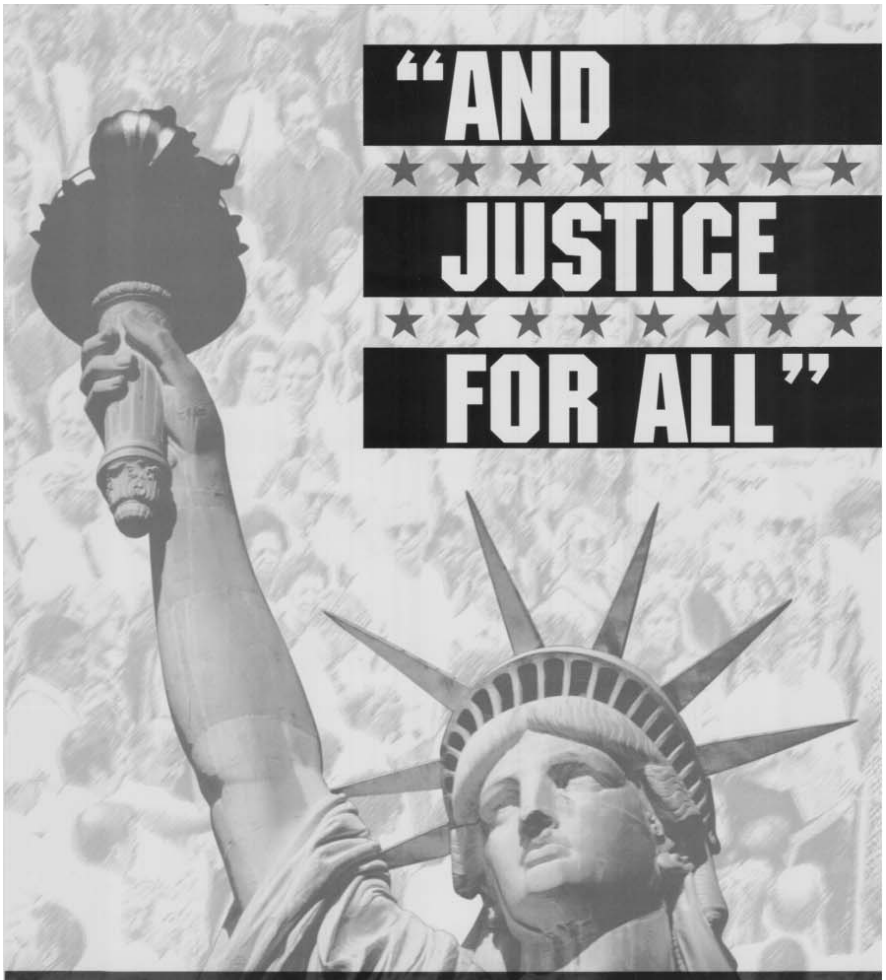

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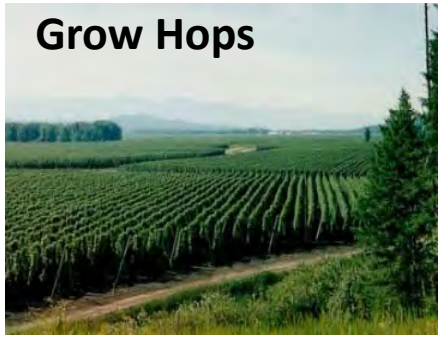
USDA
UNITED STATES DEPARTMENT OF AGRICULTURE

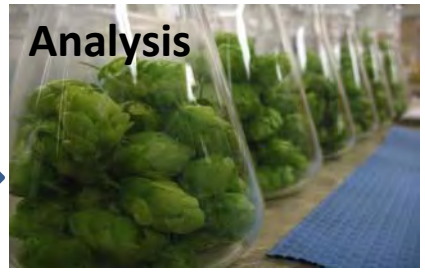
FORM AD-475-A (REVISED 9/2006)

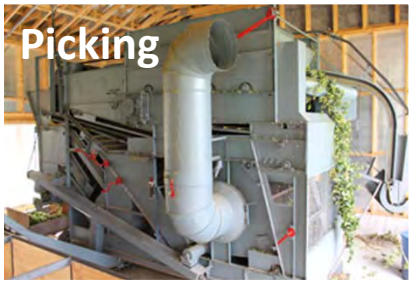
Hop Production: Harvest and Post-Harvest Considerations

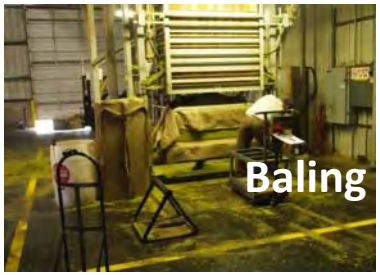
Dr. Rob Sirrine
Michigan State University Extension
Ontario Hop Growers Association
Spring Educational Workshop
March 22, 2014

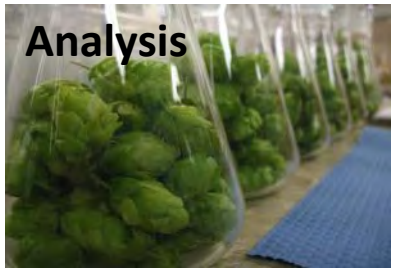
Hop Value-Chain











Hammer Mill & Pelletizer

Marketing/Sales

Whole cone

Pellets

I. Training Date

Present-day cultural treatments are clearly based on the optimum date of training

1. Cultivar

2. Weather

- Biological characteristics show that young hop runners are much affected by low temperatures
- Bine length (i.e. an average of 60 cm)
- In a long cold period (slow warm-up) = slow regeneration, do not select the longest shoots that have been less exposed to the cold, but those that have sprouted later
- The climatic conditions in Middle Europe, suggest the best date for training is after 10th May in a typical year. (~49 N)
- Once suitable conditions occur it is necessary to start training at once, otherwise the yield will be reduced

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

Training Date

- Early training can lead to reduced yield (ex. Galena)
- Training date is variety-specific but usually occurs during May in the Willamette valley.
- Very little information in the literature as research results have been inconclusive

- Source: Townsend, S. Factors affecting hop production and quality.

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

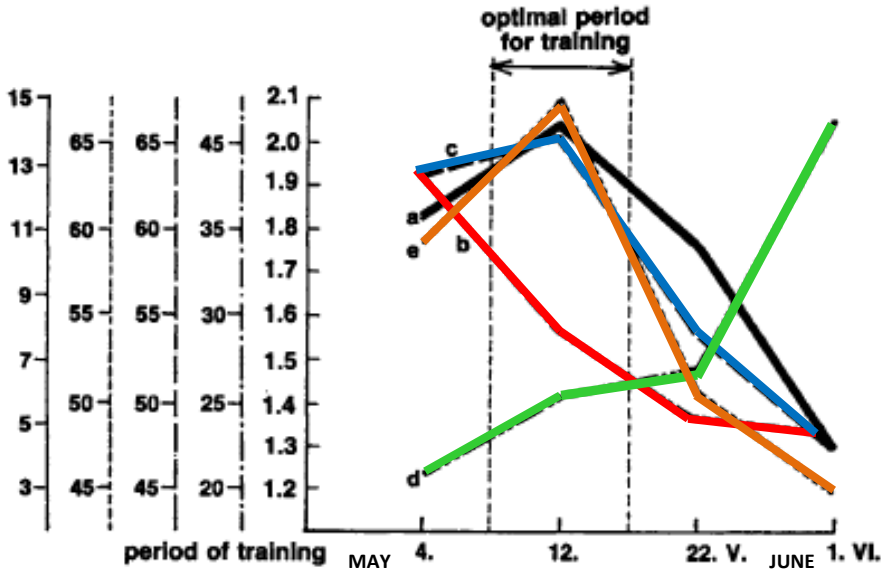


Fig. 93. Effect of time of starting training on the structure of the hop plant and on the yield of cones: a – yield (in kg) of fresh hop per plant, b – length of cones in mm, c – number of shoots, d – density of setting (number of cones per 10 cm of shoot), e – mean length of shoots (in cm).

