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ORIGINAL ARTICLE

Prospects of Cannabis and its Cultivation in Sri Lanka

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Abstract

Cannabis (*Cannabis sativa* L) is cultivated commercially in various parts of the world, predominantly for its medicinal properties (medicinal-type) and as a source of fibre and oilseed (fibre-type). The plant is known to contain over 567 chemical compounds out of which about one hundred chemicals belong to the highly valued unique class of Cannabinoids. At present, more than 25,000 Cannabis-based products worth 344 billion US$ are available at the world market. In a situation where the environmental agriculture is principally promoted, the present paper reviewed the applicability and potential worth of cultivating Cannabis as a medicinal plant in Sri Lanka. At present, Cannabis is restricted to be used in Sri Lanka, though the country spends about US$ 27,000 annually to import Cannabis for medicinal preparations. Cannabis is well-known for its wide range of environmental adaptation, higher nutrient and water use efficiency, low dependency on external inputs such as fertilizers and pesticides, high economic return for a unit area of land, and ability to cultivate both in indoors and outdoors. Considering the genetic resources and inherent knowledge, along with favourable climatic conditions available in the dry zone, suggest that Cannabis is an ideal crop, which could assure higher economic benefits under low inputs. While serving as a venture of foreign earnings, local cultivation would halt the country's dependency on importation of Cannabis-based raw materials. However, legalization and cultivation should be rigorously monitored by an authorized body to ensure that the production meets the health regulations and utilized accordingly.

Keywords*- Cannabis sativa, Cannabinoids, Fibre-type, Medicinal properties*

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1. What is Cannabis?

Cannabis is a plant with multiple uses and known by humans for over 4000 years. Though it is basically used to prepare medicinal and psychoactive drugs, the plant is extensively used worldwide for its wide range of other benefits (Nascimento et al. 2017). The first reference of consumption of Cannabis has been documented in one of the oldest Chinese medicine books belongs to 2700 BC named as ShennongpênTs' aoching (Elhendawy et al. 2018). It is believed to be originated in Central Asia (Farag & Kayser 2017). Cannabis also known as Kansa, Ganja, Hemp, Marijuana, and Weed (Erkelens & Hazekamp 2014; Weliange 2017) belongs to the family Cannabaceae and genus *Cannabis*, which has three species (Pollio et al. 2016) namely *Cannabis sativa* L, *Cannabis indica* Lam and *Cannabis ruderalis* Janisch (Clarke & Merlin 2013; Gloss 2015; Sawler et al. 2015). According to Clarke and Merlin (2016), *C. indica* and *C. sativa* have been identified as the two species coming under genus *Cannabis.* At present, both *C. sativa* and *C. indica* are recognized as the mostly cultivated and economically important types of the *Cannabis* (Thomas & ElSohly 2016). However, many authors have described that *C. sativa* is single species of the genus (Small 2002; McPartland et al. 2018; Zhang et al. 2018), which has several subspecies and varieties. Commercial cultivation of Cannabis is done for its medicinal and psychotropic properties and as a source of fibre and oilseed (Andre et al. 2016: Booth et al. 2017: Punja et al. 2021).

2. Botany

Cannabis is a herbaceous, dicotyledonous annual flowering plant (Borille et al. 2017; Farag & Kayser 2017). Usually, it is dioecious, with male and female flowers in separate plants and rarely it has monoecious (male and females flowers are in same plant) phenotype (hermaphrodite) (Thomas & ElSohly 2016). The plant stem is erect and 0.2–2.0 m tall, however, most of the plants reach up to 1–3 m of heights (Rajput & Kumar 2018). The stems are generally angular and furrowed. It has a branched stem and branching is taken place either opposite or alternatively (Amaducci et al. 2015; Farag & Kayser 2017). *Cannabis sativa* is a relatively tall plant, which can grow up to 5–8 feet height or more and laxly branched (Variation et al. 1970). The plant has a strong tap root system where roots are adventitious and straight and the taproot can reach down to 2 m depth depending on soil (Borille et al. 2017; Farag & Kayser 2017).

Leaves of Cannabis are green in colour and palmate with 5–7 lobes. Though the length and the width of a leaflet is 6–11 cm and 2–15 mm, respectively, the size and shape of the leaflets vary with the genetic background. Leaf margins are serrated.

The arrangement of the leaves is either opposit e, alternate or spiral (Gloss 2015; Farag & Kayser 2017). The petiole length of a leaflet is 2–7 cm (Chandra et al. 2017a)

The plant is having small hairs call trichomes though their functions are not yet identified.

They may help in preventing herbivore attacks while minimizing moisture loss from the leaves.

Usually, delta-9-tetrahydrocannabinol (THC) content is higher in trichomes on female plants (Gloss 2015), which produce flowers with high number of Glandular trichomes with high content of tetrahydrocannabinolic acid (THCA) and cannabidiolic acid (CBDA) (Livingston et al. 2020). Normally, glandular trichomes in male plants are not used for medicinal purposes due to limited availability.

Usually, female plants are stronger than the male plants though these are much shorter than the male plants (Rajput & Kumar 2018). The male flower is pale green in colour, hairy and has five sepals of about 2.5–4 mm long. It contains five pendulous stamens with fine filaments and stamen. The female flowers are generally paired and sessile (Farag & Kayser 2017). The pollen which is produced by male plant carried to the female flower by air flow for the natural pollination. Seeds produced as the result of fertilization. The Cannabis plants are naturally regenerated from these seeds. Cannabis seeds grow vigorously in hot and sunny environments with neural to alkaline, nutrients and water abounded soil (Borille et al. 2017). Despite the male plants die once they bear flowers, female plants stay alive and produce seeds (Naraine et al. 2020). The fruits are small (3 to 5 mm) and single seeded thus usually referred as seeds. Seeds are elliptic shape with smooth surface and a hard shell (Zuardi 2006) and botanically known as achene (Borille et al. 2017). The weight of the seeds varies from 2 g and 70 g per 1000 seeds. Normally, the seeds produce in monoecious plants are smaller than in dioecious plants (Amaducci et al. 2005; Borille et al. 2017).

