



**“AND
★ ★ ★ ★ ★ ★ ★ ★
JUSTICE
★ ★ ★ ★ ★ ★ ★ ★
FOR ALL”**

The U.S. Department of Agriculture (USDA) is pleased to announce that it has approved the purchase of the land of the... (text is very small and difficult to read)

The Department of Agriculture (USDA) is pleased to announce that it has approved the purchase of the land of the... (text is very small and difficult to read)



Hops: Cost of Production

Rob Serrine

Great Lakes Hop & Barley Conference

April 10, 2015

MICHIGAN STATE
UNIVERSITY

Extension



Outline

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

Hop Value-Chain





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.

Hops: Trellis Design





Climbing vines

- 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)





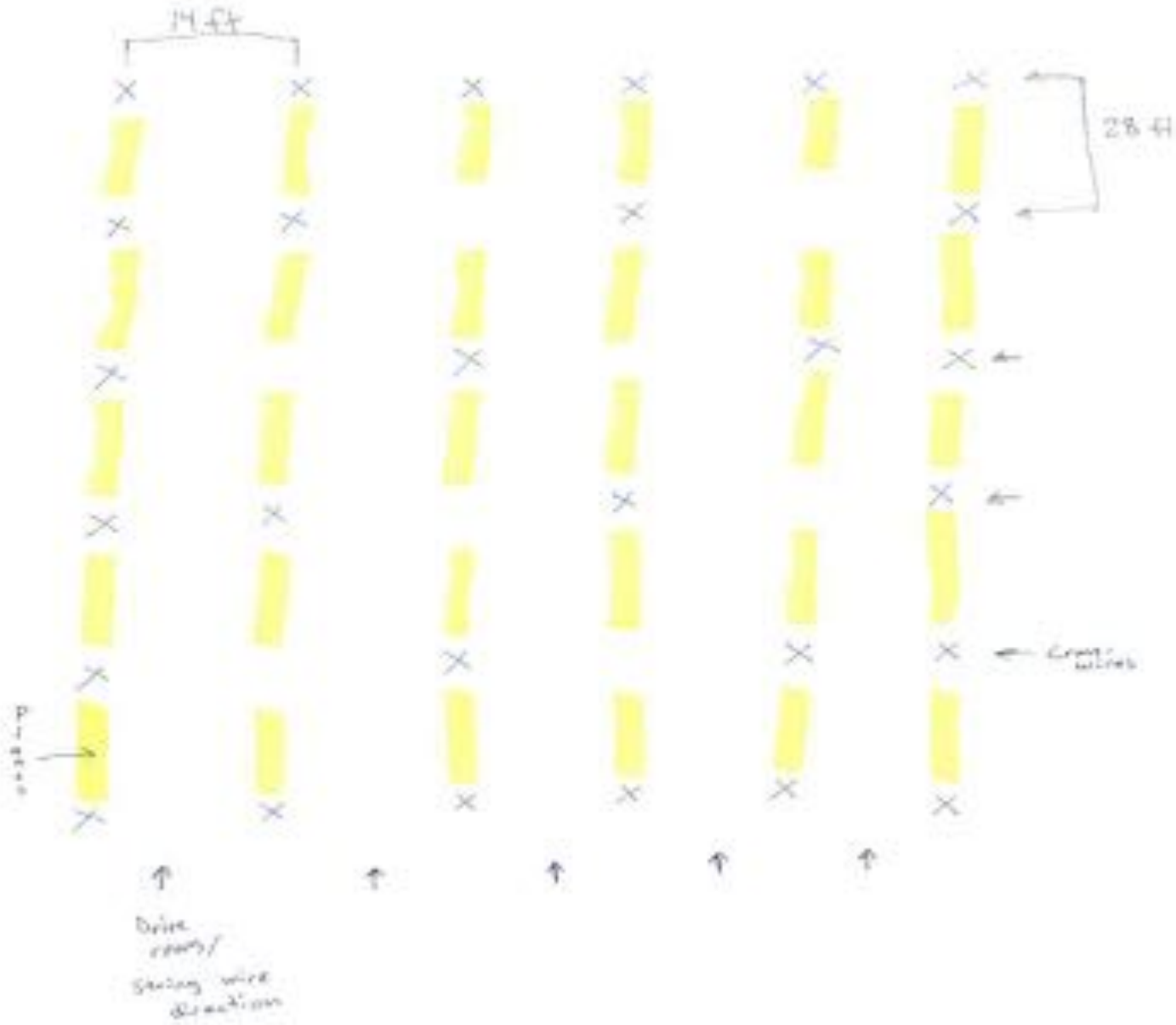
Conventional High Trellis

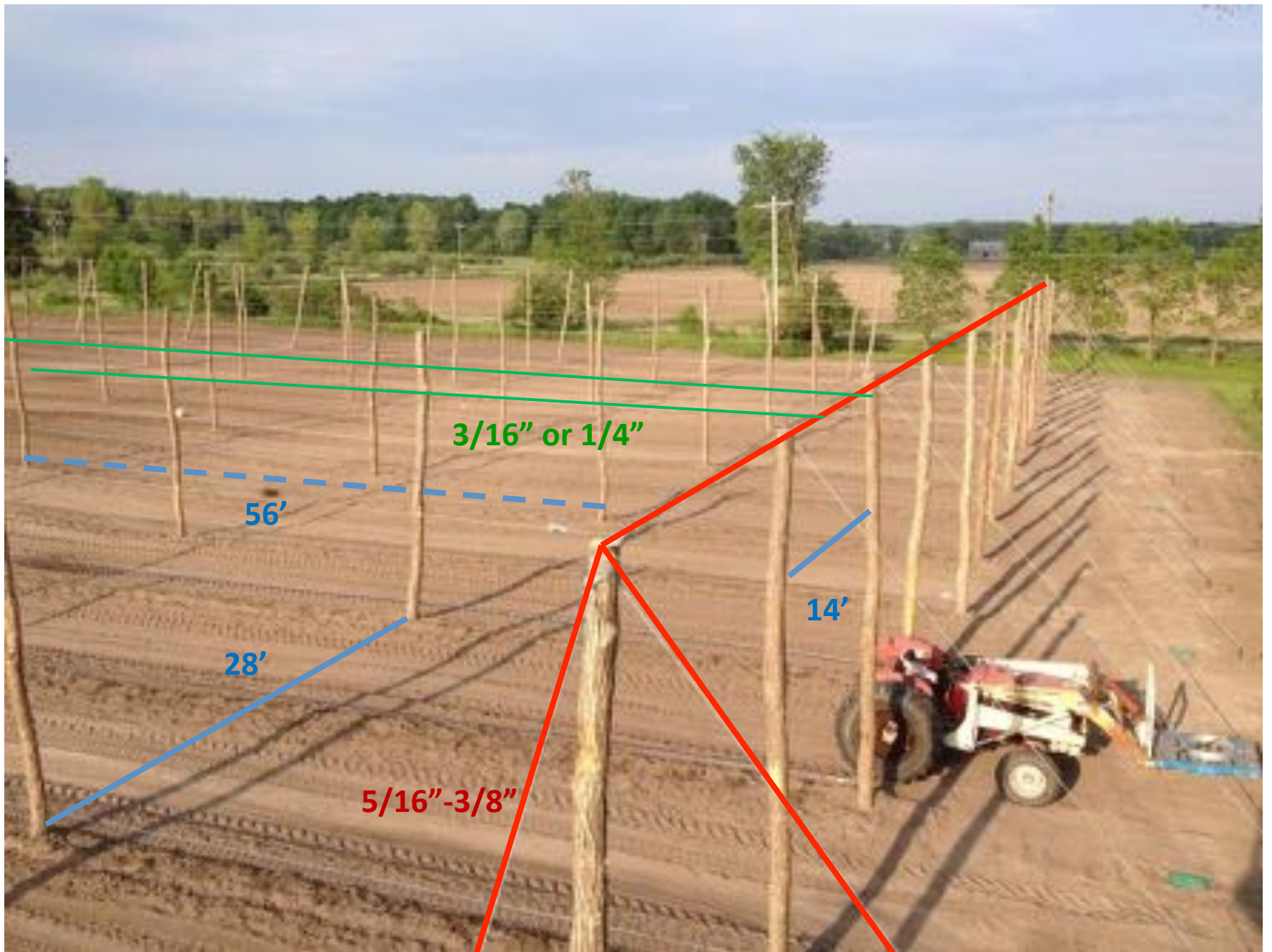






Standard Tall Trellis Hopyard Design





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





Factors that can impact hop production (growth, yield, and quality) & your net returns

