Industrial hemp and its potential

Created by: Arnab Bhowmik
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Hemp (Cannabis sativa L.) is an emerging high-value specialty crop that can be cultivated for either fiber, seed, or cannabidiol (CBD). The demand for hemp and its products has been consistently on the rise in the 21st century. The United States of America has reintroduced hemp and legalized its production as an agricultural commodity through the 2018 Federal Farm Bill. Although there is a renewed interest in the adoption of hemp due to the emerging market, its production in the United States remains limited partly because of unclear agronomic guidance and fertilization recommendations. This review article provides information on the current agronomic management practices that are available in the literature and identifies the future research needs for cultivating this multipurpose crop to address the growing market demands. Hemp production could be beneficial if managed properly. Hemp fertilizer requirements vary in accordance with the type of hemp grown (seed, fiber, or CBD), soil, environmental conditions and requires a wide range of macro- and micronutrients. Integrating management practices in hemp cultivation intended to build soil health is promising since the hemp cropping system is suitable for crop rotation, cover cropping, and livestock integration through animal waste applications. Hemp also has significant environmental benefits since it has the potential to remediate contaminated soils through phytoremediation, convert high amounts of atmospheric CO_2 to biomass through bio-sequestration, and hemp biomass for bioenergy production. This review identifies that most of the agronomic research in the past has been limited to hemp fiber and, to some extent, hemp seed but not CBD hemp. With the increase in the global markets for hemp products, more research needs to be conducted to provide agronomic guidelines for sustainable hemp production.

Multipurpose Hemp crop

Industrial hemp (Cannabis sativa L.) or hemp production has recently been the subject of increasing interest around the world, especially in the United States. Hemp is a multipurpose crop that could also be grown for its fiber, seed, oil, food, and medicinal properties. Marijuana and hemp belong to the same plant species (i.e., Cannabis sativa). However, hemp is genetically different and also distinguished by its use and chemical makeup. More than 100 different chemical compounds called cannabinoids can be extracted from hemp. Two major cannabinoids are tetrahydrocannabinol (THC) and cannabidiol (CBD). Hemp contains THC of 0.3% or less, while marijuana can contain up to 20% THC, as its primary psychoactive chemical. Certain varieties of hemp have higher levels of CBD, the non-psychoactive part, that has medicinal properties [1].

Legalization

The interest in hemp and its benefits has spurred since significant changes in the legalization of hemp in the USA[2]. For decades, federal law did not differentiate hemp from other Cannabis plants. In 2014, the United States Congress granted permission through the Farm Bill to run test programs for growing hemp in a number of US states. Since then, 41 states have passed legislation that allows hemp cultivation. The 2018 Farm Bill declassified hemp from the list of controlled substances and legalized the production of hemp as an agricultural commodity [2]. According to the 2018 Farm Bill, hemp that is allowed to be cultivated should have a THC threshold of 0.3%. Due to an increase in demand for non-food crops and other food derivatives in the agricultural sector, hemp has progressively recovered its importance [3]. In the US, the amount of hemp acreage and licenses has increased rapidly in the last couple of years.

Value-added hemp

Hemp has the potential to be an environmentally friendly and highly sustainable crop if managed properly[4]. Hemp replenishes the soil and has been proven to remediate contaminated soils [5][6][7]. Generally, it is considered as a crop that could be grown without any pesticides [8] for certain varieties [9]. Hemp has the potential to suppress weeds efficiently and can fit well in a crop rotation [10]. Additionally, some residues of hemp can be used as botanical insecticides, miticides, or repellants within programs of pest management in organic farming [11]. These properties also make it suitable for integration in an organic farming system. Hence, the advantages of this crop in agriculture are not exclusively limited to its wide range of products and applications, but also due to its potential to improve soil health that encompasses the plant, environmental, and human health components.

