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Cannabis sativa: Botany, Cross Pollination and Plant Breeding Problems

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Abstract: This review paper highlights about the Cannabis botany, problems of cross pollination, lack of Germplasm collection and absence of Genebank facilities have been discussed. Cannabis is a dioecious species, meaning that male and female flowers are borne on separate plants. The risk of cross-pollination in Cannabis is one of the unique major challenge in Cannabis industry. More research can be conducted to assess the risk of cross-pollination in Cannabis and policy should be created to mitigate that risk. Cannabis research work remains years behind than other crops because of the long legacy of prohibition and stigmatization. However, lack of public germplasm repositories remains an unresolved problem in the Cannabis industry. Therefore, accessible germplasm resources are crucial for long-term economic viability, preserving genetic diversity, breeding, innovation, and long-term sustainability of the Cannabis crop. Germplasm accessions are the building blocks for breeding of new cultivars. However, there are no public seed or Clonal gene banks for Medical Cannabis sativa (marijuana or drug type). On the other hand there are some public hemp collections. Despite its economic, medicinal, and societal importance, Medical Cannabis sativa (marijuana or drug type) is missing from the list of available species in public **Genebanks** and only exist as private collections. Most of the Cannabis varieties in the market today are hybrids (**700** hybrid strains) with both Cannabis sativa and Cannabis indica genetics. Hence there should be a public Cannabis Genebanks to play a fuller and more effective role in conservation, sustainable use, and exchange of Cannabis genetic resources.

Key words: Ayurveda, AYUSH, Cannabis, Charas, Cross pollination, Desi Vijaya, Ganja, Genebanks, Himalayan Hemp, India, Iran, Industrial Cannabis sativa (Hemp) (Fiber or grain type), Medical Cannabis sativa (marijuana or drug type).

I. Introduction

Cannabis sativa belongs to Cannabiaceae as a medicine was used before the Christian era in Asia**,** mainly in **India,** China, Bhutan, Nepal, Afghanistan, Pakistan and Iran, Persians (1-20). Cannabis has been used for thousands of years for recreational, medicinal, or religious purposes (1-35). Cannabis has a long history in India, recorded in legends and religion (1-25). The earliest mention of Cannabis has been found in The Vedas, or sacred Indian Hindu texts (1-20). Cannabis sativa L. is a widespread species in nature. In India, Cannabis is nothing but a OLD BOTTLE WITH NEW WINE (1-30). According to Ayuverda in India, the medicinal value of the Cannabis plants was well documented as Vijaya and often known as Desi Vijaya (1-35). This was the first Indian written evidence to support the medicinal value of Cannabis plants which was well documented in Ayuverda in India (1-25). The earliest written reference to Cannabis in India may occur in the *Atharvaveda*, dating to about 2500 BCE (1-20). It is found in various habitats ranging from sea level to the temperate and alpine foothills of the Indian Himalaya Region from where it was probably spread over the last 10,000 years (1-40). Many historians believed that Indian Himalayan Region was the centre of origin of Cannabis sativa and Cannabis indica (1-25). The use of the Cannabis plant as a source of therapeutic compounds is gaining more importance since restrictions on its growth and use are gradually reduced throughout the world (1-35). Ecology and economy of the Indian Himalayan regions is highly influenced by hemp cultivation known for medicine, fibre and hempcrete (1-30). In fact, the primary difference between Industrial Cannabis sativa (Hemp) (Fibre or grain type) and Medical Cannabis sativa (marijuana or drug type) is this legal Δ9-tetrahydrocannabinol Δ9-THC threshold, which results from selective breeding for different uses (1-35).

The pharmacology and therapeutic efficacy of Cannabis preparations and its main active constituent Δ9-tetrahydrocannabinol (Δ9-THC) and Cannabidiol (CBD) have been extensively reviewed (1-40, 79-80). However, the

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determination of the chemical structures of its Cnnabinoids, terpenes, and many other constituents, and of the pharmacological actions and possible therapeutic uses of some of these compounds, began less than 100 years ago (1-50).

Cannabis plants and their extracts offer several applications such as fibres, building materials, confectionery and beverages, dietary supplements, cosmetics, medicinal drugs, as a source of a textile fibre, oilseed, and intoxicating drugs such as marijuana and substances for recreational purposes (1-50). As a plant, it is valued for its hallucinogenic and medicinal properties, more recently being used for pain, glaucoma, nausea, asthma, depression, insomnia, and neuralgia (1-45). Cannabis derivatives are used in HIV/AIDS and multiple sclerosis (1-29).

However, Cannabis breeding programmes are very slow since long time restrictions around this plant (1-56). In industrial applications, male Cannabis plants are desirable for their more rapid growth and higher quality fibre quality, as well as their ability to pollinate female plants and produce grain (25-63). In medicinal applications, female Cannabis cultivars are more desirable for their ability to produce large amounts of secondary metabolites, specifically the Cannabinoids, terpenes, and flavonoids that have various medicinal and recreational properties (1-50). The following section highlights about the Indian Himalayan hemp, FSSAI-2021 new regulations, the problems of cross pollination and challenges of Cannabis breeding.

II. Cannabis sativa: Himalayan Hemp

Indian Himalayan Hemp cooperative community preserves the indigenous Himalayan hemp strain by using an eco-socio-capitalistic model with the help of farmers residing in the Indian Himalayan Belt (Figure-1, 2, 3, 4) (54-56). Himalayan Hemp is a Himachal Pradesh state, India Organisation founded by Haneesh Katnawer with Sonam Sodha, Community Representative at Himalayan Hemp, has already managed to develop World first lab-validated and Government recognised hemp sanitary pad and constructed Himachal Pradesh state, India first hemp building (54-56). Haneesh Katnawer is a Cannabis hemp entrepreneur, community leader and startup consultant working in a cooperative model with innovators, farmers, and artisans to preserve the indigenous variety of Cannabis hemp plants by creating eco-conscious products like World's 1st Cannabis hemp sanitary pad, India's 1st hemp building, India's only N95 hemp mask, and many other products related to textiles, construction, food, agriculture and cosmetics (54-56). Despite the ongoing advancements in the menstrual health, existing disposable sanitary pads used by the majority of the women continue to be the major reasons for ovarian cancer, caesarean cancer, skin dermatitis, hormonal dysfunction and thyroid based conditions (54-56). Therefore, Himalayan Hemp decided to make Cannabis hemp based sanitary pads for menstruating women to provide them a dermatologically safe alternative during their periods while enjoying the benefits of the medicinal plant (54-56, 60-77). Himalayan Hemp is based in Vill Small Bhojpur Block, Indora via Bandori district, Kangra-176402, Himachal Pradesh state, India (54-56).

Phytochemical compounds found in Himalayan Hemp are unique in terms of geo-diversity and should be studied further as they can provide cure for many illness (54-56). Moreover, rest of the parts of Himalayan Hemp can be used for making a variety of products such as Hemp Textiles, Hempcrete, Food, Bioplastics, Biofuel, etc (54-56, 60-75).

