Natural History of Hops

Hops are the female flower clusters (commonly called seed cones or strobiles), of a hop species, *Humulus lupulus*. The hop plant is a vigorous climbing, herbaceous perennial, usually trained to grow up strings in a field called a hopfield, hop garden or hop yard when grown commercially. *Humulus* is a small genus of flowering plants native to temperate regions of the Northern Hemisphere. The hop is part of the family Cannabaceae, which also includes the genus Cannabis (hemp). Hops for beer making grow from the rhizomes of female hop plants. Rhizomes look like root cuttings but have buds growing from them that will become new vines. Rhizomes also contain stored nutrients to support initial growth.

Although frequently referred to as the hop vine, it is technically a bine; unlike vines, which use tendrils, suckers, and other appendages for attaching themselves, bines have stout stems with stiff hairs to aid in climbing. It is a perennial herbaceous plant which sends up new shoots in early spring and dies back to the cold-hardy rhizome in autumn. Training (or twiddling) the bines up strings or wires supports plants, allowing them significantly greater growth with the same sunlight profile. Energy that would have been required to build structural cells is also freed for crop growth. Hop shoots grow very rapidly and at the peak of growth can grow 8 to 20 inches per week. Hop bines climb by wrapping clockwise around anything within reach, and individual bines typically grow between 7 to 50 feet, depending on what is available to grow on. The leaves are opposite, with a 2.8 to 4.7 inch leafstalks and a heart-shaped, fan-lobed blades 4.7 to 9.8 inches long and broad. The edges are coarsely toothed. When the hop bines run out of material to climb, horizontal shoots sprout between the leaves of the main stem to form a network of stems wound round each other.

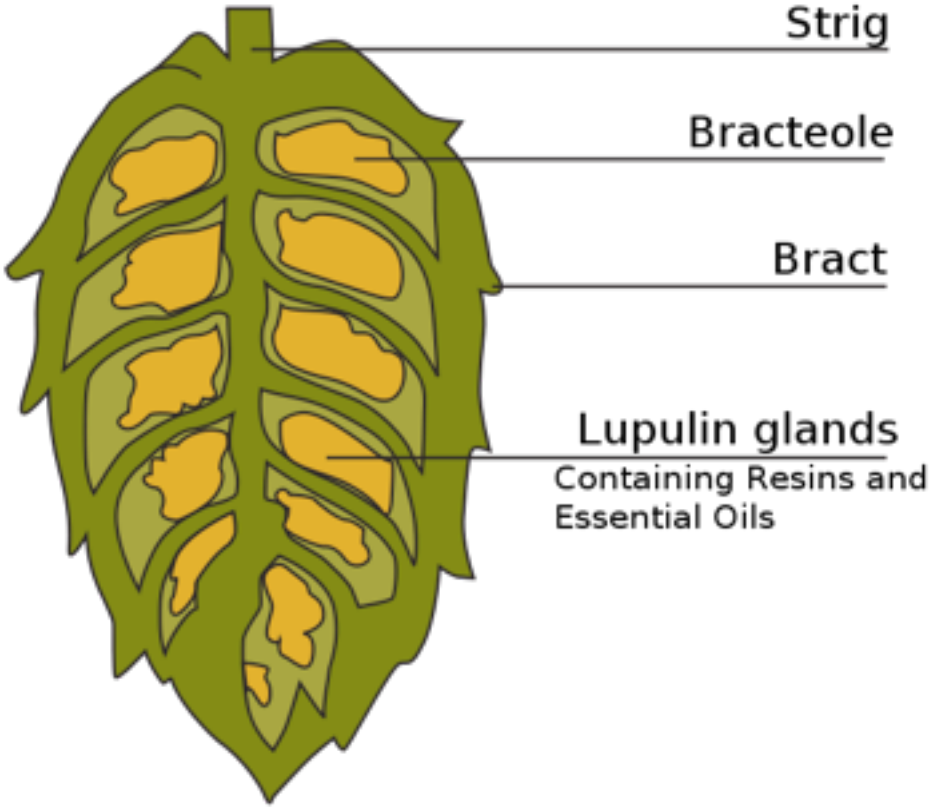
Male and female flowers of the hop plant develop on separate plants (dioecious). Female plants, which produce the hops flowers used in brewing beer, often are propagated vegetatively and grown in the absence of male plants. This prevents pollination and the development of viable seeds which are considered undesirable for brewing beer. Only female plants are grown in hop fields because these seeds are undesirable for brewing beer.

History of Hops

The first documented instance of hop cultivation was in 736, in the Hallertau region of present-day Germany, although the first mention of the use of hops in brewing in that country was 1079. Not until the thirteenth century in Germany did hops begin to start threatening the use of gruit for flavoring. In Britain, hopped beer was first imported from Holland around 1400; however, hops were initially condemned in 1519 as a "wicked and pernicious weed." In 1471, Norwich, England banned use of the plant in the brewing of beer, and not until 1524 were hops first grown in southeast England. It was another century before hop cultivation began in the present-day United States in 1629.

