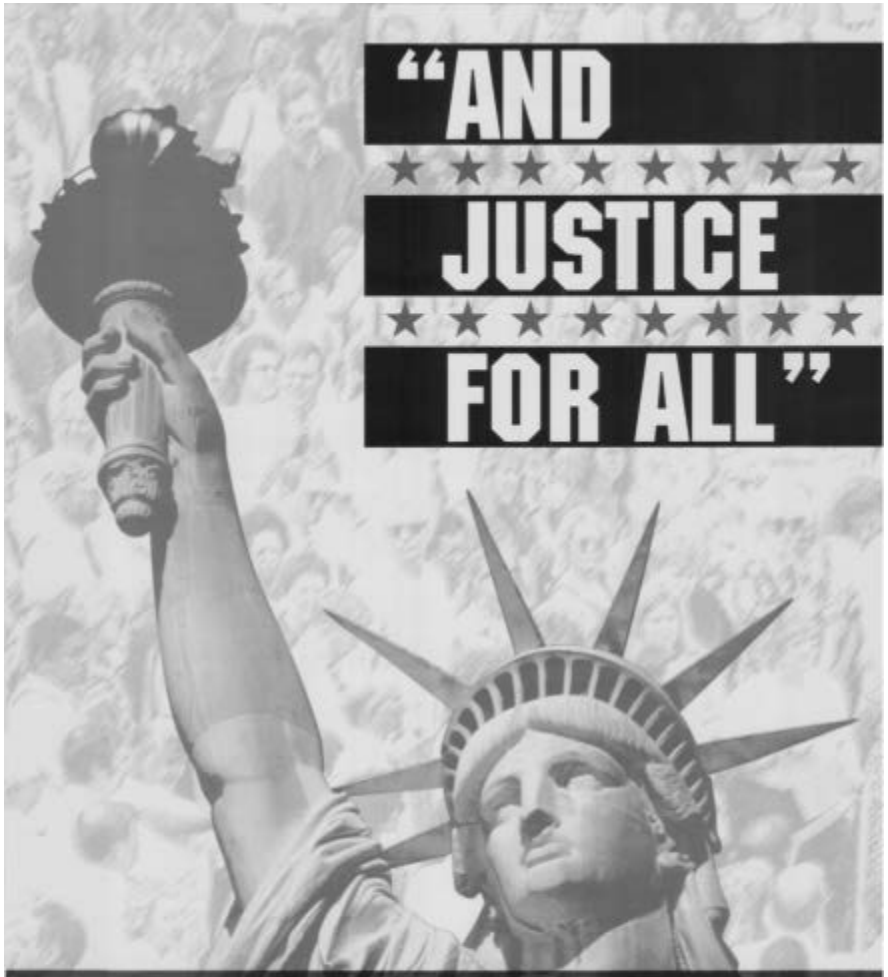

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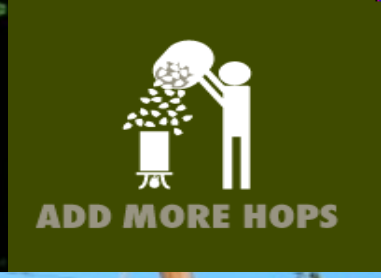
USDA United States Department of Agriculture

Form AD-475-A (revised 9/2006)







Hops Production

Rob Sirrine

Ag Action Day

Kalamazoo, MI

January 29, 2015

MICHIGAN STATE UNIVERSITY | Extension

Outline

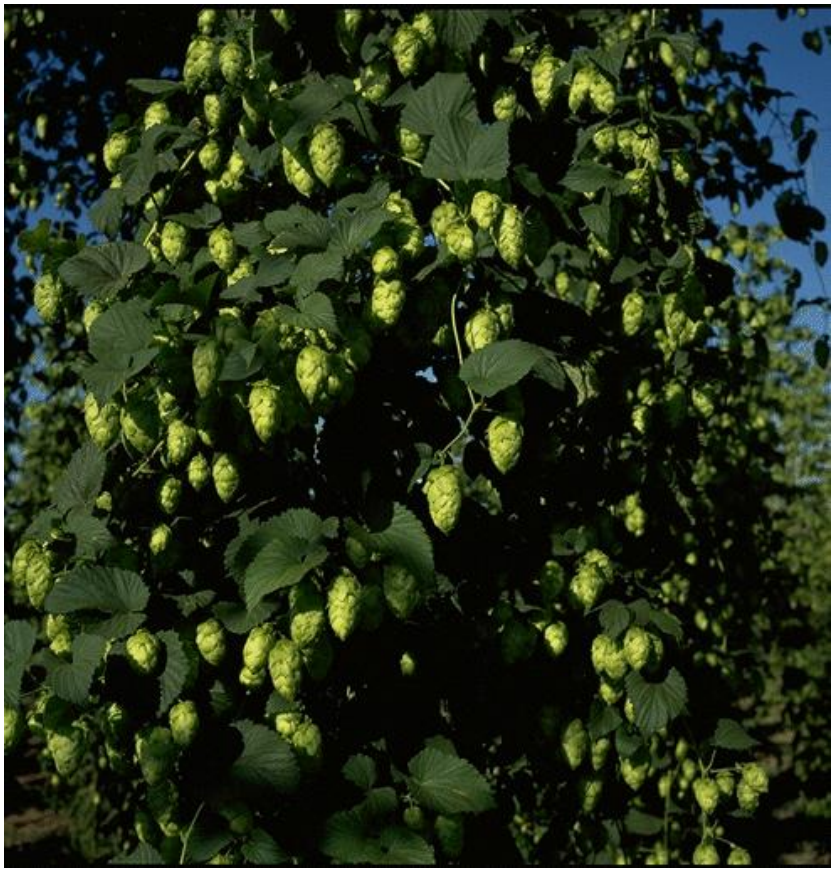
- Taxonomy
- Trellis Setup and Hopyard Design
- Hops: Stages of Production/Processing
- Associated Management Practices
- Market Outlook
- Cost Overview





What are Hops?

- Hops are dieoecious (male and female plants)
- Perennial below ground
- Annual above ground
- Produce annual bines from an overwintering rhizome (below ground stems)







The Cones

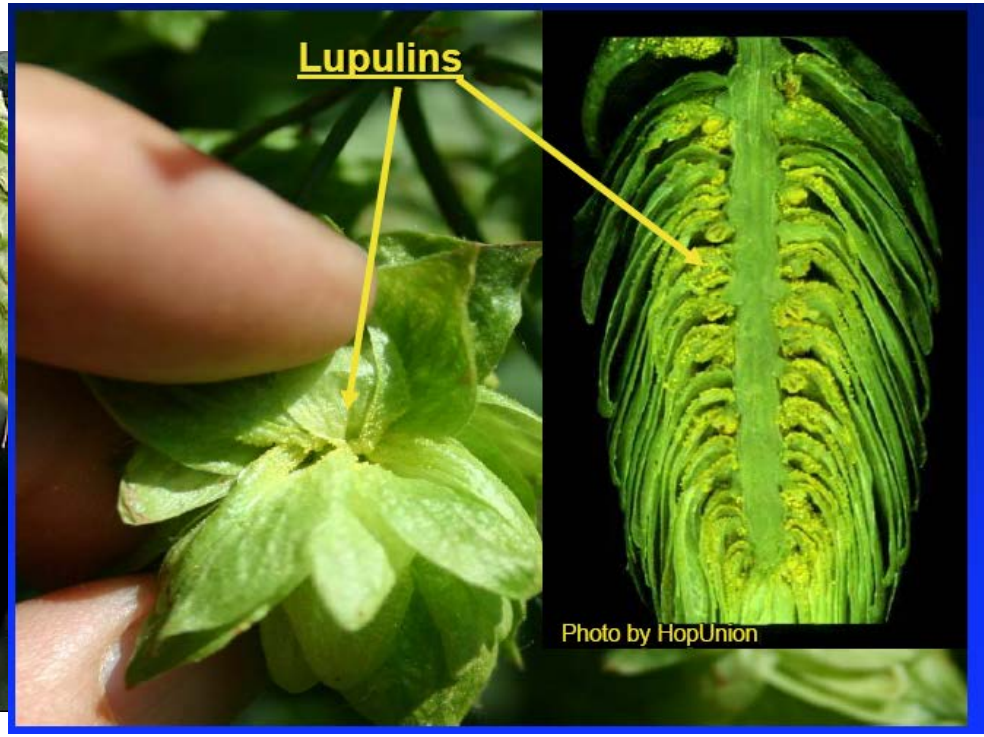
- Only the female flower “strobile” or “cone” is desirable for use in beer production
- Male plant-no real commercial value except in breeding programs
- Cones (0.5-4 in.) light green, papery, contain Lupilin glands (modified vine hairs)
- Glands contain the alpha and beta acids, and essential oils





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, crystal, amarillo,

Brewing

When are hops added?

- On the hot side
  - To the boil (brew kettle)
    - At the beginning (primarily for bitterness)
    - At the end (primarily for aroma)
  - After boiling but right before cooling (just aroma)
- On the cold side (bright tank/secondary tank) – dry hopping
  - Solely for aroma

Hop Value-Chain

Marketing/Sales

Whole cone

Pellets

Hops: Trellis Design

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Climbing bines

- Bine climbs with the aid of "Trichomes"
- In the wild-they climb up companion species
- Commercial production-Requires a trellis system for support
- Typical set-up
  - 18' tall
  - Plants spaced 3' x 14'
  - 1000-1200 plants/acre

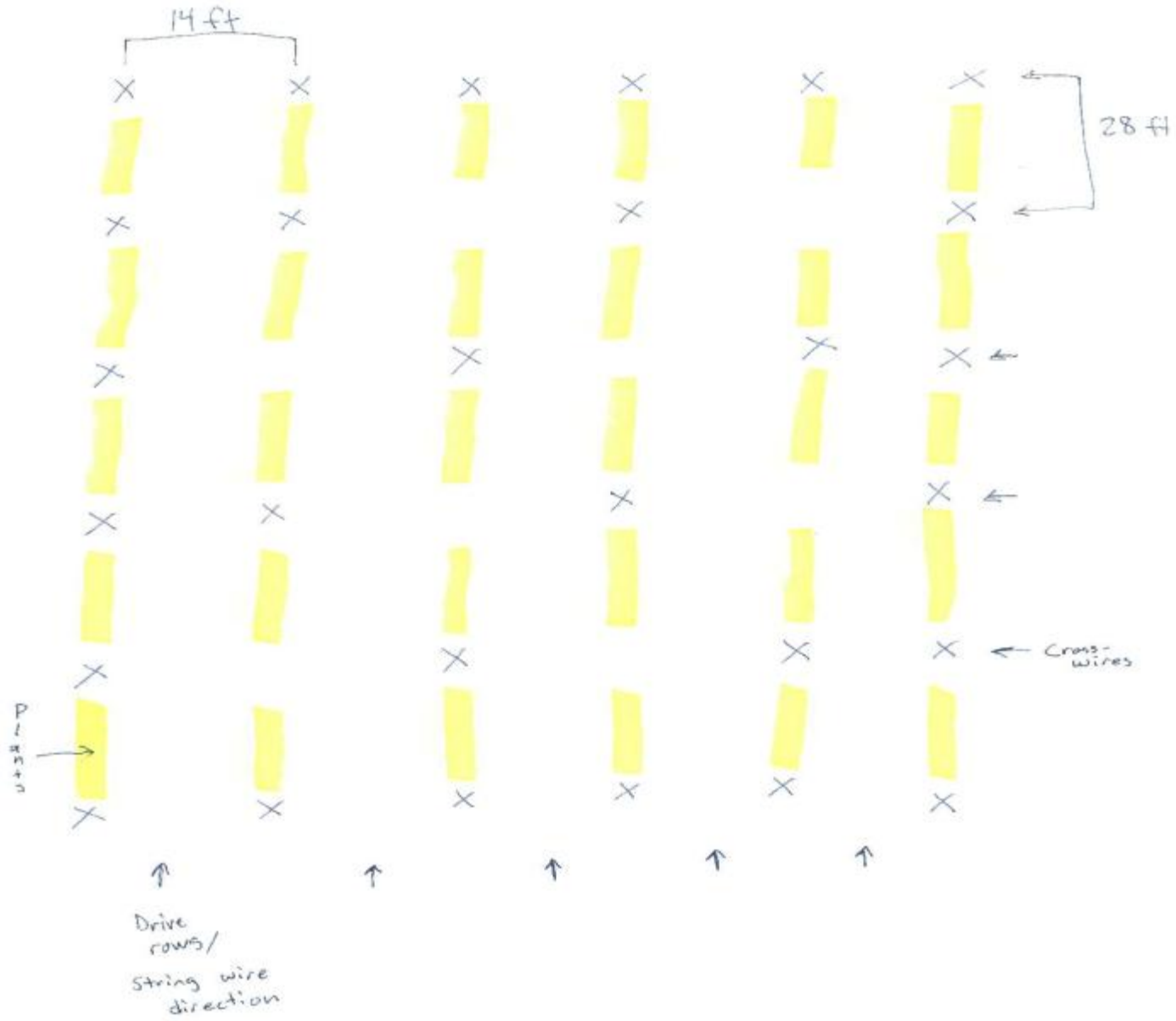
- Vine wraps around string-clockwise-function of phototropism (light) and thigmotropism (touch)

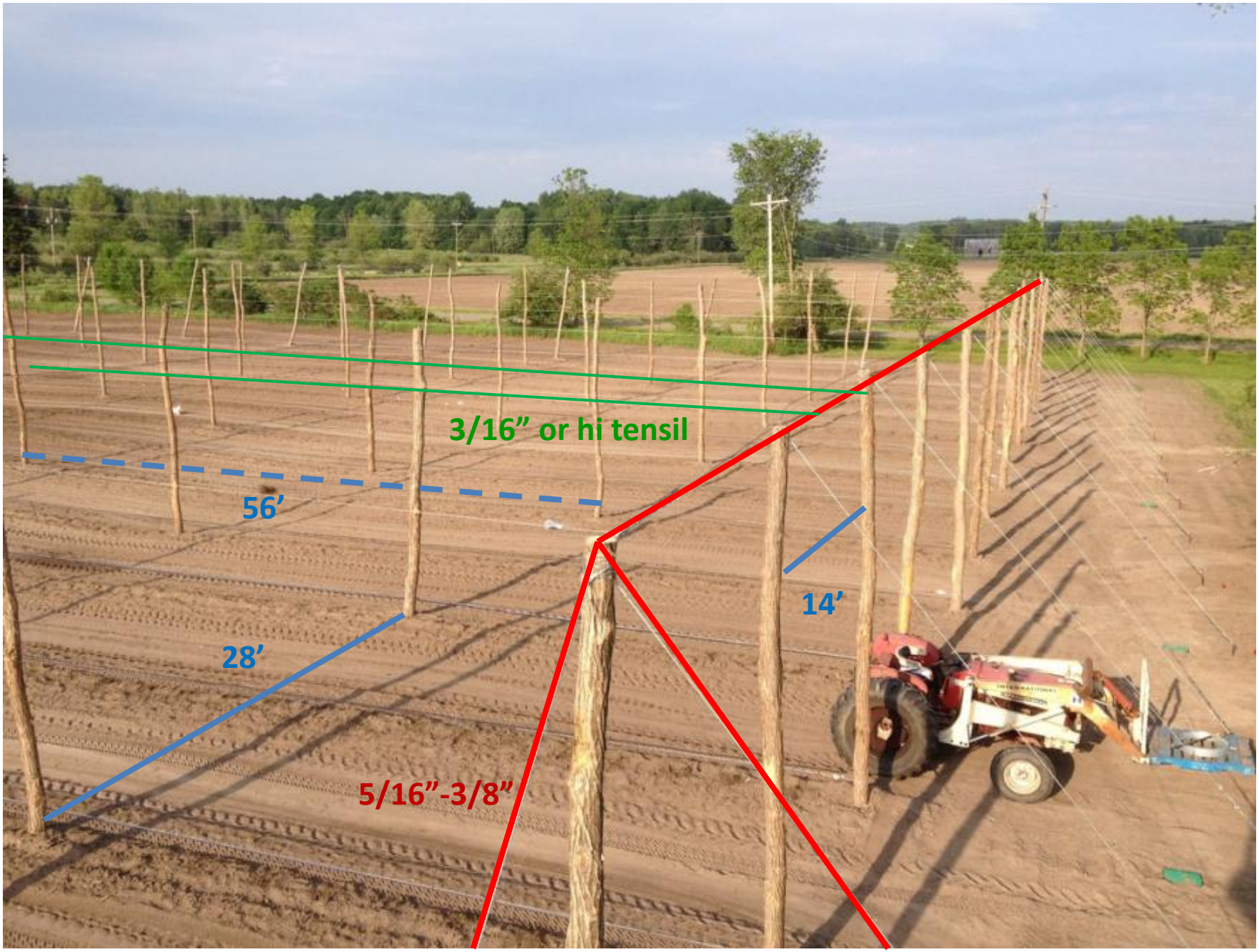
Conventional High Trellis


686GXR

Standard Tall Trellis Hopyard Design

N





Carr creek hops

Important to build a Solid Trellis!!