Generally, the growth cycle of the plant could be divided into four phases which commence with germination and seedling emergence followed by the vegetative stage. Flowering and seed formation occur at the third stage followed by the last stage of senescence. During the vegetative growth stage, the plant is photosensitive which continues through the flower development stage (Salentijn et al. 2015; Borille et al. 2017).

3. Chemical composition

The Cannabis plant contains more than 567 chemical compounds out of which Cannabinoids, Terpenoids compounds, Nitrogenous compounds, Non-cannabinoid phenolic compounds, Flavonoids, and Steroids compounds are recognized to be the most important compounds (Elhendawy et al. 2018; Gonçalves et al. 2020). About 100 chemical compounds belong to the unique class of Cannabinoids (Borille et al. 2017), which are organic molecules having a Polyphenolic structure (Fig. 1). Cannabinoids interact mainly with type 1 and type 2 also called as CB CB2 cannabinoid receptors. These can also be interacted with other receptors such as serotonin receptors and transient receptor potential (TRPV) canals of the vanilloid type, resulting in physiological effects, including psychoactivity or euphoria, motor dysfunction, analgesia and immunomodulation. The composition of Cannabinoid compounds differs according to the varieties and the biological and physiological responses (Yang et al. 2020).

The delta-9-tetrahydrocannabinol (THC) and the Cannabidiol (CBD) can be identified as the most abundant and widely recognized Cannabinoids compounds found in Cannabis (Nascimento et al. 2017). THC has been widely documented as a pro- and anticonvulsant, while CBD has been widely verified as an anticonvulsant (Whalley et al. 2019). THC is the most significant compound that is responsible for Cannabis' psychoactive outcomes. However, THC levels of the plant vary based on the breed and the countries. *C. ruderalis* contains very low THC contentment than *C. sativa* and *C. indica* (Gloss 2015). *Cannabis sativa* produces more THC than CBD and *C. indica* produces THC and CBD at about 1:1 ratio. *Cannabis. sativa* contains higher THC and lower CBD levels than *C. indica* (Thomas & ElSohly 2016). In fact, it has been reported that the THC levels differ from 3% to 12–16% or higher (Kalant 2001; Madras 2015). When a concentrating technique is used in determining the content, very high levels of THC has been reported (Stogner & Miller 2015; Madras 2015). According to an Australian study, total THC content varied between 1–40% and total CDB content differed between 0 and 6% (Gloss 2015) and according to the US data, Cannabis contains 8.8% of THC and 0.4% CBD levels (Swift et al. 2013). There is a herbal or sweet smell in *C. sativa* and an acrid or skunky smell in *C. indica* due to terpenoid profile of Cannabis (McPartland & Guy 2017).

Tetrahydrocannabivarin (THCV), Cannabigerol (CBG), Cannabinol (CBN), cannabichromene (CBC), Cannabidolic Acid (CBGA), delta-8-THC, Canabigerolic Acid (CBGA), and Cannabichromenic Acid (CBCA) are other common Cannabinoids chemicals compounds which contribute to the medicinal values of the Cannabis plant (Table 1).

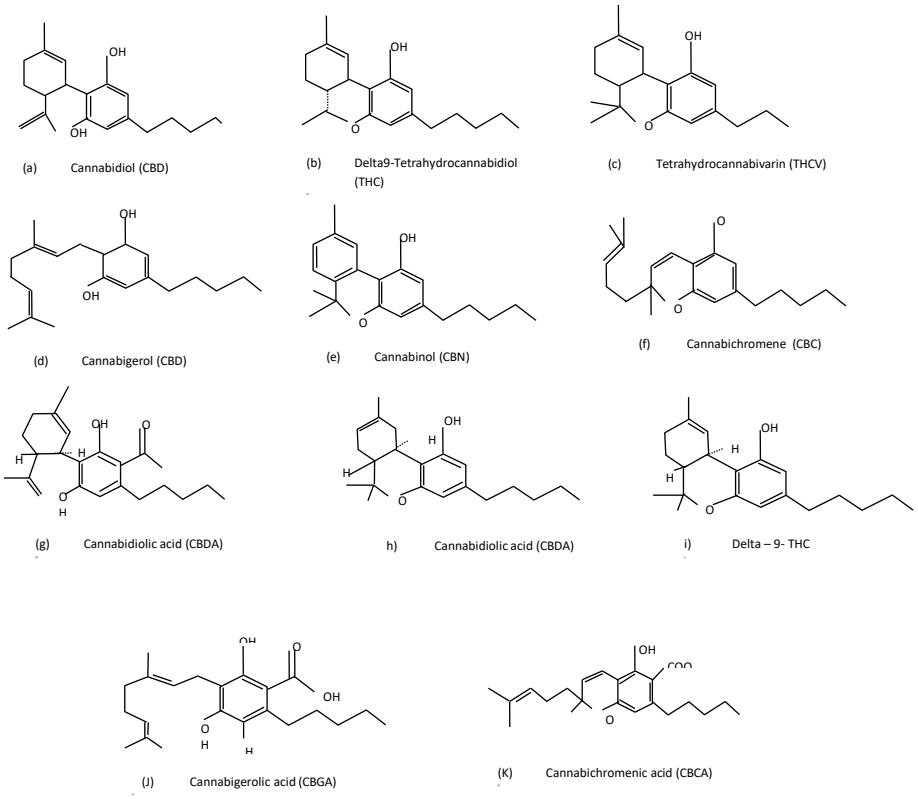

Figure 1: Chemical structures of some cannabinoids which exhibit medicinal properties. Source: Weliange (2020)