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

II. 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


TOPCUTTER
TOPCUTTER
PALE ALE

Top Cutter


LOFTUS
RANCHES


LOFTUS RANCHES
LOFTUS RANCHES

http://1859oregonmagazine.com/2012-november-december-1859-oregon-hops#0

Idaho-Video

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

WOLF Bine Loader AN 60 LG

video

Appropriate Trailer

III. 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:

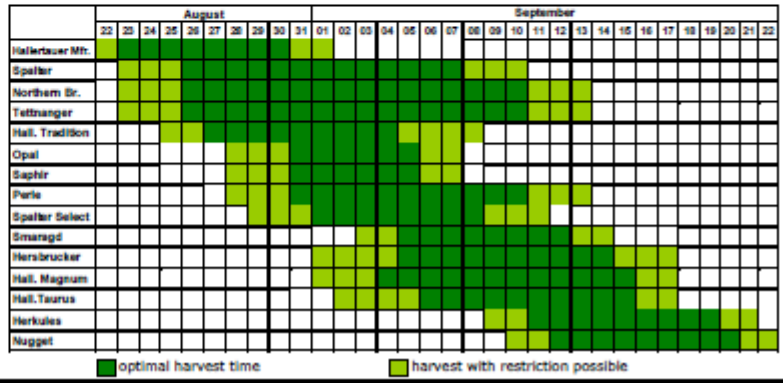
- α-acid contents
- yield
- external quality (color and shine, infection with diseases and pests, shattering)
- aroma (aroma intensity, oil content and composition)
- vigor and vitality of the plant (in the next season)

↓

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

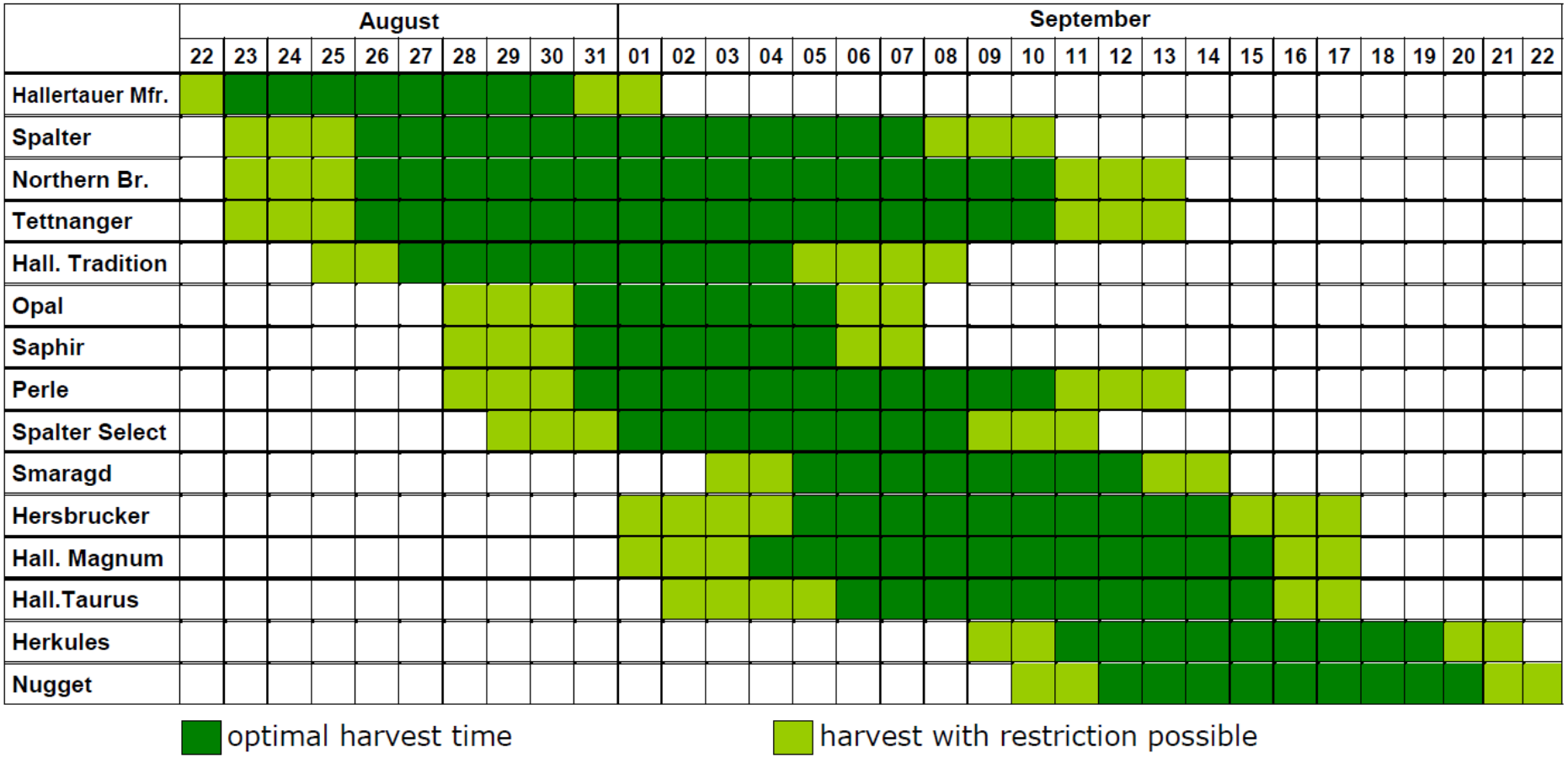
LfL Pflanzenbau

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

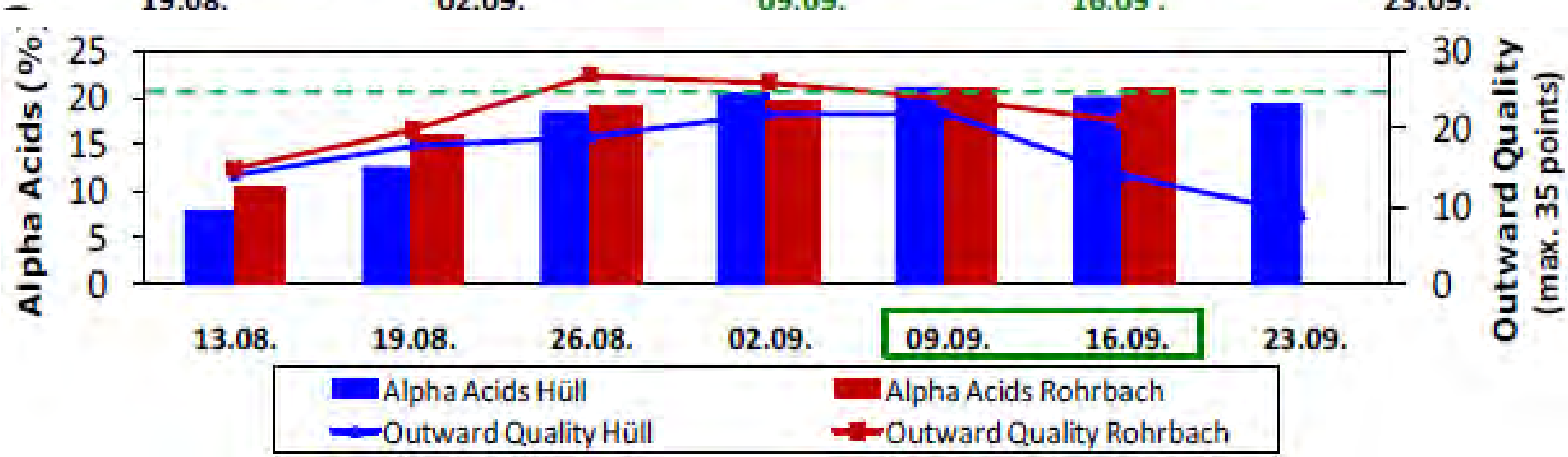
A. Lutz, J. Kneidl, E. Seigner , and K. Kammhuber



Biogenesis studies

Single bines of the most important hop cultivars are harvested at 2 different locations each week starting in mid August till late September. Cone samples are analysed at once and data concerning chemical compounds, aroma, external quality and yield are assessed.

Herkules 2008



Bailey et al. 2008. The influence of hop harvest date on hop aroma in dry hopped beers. World Brewing Conference 2008.