Hops were cultivated on a continuing basis around the 8th or 9th century AD in Bohemian gardens in the Hallertau district of Bavaria and other parts of Europe. However, the first documented use of hops in beer as a bittering agent is from the eleventh century. Prior to this period, brewers used a wide variety of bitter herbs and flowers. Dandelion, burdock root, marigold, horehound (the German word for horehound means "mountain hops"), ground ivy and heather were often used prior to the discovery of hops (commonly referred to as gruit). Hops are used extensively in brewing today for their many purported benefits, including balancing the sweetness of the malt with bitterness, contributing a variety of desirable flavors and aromas, and having an antibiotic effect that favors the activity of brewer's yeast over less desirable microorganisms. Historically, it is believed that traditional herb combinations for ales were abandoned when it was noticed that ales made with hops were less prone to spoilage.

Cross-section drawing of a hop



Hop in Brewing

Hop resins are composed of two main acids: alpha and beta acids. Hops also serve two main purposes: bittering and aroma.

Alpha acids have a mild antibiotic/bacteriostatic effect against Gram-positive bacteria, and favor the exclusive activity of brewing yeast in the fermentation of beer. Alpha acids are responsible for the bitter flavor in beer.

Beta acids do not isomerize during the boil of wort, and have a negligible effect on beer taste. Instead they contribute to beer's bitter aroma, and high beta acid hop varieties are often added at the end of the wort boil for aroma. Beta acids may oxidize into compounds that can give beer off-flavors of rotten vegetables or cooked corn.

Bittering hops have higher concentrations of alpha acids, and are responsible for the large majority of the bitter flavor of some beers.

Aroma hops usually have a lower concentration of alpha acids (~5%) and are the primary contributors of hop aroma and (non-bitter) flavor.

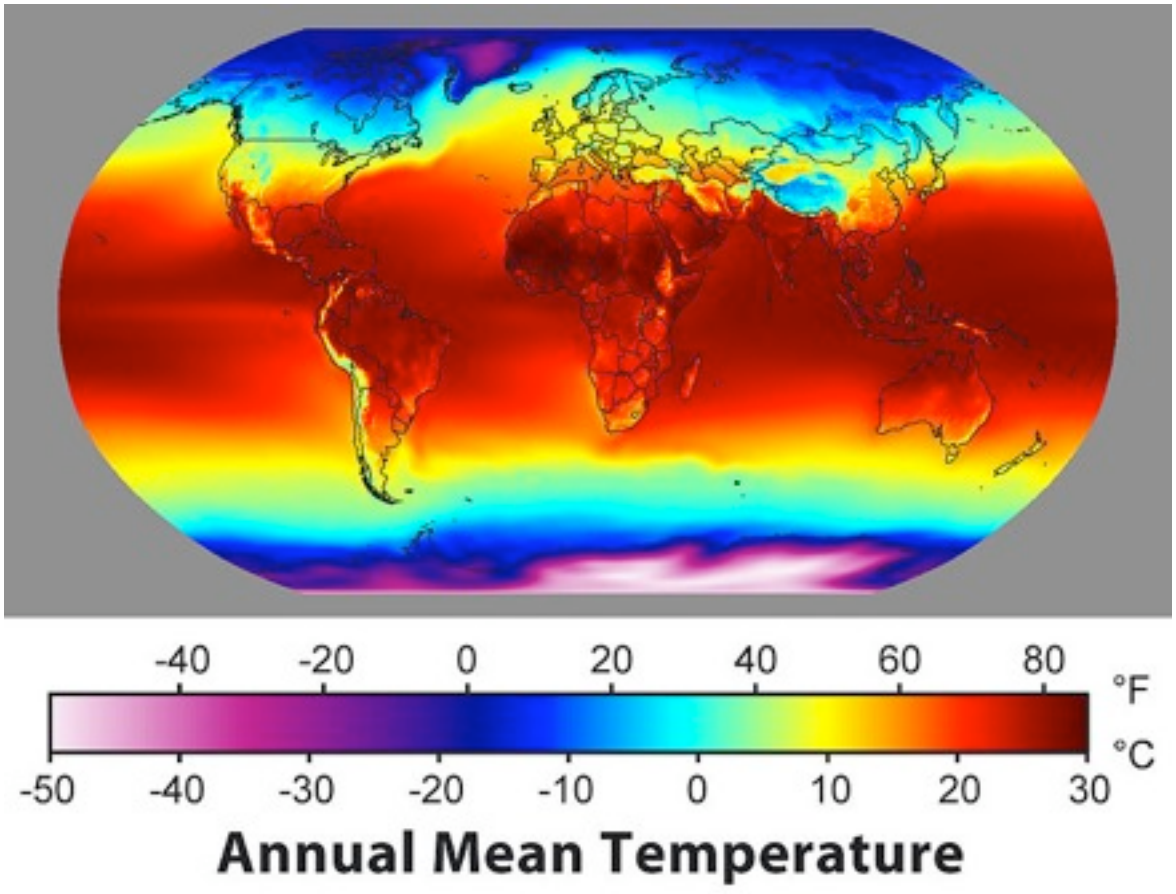
The degree of bitterness imparted by hops depends on the degree to which otherwise insoluble alpha acids are isomerized (chemical structure re-arranged to render the oil soluble) during the boil, and the impact of a given amount of hops is specified in International Bitterness Units (IBUs).