- 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

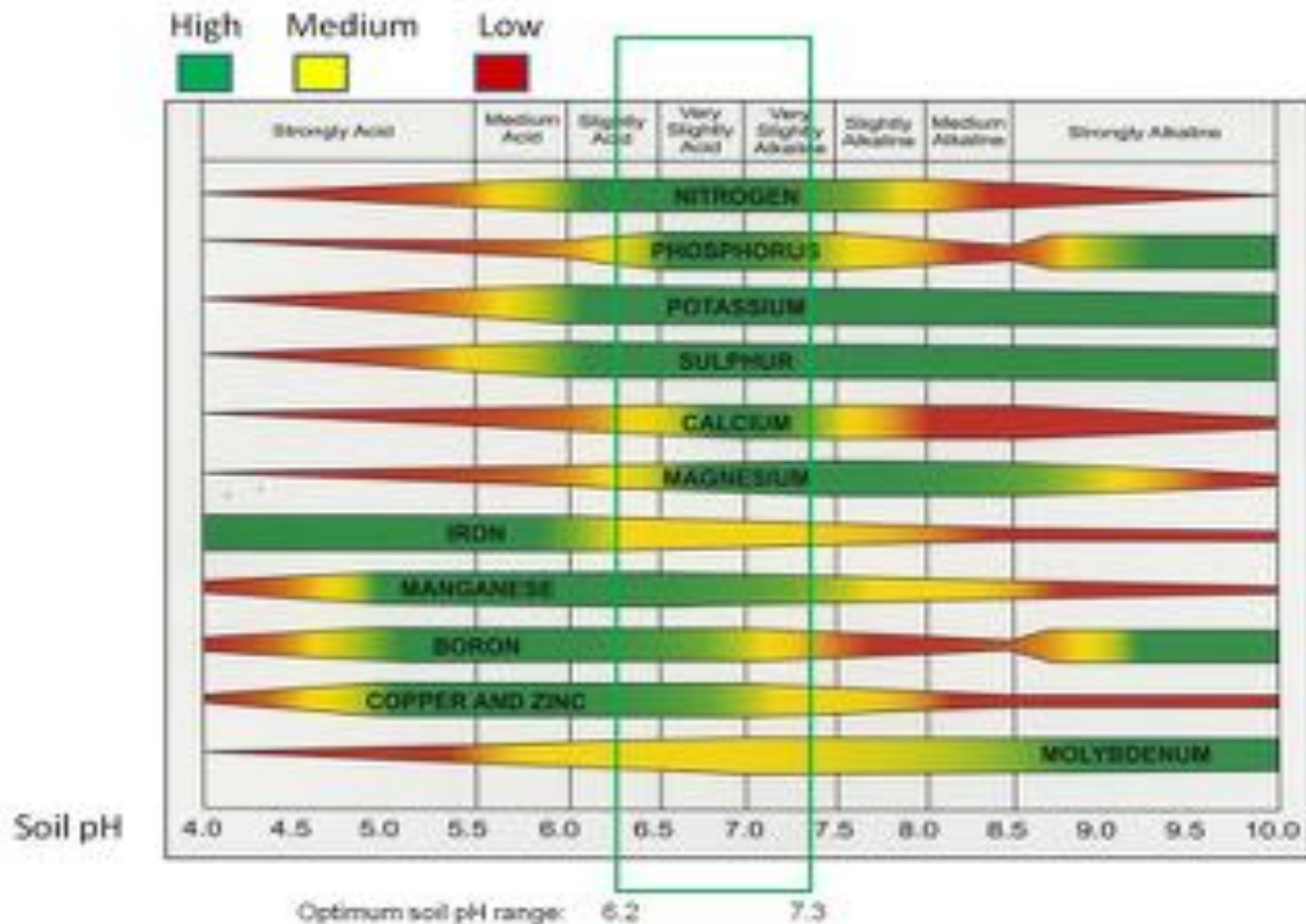


Source: Neve, R.A. Hops. 1991

Hops and pH

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

How soil pH affects availability of plant nutrients





Hop Production Stages

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



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**





Variety	Usage	Disease Susceptibility*		
		Powdery Mildew	Oomy 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 Mittlefeh	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
Parla	Aroma	S	R	MR
Pioneer	Bittering	MR	MR	U
Saxxon	Aroma	S	MS	S
Saxxon 35	Aroma	S	MS	S
Spatel	Aroma	S	R	MR
Stirling	Aroma	MS	MR	U
Teamaker	Aroma	MR	MR	S
Tetnanger	Aroma	MS	MS	S
Tolhurst	Aroma	S	S	U
U.S. Tetnanger	Aroma	MS	MS	S
Vanguard	Aroma	S	S	U
Willamette	Aroma	MS	MR	S

Variety selection

1. What brewers want
2. Yield
3. Disease resistance
4. Location-soil type, etc.

These will affect your bottom line



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



Kinsey Agricultural Services, Inc.

267 County Highway 987 • Charleston, MI 48824
Phone 877-463-0862 Fax 877-463-4327 e-mail KAS@KinseyAg.com

Client: MICHIGAN STATE UNIVERSITY EXTENS

City: SUTTONS BAY, MI

Date: 10-Sep-12

Location		TORY STATION		Previous Analyses & Applications			
One		HOPS (HOPS)					
Field / Source		N					
Lab No.		80100					
Total Exchange Capacity (CEC)		7.58					
Desired Ca - 1/2 Percent		55 - 14					
pH of Soil Sample		7.0					
Humus Content Percent		1.8					
BASE SATURATION PERCENT				%		%	
Calcium (50 to 70%)		76.18					
Magnesium (10 to 20%)		15.67					
Potassium (2 to 5%)		2.88		FOR ORGANIC		FOR CONVENTIONAL	
Sodium (.5 to 3%)		0.92					
Other Bases (K/Na/Cl)		4.28					
EXCHANGEABLE HYDROGEN (10 to 15%)		6.00					
		RECOMMENDATIONS					
		Amendment		Lbs/Acre		Lbs/Acre	
N	NITROGEN	Desired Value	38	FEATHER MEAL 13-0-4 (B)		UREA 46-0-0 (C)	
				FEATHER MEAL 13-0-4 (B)		SULF 21-0-0-24 (D)	
S	SULFATE - S	Value Found	18	SULFUR 90-00% (E)		SULFUR 90-00% (E)	
				COMPOST		LIQUID N 32% (F)	
P	PHOSPHATES	Desired Value	750				
		Open Value					
		Value Found	626				
		Deficit/Surplus	-124				
Ca	CALCIUM	Desired Value	2042	NONE			
		Value Found	2309				
		Deficit/Surplus	+267				
Mg	MAGNESIUM	Desired Value	250	NONE			
		Value Found	285				
		Deficit/Surplus	+35				
K	POTASSIUM	Desired Value	442	POT SULFATE 0-4-96 (G)		POT SULFATE 0-4-96 (G)	
		Value Found	170	256		256	
		Deficit/Surplus	-272				
B	BORON	Desired Value	30				
		Value Found	32				
		Deficit/Surplus	-2				
Mn	Manganese	e.p.m.	0.58	BORAX 11%		BORON 14.2%	
		e.p.m.	411				
		e.p.m.	50	MANG SULF 20%		MANG SULF 20%	
		e.p.m.	1.40	CU SULFATE 20%		20	
		e.p.m.	0.92	ZINC SULFATE 36%		ZINC SULFATE 36%	

(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 all season.

