

Proceeding Paper

Benefits of Cultivating Industrial Hemp (*Cannabis sativa* ssp. *sativa*)—A Versatile Plant for a Sustainable Future [†]

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Abstract: Industrial hemp, as a diverse plant, can be a revolutionary crop for a better future and for upcoming generations. It is an eco-friendly and worthwhile crop that complements a sustainable growth system. Industrial hemp farming has the potential to dramatically minimize the amount of carbon impact on the environment and can be cultivated with little or no usage of chemical pesticides or fertilizers. The advent of the COVID-19 pandemic crisis has significantly raised health awareness among the people, fueling the growth of the hemp market at a great pace. The stalks, seeds, and leaves are converted into various construction materials, textiles, paper, food, furniture, cosmetics, healthcare products, and soon. Bioplastics, biofuels, and biopesticides are some of the innovative applications of the plant, which are subjects of research and debate at present time. It is not only a treasure for the industrial sector but also a dignified plant for sustainable farming systems. The benefits of industrial hemp cultivation will uplift the socio-economic level of the farmers globally and can even add to the GDP per capita of nations to a great extent. The future of the plant strongly depends on market demand for its bio-based products that will help the plant to establish itself as a worthy sustainable crop.

Keywords: sustainable; bioplastics; biofuels; carbon impact; biopesticides; innovative



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1. Introduction

Being a diverse one, hemp or industrial hemp can be a revolutionary plant for a better future and upcoming generations. Due to its immense contributions, hemp is emerging as a vital agricultural commodity, and the appeal for its merchandise has increased steadily in the present century. It is an eco-friendly and worthwhile crop that complements a sustainable growth system. Growing hemp improves local states' economies and creates job possibilities, particularly in agriculture-dependent areas. The revival of this centuries-old multifaceted crop can be a turning point and shows ways to change the livelihood of farmers worldwide. The benefits of hemp production will improve farmers' socio-economic status around the world and may potentially contribute to a significant increase in countries' GDP per capita.

There exists a misconception and, so, hemp is sometimes confused with marijuana. However, hemp has a different genetic makeup; the chemical constitution also differs. The hemp plant contains two main cannabinoids: tetrahydrocannabinol (THC) and cannabidiol (CBD). The content of THC in hemp is only 0.3% or even less, compared to that of marijuana that contains up to 20%. Certain hemp species may possess medicinal properties even though the CBD content may be high. Cannabinoids are primarily found in the trichomes of female flower bracts. The concentrations of cannabinoids are much lower in the root, shoot, and leaf tissues, and negligible amounts are found in the seed, seed oil, and pollen of the plant [1].

Richard Evans Schulte wrote: "Hemp is a green, very abundant and ubiquitous plant, economically valuable, a versatile and multi-purpose product, possibly dangerous

and certainly in many ways mysterious" (Schultes 1970). This definition is relevant in illustrating valuable characteristics although it is antithetical to the nature of the crop.

2. Methods

A literature review was conducted by searching on electronic databases, including Google Scholar, Science Direct, Scopus, and PubMed, for studies focusing on the benefits of cultivating industrial hemp and finding out whether it can be a sustainable crop or not. The terms "Hemp", "*Cannabis sativa*", "medicinal usage", "essential oil", "bioactive components", and "various growing conditions" were used to search all recent English-language papers published between 1998 and 2020. All reports and reviews linked to the subject were also examined in the list of references of all relevant articles.

3. Origin

Hemp is believed to have originated from Central Asia, i.e., the intermediate region among Central Asia, Himalayas, Siberia, the South Caucasus, and the southern region of the Caspian Sea [2]. The origin center of hemp unambiguously covers eastern, central, southern, and western regions of Asia. Archaeologists have considered China as the most conceivable center of origin. Hemp was introduced to Europe around 1200 B.C., and it eventually expanded to other areas of the world. Hemp became popular in Europe since it was primarily utilized in the manufacturing of paper, and it was even used to print Bibles. In 1794, George Washington urged the farmers to make the most of the Indian hemp seeds and sow them everywhere [3].