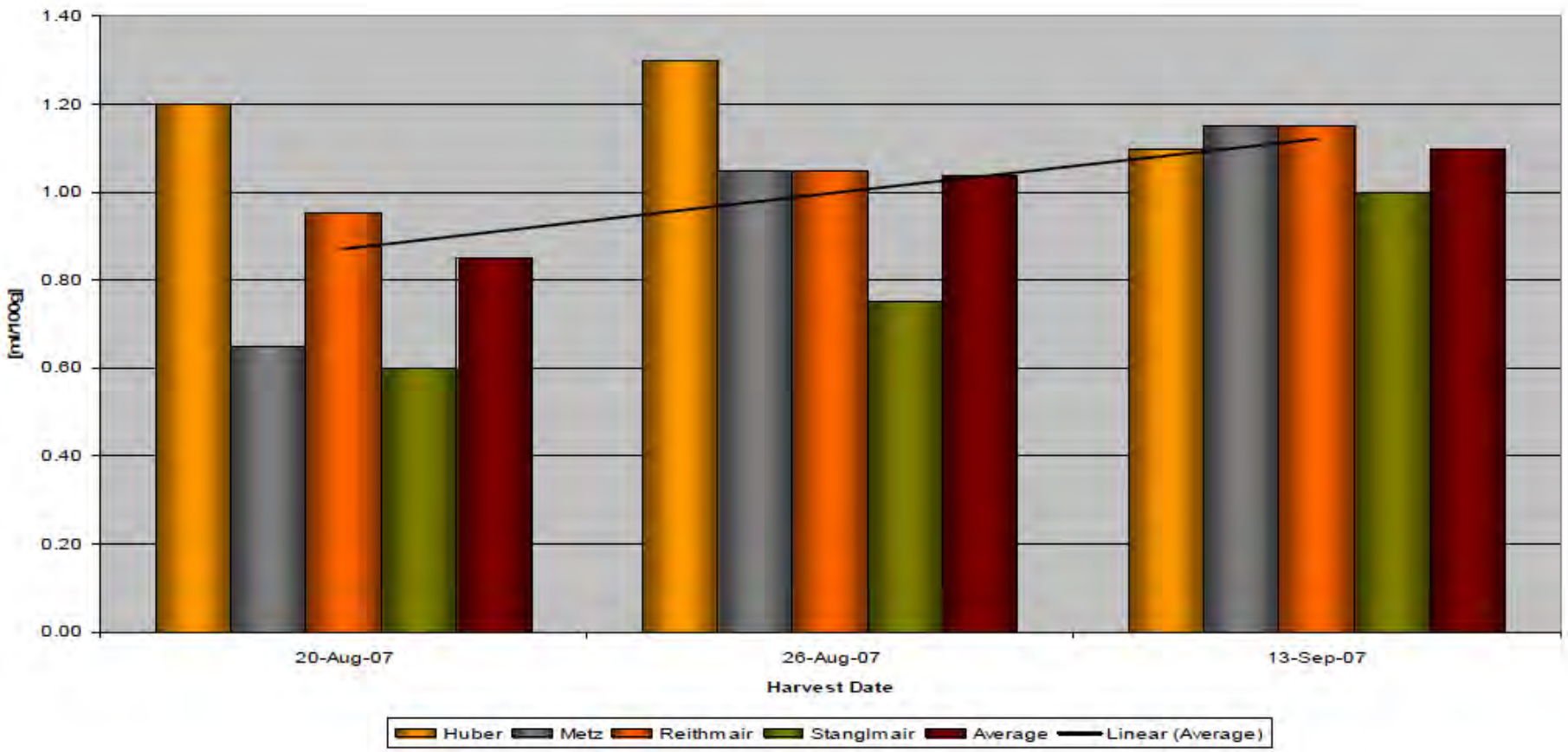


Fig. 1: Total hop oil content in hops during harvest

Sharp, Townsend, Qian, Shellhammer, 2013. Harvest Maturity of Cascade and Willamette Hops. Masters Thesis. Oregon State University.

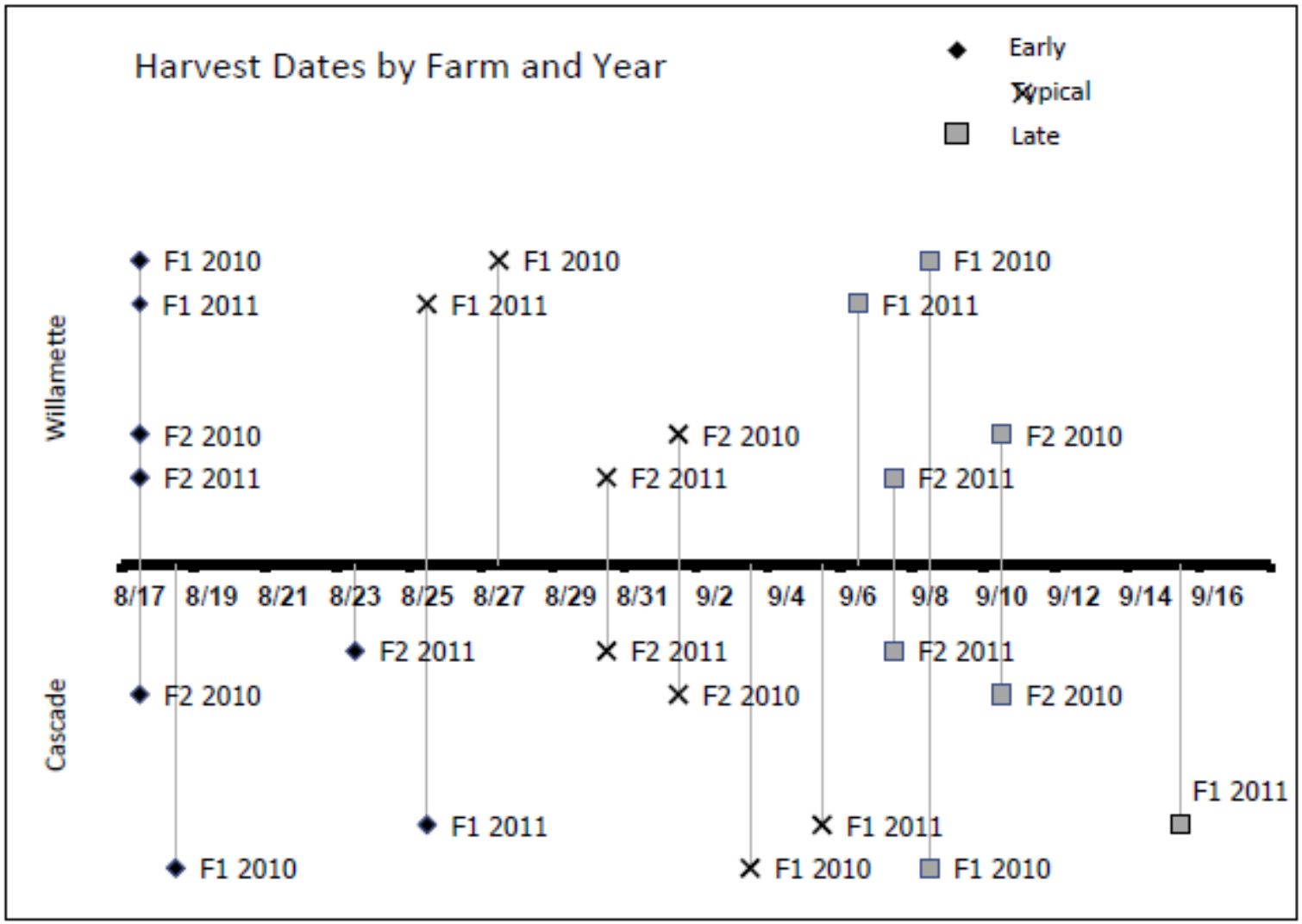


Figure 1: Harvest dates for Willamette and Cascade hops for the 2010 and 2011 growing seasons. Harvest time points Early, Typical, and Late are shown for each cultivar and both locations. Farm I (F1) and Farm II (F2).