Short Trellis

- 3’ x 8’, 9’, or 12’
- Labor Reduction
- Lower Establishment Cost
- Lower yields
- Ill-adapted varieties

Alternative Spacing: NZ

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

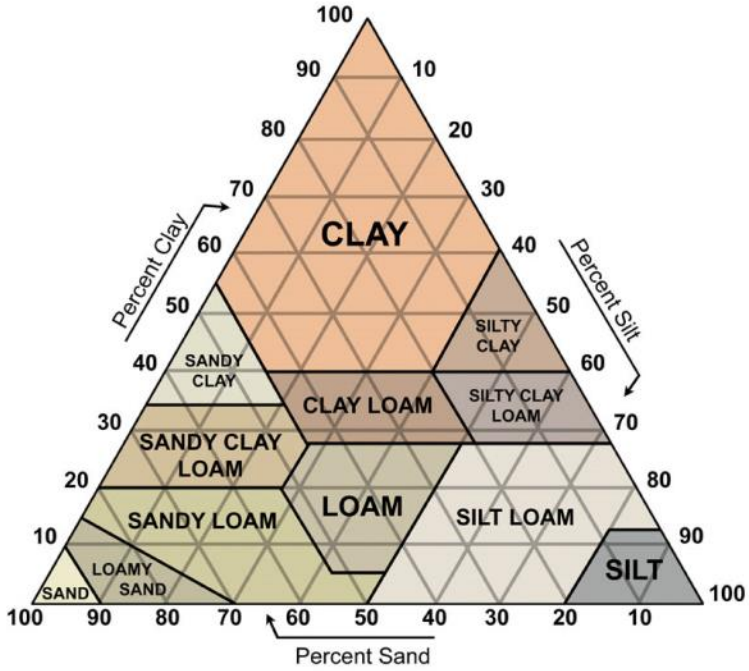
- Environment (temp, day length, soil texture, weather)
- Production Practices
  - Cultivar
  - Soil fertility
  - Disease, pest, and weed pressure and control
  - Training and timing of training
  - Harvest and harvest timing
  - Irrigation
  - Post-harvest processing and storage





Environment

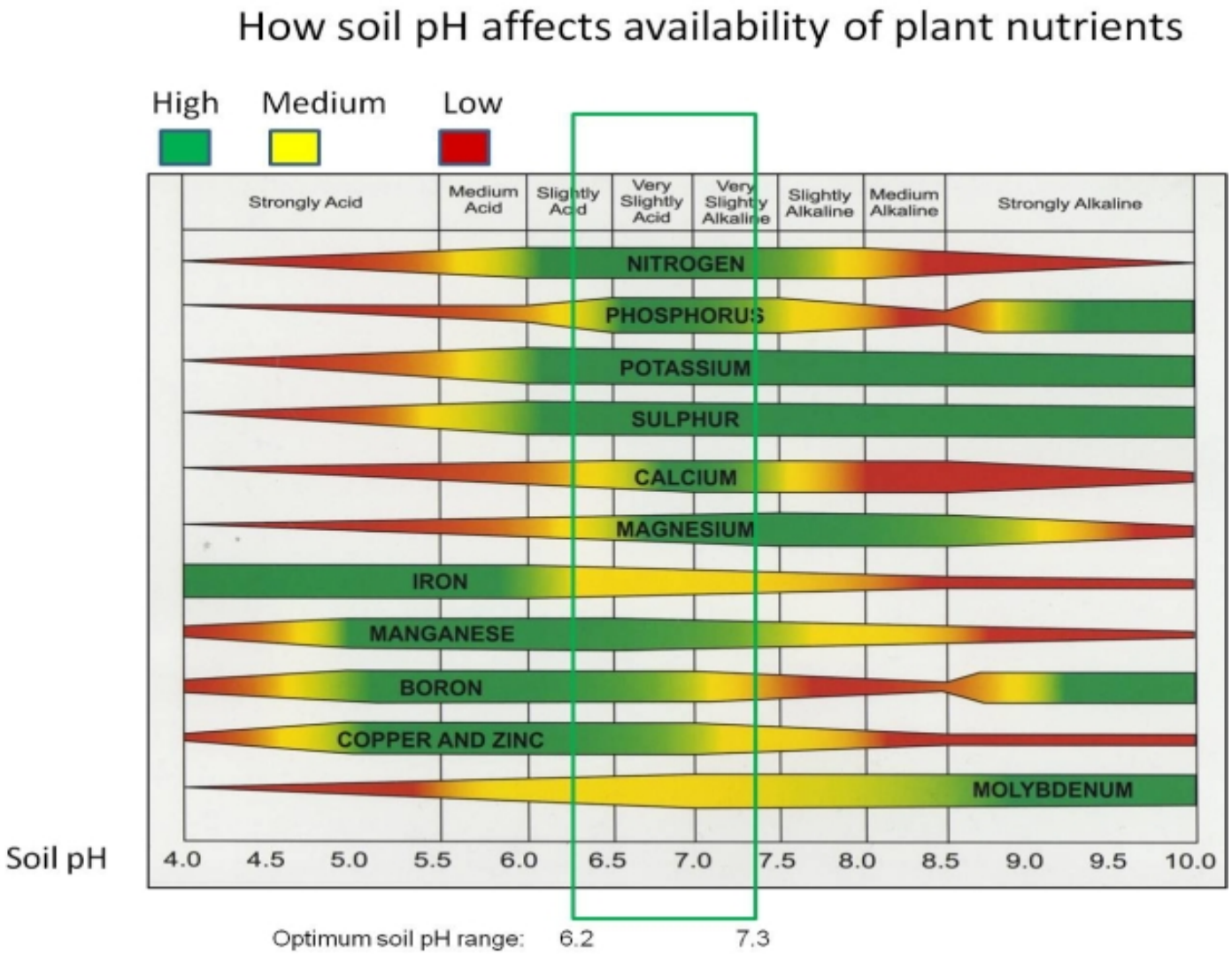
- Grow in a variety of soils from clay to sand
- Prefer well-drained soils
  - Sandy loam or silt loam
- Problem with heavy, poorly drained soils
  - May delay getting into field
  - Increase disease issues/rotting
- Problem with overly sandy soils
  - Hi input costs



Source: Neve, R.A. Hops. 1991

Hops and pH

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



Topography

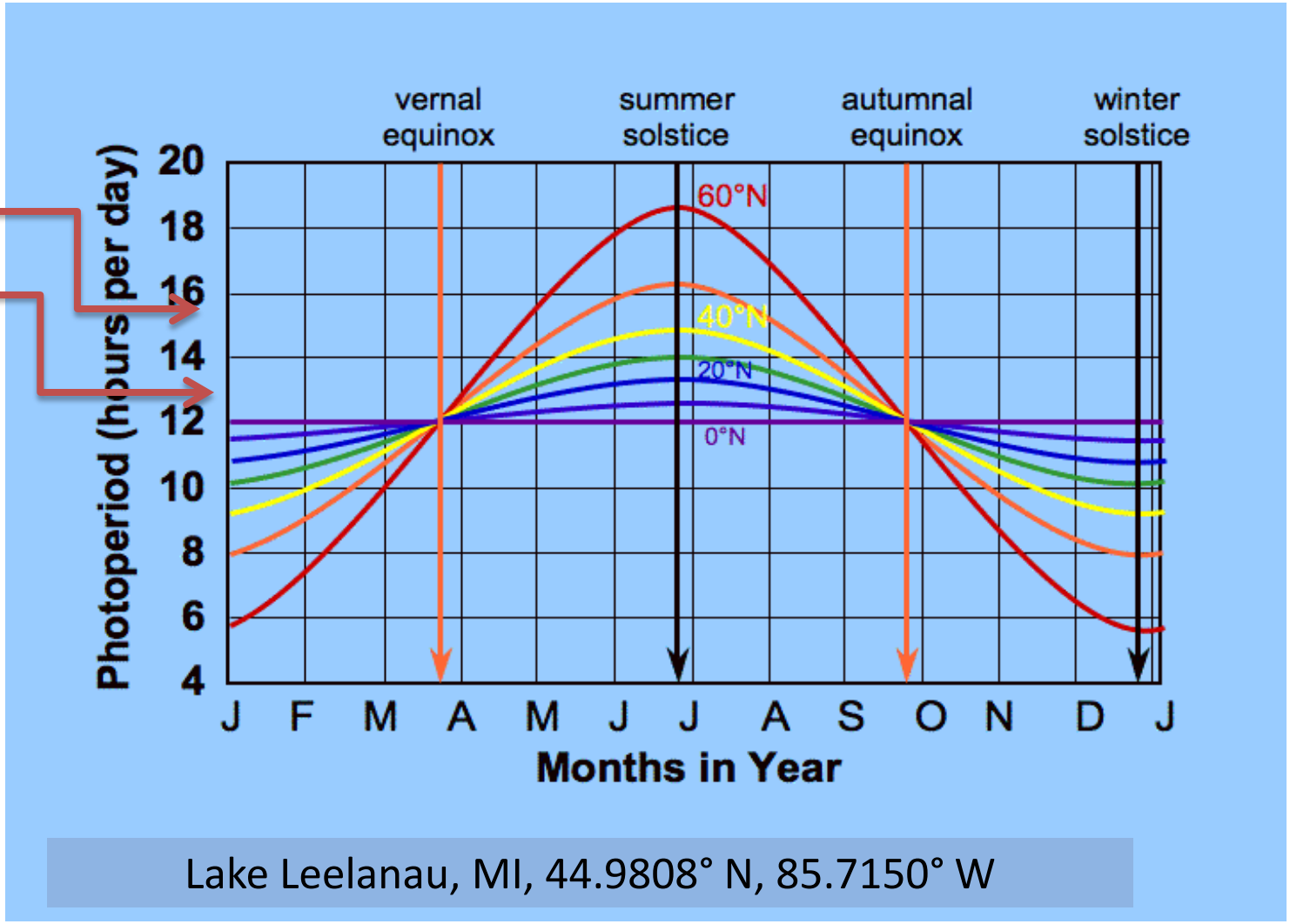
- Photo credit: Maggie Hoffman

Photo: David Warren

Photoperiod Sensitivity (why location matters)

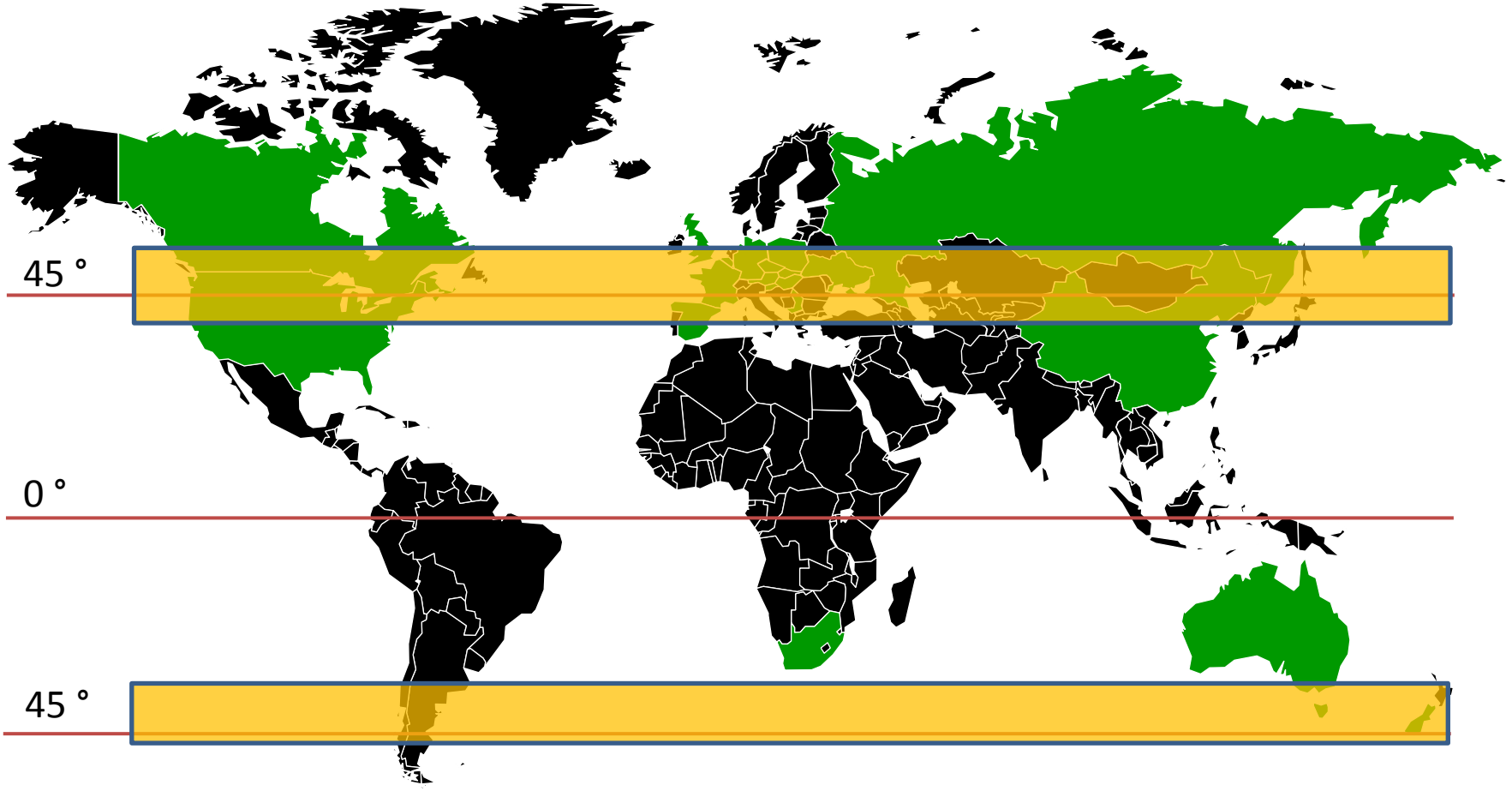
Floral Initiation

Plant growth begins



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

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

Source: Jason Perrault, Perrault Farms





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
  - Not much happening
  - Planning for next season

Source: Jason Perrault, Perrault Farms



What Varieties to plant?

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

Variety	Usage	Disease Susceptibility*		
		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





Spring Regrowth (April-May)

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

Source: Jason Perrault, Perrault Farms

Photo credit: Erin Lizotte

Spring Regrowth (April-May)

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

Source: Jason Perrault, Perrault Farms

PLOT ID: G3F7Y

Kinsey Agricultural Services, Inc.

297 County Highway 357 - Charleston, MO 63834
Phone 573-683-3880 Fax 573-683-6227 e-mail neal@kinseyag.com

Client: MICHIGAN STATE UNIVERSITY EXTENS City : SUTTONS BAY , MI Date : 12-Sep-12

Location			HORT STATION		Previous Analyses & Applications						
Crop			HOPS / HOPS								
Field / Sample			N								
Lab No.			B0103								
Total Exchange Capacity (M.E.)			7.58								
Desired Ca : Mg, Percent			66 : 14								
pH of Soil Sample			7.0								
Humus Content, Percent			1.9								
BASE SATURATION PERCENT					%		%		%		
Calcium (60 to 70%) } 80%			76.15								
Magnesium (10 to 20%) } 80%			15.67								
Potassium (2 to 5%)			2.88	FOR ORGANIC					FOR CONVENTIONAL		
Sodium (.5 to 3%)			0.92								
Other Bases (Variable)			4.38								
EXCHANGEABLE HYDROGEN (10 to 15%)			0.00	RECOMMENDATIONS							
				Amendment	Lbs/Acre					Lbs/Acre	
ANIONS	NITROGEN Lbs/Acre	ENR Value	58	FEATHER MEAL 13-0-0 (a) FEATHER MEAL 13-0-0 (b) COMPOST	450 375	(See Note Below)		UREA 46-0-0 (c) AMSULF 21-0-0-24 (d) CAN 17 N (e) LIQUID N 32% (f)		40 125 50 125	
ANIONS	SULFATE - S p.p.m.	Value Found	16	SULFUR 90-92% (g)	75			SULFUR 90-92% (g)		75	
ANIONS	PHOSPHATES as (P2O5) Lbs/Acre	Desired Value Olsen Value Value Found Deficit/Surplus	750 636 -114								
						Amend	added	Amend	added	Amend	added
CATIONS	CALCIUM Lbs/Acre	Desired Value Value Found Deficit/Surplus	2062 2309 +247	NONE							
CATIONS	MAGNESIUM Lbs/Acre	Desired Value Value Found Deficit/Surplus	250 285 +35	NONE							
CATIONS	POTASSIUM Lbs/Acre	Desired Value Value Found Deficit/Surplus	443 170 -273	POT SULFATE 0-0-50 (h)	250			POT SULFATE 0-0-50 (h)		250	
CATIONS	SODIUM Lbs/Acre	Desired Value Value Found Deficit/Surplus	35 32 -3								
						P.P.M		P.P.M		P.P.M	
TRACES	Boron	p.p.m.	0.88	BORAX 11%	20			BORON 14.3%		15	
TRACES	Iron	p.p.m.	411								
TRACES	Manganese	p.p.m.	83	MANG SULF 28%	50			MANG SULF 28%		50	
TRACES	Copper	p.p.m.	1.40	CU SULFATE 23%	20	(Or 5 lbs/acre per year for 4 years.)				20	
TRACES	Zinc	p.p.m.	8.50	ZINC SULFATE 36%	35			ZINC SULFATE 36%		35	

NOTES

(a) Apply 1 week or so before spring growth begins.
(b) Apply 1 week or so before bloom.
(c) Work into soil immediately or water in with a minimum of 1/2 inch of water.
(d) Apply in early spring.
(e) Apply at bloom.
(f) Apply at bloom.
(g) Sulfur applications including the sulfate form of 50 lbs/acre or more need to be applied at least 6 months prior to next soil sampling.
(h) Apply an additional 250 lbs/acre of Potassium Sulfate (0-0-50) during the growing season.