An ancient relationship between rural communities and Cannabis has long been existed high in the Indian Himalaya region (54-56). Today, the rising popularity of hemp could revive this fast-disappearing cultural heritage (54-56, 60-78). High in the Indian Himalayas, wild Cannabis grows tall on mountainous slopes, nestling whole villages in a leafy embrace (Figure-1, 2, 3, 4) (54-56). The presence of the hemp plant is intertwined in local culture, religion, and folklore wild Indian cannabis plant which grows up to 15- 20 feet in height as well (so far) (54-56). According to Himalayan ethnobotanist G.K. Sharma, Cannabis was first referred to in the *Vedas* as early as 4,000–5,000 BC (54-56). The sacred Sanskrit texts describe it as a "**Liberator**" and "**Joy Giver**," while its medicinal use dates back to the Sushruta Samhita, one of the foundational texts on Ayurvedic medicine (1-25; 54-56). In his unexpectedly poetic genre of academic writing, Sharma himself called Cannabis as "one of the oldest associates of man (54-56). Many village communities in the remote mountain regions of Himachal Pradesh state and Uttarakhand state, India have long depended on its flowers, leaves, stalks, and seeds to feed, clothe, and finance them (54-56). Ecology and economy of the Indian Himalayan regions is highly influenced by hemp cultivation known for medicine, fiber and hempcrete (1-35; 54-56). On the basis of the abundant presence of wild Cannabis, the Himalayan mountain ecosystem creates the perfect conditions for its cultivation (54-56). However, when Cannabis was outlawed in India under the Narcotic Drugs and Psychotropic Substances (NDPS) Act in 1985, many of the rural communities in Indian Himalayan region were forced to rethink their relationship to the plant that once provided their livelihoods (54-56, 60-78).

Growing Cannabis (hemp) (Figure-1) as a household product is still common across all the Himalayan mountain regions, especially Uttarakhand and Himachal Pradesh state, India (54-56, 65-78). Rashmi Bharti, the cofounder of Avani–A nonprofit organization, worked with farmers and artisans from the Bora Kuthalia community in Uttarakhand state, India for over 20 years (54-56). In Himalayan region, every family have four or five plants where they have used the seed, and the rural community historically processed the fiber (54-56). Local farmers in the Himalayan region were also involved in extracting the fibre manually with the teeth, spinning it using a drop spindle, and weaving it on a waist loom to make sacks for grain, ropes, and floor

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mats (54-56). Although the quotidian use of cannabis as food or fiber was technically permitted under the NDPS Act (54-56). However, confusion resulted in irregular enforcement and a growing stigma around the hemp plant, stemming from doubt as to whether or not it was actually legal (54-56). As a result, the community started to abandon their craft and witnessed the decline of the craft traditions associated with its production (54-56). "Most of the families in the Indian Himalayan regions have burned their waist looms, and very few young people are continuing to weave hemp (54-56).

Avani–A nonprofit organization work seeked to preserve the traditional hand spinning and weaving skills by providing the community with alternative fibre sources, such as Tibetan sheep wool, and even training them in the cultivation of silk (54-56). Now, as global awareness builds around the environmental benefits of Himalayan hemp, the states of Uttarakhand, Himachal Pradesh and Uttar Pradesh, India have taken steps to legalize the cultivation of low-THC varieties for organizations in possession of a government license (54-56).

Alternatively, research could be done on the Himalayan hemp plants in the hope of finding seeds that naturally contain less THC, or working with scientists to breed them (54-56). Yet if these are patented by one single corporation, they would effectively become a private commodity, taking the power out of smallholder farmers' hands and in turn leaving them vulnerable in those of larger private corporations (54-56). In the neighbouring state of Himachal Pradesh, Haneesh Katnawer cofounded the Himalayan Hemp Cooperative with Sonam Sodha to help to preserve the native Cannabis strains, while rebuilding the lost village ecosystems that once revolved around their cultivation through the establishment of a cooperative society in the Kangra valley (54-56). Katnawer too believes that safeguarding Himalayan hemp will protect the biodiversity and cultural heritage of the local area (54-56). Furthermore, Himalayan region where hemp is grown as a weed in the forest area is restricted and prohibited area since area belongs to the Forest Department of State, and Central Government of India. Therefore, special permit or licence is needed to grow Cannabis with low content of 0.3% of THC.

Globally, more than 70 countries grow hemp, with China being the largest hemp producing and exporting country, responsible for an estimated one-fifth of total global production (54-56). China quietly grew into a Cannabis superpower. For the farmers, the crop is green gold – hemp brings in more than 10,000 yuan (US$1,500) per hectare, compared to just a few thousand yuan for more common crops like corn. It also has few natural enemies so there's little need for expensive pesticides. On 15th November 2021 FSSAI, Government of India, New Delhi has recognized hemp seed and hemp seed products as food. This will help to boost the economy of the local hemp farmers in Indian Himalayan region. Himalayan hemp is also used to make sanitary pads, masks and hygienic and healthy products to cherish the benefits of 100% organic, naturally existing from the indigenous plant (Himalayan Hemp).

The Genesis of UKHI- Hemp Foundation

The story of the genesis of UKHI-Hemp Foundation began at the time when Vishal Vivek, Jaspreet Singh, and Vivek Singh, co-founders of UKHI-Hemp Foundation fell in love with the rugged charms of Uttarakhand state, India (55, 65-75). Currently Vishal Vivek is the CEO and Co-Founder of the UKHI-Hemp Foundation (https://hempfoundation.net/vishal-vivek/) (55, 65-70). The office of UKHI- Foundation is located at UKHI Bhawan 1449, 21 D Faridabad, Haryana- 121007, India.

Uttarakhand state, India has seen mass migration. The most of the villages in Uttarakhand state, India are either uninhabited or full of old men, women and children as male members have moved to cities in search of jobs (55, 65-75). Though these families have small farms but they do not do any agricultural farming as animals destroys their crops (55; 65-70). Furthermore, 80% of the farmers have left farming in the hills of Uttarakhand state, India (55, 65-75). There was a problem with mass migration, where people from the unknown villages left their homes in search of a better life (55, 65-75). Seasonal migration in search of income became the rule (55, 65-70). The age-old texture of these farming communities was broken down (55, 65-70). Family life suffered due to the long absence of its male members. Poverty and starvation did not end (55, 65-70). The lives of hemp farmers are marked by a great deal of hardship (55, 65-70). They live in mountainous areas with bad roads, little access to education, and no job prospects (55, 65-70). They are caught in a vicious cycle of economic deprivation (55, 65-75). They have lived like this for generations, and UKHI-Hemp Foundation wanted to make a difference in the farmers life (55, 65-70). UKHI-Hemp Foundation mission is to eradicate hunger and poverty from the farming families of rural Uttarakhand. "Is it possible to give these people a better life in their own villages" (55, 65-75). Breaking the stigma about the use of hemp is one way to bring the men back to their homes and reinstate prosperity in the villages (55, 65-70). These families struggled to survive when hemp and its products got banned in India (55, 65-70). The Himalayan terrain where they live is suitable for just a few crops with hemp being one of them (55, 65-75).