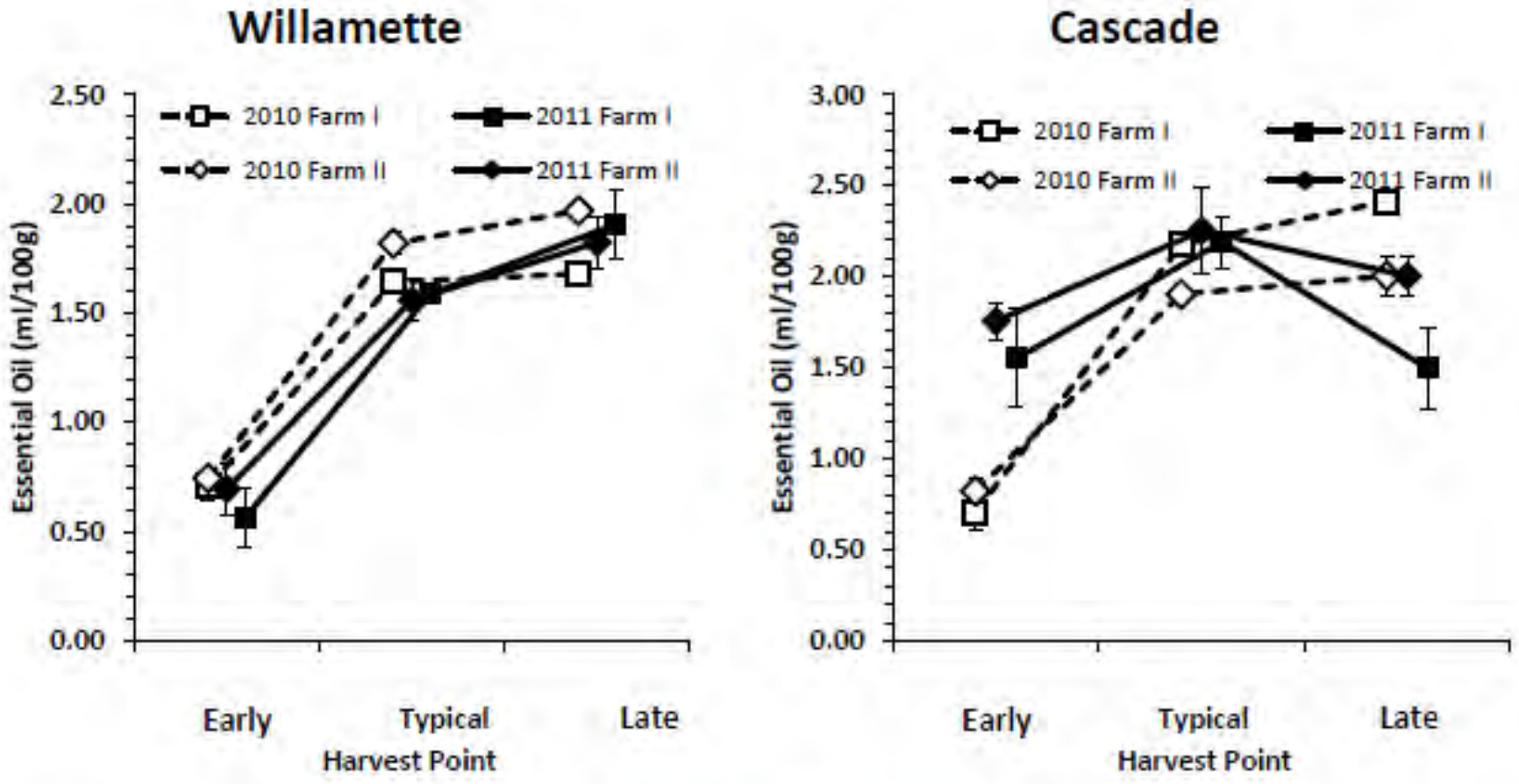


Figure 5: Essential oil content of Willamette (left) and Cascade (right) hops at different harvest points by farm and year. Note, the more pronounced effect of year on Late harvested Cascade hops. Error bars represent standard deviation.

Sensory Evaluation (Taste Test)

Table 6: Summary data for consumer acceptance testing of Typical and Late Harvest Hopped Beers

Attribute	*Typical*	*Late*
Overall Liking**	7.11 [a]	6.26 [b]
(SD)	(0.83)	(1.61)
Aroma Liking**	6.92 [a]	5.82 [b]
(SD)	(1.31)	(1.96)
Flavor Liking**	6.98 [a]	6.23 [b]
(SD)	(1.03)	(1.68)

**, ***Attribute Significant at $p<0.01$, and 0.001, respectively. Means within a row with different letters are significantly different from one another at $p<0.05$ by Tukey's HSD. Standard deviations are shown in parentheses below means. Scale: 1 = dislike extremely, 9 = like extremely.

"Beers brewed with typical harvested Cascade hops were significantly distinguishable in sensory analysis and preferred by consumers over late harvested cascade hops."

Sharp et al. 2013. Conclusions

- While increased oil volumes may be desirable for aroma type hops, other properties of the hops should be considered at each harvest time point to determine the overall quality of the hops.
- Hop Storage Index can be a useful measure of the quality of a hop sample in terms of the bittering acids, but fails to tell the entire story of a hop's quality from an aromatic perspective.
- Quality indices such as shatter and discoloration were not quantified in this study, however, it was noted that later harvested hops had a higher tendency to shatter or break apart during processing.

Sharp et al. 2013, Conclusions Cont.

- Furthermore, variation in hop cone color was noticeable across the three harvest dates. The earlier the harvest date the greener the color of the hop cones. A yellowing and eventual browning was observed corresponding to later harvest dates.
- These observations could have commercial significance since brewers often use color as an indicator of healthy and/or high quality hops when considering hop purchase.

Murphy and Probasco, 1996. The development of brewing quality characteristics in hops during maturation. MBAA TQ vol. 33, no. 3: 149-159.

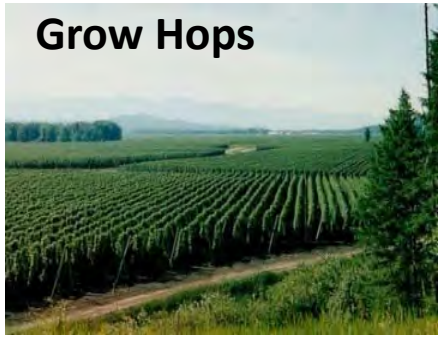
- 1990-1992 researched 4 hop varieties
- Willamette, mt. hood, nugget, galena
- Harvested 4 weeks before normal to 2 weeks after
- Measured dry matter, moisture, bitter substances and essential oils

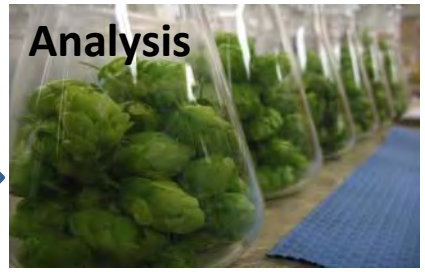
Results

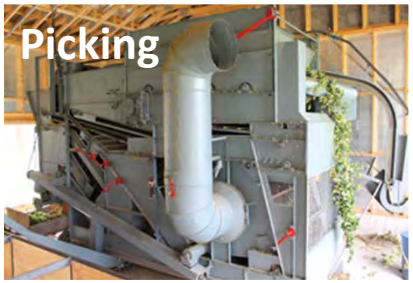
- alpha acid content reached a maximum when the dry matter content was between 22 and 24% (typical point of harvest)
- beta acid content peaked at a dry matter content of less than 22%
- total essential oil content increased steadily beyond harvest period
- storage stability of the alpha acid content of the bittering varieties (Galena and Nugget) was not significantly affected by the harvest date
- that of aroma varieties (Willamette and Mount Hood) was improved by late harvesting

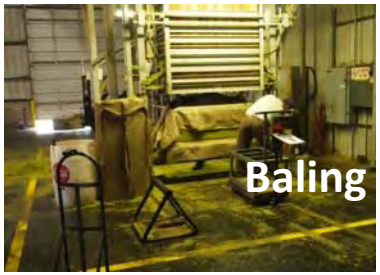
- it is possible to obtain hops with brewing properties somewhat different from those which are normally characteristic of the variety in question by harvesting earlier or later than usual.

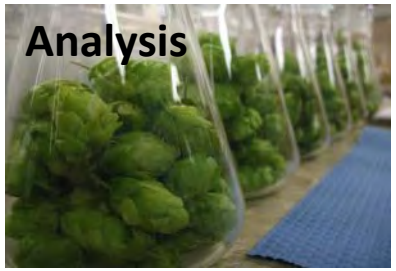
Hop Value-Chain











Hammer Mill & Pelletizer

Marketing/Sales

Whole cone

Pellets

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.