NOTE: Could use compost here if Ca & Mg levels in the compost are not too high. Should not be applied though without an analysis first to determine the effects this would have on soil nutrient content.

A service of Kinsey's Agricultural Services : Checked by ____NK____ 1203080_133637

ALL RECOMMENDATIONS ARE TO BE SOIL-APPLIED AND BROADCAST UNLESS OTHERWISE SPECIFIED

Pruning/crowning

Hops: Planting, Stringing, Training, Thinning

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Planting

- Michigan is moving away from rhizomes
  - Disease
  - Reliability
  - New local supplies of certified plants
- Plant starts can be planted throughout the growing season but generally in spring
- Have your trellis and irrigation in place before planting

Photo Credits: Great Lakes Hops

- At least 2000 strings/acre (2 per plant)
- Video

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





Meanwhile In Michigan

2 options for stringing

1. W clips

2 options for stringing

2. Tie strings to a lower wire

http://onspecialtycrops.wordpress.com/2013/05/14/hop-update-may-14-2013-stringing-trellising-and-irrigation/





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





Training

- 3-4 bines
- Clockwise only
- Timing-Cultivar and weather dependent
- Will likely have to re-train

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

May 12- Highest yield of fresh cones (2.05 kg)

June 1- Lowest yield (1.26 kg)

Late training reduced the yield by 38.5 % (June 1)

Early training reduced yield by 10.3 % (May 4)

Color of cones poorest with earliest training

Delayed training decreased mean length of harvested cones but increased their setting density

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

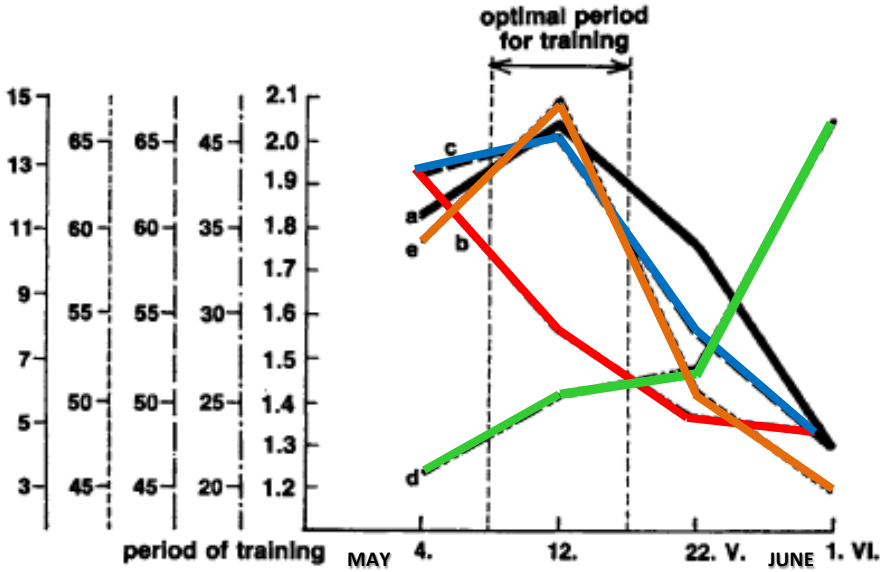


Fig. 93. Effect of time of starting training on the structure of the hop plant and on the yield of cones: a – yield (in kg) of fresh hop per plant, b – length of cones in mm, c – number of shoots, d – density of setting (number of cones per 10 cm of shoot), e – mean length of shoots (in cm).

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






ADD MORE HOPS

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

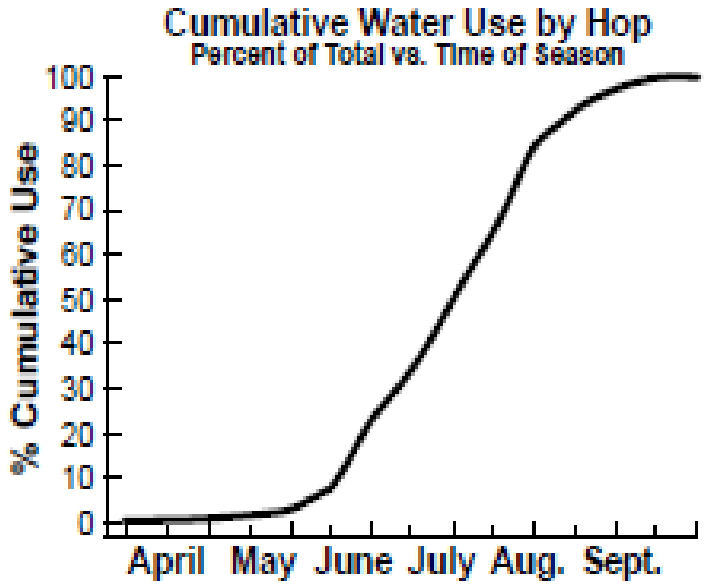


Fig. 1. Cumulative water use of hop during the growing season.

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

Irrigation: Examples

- Loftus Ranches
- Run two drip tubes per row
- 8 gallons per plant per day in hot season (4 on, 8 off, 4 on)
- ~8000 gallons/acre





Irrigation: Examples

NWMHRC

- Run one drip tube per row
- .42 gallon emitters every two feet
- RAM tubing
- 30 minute flush, 45 minute fertigate, 30 minute flush (every other day)
- NOT ENOUGH WATER





Fertigation

Vegetative Growth(May-July)

- Critical Stage for the purposes of crop production, occurs from end of May-end of July

- Two Phases:
  1. May-early July: Plant growth mainly in main vine and leaves
  2. July: Bulk of above ground growth occurs in the 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

Source: Jason Perrault, Perrault Farms

Hop Growing Requirements: **Fertility**

- Soil Test Before planting
- Tissues Tests and Soil tests
- Recommended fertilization rates:
  - Nitrogen (N) = 140 lbs/acre
    - Mid-April with urea (40-0-0) every 2-3 weeks then later come in with triple 16
    - End in late-June
    - No more than 25 lbs/acre at one time
  - Phosphorous (P) = 60-100 lbs/acre
  - Potassium (K) = 100 lbs/acre (potash)
- Eg. Yakima Valley
  - Highest average yield included a 90 lbs. N/ac as a spring application, followed by 90 lbs. N/ac administered through fertigation, ending in June (180 lbs. of N/ac total)





Weed control




Pests and Diseases

- **Hop aphid** *(Phorodon humuli)*

- **Spider Mites** (*Tetranychus urticae)*

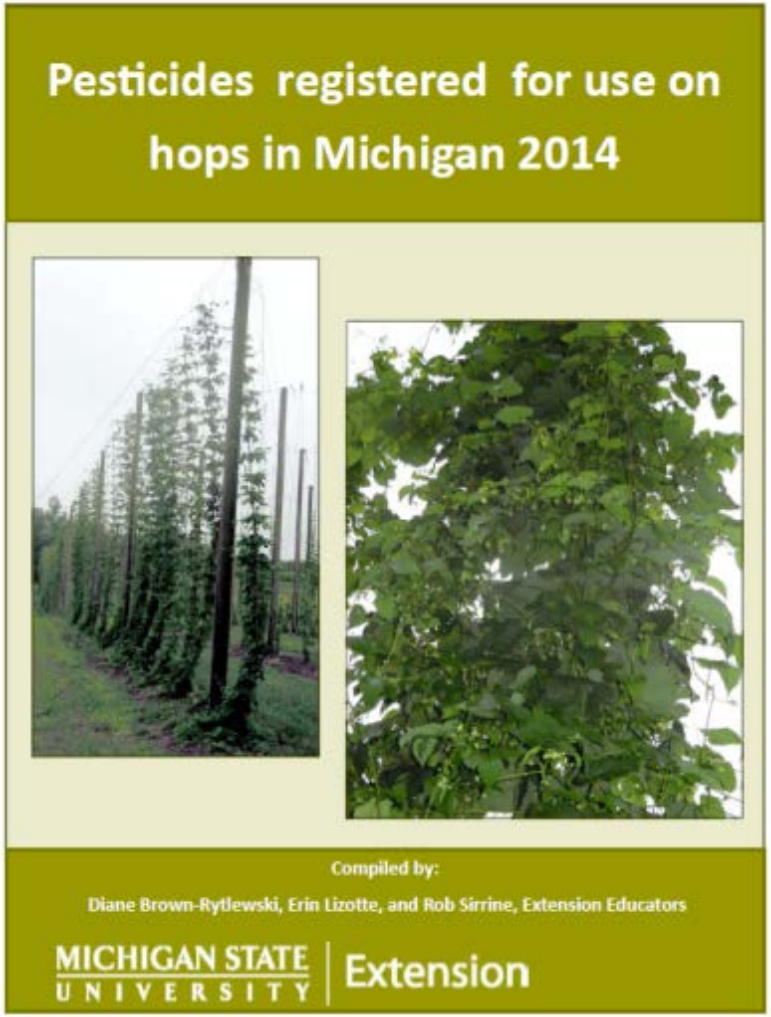
- **Potato Leaf Hopper** (*Empoasca fabae*)

- **Downy mildew**
  (*Pseudoperonospora humuli)*

- **Powdery mildew**
  (*Podosphaera macularis)*

Resources for pesticide labels

- Crop data management systems
  - www.cdms.net
- GREENBOOK
  - www.greenbook.net
- Agrian
  - http://www.agrian.com/home/label-lookup/overview#
- New Bulletin→
  - http://www.hops.msu.edu







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-cut off N, add K

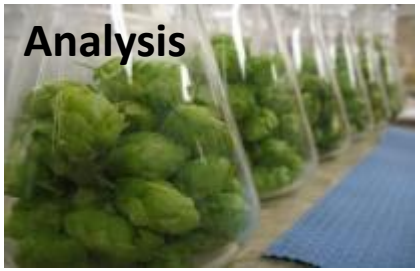
Source: Jason Perrault, Perrault Farms

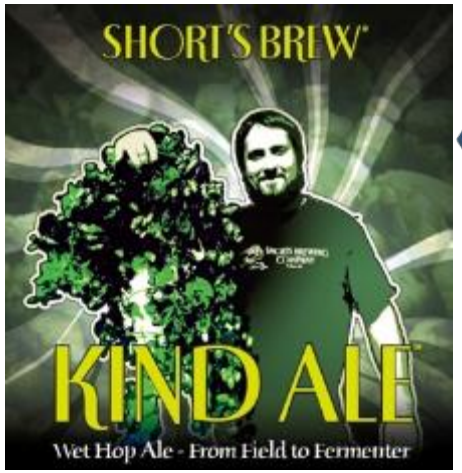
Preparation for Dormancy (September)

- 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

Source: Jason Perrault, Perrault Farms

Hop Value-Chain





Hammer Mill & Pelletizer

Marketing/Sales

Whole cone

Pellets

Harvest Timing

Hop is 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 which is varied by the weather situation, location conditions and the cutting time.

Harvest time crucially affects:

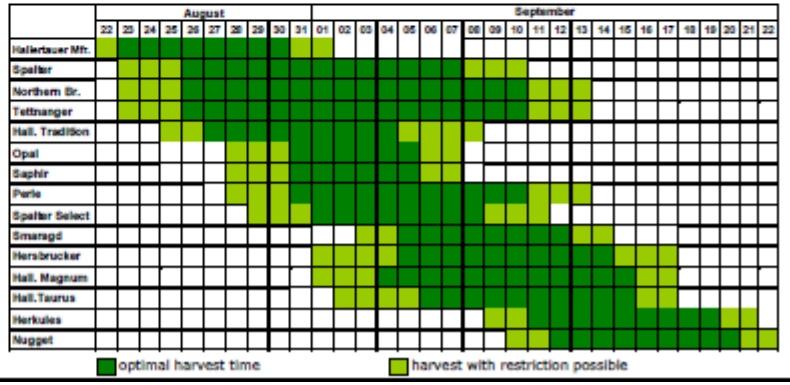
- α-acid contents
- yield
- external quality (color and shine, infection with diseases and pests, shattering)
- aroma (aroma intensity, oil content and composition)
- vigor and vitality of the plant (in the next season)

↓

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

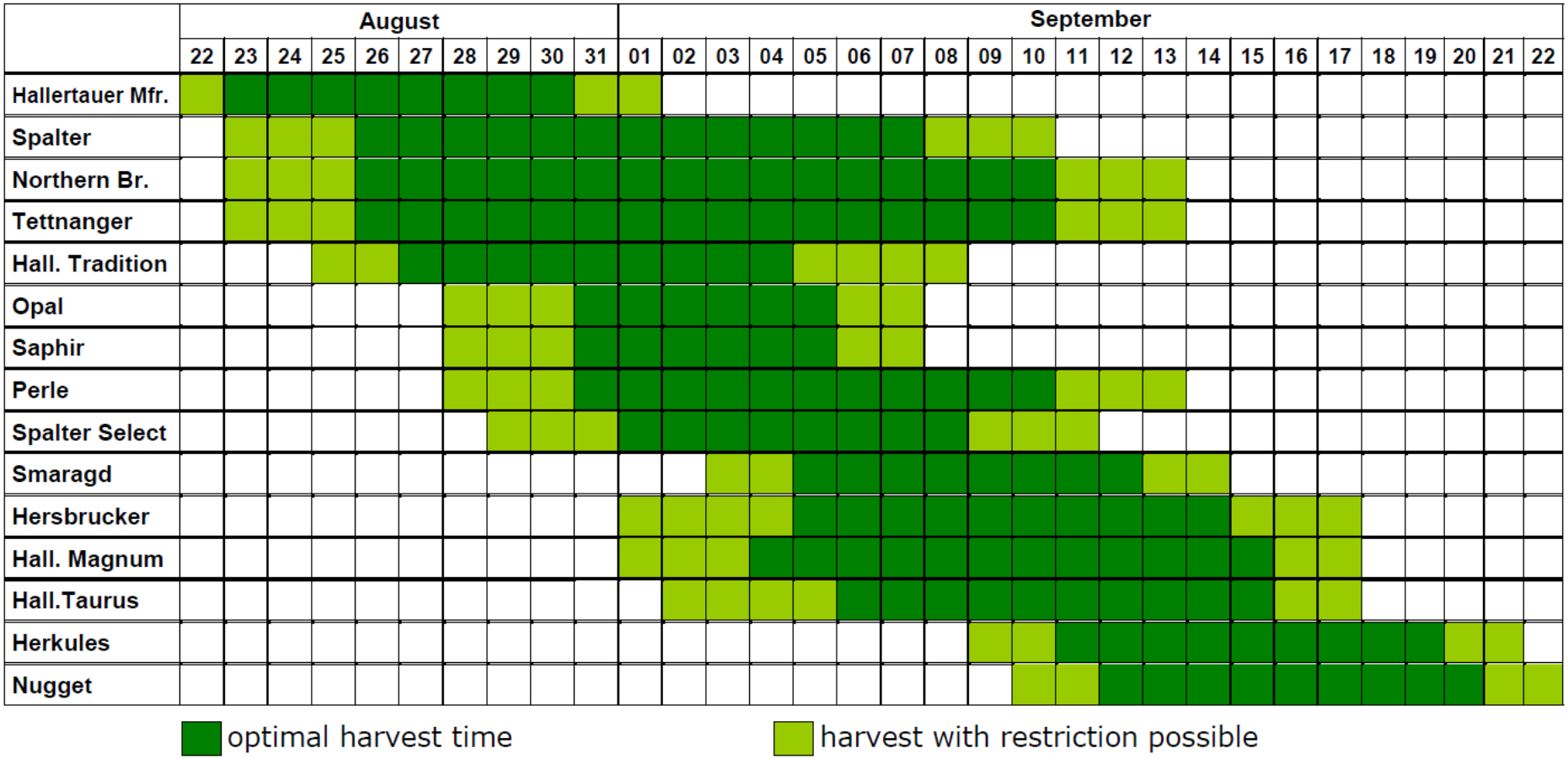
LfL Pflanzenbau

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



Removing the guesswork

Hop Cone Testing

Dry Matters $20

- By focusing on moisture content, dry matter analysis provides growers with the necessary information to forecast peak harvest windows based on hop cone maturity.
- Studies have shown a direct correlation between dry matter and cone color.
- As dry matter increases above 25%, hop quality begins to deteriorate, resulting in diminished color and off aromas.
- When utilized on a frequent and annual basis, dry matter analysis can predict moisture trends within a given lot and assist growers in refining their harvest schedules to be increasingly efficient.
- Require a 100g sample of un-dried, raw hops and a minimum 1 day turnaround.