Majority of historians believe that the hemp plant is indigenous to both Central Asia and the Indian subcontinent and is widely found in the Himalayan mountain regions extending to Nepal as well as even Bhutan and Myanmar. Scriptures such as the Vedas have estimated the plant to be at least 3400 years old and even considered it a sacred plant.

4. Morphology

The hemp plant belongs to the family of Cannabaceae under the order Rosales. *Cannabis indica*, *Cannabis sativa*, and *Cannabis ruderalis* are the three species that comprise the genus *Cannabis*. *C. indica* was designated by Lamarck (1785) in Southeast Asia and South Africa for plants of Indian origin and their descendants. There exist eight distinguishable characteristics between *C. sativa* and *C. indica* based on morphological characters, such as stalk length, branching habit, leaflets, and flowers [4]. *Cannabis sativa* is an erect annual herb with palmate-shaped leaves and greenish-yellow-colored small flowers. The herb may grow up to 4 m tall, while leaves are grey-green and up to 12 cm long. The flowers form spike-like or branched clusters depending on the sex type. Spike-like clusters grow on the pistillate plant while branched clusters are formed on staminate plants [5]. The fruit is an achene that is small, dry, and thin-walled consisting of only one seed. The mode of pollination in the hemp plant is anemophilous, whereby pollen is disseminated by the wind. Most of the species of *Cannabis* are generally short-day plants while *Cannabis sativa* subsp. *sativa* var. *spontanea* may be day-neutral. Flowering in hemp plants is brought about by a dark period of approximately 12 h, while flowering is inhibited if the day length is longer. The photoperiodic fluctuations can be controlled if the plant is grown under protected conditions.

5. Cultivation

Hemp grows well in temperate, subtropical, and tropical climatic conditions. It generally prefers mild climate, humid atmosphere, and rainfall of at least 600–700 mm per year. Industrial hemp grows well in a variety of soil types, although it favors sandy loam-textured soil with adequate drainage [6]. Hemp is highly sensitive to water logging conditions, and so poor drainage conditions may result in serious injury to the crop. Moreover, optimum soil moisture condition should be available for proper seed germination and good institution of the young plants. Heavy clay soil and sandy soil should be avoided as they are

unsuitable because of their low water-holding capacity. Soil should be thoroughly prepared, and the hardpans should be broken for proper drainage. Water logging conditions in the soil cause plant mortality particularly in young plants. Industrial hemp is a short-day plant, and the day length influences the quantity of light received by the hemp plant, impacting the production of distinct hemp types [6].

Spacing in hemp relies on the aim it is cultivated for, i.e., fiber, seed, or cannabidiol (CBD). Hemp cultivated chiefly for fiber is planted closely together to promote stalk elongation while reducing branching, which can guarantee longer and stronger fiber yield. High-density planting alone does not suppress weed growth; however, doing so conjointly leads to the assembly of high-quality fibers. On the other hand, proper spacing is enforced when hemp is planted for seed functions. Apart from these, nitrogen, phosphorus, and potassium play a vital role in the fertility-demand facet of the hemp, when gauging the growing conditions. The use of N fertilizers influences the plant height, biomass for fiber hemp varieties, and grain and protein content for seed-yielding varieties [6]. Phosphorus (P) imparts vigor and resistance against pests. The planting time of hemp relies on the weather and soil conditions, though some researchers claim that the ideal time for sowing in the field is from May to June.

6. Applications

6.1. Paper

Hemp has the potential to substitute for trees in terms of paper production, thereby stabilizing the effects of deforestation. Historically, the Chinese mastered the technique of producing paper from hemp fiber a thousand years ago. Hemp paper possesses higher strength, length, and fineness compared to conventional wood paper. Moreover, the plant grows at a faster rate which implies more production of paper within a smaller period as compared to trees, which take years to grow. Apart from that, the quality of paper obtained from hemp is better and more durable than that produced from trees.

6.2. Substitute for Plastic

Though plastic is an inevitable part of our day-to-day life, nevertheless, we can replace it with biodegradable plastics which we call “bioplastics”. The poly saccharide obtained from hemp can be extracted and used to create cellophane, rayon, celluloid, etc., which will help to scale back the dependency on petrochemical-based plastics. This will tackle the issues associated with plastic degradation to some extent and also have a low impact on the environment.