Table 1: Medicinal properties of some cannabinoids

Chemical compound	Medicinal properties	Reference
Cannabidiol (CBD)	**Used for** • Formulating drugs for some neurological and neurodegenerative disorders • Treating chronic pains • Curtailing the addiction or consumption of alcohol and opioids such as heroin and morphine	Juknat et al. (2011) Russo & Marcu (2017) Boyaji et al. (2020) Navarrete et al. (2021)
delta-9-tetrahydrocannabinol (THC)	**Used as** • Bronchodilator and neuroprotective antioxidant • A remedy for glaucoma, Parkinson and Alzheimer's disease • A treatment to minimize the complications in organ transplanting • Immunologic-modulator and appetite stimulant • Analgesic and antiemetic stimulant • A treatment of multiple acute and chronic health disorders • A treatment of nausea and vomiting associated with cancer chemotherapy, anorexia • A treatment of cachexia associated with HIV and AIDS patients • A treatment for pain and muscle spasms in multiple sclerosis • A modulator of memory, emotions, and movement	Nagarkatti et al. (2009) Grant et al. (2012) Borgelt et al. (2013) Koppel et al. (2014) Hill (2015) Boggs et al. (2016) Russo & Marcu (2017) Abioye et al. (2020)
Tetrahydrocannabivarin (THCV)	**Good at** • Reducing weight loss and body fat • Lowering serum leptin levels • Inducing anticonvulsant effects	Wargent et al. (2013) Englund et al. (2015) Russo & Marcu (2017) Abioye et al. (2020)

	• Decreasing fasting plasma glucose levels • Increasing β-cell functions • Treating type 2 diabetic patients • Reducing food intake • Enhancing energy expenditure and insulin response • Lowering liver triglyceride levels	
Cannabigerol (CBG)	**Used for** • Treating cancer, detrusor overactivity and bladder pain • Lowering cell proliferation in several cancer cell lines • Treating prostate and colorectal carcinoma, gastric adenocarcinoma • Treating mood disorders • Conditioning the skin • Enhancing sex hormonal dysregulations • Healing dietary disorders • Healing bones	Ligresti et al. (2006) McAllister et al. (2007) Ligresti et al. (2016) Deiana (2017) Russo & Marcu (2017)
Cannabinol (CBN)	**Used for** • Antibiotic and anti-inflammatory preparations	Russo & Marcu (2017)
cannabichromene (CBC)	**Used for** • Anti-inflammatory drug preparations • Promoting brain functions • Antimicrobial drug preparations	Appendino et al. (2008) DeLong et al. (2010) El-Alfy et al. (2010) Tubaro et al. (2010) Maione et al. (2011) Russo & Marcu (2017)

4. Geographical distribution

Cannabis is reported to be originated in China in Central Asia where a variety of genetic resources of wild populations along with improved cultivars are distributed covering the most part of the country ranging from 23–51° N to 80–125° E (Zhang et al. 2018). The plant has been introduced to Eastern Europe in 3000 B.C.

and reported to be existed in Middle East, Korea and Japan since 2000 B.C. (Warf 2014). Cannabis has been distributed in South Asia during the period of 1000–2000 B.C. Southern American countries received Cannabis somewhere in the 16th century, in fact after Americans started to use Cannabis. At present, it is distributed in more than 50 countries around the world and cultivated as a crop with multiple uses including production of food, medicine, fibre, clothes, papers, and cosmetics (McPartland et al. 2019). According to the historical and archaeological sources, it has been used in China for obtaining fibres since 4000 B.C. The medicinal uses of Cannabis broadly spread in India from the starting of Christian Era to the period of 18thcentury and after that it was distributed to Middle East and Africa (Zuardi 2006). Cannabis cultivation increased continuously in Europe from the 16th century to the 20th century (Amaducci et al. 2005). In 1150, papers which are manufactured by Cannabis introduced in Spain and Italy. After that, Cannabis has been cultivated exclusively for fibre production in Europe (Zuardi 2006). According to Diddeniya & Kulatunga (2021), Cannabis has been used over the years in Sri Lanka as an ingredient in medicinal preparations to treat more than 50 illnesses.

5. Cultivation of Cannabis

Cannabis is commercially cultivated as a source of food (seeds), fibre (stems), and drugs (flowers) (Mercuri et al. 2002; Clarke & Merlin 2013, 2016). It is well-adapted to a range of agro-ecological conditions and considered to be an environment friendly crop (Cosentino et al. 2012; Angelini et al. 2016). The cultivation of cannabis began with open field outdoor growing, which was later followed by indoor cultivation under controlled environmental conditions (Punja 2021).

Soil and climatic requirements

Although, Cannabis shows a wide range of environmental adaptation, it is advisable to select local varieties as they tend to perform better than those newly introduced to the area. Basically, the adaptation of a variety depends largely on their sensitivity to photoperiod and temperature (Amaducci et al. 2012; Hall et al. 2012). Cannabis generally prefers high temperatures and a relatively long photoperiod (Cole & Zurbo 2008; Hall et al. 2013; Hall et al. 2014a; Humphries & Florentine 2019). Therefore, optimum production could be expected when the average temperature is 25°C–30°C (Chandra et al 2011a, b). Cannabis plant needs 8 and 12 hours of photoperiod for vegetative growth and initiation of flowering, respectively. This crop is very sensitive to frosts. Very high temperatures may result in early maturity, flowering and stunted growth (Cole & Zurbo 2008; Hall et al. 2012). Time taken to start flowering is vital as it determines both quantity (Struik et al. 2000) and the quality (Amaducci et al. 2005, 2008a) of the yield. Around 75% of humidity is required for juvenile stage while 55%–60% humidity is recommended for active vegetative and flowering stages (Thomas & ElSohly 2016).

Well drained soils such as sandy loam or clay loam are the best soils for cannabis, as water logging can damage the root system of the plant (Amaducci et al. 2005; Humphries and

Florentine 2019). Cannabis grows well when the soil has a pH level ranging from slightly acidic to slightly alkaline (Farag & Kayser 2017; Humphries and Florentine 2019). For commercial cultivations, compacted soil should be avoided as such soils could hamper the growth of taproot, which generally could penetrate towards the deeper layers of the soil. The taproot then could enrich the soil by bringing the nutrients from the deep to the top, where the majority of active root mass is distributed (Amaducci et al. 2008b; Zatta et al. 2012). Cannabis is identified as a good candidate for crop rotation, as its root system improves the nutrient status of soil (Amaducci et al. 2005). The nitrogen use efficiency of Cannabis is also known to be exceptionally high compared to many other field crops (Tang et al. 2017).

