An Introduction to Hop Production

Great Lakes Hop and Barley Conference
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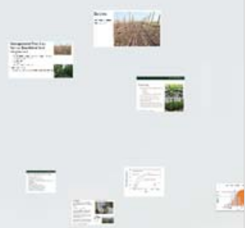


Outline

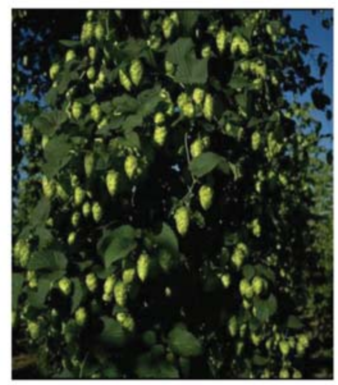
- What are hops?
- Hops: Stages of Production
- Value chain: From planting to sales
- Economics
- Market Outlook and Opportunities

Hops Overview
Natural History and Taxonomy

- *Humulus* is the genus of herbaceous climbing plants
- *Humulus* is one of two genera in the Cannabinaceae family, the other being *Cannabis*
- ***H. lupulus***, *H. japonicus*, and *H. yunnanensis*

Physiology

- Hops are dioecious
- Perennial below ground
- Annual above ground
- Produce annual bines from an overwintering rhizome (below ground stems)



Saaz, 15 years, excavation work
Žatecký poloraný červeňák, 15 let, výkopové práce

Climbing Bines

- Bine climbs clockwise with the aid of trichomes
  - Phototropism
  - Thigmotropism
- In the wild, hops climb up a companion species or support
- Commercial production requires a trellis

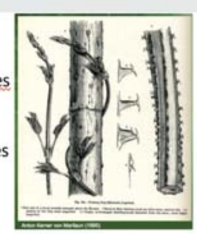


Table 1. Typical row and plant spacing in various hop-producing regions of the world (Oldham 2016; Kořen 2007; Rybáček 1991).

Country	Region	Dominant growing system*	Typical spacing between rows (m)	Typical plant spacing along the row (m)
Germany	Hallertau	V-trellis	3.2	1.3–1.7
USA	Washington State	V-trellis	4.0	0.9
Czech Republic	Saaz, Trschitz and Auscha	V-trellis	3.0	1.0
United Kingdom	West Midlands and south-east	Low 2D trellis	2.5	0.6–0.9
New Zealand	Nelson	V-trellis	2.5	1.2

Note: The openness of the V-trellis systems varies considerably from country to country with differences in row spacing. V-trellis canopies in Washington State, USA are much wider than those in Germany or New Zealand.

14' x 3.5'
889 hills
55 poles
1778 strings/acre

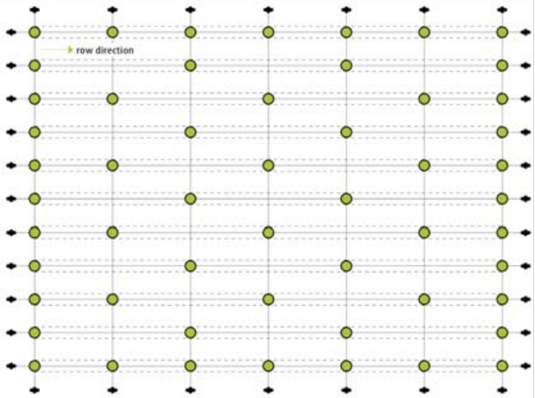


Figure 4. A possible hop yard design plan showing distribution of posts, cables, wires, stays and anchors.

Thigmotropism

- Thigma= "touch"
- Tropism= turning of all or part of an organism in a particular direction in response to an external stimulus
- Climbing plants- cells *not* in contact are stimulated by hormone to grow faster
- Hops grow clockwise

Phototropism is a directional response that allows plants to grow towards, or in some cases away from, a source of light.

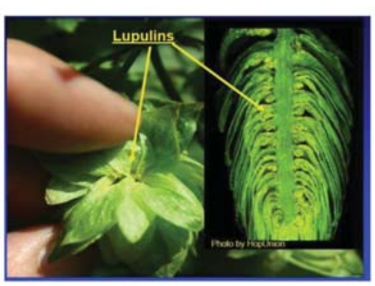
Photoperiodism is the regulation of physiology or development in response to day length. Photoperiodism allows some plant species to flower—switch to reproductive mode—only at certain times of the year.

Cones

- Only the female flower "strobile" or "cone" is desirable for use in beer production
- Males-no real commercial value except in breeding programs
- Cones (0.5-4 in.) light green, papery, contain Lupilin glands

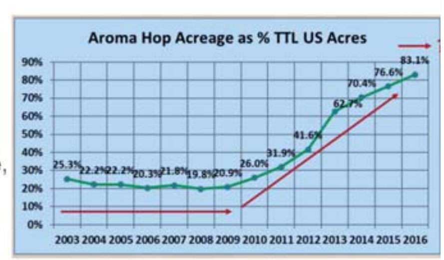
Lupulin

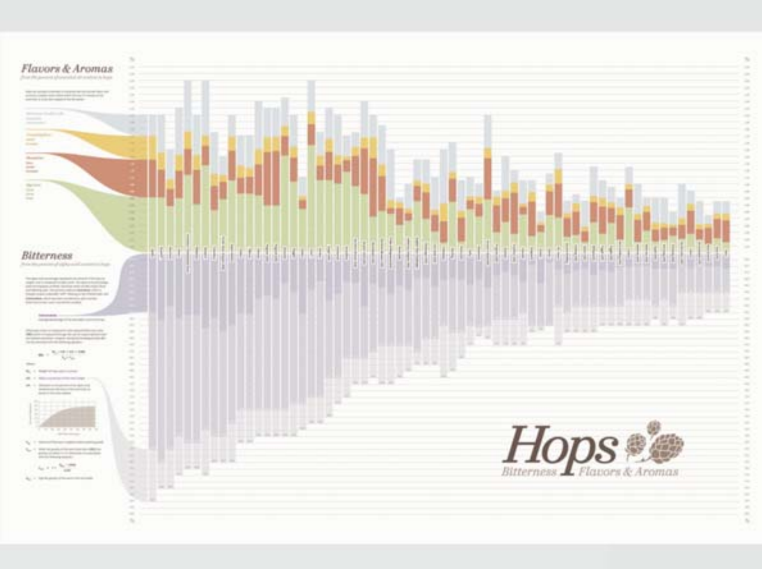
- Essential oils: well over 100 compounds contribute to aroma
- Soft resins: beta acids, and the all important alpha acids.

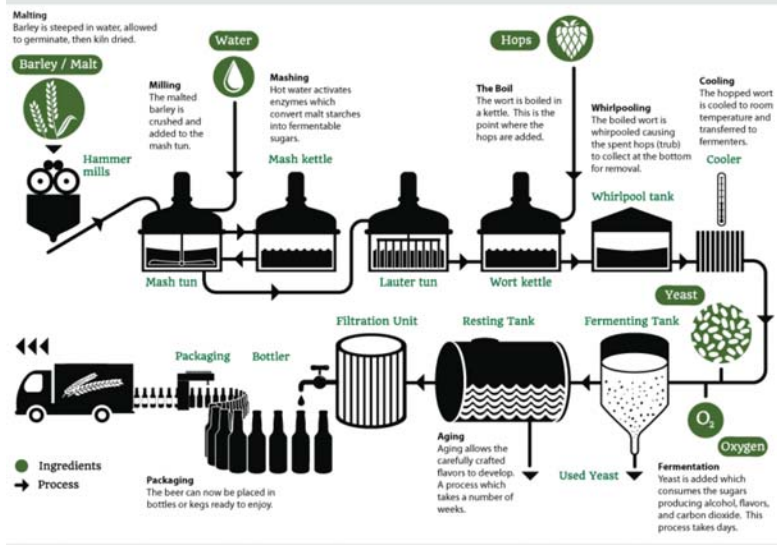


Two Distinct Markets

- Alpha/Bitter
  - Processed hops
  - Yield measured in kg. Alpha per acre
  - Typically hi-alpha varieties, increasingly aroma
  - Eg. columbus, nugget
- Aroma
  - Minimal processing
  - Yield measured in lb. per acre
  - Typically aroma varieties
  - Eg. Cascade, amarillo, simcoe, centennial, etc.



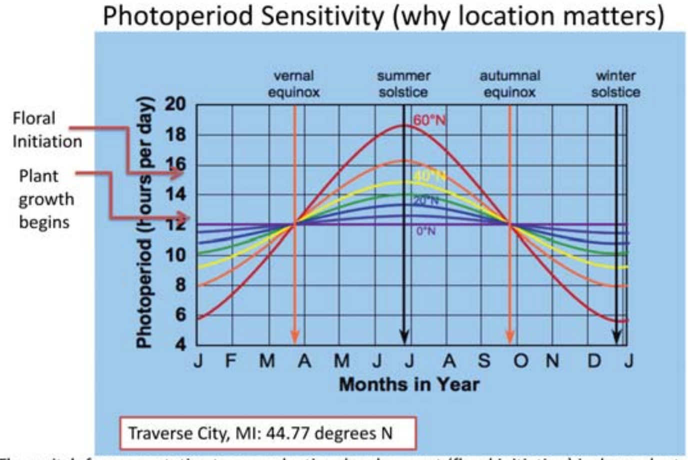




Factors that can impact hop production (growth, yield, and quality)

- Environment (temp, day length, soil texture, weather)
  - Day length drives production stages (photoperiod sensitive)
  - Latitude determines day length
  - Heat determines growth during each stage
- Production Practices
  - Cultivar
  - Soil fertility
  - Disease, pest, and weed pressure and control
  - Training and timing of training
  - Harvest and harvest timing
  - Irrigation
  - Post-harvest processing and storage

Photoperiod Sensitivity (why location matters)



The switch from vegetative to reproductive development (floral initiation) is dependent on: 1) Cultivar, 2) Number of nodes (part of stem where leaf grows), 3) Day length (15 hrs of light)

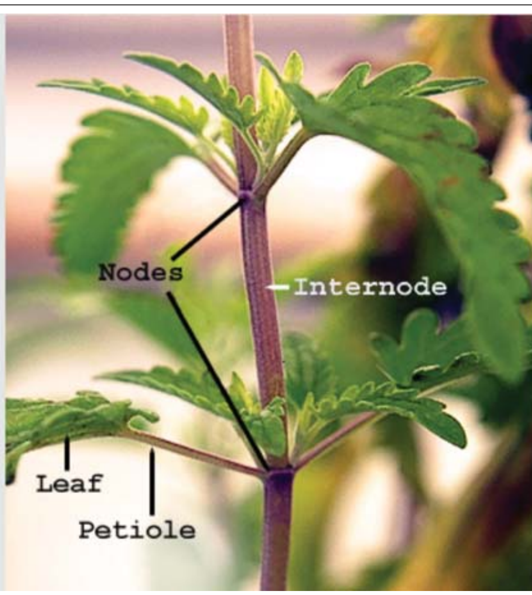


TABLE I

Effect of 3 weeks of short days (10 h) on the flowering of three varieties of hop

Fuggle—6 replicates, CC 31 and New York Hop—5 replicates

Cultivar	Mean node no. when subjected to short days	No. plants vegetative	No. plants flowering
Fuggle	15·7	6	0
	19·3	6	0
	22·3	3	3*
	26·3	0	6
CC 31	9·1	5	0
	11·8	4	1*
	14·8	0	5
	18·7	0	5
	20·2	0	5
	26·4	0	5
New York Hop	10·2	5	0
	12·5	5	0
	15·8	5	0
	19·2	3	2*
	21·8	0	5
	25·4	0	5

* Flowers were observed at the end of the second week of short-day treatment.

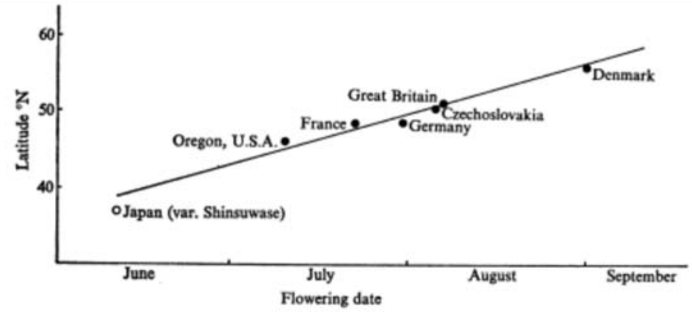


FIG. 4. Flowering date of the cultivar Fuggle grown at different latitudes.

