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A Review on Cultivation of Hop Shoots *(Humulus lupulus)*

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Abstract

Humulus lupulus or Hop shoots is a hardy dioecious perennial climbing plant that belong to the family Cannabinaceae. It is well-known in the brewing business for its high value. The Strobiles or 'cones' of the female plant are used for commercial purposes, whilst the male plants are used only for hybridization. Hop shoots is a delicate vegetable in most of the European countries and fetch a very high price in the market. The plant can grow in a wide range of soil conditions, from light sandy to clay. Hop shoots can be propagated vegetatively through stem/leaf cuttings, rhizomes or asexually. Hop shoots find a variety of uses in the field of medicine, industry, food and fiber. Presently, hop shoots are cultivated in nearly 15 nations around the world, with the United States being the leading producer. The present review deals with the reproductive biology, taxonomical description, cultivation, uses, marketing, commercial approaches and future aspects of the crop

Keywords: Brewing, Hop shoots, marketing, medicine

1. Introduction

Hops are a hardy dioecious perennial climbing plant belonging to the family of Cannabinaceae having their roots of origin from North America, Europe and Asia. The hop shoot plant has been known for its immense value in the food industry. The hop shoots were initially considered as weeds before its distinctive properties were exposed, namely that it has specific antibacterial effects. *Humulus lupulus,* the word 'lupulus' is of Latin origin which means 'wolf'. On the other hand, 'humulus' is derived from humus (the organic component of the soil). The word Hop is derived from the English word 'hoppian', German 'hopfen' or 'hopsen' (Conway and Synder, 2008). The origin of hop shoots and their use are shrouded in ambiguity. The plant has been in use since time immemorial. Hops were only utilized as a salad plant by the Greeks, and young shoots of the plant are still consumed as a salad vegetable in parts of central Europe. European cultivars and wild hop shoots are said to have originated in central Europe, were brought from the East by migrants, or were simply produced from native wild hops. However, it has been presumed that European wild hops are the consequence of prior incursions and are not a native European plant. (Murakami et al., 2006).

Based on a study, wild hop shoot contains less than 67 mg 100 g^{-1} of oxalic acid and high vitamin C levels (about 40 mg 100 g^{-1}) (Rossini et al., 2020; Sanchez-Mata et al., 2012). The medicine made from hops stems has been shown to have a good curative impact in the treatment of tuberculosis (TB). Apart from that, key alpha acids found in stems such as lupulones and humulones are thought to be beneficial in killing cancer cells and preventing leukemia cells from causing further bone damage.

2. Biology

Hop is a rhizomatous plant, which means that it contains underground stems that can generate new roots and shoots. A big taproot and tiny lateral roots comprise the root system of the plant (Getty et al., 2015). Hop stems which grows vertically are termed bines (rather than vines) because they climb by wrapping around a supporting structure in a clockwise orientation and clinging to the surface with stiff, hooked hairs. The Stems are hexagonal in shape and have red, green or purple stripes on the margins (Getty et al., 2015).

Hops possess distinct male and female plants, i.e., dioecious in nature. They are easily identifiable throughout the blossoming season. Males create panicles with many blooms, each having 5 anthers, while females generate tiny "burrs" that mature into little cones called "strobiles"(Haunold, 2010). The Strobiles or "cones" of the female plant have commercial significance, while the male plants are solely utilized for hybridization. Male flowers are multi-branched panicles with

many small flowers, but female cones have 20-60 solitary flowers (Rybacek, 1991). Male plants generate pollen that is transported by the wind to female cones, and the ensuing fertilized female flowers produce seeds. Pollination increases yields by increasing cone size and seed set.

3. Taxonomical Description

Previously, hops were classified to the Moraceae (mulberry) family, but it is now widely accepted that hops belong to the Cannabinaceae (hemp) family (Small, 1978; 1980). This family contains two genera: hop (Humulus) and hemp (Cannabis). Despite the fact that the two are "botanical relatives," there is no evidence of hallucinogenic chemicals in hops (Haunold, 2010). Hops are a member of the Cannabinaceae (hemp) family, which contains two genera, hop (humulus) and hemp (cannabis). Again, there are three species in the genus Humulus: *Humulus lupulus* (common hop), *Humulus japonicas* (Japanese hop), and *Humulus yunnanensis*.