Planting materials

Cannabis can be commercially grown both as outdoor and indoor cultivations. Planting materials could be obtained through seeds and vegetative means which include *in-vitro* micro propagation as well (Farag & Kayer 2017; Chandra et al. 2017b). Cannabis plants are cross-pollinated thus the yield and the chemical composition could vary if seeds were used as planting materials. Furthermore, such cultivations may have equal number of male and female plants (Chandra et al. 2020). Therefore seeds are generally extracted from artificially pollinated plants grown in greenhouses (Hempicine 2017). Selected plants which are ready to bloom within next 2–3 weeks are used for the artificial pollination. Female flowers are pollinated with the pollens collected into a poly bag or glass jar using small brush and covered to prevent unwanted pollination and contaminations. Around 20–30 fully matured seeds could be easily extracted from a pollinated single flower bud. Cannabis seeds are germinated within 4 to 7 days at 21–26 °C temperature and 12 h photoperiod (Chandra et al. 2017b). For outdoor cultivation, seeds are raised in two inches of small biodegradable peat-based pots and established outdoors directly (Chandra et al. 2017b). The life cycle of the cannabis plant is completed within 4–6 months depending on the method of propagation and the variety (Farag & Kaser 2017).

Indoors cultivation is done with cuttings taken from mother plants of a desired genotype (Lewis et al. 2017). As Cannabis is dioecious, only female plants that bear inflorescences are selected for taking cuttings (Punja and Holmes 2020). Top or stem cuttings of about 10–15 cm long with at least two nodes are selected and a hormone such as indole-acetic acid is used to induce rooting. These are then planted in containers filled with a growing substrate such as coco-fibre, rockwool or peat/soil (Punja 2021). Cuttings takes around 5 to 14 days to induce rooting and during the period high relative humidity should be maintained inside the chamber (Wouter 2014). Well rooted cuttings can be used for indoor and outdoor cultivations. For outdoor cultivation, well rooted cuttings could be propagated using automated planters. In addition, cuttings can be directly propagated in a hydroponics system (Chandra et al. 2017b; Lata et al. 2009). Due to

the dioecious habitat and cross pollination nature of Cannabis, it is difficult to maintain homogeneity of chemical composition. Therefore *in vitro* propagation of Cannabis is employed to maintain homogenized plants. In this regards, nodal segments of the mother plants are reported to be used as the explants (Jain and Singh 2016).

At present, hydroponics farming is also employed in cultivating Cannabis. Furthermore, reports are available on the use of aeroponics also, which in fact minimizes the cost of production. Growers have experimented on aquaponics techniques as well for Cannabis production (New Frontier Data 2019). When integrated farming system is used in aquaponics with tilapia (fish), no chemical fertilizer is added to enhance the growth of Cannabis. In another integrated system, Cannabis is cultivated nearby tanks where tilapia is cultured where Cannabis absorbs nutrients from the waste of tilapia while supporting water filtration through its root system (New Frontier Data 2019).

Weed Management

Cannabis is a crop resistant to weeds, as the plant with its fast growth rate and broad, overlapping leaves, could easily outcompete with weed species (McPartland 1997). The seeds of *C. sativa* are known to have an ability to germinate much quicker than many weed seeds (Amaducci et al. 2005; Campiglia et al. 2017). Their rapid growth rate along with high seedling densities enables the crop to cover 90% of the ground area within a period of just two to four weeks (Zatta et al. 2012). The maintenance of high plant densities is therefore considered to be the most effective means of weed control in Cannabis cultivations (Hall et al. 2014b; Campiglia et al. 2017). Furthermore, Cannabis possesses the ability to produce some allelochemicals which could suppress the growth and establishment of weeds (Campiglia et al. 2017). Therefore, continuous cultivation of Cannabis for several years in the same piece of lands negatively affects the seedbanks for problematic weeds (Humphries and Florentine 2019). It has been reported that *C. sativa* is able to produce a germination inhibiting essential oil, which could suppress some agricultural weeds by acting as an effective botanical herbicide (Agnieska et al. 2016). However, the effectiveness of this essential oil is known to be poor against some monocot species, thus grass weeds could still be problematic and may need some control measures (Agnieska et al. 2016). Furthermore, as the seedlings of *C. sativa* are very sensitive to herbicides, even residuals of herbicides could hamper seed germination and seedling development of Cannabis. Therefore, it is advisable to avoid use of herbicides in cropping systems, where *C. sativa* is used as a component of crop rotation (Amaducci et al. 2005). The highly competitive nature and low-maintenance requirements make the crop establish itself in the natural environment also (Reisinger et al. 2005).

Pest and diseases

Cannabis sativa is generally recognized to be a high yielding, agricultural crop with minimum or no pesticide requirements (Angelini et al. 2016). According to Bedini et al (2016), *C.*

sativa is known to display features of a natural repellent to a wide range of insect pests and molluscs. Furthermore, it is repellent to nematodes (Kayani et al. 2012; Mukhtar et al. 2013), some fungi and other microorganisms (Novak et al. 2001; Nisson et al. 2010). As stated by McPartland (1996), though several insect pests are reported be associated with Cannabis, a very few of them cause economic damages. At the early stage of growth, cut worms, flea beetles, crickets, slugs, and rodents are found to damage the crop. At later stages, budworms, leaf miners, stem borers, beetle grubs, root maggots, termites and ants are considered as minor pests. However, pests like aphids, whiteflies and mealy bugs may cause considerable damage to the crop (McPartland et al. 2000) thus need control measures.