There is a close relationship between flowering date and latitude of the growing area (Fig. 4), suggesting that daylength is probably one of the decisive factors determining the normal flowering date of any particular variety in *interaction with temperature* and the date at which 'ripeness to flower' is reached. (Thomas and Schwabe, 1969)

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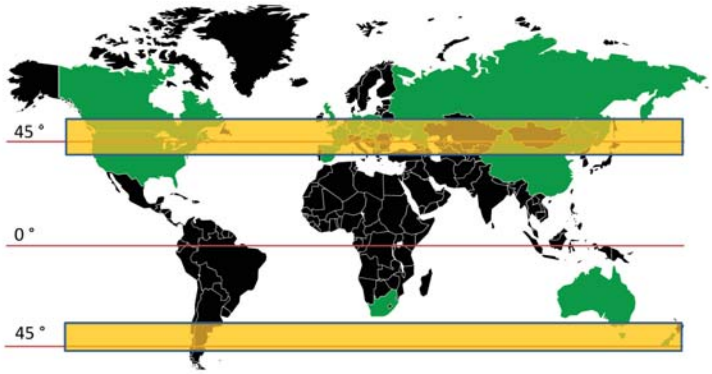
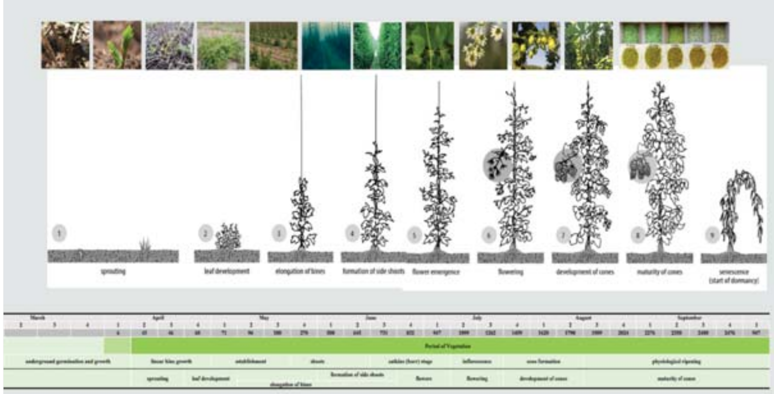
Latitude and Daylength



Results in: Hop Production Stages

- Stages of Growth
  - Dormancy
  - Spring regrowth
  - Vegetative growth
  - Reproductive growth
  - Preparation for dormancy
- Each stage requires its own unique management regime



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FALL/WINTER

Dormancy (October-March)

- In late summer the plant allocates photosynthetically derived starches to the storage roots
- Starch is converted into soluble sugars
- Sugars are the energy needed for spring-regrowth

In the field

- Trellis repair/installation
- Planning for next season

Management Practices
New vs. Established Yard

- BABIES (year 1 and 2)
  - Planting
  - Weed control-no round-up or AIM (maybe AIM in yr 2)
  - Fertilizer-yes but lower rates
  - Crowning-no
  - Pruning-no
  - Harvest- probably not in yr 1
- Mature (year 3+)
  - Spring maintenance (weeds, fertility, crowning, pruning)

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Planting

- Michigan moving toward plants
  - Disease
  - Reliability
  - Local supplies of certified plants
- Planting-usually in Spring
- Trellis and irrigation in place before planting
- Before you purchase quantity, request samples and send them immediately to a University lab

Photo credit: top-Piedmont Hops, bottom- USA Hops

What Varieties to plant?

1. What brewers want
2. Yields
3. Disease susceptibility
4. Location-soil type, etc.

		Disease Susceptibility*		
Variety	Usage	Powdery Mildew	Downy Mildew	Verticillium Wilt
Brewers Gold	Bittering	S	MR	MR
Bullion	Bittering	S	MR	R
Cascade	Aroma	MR	MR	MR
Centennial	Bittering	MR	S	U
Chinook	Bittering	MS	MR	R
Columbia	Aroma	MS	MR	S
Comet	Bittering	R	S	R
Crystal	Aroma	R	S	R
East Kent Golding	Aroma	S	S	MR
First Gold	Bittering	R	S	MR
Fuggle	Aroma	MS	R	S
Galena	Bittering	S	S	R
Glacier	Aroma	S	S	U
Hall. Gold	Aroma	MS	R	S
Hall. Magnum	Bittering	S	R	MR
Hall. Mittelfrüh	Aroma	MS	S	S
Hall. Tradition	Aroma	MR	R	MR
Horizon	Bittering	MS	S	MR
Late Cluster	Aroma	S	S	R
Liberty	Aroma	MR	MR	U
Mt. Hood	Aroma	MS	S	S
Newport	Bittering	R	R	U
Northern Brewer	Bittering	S	S	R
Nugget	Bittering	R	S	S
Olympic	Bittering	S	MS	R
Perle	Aroma	S	R	MR
Pioneer	Bittering	MR	MR	U
Saazer	Aroma	S	MS	S
Saazer 36	Aroma	S	MS	S
Spalter	Aroma	S	R	MR
Sterling	Aroma	MS	MR	U
Teamaker	Aroma	MR	MR	S
Tettnanger	Aroma	MS	MS	S
Tolhurst	Aroma	S	S	U
U.S. Tettnanger	Aroma	MS	MS	S
Vanguard	Aroma	S	S	U
Willamette	Aroma	MS	MR	S

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Soils

- Grow in a variety of soils from clay to sand
- Prefer well-drained soils
  - Sandy loam or silt loam
- Problem with heavy, poorly drained soils
  - May delay getting into field
  - Increase disease issues/rotting
- Problem with overly sandy soils
  - Hi input costs

Source: Neve, R.A. Hops. 1991

Web Soil Survey

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Essential Plant Nutrients for Growth-Derived from soil and/or fertilizer

Macronutrients

- Primary:
- N –Nitrogen
- P –Phosphorus
- K –Potassium

Secondary:

- S –Sulfur
- Mg –Magnesium
- Ca -Calcium

Micronutrients

- Zn –Zinc
- B –Boron
- Fe –Iron
- Mn–Manganese
- Cu –Copper
- Mo –Molybdenum
- Ni –Nickel
- Cl-Chlorine

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What to test

- Soil pH
- Phosphorus
- Potassium
- Calcium
- Magnesium
- Zinc
- Boron
- Manganese
- Organic matter
- C.E.C.

AGRICULTURAL SOIL REPORT

Crop: Hops

ELEMENT	ANSWER	INTERP	SHOULD BE	ELEMENT	ANSWER	INTERP	SHOULD BE
pH-Soil	7.5	Slightly Basic		Sulfur-ppm	17	Low	20 +
pH-SMP				Calcium-ppm	1869	Optimum	1,800 +
Soluble Salts	0.10	Optimum	< 1.5	Magnesium-ppm	171	Low	250 +
% Lime	L	1.5 to 3.0 % lime		Sodium-ppm	77	Optimum	< 225
% Organic Matter	1.52	Low		Zinc-ppm	2.5	Optimum	1.0 - 3.0
Nitrates-ppm	10	Low	10 - 35	Copper-ppm	0.4	Low	0.8 - 2.5
Ammonium-ppm	6	Optimum	5 +	Manganese-ppm	2	Very Low	6 - 30
Phosphorus-ppm	19	Low	25 - 40	Iron-ppm	21	Optimum	7 +
Phos-ppm-Bray			50 - 100	Boron-ppm	0.3	Very Low	0.7 - 1.5
Potassium-ppm	161	Low	300 +	TBS%	41		

Texture	Loamy Sand	Water Holding Capacity/foot	0.95	Bulk Density	1.6
Cation Exchange Capacity - CEC	8	P Index	78		
Percent Base Saturation	141				

BASES	IDEAL	YOURS		NO3 ppm	NH4 ppm
Calcium-% of CEC	65-80	117	1 Ft	10	6
Magnesium-% of CEC	10-20	18	2 Ft		
Potassium-% of CEC	2-6	5	3 Ft		
Sodium-% of CEC (ESP)	< 5	1	Total N PPM		16
Hydrogen-% of CEC	< 15		Lbs N / Acre		48

Ratio	Ideal	Yours	Evaluation	Recommendations
Ca:Mg	6-20:1	11 :1	OK	
Ca:K pH >7	15:1	12 :1	OK	
Ca:K pH <7	10:1	:1		
Ca:P pH >7	100:1	98 :1	OK	
Ca:P pH <7	40:1	:1		
P:Zn	15:1	8 :1	OK	
P:Mn	4:1	10 :1	High	Watch Mn
P:Cu	25:1	48 :1	High	Watch Cu
Zn:Cu	3:1	6 :1	High	Watch Cu
Mn:Zn	3:1	1 :1	OK	
Mn:Cu	7:1	5 :1	OK	
K:B	200:1	537 :1	High	Watch B
Mg:K	2:1	1 :1	Low	Watch Mg

Fertilizer Suggestions in Pounds per Acre for the whole season		
Crop	Hops	Hops
Yield Goal	8 Bales	16 Bales
Past Crop	Fallow	
Acres	15	
Nitrogen	72	192
Phosphate	34	201
Add Phos for P INDEX	37	
Potash	71	302
P.F. Sulfur	5	45
Elemental Sulfur	27	
Gypsum		
Lime		
Dolomite	0	
Magnesium	10	10
Zinc		3
Manganese	2	9
Copper		2
Boron	1	3

Split apply Nitrogen. Nitrogen, sulfur and boron recs are made for the year. All other nutrient recs can be split over a two-year program. Tissue and soil test in-season gives the best results.

P.F. Sulfur = Plant Food Sulfur   Elemental Sulfur = Reclamation Sulfur

EXTRACTABLE NUTRIENTS					SOIL SOLUTION			
ELEMENT	ANSWER	SHOULD BE	RECS	PRE-PLANT SUGGESTIONS	ELEMENT	ANSWER	SHOULD BE	ADD WEEKLY
			LBS	LBS			LBS / DAY	LBS
Phosphorus-ppm	19	25 - 40	34	22	P-lbs	0.8	2	5.0
Potassium-ppm	161	300 +	71	35	K-lbs	5	10	20
Calcium-ppm	1869	1,800 +	*	see 1	Ca-lbs	4	5	*
Magnesium-ppm	171	250 +	10	5	Mg-lbs	5	2	
			LBS	LBS			grams / DAY	OZ
Zinc-ppm	2.5	1.0 - 3.0			Zn-grams	48	28	
Copper-ppm	0.4	0.8 - 2.5			Cu-grams	14	14	
Manganese-ppm	2	6 - 30	2	1	Mn-grams	11	28	0.5
Boron-ppm	0.3	0.7 - 1.5	1	1	B-grams	34	60	0.8

*** Refer to soil report for Calcium recommendations, if needed.**

All chelating products can be used if the zinc, copper and magnesium are adequate. When the levels are below the should be levels, you need to use the elements in the sulfate forms. Disease suppressions are caused by the elements in their metallic forms. Chelates are an excellent sources for plant and production needs.

PRE-PLANT:

For disease suppression add 1/2 of the weekly recommendations for all micro nutrients in a sulfate or water soluble oxide in calcareous soils.
For plant needs and maximum bulking add the other 1/2 in chelate form by using the SV (Secret Vault) program to monitor weekly requirements.

1. If calcium is over 1800 and there is free lime, use acid residue fertilizer and elemental sulfur to form gypsum from free lime.
2. If no lime and calcium is less than 1800 and soil solution is less than "should be" add 250 lbs. of gypsum pre-plant.

If phosphate, potash and magnesium in soil solution are less than requires consider putting filed on the SV Program to monitor it. If you are using the SV program and the phosphate, potash, and magnesium "should be" levels in the soil solution are higher than results on the SV Program, it is because the sample is taken with out the influence of the root system. In season results are lower because plant root gives off carbonaceous exudates.

"Always practice the laws of Agronomy."
John P. Taberna, Soil Scientist

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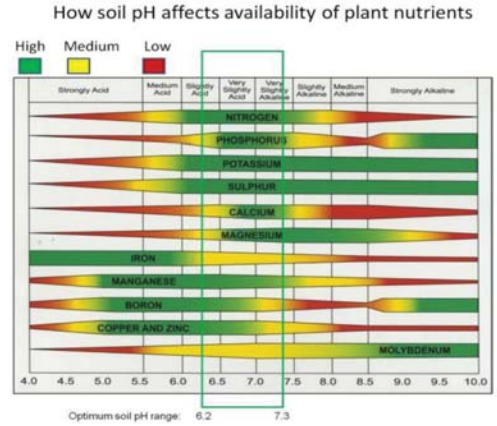
Hops and pH

- pH optimum(6.2-6.5)
- Lime if too low



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Spring Regrowth (April-May)

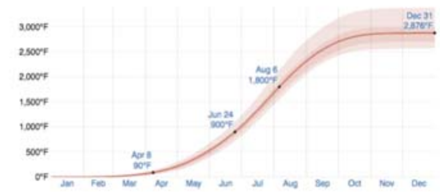
- Increasing day lengths and temperatures - end of dormancy
- Plants emerge from dormancy
- Initial regrowth-rapidly producing vines unsuitable for production
- Plant uses energy reserves through May-starches and sugars reach their lowest points of the year
- Supplemental nutrient management is needed

Source: Jason Perrault, Perrault Farms

Photo credit: Erin Lizotte

Growing Degree Days

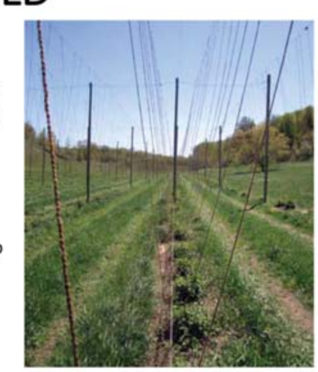
Yakima, WA
1st spring blooms ~April 8



Traverse City, MI
1st spring blooms ~May 1

Spring regrowth- FIELD

Spring Regrowth (April-May)
- In the Field
  - Spring pruning- April (removing initial growth)
    - Encourage more hearty secondary growth
    - Reduce disease
  - Weed Control
  - Fertilizer application
  - Twining
  - Training-one of most important aspects of hop production
    - Timing is varietal specific
    - Generally 3 vines per string
  - Irrigation begins



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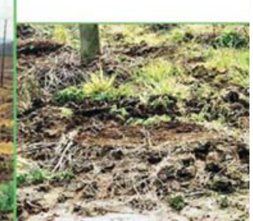
In the Field: Pruning/crowning in Oregon





PRUNING –determines training date

Why?