Humulus lupulus (2n= 2x=20) is the most commonly cultivated species. Similarly, *Humulus japonicus* has distinct male and female plants. It is a fast-growing annual that is primarily utilized for aesthetic purposes; however, it does generate a few resin glands. It also has a different chromosomal number than common hop (17 in males, 16 in females), therefore the two species are incompatible. Except for the fact that it grows at high elevation and low latitude of 25°N in areas of China, little is known about the species *H. yunnanesis* (Dodds, 2017). Plant breeders may be interested in this species in the future for producing variants that can grow effectively throughout a broader range of latitudes.

4. Cultivation

4.1. Climate

Hop shoots plants thrive at latitudes ranging from 30 to 50 degrees north and south of the equator. Cold winter temperatures are required to physiologically prepare the plant for spring re-growth (Haunold, 2010). Hop shoot plants require certain climatic conditions for best development, production, and cone quality, including cold temperatures during dormancy, moderate temperatures in spring, enough moisture throughout the growing season, and dry weather for harvest. The amount, frequency and timing of rainfall influence the growth and development of the plant, eventually leading to an impact on production as well.

4.2. Soil

Hop shoots can thrive in a variety of soil types, from light sandy to clay. Hop shoots are deep-rooted plants, although the majority of the feeder root system is found in the upper section of the top soil. Plants require a steady supply of water throughout the growth season. A deep, light textured soil, but free of waterlogging is considered ideal for the cultivation of Hops hoots. Soil pH is essential because it affects plant nutrient availability; if it is not in the correct range, it can result in elemental shortages or toxicity. Before planting, it is critical to determine the pH of the soil and make any required adjustments. A pH of 6-7 is considered optimum for its growth. In an experiment it was found that a pH range of 6.5 to 7 supports increased K availability, absorption, and accumulation in plant leaf tissue, as well as increased photosynthetic capability and production (de Jesus Guimaraes, 2021).

4.3. Propagation

Hop shoots can be propagated through asexual or vegetative methods. The vegetative methods of production include stem/leaf cuttings and Rhizomes. Dormant rhizomes obtained from the mature crown in the cooler months or green cuttings from current season growth in spring or summer generate the majority of new plants (Dodds, 2017). Rhizomes are underground shoots that can be trimmed from the crown, split into pieces, and planted directly in the hop yard, raised in pots and even grown under protected conditions like Greenhouses. Rhizome cuttings can be planted vertically or horizontally with the buds facing upwards. On the other hand, green stem cuttings obtained in the spring and early summer can be a convenient technique to propagate a large number of new plants during the growth season.

4.4. Planting

Hop shoots are planted in the spring as soon as the plot can be worked and the risk of frost has gone. Hop shoots are propagated from rhizomes, which are typically accessible from March to May. Rhizomes should be stored in a cool, moist place until they are ready to be planted. It is critical to space the plants properly to allow for enough growth (Bamka and Dager, 2002). The spacing between rows is determined by the size of the equipment used for tilling, mowing, and harvesting. Growers use trellising systems for commercial agriculture. The traditional high trellising technique is made up of a permanent structure of poles and wire to which strings are tied each year to give support for the hop bines (Neve, 2012). The top height of such structures might vary, although it generally varies from 5 m to 8 m. The V-trellis training technique is the most widely utilized in hop production across the world (Rossini et al., 2021). Based on a research conducted, it was found that plastic growing tunnels are more stable and generate a high yield of hops in small-scale production systems.