This has resulted in the birth of UKHI-Hemp Foundation, A trust (NGO) aiming at empowering rural India's farmers particularly Uttarakhand state, India through the scientific and market-driven cultivation of hemp, with a focus on organic farming practices (55, 65-75). UKHI wanted to change this problem in an opportunity for these people (55. 65-70). Though logistics is very hard, due to unmaintained mountain roads traveling to the nearest market or city is a nightmare (55, 65-70). Practically no

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industry exists in these mountains (55, 65-70). UKHI members have travelled to dozens of remote mountains, trained these great women in their traditional craft of weaving, sewing, accessory making and provide them jobs (55, 65-70). UKHI- has created a value chain and involved hundreds of women in farming (hemp farming is less labour intensive), retting of hemp plants, degumming, carding, sewing, handlooms etc (55, 65-70). UKHI- Hemp Foundation also believed that women are like the roots of the tress, if you empower a woman she will empower an entire community around her (55, 65-70).

UKHI-Hemp Foundation, a trust (NGO) (Figure-3) mission is twofold: Improving the lives of hemp farmers in India, and facilitating eco-friendly consumption patterns worldwide (55, 65-70). UKHI-Hemp Foundation also connected hard working and impoverished hemp farmers in India with the right markets (55, 65-75). Hence the main aim of the UKHI- Hemp Foundation is to help the local farmers to improve their lives and get access to modern amenities (55, 65-70). Empower women and men to ensure a better future for their families (55, 65-70). Hemp grows wild in Uttarakhand. It is part of the state's natural vegetation (55, 65-70). UKHI have introduced commercial hemp cultivation following a cluster development approach (55, 65-75).

UKHI- Hemp Foundations wanted to restore the balance between human needs and natural resource utilization (55, 65-70). Every product purchased by the customer carries the care, love, and passion of at least one farmer and his family from the remotest village of Uttarakhand (55, 65-70). Hemp is not just a crop. It is the emblem of the change that can improve the economic condition of the thousands of families weaving their hopes and dreams with hemp (55, 65-70). Change does not come easily and it was biggest challenge for UKHI (55, 65-70). UKHI- Hemp Foundations is involved in the production of the finest quality of environmentally friendly textiles and products available to the rest of the world (55, 65-70). The Himalayan terrain has no match anywhere in the world. Hemp is a natural vegetation of that terrain (55, 65-70). When yarn is processed from those hemp bast fibres using minimally invasive technology, hemp yarns of the best quality is processed (55, 65-75). Fallen foliage on the ground and the dung of grazing animals supply all the extra nourishment for the growth of the organic hemp (55, 65-75).

UKHI also aimed to break the stigma that shrouds the cultivation of the hemp crop and production of hemp products (55, 65-70). Each member of the UKHI has taken the time to inform and educate our peers, consumers, and farmers about the benefits of hemp (55, 65-70). Spreading awareness is the only way to remove the misconceptions of people still have about the highly useful plant hemp (55, 65-70). The local farmers of Uttarakhand state, India already have a rich tradition of organic farming. The Uttarakhand state, India is also one of the few places where the use of fertilizers and other chemical agricultural items is a legal offense (55, 65-70). UKHI is further refining and strengthening this existing wisdom by integrating natural farming principles (55, 65-70, 79, 80).

UKHI also build awareness about natural farming among the local farming families of Uttarakhand state, India (55, 65-75). Through the systemization of the natural farming approach, local farmers are deepening their existing insights about traditional organic farming techniques (55, 65-70). They are also adapting these techniques to the natural farming approach. Through this initiative, UKHI are contributing to the conservation of the delicate ecological balance of the Indian Himalayan Region (IHR) (55, 65-70). Uttarakhand state, India has outlawed the use of fertilizers and other agricultural chemicals (55, 65-75). All farming in the state is fully organic. **Rudraprayag** is a district in Uttarakhand state where most of hemp grows organically (55, 65-75). Local farmers rich with insights on organic farming accumulated through generations ensure the health of our plants (55, 65-75). UKHI also have organic certification from a center accredited by the Agriculture and Processed Food Export Development Authority (APEDA), Government of India (55, 65-75). UKHI has a social mission: end poverty and hunger in Rudraprayag. UKHI has also enabled the farming families of the district to link their products to the global market where demand for hemp and products derived from it is on a continual rise (55, 65-77).

The acceptance of hemp sparked a light in the lives of those who grow the crop and make the hemp-related products (55, 65-70). Hemp (Cannabis sativa) is a natural vegetation of the Uttarakhand region. Promoting hemp cultivation matches with the natural farming model and contributes to conserving the fragile ecosystem of the Indian Himalayan Region (IHR) (55, 65-77). As a plant, hemp also embodies several of the natural farming principles. Hemp can grow on infertile land (55, 65-70). Hemp is exceptionally efficient in absorbing nutrients from the soil. They do not need any additional fertilizers or manures (55, 65-70). Hemp is naturally pest-resistant. Technically a weed, it grows fast to outgrow any other weeds (72, 73-77). These two features eliminate the need for herbicides and pesticides (55, 65-70). In Rudraprayag, a district in the Himalayan state of Uttarakhand in India where organic farming of hemp is successful by UKHI (55, 65-70). UKHI is involved in the manufacture of the rich bast fibers that yield hemp yarns of amazing strength and quality (55; 65-77).

Namrata HempCo Limited (NHempCo)

The Namrata HempCo Limited **(**NHempCo) was founded by passionate endeavours of an entrepreneur couple, Harshavardhan Reddy Sirupa and Narmrata Reddy Sirupa. The couple were inspired by the of Government of India special brainstorm session **Make in India Campaign**. The products made from the industrial hemp are biodegradable, toxic free, pollution free and negative carbon footprints (1-50; 60-75) If hemp plants are grown organically under optimal conditions, all the

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traces of chemicals and other harmful toxins can be eliminated. Industrial hemp is an extremely versatile crop that can be used to make wide range of products required in day-to-day life from food, fabric to fuel and plastic (1-50, 60-75). NHempCo has reserved 15 acres of its agriculture farm in Alamuru, a small village situated in Anantpur district, Andhra Pradesh, India exclusively for the organic cultivation of industrial hemp with the help of local farmer communities. In addition to this, they have also established labs and testing units involved in R& D activities. NHempCo is headquartered in Bangalore, Karnataka, India (Narmata | Hemp (www. nhempco.com) (70-77).

Some of the Indian biotech companies are A Bangalore, Karnataka based Namrata HempCo Limited (NHempCo) was founded by Harshavardhan Reddy Sirupa and Narmrata Reddy Sirupa, UKHI-Hemp Foundation**,** Cannabis Wellness, Keran Vankayala, Andhra Pradesh, Pan India Medical Cannabis and Hemp Association (PIMCHA), Mumbai, Bombay Hemp Company, BOHECO, Global Hemp Solution India Pvt Ltd, Ghaziabad, UP, Hemp Horizons Pvt Ltd, Delhi, Happie Hemp Pvt Ltd, Ayurvedic Hemp Wellness, Bangalore, Karnataka, Satliva, Himalayan Hemp, Hemp Fabric Lab, Vedi Herbals, Happy Hemp, SUI, ItsHemp, Bhu:Sattva's, Health Horizons, Hemis, Hemp Republic, Hempsters, B.E. Hemp, India Hemp Co., Inc, India Hemp Organics, ItsHemp, Health Horizons, Hemis, TheTrost, and Gin-Gin) involved in promoting the Indian hemp products marketing, research, cultivation, harvesting, processing, manufacturing, trading, wholesaling, retailing, innovating, advocating both across the nation and around the world.