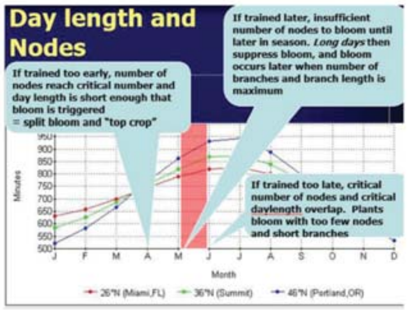
Can depend on plant vigor

Some plants want to hold back

Some plants want to get to top wire asap

Could also depend on specific block (eg. weak centennial in one block maybe is trained earlier)

Also depends on desired harvest time



• 1778 strings/acre (2 per plant)

http://roguefarmsblog.wordpress.com/category/crops/hops-crops/

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W Clips

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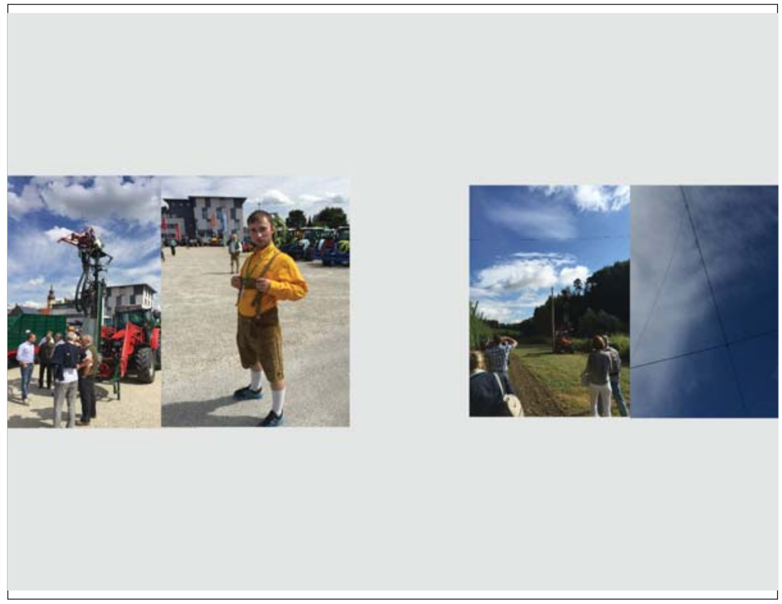


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Lesson: Weed control-especially w/ babies hops

Weed control

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Vegetative Growth(end of May-July)

•Critical Stage for the purposes of crop production

•Two Phases:

1. May-early July: Growth in main vine and leaves
2. July: Most above ground growth occurs in lateral production (side arms)

- Plant reserves used up
- Plant already determining yield
  - •Aggressive management!!
  - Maximize health of plant & growth

Source: Jason Perrault, Perrault Farms

Vegetative Growth(May-July)

- In the Field
  - IPM-monitor, monitor, monitor
  - Pest/Disease/Weed Control
  - Fertility Management!!!
  - Irrigation
  - End of May/Early June-train hops
    - Training-one of most important aspects of hop production
      - Timing is varietal specific
      - Generally 3 vines per string
  - Mid-June Petiole tests and foliar spray
  - End of June internode spacing should be about 8 inches
  - End of July-foliar spray micros

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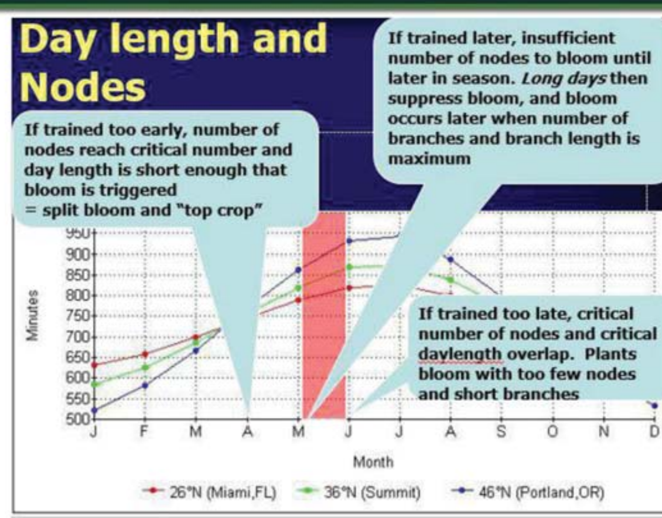

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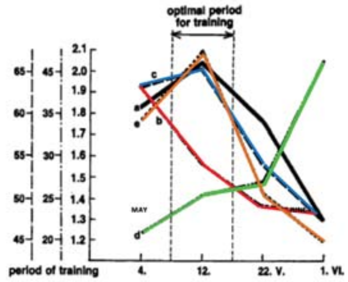
Lessons Learned: Training Date

1970-1973 Studied the effect of the date of training
a. Yield
b. Length of cones
c. Number of shoots
d. Density of setting (# cones per 10cm of shoot)
e. Mean length of shoots



Yield Reductions

Late training (June 1) = 38.5 %
Early training (May 4) = 10.3%

TAKE HOME: the date of training principally affects the yield of cones and their quality

RybaCek, V. 1991. Hop Production. Developments in Crop Science 16. Pg. 205

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Hop Growing Requirements: Fertility

- Tissues tests and Soil tests
- Recommended fertilization rates:
- Nitrogen (N) = 150-200 lbs/acre total
- April-May with urea (40-0-0) every week (100 lbs: 25 lbs each week)
- Mid-May: Triple 16
- May-burn/prune back flag shoots
- June-75-100 lbs liquid N (28N solution)
- Boron, Iron, Manganese, Zinc, Copper
- Phosphorous (P) = 60-100 lbs/acre
- Potassium (K) = 100 lbs/acre (potash)

Fertigation

Any nutrients in a soluble form are available for plant uptake right after application, allowing the farmer greater control over nutrient availability to the crop.

More efficient use of fertilizers.

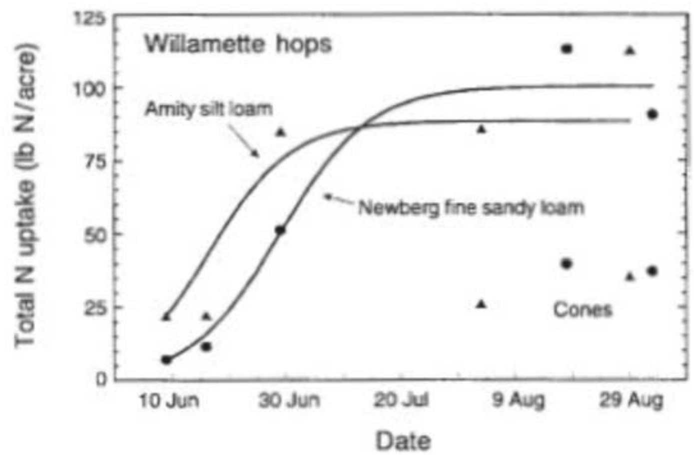
Nutrients may be applied on a daily, weekly, or less frequent basis, depending on the overall nutrient management plan for the crop.

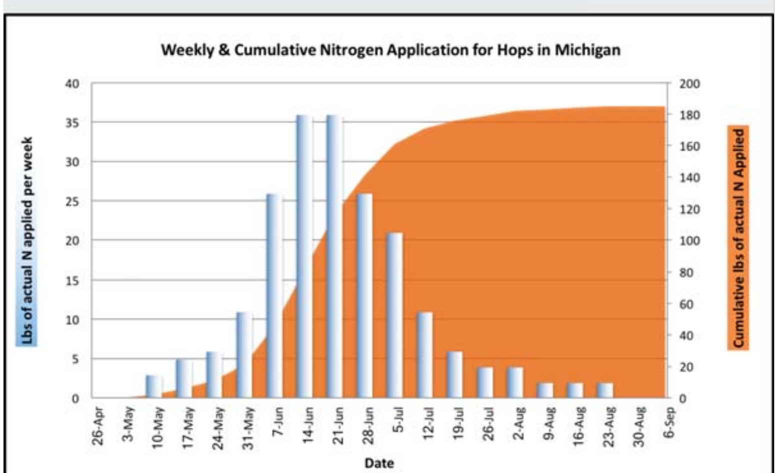
When nutrients are applied shortly before they are needed, growers are able to reduce loss of nutrients from the root zone.

A venturi injector operates under the principle that suction (negative pressure) is created when water passes through a zone of constriction.

Typically= irrigate, fertigate, irrigate

Positive Displacement injector





Nitrogen
- N Budget = hop N need – N (manure, cover crops, etc.) = N fertilizer
- Replacement value ~80-150 lbs/acre (removed from field each year, yield dependent).
- Timing important- only small ~10% of N is taken up by end of May
- Babies = ~75 lbs/N/acre (actual N)

Phosphorous
- Requirements low when compared to N and K
- 9-10 bale/ac yield only removes 20-30 lbs of P/ac

Potassium (K)
- Hops take up 80–150 lb K/a.

Boron
- In western Oregon hopyards, boron applications are recommended when values are 1.5 ppm or below.

Zinc
- Required for optimum growth. Zn deficiency is associated with high soil pH >7.5

Hop yield evaluation depending upon experimental plot area under different n management. Bavec. 2003.

- Target nitrogen rate of 160 kg mineral N/ha (at the level from 40.0 to 62.5 kg nitrate N/ha in soil depth to 0.3 m) and cheaper combination of calcium-ammonium nitrate (50 kg N/ha) at the beginning of vegetation plus urea (110 kg N/ha) for top dressing can be recommended.
- 143 lbs/ac total N
- 36-57 lbs/ac nitrate tilled in to ~1 ft
- 45 lbs/ac ca nh4 n03 at beginning of vegetation + urea top dressed 100 lbs/ac

Optimum Nutrient Ranges

NUTRIENTS	JOHN I HAAS	Plant Analysis Handbook III Vegetative Stage- Pre-Bloom	Plant Analysis Handbook III Reproductive stage & Full Bloom	Western Labs 5.5 ft above ground
Nitrogen (%)		3.2 - 5.6	2.13 - 3.93	4.0
Potassium (%)	1.49 - 2.5	1.6 - 3.4	0.97 - 2.55	3.0
Phosphorous (%)	0.29 - 0.6	0.27 - 0.54	0.18 - 0.43	0.4
Calcium (%)	0.79 - 1.2	1.03 - 2.57	3.09 - 6.05	2.5
Magnesium (%)	0.24 - 0.8	0.29 - 0.67	0.55 - 1.71	0.4
Manganese (ppm)	25 - 150	45 - 125	50 - 150	85
Iron (ppm)	30 - 60	44.3 - 97.9	35.4 - 151	
Copper (ppm)	10 - 25	8 - 29	5.7 - 16.6	10
Boron (ppm)	24 - 75	17.6 - 63.2	48 - 150	55
Zinc (ppm)	24 - 50	23.2 - 108	19.4 - 57.1	60
% Sulfur Sampled Basis	0.16 - 0.32	0.2 - 0.34	0.18 - 0.30	0.25
% Sulfur Dry Matter Basi	0.16 - 0.32	0.2 - 0.34	0.18 - 0.30	
Mo		0.5 - 3	1 - 5	
Na	0 - 1400			
NO3 ppm	4000-12000			