(F) Apply all season.

(G) Sulfur applications including the sulfate form of 50 lbs/acre or more need to be applied at least 3 months prior to next soil sampling.

(H) Apply an additional 200 lbs/acre of Potassium Sulfate (0-0-60) 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.



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
- Before you purchase quantity, get some sample plants and send them immediately to your University lab





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.

Pruning/crowning





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



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



Somewhere In Michigan





Options for stringing

1. W clips





Options for stringing

2. Tie strings to a lower wire





<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





Table 2. 2013 Hopyard Annual Operating Costs (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
<i>Subtotal</i>	\$ 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
<i>Subtotal</i>		\$ 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





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

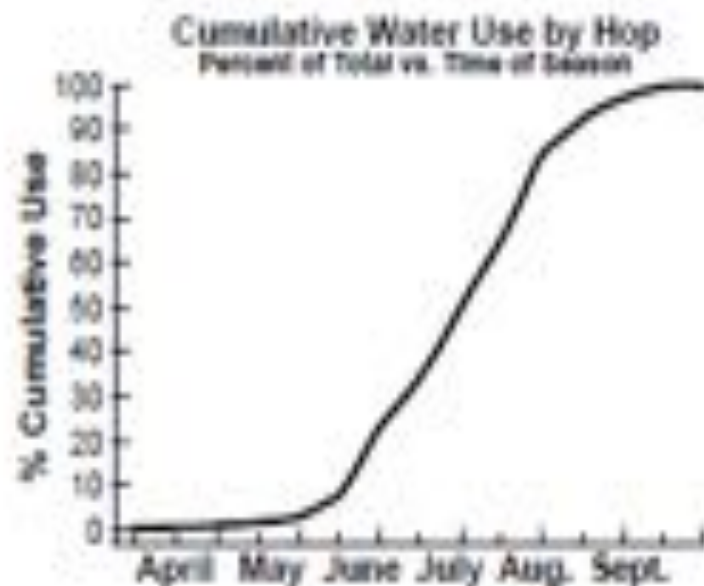


Fig. 1. Cumulative water use of hop during the growing season.



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





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) = 150 lbs/acre
 - Mid-April with urea (40-0-0) every 2-3 weeks then later come in with triple 16
 - End in July
 - 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>

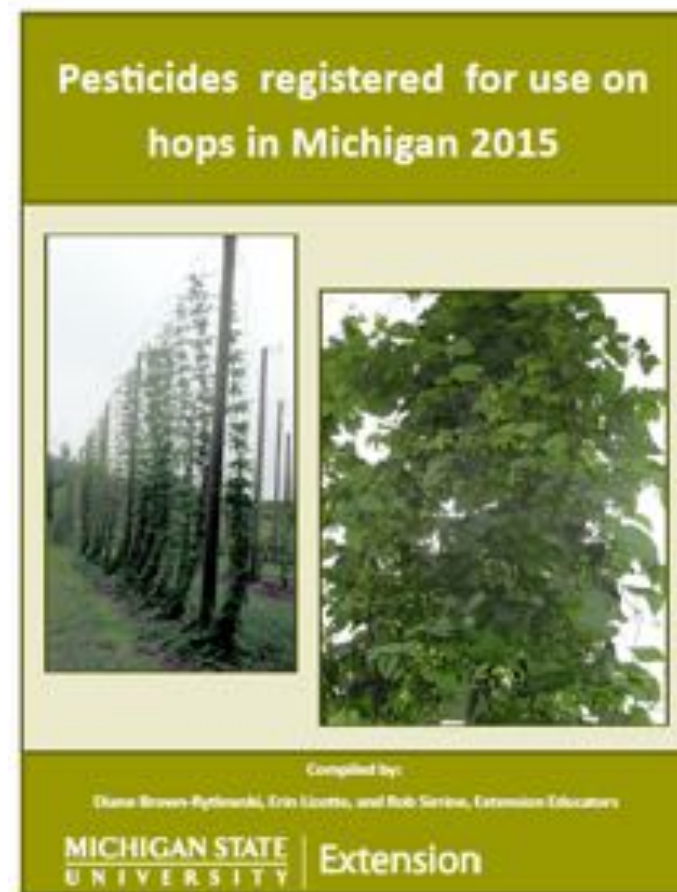




Table 2. 2013 Hopyard Annual Operating Costs and Returns (Per Acre)

	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
<i>Subtotal</i>	<i>\$ 2,565.00</i>	<i>\$ 3,830.00</i>	<i>\$ 3,830.00</i>	<i>\$ 3,830.00</i>	<i>\$ 3,830.00</i>
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
<i>Subtotal</i>		<i>\$ 1,850.00</i>	<i>\$ 1,850.00</i>	<i>\$ 1,850.00</i>	<i>\$ 1,850.00</i>
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



End of July

- Floral Production has commenced
 - Plant shifts energy into cone production
 - 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





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)
- Cured
- Baled
- Cold storage



Hop Value-Chain



Harvest Timing

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:

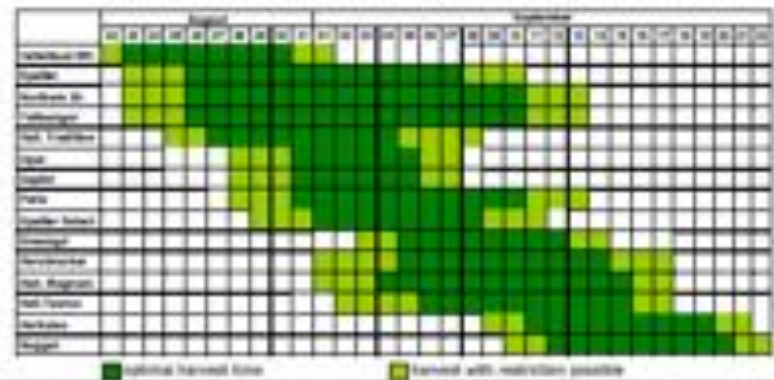
- α -acid contents
- yield
- external quality (color and shine, infection with diseases and pests, shattering)
- aroma (aroma intensity, oil content and composition)
- vigor and vitality of the plant (in the next season)



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



Removing the guesswork



Harvest Package \$50

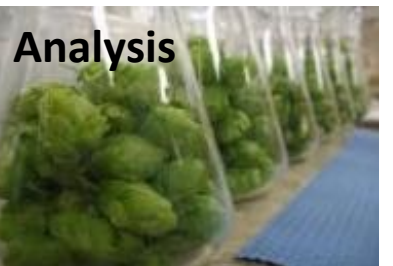
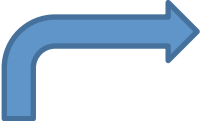
- Combining Brewing Values (alpha acids, beta acids, and hop storage index (H.S.I.)) and Dry Matter analysis, the Harvest Package is designed with hop farmers in mind.
- Results provide growers with content and characteristics of their hops and/or fields and can be utilized on an annual basis to establish 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.