4.5. Irrigation

Hop shoots are a high-value crop, and water stress affects both productivity and quality. Plants require a steady supply of water throughout the growth season. The amount and frequency of supplemental irrigation required is affected by many factors including climate, soil characteristics and plant-specific attributes (Jackson et al., 2019). Unavailability of sufficient amount of moisture results in plant stress and can lead to lower yields and even death of the plant. Water stress symptoms include reduced plant vigour, halted growth,

drying of leaves, and, in severe situations, plant withering. Excess water, on the other hand, might be troublesome. When the soil becomes overly moist as a consequence of over-irrigation, prolonged precipitation, or inadequate drainage; leaching of nutrients may occur, resulting in severe economic repercussions as well as environmental harm owing to nutrient pollution of groundwater. Plant stress is minimized when plant water demand and available soil moisture are balanced, and soil nutrients stay within the rooting zone (Jackson et al., 2019). Drip irrigation is ideal for water supplementation since the plant has a shallow root system. Overhead and furrow system of irrigations are also utilized to irrigate large plantations.

4.6. Fertilization

Hop shoots do not grow well in acidic soils, therefore liming should be done as needed to keep the pH above 6.5 (Neve, 2012). The nutrient requirements of the crop differ based on soil tests, varieties, yield potential, and growing location. Nitrogen is a critical nutrient for hop bine establishment and is applied at a rate of 45-68 kg acre^{-1} (100-150 pounds acre^{-1}). For best outcome, nitrogen is applied by mid-June. Potassium is mostly utilized by hop cones, although it also promotes the development of leaves and bines. Potassium (K) is required at a rate of approximately 68 Kg acre^{-1} (150 pounds acre^{-1}). While, phosphorus (P) requirement is small as compared to N and K. The optimum rate of phosphorus application is about 9-13 kg acre^{-1} (20-30 pounds acre^{-1}) (Gingrich et al., 1994).

5. Harvesting

Fresh hop shoots are consumed as vegetables which are accessible in the spring. The developing shoots are purple in early spring. Hop plants desire to expand and they transmit runners underground, and shoots that cover the entire region of the hop yard if they aren't trimmed off. Some of the hop shoots may remain white due to exposure to the sun. Hop plants continue to put up new shoots even after all of the early spring shoots have been removed. Later in the spring, the shoots grow greener and have more and bigger leaves. Generally, the tender tips of the shoots are harvested for fresh consumption as salad or for other dishes.

6. Insect and Pest Management

Mildew inoculums, aphids, and spider mites are the most persistent and troublesome diseases and pests that may seriously jeopardize hop shoots output. Downy mildew can survive the winter as mycelium in infected hop rootstocks. Common insect pests in the hop yards include Japanese beetles, leafhoppers, aphids and spider mites. The Two spotted spider mites having piercing–sucking mouthparts feeds on the leaves and cone mesophyll cells. Stippling, or pin-prick sized brown patches on leaves is the first symptom of damage. On the other hand, the damson-hop aphid thrives during cool, damp growing seasons and feeds on the phloem of the hop plants (Calderwood et al., 2015). Foliar feeding can affect plant production at high population levels, thereby limiting hop shoot production and quality. Similarly, potato leafhoppers and Japanese beetles also feed on the hop leaves, significantly reducing the plants photosynthetic activity (Rossini et al., 2021). Integrated pest management strategies will help to reduce the pest populations considerably in the Hopyards.

7. Uses

Although hops are best recognized as one of the four components in beer, they were originally used as a medicinal herb. Almost all parts of the hop plant include bioactive chemicals such as flavonoids and bitter acids, which have antibacterial, antioxidant, and antifungal properties (Rossini et al., 2021).

7.1. As a medicine

Hops have been used as a medicinal herb for over 2000 years (Koetter and Biendl, 2010). It was utilized by ancient physicians to treat leprosy, foot odour, constipation, and blood cleansing (Karabin et al., 2016). Hop preparations have long been suggested as a moderate sedative beneficial for relieving mental stress and promoting sleep since the nineteenth century (Rossini et al., 2021). In 1813, the French chemist Planche discovered lupulin, a fine yellow resinous compound found in the female flowers of hops. This lupulin induces sleep and relieves excessive nerve irritation without producing constipation (Koetter and Biendl, 2010). Another important medicinal property of hops is its estrogenic activity (Chadwick et al., 2006).