Bittering hops are boiled for a longer period of time, typically 60–90 minutes, in order to maximize the isomerization of the alpha acids. They often have inferior aromatic properties, as the aromatic compounds evaporate off during the boil. Unboiled hops are only mildly bitter.

Aroma hops are typically added to the wort later to prevent the evaporation of the essential oils, to impart "hop taste" (if during the final 10 minutes of boil) or "hop aroma" (if during the final 3 minutes, or less, of boil). The essential oils of aromatic hops will evaporate if boiled too long. Aroma hops are often added after the wort has cooled and the beer has fermented, a technique known as "dry hopping", which contributes to the hop aroma. The four major essential oils in hops are Myrcene, Humulene, Caryophyllene, and Farnesene which comprise about 60–80% of the essential oils for most hop varieties.

Today there is a substantial amount of "dual-use" hops as well, which have high concentrations of alpha acids and good aromatic properties. These can be added to the boil at any time, depending on the desired effect. Flavors and aromas are described appreciatively using terms which include grassy, florally, citrusy, spicy, piney and earthy. Most of the common commercial lagers have fairly low hop influence, while true pilseners should have noticeable noble hop aroma and certain ales (particularly the highly-hopped style known as India Pale Ale, or IPA) can have high levels of bitterness. Wet hoping is when undried, fresh hops are used.

Climate Conditions



The optimal growing regions for hops are between 30-50 degrees latitude. If you consider the Pacific Northwest, which is the optimal region of North America for growing hops, you can glean the optimal climate and growing conditions for hops. These characteristics are frequent rainfall, geology mostly absent of limestone, acidic soils and moderate mean annual temperatures

(think of temperate regions of coniferous forest and not deciduous forests). Kentucky is on the border of temperate to sub-tropical climate (deciduous temperate forests). Additionally, the geology is mostly limestone, resulting in hard water and neutral to basic soil conditions.

Notes on Alpha-acids

Alpha-acid content can be predicted by basic environmental/meteorological variables. Most important for alpha-acid production:
1) Even distribution of water (think Pacific Northwest, well drained, acidic soils, frequent and short rainfalls)
2) Sunlight stimulates acid production within the hops flowers. Increased sunlight will also reduce soil moisture (decrease alpha acids).
3) Increases in mean annual temperature over that of native hop region will decrease alpha-acid content. Acids will still be produced, but high alpha acids hops will not reach full potential in warmer temperate to hot, humid climates.

Soil Conditions

A deep humic and loamy (sand, silt and clay) soil is best. Soils with an acidic pH of 6 to 7, resulting from the humic soil composition, is ideal for hop production. Poorly drained, strongly alkaline or saline soils should be avoided. Although hops do require a lot of water to sustain their growth, they prefer WELL-DRAINED soil; this can be accomplished by raising the level of your plants in either mounds, or even a raised bed if you are planting in a low spot. The more organic material that you incorporate into the soil (manure, compost, sawdust, peat), the better it will drain excess water and yet still retain an appropriate level of moisture for the plant. It is not recommended that you just dig a ditch in clay and fill it with organic material, because this will probably amount to the same thing as organic material sitting in a pond; if your soil is very heavy clay that does not drain well, then consider a raised bed, with or without a supporting perimeter, or at least build your mounds sufficiently high enough with a mix of soil and organic material so that the rhizomes are higher than the surrounding yard, and the mound can still drain well. Frequent watering or drip irrigation will be best, especially for new rhizomes. For well established plants with a good, deep root system, less-frequent, deep watering is probably okay (just like in nature), but you really don't want the plants to be wanting for water, or they won't be able to achieve their phenomenal maximum growth.