CANNABIS NUTRIENT DEFICIENCIES & EXCESSES

Nutrients	Role	Deficiency Symptoms	Excess Symptoms
Nitrogen (N)	Facilitates plant growth, provides the "green" response in plant, necessary for photosynthesis, increases yields (up to point of diminishing returns)	Poor growth, stunting, yellow leaves, cones are small an undeveloped,	Internodes are too long, increased insect and disease issues
Phosphorous (P)	Photosynthesis, cell division, nucleus formation, stimulates root growth and energy transfer	downward curling of lower leaves, dull appearance	Can cause zinc deficiency in alkaline soils, water quality issues
Potassium (K)	Role in metabolic process, production and translocation of carbohydrates, water intake, respiration, positive effect on cone ripening, production of lupulin, and resin and essential oil content	Weak bine growth and reduced burr formation, bronzing between veins, reduced N use efficiency	Can induce Mg deficiency
Sulfur (S)	Activates plant enzymes	Stunted growth, spindly stems, yellow leaves, usually in coarse textured soils prone to leaching	
Calcium (CA)	Root and leaf growth, cell wall structure and strength, does not move in plant-deficiency develops on new leaves, counteracts the effects of alkali salts	Young tissue and growing points, yellowing and death of leaf margins	Can induce deficiencies in other + charged ions (ammonium, K, Mg)
Magnesium (Mg)	Essential for photosynthesis, helps activate plant enzymes needed for growth, role in the quality and quantity of hop cones, can increase lupulin levels,	Older leaves yellowing between veins, most common in acid soils	
Iron (Fe)	Mainly concentrated in the leaves, essential for synthesis of chlorophyll	Yellowing on young leaves between veins while veins remain green, most common in alkaline soils	
Manganese (Mn)	Activates plant enzymes, mainly concentrated in hop leaves	Becomes limited in high alkaline soils, yellowing of young leaves and white speckling	In low pH soils can interfere with iron uptake
Zinc (Zn)	Concentrated in apices and young organs such as leaves, enzyme activator, hops are very sensitive to zinc deficiency	Weak growth, short laterals, poor cone production. Leaves are small misshapen, yellow, curled upwards, common when pH is greater than 7.5	
Copper (Cu)	Functions as a catalyst in photosynthesis and respiration, is a constituent of several enzyme systems involved in building and converting amino acids to proteins		
Boron (B)	regulates metabolism of carbohydrates, cell wall component	Delayed shoot emergence, stunting, distortion and crinkling of young leaves. Most common in acid/sandy soils	
Molybdenum (Mo)	Used by enzymes, important for N metabolism, high sulfates can reduce plant uptake of Mo.	Young leaves become chlorotic with light brown spots, speckling around veins. Deficiencies have been reported in acidic soils (pH <5.8)	

Table 1. Table of antagonistic elements

EXCESS ELEMENT	NUTRIENT(S) AFFECTED
Nitrogen	Potassium, Calcium
Potassium	Nitrogen, Calcium, Magnesium
Phosphorus	Zinc, Iron, Copper
Calcium	Boron, Magnesium, Phosphorus
Magnesium	Calcium, Potassium
Iron	Manganese
Manganese	Iron, Molybdenum, Magnesium
Copper	Molybdenum, Iron, Manganese, Zinc
Zinc	Iron, Manganese
Molybdenum	Copper, Iron
Sodium	Potassium, Calcium, Magnesium
Aluminum	Phosphorus
Ammonium Ion	Calcium, Copper
Sulfur	Molybdenum

Insect, weeds, disease control







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Lessons Learned: Irrigation

- 75-80% of total annual hop water use occurs after mid-June
- Greatest daily amounts late July-early August
- Majority of roots are in top 4'
- Hops usually extract 50-60% from top 2', but can extract water from 8' or below
- Overall use around 30 inches/year, depends on season
- $-right size your well, different zones for different cultivars

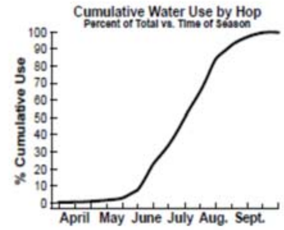


Fig. 1. Cumulative water use of hop during the growing season.

Evans, R. 2003. Hop Management in water short periods. EM4816. WSU Extension Bulletin

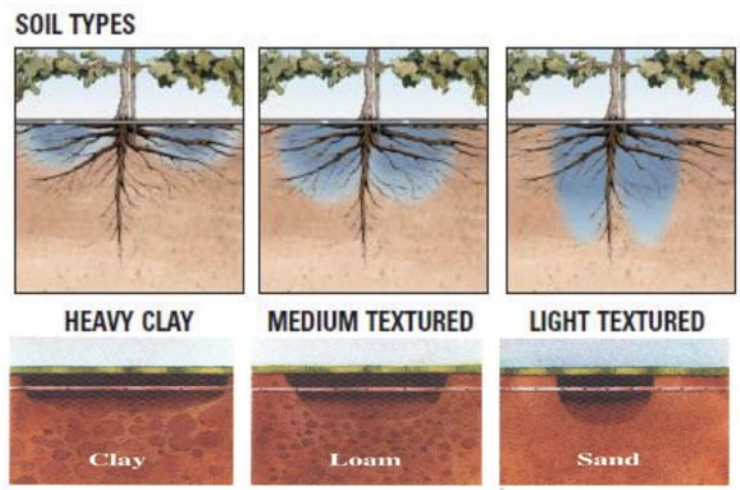
Why Irrigate?

- Ability to apply water when, where, and in the amounts necessary to satisfy the needs of the hop plant
- Ability to most economically and efficiently apply nutrients; spoon feed
- More uniform, successful and rapid plant establishment and growth
- Significant yield increases of greater than 20% vs. unirrigated. (20% is considered a low number)
- Increase of Alpha acids vs. unirrigated

▲ Growth @ 12 months from planting

Trickl-eez Company - Chris Lattak

How does water move in the soil?



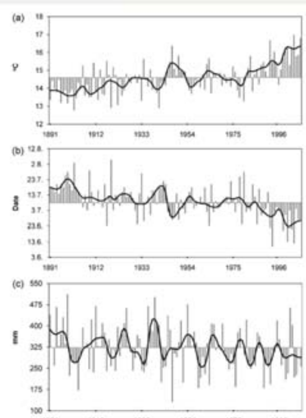


Fig. 2. (a) Average air temperature of the Czech hop cultivation area for the summer half-year (April–September) in the period 1891–2006. Bars indicate deviations from the average value and 4253H filter has been used to show the underlying trend. (b) The beginning of flowering of Saaz hops in the Czech hop cultivation area in the period 1891–2006. Bars indicate deviations from the average value and 4253H filter has been used to show the underlying trend. (c) Seasonal (April–September) precipitation totals in the Czech hop cultivation area in the period 1891–2006. Bars indicate deviations from the average value and 4253H filter has been used to show the underlying trend.

Mozny et al. 2009. The impact of climate change on the yield and quality of Saaz hops in the Czech Republic. Agricultural and Forest Meteorology 149: 913-919.

- The impact of climate change on the production and quality of hops Humulus lupulus will depend on future weather conditions in the growing season. Our simulations suggest that hops will be particularly vulnerable to a change in climate. Even with the modest warming so far experienced yields have stagnated and quality declined. Recorded observations show an increase in air temperature which is associated with an earlier onset of hop phenological phases and a shortening of the vegetation period. Simulations using future climate predict a decline in both yields, of up to 7–10%, and a-acid content, of up to 13–32%, the latter a major determinant of quality. The concentration of hop cultivation in a comparatively small region in the Czech Republic makes it more vulnerable than if the crop were grown in more areas with different climates. Thus climate change may gradually lead to changes in the regionalization of hop production. Policy assistance may be necessary for the adaptation of the Czech hop growing industry to changed climatic conditions.

End of July

- Floral Production has commenced
  - Plant shifts energy into cone production
  - Vegetative production is diminished
  - Photosynthetic capacity of the plant is maximized
  - By time cones matures they can account for up to 50% of the total above ground dry matter
  - Cannot increase cone numbers
  - Focus on: plant health to maximize cone weight and resin/oil content
  - Water management-July-August most of H2O
  - Nutrient management- reduce N, add K

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Removing the guesswork

AlphaAnalytics

Harvest Package $50

- Combining Brewing Values (alpha acids, beta acids, and hop storage index (H.S.I.)) and Dry Matter analysis, the Harvest Package is designed with hop farmers in mind.
- Results provide growers with content and characteristics of their hops and/or fields and can be utilized on an annual basis to establish trends within a given hop variety or lot location.
- Prior to harvest, these results specifically equip growers with the necessary information to plan peak harvest windows and make informed decisions regarding alpha content, hop cone maturity and overall hop quality.
- Require a 200g sample and a minimum 1 day turnaround

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Preparation for Dormancy (September)

- Harvest!!!!!
- Vines cut (bottom then top)
- Laid down into trailer
- Taken to picking machine
- Cones dried for 8-12 hours (10% moisture)
- Dried cones cooled 12-24 hours
- Cold storage

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Lesson: Harvest Timing Variety Dependent

Hops are harvested upon reaching the "technical ripeness" (highest brewing value), not at full or "physiological" maturity. **Each variety has its own specific, genetically determined optimal time of harvest. Varies by the weather, location, biological window, and the cutting time.**

Harvest time crucially affects:
- α-acid contents
- yield
- external quality (color and shine, infection with diseases and pests, shattering)
- aroma (aroma intensity, oil content and composition)
- vigor and vitality of the plant (in the next season)

↓

Economic interest of hop growers, traders and brewers

Results from harvest time studies
- 5 – 8 harvest times (2 dates / week), 4 replications with 20 bines each
- 3- 4-year-trials (climate, health and vitality)
- data for yield, α-acid contents, aroma, external quality, shortcomings assessed

Lutz et al. 2009. The Right Time to Harvest Optimal Yield and Quality. Bav. State Research Center for Agriculture. Institute for Crop Science and Plant Breeding Hop Research Center Hüll

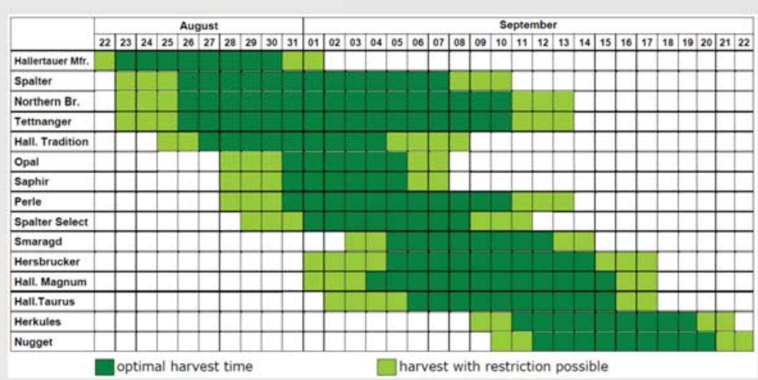
LfL Pflanzenbau

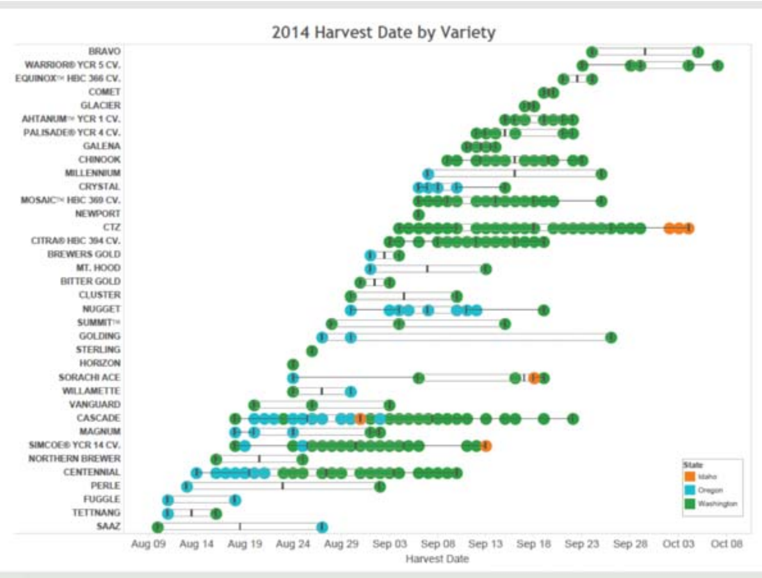
Bav. State Research Center for Agriculture

Institute for Crop Science and Plant Breeding
Hop Research Center Hüll

The Right Time to Harvest Optimal Yield and Quality

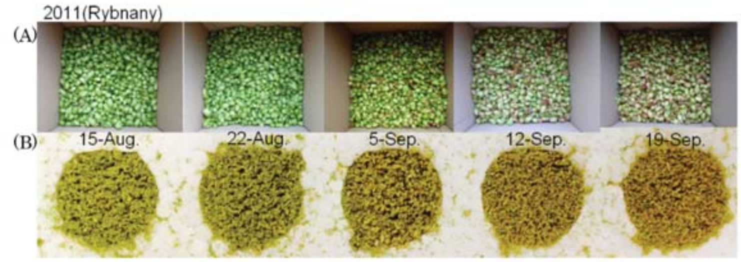
A. Lutz, J. Kneidl, E. Seigner, and K. Kammhuber