Removing the guesswork

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.

Harvest Systems

- Cut Bottom
  - By hand
  - Bottom Cutter
- Cut Top
  - By hand, scaffold/platform
  - Top cutter
- WOLF Bine Loader AN 60 LG
- Load onto trailer
- Transport to Picking Machine

By Hand

Bottom Cutter


FRESH
TOPCUTTER
PALE ALE

Top Cutter

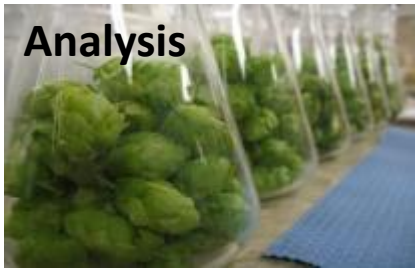
http://www.mrdavidj.co.uk/?p=1089

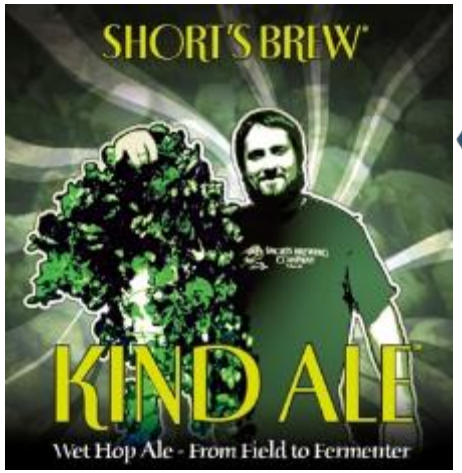
WOLF Bine Loader AN 60 LG

video

Appropriate Trailer

Hop Value-Chain





Hammer Mill & Pelletizer

Marketing/Sales

Whole cone

Pellets

Transport to the Picker

Degradation potential

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

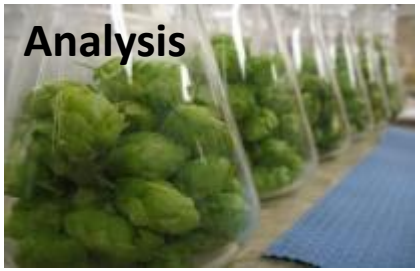
In terms of the drying process picked hop cones can be regarded as a living organism whose basic life processes, particularly respiration, are continuing. They first react to being removed from the plant by a higher intensity of respiration. Rybacek, 1991.

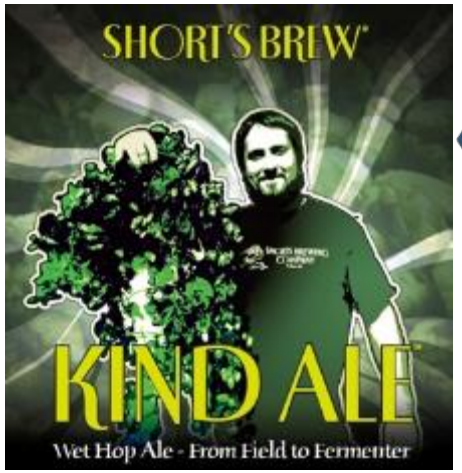
Transport Costs

- Assume 5 acres (1000 plants/acre; 2 strings/plant=10,000 vines)
- Truck/Trailer (170 vines/load)
- 30 miles from picking station (60 miles R.T.)
- Need about 60 round trips
- $.55 Per Mile x 3600 miles = $1980
- Labor ($10/hr) 6 trips/day for 10 days, 80 hrs minimum= $800
- Processing costs (~$5/lb x 1500 lbs/ac)= $7500

Total $10,280

Hop Value-Chain





Hammer Mill & Pelletizer

Marketing/Sales

Whole cone

Pellets

Picking

Considerations

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

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

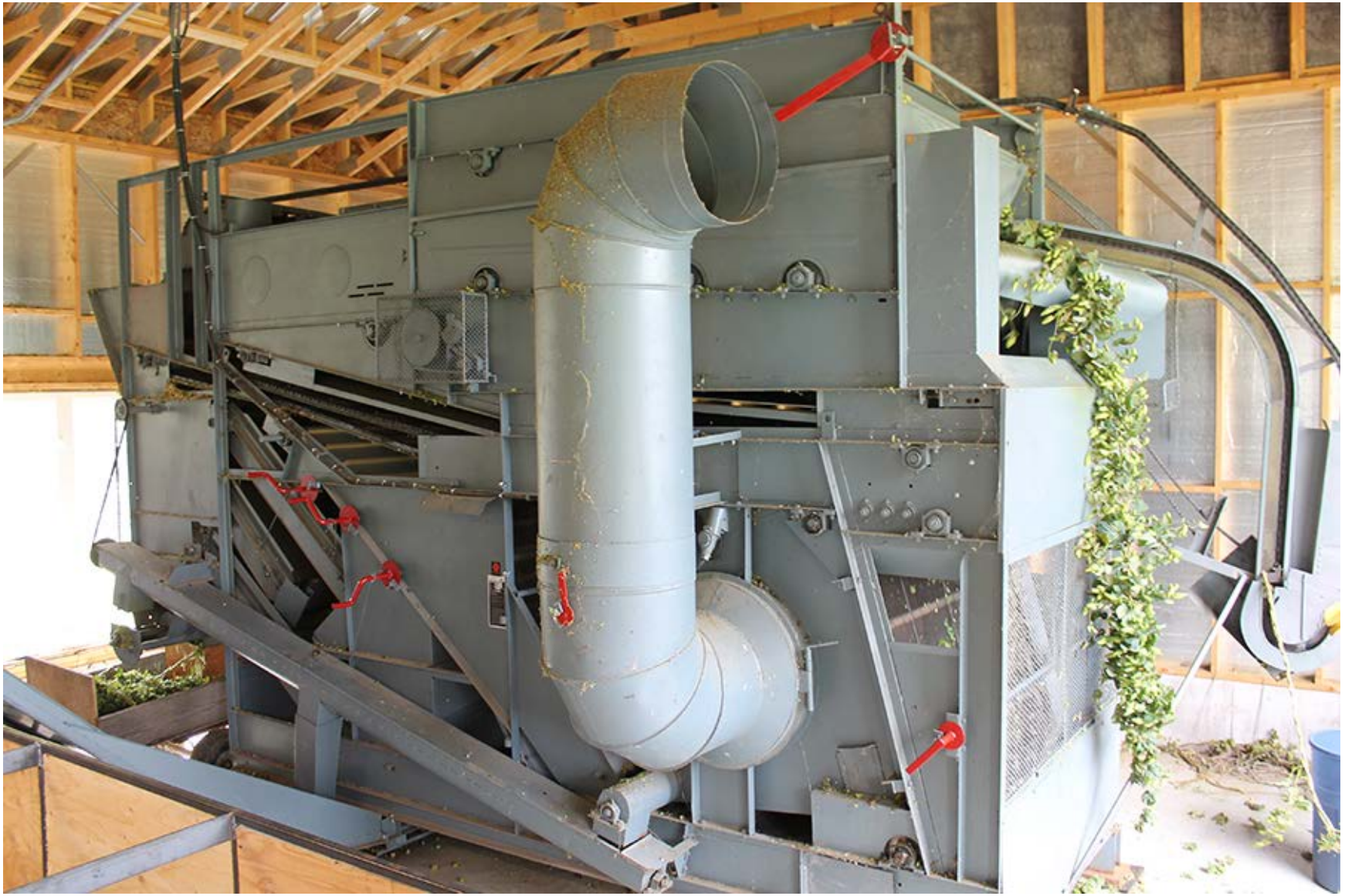
Hand Picking

- Not recommended for >1/3 acre

Wolf Type I

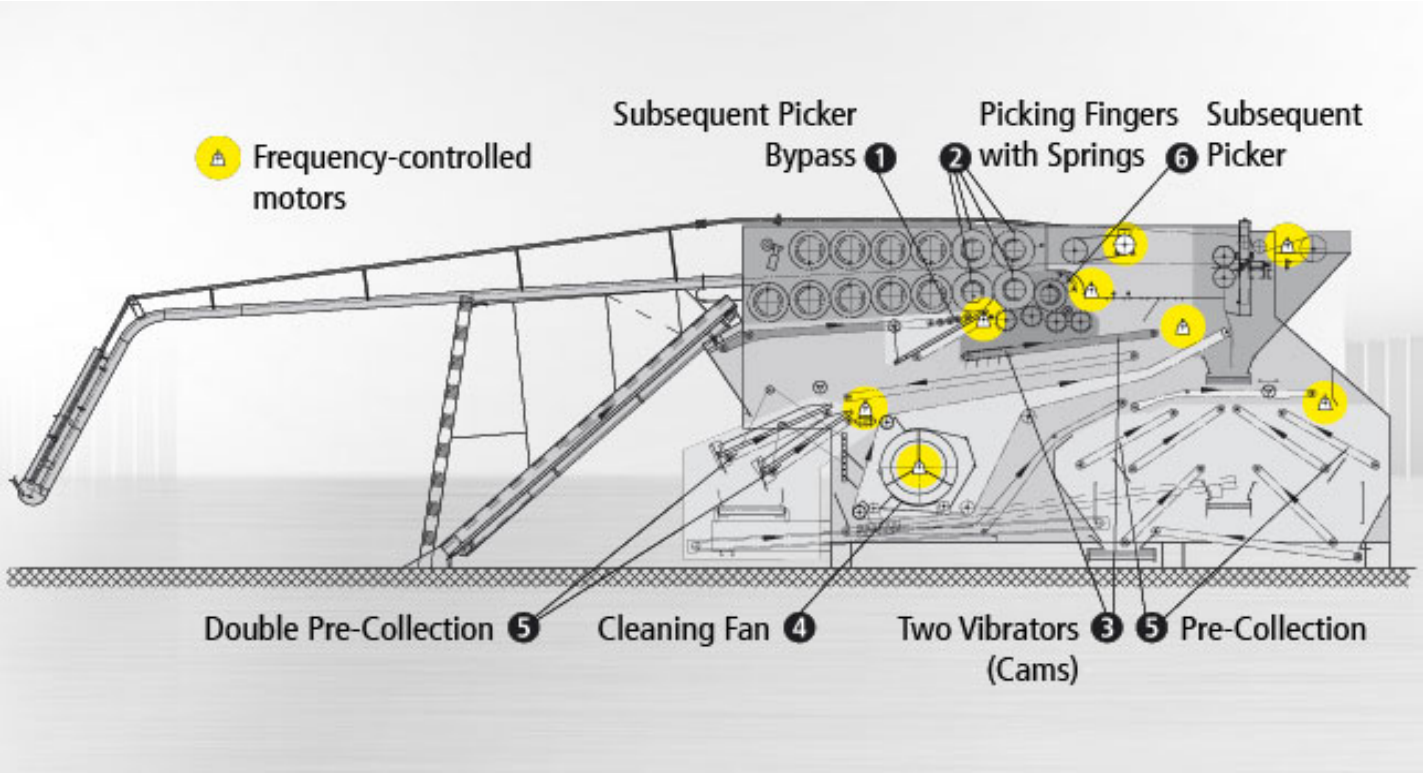
WOLF 140

WOLF 170



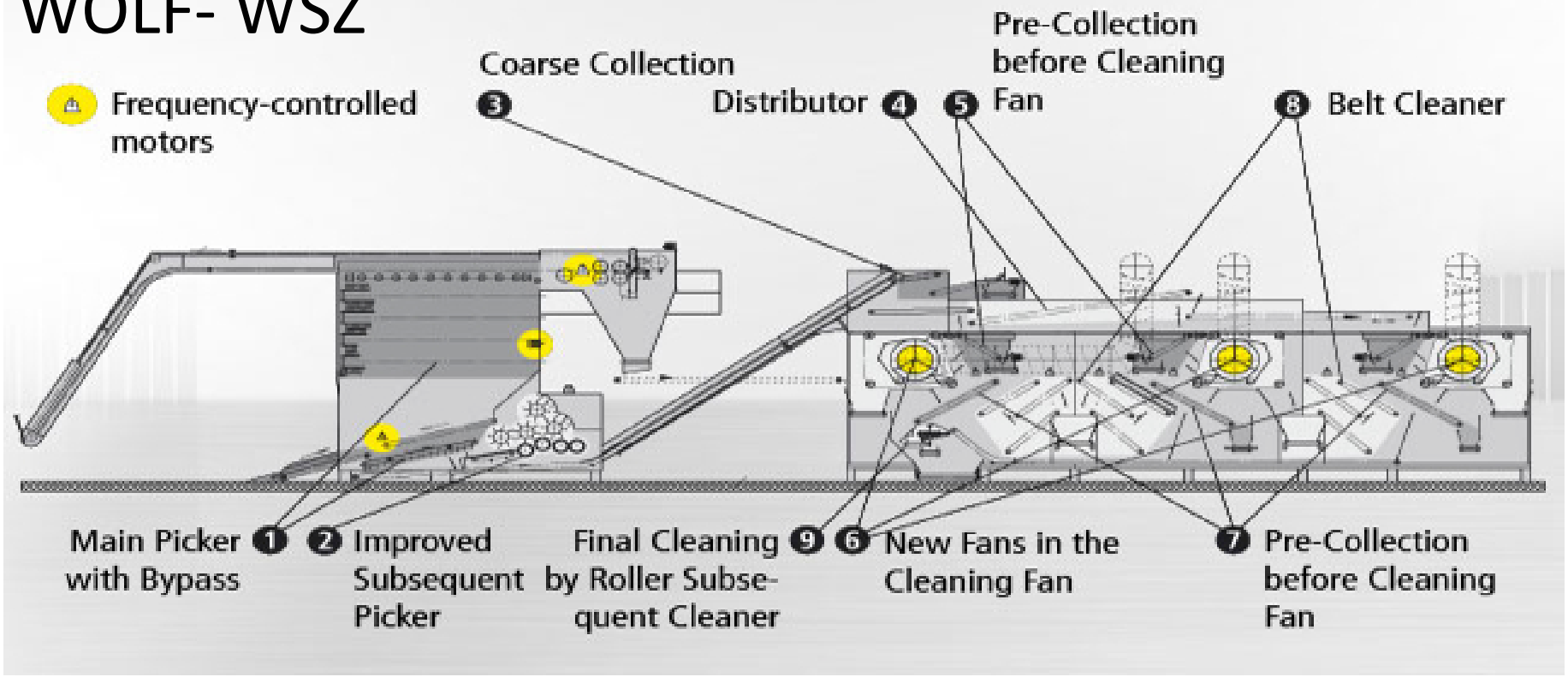
WOLF 230

WOLF 513



Type	WHE 511	WHE 513
Crop Performance	340 - 480 bines / h	350 - 510 bines / h
Length	approx. 17,90 m	approx. 17,90 m
Height	approx. 4,70 m (at 0,35 m high feet)	ca. 4,70 m (at 0,35 m high feet)
Width	approx. 6,80 m	approx. 6,80 m
Performance	approx. 35,0 kW	approx. 35,0 kW

WOLF- WSZ


Frequency-controlled motors
Coarse Collection
3
Distributor
4
5
Pre-Collection before Cleaning Fan
8
Belt Cleaner
Main Picker with Bypass
1
2
Improved Subsequent Picker
Final Cleaning by Roller Subsequent Cleaner
9
6
New Fans in the Cleaning Fan
7
Pre-Collection before Cleaning Fan

WOLF

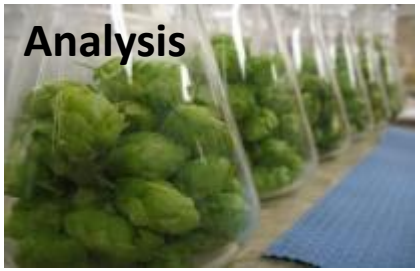
- Type I ~20,000-$25,000
- 140 ~$28,000-$36,000 6-7 Ha
- 170 ~$40,000 8 Ha
- 220/230 ~$50,000 12-14 Ha
- WHE 513 ~$250,000 30-40 Ha
- WSZ---A LOT.