IV. Transport to the Picker

Degradation potential

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

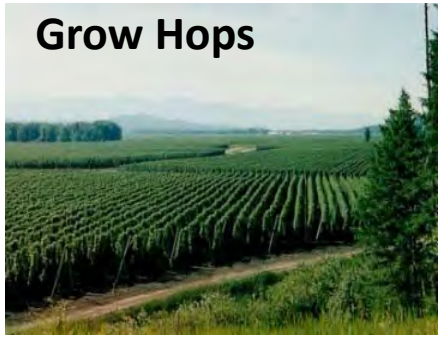
In terms of the drying process picked hop cones can be regarded as a living organism whose basic life processes, particularly respiration, are continuing. They first react to being removed from the plant by a higher intensity of respiration. Rybacek, 1991.

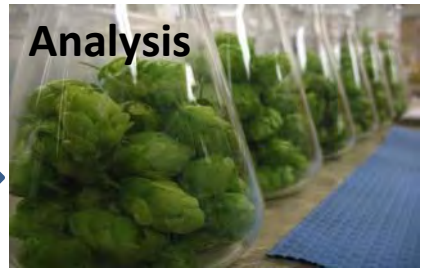
Transport Costs

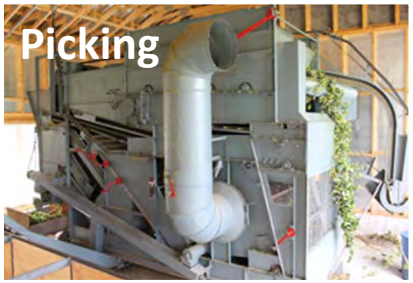
- Assume 5 acres (1000 plants/acre; 2 strings/plant=10,000 vines)
- Truck/Trailer (170 vines/load)
- 30 miles from picking station (60 miles R.T.)
- Need about 60 round trips
- $.55 Per Mile x 3600 miles = $1980
- Labor ($10/hr) 6 trips/day for 10 days, 80 hrs minimum= $800
- Processing costs (~$5/lb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

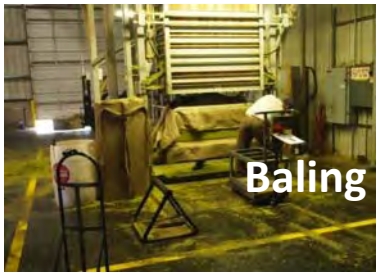
Total $10,280

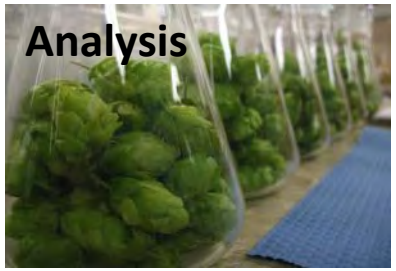
Hop Value-Chain











Hammer Mill & Pelletizer

Marketing/Sales

Whole cone

Pellets

V. 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

Bine 3060 Harvester

- **Harvest Rate**
  "The Bine 3060 is designed to process up to 50 bines/hour (depending on variety and production method) with as few as 3 people. An average of 20-40 bines/hour is a reasonable rate."
- "Bine implement suggests it is capable of less than 1% crop loss and better than 95% cleanliness."

- The 2014 Bine 3060 Harvester is $12,730 plus shipping.
- Platform not included

Back of the envelope calculations

1. 20-40 bines/hour = 25-50 hours/acre or 60-125 hours/ha

2. Based on bines/hour WOLF projections (WOLF 140 = 140 vines/hour & 6-7 Ha/season)

3. Best guess =the 3060 could do 1 Ha.

Published on Aug 27, 2013

“While I feel this product would be sufficient for a small scale grower, I don't know that I would recommend it for someone who has more than a couple of acres. It's definitely better than picking by hand, but there are some things that could have been done better in my opinion. It definitely takes more than the recommended two people to run it, and there are a couple of bottlenecks that cause this to happen. In particular having the feeder up so high requires an extra person to hand up hop bines. Also, the hops get stuck inside the machine and require someone to manually pull them through somehow. Other than that, if you run a hop yard with less than 2 acres, this machine would improve the process of harvesting. It is rated to process 1 acre in approximately 33 hours.”

Bine 3060 Video

UVM Mobile Hop harvester

UVM Mobile Hop Harvester

- **DESIGN REQUIREMENTS**

  The mobile hop harvester was designed to perform according to the following specifications:
- **Capacity** 2 bine/min

  8 hr/acre

  10,000 lbs/day wet {2,000 lbs/day dry}
- **Portability** over road with standard tow hitch & full size pickup truck
- **Safety** similar to standard farm equipment
  - training and personal responsibility required
- **Power** PTO / direct hydraulic
- **Cone Damage** <5% by volume
- **Operation** team of two trained operators

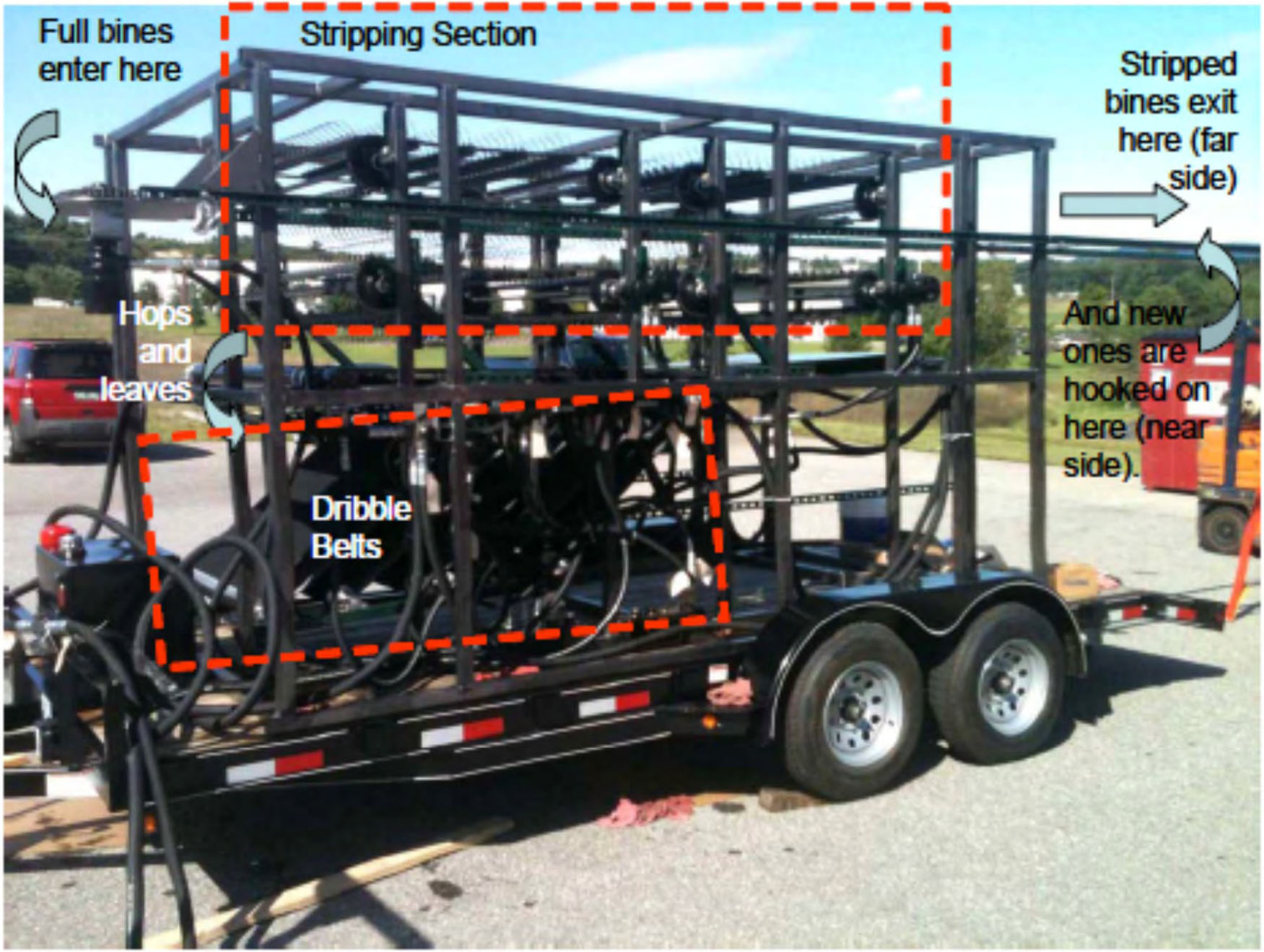


Figure 1. Photo of the harvester during initial test, showing main sections in place.