6.3. Fuel

Hemp oil is unquestionably among the contenders to be used as a biofuel. Biofuels made from hemp-like bioethanol and biodiesel have the potential to replace the utilization of traditional or fossil fuels. Several nations have currently united to reduce the utilization of fossil fuels; in such a scenario, biofuels made from hemp will inherit the usage and emerge as renewable alternatives [7]. However, because of the shortage of economic vigor and lower production of the crop, it has failed to emerge as a viable biofuel.

6.4. Textiles

The textile fibers obtained from hemp are much more durable and versatile as compared to cotton fibers. Hemp fiber is grown and processed without the use of pesticides or chemicals, making it an eco-friendly product. Some vital properties of the hemp fiber include: Eco-friendly and sustainable, strong and sturdy fiber, prevents the formation of bacteria through wetness absorption, recyclable, and intercepts the UV rays.

6.5. Building Materials

Bio-based building materials obtained from hemp provide several benefits over standard building materials, primarily because of its properties, such as sturdiness, lightweight,

fire-proof, water-resistant, self-insulation, pest resistance, and low production cost. Based on some reports, these bio-based materials are ideal for resisting damage caused by natural hazards, such as earthquakes, floods, and hurricanes [8]. Moreover, some studies claim that the building materials obtained from hemp can even capture carbon dioxide, thereby causing fewer carbon emissions.

6.6. Beverages

Hemp drinks are the next big thing for the nutrient trade. The higher part of the hemp is harvested, collected, and cold-pressed to obtain the hemp juice. The cold-pressing method helps in retaining the natural flavor, color, and active ingredients of the plant. Hemp juice is considered an excellent organic food that is drug-free. Hemp milk is another product that can be obtained from hemp seeds. This can be an alternative for vegans around the world. Hemp tea prepared from the leaves or flowers is devoid of any psychoactive effect, which makes it a quality product with therapeutic and soothing properties.

6.7. Cosmetics

Essential oils obtained from hemp seeds have a high value in the market. Hemp oil with its natural ingredients can emerge as an alternative to petroleum-based cosmetics and other skincare products. Cosmetic items from hemp include hand soap, shower cream, lip balm, face cream, foot cream, and many more. The therapeutic effects present in these oil-based products and other benefits attract consumers who have a sensitive well-being and are environmentally concerned.

6.8. Horticulture

Hemp shives are used for mulching in horticultural orchards as well as gardens. The mulch helps in maintaining soil moisture conditions, minimizing soil erosion, moderating soil temperatures, and suppressing weed growth [8]. As a result, it eliminates the need for weedicides and prevents seed germination of unwanted plants. Apart from that, hemp mulch protects against harsh and fluctuating weather conditions by acting as an insulating layer.

6.9. Biopesticides

Hemp essential oil has emerged as a powerful tool for controlling insect pests. Some researchers have claimed that the essential oils act as effective control tools against *Aedes albopictus*, also known as the tiger mosquito or forest mosquito, and *Physella acuta*, an air-breathing freshwater snail [8]. Thus, biopesticides can be obtained from industrial hemp which in turn may reduce the dependence on synthetic pesticides to some extent. This will not only help to affect the target pest but also safeguard natural enemies and other beneficial organisms. Most importantly, hemp-based biopesticides are of minimal risk to human health as well as the soil and environment.

6.10. Phytoremediation

Hemp effectively improves the health and quality of the soil. One of the important properties of hemp is phytoremediation, which refers to the ability of the plant to remove unwanted and harmful contaminants from air, soil, and water. Heavy metals, such as cadmium, lead, and nickel, are absorbed by the plant, thereby reducing the effect of toxic metals in the soil as well as on human health [3]. Hemp, being a fast-growing crop, can absorb more contaminants and toxic metals in a shorter period, thereby rendering the soil contaminant-free at a faster rate. Moreover, hemp has the ability to flourish in contaminated soils where other crops might not thrive.