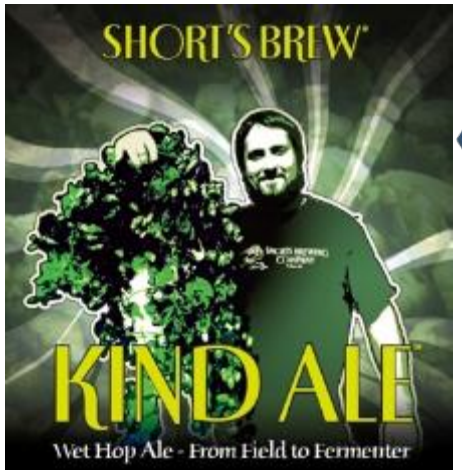
513 video


GMC

www.ibabuzz.com

Hop Value-Chain





Hammer Mill & Pelletizer

Marketing/Sales

Whole cone

Pellets

Drying

The drying process is affected by many factors and lasts 5-8 h or more. It has its own peculiarities and is regarded as **the most important operation in the harvesting process.**

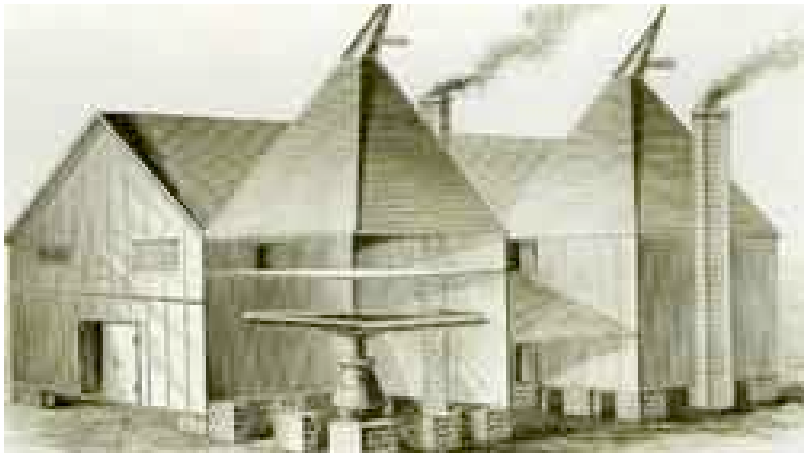
Four basic parameters which affect the drying procedure and its result are:

1. specific drying properties of the hops being dried;
2. drying temperature;
3. volume of air and the speed of its movement;
4. other factors.

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

The importance of the drying process

- The basic process around which the hop harvest should be organized, is the drying operation.
- Therefore, the preceding operations, both in time and volume, should be matched to the speed of the drier.



19th century storage, From: The Hop Atlas 1994 by Heinrick J. Barth. http://freshops.com/hop-growing/hop-gardening

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

Dryer Types

- Bed

- Louvered

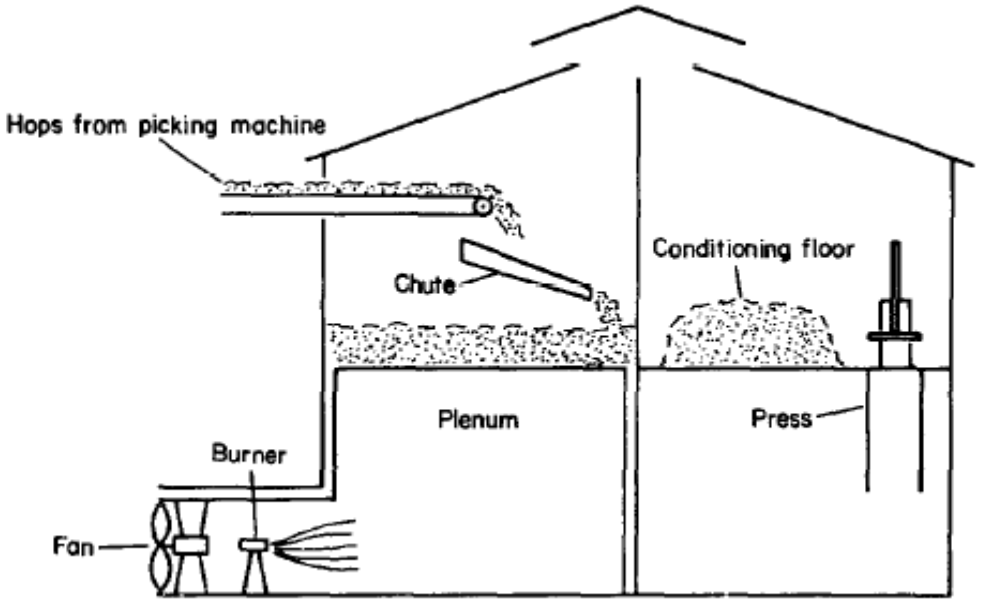


Fig. 1. Deep bed drier

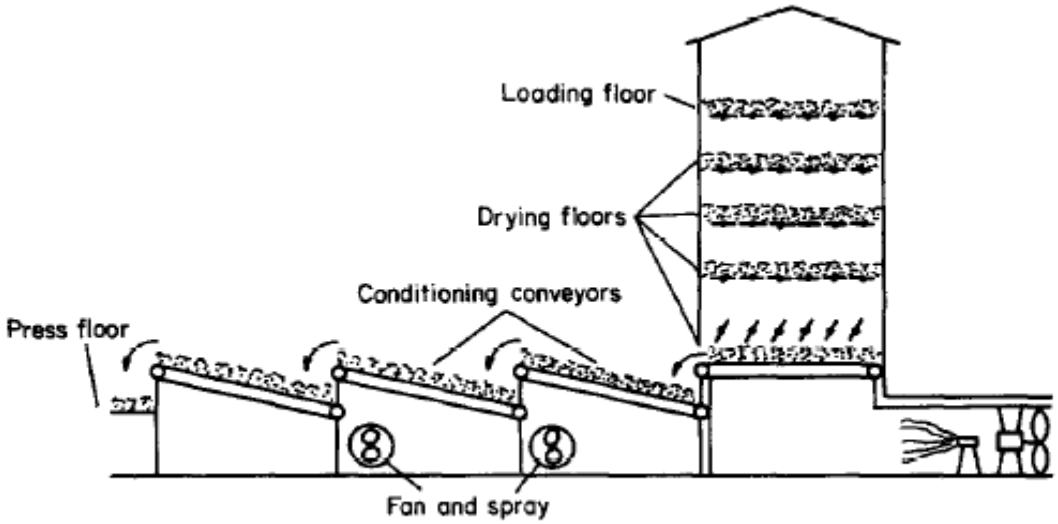


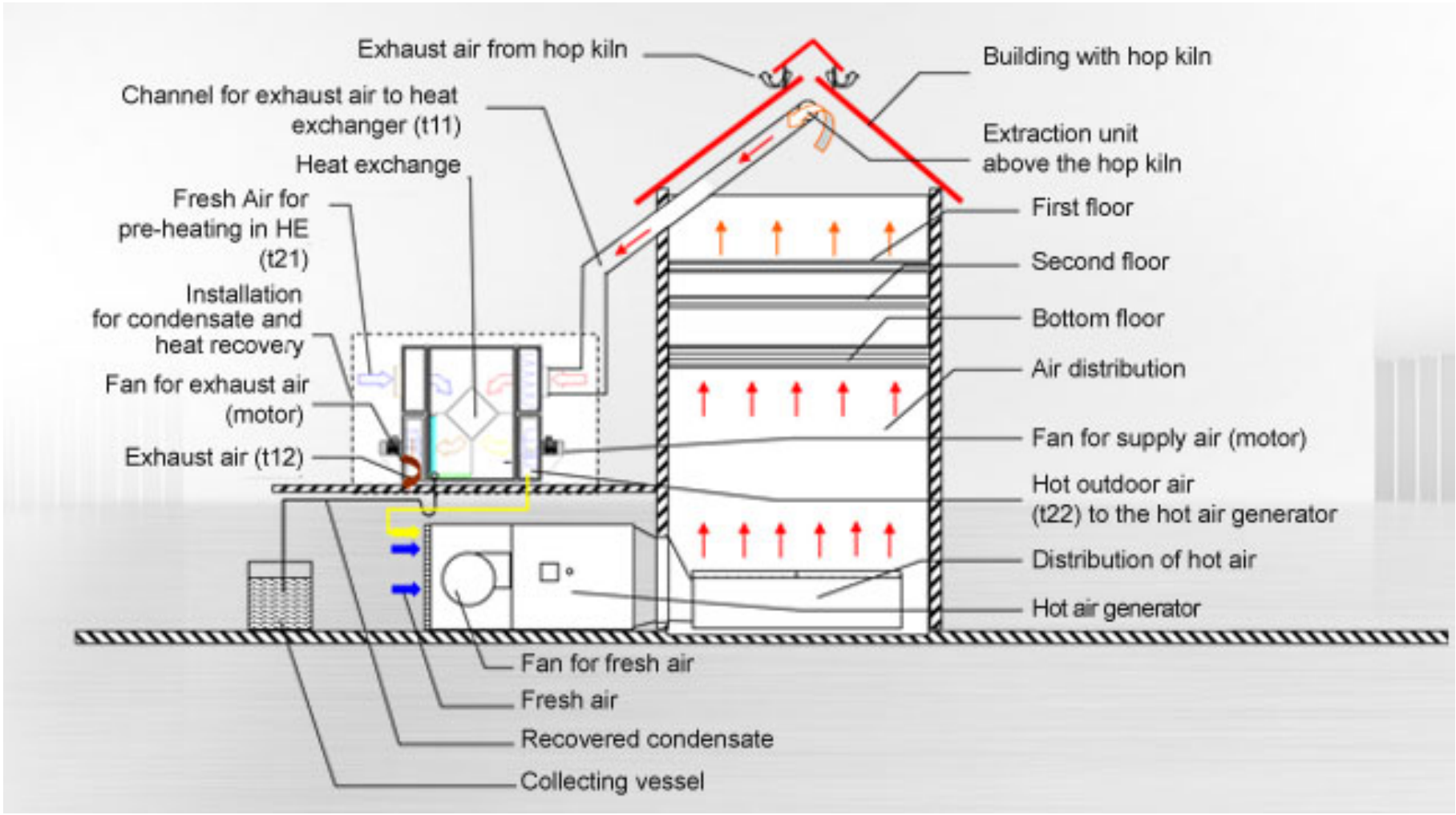
Fig. 2. Falling bed drier

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

Wolf-Modern system



UVM Modular hop oast

NW CROPS & SOILS PROGRAM

UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

Modular Hop Oast

Introduction

Hops are commonly harvested at 75-80% moisture by weight, but are ideally pelleted, packaged and stored only after they are dried to 8-10% moisture. To put this into perspective consider that a pound of "dry" hops starts out with about 3 pounds of water (a little less than a half gallon) that has to be evaporated by drying.

In large, commercial hop production whole buildings are dedicated to the careful process of drying hops to the desired storage moisture. Given the nascent, distributed, and small-scale nature of Vermont's resurging hop industry a different approach is needed. To this end, a modular hops oast has been developed and demonstrated by UVM Extension and Borderview Farm. This oast is designed as an integrated cabinet drier that holds trays of hops. The drying is accomplished with a fan, heater and controller.

The oast includes two 4'x4'x8' cabinets with independent access doors and controls. Total capacity is 600 lbs wet hops which can be dried in 8 hours.

Different hop varieties can be kept separate in the oast by placing them in different trays. A total of 8 trays can be accommodated in each cabinet. Wire mesh is used as the bottom for the trays which allows air flow through the hops.

Design

The aim of the design is to use readily available materials and common construction skills and to result in a modular and scalable oast that supports hop growers of various scales. A base module of 4' W x 4' D x 8' H makes use of standard building materials well and allows for conveniently sized hop trays. All of the main structure is made with standard construction lumber and plywood. The electrical system is 220 VAC single phase and uses fairly common parts and wiring. The fan motor is 1/4 hP and the fan impeller is a 24 inch vane axial design capable of 3250 CFM at 0.7 iwc pressure rise (at 1750 RPM). The majority of air flow is circulation within the cabinet, however in order to dry the hops the humidified air must be removed. Holes are drilled in the top of the cabinet at high pressure and low pressure areas along the impeller resulting in exhaust and fresh air intake respectively. The placement of these holes and the degree to which they are open or covered determines how much "stripping" air is pulled through the cabinet. The heating element is a 3500 Watt bent tubular heater. Although one can dry hops using unheated, ambient air, the addition of well controlled heat to the air allows for quicker drying reducing labor and maintaining higher quality hops. The components used in this oast have been selected to dry 300 lbs of wet hops from 80% moisture to 10% moisture in 8 hours with little to no labor required.

The fan and heater are installed on the ceiling of the cabinet. A PID controller (inset) rests on top of the cabinet and ensures temperature control.

A proportional-integral-derivative (PID) controller has been used in this system. This type of controller allows the user to set a target temperature and by monitoring the actual temperature in the cabinet using a thermocouple it "zeroes" in on the set-point. This differs from a thermostatic control which would provide an "average" temperature of the set-point but with sometimes wide fluctuations above or below it. The PID controller is always monitoring the difference between the set-point and the actual temperature, the historical difference, and the rate at which this difference is changing in order to predictably adjust the heater operation to attain the desired temperature.

Cost (per 4'x4'x8' cabinet)

Lumber/Screws/Hardware	$246
Angle Iron for Tray Rack	$104
1/3 H.P. Fan Motor	$110
Fan Blades (from Multi-Wing)	$78
Heating Elements 3500 Watt (from Chromalox)	$332
Controls	$100
Total Materials	$970
Labor	30 Hours

Plans for the UVM Modular Hop Oast including design drawings, a bill of materials, and a description of the machine are available for download from http://www.uvm.edu/extension/cropsoil/wiki/.

A project of University of Vermont Extension; Vermont Agency of Agriculture, Food and Markets; and Massachusetts Department of Agricultural Resources through the USDA Specialty Crops Block Grants Program.

VERMONT
AGENCY OF AGRICULTURE, FOODS & MARKETS
MDAR USDA

Contact:
UVM Extension NW Crops and Soils Team
The Vermont Hops Project
Email: hoppening@uvm.edu
Phone: 802 524 6501

NW CROPS & SOILS PROGRAM

UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

Modular Hop Oast

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EMPIRE
HOPS FARM


WERNER

Louvered, multilevel Hop Dryers

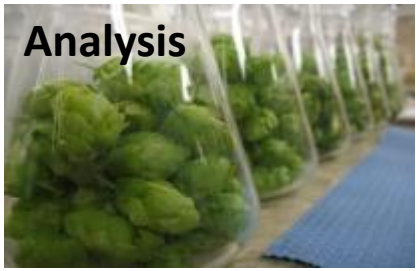
- Louvered Dryers are exceptional space savers and easy to use.
- The drying process typically takes place on three levels, on two shelves and in louvered drawer.

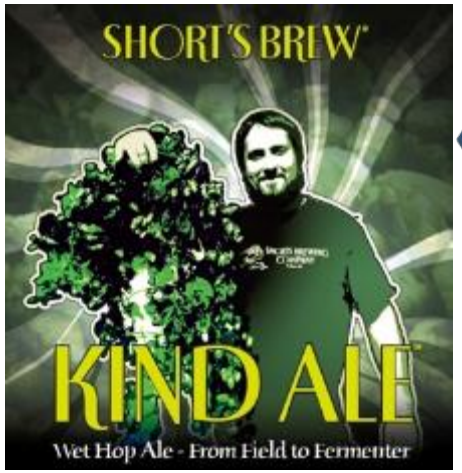
Yakima, WA


ithinkaboutbeer.com©


ithinkaboutbeer.com©

Hop Value-Chain





Hammer Mill & Pelletizer

Marketing/Sales

Whole cone

Pellets

Conditioning

Considerations

- Humidity- (In 2 hours you could go from 9% to 13% moisture)
- Throughput and timing
- Space requirements
- Food safety?

- Pictured here are heaps of hops freshly dropped from the kiln….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.”

Potential for reductions in quality: Storage

Low relative humidity -the moisture content of the bracts falls and the cones will tend to disintegrate if they are subsequently manipulated.

High relative humidity- moisture content of cones in the outer layer of the heap increases and such cones have a reduced sparkle and there is a change from the original colour after pressing.

1. Baling/processing immediately after conditioning
2. Cold storage of the raw hops result in considerably fresher hop products

	Good conditions		Unsatisfactory conditions	
	Damage in % rel.	Remaining value in %rel.	Damage in % rel.	Remaining value in % rel.
Kilning and conditioning	5	95	15	85
Storage of raw hops	8	87	40	51
Product manufacturing	2	86	5	48
Pellet storage for 1 year	6	81	16	41
Oversea transport	5	76	20	33

Forster, A. 2001. The Importance of the Crop Year for Evaluating Hop Products. Technical Publications. *Brauwelt International, No. 1/01, 32 – 37, 2001*

Baling

Considerations

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

“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.”

Mechanical German RB-60 Presses / Balers


NO SMOKING
NO FUMAR

HOPUNION LLC

Recommendations

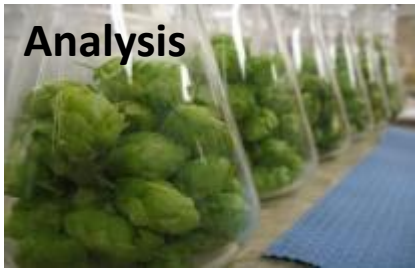
Packaging: Whole Hops are sold in the following quantities:

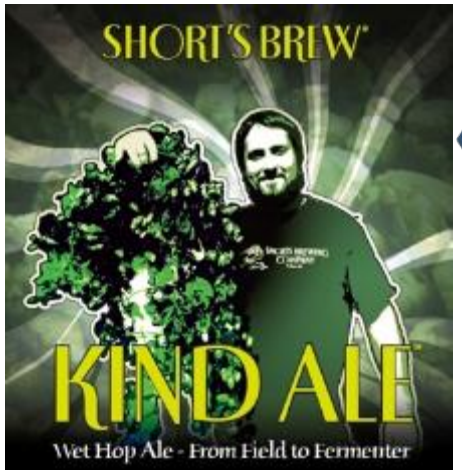
Bales (US Bales = 200 lbs / Import bales = 120 lbs)
½ Bales (US = 100 lbs / Import = 60 lbs)
¼ Bales (50 lbs, vacuum sealed and nitrogen flushed)
Mini-bales (13 lbs, vacuum sealed and nitrogen flushed)

Storage and Best By Recommendations: For maximum protection of bitterness potential and aroma, whole hops should be stored in temperatures below 35°F. Vacuum sealing the whole hops with an inert gas in a laminated plastic/aluminum foil pouch will drastically reduce the rate of oxidation and is recommended for long term storage.