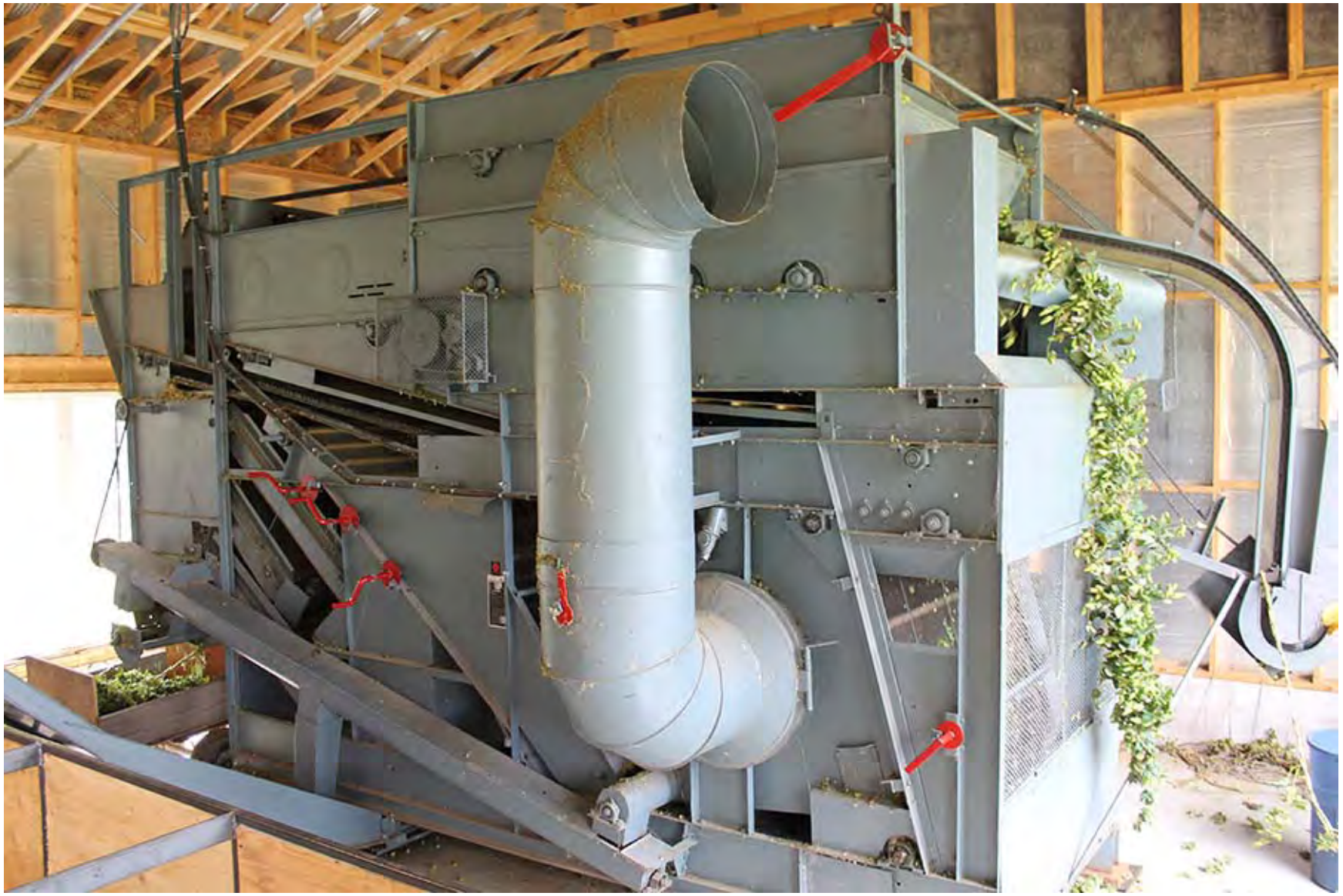
Cost Summary

Trailer	$3500
Frame and Subframe	$1800
Stripping Section	$4100
Motors, Pump, & Hydraulics	$5800
Conveyor Belts & Rollers	$4200
Bine Feed	$1200
Total Material	$20,600
Fabrication Labor	$32,000
TOTAL	$52,600

Christopher Callahan, PE, Callahan Engineering, PLLC, November 5, 2011 – Troy, NY
"Mobile Hop Picker"