Health Benefits of Hemp

Cannabis Hemp is the natural source of hundreds of phytocannabinoid compounds including CBD (Cannabidiol) (1-45, 71-77). These compounds have medicinal properties that range from anti-inflammatory and anti-emetic to anti-carcinogenic (1-25; 55, 65-75). Hundreds of teams from across the world are looking for pure hemp seeds and oil for research and medicinal purposes (1-25; 55, 65-71). Thousands more are interested in the durable fiber that the plant produces and the hemp seeds that contain high protein (1-35; 55, 65-70). In the last few years, people have embraced the role of hemp as a natural cure for many diseases and super food across the globe (1-25; 55, 65-77).

The hemp seed industry is expected to witness the fastest CAGR from 2022 to 2030 (55, 65-75). Hemp seeds (Figure-3, 4) have minimal amounts (0.2 to 0.3%) of the psychoactive compound THC that's found in high concentrations (20-35%) in Medical Cannabis sativa (Marijuana) (1-40;55, 65-75). Further THC is the compound that is responsible for creating the high and therefore, hemp seeds are not harmful (1-40; 55, 65-71). Hemp seeds are becoming popular each day in food and beverage, pharmaceutical, personal care, cosmetics industries (1-50; 55, 65-73). Hemp seed is a common ingredient in making: Bath gels, Soaps, Lotions, Shampoo, and many other products (1-40; 55, 65-71). There are 4 ways one can use hemp seeds: Eat raw, cooked, or roasted, use for non-dairy hemp cheese and hemp milk, shelled as hemp hearts and cold-pressed to produce hemp seed oil (1-45; 55, 65-77).

Hemp seeds (Figure-3, 4) come with **Omega-6 and Omega-3** fatty acids (1-30; 55, 65-73) Furthermore, the ratio of Omega-6 to Omega-3 fatty acids in hemp seeds is the optimal level for nutritional benefits (1-50, 71-77). Furthermore, hemp seeds come with a plant compound called terpenes which prevents tumour growth and helps to protect the brain (1-25; 55, 65-70). Hemp seeds contain high amounts of protein (55, 65-77). The seeds increase immunity and decrease the amount of toxic substances in the body (1-25; 55, 65-70). Thus, hemp seeds are especially beneficial to anyone who is a vegetarian or vegan (1-35; 55, 65-73). Hemp seeds are one of the highest sources of fatty acid. One of the omega-6 fatty acids found in hemp seeds is **Gamma-Linoleic acid** (GLA) (1-25; 55, 65-73). The fatty acid comes with anti-inflammatory properties and works similar to drugs such as ibuprofen (55, 65-80).

Hemp seeds (Figure-3, 4) contain all 20 amino acids including the 9 are rare and unique essential amino acids (1-35; 55, 65-80). Hemp seeds contain vitamin B1, vitamin B2, vitaminB6, calcium, and magnesium (1-35; 55, 65-73, 79-80). The nutrients strengthen the bones, inhibits bone breakdown, strengthen immunity, and elevate mood (1-35; 55, 65-70). Hemp seeds boost immunity and reduce the amount of toxic substances in our bodies Furthermore, the human body can absorb the protein content from hemp seeds without much hassle (1-35; 55, 65-71). Hemp seeds are a rich source of magnesium. Magnesium prevents coronary heart disease and regulates our heartbeat (1-35; 55, 65-71). Hemp seeds come with linoleic acid involves in the reduction of blood pressure and lowers cholesterol levels by up to 15% (1-35; 55, 65-71). Hemp seeds can be eaten topped with yoghurt smoothies, and cereals or raw (1-35; 55, 65-70).

Hemp seed oil improves dry and itchy skin and relieves the symptoms of eczema. Furthermore, hemp seed oil helps to treat acne as well (1-25; 55, 65-73). Further hemp seed oil has anti-inflammatory and antimicrobial properties (1-40; 55, 65-73). Hemp seed oil can also be applied topically to the skin or use the oil in cooking to add nutritional benefits to meal (1-30; 55, 65-73).

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III. Cannabis sativa (Hemp): 2021-FSSAI Indian Regulation

On 15th November 2021 FSSAI, Government of India, New Delhi has recognized hemp seed and hemp seed products as food (1-25). This notification regulates and allows for sale of products derived from 'non-viable seeds of the Industrial Cannabis sativa (Hemp) (fiber or grain type) /other indigenous Himalayan Cannabis species *(*1-29). Further the cultivation of hemp is as usual and comply with the NDPS Act and State Government laws (9-30).

India with the current population of 1.45 billion is the land of pharmacy and world leader in the production and utilization of herbal medicine (1-25). India is an emphasis for development of Ayurveda, Unani, Siddha, Homoeopathy and alternative natural herbs based health science (AYUSH) (1-25). Presently, there are a few hemp companies that operate with an Department of AYUSH license, Government of India, New Delhi, India regulated by the DCA, some of which are also recognized by the Department for Promotion of Industry and Internal Trade (1-25). However, is no longer the import of charas, Ganga, Bhang or Medical Cannabis sativa (marijuana or drug type) into India was entirely prohibited by the Government of India nearly two decades ago (1-25). The consumption of Cannabis resin (Charas) is prohibited everywhere in India (1-30). Cannabis sativa is also commonly known as marijuana, Bhang, Ganja, and Charas, which are banned in India as an illicit drug. Sales and cultivation of Medical cannabis (marijuana type) are illegal in India (1-25).

On other hand Industrial Cannabis sativa (hemp or fiber type) (Figure-2) has been legalized for commercial cultivation in Canada since 1998, Medical Cannabis sativa (marijuana or drug type**)** was only legalized in Canada for commercial production for medicinal use in 2014 and for recreational use in 2018 (33-39). During the last decade, the industrial properties of Cannabis (Hemp) for applications in textiles, paper, building materials, cosmetics, foods, and pharmacological properties have been broadly studied and supported (33-46). With legalization, isolated Cannabinoids are now legal for the development of medicinal and edible products (33-40). To date, 115 unique Cannabinoids (e.g., Cannabidiol (CBD), Cannabichromene (CBC), and Cannabigerol (CBG)) with potential medicinal applications (25-40). Furthermore a total of 560 secondary metabolites have been identified in Cannabis (33-46). The Cannabis market is growing exponentially. The US industrial hemp-derived CBD market alone is expected to reach $23.7 billion by 2023, up from the current value of $5 billion, and US farmers are seeing revenues of up to $45 000 per acre (www.brightfieldgroup.com) (20-46).

So far, the focus of growers has been on major Cannabinoids (e.g., THC and CBD) (25-46). Recently, however, more rare Cannabinoids (e.g., Cannabigerol (CBG) and Tetrahydrocannabivarin (THCV)) are gaining interest in the pharmaceutical industry (20-46). It is noteworthy that Cannabis cultivars with high levels of some rare cannabinoids (i.e., THCV) tend to share a genetic background with landraces known for their invigorating highs (CANNUSE, http://cannusedb.csic.es/) (25-46). Therefore, the intensification of Medical Cannabis sativa (marijuana or drug type) production stimulated breeding activities aimed at developing new, improved cultivars with precisely defined, and stable Cannabinoid profiles (1-46).

