil depending upon various factors such as plant variety, environmental factors, cultivation conditions, etc. (Rezvankhah et al. 2019). Hempseed oil is rich in polyunsaturated fatty acids (70–80%) and have unique ratio of 3:1 of omega-6 and omega 3-fatty acids (Smeriglio et al. 2016; Rezvankhah et al. 2019). Due to being rich in α-linolenic acid and γ-linolenic acid, hempseed oil has received great attention for various applications from foods to cosmetics (Cerino et al. 2021). The oil is also rich in tocopherols having the total tocopherol contents of 832.61 and 927.67 mg/kg for oils obtained by Soxhlet extraction and microwave assisted extraction (MAE), respectively (Rezvankhah et al. 2019). Hempseed oil is also rich in various antioxidant polyphenolic compounds. The methanol extract of the cold-pressed oil obtained from the Finola cultivar of *C. sativa* contained various antioxidant compounds such as phenolic acids (gallic acid, protocatechuic acid,

vanillic acid, chlorogenic acid, etc.) and flavonoids belonging to different subgroups including flavonols (e.g. quercetin and kaempferol glycosides), flavanones (eriodictoyl, naringenin, naringin, etc.), isoflavones (diazein, genistein), flavone (apigenin) and flavanols (catechin, epicatechin) (Smeriglio et al. 2016).

Hempseed oil is used for various purposes from as cooking oil to an ingredient in cosmetic formulations, detergents, soaps, lighting, lubricants, etc. Recent studies are also focused to explore its potential as a source of biofuel (CAB International 2021; GBIF Secretariat 2021; Cerino et al. 2021).

1.4.2 As Therapeutic Agent in Modern Medicine

Cannabis sativa has multipurpose application in medical and pharmaceutical field. Hundreds of compounds have been reported from this plant including cannabinoids, phenolic compounds and terpenes (Andre et al. 2016). Psychoactive tetrahydrocannabinol (THC) compounds such as (-)-*trans*-$\triangle^9$-tetrahydrocannabinol ($\triangle^9$-THC) and (-)-*trans*-$\triangle^8$-tetrahydrocannabinol ($\triangle^8$-THC) have received widespread attention due to their both therapeutic potential and narcotic properties. More than 100 cannabinoids are reported which include both psychoactive ones and non-psychoactive such as cannabidiol (CBD) derivatives. The content of THC and CBD derivatives is reported to be inversely proportional (Small 2015). Small and Cronquist (1976) had proposed 0.3% content of THC as a differentiating factor for *C. sativa* subsp. *sativa* (<0.3% THC) and *C. sativa* subsp. *indica* (>0.3% THC) for dry inflorescence or young infructescence. However, other than genetic factors, their contents also vary depending upon the plant part, flowering stage of the plant, cultivation conditions, etc.

Hundreds of preclinical and clinical studies have been published regarding the therapeutic benefits of *C. sativa*-based products for pain management, multiple sclerosis, injury, cancer, diabetes, mental health condition, etc. various systematic reviews have also been published. Pratt et al. (2019) analyzed the published systematic reviews on medical benefits of *Cannabis* products and concluded that the outcomes of these reviews were not sufficient to draw a conclusion on their therapeutic benefit. Similarly, Lim et al. (2021) systematic review of clinical and preclinical research articles about the potential therapeutic benefits of hemp products in various conditions such as dependence, anxiety and constipation and reported that the finding in these studies were not sufficient to provide clinical evidence. Based on the analysis of systematic reviews of randomized trials, Riera et al. (2022) reported that cannabinoids were not therapeutically effective in pain management, but had some benefits in chemotherapy induced nausea and vomiting.

Non-psychotic compounds such as cannabidiol are receiving increasing attention in recent years for their medicinal purposes in management of opioid dependence, pain, cancer, anxiety, etc. The most commonly available formulation is CBD oil (also known as hemp oil) in which the extracts of flowers or leaves of industrial hemp are dissolved in edible oils (Hazekamp 2018; VanDolah et al. 2019). In general, the

content of THC in CBD oils should be below 0.3% and the content of CBD about 12–18% (VanDolah et al. 2019). But, the analysis of various marketed CBD oils samples has shown very high content of THC and researchers have been recommending strong guidelines for the standardization and regulation of these products (Hazekamp 2018; VanDolah et al. 2019). Various natural and synthetic derivatives of CBD are being investigated in pre-clinical and clinical studies to understand their mechanism of action, therapeutic potentials, adverse effects and safety profiles (Morales et al. 2017; Nelson et al. 2020).

1.4.3 As Source for Fiber for Various Purposes

Use as fiber is considered to be one of the oldest uses of hemp plant and many archaeological discoveries from China support its use in textile even before the introduction of cotton (Liu et al. 2017). The long and strong fiber in hemp was traditionally used for rope, sails, tarpaulin, canvas bags, clothes and sacs (Watanabe et al. 2005). In recent years, the growing interest in renewable biomass has resulted into the great emphasis on industrial hemp, a fast-growing herbaceous plant, as a potential source of biomass. Fibers obtained from hemp are also used as substitute of glass fibers and to produce bioplastics (Andre et al. 2016). Hemp fiber was also used traditionally to make paper (Liu et al. 2017). Petit et al. (2020) reported that the quality of hemp fiber was affected by environmental factors such as temperature, cultivation conditions and water availability along with genetic factors. Proper understanding of these factors may help in optimal cultivation condition of hemp for obtaining high quality multi-purpose fiber.

1.5 Conclusion

Hemp (*C. sativa*) is one of the oldest cultivated plants and has been used by humans for various purposes from medicinal to food and fiber. Long history of utilization and cultivation by humans has resulted in various verieties of this plant with varying contents of THC and CBD. Strict regulation on the cultivation and use of the products obtained from the plant specially the cultivars with high THC content has resulted in extensive research on the cultivars with low THC content to be used as a source of fiber, CBD oil and hempseed oil along with other non-therapeutic purposes. Further research is necessary to understand the therapeutic benefits of hemp-base products in human health. However, it has high market demand for food and nutraceutical properties of hempseed oil and the wide application of fibers from stems in textiles, fabrics, composites and biofuels. Evidence based regulatory practices, innovations in plant cultivation and product formulations, standardization of the products and commercialization can contribute to global economy and sustainable development.

Acknowledgments Author would like to thank Mr. Basu Dev Neupane and Mr. Prakash Poudel for providing photographs used in this book chapter.

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