Disease incidences in Cannabis are not common, however some pathogens such as *Fusarium* and *Pythium* species can cause severe damages at the propagation and vegetative growth stages (Punja 2021). Due to their infections, plants may show stunted growth at the beginning and later plant death. Furthermore, these diseases could continuously affect the plant until flowering if control measures were not taken. The powdery mildew could damage the foliage of indoor plants and outdoors cultivations can be severely affected by several leaf-spotting fungi. Disease control is basically done through preventive measures at the beginning and then reducing the spread of the diseases. At the mature stage, some pathogens such as *Botryis* and *Fusarium* species could attack the inflorescence destroying the flower buds, which may cause a yield loss up to 20% (Punja 2021).

Fertilization

As stated by Backer et al (2019), the yield and cannabinoid content of Cannabis vary with several factors which include variety, plant density, light intensity, and fertilization. However, information available on the impact of different agronomic practices on yield and cannabinoid profiles is less compared to many other crops. Contrastingly, some reports on fertilizer application (Malceva et al. 2011; Caplan et al. 2017), microbial inoculants (Winston et al. 2014), light intensity and photoperiod (Chandra et al. 2011a, 2015), temperature (Chandra et al. 2011a), physiological stresses (Marti et al. 2014) and elicitors (Flores-Sanchez et al. 2009; Mansouri and Asrar, 2012; Mansouri et al. 2013 & 2016) are available. However, broad recommendations are hard to make as the published works have been done in different geographical regions using different methodologies.

The impacts of external supplementation of nutrients on growth, morphology and biochemical composition of Cannabis have been investigated under different conditions by some authors (Jin et al. 2019). *Cannabis sativa* is generally known to be a high yielding crop, which needs a minimum or no fertilizer (Amaducci et al. 2008a). As reported by Struik et al. (2000) and Prade et al. (2011), the effect of nitrogen on Cannabis is negligible in fertile soils. However, significant yield enhancements could be achieved when nitrogen

supplementation is done under nitrogen limiting conditions (Struik et al. 2000; Amaducci et al. 2002; Vera et al. 2010; Finnan & Burke 2013). In the case of fibre-type Cannabis, the nitrogen fertilizer requirement was estimated to be 50–200 kg N ha^{-1} (Aubin et al. 2015), which in fact is almost similar to that of the other high-yielding field crops. However, the corresponding figure for drug-type Cannabis is not available yet basically due to lack of literature on open field cultivation of them. Furthermore, it is apparent that nutrient requirement of a species depends vastly on growing conditions and the stage of growth. Generally, for short term crops, fertilizer application is done as a basal dressing. In this connection, Finnan and Burke (2013) observed no significant increase in stem yield of Cannabis when nitrogen was given as split applications compared to the application at the sowing. According to Desanlis et al (2013), Cannabis plants tend to be lodging in response to excessive rates of nitrogen though rapid stem elongation could be observed. Furthermore, excess nitrogen could result in reduced THC content in Cannabis leaves (Bócsa et al. 1997; Wu et al. 2010).

According to Jin et al (2019), Cannabis displays relatively poor response to externally applied potassium and phosphorous by contrasting to nitrogen. No correlation between Cannabis yield and potassium fertilization was observed by Finnan & Burke (2013) who reported, based on their findings, that Cannabis required lower amount of potassium than many other crops. The study further suggested to apply 65 kg ha^{-1} of potassium annually. Similarly, Ivonyi et al (1997) reported that the stem growth of Cannabis does not depend on P fertilization and requirement of P may range from 52 to 67 kg ha^{-1}.

In contrast, information linking the plant nutrition and the quality characteristics of the Cannabis yield is limited (Jin et al 2019). According to Grabowska & Koziara (2005), both fibre yield and fibre strength are reduced by the excess rate of nitrogen though vegetative growth could be enhanced in fibre-type Cannabis. In fact, the fibres of the plants which receive excessive nitrogen do possess a larger lumen resulting in poor technical characteristics. Malceva et al (2011) also reported higher seed yield with lower oil content when Cannabis received excess nitrogen. However, all these attributes may vary with time and location of cultivation (Jin et al. 2019).

Cannabis production under indoor conditions is often done targeting a quality production for medicinal purposes. Caplan et al (2017) studied the impact of organic fertilizer on the growth and flowering of Cannabis grown in coir-based growing media. During this study, a liquid mixture (N-P-K ratio of 4:1.3:1.7) had been applied at different rates during vegetative growth stage and revealed that optimization of fertilizer could increase the yield. Accordingly, floral THCA and CBN concentrations were not affected by the rate of fertilization, though THC concentrations varied. Time requirement for the maturation could also be reduced by the optimal fertilization during the early stage of growth (Caplan et al. 2017). Under indoor

conditions, it is obvious that growing substrates could be decisive for any crop. According to Caplan et al (2017), coir or peat-based substrates are used in producing Cannabis at industrial scale in North American region. As different substrates possess different physical and chemical characteristics, fertigation of these substrates is essentially needed. In this context, Cannabis grown in coir-based organic substrates and treated with a liquid organic mixture (4.0N–1.3P–1.7K) at the rate of 389 mg N L^{-1} resulted in high yield with increased cannabinoid contents (Caplan et al. 2017).

Irrigation

Cannabis sativa possesses a strong root system with a tap root which could penetrate to the soil down to two meters enabling the plant to absorb moisture from deeper layers of soil, thus the water requirements of the crop is considered to be moderate (Amaducci et al. 2008b; Humphries & Florentine 2019). Cannabis is therefore known to be a drought resistant plant and moisture deficit along with high temperature is reported to enhance flowering (Amaducci et al. 2008c) though such conditions reduce the plant growth (Abot et al. 2013). According to Schäfer & Honermeier (2006), dry conditions negatively impact on plant height and stem diameter. The water requirement of the crop could easily be met with an annual rainfall of about 600–700 mm (Humphries & Florentine 2019). Without rainfall, a minimum irrigation would be enough for the crop (Zatta et al. 2012; Humphries & Florentine 2019). Under European conditions, Cannabis gives optimum yield when the plant receives around 500–700 mm moisture (Bócsa & Karus 1998), while many regions Cannabis cultivation is rain-fed cultivations.