Industrial Cannabis sativa (Hemp) (Fiber or grain type)

Furthermore, Industrial Cannabis sativa (Hemp) (Fiber or grain type) is cultivated to produce fibre (Figure-2), grain (Figre-3, 4) or non-intoxicating medicinal compounds such as Cannabidiol (CBD) (1-46). As defined by law, Industrial Cannabis sativa (Hemp) (Fiber or grain type) has less than 0.3% **Δ9-Tetrahydrocannabinol (THC)**, the psychoactive component in Medical Cannabis sativa (marijuana or drug type) (1-40). In fact, the primary difference between Industrial Cannabis sativa (Hemp) (Fibre or grain type) and Medical Cannabis sativa (marijuana or drug type) is this legal THC threshold, which results from selective breeding for different uses (1-35; 42-46). Both as members of the same species, the two crops have more in common than not, including the vexing ability to crossbreed (42-46). Cannabinoids, including the valuable end products, **Δ9-Tetrahydrocannabinol (THC)**, and Cannabidiol (CBD), are concentrated in the female flower tissue (1-25; 42-46). A study by Meier and Mediavilla, 1998, found that pollination decreased the yield of essential oils in Cannabis flowers by 56% (42).

Today, the most of the Medical Cannabis sativa (Marijuana or drug type) is **Sinsemilla** (Spanish for “without seeds”) and seeded crops are considered as inferior, commanding a lower price in the marketplace (42-26). This strategy is now also being applied by Industrial Cannabis sativa (Hemp) (Fiber or grain type) growers producing **Cannabidiol (CBD)** (42-46). Industrial hemp grown for grain or fiber is a another story (42-46). Male plants and pollen are required to create Cannabis sativa (Hemp) (Fiber or grain type) grain used for food, feed and oil (42-46). Cannabis sativa (Hemp) (Fiber or grain type) does not require pollination, but the prohibitive cost of planting feminized seed or female clones means that hemp fibre fields will usually include male plants (42-46). As a result, the recent introduction of hemp grown for grain and fiber in many countries increases the risk of pollination for marijuana and Cannabidiol (CBD) hemp growers (42-46). Therefore, industrial hemp increases rather than creates this risk because Cannabis pollen has been blowing across the cultivated and non-cultivated agricultural area (42-46). This is a major problem of growing marijuana and hemp fibers in outdoor settings in agriculture farms close to each other (42-46).

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IV. Cannabis sativa: Difference between Hemp and Marijuana

Cannabis has been reported to contain over 560 different compounds, out of which 120 are Cannabinoids (1-40). Among the Cannabinoids, **Δ9-Tetrahydrocannabinol (THC)** and Cannabidiol (CBD) are the two major compounds with very different pharmacological profile and a tremendous therapeutic potential (1-40). Cannabis sativa L. has a long history of human use for fibre, food, medicine, and its psychoactive properties (1-46). The species can be categorized based on taxonomic relationships or chemotype but is often divided and regulated based on the level of psychoactive Cannabinoids that are produced (1-35).

In most countries (e.g., India, Canada, the USA, and the EU), plants that produce below 0.3%, **Δ9-Tetrahydrocannabinol (THC)** are regulated as Industrial Cannabis sativa (hemp or fiber type), and plants with 0.3% or greater THC are classified as Medical Cannabis sativa **(marijuana or drug type).** Most pharmaceutically important Cannabinoids are Cannabidiol (CBD) and the psychoactive, **Δ9-Tetrahydrocannabinol (THC)** (THC) (1-46). The relative content (in % of dry weight) of the latter divides Cannabis genotypes into two groups: (i) Industrial Cannabis sativa (hemp or fiber type) (defined as containing less than 0. 3% **Δ9-Tetrahydrocannabinol (THC)** by dry weight in Europe, USA, Canada, India) and commonly grown as a field crop and (ii) Medical Cannabis sativa (marijuana or drug type) with 25-35% of THC (The European Commission, 2014), cultivated under strict legal restrictions (1-40).

Botany: Male Cannabis plant

The male Cannabis plant is a staminate, meaning it has stamen or pollen-producing reproductive organs (25-50). Male plants are sometimes cultivated for fibre and are more commonly used for breeding new varieties of intoxicating Cannabis (20-50). During their flowering phase, male cannabis plants release pollen, which will prompt a female plant to start producing seeds (10-45). This practice diverts energy from flower production and reduces the overall yield. To maximize the flower yield and prevent seed production, keep male and female plants separated (10-50). The male cannabis plant is capable of producing cannabinoids, but its trichomes are sparsely dispersed across its surface. Males do not produce nearly as many trichomes as a female Cannabis. The reproductive anatomy of the male plant includes: Stamen: The organ of the male plant that produces pollen and releases it into the wind, where it may be carried to the stigma of a female plant for pollination (1-50). Anther: The sacks that produce and hold pollen within the stamen. Anthers hang by a small filament. Together, the anther and the filament make up a stamen. Pollen: Microscopic grains produced and contained in the anther that fertilize the female plant when released (1-40).

Botany: Female Cannabis plant

Cannabis is a **dioecious** plant, meaning it can be categorically divided into male and female plants (1-25). Male plants produce the pollen necessary for a female plant to produce seeds, while the female plant is the one to naturally produce more of the major Cannabinoids, namely Cannabidiolic acid (CBDA) and Tetrahydrocannabinolic acid (THCA), which convert to CBD and THC, respectively (1-45). Cannabis also produces several other valuable compounds, such as terpenes and flavonoids, that potentially work synergistically with the cannabinoids to enhance desired and therapeutic effects (1-46). There are some monoecious varieties of cannabis with male and female flowers on the same plant, and stress can also induce the production of male flowers on female plants, but these are exceptions to the plant's normally dioecious nature (30-56). Flowering is induced when day and night lengths become equal. Male cannabis plants flower for a period of two to four weeks, and a single male flower can produce 350,000 pollen grains. Pollen is carried to female plants on the wind and can travel great distances when conditions are favourable. Bees will collect Cannabis pollen but are generally not attracted to the female flowers to contribute to pollination (1-35).

V. Cannabis sativa: Sexual Dimorphism

Cannabis (Cannabis sativa L.) naturally shows sexual dimorphism with a small proportion of monoecism (25-48). Cannabis sex determination could be modified by applying exogenous growth regulators or chemicals, which can influence the ratio of endogenous hormones and hence the incidence of sex organs (Truta et al., 2007). Silver compounds such as Silver Nitrate (AgNO3) or Silver thiosulfate (Ag2S2O3; STS) have been found to have masculine effects in many plant species, e.g., in Coccinia grandis (Devani et al., 2017), Cucumis sativus (Den Nijs and Visser, 1980), Silene latifolia (Law et al., 2002), Cucumis melo (Owens et al., 1980), and also Cannabis sativa (47). In one of the recent study, the effects of several exogenous substances, known to be involved in sex expressions, such as Silver thiosulfate (STS), gibberellic acid (GA), and Colloidal silver, were analyzed (47). In this study various concentrations were tested within 23 different treatments on two high Cannabidiol (CBD) breeding populations (47). This study showed that spraying whole plants with Silver thiosulfate (STS), once is more efficient than the application of STS on shoot tips while spraying plants with 0.01% GA and intensive cutting is ineffective in stimulating the production of male flowers (47). Additionally, spraying whole plants with Colloidal silver was also shown to be effective in the induction of male flowers on female plants, since it produced up to 379 male flowers per plant in Cannabis (47). The viability and fertility of the induced male flowers were confirmed by fluorescein diacetate (FDA) staining of pollen grains, in vitro and in vivo germination tests of pollen, counting the number of seeds developed after hybridization, and evaluating germination rates of developed seeds (47).