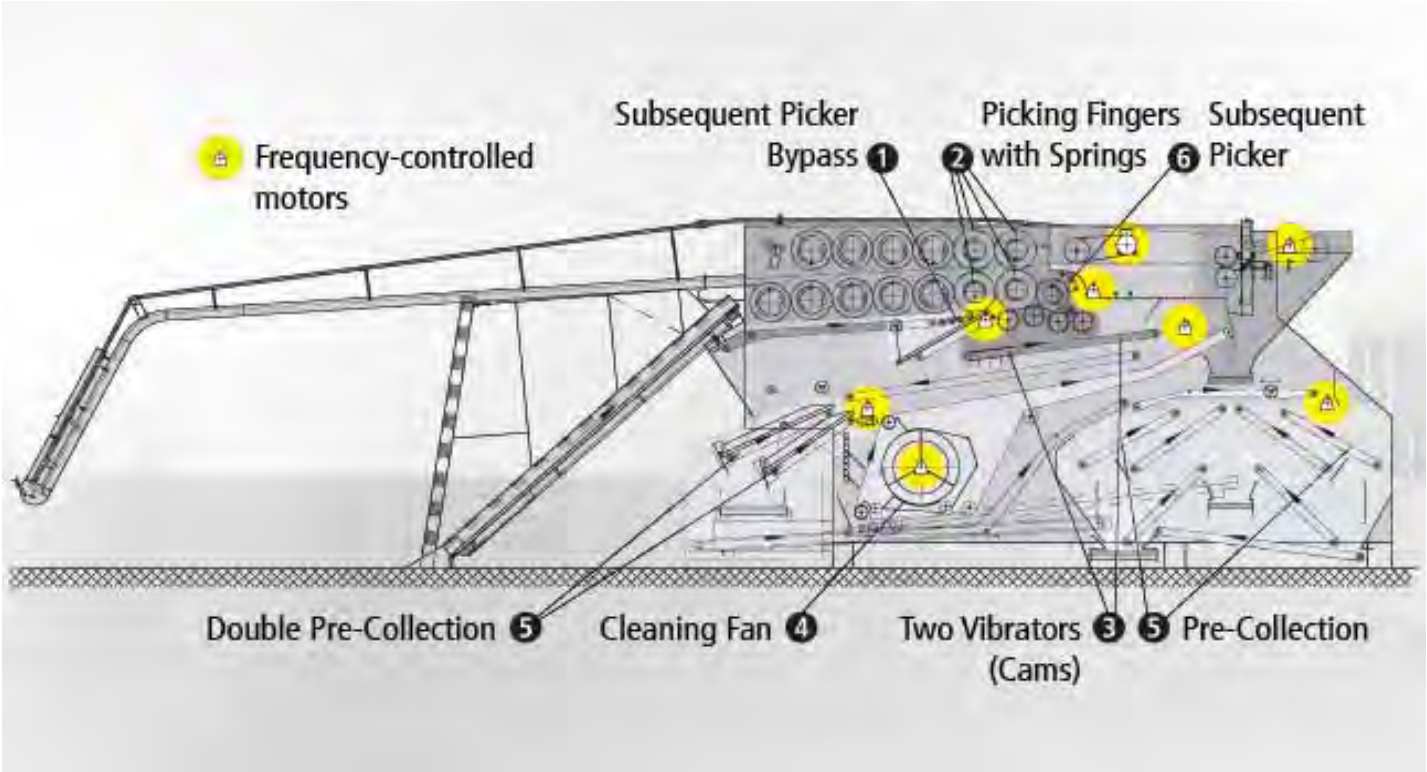
WOLF 140

WOLF 170



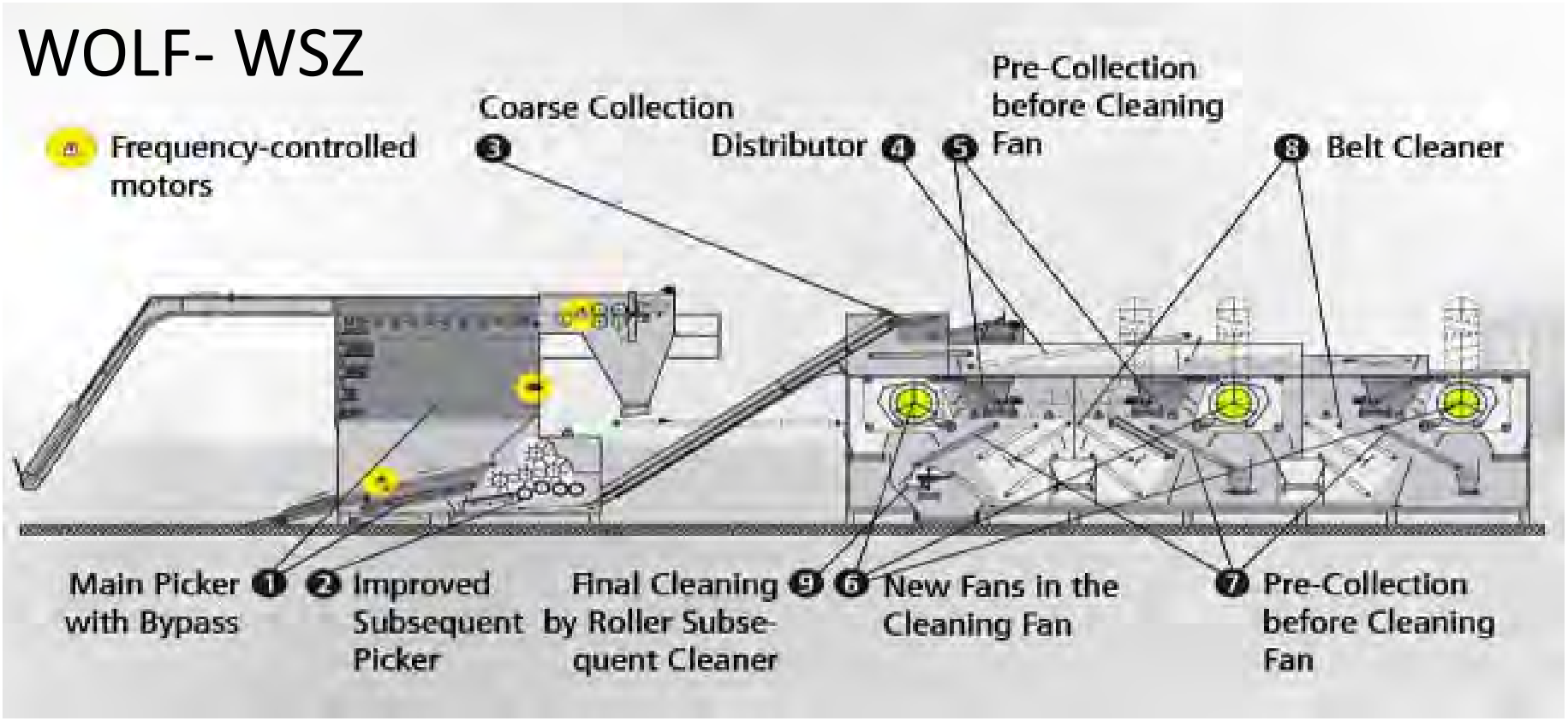
WOLF 230

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

WOLF

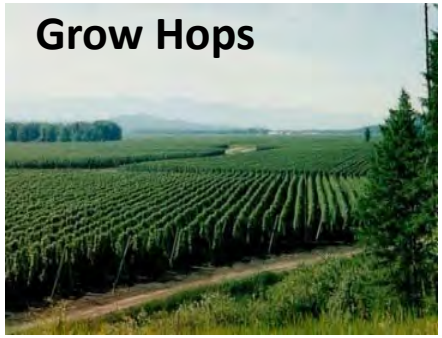
• 140 ~$28,000-$36,000	6-7 Ha
• 170 ~$40,000	8 Ha
• 220/230 ~$50,000	12-14 Ha
• WHE 513 ~$250,000	30-40 Ha
• WSZ---A LOT.	

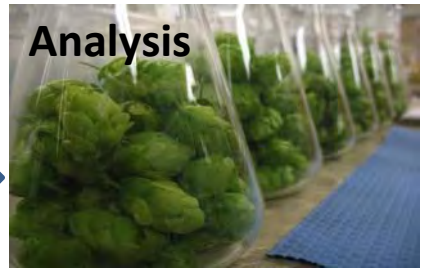
513 video

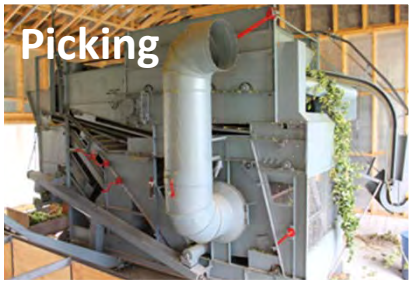

GMC

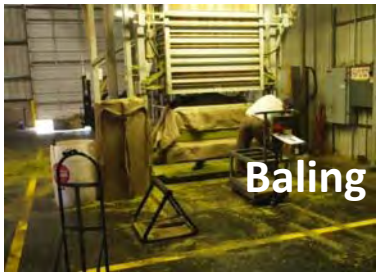
www.ibabuzz.com

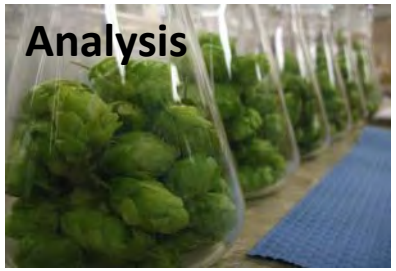
Hop Value-Chain











Hammer Mill & Pelletizer

Marketing/Sales

Whole cone

Pellets

VI. 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.

Factors that influence drying

1. Factors that can be directly controlled
   - air temperature
   - air velocity
   - bed depth

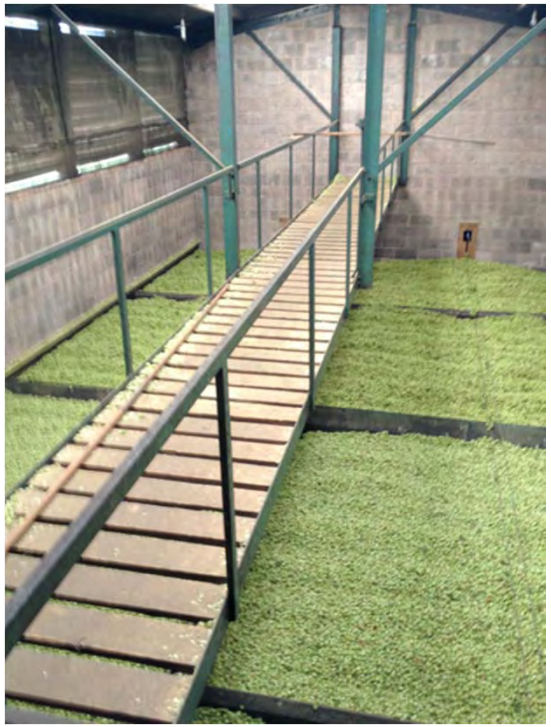
2. Factors that cannot be controlled
   - hop moisture content
   - air humidity
   - hop condition

P. E. DOE; R. C. MENARY* 1979. **Optimization of the Hop Drying Process with Respect to Alpha Acid Content. J Agric Engng Res (1979) 24, 233-248.**

Drying Temperature

Quoted drying temperatures ranges:

- TOMES (1891), 30 °C
- TOMES (1924), 38^0 °C
- ZAZVORKA-ZIMA (1938), 40 °C-maximum 45 °C
- ZAZVORKA-ZIMA (1924), 55 °C
- SCHUSTER-KREININGER (1955), maximum 60 °C
- KUNZ-SKLADAL (1958), 40-50 °C
- DREXLER (1961), 50-53 °C
- BAILEY (1958), 65 °C
- BAILEY (1963), 55-60 °C, maximum 65 °C
- FRIC-MAKOVEC (1965), 55^60 °C.



http://www.mrdavidj.co.uk

- All of these authors agree that there is a maximum drying temperature limit, which, if exceeded, is likely to reduce hop quality.
- *The temperature of the air* is the most frequently quoted indicator, because it is the most easily measured.
- However this temperature is not always solely decisive as the final temperature effect on the quality of the dried hop.