Currently, the agriculture sector is a net producer of greenhouse gas emissions both directly through conventional farming practices that deplete soil organic carbon stocks and N fertilizer additions that lead to emissions of nitrous oxide and carbon dioxide and indirectly through land use change [12]. Hemp's fast growth makes it one of the fastest sources of CO_2-to-biomass conversion. Hemp has been proven to be an ideal carbon sink as it can capture more CO_2 per hectare than other commercial crops. Hemp can sequester higher amounts of carbon by photosynthesis and then store it in the plant's body and roots through bio-sequestration. One of the other potential uses of hemp biomass would be production of biochar for soil application. Biochar is a carbon-rich product generated from a controlled process called pyrolysis, a thermal decomposition of biomass (wood, manure, crop residues etc.) in an oxygen-limited environment. Pyrolysis converts 10–50% of the original biomass carbon into biochar carbon, which is more stable, persists in soils for hundreds to thousands of years and is steadily over a long time period. Several field and laboratory incubation studies have proved that biochar may improve soil microbial community stricture and reduce the greenhouse gas emissions from soil management practices [13] [14].

Hemp and Soil Health

Soil health is defined as the capacity of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation. In the advent of changing climate, animal manures, composts and cover cropping has been identified as a soil builder because of its enormous impact on improving soil health and provide environmental benefits [15] [16]. The nutrient content of animal wastes varies depending on different factors like feed source and type, animal age, handling and storing techniques, temperature, and moisture content. Organic amendments provide nutrients that are essential for plant's need, e.g. nitrogen, which is one of the crucial nutrients required for hemp cultivation. They also add carbon to the soil and improve soil biodiversity. Organic amendments also help reduce nutrient run-offs and leaching of nitrates in the soil. Although various environmental benefits can be derived from organic amendment applications, these benefits are optimized when it is applied at an appropriate time and at appropriate amounts and ways. Improper management might contribute to increased greenhouse gas emissions e.g. carbon dioxide and nitrous oxide [15]. Organic amendments come in various kinds, and can be used depending on location and availability. The commonly used types of manures in hemp production are horse, cow, and chicken manure. Hemp is naturally adapted to using mammalian manure, e.g., horse manure as fertilizer, and it can also efficiently employ stocks of livestock manure [17]. Composting of manure is a process that is recommended because it enhances the quality of manure and has been reported to improve soil health properties [18]. Chicken, horse and cow manure, is recommended to undergo composting before usage to decrease the likelihood of pathogens. It has been reported to contain about 1–2% N and 1–3% K but amounts might vary depending on the type of animal waste used. Although there is a huge potential to incorporate animal wastes for hemp production not much has been reported. Incorporating leguminous cover crops that have biological N fixing capacity also has the potential to provide supplement nitrogen requirements for the main crop in the cropping system. Cover crops also provide ecological benefits to the soil by suppressing weeds and pest pathogens, control soil erosion, help build and improve soil fertility, and increase biodiversity [15][16][17].

Future prospects

Hemp production in the USA has been on the rise since the 21st century and more US states have attempted to establish a hemp production system following deregulation according to the 2018 US Farm Bill. This has significantly increased the potential for hemp markets in America. Many products can be derived from hemp, but the most enterprising situation for hemp in the USA is oilseed production and CBD extraction from hemp flowers for pharmaceutical uses. Although there is a renewed interest in the adoption of hemp, its production in the USA remains limited partly because of unclear agronomic guidance and fertilization recommendations, especially for CBD hemp in different soil and environmental conditions. Hence, it is essential to explore and update the scientific knowledge of hemp in order to understand and recommend the best management practices. Hemp cultivation requires intensive management, and environmental conditions like seedbed preparation, soil type, day length, seeding rates, dates, harvest dates, etc., are all impacted by the type of hemp variety employed. Hemp varieties grown for fiber, oil seed, and CBD have different fertilizer requirements and most of the fertility trials in the past have been limited to hemp for fiber. This review also describes the potential of integrating agronomic management practices intended to improve soil health like crop rotation, cover cropping, mulching, and manure application to hemp cultivation. Hemp is a potential emerging multipurpose crop with not only economic but also soil health benefits through phytoremediation, bio-sequestration, and bioenergy production.

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Keywords

Cannabis; hemp CBD; hemp fiber; hemp oilseed; soil health for hemp; agronomic management practices

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