By Hand





Hop Value-Chain



Hammer Mill & Pelletizer

Transport to the Picker

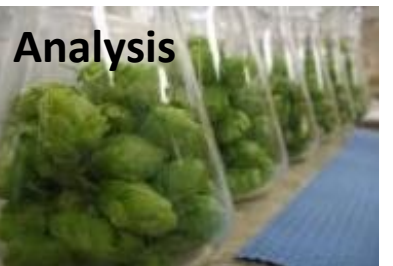
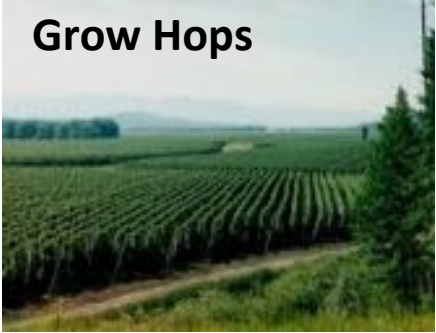
Degradation potential

- 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.



Hop Value-Chain



Hammer Mill & Pelletizer

Picking

Considerations

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



Hand Picking

- Not recommended for $>1/3$ acre



WOLF 170

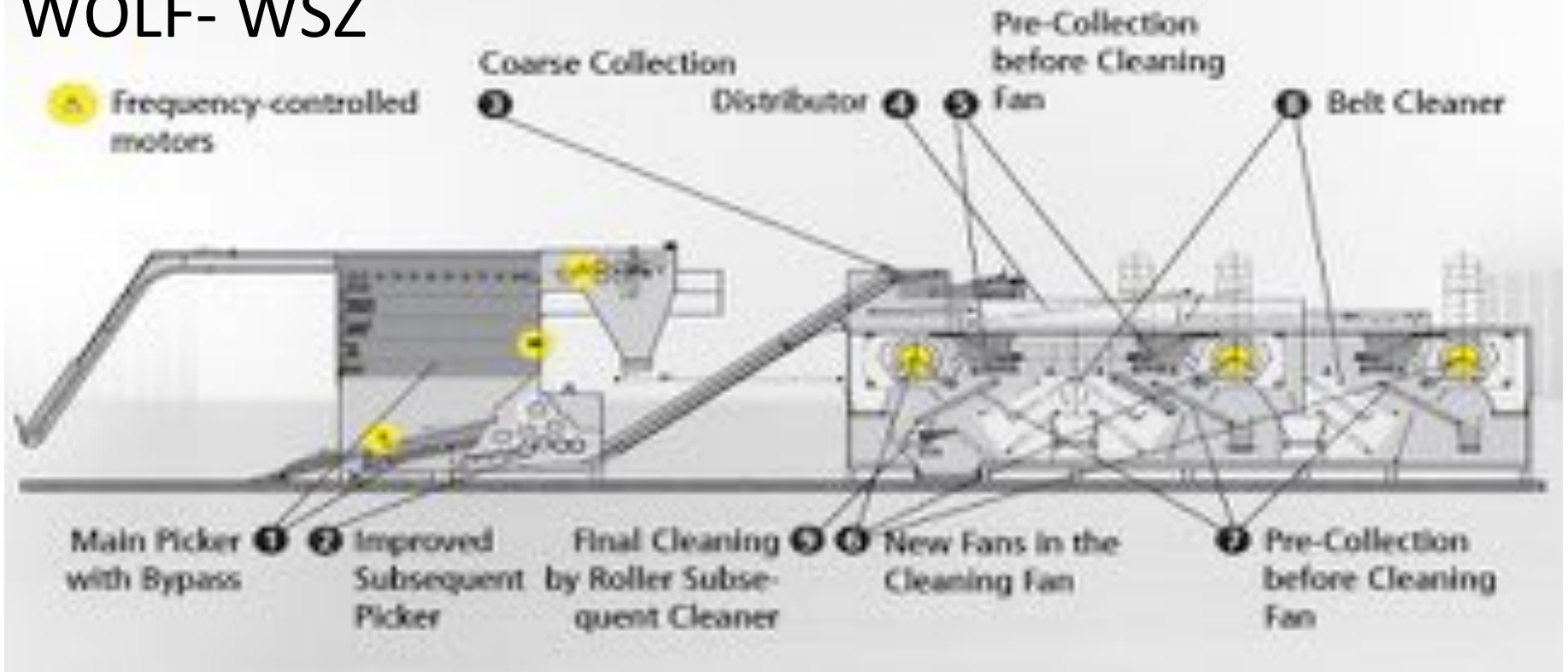


WOLF 513



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

WOLF- WSZ



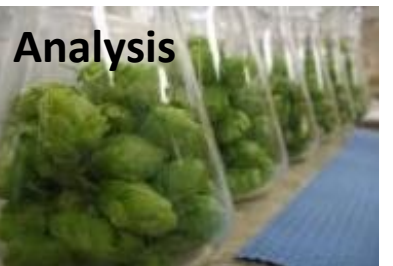
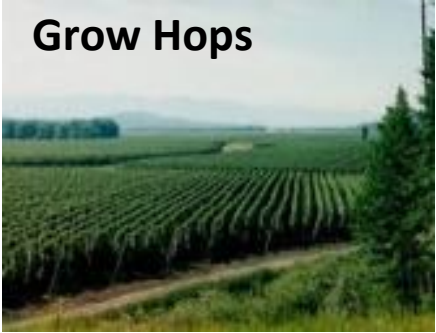
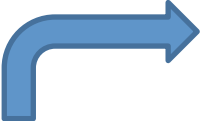
Used Wolf 2014-2015 price list

- Type 1 \$15,000.00 lim. supply
- 140 - 5 drum \$23,500.00
- 140/170 -7 drum \$25,500.00
- 220 \$40,000.00
- 280 \$45,000.00
- 400 \$85,000.00
- Pellet mill w/ vac bagger \$85,000.00
- Drying floor w/ heater \$7,500.00
- Baler \$6,500.00

Note: Does not include shipping, build-out, electrical panel

[513 video](#)

Hop Value-Chain



Hammer Mill & Pelletizer

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 impel-

NW CROPS & SOILS PROGRAM



UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

Modular Hop Oast

ler 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 berit 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-

Cost (per 4'x4'x8' cabinet)

Lumber/Screws/hardware	\$245
Angle iron for Tray Rack	\$104
1/4 HP Fan Motor	\$110
Fan Blades (from Multi-Wing)	\$78
Heating Elements 3500 Watt (from Chromalox)	\$330
Controls	\$100
Total Materials	\$970
Labor	30 Hours

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.

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/cropsol/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.



Contact:
UVM Extension NW Crops and Soils Team
[The Vermont Hops Project](http://TheVermontHopsProject)
Email: hops@uvm.edu
Phone: 802 524 8505

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.
- \$8k + \$4-6k





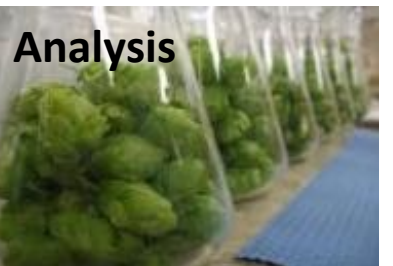
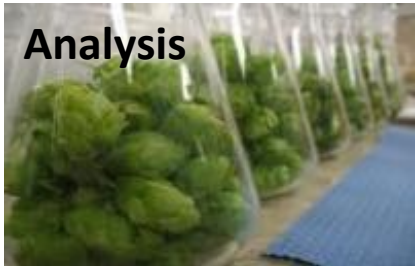
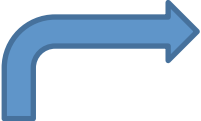
Yakima, WA







Hop Value-Chain



Conditioning



Considerations

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

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.”