VI. Cannabis sativa: Male and Female plants

Male and female Cannabis plants share a common basic anatomy of roots, stems, and leaves (1-49). Both plant sexes produce trichomes, the glandular appendages on the surface of the flower that produce and hold the plant's Cannabinoids and terpenes (1-45). However, the Cannabis female plant produces far more trichomes than the male plant. Beyond these basics, Cannabis anatomy varies significantly between male and female plants (25-50). Marijuana refers to the dried leaves, flowers, stems, and seeds from the Cannabis sativa or Cannabis indica plant (1-56). The Cannabis plant contains the mind-altering chemical THC and other similar compounds. Extracts can also be made from the Cannabis plant (1-50). In the 1970s, marijuana growers found that preventing pollination by rogueing out male plants or producing only females (through clonal propagation or sowing of feminized seed) could greatly increase the yield and potency of their crop (25-50). This works because Cannabis is one of the few plant species that can actively increase the number and size of its female sex organs in response to prolonged virginity according to Small and Naraine, 2016 (30-50). The longer female plants go unpollinated, the more flowers are produced and the larger they get (30-50).

Cannabis Species

Cannabis is a genus of annual flowering plant. Cannabis is often divided into 3 species—**Cannabis sativa**, **Cannabis indica**, and **Cannabis ruderalis**—but there is significant disagreement about this, and some consider them subspecies of the same parent species (1-56). Most of the Cannabis varieties on the market today are hybrids with both Cannabis sativa and Cannabis indica genetics (1-50). Hybrid refers to a strain created by combining both Cannabis indica and Cannabis sativa strains (30-60). Many commercial producers crossbreed Cannabis plants to develop new strains with specific characteristics (1-50).

Cannabis ruderalis flowers as a result of age, not light conditions, which is called Autoflowering (59). It is principally used in hybrids, to enable the hybrid to have the **Autoflowering** property (50-59). There are >700 recreational Cannabis, often with colourful names (45-59). Some are strains of Cannabis sativa and Cannabis indica subspecies and the most are crossbred hybrids (40-59). Cannabis indica plants tend to grow short with thick stems and broad, deep-green leaves. They also have shorter flowering cycles, and grow sufficiently in cold, short-season climates. Cannabis sativa plants have longer flowering cycles, fare better in warm climates with long seasons, and usually grow taller with relatively light-green, and narrow leaves (39-50). Knowing the morphological, or physical form differences between Cannabis indica and Cannabis sativa plants is more useful to growers and cultivators than virtually anyone else in the cannabis space, despite the terms common use in the consumer marketplace (30-50). Every part of the cannabis plant is usable. Historically, cannabis has been bred by humans for three distinct purposes: Fibre - harvesting cannabis stalks, typically from hemp varieties. Seeds - harvesting seeds from a female hemp plant for its rich oil and protein content. Drug-type cultivars - harvesting cultivated varieties for their psychoactive and therapeutic Cannabinoids (1-56).

From seed to harvest, the cannabis plant's growth cycle can last anywhere from 10 to 26 weeks (1-56). The life cycle has three main stages: germination, vegetation, and flowering. Like the most plants, Cannabis requires light, air, nutrients, and a medium to house its roots. The amount and duration of light the plant is exposed to dictates the growth stage of the plant.

VII. Cannabis: Morphology

Cannabis is known as a dioecious species, meaning that male and female flowers are borne on separate plants. The female Cannabis plant is a pistillate, meaning it has pistils and stigmas. Furthermore, female Cannabis plants are often referred to as "**Sinsemilla**," translated from Spanish as "without seeds. (25-56). Sensemilla refers to all non-pollinated female plants. Sensemilla plants are ideal for marijuana growers because they offer the highest potential yield of Cannabinoids (15-56). Pollinated female flowers, or female flowers with seeds, produce a less desirable product than flowers from seedless marijuana. The flowers produced by the female plant. Colas are covered with Cannabinoid- and terpene-rich trichomes and commonly called as **buds or nugs** (1-50). A **Cannabis bud** is not to be confused with the botanical definition of the word bud: a newly emerging plant. **Bracts:** Small, scale-like leaf structures that encapsulate and protect the seeds. Bracts are often referred to as calyxes, though this term is botanically incorrect. The female Cannabis plant does, however, have calyx cells within the delicate layer of tissue between the seed and the bracts that encapsulate it (20-56). **Stigmas:** The reproductive parts of the Cannabis plant, which catches pollen from the male plant. Stigmas are commonly and incorrectly referred to as pistils. Two stigmas protrude from one pistil. **Pistil:** The reproductive parts of the female Cannabis flower that are activated if pollen is captured by the stigmas. **Sugar leaves:** The small leaves that hold Cannabis buds together. They are called **Sugar leaves** due to the high concentration of trichomes that have a sugar like appearance (1 -54).

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VIII. Cannabis: Hermaphrodite

A hermaphrodite is a rare monecious plant, meaning it develops both male and female sex organs (25-50). The term monecious stems from the root "mono," meaning "one (25-50). While there are multiple reasons that a plant may exhibit both signs, hermaphrodites are primarily formed if a female plant is exposed to extreme conditions during key stages of growth, such as insufficient light or harsh environmental conditions. Signs of a hermaphrodite typically showed late into flowering (25-50). In a final attempt to continue their seed line, a Sensemilla crop will occasionally produce a few hermaphrodites (25-50). While the pollen of these hermaphrodites is frequently unviable, marijuana growers should remove hermaphrodites when they occur to eliminate the risk of pollination (25-50). Hermaphrodites will also produce a lower overall flower yield as the plant is forced to divert energy into the production of seeds that would have otherwise been used for the production of trichome-rich flowers (25-50).

UKHI- Hemp Foundation: Hemp Germplasm Research in India

Plant germplasm research is critical for crop improvement. Higher productivity at lower inputs is the general focus of plant germplasm research globally (55, 65-70). However, hemp has special needs, and UKHI- Hemp Foundation are taking care of that (55, 65-70). The initiation and application of dwarfing germplasm resources for rice and wheat caused the success of the Green Revolution (55, 65-70). The key factor behind the success of the Green Revolution was the dwarfing of plants like rice and wheat to significantly increase their yields. This same technique of developing hemp cultivars with short stature and high yield is a recommended focus area of hemp germplasm research (55, 65-70). The reason is that taller plants are favoured for fibre use, while shorter versions are preferable for the use of seeds and flowers (55, 65-70). The current technique is to plant the seeds differently (55, 65-70). Densely sown seeds results in taller plants with virtually no branching used for fiber (55, 65-70).