Harvesting, drying, conditioning, and baling video-WOLF

Hop Value-Chain





Hammer Mill & Pelletizer

Marketing/Sales

Whole cone

Pellets

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

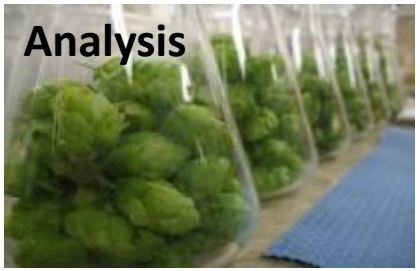
Oil Content $20

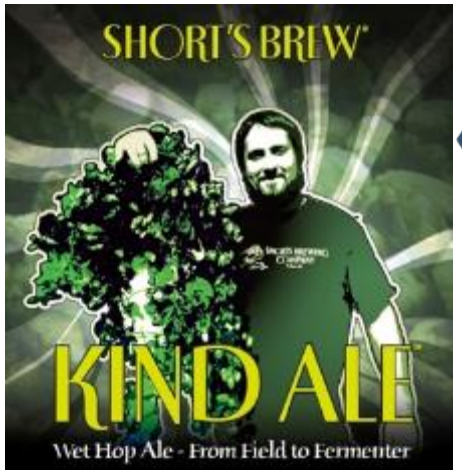
- Provides a value for the volume of oil in a hop sample

Volatile Oil Profile $100

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

Hop Value-Chain





Hammer Mill & Pelletizer

Marketing/Sales

Whole cone

Pellets

Pelletizing

Considerations

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

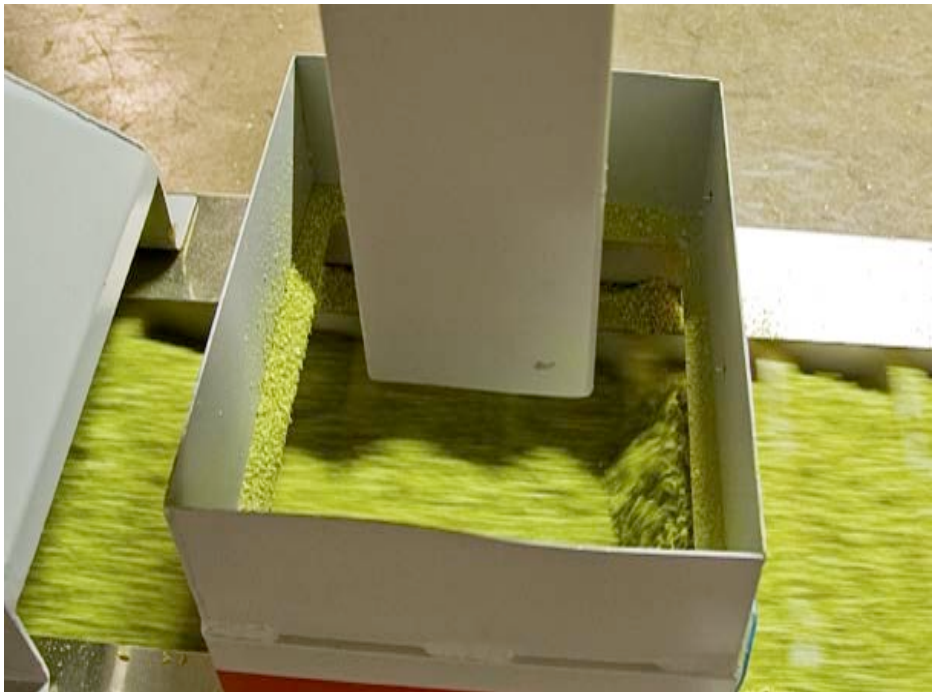
Small-scale MI processors

- Pelletizing http://www.youtube.com/watch?v=hn3nc1UBiNY

LM $36,000
350-1000 lbs/hour
Max- 50 C around 120 F

http://www.makepellets.ca/Hophead%202-1.jpg

Indie Hops



Patient, but Prompt
In less than 20 minutes from breaking up the fresh hop bales, we have the pellets cooled to ambient temperature. Nitrogen flush vacuum packing follows, then immediate storage in the freezer.

Steady as She Goes
Jim Solberg, our fearless leader, architect and operator of the all-important broom handle, dialing in the speed and volume.

The holy grail of hop pelleting is to convert the form of the whole cone without sacrificing essential oils and acids. Heat, in a word, kills. The industry standard hovers around 130F. We've clocked our hops at the pellet die consistently at or under 110F.

Freshness Never Smelled So Hoppy! Final pellets ready for an inert environment and 26F storage until it's their turn to show off at your local brewery.

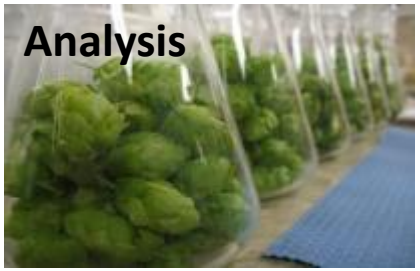
Hop Oils are a Terrible Thing to Waste: keep 'em cool!

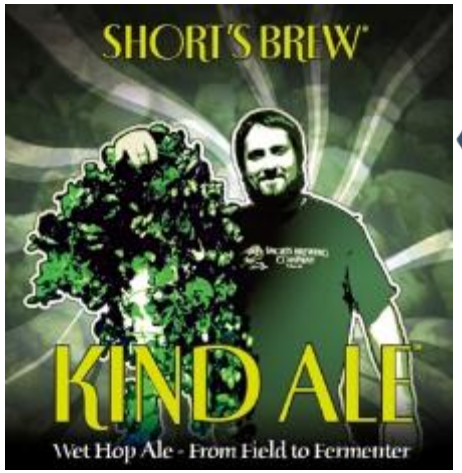
- “There is published evidence that hops should not be pelletized at temperatures in excess of 55°C (131°F).
- The process of milling and pelletizing hop cones dramatically increases the rate of hop acid and oil oxidation.
- When the processing temperature is lowered, the quality of the essential oils in the pellet are better preserved and closer to that of an unpelletized hop, which from an aroma perspective is a good thing for a brewer.”

Tom Shellhammer, Ph.D., Nor'Wester Professor of Fermentation Science, Oregon State University

HopUnion video

Hop Value-Chain





Hammer Mill & Pelletizer

Marketing/Sales

Whole cone

Pellets

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

Package Size

Who are you selling to?

- Home brewers? 1 oz.
- Brewers- 1 lb-10 lbs +?


HOPS
HOP PELLETS
(Humulus Lupulus)
Stickelbract
Alpha 14.1 %
Batch: 11086-03
100g net
3.52 oz net
PACKAGED BY:
Store in a cool place.
Re-seal after use.
HOPS
HOP PELLETS
(Humulus Lupulus)
Nelson Sauvin
Alpha 12.3 %
Batch 11179-04
PACKAGED BY:

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

The effects of storage temperature on the chemical composition of hop pellets

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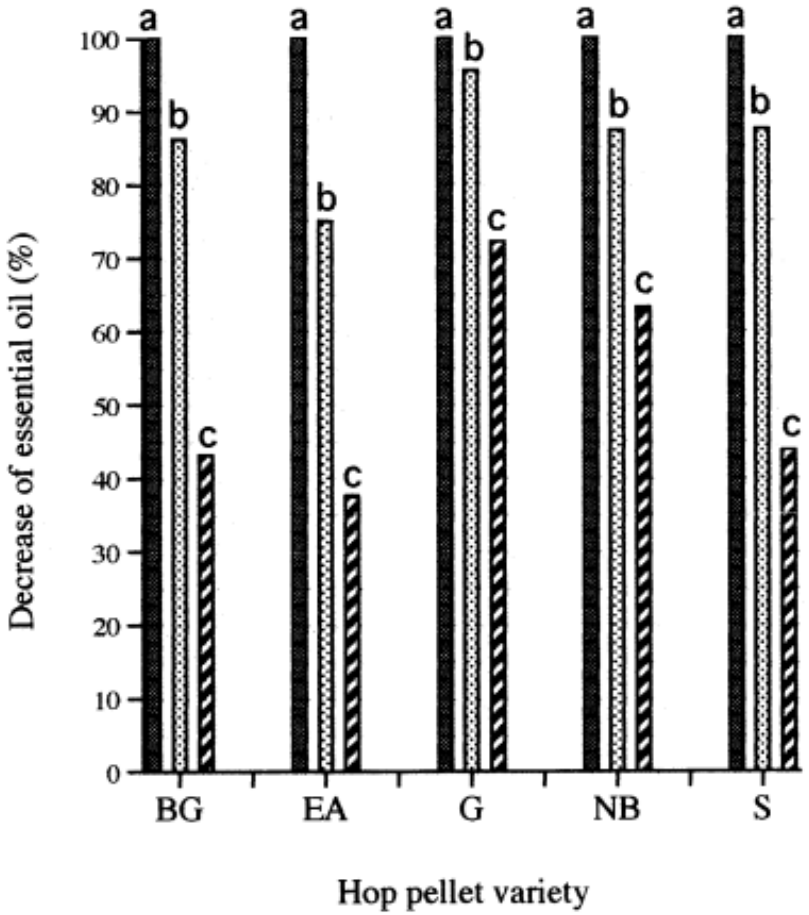


Fig. 5. The effect of 6 months storage on essential oil of hop pellets. BG, Brewers Gold; EA, Efes Aroma; G, Galena; NB, Northern Brewer; S, Saaz; a, Initial; b, 3°C storage; c, Room temperature storage.

Process Biochemistry 36 (2001) 1053-1058.

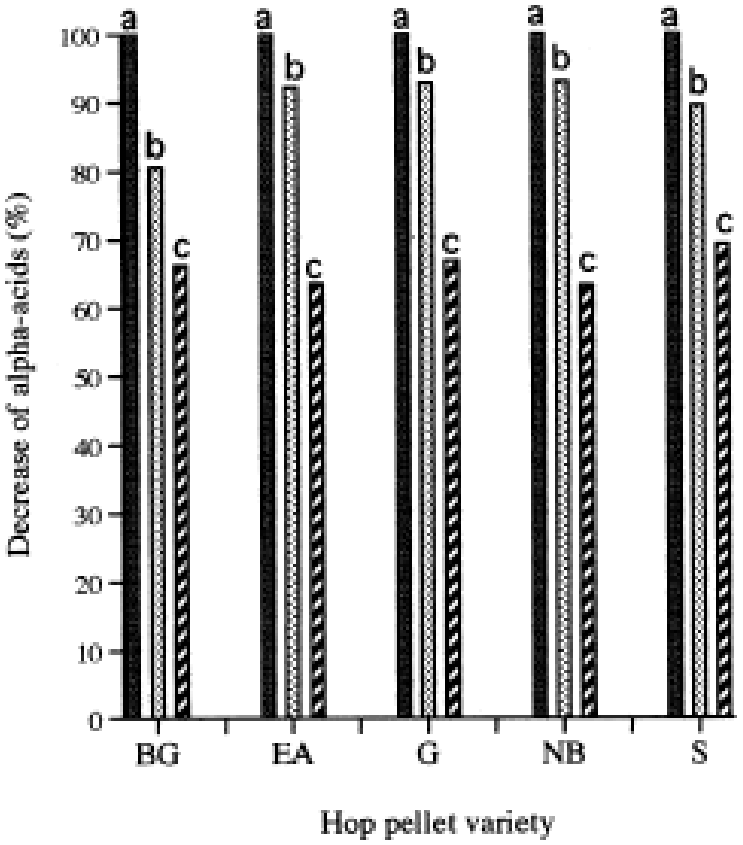
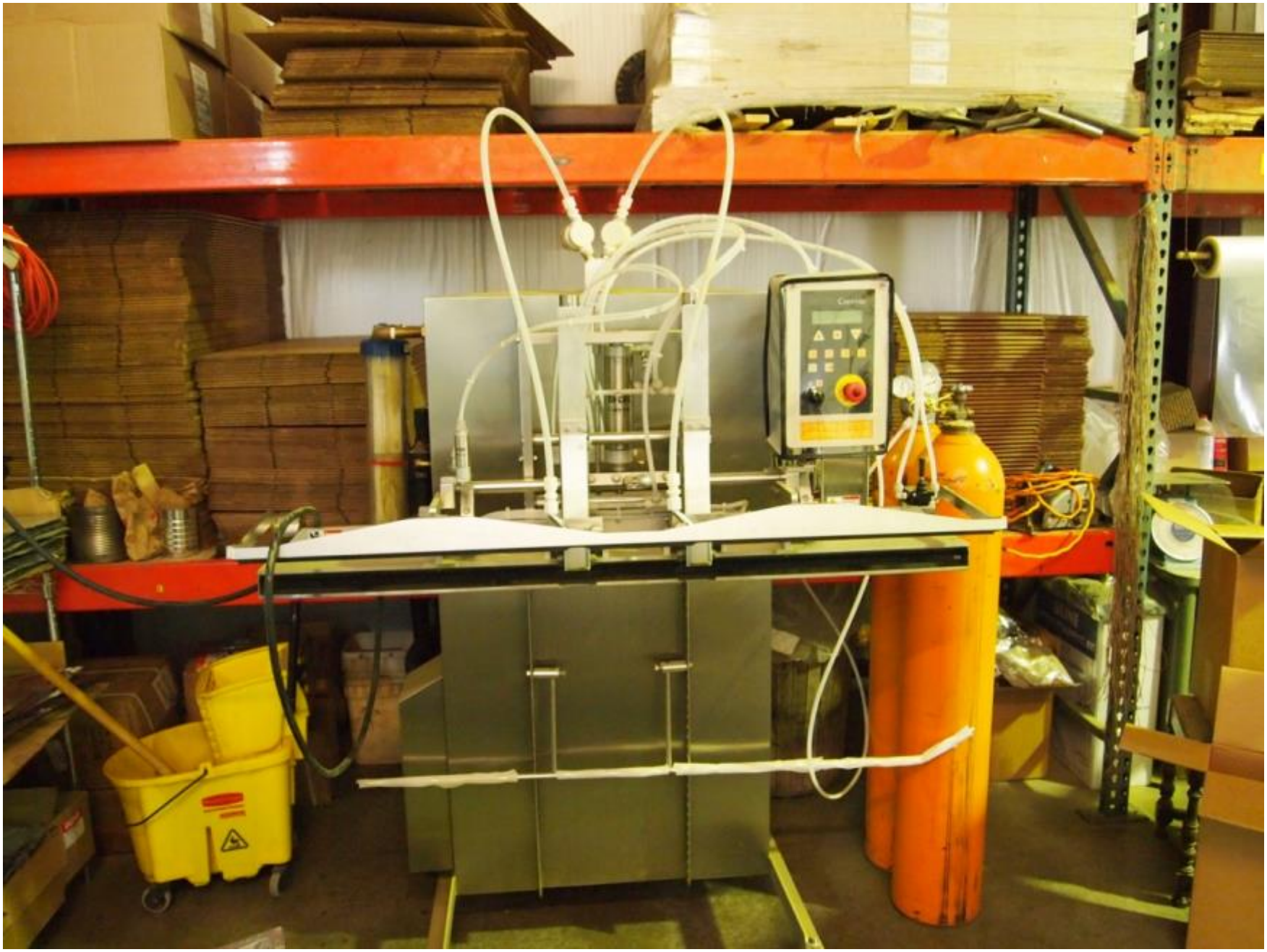


Fig. 1. The effect of 6 months storage on alpha-acids of hop pellets. BG, Brewers Gold; EA, Efes Aroma; G, Galena; NB, Northern Brewer; S, Saaz; a, Initial; b, 3°C storage; c, Room temperature storage.