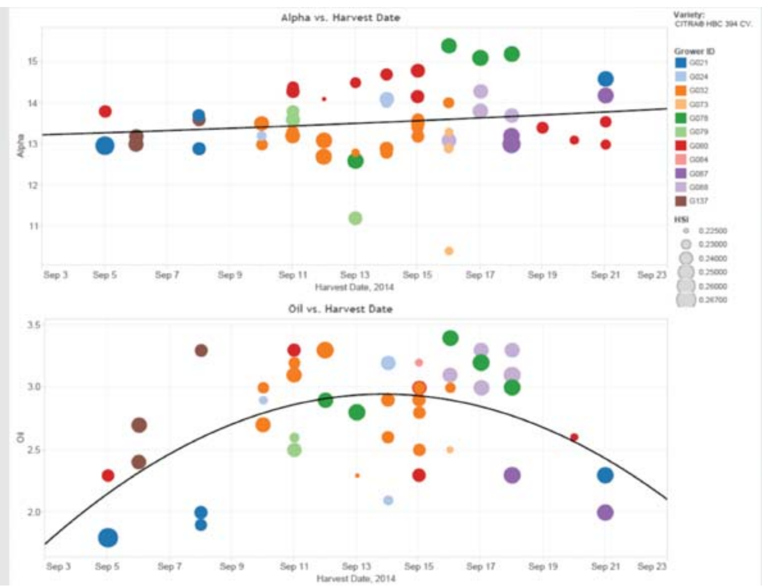


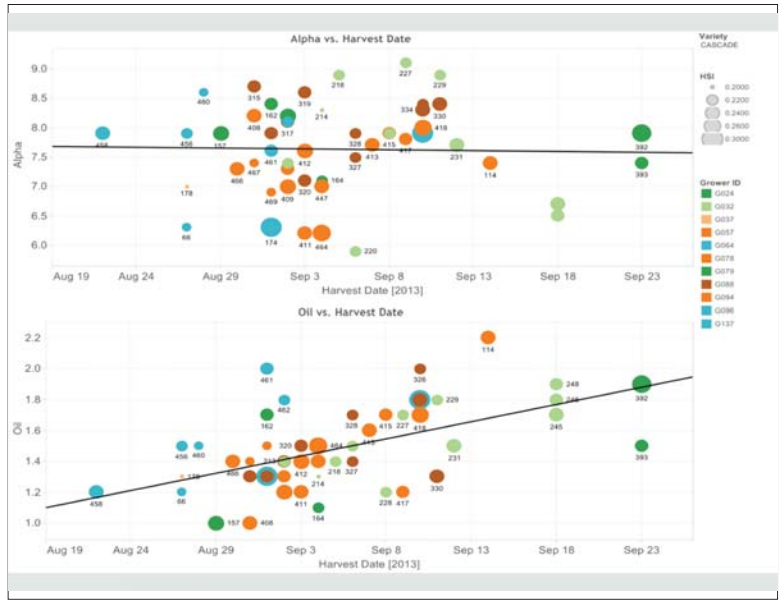
Physiological ripening

H. Matsui et al. / Food Chemistry 202 (2016) 15–22

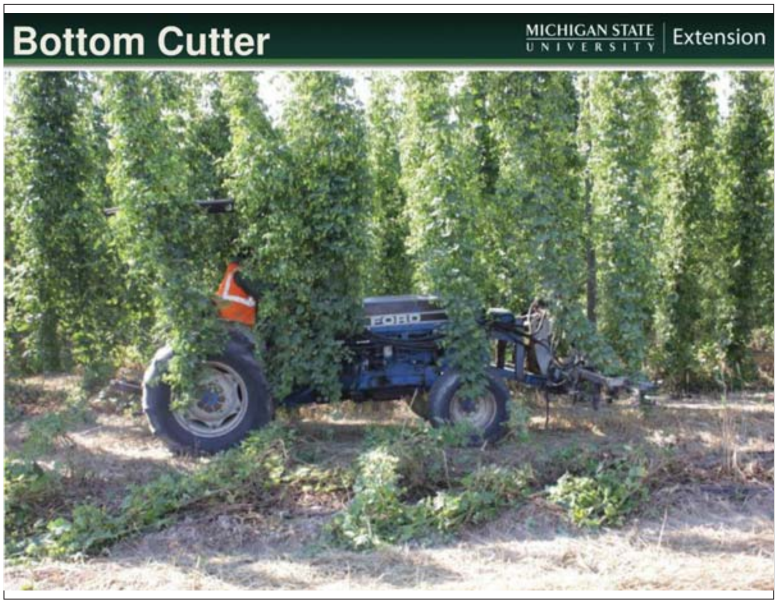


Appearance of hop, according to its harvest date. Raw hop cones (A), ground hop cones (B).





By Hand


Bottom Cutter
MICHIGAN STATE UNIVERSITY
Extension
FORD


MICHIGAN STATE UNIVERSITY
Extension
Top Cutter


MICHIGAN STATE UNIVERSITY
Extension


hopheadfarms
Berrien Springs, Michigan >

Lessons Learned: Transport to the Picker

Degradation potential

- Distance?
- Humidity level?
- Time of harvest (early a.m. or noon)?
- Temperature at harvest?
- Cost

In terms of the drying process picked hop cones can be regarded as a living organism whose basic life processes, particularly respiration, are continuing. They first react to being removed from the plant by a higher intensity of respiration. Rybacek, 1991.

Picking

Considerations

- Acreage
- Speed (bines/hour)
- Drying capacity
- Pelletizing capacity
- Storage
- $$$
- Varieties
- Scheduling!!

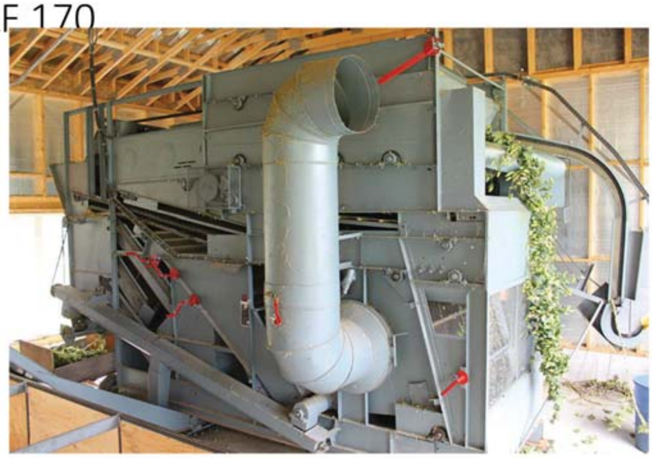
http://brewpublic.com/brewpubs/in-hop-pursuit/

Lessons Learned: Hop Picking Capacity

Picker	bines/hour	total
• 140	140	15a
• 170	170	20a
• 220/230	220	32a
• WHE 513	500	80-100a
• WSZ 1000	800-1150	
• Danhauer	1.5 acres	a lot

513 video

WOLF 170



WOLF 280, + automation panel $75k+
Louvered dryer- used $20K
Baler - used $15K
Buskirk pelletizer $80K
Pole barn $80K+

200 ac + other growers
30,000 sq ft. harvest facility (2 WOLF 1000s)
15,000 sq ft. processing center and cold storage

VI. Drying

The drying process is affected by many factors and lasts 5-8 h or more.

It is regarded as the most important operation in the harvesting process.

1. air velocity
2. air moisture content
3. bed depth
4. air temperature

Factors that influence drying

1. air velocity
2. air moisture content
3. bed depth
4. air temperature

Contribute to the effectiveness of drying and the resulting aromatic, physical, and storing properties of dried hops.

Dryer Types

- Bed
- Louvered

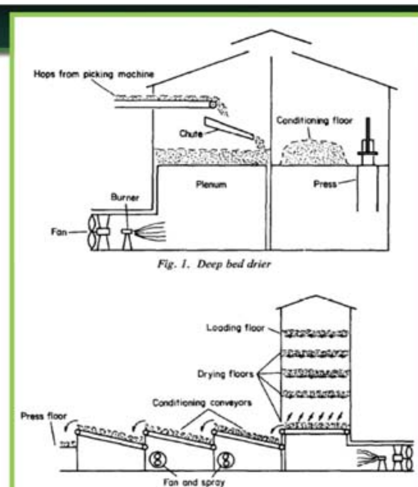


Fig. 1. Deep bed drier

Fig. 2. Falling bed drier

Dryer Types: Bed Dryer

The current practice is to load the whole floor before starting the fan and burner. The hops dry progressively from the bottom of the bed to the top in around 8-12 hours.

www.hoppris.com

Louvered, multilevel Hop Dryers

- Louvered Dryers are exceptional space savers and easy to use.
- The drying process typically takes place on three levels, on two shelves and in louvered drawer.

Indicators of overheating

- If heated properly, lupulin remains lemon yellow.
- Too hot- lupulin color changes to brown
- This indicator has a direct relationship with the hop chemical content
- Eg. Chemical analysis will show that hi-temps= greater content of hard resins = reduced quality

The effect of kilning air temperature on hop essential oil content and aroma

Presenter: Thomas P. Nielsen, Sierra Nevada Brewing Co., Chico, CA
Coauthors: Val Peacock, Hop Solutions, Inc., Edwardsville, IL; Scott Garden, John I. Haas, Yakima, WA; Patrick Smith, Loftus Ranches, Moxee, WA

2013 MBAA Conference

- Presented results of 2012 Hop drying study conducted in Yakima
- Funded by HQG and John I. Haas
- Compared drying temps of 130 F vs. 150 F
- Citra and Cascade hops
- Sampled top, middle, and bottom of the beds in 3 different locations in each kiln

Citra® - Haas Golding Farm

Bed Depth 26 inches

130° F Moisture Data

	Bottom Avg.	Middle Avg.	Top Avg.
Kiln #7	7.80%	13.66%	21.70%
Kiln #9	5.99%	10.39%	18.09%
Kiln #11	4.76%	8.66%	20.10%
Avg	6.18%	10.90%	19.96%

150° F Moisture Data

	Bottom Avg.	Middle Avg.	Top Avg
Kiln #8	7.47%	11.83%	24.13%
Kiln #10	3.51%	3.20%	12.39%
Kiln #12	2.96%	6.39%	19.36%
Avg	4.65%	7.14%	18.63%

- *The interdependence of picking and drying* is very difficult to accommodate, it requires a matched efficiency and similar operation rate of both parts.
- The efficiency of the whole centre depends on the drier, which influences the other components.

Rybacek, V. (ed). 1991. Developments in crop science 16: Hop Production. Elsevier. Amsterdam.

- Matched to the WHE-513, 30-40 Ha
- 180-360kg/per drawer
- Each drying cycle about 4 hours
- Two yr, 2 phased project ~$3 million dollars

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Lessons Learned: Conditioning

Considerations
- Throughput and timing
- Space requirements
- Humidity

- “the hops are left in these heaps for 12 hours in a staged process known as “conditioning”.
- The heaps are re-piled for a further 12 hours across the floor in which time the moisture level continues to equilibrate to ensure consistency across the kiln prior to baling.
- Target moisture level for our hops is around 9.5 % (+/- 1 %) which requires a high level of patience and skill to achieve.
- The hops pictured here are Cascades on the kiln floor at Machops in Motueka and are a beautiful sample.”

Baling

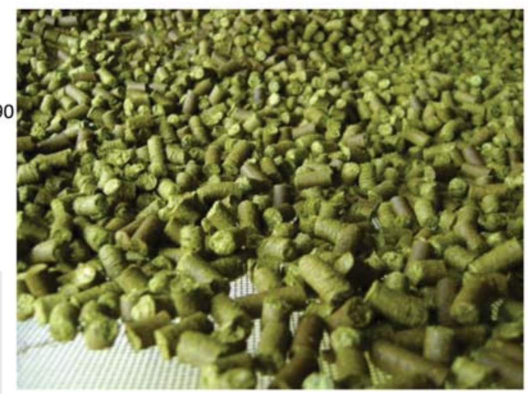
Considerations
- Timing
- Quantity of hops
- Size
- $$ baler
- Storage
- Transport

Mechanical German RB-60 Presses / Balers

“Whole leaf hops are voluminous, but turning them into a bale makes them more compact and stackable, and overall easier to store. It also cuts down on oxidation, which affects brewing quality.”

Pelletizing

Considerations
- Temperature
- Time
- Final product (eg. t-90 or t-45)
- Machine type
- Machine $$
- Facility



- pellets- preferred storage method
- increased density- less surface area exposed to oxygen

Pelletizing Lesson: Throughput efficiency

- Michigan Hop Alliance
- Buskirk-75 lbs/hour

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- New Buskirk
- Capacity-600 lbs/hour

- Lawson Mills
- 800-1000 lbs/hour
- Max- 50 C / 120 F
- Cool Die Press
- Bagging and packaging is what slows things down
- $50,000+

Global Cold Chain Alliance

- Optimum storage temp. is 24 to 28°F (-4.44 to -2.22°C) at a relative humidity of 70 to 85% relative humidity, with little air movement to prevent excessive drying.
- Sufficient space should be allowed around the bales for ventilation, so that any heat generated in the bale may be dissipated.
- This is particularly important immediately after baling."

http://www.gcca.org/wp-content/uploads/2012/09/Hops.pdf

Hop Analysis Services

Harvest Package $50

- Combining Brewing Values and Dry Matter analysis

Hop Profile Package $130

- Combining Brewing Values, Oil Content and Volatile Oil Profile analyses, this package is designed to help customers determine the alpha acids, beta acids, hop storage index and oil content of their hops.