Harvesting

Harvesting time varies with the variety. The maturity of the Cannabis plant is determined by visual observation and confirmed using the cannabinoid content of the plant samples which are collected from different growth stages. Whole Cannabis plant does not mature at the same time. Upper buds of the plant are matured first and are harvested first and then the other branches are harvested. Normally, Cannabis is harvested based on the favourable cannabinoids content of the plant. When harvesting plants for pharmaceutical importance, plant should not be contaminated with soil. Before start the drying process, dry leaves are removed from the mature buds (Chandra et al. 2017b). Harvesting is done by cutting the plant at the base and then it should be dried, ventilated and stored under dry conditions (Potter 2014).

In order to prepare herbal Cannabis from outdoor cultivated plants, the flowers and upper leaves are harvested from mature plants and dried naturally. These are then thrashed and sieved to take glandular trichomes fine powder to prepare a dark brown resin. Primarily, Cannabis resins contain in glandular trichomes of the female flowers. Forced-air dryers are used to dry harvested Cannabis by large-scale producers. However at small scale, ovens could be used to dry at 40 °C. Dried Cannabis should be stored in refrigerators until

use for the extraction process (Chandra et al. 2017b).

6. Uses

Cannabis is a multi-purpose medicinal plant used in various sectors including pharmaceutical, food and oil, cosmetics and personal care products, animal bedding and feed, textile and paper, building construction, plastic production and in agriculture (Small 2002; Amaducci et al. 2014). It is reported that well over 25,000 Cannabis-based products are circulated in the global market (Angelini et al. 2016).

Pharmaceutical industry

Cannabis sativa is widely used in indigenous medicine in India (Rajput & Kumar 2018) and in Sri Lanka, where it is employed in producing a number of herbal preparations used in Ayurvedic medicine (Weliange et al. 2017). Whole Cannabis plant including different parts of the plant including the leaves, roots and seeds are used in treating many non-communicable and communicable diseases including diabetes, cancer, HIV, glaucoma, chronic pain and arthritis, Parkinson's disease (Rajput & Kumar 2018; Shakil et al. 2021), and Hyperemesis Gravidarum (Koren & Cohen 2020). It is known to be effective in pharmacotherapy for pain (Hill et al. 2017) and in fibromyalgia pain (Cameron & Hemingway 2020).

Cannabinoids are capable of inhibiting the growth of cancer cells inside the body through obstructing the supply of required oxygen and nutrition (Ramer & Hinz 2015; Rajput & Kumar 2018). THC is known to be effective in treating and preventing diabetes (Cao et al. 2017; Rajput & Kumar 2018). Cannabinoids through the neuroprotective actions and decreasing the intraocular pressure, have shown the effectiveness in treating glaucoma, a major cause of blindness due and it (Tomida et al. 2004). Cannabis is known to be good at curing toothache and some disorders associated with it as the cannabinoids possess some antimicrobial features (Stahl & Vasudevan 2020).

Food, feed, and animal bedding

Cannabis seed is a healthy food with desirable nutty taste. It has been reported that the seeds contain 20-30% of carbohydrates, 20-25% of protein, 10-15% of fibre and 25-30% of oil. The seeds are also proved to contain all the essential amino acids and fatty acids (Leizer et al. 2000). At present, seeds or the flour made of seeds are found as an ingredient in number of food products such as nutritional bars or snack bars, spreads (nut butters, mayonnaise), bakery products (bread, burgers), pretzels, cookies, porridge, desserts (fruit crumble, ice cream, salad dressings), pasta, pizza, salt substitute, dairy products (yogurts, cheese, and flavoured milk) and beverages (beer and wine). Cannabis seeds are available as a canned products or vacuum packed (Small 2002).

The residue of oil extraction is found to be a good source of animal feed (Ranalli & Venturi 2004). The wood shavings of Cannabis are used as animal bedding as it is capable of absorbing high level of moisture compared to commonly use other materials. And also Cannabis bedding

generally does not produce dust and could easily be composted (Small 2002).

Oil

The oil content of Cannabis seed could be up to 35% depending on the growing environment and extraction procedure. The oil is used in cooking, production of cosmetics, plastics and some other industrial products (Ranalli & Venturi 2004). Cannabis seed oil consists with Linileic Acid (major omega-6 poly-unsaturated fatty acid) and Linolenic Acid (major omega-3 poly-unsaturated fatty acid which is caused to anticancer and anti-inflammatory) and has nutritional value due to gamma-linolenic acid (Leizer et al. 2000).

Personal care products and cosmetics

European firms have introduced personal care products which are produced using Cannabis oil and circulated all over the world. Cannabis oil is used to produce wide range of personal care products and cosmetics. Body soaps, shampoo, cream, body lotions, moisturizing cream, lip balms and perfumes are some of the personal care products and cosmetics which are produced using cannabis oil. Germany is known for manufacturing a laundry detergent using Cannabis oil (Small 2002). Cannabis is used to prepare mouth wash preparation due to the antimicrobial activities of cannabinoids (Vasudevan & Stahl 2020).

7. Demand

Global demand

At present, more than 25,000 Cannabis-based products are available at the global market (Small 2002; Angelini et al. 2016) and in 2019, the average street price for Cannabis was reported to be 126,000 LKR per kilo gram, which is approximately USD 683 (National Dangerous Drug Control Board 2020). According to New Frontier Data (2019), over 263 million people around the world consume Cannabis every year. In 2020, the global Cannabis market value was estimated to be US$ 344 billion (Fig. 2), which will be increased by 14.3% during the period from 2021 to 2028. The major factors attributed to this growth are legalization of Cannabis cultivation in different countries and increasing demand worldwide.

As per the records available until 2020, over 50 countries including Canada, most part of the United States, Germany, Luxemburg, Switzerland, Uruguay, Australia, etc. have legalized Cannabis for medicinal purposes (Aliekperova et al. 2020). Six countries; Canada, Uruguay, South Africa, Guam, Georgia, and Northern Mariana Islands have legalized Cannabis for other purposes (personal or recreational) as well. During the last decades, the demand for psychoactive substances has increased significantly (Rajput & Kumar 2018). The top five regional markets are Asia, North America, Europe, Africa, and Latin America (Fig. 3).

