# HOPS AND HOP GROWING

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**Contents**





**Summary**

Hop plants are perennials which develop annual shoots from the perennial rootstock. They grow primarily between latitudes of 30 to 50 degrees in both the Northern and Southern hemispheres. Hops have been known to mankind for a very long time. Only female plants are used for commercial production.

The female inflorescence of hop is used almost exclusively for flavoring fermented malt beverages such as beer and ale. About 30 countries have reported commercial hop production, but most of the world's hops in international trade channels come from 15 major producing areas. Dried hop flowers have been used since the middle ages but today, most hops are processed into powder, pellets, or extracts which aids shipping and handling and improves utilization efficiency.

## 1. Introduction

Hops have been known to mankind for a very long time. The ancient Babylonians and Egyptians probably knew the hop plant, but there is no record of its use by these people. The female inflorescences of Hop (*Humulus lupulus L.*) have been used for flavoring fermented malt beverages at least since the Middle Ages (Neve, 1991).

Hop products and various processed products originating from this raw material are now considered an indispensable flavoring ingredient of beer and ales produced in many countries world-wide. About 30 countries around the world are known to have produced commercial quantities of hops, but today only about 15 are major producers of this raw material for both domestic and international trade.

| **Country** | **Harvest** | | | |
|---|---|---|---|---|
| | Hectares | Metric tons | Average alpha % | Tons alpha |
| **Europe** | | | | |
| Austria | 206 | 349.9 | 6.3 | 22 |
| Belarus | 30 | 30.0 | 9.0 | 3 |
| Belgium | 176 | 320.0 | 9.9 | 32 |
| Bulgaria | 221 | 227.3 | 8.1 | 18 |
| Croatia | 16 | 24.0 | 5.5 | 1 |
| Czech Rep. | 5,389 | 5,630.6 | 3.5 | 199 |
| England | 1,063 | 1,473.0 | 7.2 | 107 |
| France | 796 | 1,480.4 | 3.2 | 47 |
| Germany | 17,671 | 32,138.9 | 8.6 | 2,766 |
| Hungary | 18 | 18.8 | 10.5 | 2 |
| Poland | 2,179 | 3,256.1 | 6.8 | 221 |
| Portugal | 21 | 27.0 | 11.0 | 3 |
| Romania | 429 | 196.0 | 7.6 | 15 |
| Russia | 228 | 158.0 | 4.5 | 7 |
| Serbia | 67 | 111.0 | 7.9 | 9 |
| Slovakia | 300 | 294.0 | 3.7 | 11 |
| Slovenia | 1,570 | 1,987.0 | 5,7 | 113 |
| Spain | 497 | 936.7 | 12.1 | 113 |
| Switzerland | 18 | 36.5 | 8.8 | 3 |
| Turkey | 331 | 280.0 | 9.3 | 26 |
| Ukraine | 1,145 | 700.0 | 5.4 | 38 |
| **Americas** | | | | |
| Argentina | 167 | 240.0 | 8.0 | 19 |
| USA | 12,510 | 27,330.7 | 10.6 | 2,891 |
| **Asia** | | | | |
| China | 4,106 | 11,395.0 | 5.4 | 617 |
| India | 62 | 42.5 | 11.1 | 5 |
| Japan | 214 | 410.2 | 6.5 | 27 |
| **Others** | | | | |
| Australia | 441 | 890.0 | 12.2 | 108 |
| New Zealand | 354 | 700.1 | 10.0 | 70 |
| South Africa | 434 | 900.2 | 13.0 | 117 |
| | | | | |
| **World Totals** | **50,659** | **91,583.9** | | **7,610** |

Table 1. 2006 World hop areas and production. ( Source: The Barth Report 2007)

Germany and the United States dominate (approximately 60%) world hop production and account for the majority of all hops moving in international trade channels. The latest production figures available for 2007 list 29 major hop producing countries which are members of the IHB (International Hop Production Bureau), and data in Table 1 are provided by this organization. These data give a nearly 100% overview of worldwide production, but do not include some minor producers who are not members of the organization.

## 2. Taxonomy of Hops

Earlier taxonomists had assigned hops to the *Moraceae* (mulberry) family, but today it is commonly agreed that hops belong to the *Cannabaceae* (hemp) family (Small, 1978, 1980). This family includes two genera, hop (*Humulus*) and hemp (*Cannabis*). Although the two are "botanical cousins", there is no record of any hallucinogenic compounds found in hops.