Brewing Values $35

- Alpha acids, beta acids, and hop storage index (H.S.I.) values

Dry Matters $20

- Dry matter analysis provides growers with the necessary information to forecast peak harvest windows based on hop cone maturity

Oil Content $20

- Provides a value for the volume of oil in a hop sample

Volatile Oil Profile $100

- Volatile Oil Profile provides a specific value for the most important oil compounds

Packaging and Storage

Considerations

- Oxygen and Photosensitivity
  - Hops are photosensitive and, therefore, long exposure to light changes their biochemical structure as is shown by a typical red-brown colour, which is commercially undesirable.
- Package size and quality
  - 3-ply Al-folium bags under inert N2 atmosphere-vacuum sealed
- Cold storage-YES

Packaging

- Pellets are packed in laminated foils with an aluminium layer as a barrier against diffusion of oxygen
- Sealed under inert gas and/or vacuum packed
- Foil material used meets all food industry packaging regulations.
- Residual oxygen content in the foil packs is < 2% by volume
- Pack sizes are available from 1 kg to 500 kg

Crosby Hop Farm LLC
Mylar utilizing our MTEK CORR-VAC
Double Nitrogen flush
Soft or hardpack depending on customer stored 26 degrees

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Cold Storage

- For AB-This freezer keeps the hops stored within at a constant 18-26 degrees Fahrenheit at a 70% relative humidity.

http://www.fwwarehousing.com/divisions/5/cold-storage.html

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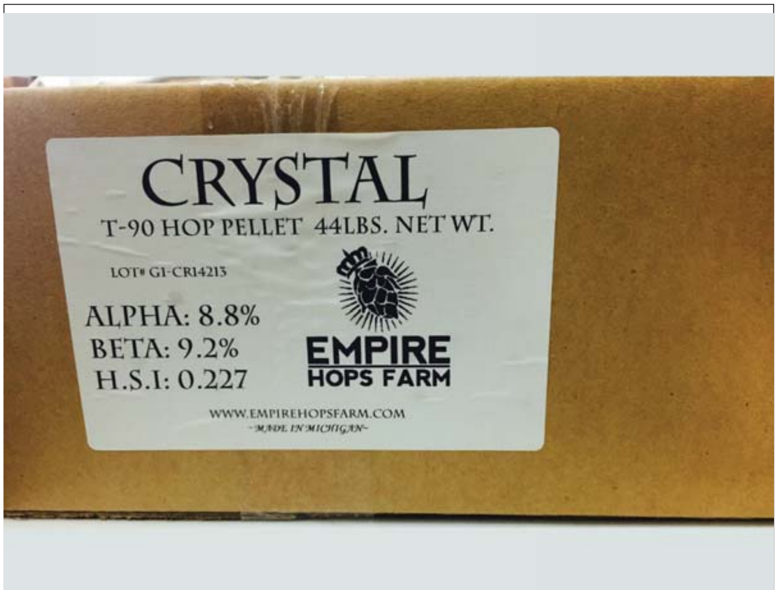
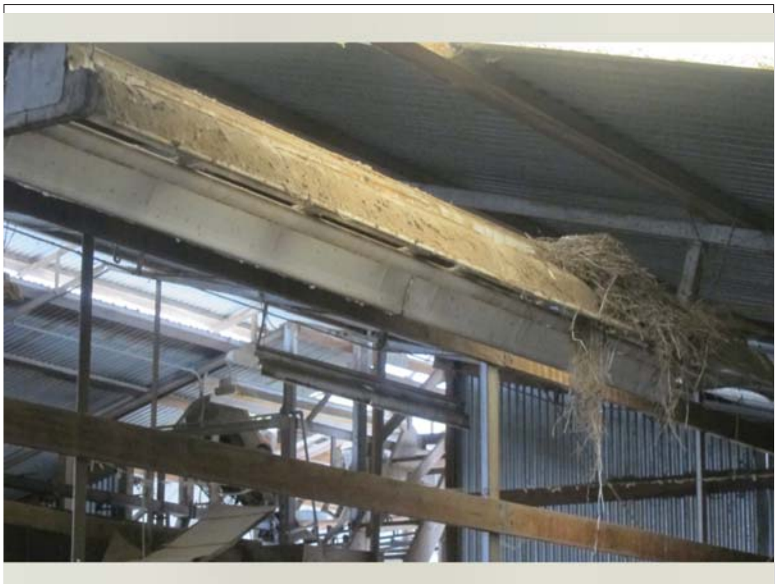
What information will a brewer want to know?

- Lot number (variety/location)
- Lot weight of bales
- Weight of finished pellets (% loss)
- AA% (of bales AND pellets)
- BA% (of bales AND pellets)
- Moisture (of bales AND pellets)
- HSI (of bales AND pellets)
- Pellet die and screen size used
- Pellet density (lbs. / cubic foot)
- Oxygen content
- Pellet temperature
- Essential oils?


CRYSTAL
T-90 HOP PELLET 44LBS. NET WT.
LOT# GI-CR14213
ALPHA: 8.8%
BETA: 9.2%
H.S.I: 0.227
EMPIRE
HOPS FARM
WWW.EMPIREHOPSFARM.COM
~MADE IN MICHIGAN~


• Hops are a food product
• Authorized personnel only
• Protective clothing must be worn if in contact with hops
• El lúpulo es un producto alimenticio
• Solo personal autorizado
• Ropa de protección deben ser usados en caso de contacto con lúpulo
Perrault Farms, Inc.



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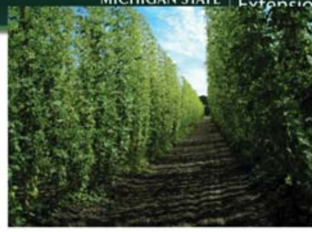
ROY FARMS, INC

MOXEE WA USA



Are Roy Farms hops traceable back to field origin and chemical treatment?

Absolutely!

Back about 10 years ago it became apparent that brewers wanted to know more about food safety issues related to their hops—what chemicals had been applied, how close to harvest they had been applied and more.

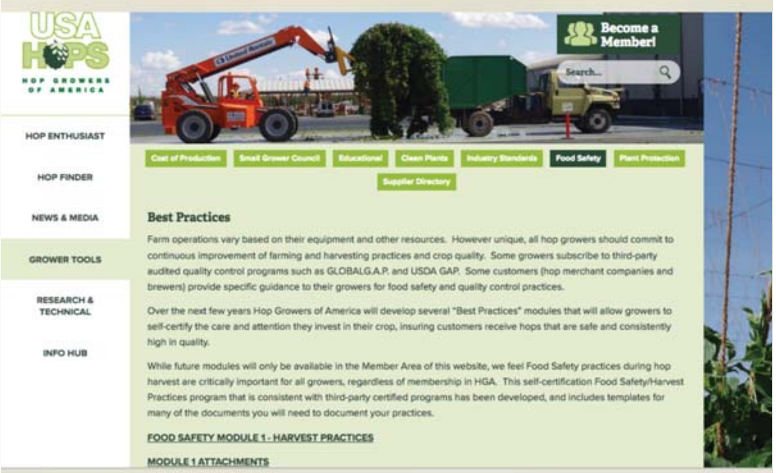
Traceability and food safety concerns (and data gathering) do not end at harvest, our attention to data gathering and reporting are core elements of assigning harvested crop to inventory and logistical planning for sales.

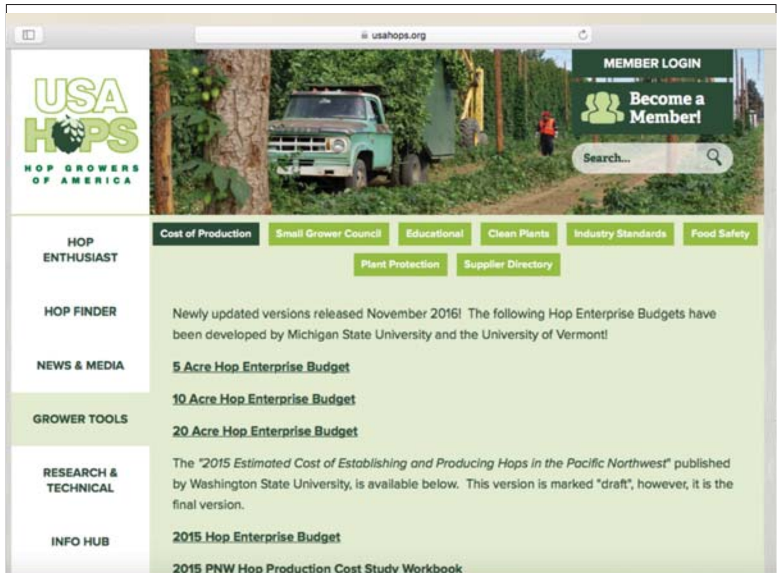
GLOBALG.A.P. OTCO USDA ORGANIC K SALMON SAFE

HOP GROWERS OF MICHIGAN EST. 2014

2016 MDARD Specialty Crop Block Grant. Hop Quality Improvement, Training and Verification Program. $76,415

GLOBALG.A.P.





Expenses

- Hopyard Infrastructure
- Build-out Labor
- **Equipment**
  - **Grow only?**
  - **Grow, harvest, dry, bale, store?**
  - **Scale?**
- Annual Expenses
  - Field
  - Harvest & Post Harvest
  - Loan
  - Farm Overhead

5 ACRE HOP YARD (GROW ONLY)

Authors: J Robert Sirrine, Michigan State University Extension; Julian Post, University of Vermont

This document is intended to serve as a a tool for producers interested in growing hops. Figures below are estimates based on survey data from small-scale growers in multiple states. Your figures will likely vary; you should add figures that accurately represent your operation. While this document has been vetted by several experts within the hop industry, you may need to add additional rows to account for unintended ommissions.

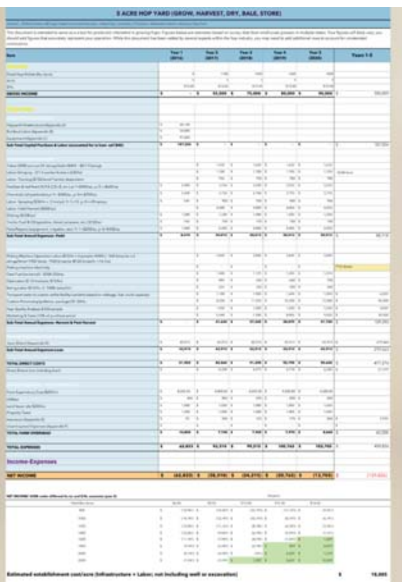
Item	Year 1 (2016)	Year 2 (2017)	Year 3 (2018)	Year 4 (2019)	Year 5 (2020)	Years 1-5
Income						
Dried Hop Pellets (lbs./acre)	0	1100	1500	1600	1800	
acres	5	5	5	5	5	
$/lb.	$ 10	$ 10	$ 10	$ 10	$ 10	
GROSS INCOME	**$ -**	**$ 55,000**	**$ 75,000**	**$ 80,000**	**$ 90,000**	$ 300,000
Expenses						
Capital Purchase/Labor						
Hopyard Infrastructure (Appendix A)	$ 65,146					
Buildout Labor (Appendix B)	$ 24,680					
Equipment (Appendix C)	$ 46,000					
Sub-Total Capital Purchase & Labor (accounted for in loan- cell B41)	**$ 136,026**	**$ -**	**$ -**	**$ -**	**$ -**	$ 136,026
Annual Expenses-Field						
Twine (2400 pre-cut 22' strings/bale-$400. ~$0.17/string)		$ 1,632	$ 1,632	$ 1,632	$ 1,632	
Labor-Stringing -(11.5 worker hrs/ac x $30/hr) $340/ac		$ 1,700	$ 1,700	$ 1,700	$ 1,700	~$340/acre
Labor- Training ($150/acre) *variety dependent		$ 750	$ 750	$ 750	$ 750	
Fertilizer & leaf feed (N,P,K,S,Zn,B, etc.) yr 1~$400/ac, yr 2~~$650/ac	$ 2,000	$ 3,250	$ 3,250	$ 3,250	$ 3,250	
Chemicals (all pesticides) yr 1~ $500/ac, yr 2~~$750/ac	$ 2,500	$ 3,750	$ 3,750	$ 3,750	$ 3,750	
Labor- Spraying ($30/hr x .3 hrs/ac). Yr 1~12, yr 2~~20 sprays	$ 540	$ 900	$ 900	$ 900	$ 900	
Labor- Field Harvest ($800/ac)		$ 4,000	$ 4,000	$ 4,000	$ 4,000	
Disking ($128/ac)	$ 1,280	$ 1,280	$ 1,280	$ 1,280	$ 1,280	
Tractor Fuel & Oil (gasoline, diesel, propane, etc.) $150/ac	$ 750	$ 750	$ 750	$ 750	$ 750	
Parts/Repairs (equipment, irrigation, etc). Yr 1~$200/ac, yr 2~$400/ac	$ 1,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	
Sub-Total Annual Expenses- Field	**$ 8,070**	**$ 20,012**	**$ 20,012**	**$ 20,012**	**$ 20,012**	$ 88,118