Asia is the world largest Cannabis market with 39% of global sales, where comparatively higher average price is paid for Cannabis than other markets. The contribution to the global sales from North America and Europe has been estimated to be 25% and 20%, respectively (Amaducci et al. 2014

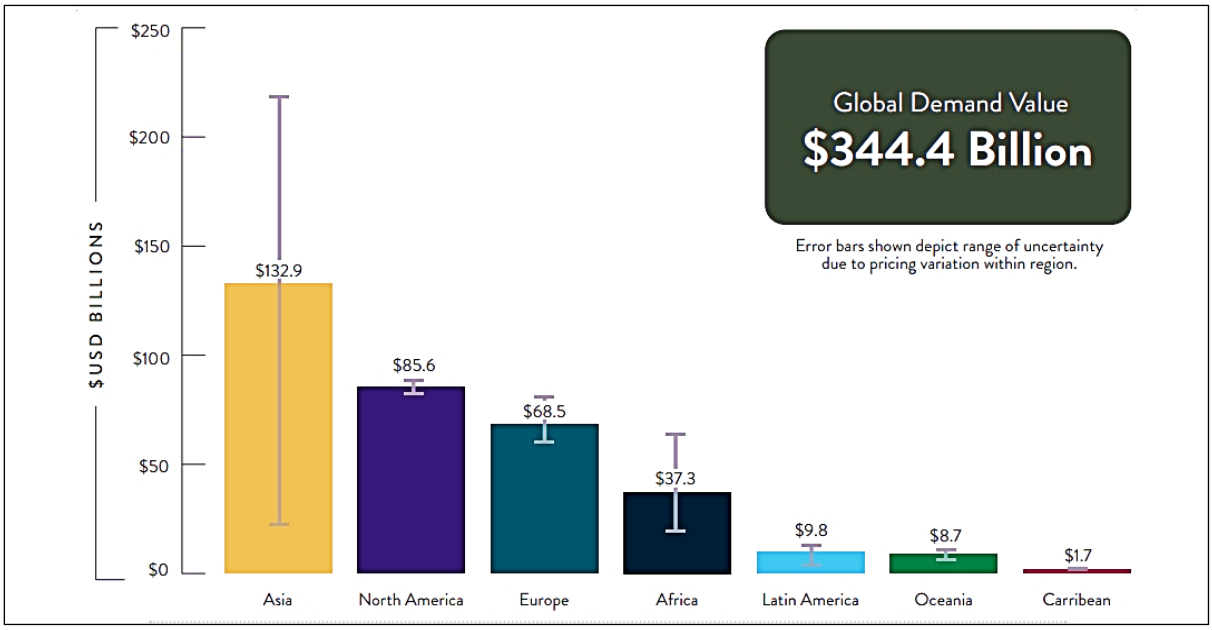

Figure 2: Total estimated value of Cannabis demand by region (Estimated in USD Billions)

Source: New Frontier Data (2019)

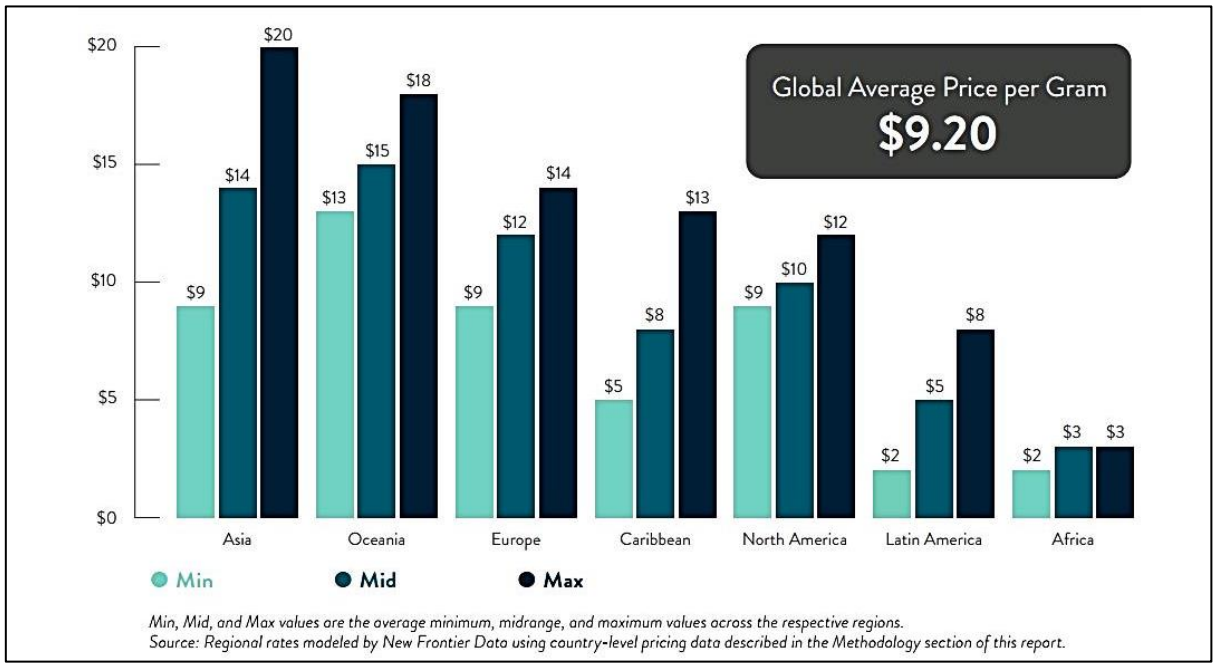

Figure 3. Average price of Cannabis per gram by region (USD)

Source: New Frontier Data (2019)

Local demand

Since, use of Cannabis is illegal in Sri Lanka, no reliable information is available on production and consumption. However, according to the sources of Ayurvedic Drug Corporation, 252 kg of Cannabis have been used to produce Ayurveda medicines (mainly Madanamodaka and Kameshvarimodaka) in 2018 (Handbook of Drug Abuse Information (2019). As stated by