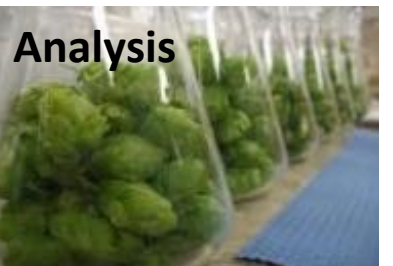
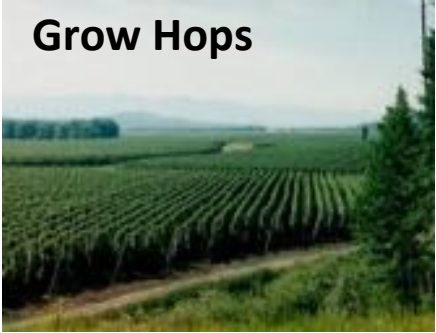
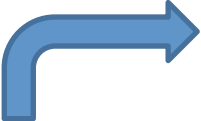


Mechanical German RB-60 Presses / Balers ~\$7k





Hop Value-Chain



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

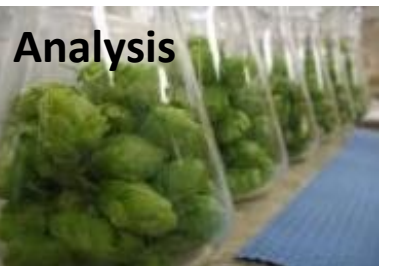
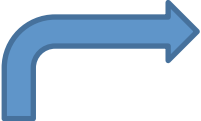
Oil Content \$20

- 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

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>



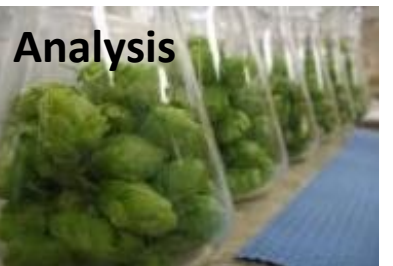
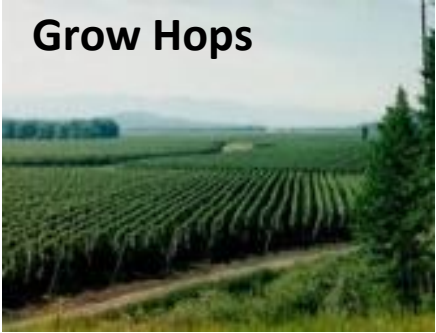
LM \$36,000

350-1000 lbs/hour

Max- 50 C around 120 F

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

Hop Value-Chain



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

Cold Storage

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





Marketing and Sales

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



Further considerations

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



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
<i>Subtotal</i>	\$ 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
<i>Subtotal</i>		\$ 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.)					
<i>Subtotal</i>	0	\$ 5,000.00	\$ 7,250.00	\$ 9,500.00	\$ 9,500.00
Total costs	(\$2,565)	(\$10,680)	(\$12,930)	(\$15,180)	(\$15,180)
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 (\$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.**

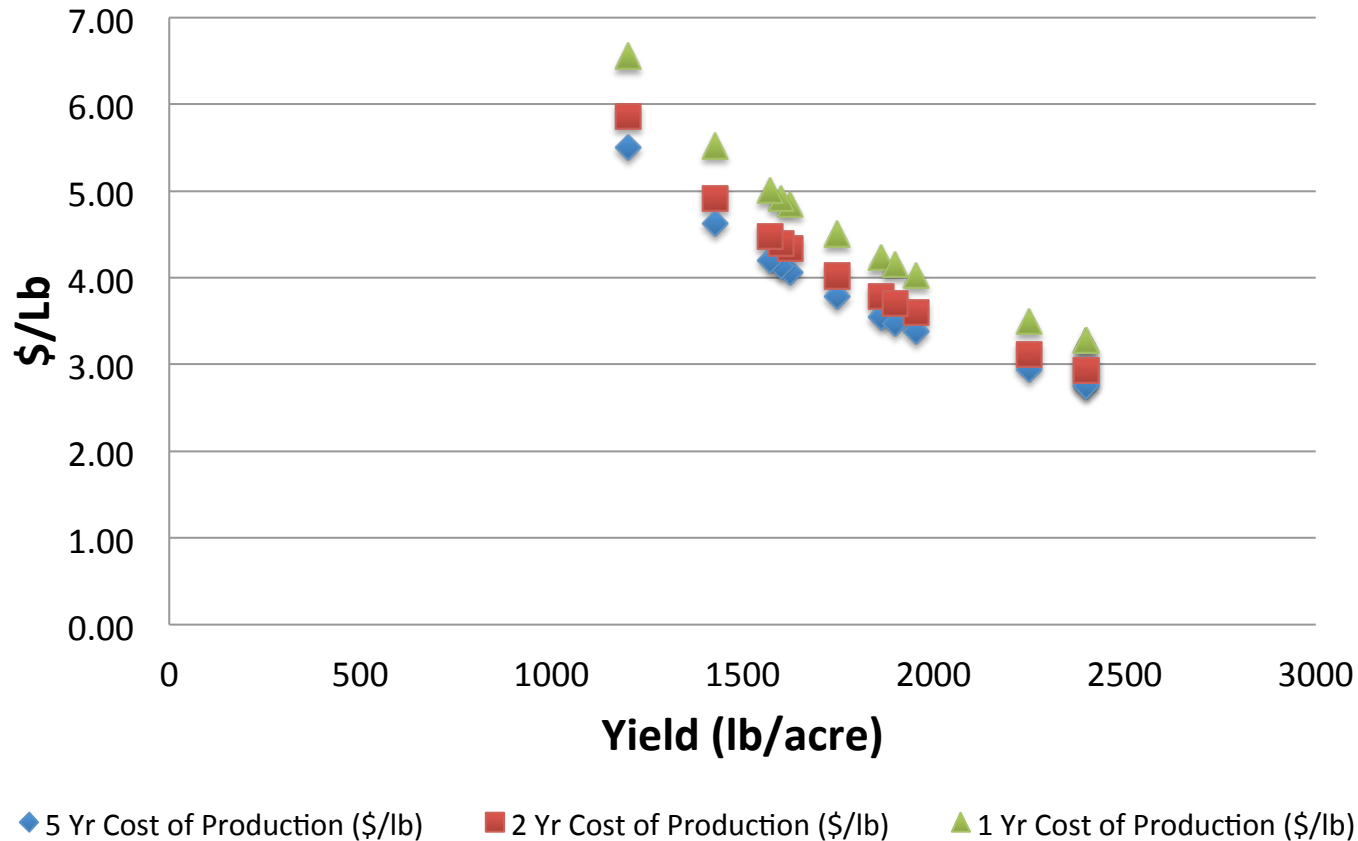
Cost of Production per pound by variety

Hop Variety	Yield (lb/acre)	5 Yr Cost of Production (\$/lb)	2 Yr Cost of Production (\$/lb)	1 Yr Cost of Production (\$/lb)
Ahtanum	1862	3.55	3.78	4.23
Cascade	1748	3.78	4.02	4.51
Centennial	1625	4.06	4.33	4.85
Chinook	1953	3.38	3.60	4.03
Citra	1428	4.63	4.92	5.52
Columbus	2250	2.94	3.12	3.50
Crystal	1600	4.13	4.39	4.92
US Northern Brewer	1200	5.50	5.86	6.56
Simcoe	2400	2.75	2.93	3.28
Sterling	1900	3.48	3.70	4.15
Warrior	2400	2.75	2.93	3.28
Willamette	1572	4.20	4.47	5.01