UKHI- Hemp Foundation are also planning, coordinating, and implementing germplasm research with the domesticated and wild variations of hemp in the Indian Himalayan Region (IHR) to feed into National crop improvement program (55, 65-70). This is critical for pre-breeding characterization and the evolution of new cultivars. Seeds sown away from each other allow the plants to remain shorter and have branches (55, 65-70). This is the farming technique for plants meant for the use of seeds and flower use. Appropriate dwarfing germplasm research can create improved new mixed-use cultivars. This is an emerging global research area and UKHI is committed to being a part of process (55, 65-70).

Since then, the world has realized the criticality of plant germplasm research for introducing agricultural improvements in crop production (55, 65-70). Genetically heterogeneous germplasms are rich resources for agricultural research. They provide the building blocks for producing newer, more improved varieties of any crop (55, 65-70). UKHI aims at making Uttarakhand state, India the hotbed for germplasm research, in collaboration with the scientific, research, and agricultural communities of the state (55, 65-70). The questionable legal status of hemp worldwide has resulted in the relative absence of germplasm research for hemp. India is no exception (55, 65-70). There is a need, therefore, to conduct germplasm research with the wild varieties growing across the Indian Himalayan Region (IHR), and domesticated varieties (55, 65-70). Such research is vital for crop improvement. Especially since legal prohibition has deprived hemp of the benefits of germplasm-based agricultural research with other crops (55, 65-70). Germplasm research of hemp is also important from the perspective of THC control (55, 65-70).

Hemp grows naturally in the Indian Himalayan Region (IHR) just as marijuana does (55, 65-70). The use of both hemp and marijuana had been intricately woven in traditional lifestyle and Hindu religious regions of this area before the government clamped down on it (55, 65-70). Growing recognition of the versatility of hemp and its many environmental benefits has acted as a catalyst for the decriminalization of hemp in many countries around the globe (55, 65-70). The Indian government also legalized supervised cultivation of hemp in the Himalayan state of Uttarakhand. It is important to ensure that the hemp grown in the region does not cross the legal limit of 0.3% THC control (55, 65-70). Also, in the EU countries, for instance, the THC limit for legal hemp is 0.2%. For the products of Uttarakhand state, India farmers to be accepted in the EU countries, the THC content of the hemp they grow needs reduction from the 0.2% or 0.3% level which constitutes another significant aspect of germplasm research (55, 65-70).

IX. Cannabis: Cross Pollination Problems

Cannabis outdoor farming is very expensive and highly risk due to many factors such as cross pollination problems, maintenance, labour and production cost (1-50). The risk of cross-pollination in Cannabis is one of the unique challenge in the outdoor farming settings (25-65). The most important strategy involves geographic or physical isolation (42-46). Cannabis industry experts recommend a minimum distance of 10 miles between outdoor Cannabis fields (1-35; 42-46). Research has shown that pollen can travel much further than 10 miles, but the amount of pollen transported decreases logarithmically with increasing distance from the source (1-37; 42-46). Therefore, the risk of pollination should be negligible beyond ten miles from a pollen source (30-56). While geographic isolation may be a technically feasible strategy, application of such strategy in the field in outdoor settings is more complicated. Maintaining isolation distances requires identifying where Cannabis is being grown (25-50). Although the Government Agencies maintain records on where cannabis is produced, there is currently no coordination between the agencies regarding this issue and the location of cannabis fields is not public information (25-54). Maintaining geographic isolation would therefore, required voluntary sharing of location information by growers (1-50). Even if growers could be encouraged to share this sensitive information, enforcement of isolation distances would be difficult (25-50). Important variables related to pollen transport and viability include wind speed, direction, precipitation and humidity, topography, physical barriers, time since release, etc. For example, A study by Small and Antle, 2003 (43) on pollen dispersal in Cannabis found that a 3-mile isolation distance downwind was equivalent to a 0.6-mile distance upwind in terms of the amount of pollen deposited (25-54).

Physical isolation accomplished by growing marijuana or CBD hemp indoors with air filtration systems can achieve the same result as geographic isolation, but also dramatically increases the cost of Cannabis production (25-50). Growing grain or fiber hemp indoors is not practical given the scale required to achieve profitability with these lower value commodities (25-54). However, it may be possible to physically isolate grain/fiber hemp and the pollen it produces using strategic windbreaks or irrigation. Borders of thick crops or trees planted downwind may be able to intercept a great deal of pollen. A study by Ushiyama et al., 2009 (46), found that windbreaks reduced dispersal of maize pollen by 30-60% depending on their design (46). Precipitation or irrigation water can weigh down pollen and prevent it from floating away on the wind (26-50). However, research on the use of these techniques in cannabis is lacking (25-52). Therefore, the risk of cross-pollination in cannabis by simply banning marijuana, industrial hemp, or male cannabis plants specifically is a major issue (25-50). In Michigan state, USA Ballot Proposal 1 of 2018 legalized both recreational marijuana and industrial hemp. However, it is unlikely that either would be banned at the state level to address cross-pollination (30-50). Hence, cooperation and a little creativity should hopefully make it possible for all sectors of the cannabis industry to coexist (25-52). As noted above, flowering in Cannabis is controlled by day length (1-47). Artificial shading can therefore, be used to induce flowering at almost any time of the year (25-50). This technique is feasible for marijuana and CBD hemp growers working on a relatively small scale. It requires a shading structure and extra labour to cover and uncover plants daily, but is not prohibitively expensive (25-50). Forcing flowering via controlled light regimes is likely not a realistic option for grain and fiber hemp grown at a larger scale (25-50). However, auto-flowering Cannabis cultivars that flower based on age rather than photoperiod do exist. If the auto-flowering trait could be bred into elite Cannabis cultivars, it could be used to off-set the release of pollen in hemp from flowering in female marijuana and CBD hemp plants (26-50). Hence more research can be conducted to assess the risk of cross-pollination in Cannabis and policy created to mitigate that risk. (10-50). After so many years of prohibition, it would be a shame to see factions develop within the Cannabis industry that limit potential growth by favouring either marijuana/CBD hemp or grain and fiber hemp (1-50). Together, with cooperation, an equitable solutions to the problem of cross-pollination should be identified (1-50).

Cannabis Breeding Problems and Challenges

Modern breeding is very slow in case of Cannabis since long time restrictions around this plant (4, 22-28; 33-50; 57-64). Most importantly, the Cannabis research community suffers from a lack of sufficient understanding of the Cannabis genetics and how the key traits are expressed (26). While agriculture has catapulted into the modern era with the application of modern breeding techniques and genomic tools, Cannabis remains years behind other crops because of the long legacy of prohibition and stigmatization (4, 22-28; 33-50; 57-64). The main goal of breeding is to develop new cultivars with valuable traits (26). Conventionally, a foundational germplasm (i.e., the seeds, plants, or plant parts) that includes landraces, crop wild relatives, and developed varieties, forms the basis for modern plant improvement (26, 64). Hence, germplasm accessions are the building blocks for breeding new cultivars (4, 22-28; 33-50; 57-64). Similar to other crops, access to germplasm collections is essential for research and breeding in cannabis and to ensure that genetic diversity is maintained for future use (26). As cannabis regulations are liberalized, hence there is an opportunity to speed up the process of breeding and further displace valuable germplasm around the world (4, 22-28; 33-50; 57-64). Cannabis particularly hemp (Low THC) is legalized and is accepted as an agricultural commodity in many places around the world including India (1-30). However, lack of public germplasm repositories remains an unresolved problem in the Cannabis industry (4, 22-28; 33-50; 57-63). The success story of any commercial crop including Cannabis in the global market depends on the acquisition, preservation, and evaluation of germplasm, including landraces and ancestral populations (26, 64). Therefore, accessible germplasm resources are crucial for long-term economic viability, preserving genetic diversity, breeding, innovation, and long-term sustainability of the crop (26).