The genus *Humulus* has two species: *Humulus lupulus* (common hop), and *Humulus japonicus* (Japanese hop). *Humulus lupulus* is a diploid ($2n = 2x = 20$) herbaceous perennial plant with annual shoots that climb in a clockwise direction in both the Southern and Northern hemispheres on supporting strings, wires, or poles, sometimes reaching heights of over 7 meters. Daily growth during the prime growing season can be as much as 25 cm. The species has separate female and male plants, a condition termed "dioecious". They can easily be identified at flowering time. Females produce tiny "burrs" which develop into small cones (called "strobiles") while males produce panicles with numerous flowers, each containing 5 anthers.

*Humulus japonicus* also has separate female and male plants. It is an annual which is used mostly for ornamental purposes although it also produces a small number of resin glands. It also differs from common hop in its chromosome number (17 in males, 16 in females) and the two species are not cross compatible.

Wild hops have been found on three continents: Europe, North America, and Asia. Taxonomists differentiate 5 distinct subspecies (Small, 1978, 1980): *Neo-mexicanus*, *pubescens*, *lupulus*, *lupuloides* and *cordifolius*. All are cross compatible. Most commercial hops grown for brewing purposes have originated from the subspecies "*lupulus*" found in Europe. One gene responsible for increased brewing value of hops appears to have originated from a native female North American hop found in 1919 in Manitoba, Canada (Salmon, 1934). This plant was introduced into the hop breeding program at Wye College, England and one of its offspring, Brewer's Gold, has been used widely to produce cultivars with outstanding brewing value.

## 3. Ecology

Hop plants require long day-length for flowering and therefore, are best adapted to latitudes between 30 and 50 degrees latitude north and south of the equator. This area assures long summer days and moderately cold winters when the plant is dormant. Cold winter temperatures are necessary for physiologically conditioning the plant for spring re-growth.

Annual crop bearing shoots develop on female plants from the perennial rootstock ("crown"). They normally emerge in early spring and grow to a height of 5 – 7 meters on poles or under a trellis system. Flowering starts in late June or early July in the Northern hemisphere, depending on the maturity traits of specific cultivars selected for harvesting dates. At maturity, vines are cut in the field and cones are separated in commercial picking machines, dried, packaged and stored in controlled temperature warehouses, often under frozen conditions to maintain optimal brewing value. Remaining basal shoots die back in the fall to the ground surface, but the below-ground rootstock containing numerous dormant buds for the next season can survive severe winters.

Hops grow well in a variety of soils ranging from sandy to loamy and the root system can reach a depth of several meters. Plants require an ample supply of moisture during the entire growing season. The annual crop-producing vines develop from below-ground buds on the perennial crown and start growing in late winter or early spring.

Premature early spring re-growth is normally removed either mechanically or by chemical means to assure uniform re-growth at proper training time. Vigorous shoots are hand trained on supporting strings in a clockwise direction in late April to mid-May (northern hemisphere), depending on variety. They reach the top of the trellis (5 to 7m) in about 5 to 6 weeks. Flower buds develop on laterals, called "side-arms" and flowering starts in late June to mid-July, depending on the variety.

Mature cones are harvested about 5-6 weeks later, depending on the variety. In the United States, harvest starts about July 20, and about 10 days later in Germany. Today most hops around the world are harvested by mechanical picking machines and labor intensive hand picking is no longer practiced. Hop cones are dried in semi-automatic kilns to about 10% moisture content and compressed into "bales" (about 200 lbs. weight in the US; 50 kg in Germany) and shipped to cold storage facilities (generally frozen) to retain maximum brewing value. They may be used directly by adding "leaf hops" directly to the brew kettle at proper time during the boiling process, or be processed into various products such as powder, pellets, or extract.

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**Biographical Sketch**

**Alfred Haunold** was a research geneticist (hops) at the US Department of Agriculture, ARS, Corvallis, OR since 1965. After his retirement from US Government service in July 1995 he is now active as research collaborator at the US Department of Agriculture, ARS, and as courtesy professor at the Crop Science Department, Oregon. State University. He holds a Ph.D. in plant breeding, botany, and chemistry

from the University of Nebraska, Lincoln, NE (1960). Among his most important scientific accomplishments are: the introduction of high-protein genes from soft white wheat to hard red winter wheat, and the development of high-amylose breeding lines in corn. He was also a member of a research team which has released 16 new hop varieties and 31 hop breeding/germplasm lines.

Dr. Haunold is author or co-author of over 100 scientific publications on wheat genetics, corn starch biosynthesis, hop breeding, hop genetics, and cytology. Among the many awards he received, the most noteworthy ones are: the International Order of the Hop (Strasbourg, France, 1983) and the Award of Distinction of the American Society of Brewing Chemists (Victoria, BC., Canada, 2001). He is also Honorary Life Member of the American Society of Brewing Chemists.