<http://www.brewersassociation.org/best-practices/hops/cost-of-hop-production>

Why variety and yield matter

Cost of Production \$/Lb by Average Yield Lb/Ac



- $R^2 = .95, p < 0.0001$

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

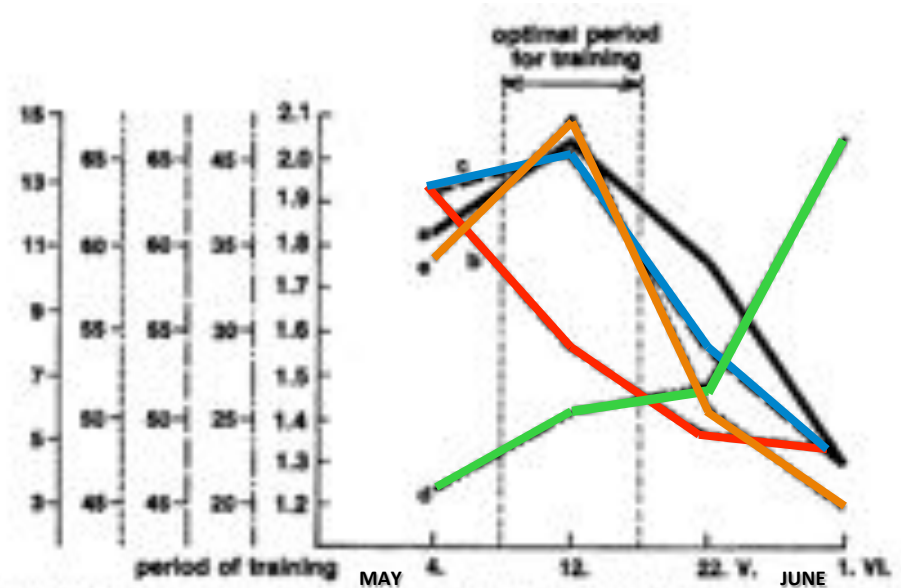


Fig. 93. Effect of time of starting training on the structure of the hop plant and on the yield of cones: a - yield (in kg) of fresh hop per plant, b - length of cones in mm, c - number of shoots, d - density of setting (number of cones per 10 cm of shoot), e - mean length of shoots (in cm).



What if price drops to \$10/lb?

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.)		-	-	-	-
<i>Subtotal</i>	<i>0</i>	<i>\$ 5,000.00</i>	<i>\$ 7,250.00</i>	<i>\$ 9,500.00</i>	<i>\$ 9,500.00</i>
Total costs	(\$2,565)	(\$10,680)	(\$12,930)	(\$15,180)	(\$15,180)
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 (\$10/lb)	0	\$ 7,500	\$ 11,250	\$ 15,000	\$ 15,000

Net Revenue/acre

\$ (2,565.00) \$ (3,180) \$ (1,680) \$ (180) \$ (180)



- **Other potential issues**

- Seed, stem, leaf content. How much is docked?
- Hand picking-increases labor costs
 - one bine per hour?
 - 1000 hours to do one acre
 - ten people-100 hours -2 weeks?
 - \$10,000 in labor alone
- How do you become a millionaire farming?
- Start with \$2 million, pretty soon you will have \$1 million