Brewer Needs

- Hops are generally purchased as extracts, whole flower, or pelletized with quality defined by:
- α-acid, B-acid (as % dry weight)
- Cohumulone content (as % α-acid)
- Total Oil (as % dry weight)
- Hop Storage Index

Results:

- Pelletized: All but one!!
- α-acid: 80%, cohumulone: 14%
- Storage or packaging: 23%

Further considerations

- Food Safety
- HAACP plan
- Traceability
- Record keeping
  - Yields
  - lot location
  - harvest date
  - quality
  - climatic conditions
- Food grade facility
  - MDARD

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

Hops: Cost of Production

MICHIGAN STATE UNIVERSITY | Extension

Table 1. 2013 Hopyard Preparation and Establishment Costs (Per Acre and Per 5 Acre yard)

Land Preparation		Per Acre	Notes		5 Acre Yard
Disc	$	26.00	$26/acre	$	130.00
Establishment					
Post Holes- digging	$	312.50	2.5 hrs * $125/hr (145 hp tractor)	$	1,562.50
Post Holes-placement	$	750.00	6 hrs * $125/hr	$	3,750.00
Poles-field	$	1,590.00	50 @ $30/pole	$	7,950.00
Poles-end~	$	1,840.00	46 @ $40/pole	$	5,360.00
Earth Anchor	$	650.00	50 per acre @ $13 each	$	3,250.00
Wire	$	1,000.00	Galvanized 7 strand ($800) + #9 ($200)	$	5,000.00
Misc Hardware/supplies	$	500.00	staples, etc.	$	2,500.00
Labor-poles	$	480.00	4 workers- $10/hr x 12 hrs	$	2,400.00
Management	$	240.00	12 hrs @ $20/hr	$	1,200.00
Hop Plants	$	3,000.00	($3/plant, 1000 plants per acre; 14' x 3.5')	$	15,000.00
Labor-planting	$	700.00	(70 hrs x $10/hr)	$	3,500.00
Irrigation^	$	1,500.00	Includes installation	$	7,500.00
Well			Variable		
Total Initial Costs	$	12,588.50		$	59,102.50

~ For a 5 acre yard: 53 field poles/ac & 27 end poles/ac=265 field poles and 134 end poles or 80/acre

^ 50 gallon/min, 2 inch main (no filtration)-cost is variable depending upon needs, # zones, etc.

Table 2. 2013 Hopyard Annual Operating Costs and Returns (Per Acre)

	Year 1	Year 2	Year 3	Year 4	Year 5
Annual Operating Costs					
Coir (1 string yr 1; 2 strings yr 2 +, $.20/ string; clips $80)	$ 240.00	$ 480.00	$ 480.00	$ 480.00	$ 480.00
Labor-stringing (5 workers x 10 hours X $10/hr)	$ 350.00	$ 500.00	$ 500.00	$ 500.00	$ 500.00
Labor-training	$ 500.00	$ 750.00	$ 750.00	$ 750.00	$ 750.00
Pest/Disease Chemicals (insecticide/fungicide/herbicide)	$ 400.00	$ 600.00	$ 600.00	$ 600.00	$ 600.00
Fertilizer	$ 250.00	$ 275.00	$ 275.00	$ 275.00	$ 275.00
IPM Consultant	$ 25.00	$ 25.00	$ 25.00	$ 25.00	$ 25.00
Repairs/Parts/Maintenance		$ 250.00	$ 250.00	$ 250.00	$ 250.00
Machinery/Labor -Stringing	$ 100.00	$ 100.00	$ 100.00	$ 100.00	$ 100.00
Machinery/Labor -Fertility	$ 300.00	$ 400.00	$ 400.00	$ 400.00	$ 400.00
Machinery/Labor -Mowing/Till	$ 100.00	$ 100.00	$ 100.00	$ 100.00	$ 100.00
Machinery/Labor- Spraying	$ 300.00	$ 350.00	$ 350.00	$ 350.00	$ 350.00
Subtotal	*$ 2,565.00*	*$ 3,830.00*	*$ 3,830.00*	*$ 3,830.00*	*$ 3,830.00*
Harvest					
Labor-harvesting (10 hrs, 4 workers-cut, load)		$ 400.00	$ 400.00	$ 400.00	$ 400.00
Management ($20/hr* 10 hrs)		$ 200.00	$ 200.00	$ 200.00	$ 200.00
Machinery ($125/hr)		$ 1,250.00	$ 1,250.00	$ 1,250.00	$ 1,250.00
Subtotal		*$ 1,850.00*	*$ 1,850.00*	*$ 1,850.00*	*$ 1,850.00*
Total Annual Operating Costs	**$ 2,565.00**	**$ 5,680.00**	**$ 5,680.00**	**$ 5,680.00**	**$ 5,680.00**

- Analysis does not include land cost or overhead like interest on loans, taxes, etc.
- Does include per hour rate for machinery, labor, and management that would be charged if hired out (opportunity cost)
- Standard trellis design is 3.5 x 14 ft ~1000 plants/acre





Post Harvest Costs					
Picking processing fees **($6/lb.)** (energy, supplies, labor, etc.)	$ 4,500.00	$ 6,750.00	$ 9,000.00	$ 9,000.00	
Transport to processor (variable)	$ 500.00	$ 500.00	$ 500.00	$ 500.00	
Interest on Equipment (picking machine, hammer mill, pelletizer)					
Sales Costs (Commission, transportation, shipping, etc.)					
Subtotal	*0*	*$ 5,000.00*	*$ 7,250.00*	*$ 9,500.00*	*$ 9,500.00*
Gross Revenue/acre					
Percent of total yield- (full production 1500 lbs. dried/acre)	0	50%	75%	100%	100%
Total yield in pounds dried/acre	0	750	1125	1500	1500
Fresh wholecone wet ($5-6 /lb.)					
Wholecone dried ($10-12/lb)					
Pellitized ($12-14/lb.)	0	$ 10,500.00	$ 15,750.00	$ 21,000.00	$ 21,000.00
Net Revenue/acre	**$ (2,565.00)**	**$ (180.00)**	**$ 2,820.00**	**$ 5,820.00**	**$ 5,820.00**

- UVM-$1.60/lb for picking only
- A couple of MI processors- ~$5.50/lb (including a 10% sales commission)
- Ontario $4.50/lb (no sales or marketing)
- Quebec and BC- (they charge 35% of sales amount) or currently $5.50/lb since they are selling for close to $16/lb (including access to mechanized harvester + dryer) and post-harvest services (including pelletization, packaging, commercialization)
- A group in Wisconsin was charging $4/lb just for pelletizing, packaging, and selling.
- **Depends on your assumptions (lbs per acre, cost of labor, payment on debt, etc.), but it looks like things are shaking out at around $5/lb for the process of picking through selling.**

Marketing

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

Hops: Markets

MICHIGAN STATE UNIVERSITY | Extension


125-Year Brewery Count
(1887-June 2012)
Number of U.S. Breweries
2,500
2,000
1,500
1,000
500
0
2,011
1,179
703
89
2,126
(Prohibition)
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year

U.S. BEER SALES 2013

OVERALL BEER
-1.9%
196,241,321 bbls

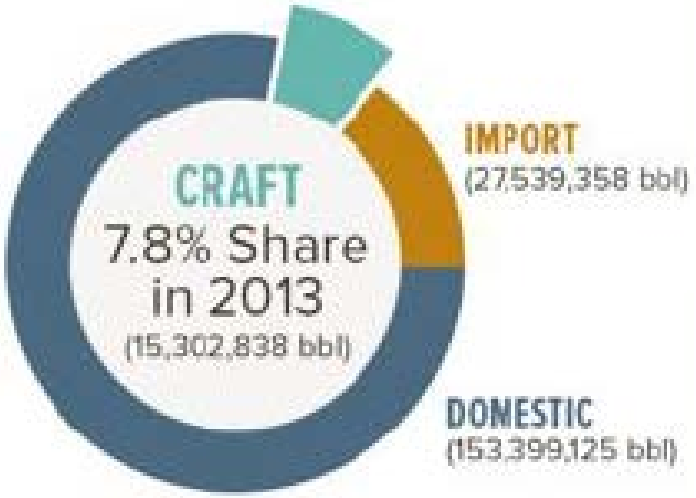
17.2%
CRAFT
15,302,838 bbls

IMPORT BEER
-0.6%
27,539,358 bbls

49%
EXPORT CRAFT BEER
282,526 bbls

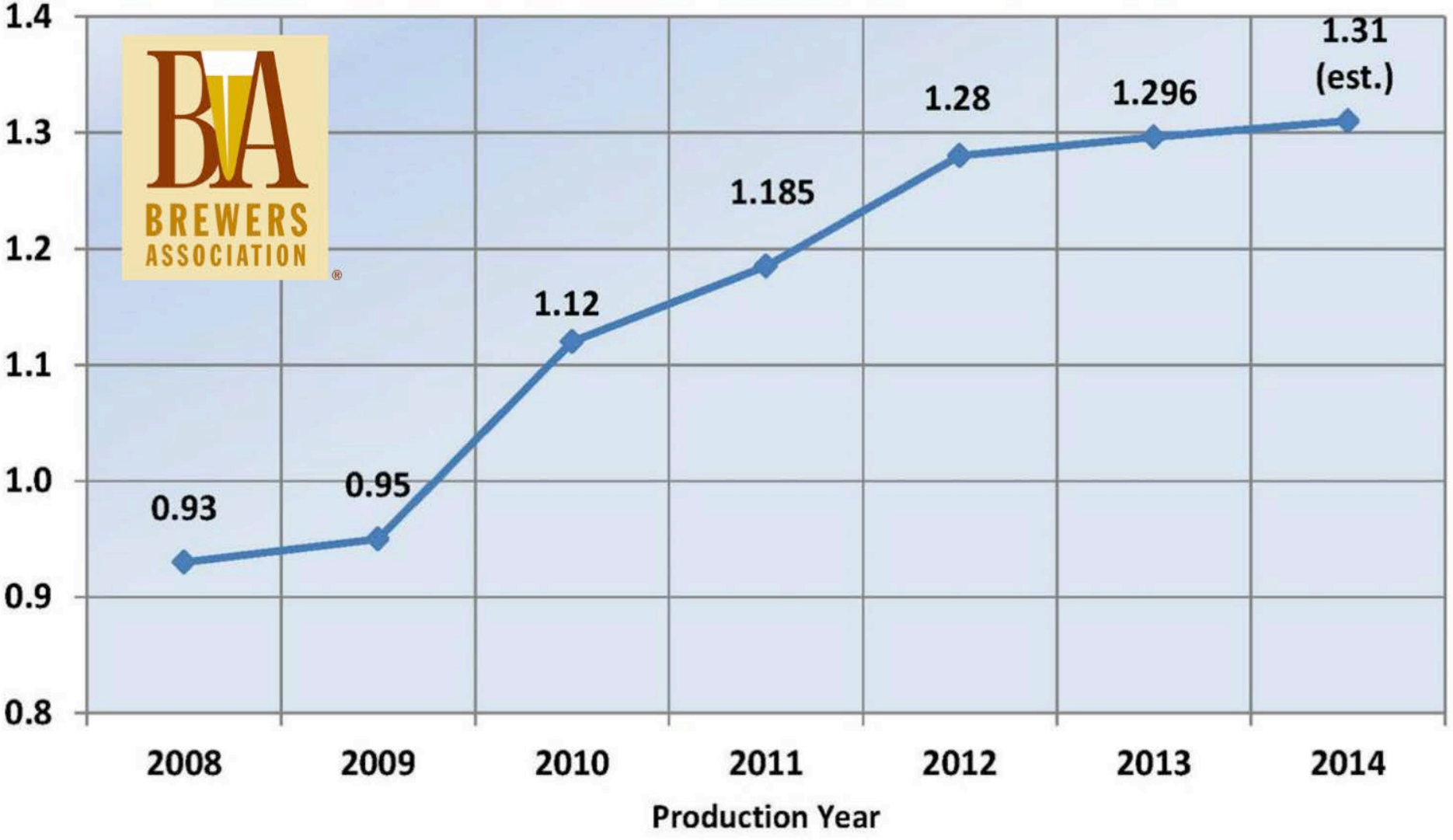
OVERALL BEER MARKET
$100 BILLION

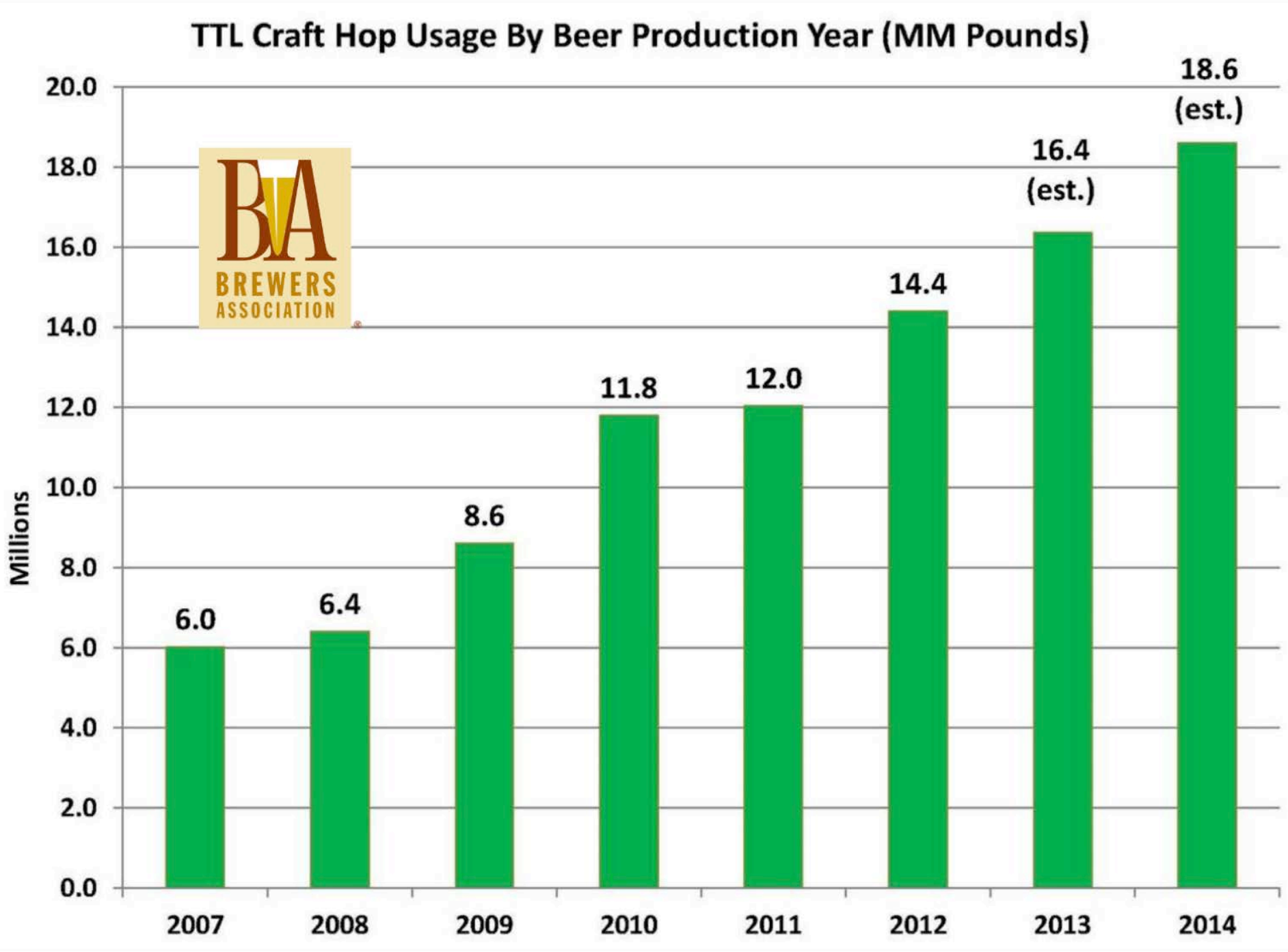
CRAFT BEER MARKET
$14.3 BILLION
20% DOLLAR SALES GROWTH