7.2. As a vegetable

Hop shoots are considered as a delicate vegetable in most of the European countries. As this herbaceous vegetable is a rich source of antioxidants, it is used for keeping the skin glowing and young. Likewise, asparagus, young hop shoots are consumed during spring which is in fact a traditional use of the plant. The leaves of the Hop shoots have a Kale-like quality and are often used as salads along with the shoots. The tender shoots of early spring are easy to sautee in a little olive oil or butter which is definitely worth eating. Fresh green shoots should be consumed soon after harvest as they possess short shelf life or otherwise should be pickled to store them for a longer period. The use of the young shoots as vegetables can definitely generate an additional income for the Hop growers (Rossini et al., 2020). Presently, hop shoots are one of the most expensive vegetables one will find in the market.

7.3. As a fiber

After harvest of the cones, the hop stems are left in the field as a waste. These stems are considered as by products and thus have limited applications. Hop stems have an exterior bark and inner pith, which is typical of every bast fiber plant. Long-length fibers (10–15 cm) with tensile properties similar

to hemp have been created from the fibrous outer bark of the stem. The resulting fibers contain high cellulose content, a low percent crystallinity, and excellent cellulose crystal alignment to the fiber axis. These properties make the hop fibers suitable for use in textile industry (Reddy and Yang, 2015; Reddy and Yang, 2009).

8. Production and Marketing

Currently, hop shoots is cultivated in almost 15 countries of the world with USA being the largest producer of the crop.

During the projected period (2020-2025), the global hop shoots market is expected to expand at a CAGR of 4.5 percent. (Anonymous, 2020). Changes in demand and produced hop shoots cultivars clearly has an influence on the hops market (Van Kerckhoven et al., 2020). Moreover, the young hop shoots as a vegetable can fetch a high price if proper marketing channels are provided.

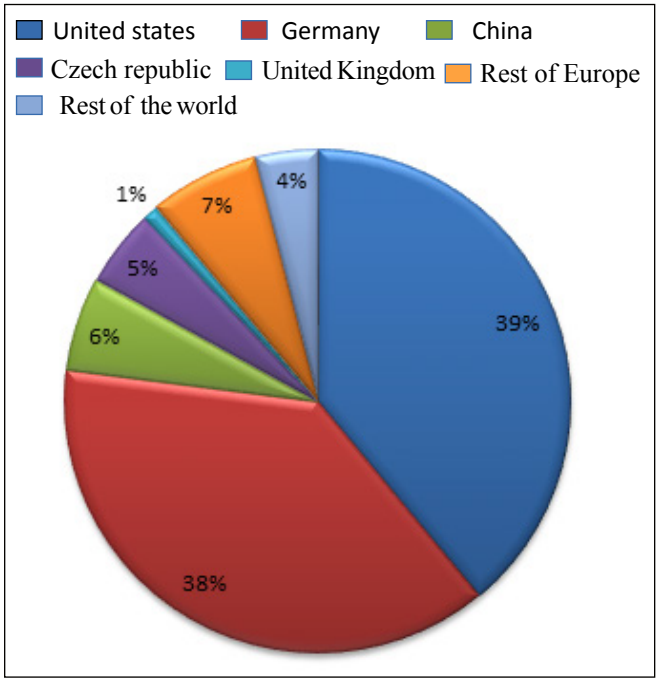

Figure 1: Global distribution share of hopshoots production; Source: Global share hop production 2020, Published by M. Shahbandeh, Feb 19, 2021. Statista 2021. @https://www.statista.com/statistics/757917/share- of-hop- production-worldwide-by-major-producer/

9. Conclusion

Right now, the lack of knowledge on effective agronomic practices and selection of suitable cultivars have aroused as constraints in the production process. As a result, precise field data are necessary for optimizing hop shoots production and preventing the stalling of such a potential crop. Finally, proper research and studies should be initiated to find solutions for filling up the gaps in the production process of the hop shoots.

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11. References

Anonymous., 2020. Global Hops Market (2020 to 2025) - Growth, Trends, and Forecast. Available from https://www.globenewswire.com. Accessed on 4th December, 2020.