Hops: Markets



MICHIGAN STATE
UNIVERSITY

Extension

125-Year Brewery Count



U.S. BEER SALES 2013

OVERALL
BEER
-1.9%
196,241,321 bbls

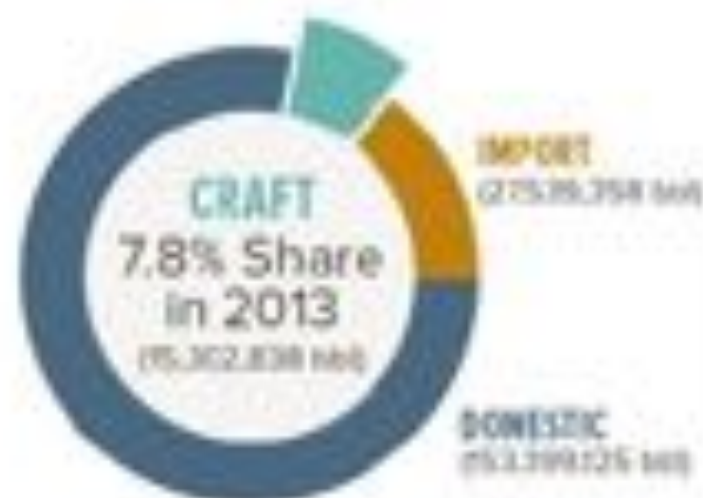
17.2%
CRAFT
15,302,838 bbls

IMPORT
BEER
-0.6%
27,526,358 bbls

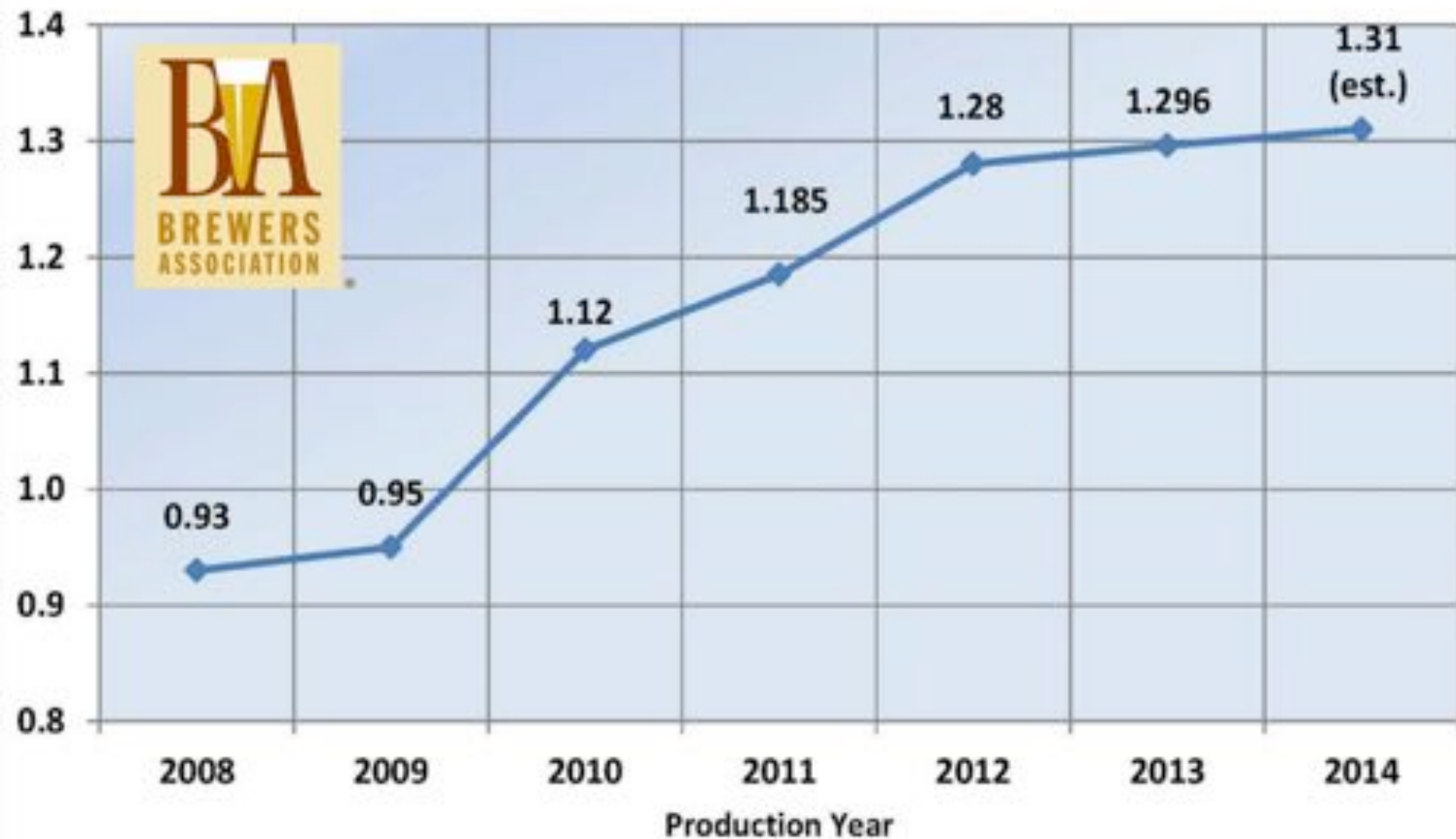
49%
EXPORT
CRAFT
BEER
282,526 bbls

OVERALL BEER MARKET
\$100 BILLION

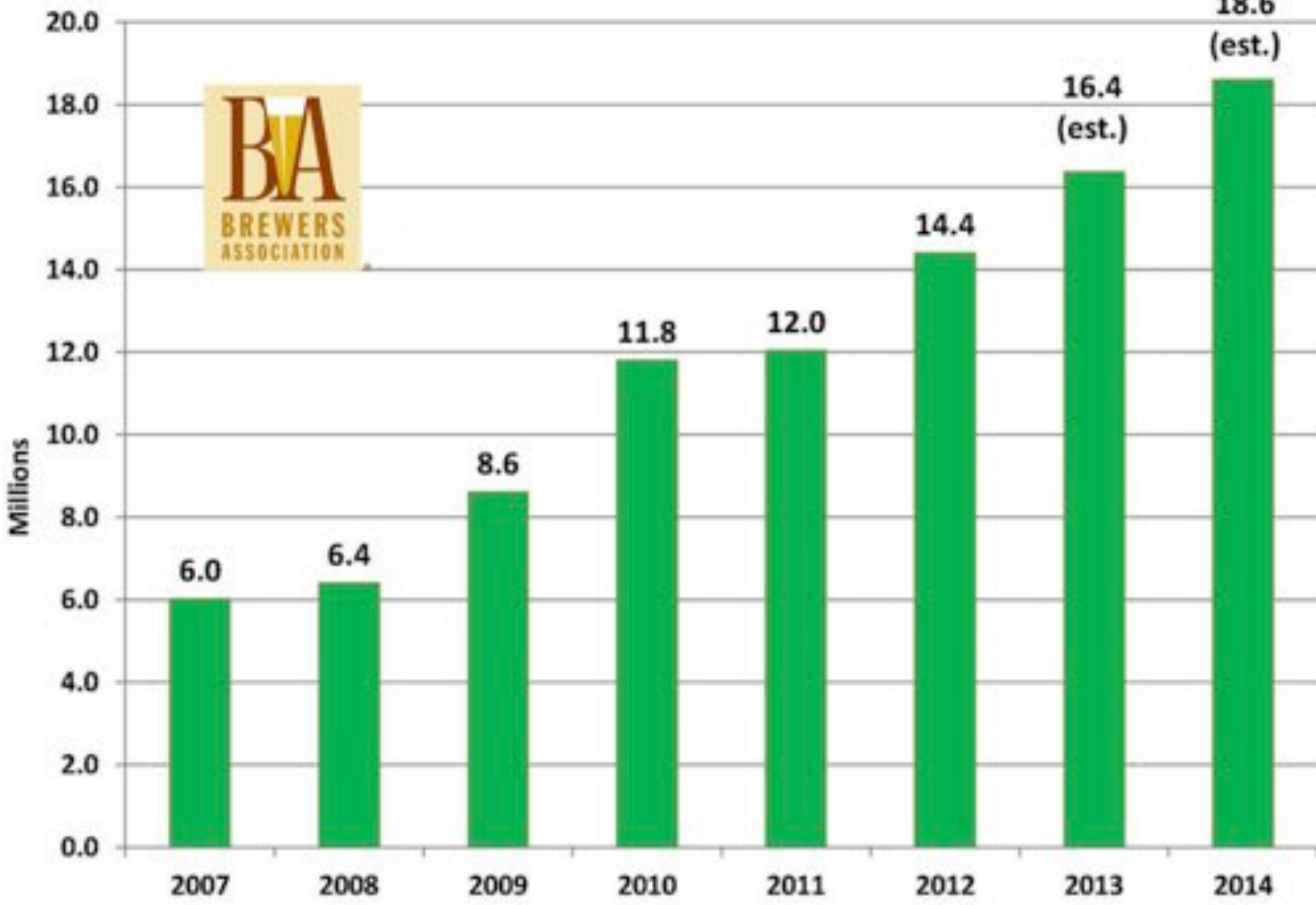
CRAFT BEER MARKET
\$14.3 BILLION
70% DOLLAR SALES GROWTH



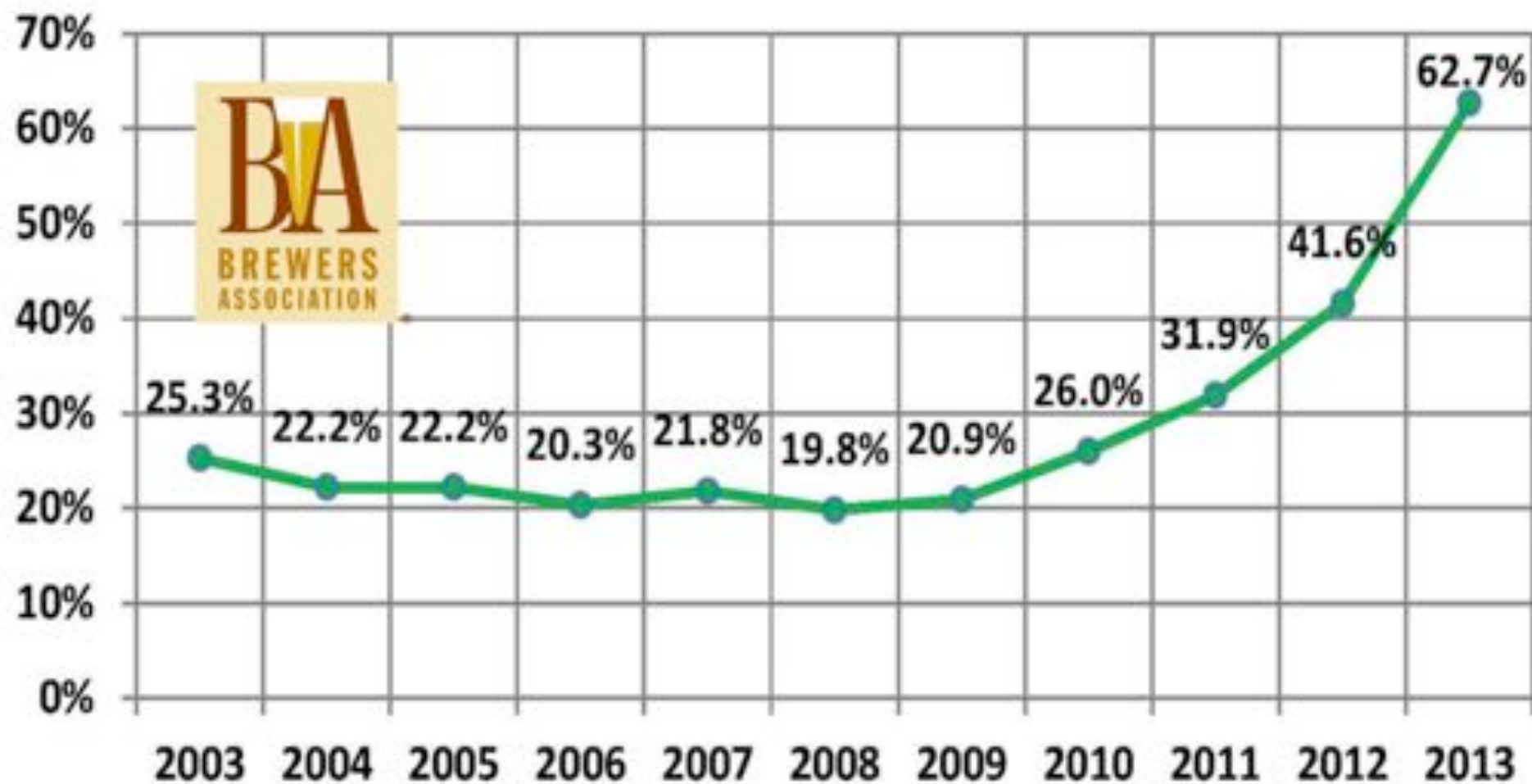
US Craft Beer Hopping Rates (TTL Pounds / TTL BBL)