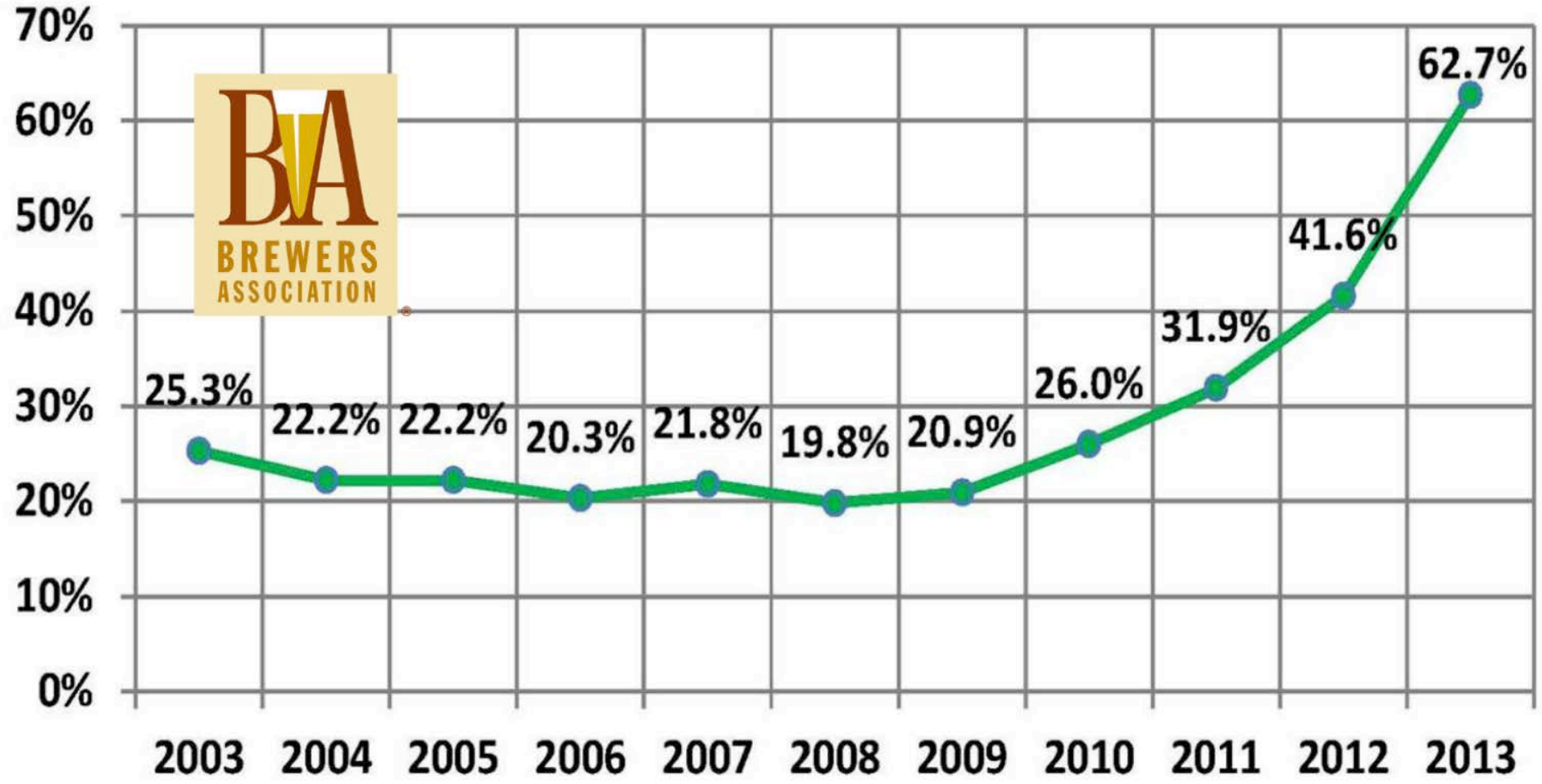
Source: Brewers Association, Boulder, CO

US Craft Beer Hopping Rates (TTL Pounds / TTL BBL)




TTL Craft Hop Usage By Beer Production Year (MM Pounds)
BREWERS ASSOCIATION
Millions
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
6.0
6.4
8.6
11.8
12.0
14.4
16.4 (est.)
18.6 (est.)
2007
2008
2009
2010
2011
2012
2013
2014

Aroma Hop Acreage as % TTL US Acres



2013 Beer Sold in MI (bbls)

All Beer 6,257,864 bbls

All Craft Beer 452,000, 7.2%

MI Craft Beer 297,000, 4.7%

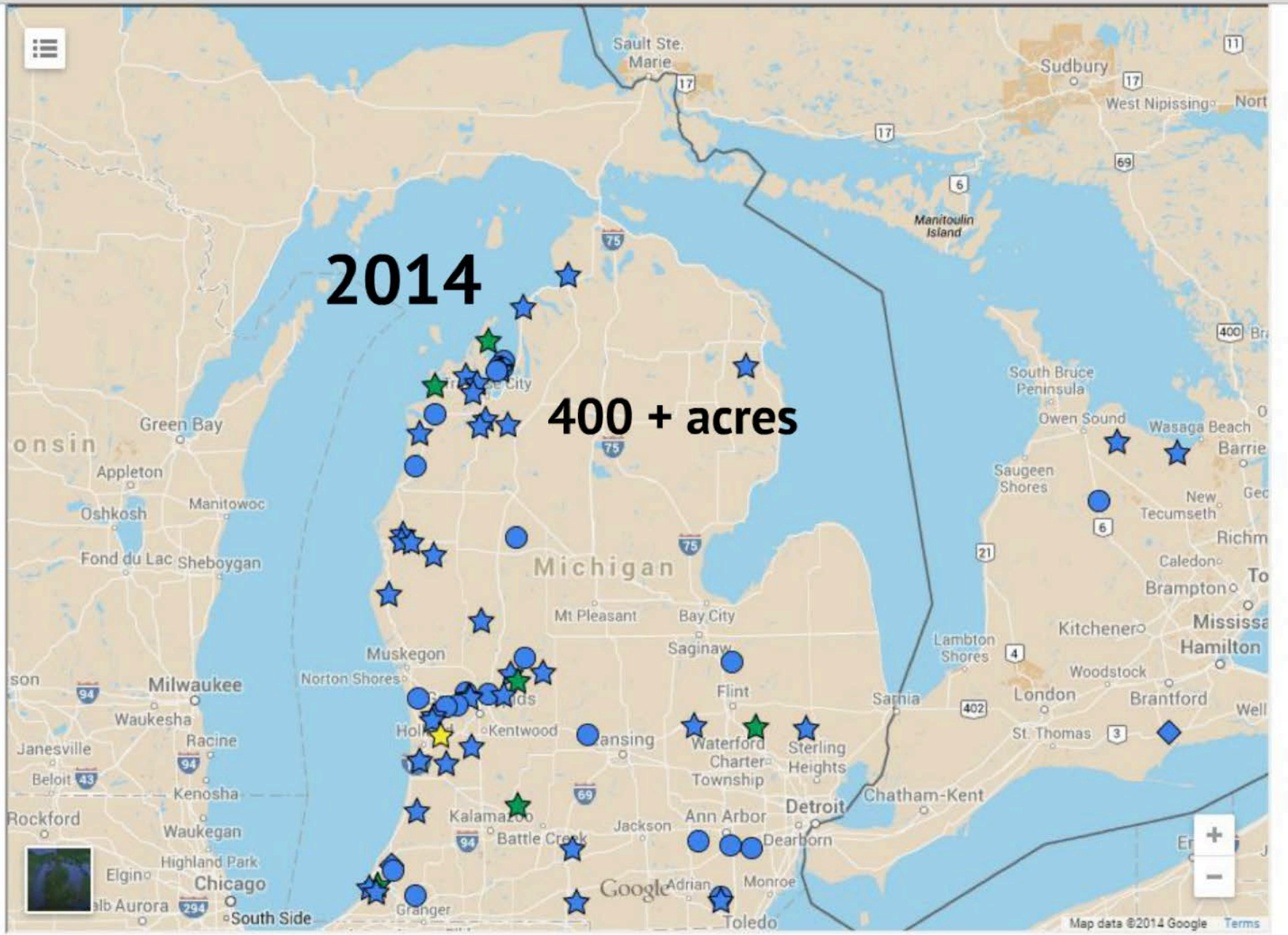
Blue Stars - Growers who have confirmed hop varieties and contact information.

Green Stars - Growers who have more than 10,000 plants and have confirmed hop varieties.

Yellow Stars - Great Lakes Hops!

Diamonds - Research centers and Universities.

Circles - Growers who have not yet confirmed data. (Turn me into a star!)



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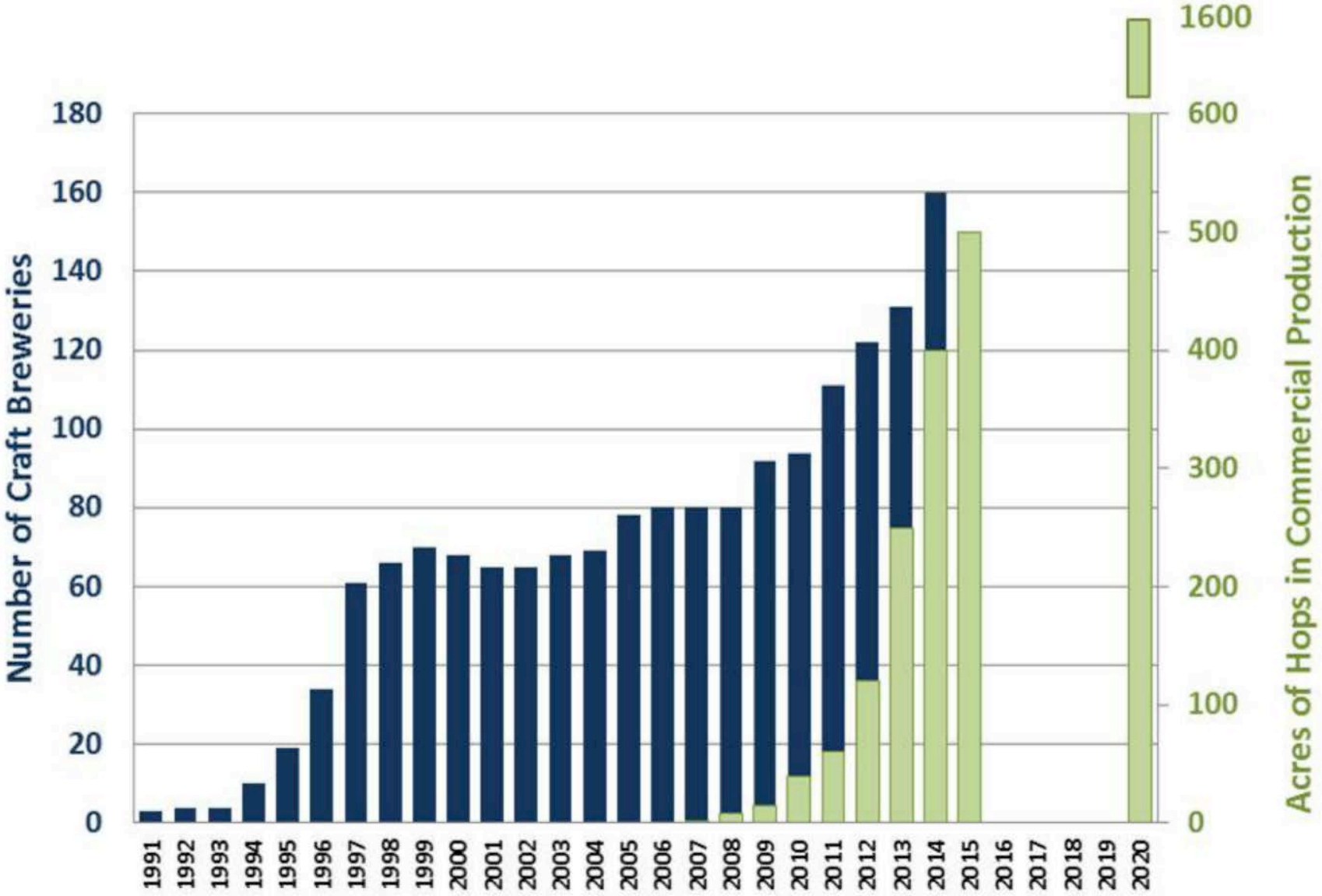
Growth in Michigan's Craft Beer and Hop Supply Chain Sectors







TAKE HOME MESSAGES

-Quality is crucial, brewers want pellets

-Do not skimp on establishment

-Post-harvest very important

-Hi initial and annual costs

-Don’t underestimate the amount of labor required

-Need for picking and processing equipment if you plant >1/2 acre

-Line up supplies well in advance

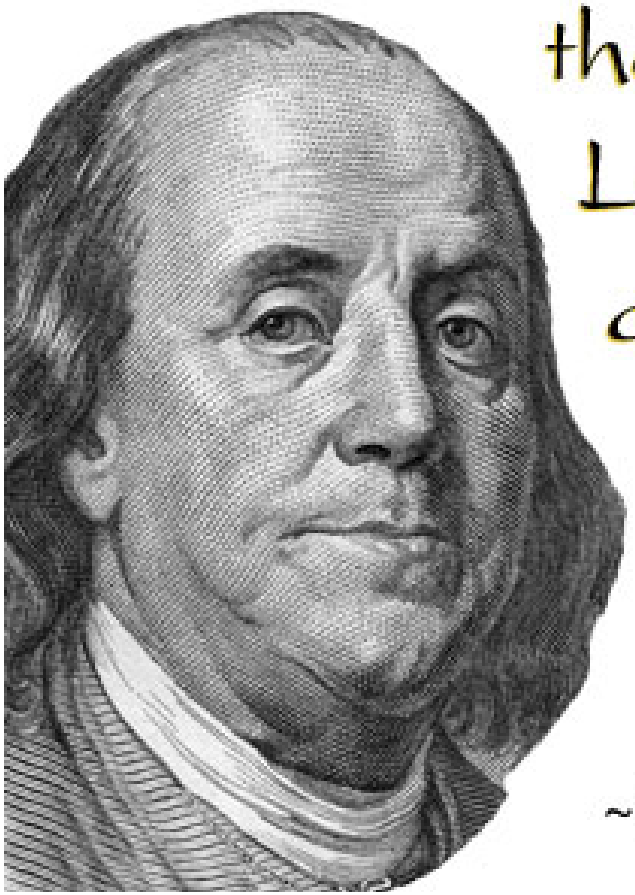
-How will you sell your hops and to whom?

-You will need a price premium to do organic



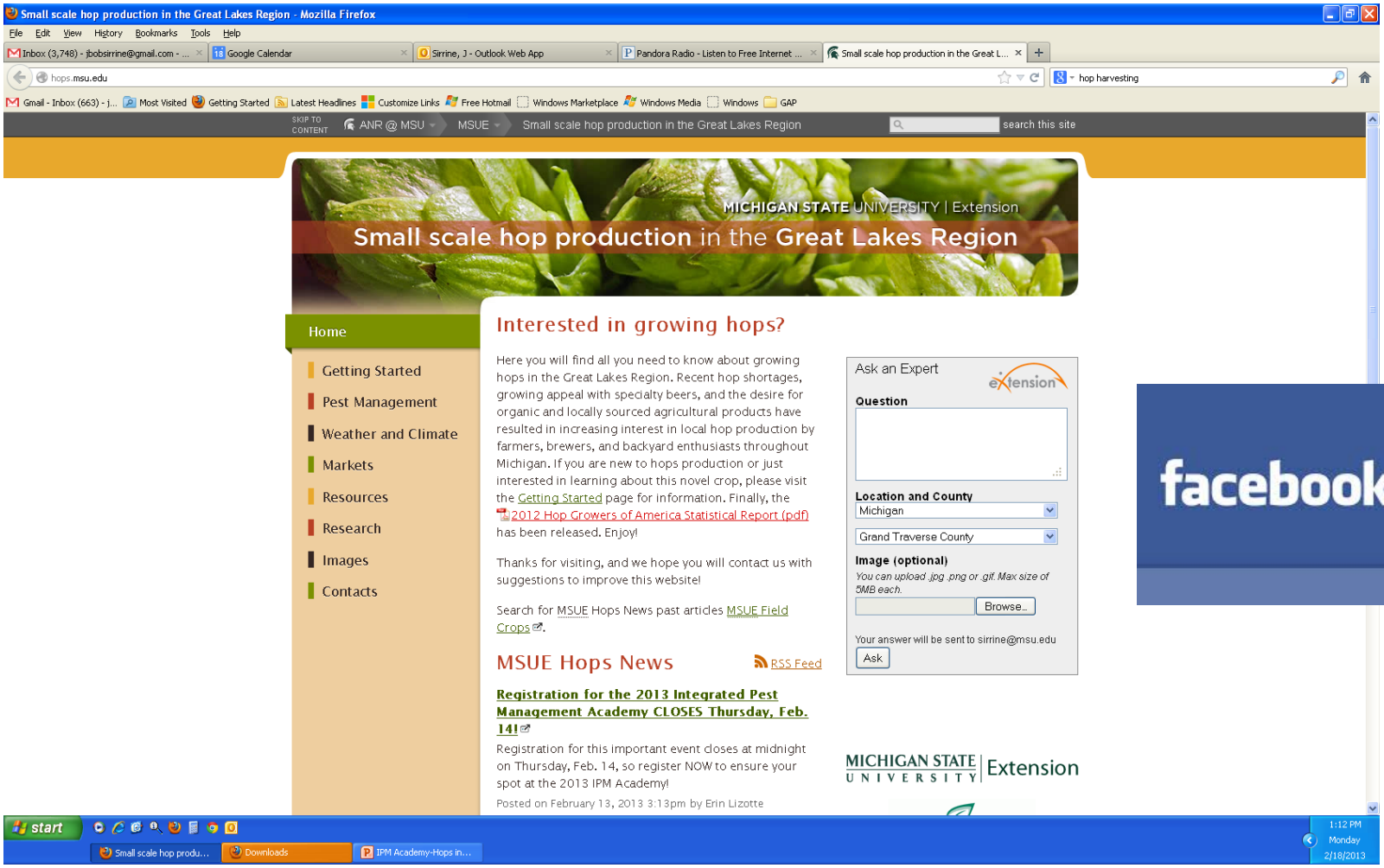


Beer is living proof that God Loves Us and wants us to be Happy



~Benjamin Franklin

http://www.hops.msu.edu



SAVE THE DATE:
2015 Great Lakes Hop and Barley Conference

APRIL 10-11, 2015
Grand Rapids, MI