		Year 1	Year 2	Year 3	Year 4	Year 5	Total
Annual Expenses-Harvest & Post Harvest							
Transport to custom harvest & processing facility (variable)			$ 2,000	$ 2,250	$ 2,375	$ 2,500	$ 9,125
Harvest/Drying/Baling $3/lb			$ 14,500	$ 22,500	$ 24,000	$ 27,000	$ 90,000
Processing $1.50/lb.			$ 8,250	$ 11,250	$ 12,000	$ 13,500	$ 45,000
Hop Quality Analysis $125/sample			$ 1,250	$ 1,250	$ 1,250	$ 1,250	$ 5,000
Marketing & Sales (10% of purchase price)			$ 5,500	$ 7,500	$ 8,000	$ 9,000	$ 30,000
Sub-Total Annual Expenses -Harvest & Post Harvest		$ -	$ 33,500	$ 44,750	$ 47,625	$ 53,250	$ 179,125
Annual Expenses- Loan (annual payment)							
Loan Detail (Appendix D)		$ 31,938	$ 31,938	$ 31,938	$ 31,938	$ 31,938	$ 159,690
Sub-Total Annual Expenses- Loan		$ 31,938	$ 31,938	$ 31,938	$ 31,938	$ 31,938	$ 159,690
TOTAL DIRECT COSTS		$ 40,000	$ 85,450	$ 96,700	$ 99,575	$ 105,200	$ 426,933
Direct $/acre (not including loan)		$ 1,614	$ 10,702	$ 12,952	$ 13,527	$ 14,652	$ 53,449
Annual Expenses - Farm Overhead							
Farm Supervisory Cost ($20/hr)		$ 4,000.00	$ 4,000.00	$ 4,000.00	$ 400.00	$ 4,000.00	
Utilities		$ 400	$ 800	$ 800	$ 800	$ 800	
Land lease rate $200/ac		$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	
Property Taxes		$ 1,400	$ 1,400	$ 1,400	$ 1,400	$ 1,400	
Insurance (Appendix E)		$ 50	$ 545	$ 725	$ 770	$ 860	$ 2,950
Unanticipated Expenses (Appendix F)		$ -	$ -	$ -	$ -	$ -	$ -
TOTAL FARM OVERHEAD		$ 10,850	$ 7,745	$ 7,925	$ 7,970	$ 8,060	$ 42,550
TOTAL EXPENSES		$ 50,858	$ 93,195	$ 104,625	$ 107,545	$ 113,260	$ 469,483
Income-Expenses							
NET INCOME		$ (50,858)	$ (38,195)	$ (29,625)	$ (27,545)	$ (23,260)	$ (169,483)

Income-Expenses						
NET INCOME	$ (50,858)	$ (38,195)	$ (29,625)	$ (27,545)	$ (23,260)	$ (169,483)

NET INCOME/ ACRE under different lb./ac and $/lb. scenarios (year 5)

Yield (lbs./acre)	Price/lb $6.00	$8.00	$10.00	$12.00	$14.00
800	$ (17,452)	$ (16,252)	$ (14,652)	$ (13,052)	$ (11,452)
1000	$ (16,652)	$ (14,652)	$ (12,652)	$ (10,652)	$ (8,652)
1200	$ (15,452)	$ (13,052)	$ (10,652)	$ (8,252)	$ (5,852)
1400	$ (14,252)	$ (11,452)	$ (8,652)	$ (5,852)	$ (3,052)
1600	$ (13,052)	$ (9,852)	$ (6,652)	$ (3,452)	$ (252)
1800	$ (11,852)	$ (8,252)	$ (4,652)	$ (1,052)	$ 2,548
2000	$ (10,652)	$ (6,652)	$ (2,652)	$ 1,348	$ 5,348
2200	$ (9,452)	$ (5,052)	$ (652)	$ 3,748	$ 8,148



BREWERS ASSOCIATION

www.brewersassociation.org

CRAFT BREWER DEFINITION

AN AMERICAN CRAFT BREWER IS SMALL, INDEPENDENT, AND TRADITIONAL.

SMALL

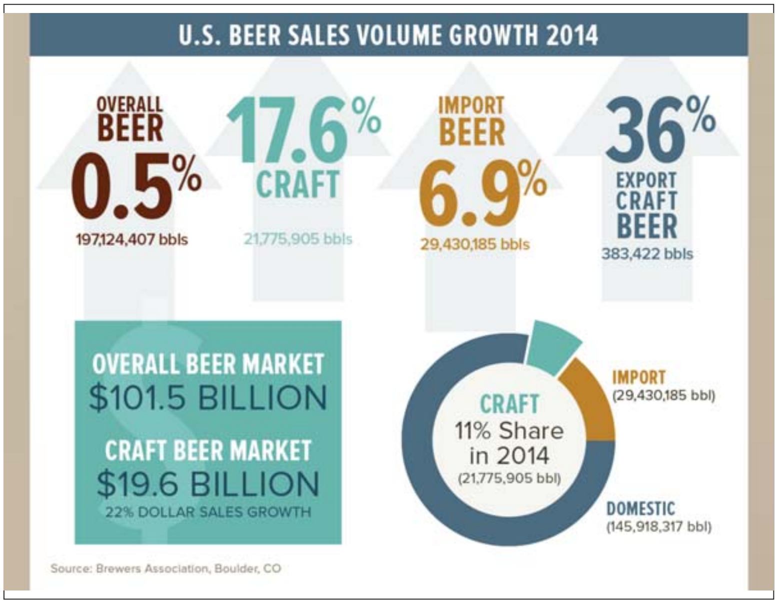
Annual production of 6 million barrels of beer or less (approximately 3 percent of U.S. annual sales). Beer production is attributed to the rules of alternating proprietorships.

INDEPENDENT

Less than 25 percent of the craft brewery is owned or controlled (or equivalent economic interest) by a beverage alcohol industry member that is not itself a craft brewer.

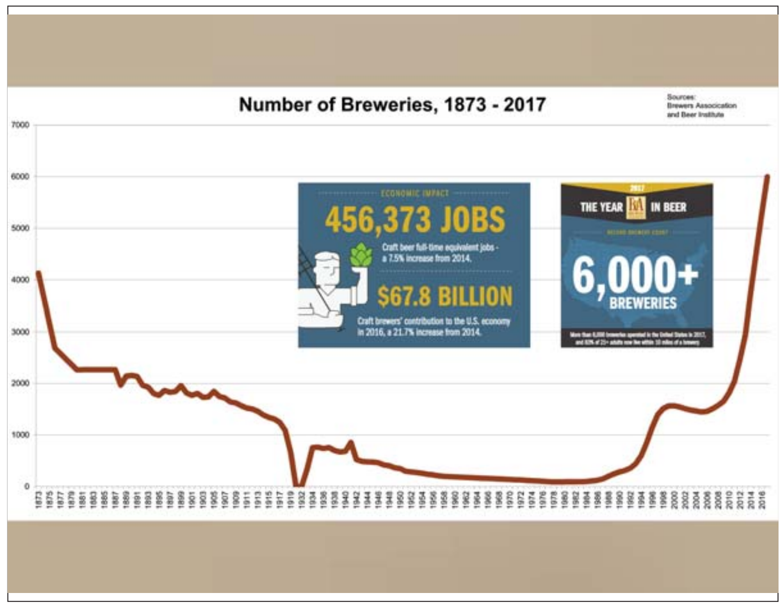
TRADITIONAL

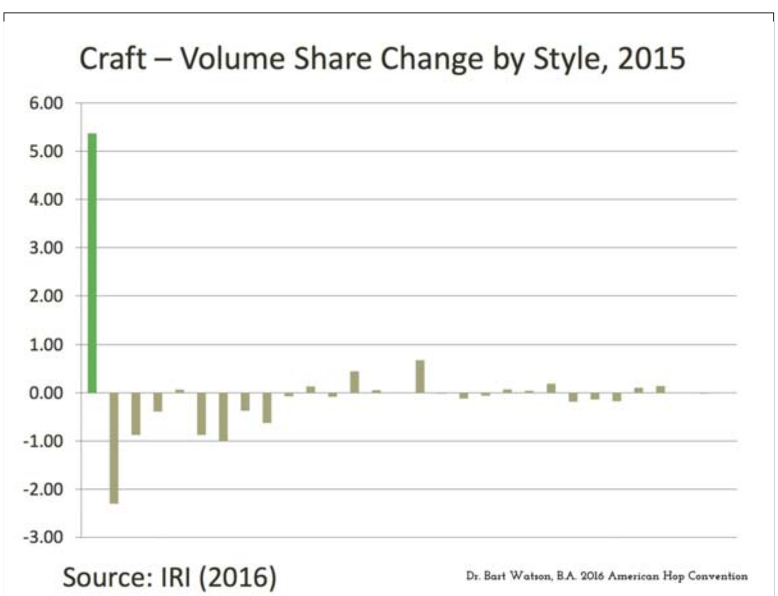
A brewer that has a majority of its total beverage alcohol volume in beers whose flavor derives from traditional or innovative brewing ingredients and their fermentation. Flavored malt beverages (FMBs) are not considered beers.


U.S. BEER SALES VOLUME GROWTH 2014
OVERALL BEER
0.5%
197,124,407 bbls
17.6%
CRAFT
21,775,905 bbls
IMPORT BEER
6.9%
29,430,185 bbls
36%
EXPORT CRAFT BEER
383,422 bbls
OVERALL BEER MARKET
$101.5 BILLION
CRAFT BEER MARKET
$19.6 BILLION
22% DOLLAR SALES GROWTH
CRAFT
11% Share in 2014
(21,775,905 bbl)
IMPORT
(29,430,185 bbl)
DOMESTIC
(145,918,317 bbl)
Source: Brewers Association, Boulder, CO


U.S. BEER SALES VOLUME GROWTH 2015
OVERALL BEER
0.2%
196,701,792 BBLS
12.8%
CRAFT
24,076,864 BBLS
IMPORT BEER
6.2%
31,245,124 BBLS
16.3%
EXPORT CRAFT BEER
446,151 BBLS
OVERALL BEER MARKET
$105.9 BILLION
CRAFT BEER MARKET
$22.3 BILLION
16% DOLLAR SALES GROWTH
CRAFT
12.2% SHARE IN 2015
(24,076,864 BBL)
IMPORT
(31,245,124 BBL)
DOMESTIC
(141,379,804 BBL)
SOURCE: BREWERS ASSOCIATION, BOULDER, CO


U.S. BEER SALES VOLUME GROWTH 2016
OVERALL BEER
0.0%
196,749,624 BBLS
6.2%
CRAFT
24,104,852 BBLS
IMPORT BEER
6.8%
33,366,352 BBLS
4.4%
EXPORT CRAFT BEER
465,617 BBLS
OVERALL BEER MARKET
$107.6 BILLION
CRAFT BEER MARKET
$23.5 BILLION
10% DOLLAR SALES GROWTH
CRAFT
12.3% SHARE IN 2016
(24,104,852 BBLS)
IMPORT
(33,366,352 BBLS)
DOMESTIC
(139,278,420 BBLS)
SOURCE: BREWERS ASSOCIATION, BOULDER, CO

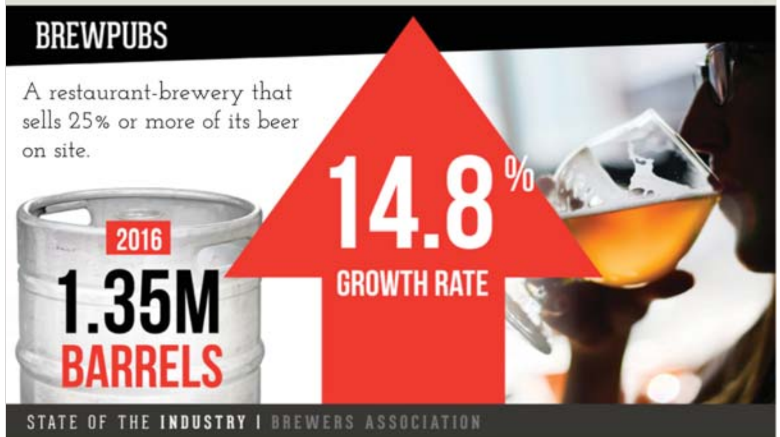

Number of Breweries, 1873 - 2017
Sources: Brewers Association and Beer Institute
7000
6000
5000
4000
3000
2000
1000
0
456,373 JOBS
$67.8 BILLION
THE YEAR IN BEER
6,000+
BREWERIES

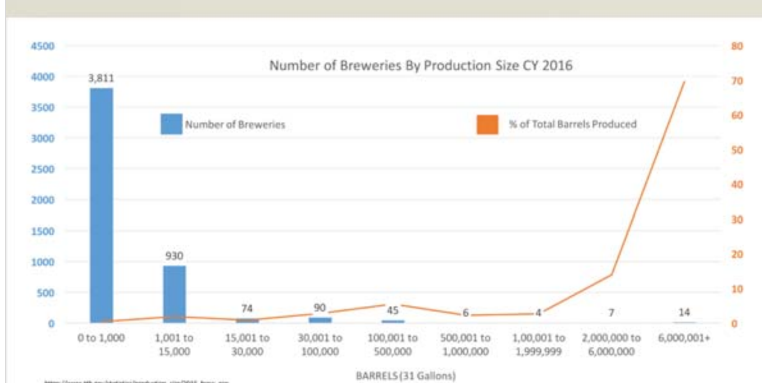

Craft – Volume Share Change by Style, 2015
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
Source: IRI (2016)
Dr. Bart Watson, B.A. 2016 American Hop Convention