Diddeniya and Kulatunga (2021), Cannabis is used in Ayurvedic drug preparations for disorders in gastrointestinal tract disorders, naadi vyuhara (nervous system), raktha vyuhava (circulatory system), prajanana sansthaana (reproductive system), and for the disorders in swasana sansthaana (respiratory system). In the traditional medicine in Sri Lanka, Cannabis preparations also include Kashaya (decoction), Guli (pills), Kalka (pastes), Choorna (powder) and Vedu (fumigation). According to the Asia and Pacific Seed Association, Sri Lanka has imported raw Cannabis by spending at least USD 500,000 since 2000. The country spends roughly USD 27,000 annually to import Cannabis. Furthermore, irrespectively the legal barrier, Cannabis is grown illegally in many parts of the country and the vast majority of the production is locally consumed.

8. Cultivation of Cannabis in Sri Lanka

Cannabis, also known as Kansa and Ganja has been used as a medicinal plant in Sri Lanka at least since early 17th century and there were some early records on cultivation as well. According to data obtained from about eleven medicinal textbooks written in Sinhala language, Cannabis is mentioned as an ingredient in more than hundred prescriptions for over fifty illnesses (Diddeniya & Kulatunga 2021). In 1675, the Dutch Colonial Rulers have banned trafficking of narcotics, including Cannabis. The ban was renewed during British rule in 19th and 20th of centuries (APSA 2019). In 1895, British rulers have prohibited use of Cannabis in Sri Lanka (Weliange 2017). Though the provisions of Poisons, Opium and Dangerous Drugs Ordinance of 1935 have criminalized Cannabis, later through the Ayurveda Act (Act No. 31 of 1961 as amended by Act No. 5 of 1962), it was allowed for the Ayurvedic physicians to obtain opium and Cannabis for medicinal preparations. However, the local requirement is primarily met with the importation of Cannabis by spending about USD 27,000 annually (APSA 2019).

The barriers imposed by the Government are considered to be the major challenges to cultivate Cannabis. Cannabis is illegal to use recreationally in Sri Lanka since 1895 (Weliange 2017). The Poisons, Opium, and Dangerous Drugs Act states that: “No person shall, without the license of the Minister, plant, cultivate, obtain, or have in his possession any poppy plant, coca plant, or hemp plant, or collect or have in his possession the seeds, pods, leaves, flowers, or any part of any such plant”. Accordingly, no provision is provided there into cultivate Cannabis even for medicinal purposes.

Even though, Cannabis has a wide range of benefits, the general public of Sri Lanka is not aware of the potential value of the plant. The majority of people still believe in that the Cannabis could only be used as a drug. Therefore, the main objective of the people who tend to cultivate Cannabis is to sell them as a drug. According to the National Dangerous Drug Control Board (2020) of Sri Lanka, Cannabis is the most used illegal drug in Si Lanka. Out of total population, 1.9% of the people have used Cannabis as a drug since last 14 years (Handbook of Drug Abuse Information 2020).

In 2020, the total number of drug related arrests was reported to be 95,495 among them the vast majority 40,732 (42.7%) was Cannabis related arrests (Drug related statistics 2020). The continuous Cannabis related arrests and the publicity given for such legal actions may have negative impacts on any attempt of cultivation. Therefore, such a social pressure could only be minimized through awareness campaigns through which the economic and social benefits of large-scale production should be highlighted.

Cannabis is a versatile plant that can be thrive in wide range of climatic and agronomic conditions (Decorte et al. 2013). It has been grown over the years in Sri Lanka even without the legal support, means that the soil and climatic conditions are suitable for the cultivation of Cannabis at commercial scale. When compared to other cash crops in Sri Lanka, Cannabis needs minimum inputs such as labour and fertilizers (Mahir & Wazeema 2020). The plant is resistant to pests and diseases as well. Usually Cannabis plant consumes relatively less amount of water (Ranalli & Venturi 2004), therefore could be cultivated with a minimum or without irrigation. The requirement of planting materials could be met with seeds or/and cuttings, where local genetic resources could effectively be used a mother stock. It is a crop which could be grown both indoors and in open fields. At present, chemical-free agriculture is promoted in Sri Lanka. Taking all the factors stated above along with the economic value of Cannabis plant into account, legalization or relaxing the laws enabling cultivation of Cannabis in Sri Lanka could be recommended. It can be an ideal candidate for both the conventional and organic farming systems to get economic yield under low inputs supporting environmentally friendly sustainable agriculture. However, relaxing the law promoting its cultivation must be regulated to ensure that the production is used for non-recreational purposes.

9. Conclusions

Cannabis sativa L is commercially grown in several countries taking its medicinal and psychotropic value (medicinal-type) or fibre and oilseed production (fibre-type) into account. Cannabis is restricted to use in Sri Lanka, though the country is known to have a well-established traditional medicinal system where imported Cannabis-based raw materials are used extensively for different kinds of drug preparations. Through establishing a local production system of Cannabis, a greater control over both the quality and quantity could be ensured while saving the expenditure on imports. Commercial cultivation could also serve as a venture for foreign earnings as the demand for Cannabis-based products at the world market is as high as USD 344 billion.

The species could easily be propagated through seeds or/and cuttings; for those local genetic resources available in Sri Lanka could effectively be used as a mother stock. The wide range of climatic adaptability and lower dependency of external inputs such as fertilizers and pesticides convince its worthiness of cultivating in the dry zone of Sri Lanka where traditional knowledge on cultivation is also available. Cannabis could be

grown without or with a minimum irrigation and by nature it could withstand against a variety of pests and diseases. Furthermore, it could be a candidate suitable for both in indoors and open field cropping systems. Based on above facts, legalization and promoting the cultivation of Cannabis in Sri Lanka is recommended. However, ensuring the consumer safety and relevant health regulations, any Cannabis production system should be monitored by an authorized body.

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