TTL Craft Hop Usage By Beer Production Year (MM Pounds)



Aroma Hop Acreage as % TTL US Acres



Concerns on the Horizon?

- Hop Usage
 - At 20% share, craft hop usage is 2/3 of current national production – even without increase in usage/lb!
- Hop Varieties
 - Larger scale only part of the challenge
 - Issues like growing windows necessitate further investment

Getting to 20/20 - Hops

- 25% increase in hop volume
- Greater increase in acreage/resources
 - 30% increase in acres
 - Acreage needed greater than hop increase
 - + Aroma vs Alpha
 - + Starting to run out of acres to switch
 - + More resource intensive
 - \$10K an acre + processing (\$5K)
 - + Capacity is fine – but harvest windows tightening
 - + “New” acres cost more

Getting to 20/20 - Hops

- 12,000 new acres?
- \$180 million minimum in acreage investments?
- Growers get it, but more work
- 25 million more pounds of hops
 - Pelletizing infrastructure
 - Storage (even 25 cents a pound adds up)
 - New technologies/products
 - Hop Hunter anyone?

Getting to 20/20 - Hops

- Other investments may double cost
 - Collective half a billion \$'s not out of the picture
- Will new areas help?
- Yes, but at the margins
 - Lack of scale
 - Higher cost
 - Uncertain demand
 - More fragmented

2013 Beer Sold in MI (bbls)

All Beer

6,257,864 bbls



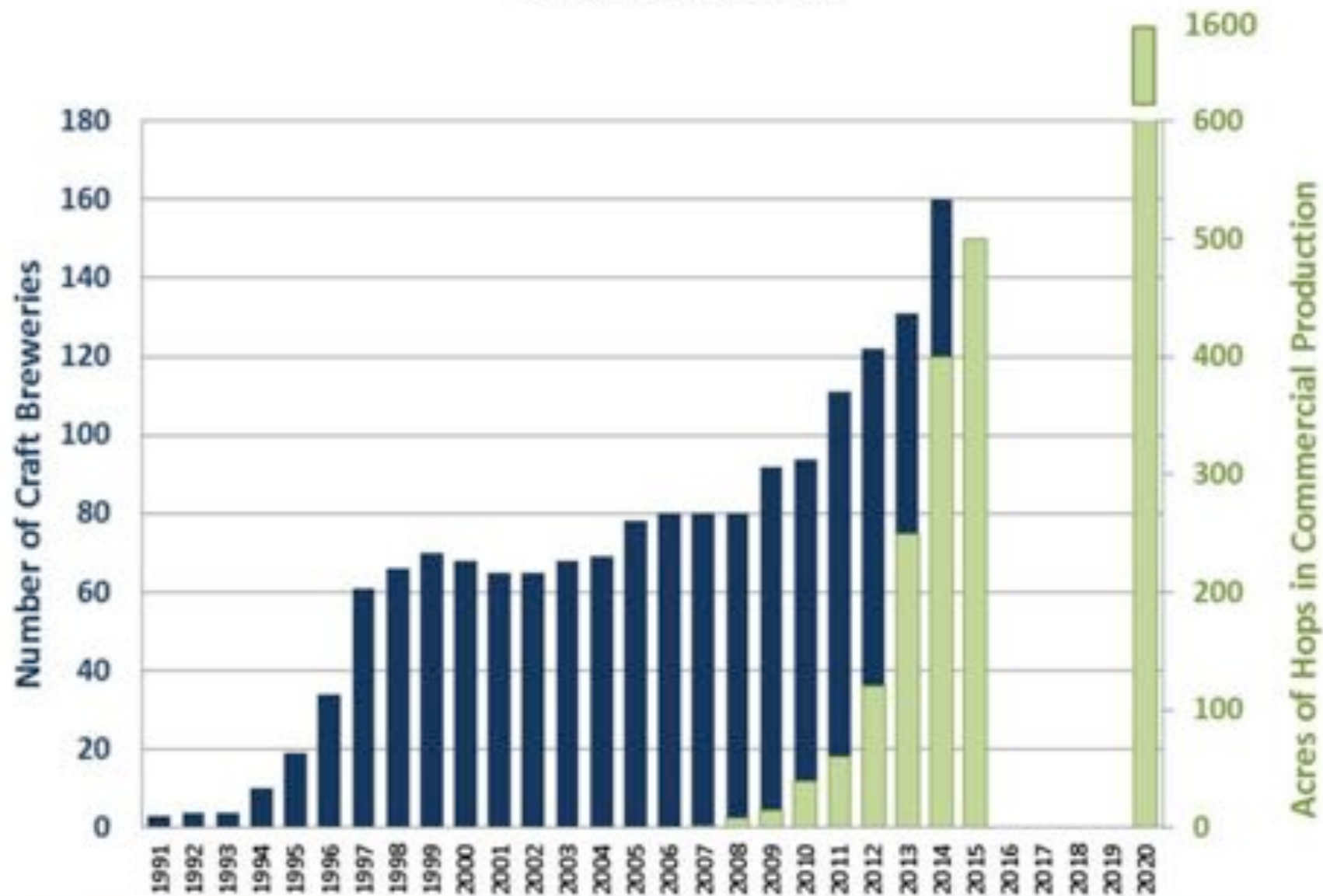
All Craft Beer

452,000, 7.2%

MI Craft Beer

297,000, 4.7%

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 >1/3 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



<http://www.hops.msu.edu>

The screenshot shows a web browser displaying the MSUE Hops website. The page features a navigation menu on the left with items like 'Getting Started', 'Pest Management', and 'Weather and Climate'. The main content area has a banner for 'Small scale hop production in the Great Lakes Region' and a section titled 'Interested in growing hops?' which includes a paragraph of text and a 'Thanks for visiting...' message. Below this is a 'MSUE Hops News' section with a registration deadline for a pest management academy. On the right side, there is an 'Ask an Expert' form with fields for 'Question', 'Location and County', and 'Image (optional)'. The MSUE logo and 'MICHIGAN STATE UNIVERSITY Extension' are visible at the bottom.



Harvesting, drying, conditioning, and baling video-WOLF