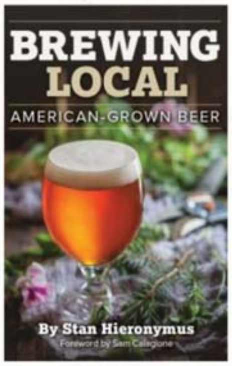

IPA's Rise
IPAs as % of Craft and Overall Beer
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
11.7%
13.9%
17.6%
22.5%
26.5%
29.3%
0.6%
0.8%
1.1%
1.5%
1.9%
2.2%
2012
2013
2014
2015
2016
2017
Craft
All Beer

2017 U.S. Hop Industry Update

- Ttl U.S. acres increased from 52,963 to 55,786 (+5.3%), an all-time high. Non-PACNW acres grew 19% to 2,500
- Ttl U.S. production increased from 88.6 MM to 106.2 MM pounds (19.8% vs CY2016: +10.7%). Non-PACNW production grew 25%.
- Total U.S. yield increased from 1713 to 1959 pounds per acre (14.4%)
- Idaho: ID production surpassed OR as the number 2 U.S. producing state; Mill 95 opened, the first processor and dealer in Idaho







Brewing Local: American-Grown Beer

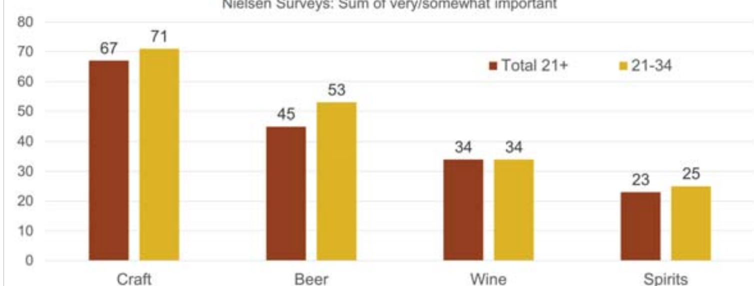
By Stan Hieronymus

Explore Local Flavor Using Cultivated and Foraged Ingredients

Americans have brewed beers using native ingredients since pre-Columbian times, and a new wave of brewers has always been at the forefront of the locavore movement. Brewers use locally-grown, traditional ingredients as well as cultivated and foraged flora to produce beers that capture the essence of the place they were made. In *Brewing Local*, Stan Hieronymus examines the history of how distinctly American beers came about, visits farm breweries, and goes foraging for both plants and yeast to discover how brewers are using novel ingredients to create unique beers. The book introduces brewers and drinkers to the ways herbs, flowers, plants, trees, nuts, and shrubs flavor distinctive beers.

How important is "local" in purchase decisions?

Nielsen Surveys: Sum of very/somewhat important

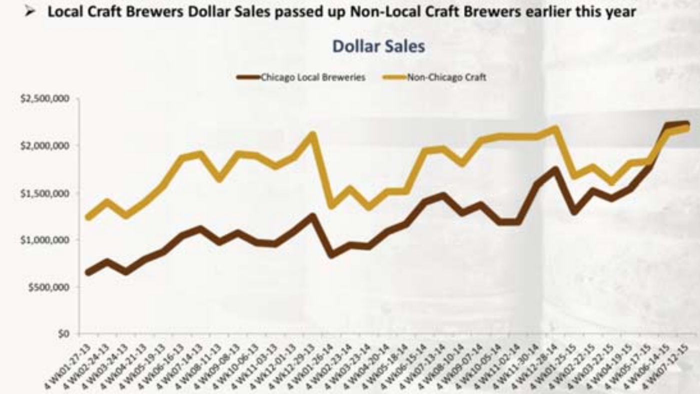


Source: Nielsen Quick Query Omnibus Survey, 12-17, 2015. (Base: LDA consumers who drink at least several times per year)

Local Craft vs Other craft Vendors

Chicago Supermarkets

- **Local Craft Brewers Dollar Sales passed up Non-Local Craft Brewers earlier this year**



Source: IRI InfoScan IRI Chicago, IL FODO Market Quad Weeks Jan 27, 2013 through July 12, 2015

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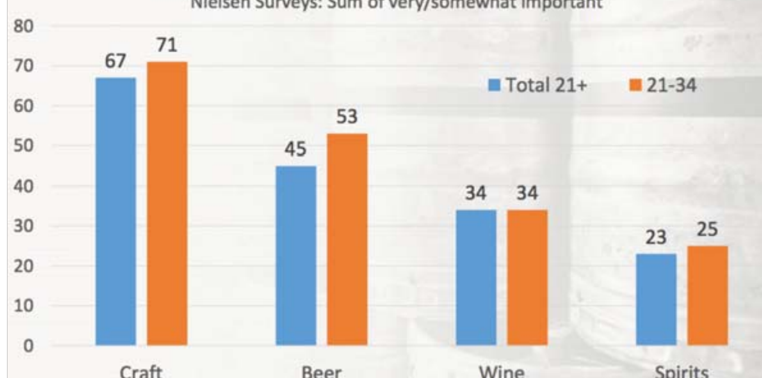


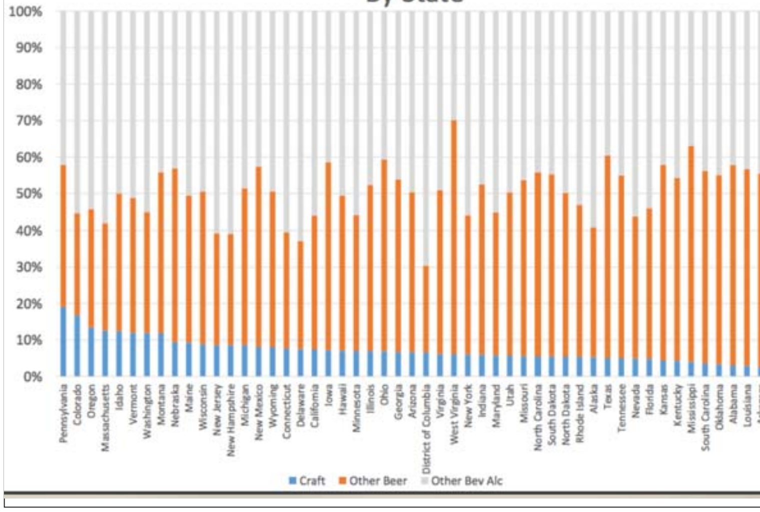
Source: Nielsen Quick Query Omnibus Survey, 12-17, 2015. (Base: LDA consumers who drink at least several times per year)

TTB Permitted Brewery Count
7,180 as of 12/31/2016

State	Count	State	Count	State	Count
Alabama	37	Kentucky	60	North Dakota	15
Alaska	36	Louisiana	**34**	Ohio	236
Arizona	110	Maine	102	Oklahoma	26
Arkansas	34	Maryland	88	Oregon	**304**
California	927	Massachusetts	146	Pennsylvania	333
Colorado	386	Michigan	379	Rhode Island	17
Connecticut	76	Minnesota	165	South Carolina	59
Delaware	25	Mississippi	**14**	South Dakota	21
DC	13	Missouri	116	Tennessee	101
Florida	264	Montana	79	Texas	266
Georgia	69	Nebraska	47	Utah	**34**
Hawaii	23	Nevada	44	Vermont	73
Idaho	67	New Hampshire	73	Virginia	209
Illinois	244	New Jersey	96	Washington	**424**
Indiana	163	New Mexico	86	West Virginia	**24**
Iowa	94	New York	394	Wisconsin	217
Kansas	47	North Carolina	260	Wyoming	33

Source: NBWA and TTB, 2017.

Craft Brewer/Beer Share of Beverage Alcohol By State



Flavor and freshness are essential

How important are each of the following when choosing a craft beer to purchase?

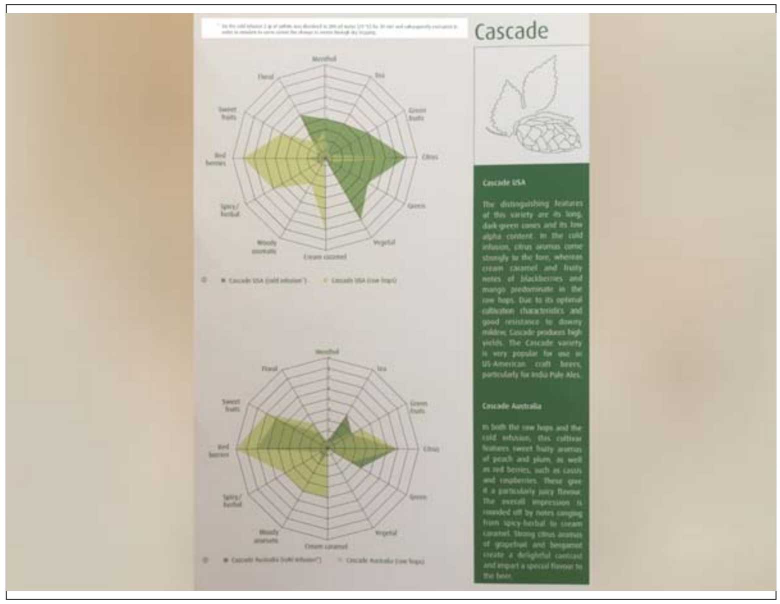
% Craft Beer Drinkers Saying Very/Somewhat Important

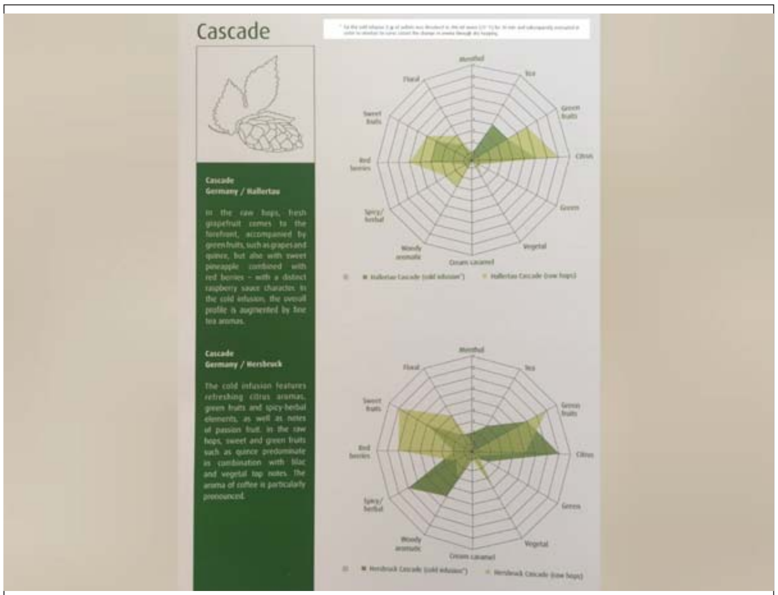
99% FLAVOR

- 95% Freshness
- 78% Aroma
- 75% Ingredients
- 68% Bitterness ⬇
- 63% Appearance ⬆
- 63% Made by Ind Brewer
- 60% Locally Made

⬆⬇ Indicates increase or decrease compared to 2015 survey

Source: Nielsen's Craft Beer Insights Poll (CIP) conducted June 2016 by Harris Poll (n=1,018 Craft Drinkers; n=555 weekly craft drinkers)





Beer Reviews

Luponic Distortion's Newest Features Michigan Hops

By Pat Evans

June 2, 2017

......In contrast to the piney, grapefruit notes Brynildson has imprinted in his head for the Pacific Northwest grown hop, he found more Mandarin orange in the Michigan grown cones. It is a showcase of terroir and how a difference of 2,000 miles can distinctly influence a hop. "I was really blown away, not just in quality but how distinct they were to those grown in the Northwest," he said. "These hops were bordering on tropical, I wasn't familiar with that from Chinooks. It was a pleasant surprise."

He said the Michigan hop emergence is surprising, especially for an "old time" brewer like him, who has long felt the new emerging hop regions might never hold their weight. As hop regions pop up, Brynildson said the first few years might be the most luscious, as hops are nutrient rich, so fresh soil might be best. "It's a legit growing region," Brynildson said of Michigan. "A lot of us, especially old timers, we thought these new hop growing regions weren't going to have a huge impact mostly because of scaling and pricing. But this little experiment changed my mind all together."

https://oct.co/essays/luponic-distortions-newest-features-michigan-hops

Luponic Distortion 006

May 2017 · Sept 2017

Marketing and Sales

- What brewers are looking for
  - Quality *Craft* product
  - Consistent supply
  - Sustainable pricing for them
  - Local relationships with hop farms

Lessons

- Don't skimp on infrastructure-trellis esp.
- Timing is crucial-pruning, training, harvest, etc.
- Irrigation and fertility
- DM control-spray every days-just do it
- You will need a sprayer
- Pest and disease control are imperative
- Transport to picker-distance
- You will need a harvester if you have more than 1/2 acre
- Right size dryer and harvester
- A baler is good to have
- Most if not all brewers want pellets
- Benefits to scale ($1.50/lb to pelletize vs. $0.40 to pelletize)
- Variety choice will be important, and how and where you source plants
- Sales-extremely important, who will you sell to?
- Know your costs (upfront and annual)-enterprise budgets
- Know what brewers want (lot #, quality measures, etc.)
- Food Safety increasingly important
- Opportunities-terroir, local, # of breweries still increasing
- Make connections with state brewers guild
- www.hops.msu.edu
- USA Hops (grower tools)

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