Bamka, W., Dager, E., 2002. Growing hops in the backyard, 1–4

Calderwood, L.B., Lewins, S.A., Darby, H.M., 2015. Survey of northeastern hop arthropod pests and their natural enemies. Journal of Integrated Pest Management 6(1), 18.

Chadwick, L.R., Pauli, G.F., Farnsworth, N.R., 2006. The pharmacognosy of *Humulus lupulus* L. (hops) with an emphasis on estrogenic properties. Phytomedicine 13(1-2), 119–131.

Conway, S., Synder, R., 2008. *Humulus lupulus-Hops***.** Food for thought: The Science, Culture, & Politics of Food Spring, 1–15.

de Jesus Guimaraes, J., de Sousa, F.G.G., Roman, R.M.S., Dal Pai, A., Rodrigues, S.A., Sarnighausen, V.C.R., 2021. Effect of irrigation water pH on the agronomic development of hops in protected cultivation. Agricultural Water Management 253, 106924.

Dodds, K.A., 2017. Hops: a guide for new growers. New South Wales Department of Primary Industries. pp. 9–38

Getty, B., Townsend, S., Detweiler, A.J., 2015. Growing Hops in the Home Garden. Oregon State University, Extension Service, 1–6

Gingrich, G.A., Hart, J.M., Christensen, N.W., 1994. Hops, 1–5

Haunold, A., 2010. Hops and hop growing. Soils, plant growth and crop production, *2*, 192–207.

Jackson, D., Siegle, L., Scoggins, H.L., 2019. Irrigation considerations for commercial hop producers, 1–7

Karabin, M., Hudcova, T., Jelinek, L., Dostalek, P., 2016. Biologically active compounds from hops and prospects for their use. Comprehensive Reviews in Food Science and Food Safety 15(3), 542–567.

Koetter, U., Biendl, M., 2010. Hops (*Humulus lupulus*): A review of its historic and medicinal uses. Herbal Gram 87(5), 44–57.

Murakami, A., Darby, P., Javornik, B., Pais, M.S.S., Seigner, E., Lutz, A., Svoboda, P., 2006. Molecular phylogeny of wild hops, *Humulus lupulus* L. Heredity 97(1), 66–74.

Neve, R.A., 2012. *Hops*. Springer Science & Business Media, 1-39

Reddy, N., Yang, Y., 2009. Properties of natural cellulose fibers from hop stems. Carbohydrate polymers 77(4), 898–902.

Reddy, N., Yang, Y., 2015. Fibers from Hop Stems. In: Innovative Biofibers from Renewable Resources. Springer, Berlin, Heidelberg, 43–44

Rossini, F., Virga, G., Loreti, P., Iacuzzi, N., Ruggeri, R., Provenzano, M.E., 2021. Hops (*Humulus lupulus* L.) as a novel multipurpose crop for the mediterranean region of Europe: Challenges and Opportunities of Their Cultivation. Agriculture 11(6), 484.

Rossini, F., Virga, G., Loreti, P., Provenzano, M.E., Danieli, P.P., Ruggeri, R., 2020. Beyond beer: Hop shoot production and nutritional composition under Mediterranean climatic conditions. Agronomy 10(10), 1547.

Rybacek, V., 2012. Hop production. Elsevier, 26–52

Sanchez-Mata, M.C., Loera, R.C., Morales, P., Fernandez-Ruiz, V., Camara, M., Marques, C.D., Tardio, J., 2012. Wild vegetables of the Mediterranean area as valuable sources of bioactive compounds. Genetic Resources and Crop Evolution 59(3), 431–443.

Small, E., 1978. A Numerical and Nomenclatural Analysis of Morpho-geographic Taxa of Humulus. Systematic Botany 3, 37–76.

Small, E., 1980. The Relationships of Hop Cultivars and Wild Variants of *Humulus lupulus*. Canadian Journal of Botany 58, 676–686.

Van Kerckhoven, S., Van Meerten, M., Wellman, C., 2020. The Dynamics of the Hops Industry. New Developments in the Brewing Industry: The Role of Institutions and Ownership, 72.