Conventionally, plant breeders and researchers depend on genebanks worldwide as a source of new traits to develop improved cultivars (i.e., commercial cultivars, landraces, and wild crop relatives). However, there are no public seed or Clonal genebanks for drug-type cannabis. On the other hand there are some public hemp collections (4, 22-28; 33-50; 57-64). The demand for Cannabis products is increasing day by day and Cannabis has got a global market of multibillion dollar business. Therefore, there is a lot of pressure on Scientific community particularly breeders and need to identify suitable genetics that can be used for production and as a source of diversity for further breeding and development (4, 22-28; 33-50; 57-64). Landraces represent the major gene pool not only to preserve genetic diversity, but also as a reservoir for rare Cannabinoids and terpenes with a high medicinal impact (26). In case of Cannabis, landrace genetics, which are the results of thousands of years of selective breeding, are in danger due to the Cannabis trend-driven market and displacement by newer, higher yielding, more potent, or more disease-resistant cultivars (4, 22-28; 33-50; 57-63). Therefore, it is essential that genebanks and researchers collect, protect, and preserve all available cannabis genetics of today before they are permanently lost (26, 64).

Cannabis faces a multitude of methodological challenges and regulatory, financial, and access barriers to conduct comprehensive basic and applied research (26). Most of the Cannabis varieties on the market today are hybrids with both Cannabis sativa and Cannabis indica genetics (4, 22-28; 33-50; 57-63). Hybrid refers to a strain created by combining both Cannabis indica and Cannabis sativa strains. Many producers crossbreed cannabis plants to develop new strains with specific characteristics. There are >700 recreational hybrid Cannabis, often with colourful names (45-59). Some are strains of Cannabis sativa and Cannabis indica subspecies and the most are crossbred hybrids. Each species can interbreed with the other species, leading to hybridization. **Cannabis ruderalis** flowers as a result of age, not light conditions, which is called Autoflowering. It is principally used in hybrids, to enable the hybrid to have the **Autoflowering** property. Furthermore, history of cannabis cultivation and breeding is somewhat unique, the loss of genetic diversity is well known in many crops worldwide (26). Until very recently (i.e., legalization), breeding of Cannabis occurred in a very small indoor operations with undocumented methods and a lack of modern technologies (26; 45-59, 64).

To promote targeted breeding of Cannabis, the following biological challenges should be considered (26) (*i*) better classification of cannabis taxonomic groups (e.g., indica and sativa), (*ii*) dioecy behavior of the cannabis plants, (*iii*) molecular mechanisms underlying flower development, (*iv*) stabilization of cultivars for uniformity, and (*v*) development of cultivars with unique Cannabinoid profiles targeting minor cannabinoid production (26, 64). In addition, the composition and content of Cannabis secondary metabolites can be affected by plant age, sex, developmental phase, growth and environmental conditions, harvesting time, storage conditions, and methods of cultivation (26). Therefore, a better understanding of these interactions is needed (26, 64).

The main issue with Cannabis industry is that Cannabis research particularly breeding is very slow and delayed because of the lack of public germplasm repositories (26). Nonetheless, these are exciting times for, more than ever, public genebanks to adopt Cannabis and preserve its diversity (26; 28; 33-50; 57-64).). In the context of our rapidly changing cannabis market, it is certain that we can expect genebanks to play a major role in enabling researchers to develop new cultivars (26; 28; 33-50; 57-63). Cannabis restrictions require a second look to allow genebanks to play a fuller and more effective role in conservation, sustainable use, and exchange of cannabis genetic resources (26; 28; 33-50; 57-63).

Genebanks have a long-term mission to preserve plant genetic resources (PGRs) with the aim that they might be used in the future, either directly or as material in breeding programs to address changing environmental conditions, new biotic pressures, or societal needs (Halewood et al. 2018; Belzile et al. 2020) (26; 28; 33-50; 57-63). Despite its economic, medicinal, and societal importance, drug-type Cannabis is missing from the list of available species in public genebanks and only exist as private collections (26; 28; 33-50; 57-63). In the context of the rapidly changing cannabis market in Canada, the USA, and other regions around the world, it is certain that genebanks could play an important role in helping to preserve genetic diversity as well as adapt and improve varieties (26; 28; 33-50; 57-63).

The reason Cannabis is absent from genebanks can mostly be attributed to governmental restricted regulations surrounding the plant (26; 28; 33-50; 57-63). In most countries, Cannabis is illegal, but even in Canada, where Cannabis was legalized in 2018, regulatory barriers persist and include stringent restrictions both on partnerships between the Cannabis industry and researchers and researchers access to Cannabis germplasm (26; 28; 33-50; 57-63). In India, Himalayan hemp or Cannabis hemp was also legalized in 2021 and considered as food with continued restrictions on Medical Cannabis (Charas or Ganja). In addition to current stringent restrictions (i.e., access to new genetics and strict inventory requirements) and security requirements (e.g., full-time surveillance and storage in safes), there is a general lack of support for public genebanks (e.g., PGRC) to preserve Cannabis seeds or clonal accessions (26; 28; 33-50; 57-64). Therefore, these restrictions required a second look to ease Cannabis seed import, export, and transfer (26; 28; 33-50; 57-63). In addition, a rigorous workflow is needed to control the viability, uniformity, and labeling of Cannabis seeds (26; 28; 33-50; 57-64). There is no doubt that diversity must be maintained in both the genetic and cytoplasmic constitution of every important crop, which includes all old and new cannabis cultivars (26; 28; 33-50; 57-64). Finally, the policy, regulatory, and research challenges that accompany the study and understanding of Cannabis are unique. Despite all the issues, research continues, understanding of Cannabis and its effects is evolving, policies are in flux, and the literature is ever-changing. The Internet spreads knowledge of genetic sequencing metabolomics, proteomics, and other disciplines such that people are going to manipulate Cannabis, as they have long done by selective breeding, to maximize its mental and physical effects and tailor the quality of those effects.

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Figure-1: Robust growth of Himalayan Hemp (Industrial Cannabis sativa-fiber type) Photo courtesy: Himalayan Hemp

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Figure-2: Himalayan Hemp fiber for textile industries and other commercial applications (Industrial Cannabis sativa-fiber type). Photo courtesy: Himalayan Hemp.

Figure-3: Hemp seeds from Hemp Foundation Photo courtesy: Hemp Foundation

Figure-4: The shelled Hemp Seeds ready for the consumption