Get rid of grass and weeds by rolling the sod off of your row rather than tilling it into the soil, as many grasses will come right back up. The easier and better approach is to kill it over a season by covering it with black plastic, but you won't have time for that if you plan to plant this spring. The herbicide Roud-Up is generally safe to use in to-be garden areas, as its half-life is only 24 hours. You can safely plant after all vegetation has turned brown, as the Round-Up will no longer be chemically active. Most people plant without regard to the chemistry of their soil, and you can probably get by with that in nearly all cases unless your soil is in poor condition. For one thing, it has been found that soil pH has no apparent effect on yield, based on testing of commercial hop farms with pH ranging from 5.0 to 7.0, although decreasing tissue manganese, which will harm plants, is one reason for maintaining soil pH above 5.7 for hop production. If you're going to go to all of the trouble with everything else, get a free soil analysis from your county extension office and then adding any necessary soil supplements; many additions take time to incorporate into the soil, but the worst case scenario is that your hops will benefit next year.

Planting and growing seasons

Hops are relative shallow growing plants. Rhizomes should be planted immediately after the last frost of the winter season. For us, this generally means the first of April. Established plants will begin growing well before this, but new plants should not be buried too early. Placing the rhizome on the ground and building a raised bed over it will promote soil drainage, but is not absolutely necessary for successfully growing hops. If you are growing in a elevated area of your yard (NOT low-lying areas), then you can simply bury the rhizomes 4-6 inches down into the ground. It is recommended that you dig a hole much large than necessary for the rhizome and fill the hole with high quality gardening soil, or fresh topsoil with humic mulches mixed in the topsoil. Hops will grow through the summer and begin to flower in the fall. Plants will remain dormant during the winter, and begin growing again around March of the following year. In regions where permafrost can reach deeper than 4-6 inches (or during unusually cold winters), deeper burying may be beneficial in the rhizomes surviving and growing the next season.

Compost and Fertilizer

The main factors to consider when applying natural or artificial fertilizer are:

1) Soil Drainage
2) Soil Nitrogen
3) Soil Acidity

Many organic mulches can be laid down for natural compost. Cypress or evergreen plants are native to regions where hops grow well, and make for excellent mulch for hops. They are rich in nitrogen, slightly acid and drain well. Pine needles make an excellent mulch. Avoid laying compost, like un-shredded leaves, that will pack tightly and hold too much moisture. Spent wort is an excellent natural compost for hop plants when mixed with other mulches that drain well. They aid the natural acidification of the soil (typical of hops growing regions) and possess high concentrations of nitrogen (from protein break-down-that foamy stuff) from the barley and adjuncts adhering to hops. Many breweries give away spent hops and barley for feed and compost (e.g. Mad River Brewery, MIlwaukee, WI).

The nitrogen content of your fertilizer is more important than the phosphorous content. Nitrogen promotes new, green growth and is critical for hard vegetative structures like stems and bines. Phosphorous is mostly important for reproductive structures and helps with root growth, photosynthesis and flower production. Hops are a viney plant and need significantly more nitrogen to support their fast growth than they have need for phosphorous. Lastly, potassium helps to strengthen canes, improve vigor and increase winter hardiness. Make sure you use a fertilizer rich in potassium.

Hops plants originate in regions with slightly acidic soils. Lime should not be applied, nor any fertilizer rich in other alkaline compounds (like egg shells). Again, mulches from evergreen sources will be rich in protein and naturally slightly acidic. This is sufficient for maintaining slightly acidic soil pH, unless alkaline fertilizers or excessive hard water (what comes out of the garden hose in Louisville, KY) are used. Miracle-Gro® Water Soluble Azalea, Camellia, Rhododendron Plant Food, for example, is designed for acid loving plants with high cellulose compositions (greater nitrogen need than phosphorous need). This is nearly identical to the biology of hops plants, and will make for an excellent hop fertilizer. Fertilizers for evergreen shrubs and trees are also ideal for growing hops.

Summary:

1) Plant hops after the final frost of the year
2) Plant rhizomes 4-6 inches deep or build a raised bed over the rhizome. Use plenty of organically rich potting soil to fill in around the rhizomes.
3) Make sure hop bines get plenty of sun, but full sunlight here in KY may be too much and/or will require daily watering (Remember: our water is very hard and alkaline, which will neutralize the acidic soil conditions. Rainwater is slightly acidic and favorable to our tap water, so choose a location where watering from the garden hose isn't necessitated).
4) Starting you hops in large pots is an easy way to move them around (until bines attach to something) to figure out where they will grow best in our hot climate.
5) Make sure plants are in an area that drains well and does not hold water. Low-lying areas with excessive clay should be avoided.
6) Use coniferous mulch sources, like pine needles and cypress, around the base of the hops plants.
7) Spent hops are an excellent fertilizer and soil conditioner.
8) Use fertilizers for acid loving plants that are rich in nitrogen and potassium, but low in phosphorous and calcium (lime).
9) Use fencing, railing, wire or clothes-lines to train bines and allow them to climb.
10) Harvest in the fall, but do not wait until the flower clusters are yellow (indicating the oils are oxidized).

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