6.11. Crop Rotation

With minimum environmental impact, crop rotation is a vital tool to maintain sustainable crop production [9]. The main motive behind crop rotation is to reduce the incidence

of pests, diseases, and weeds that are difficult to control by pesticide application. The introduction of hemp in crop rotation will not only improve soil health but also bring pest populations under control. Crop rotation, according to reports, enhances soil organic matter and organic carbon [10]. The hemp plant also influences the soil structure by its deep root system. The root system penetrates deep into the soil providing aeration, while simultaneously building soil aggregate and preventing soil erosion. According to a study, the high root biomass production in the deeper layers of the soil makes it more suitable for sustainable cropping systems [11].

Hemp is a treasure not only for the industrial sector but also a dignified plant for sustainable farming systems. Though a few important applications have been mentioned above, the plant has many more diverse uses.

7. Harvesting and Processing

Industrial hemp is harvested based on its purpose: fiber and seed. For fiber, the crop is harvested when maximum fiber volume and quality are reached. This operation is initiated before the seed set. Flowering time typically signifies the harvesting time for fiber-harvesting purposes. However, the harvesting may depend on the grower's specific quality needs. Retting is performed to separate the bast from the hurd after harvest [12]. Hurds are used to prepare animal bedding, material inputs, oil absorbents, and paper [6]. To avoid shattering losses, the seeds must be collected at optimal or higher moisture content. Swath and straight combine operations are executed depending on the weather conditions prevalent in the area. Hemp seeds after harvesting should be properly dried to preserve their quality. Storage should be conducted in well-aerated and clean chambers.

The processing of the hempseeds by cold pressing results in oil and pressing cakes which contain excellent nutritive and curative properties [13], while the stalks of the plant are decorticated to efficiently separate the hemp into fibers and hurds. For obtaining quality pulp materials, a good decorticator system is a must to generate more products within a short time. However, some international companies have developed better processing equipment at a much lower cost than the conventional decorticator [14].

8. Results and Discussion

From the study, it was found that hemp farming can definitely minimize the use of toxic fertilizers as it requires minimal usage of them. Hemp farming has the potential to dramatically minimize the amount of carbon impact on the environment. Hemp-based bioplastics, being biodegradable and lightweight, have the potential to replace oil-based plastics. On the other hand, textile and clothing industries heavily depend on cotton-based fibers, which require a huge amount of synthetic fertilizers. Under such circumstances, hemp is undoubtedly a better option.

9. Future Aspects and Marketing of Hemp

Hemp is an excellent sustainable plant for Mother Earth. Globally, the construction and its allied industries are responsible for approximately one-third of all carbon emissions, which is a matter of great concern. Moreover, researchers have claimed that worldwide plastic pollution has increased from 300 million metric tons to approximately 360 million metric tons, and, at this pace, the figures will rise by 2050. Either we need to depend less on plastics for our daily use or switch to biodegradable plastics made from plants such as hemp. Hemp is making a strong comeback and is emerging as one of the fastest expanding agricultural and industrial markets. The international market for hemp was worth 5.66 billion USD in 2020, according to Verified Market Research, and is predicted to reach 27.72 billion USD by 2028. The advent of the COVID-19 pandemic crisis has significantly raised health awareness among the people, fueling the growth of the hemp market at a great pace. The demand for hemp-based wellness and skin care products is the main factor behind the growth of the market globally. However, the legislative structure and its regulations for the use of industrial hemp are expected to hinder market growth.

Thus, there is a need to increase the legalization of cultivating hemp and make farmers aware of its benefits.

10. Conclusions

Industrial hemp is a multi-purpose crop. The unique properties of the plant make it a highly valuable and sustainable crop. There are more than 25,000 hemp-based products available in markets worldwide [15]. The stalks, seeds, and leaves are converted into various construction materials, textiles, paper, food, furniture, cosmetics, healthcare products, etc. Nutraceutical- and health-product-based markets are about to grow in the coming years, owing to the increasing awareness about health among end-users. Bioplastics, biofuels, and biopesticides are some of the innovative applications of the hemp plant, which is the subject of research and debate at present time. The growth of the hemp industry will depend on the legislative structure as well. Nations should realize the importance of this amazing plant and initiate marketing and growth policies that will be beneficial for both their economies and the environment. Lastly, the future of hemp strongly depends on the market demand for its bio-based products that will help the plant to establish itself as a worthy sustainable crop.

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