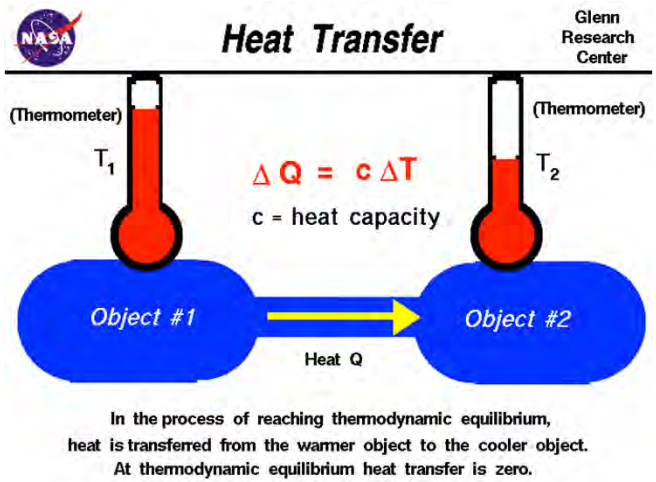
Time and thermal equilibrium

The most important question is when, and under what conditions, the temperature of the drying air is equal to the internal temperature of the hop cone.

A high air temperature need not always mean that the temperature of the heated material reaches the same level.

Of vital importance here is the time factor, i.e. the period of time over which the hops are being subjected to hop-air drying, i.e. the interval before the internal temperature of the cone reaches that of the drying air.

This condition of thermal equilibrium itself also depends on many factors, including: the speed of flow of the air, the humidity of the drying air, the moisture content of the hops, and the penetrability of the hop layer.



Why the differences in maximum temps?

"The most important factor affecting these ratings was the speed of the air flow. Older style driers with no forced ventilation had a low air flow speed; in this case, the ratings mentioned would have a lower limit."

Vs.

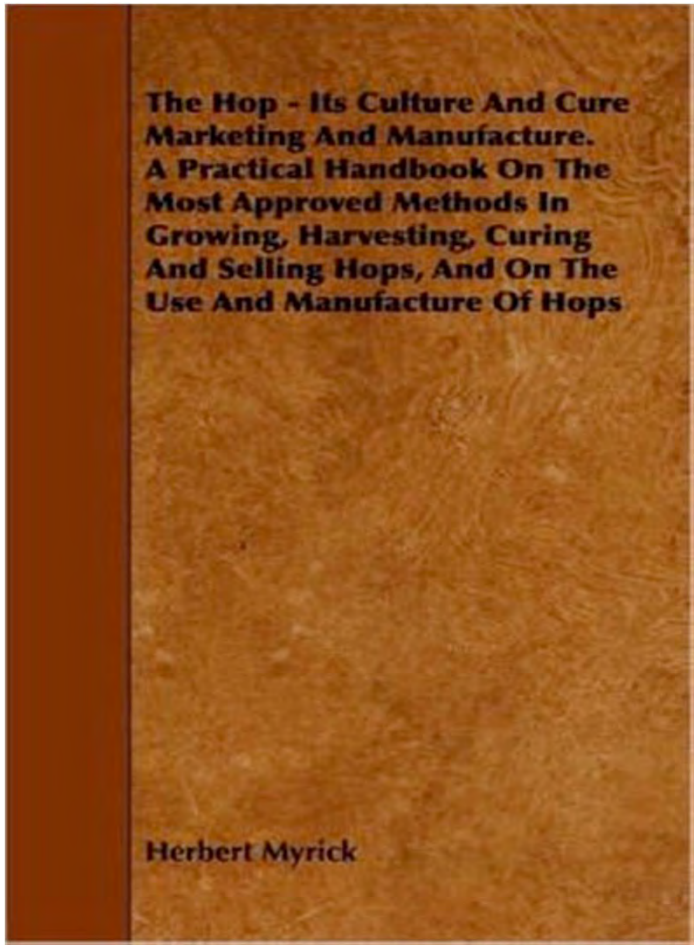
Indicators of overheating

- The effect of temperature on hop quality can be evaluated by eye according to *the lupuline colour.*
- This indicator is relatively reliable and is so simple that its value as a check on the drying process is quite obvious.

- If heated properly, lupuline colour remains lemon yellow.
- Too hot- lupuline colour changes to brown
- More apparent at higher temps and longer exposure
- This indicator has a direct relationship with the hop chemical content
- Eg. Chemical analysis will show that hi-temps= greater content of hard resins = reduced quality

Over-drying

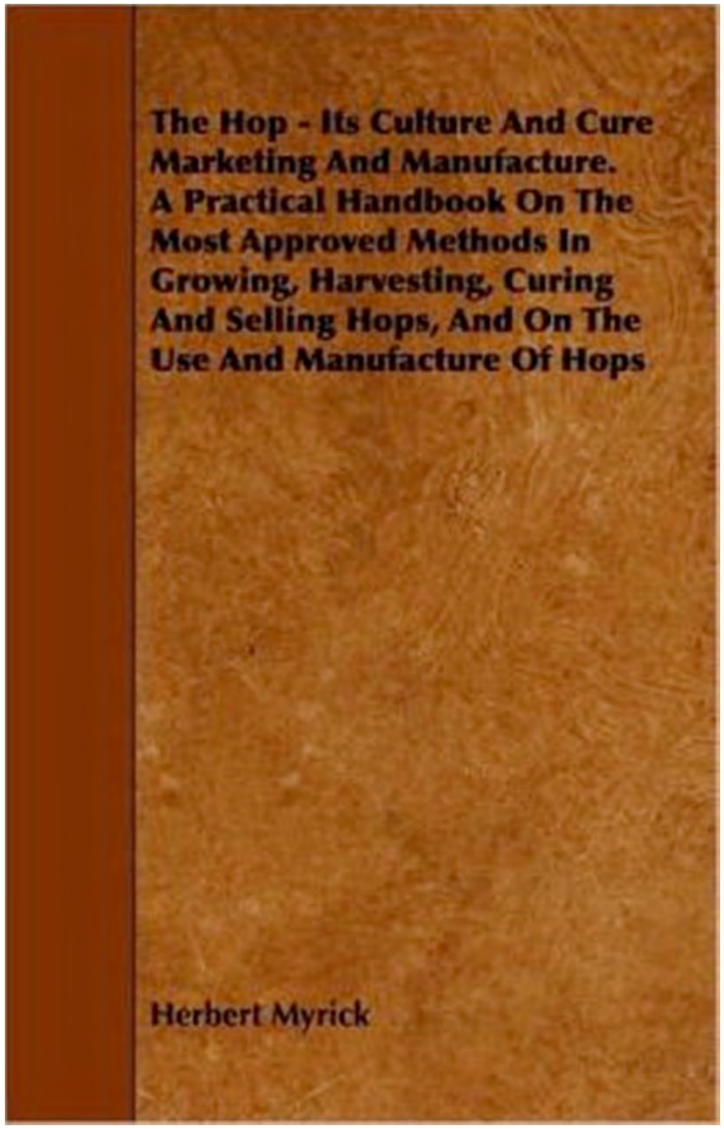
- If the hops are dried to below 5 per cent moisture they are over-dried and this has a harmful effect on their chemical composition.
- Dried hop is brittle and has low resistance to damage during handling. The bracts tend to fall from the spindle with a resultant loss of lupuline glands.



Scorched: Burning, caused by over-firing, resulting in the crystallization of the lupulin and excessive loss of and injury to brewing quality and flavor.

Under-drying

Slack or under-drying: a slack hop is one that is under-dried. Hops in this condition heat or sour, depending on the degree of slackness and storage condition. Heating, which virtually means rotting, may be occasioned by even a bunch as little as a handful of slack hops, and once started affects the entire bale, and even communicates to surrounding bales if closely stored.

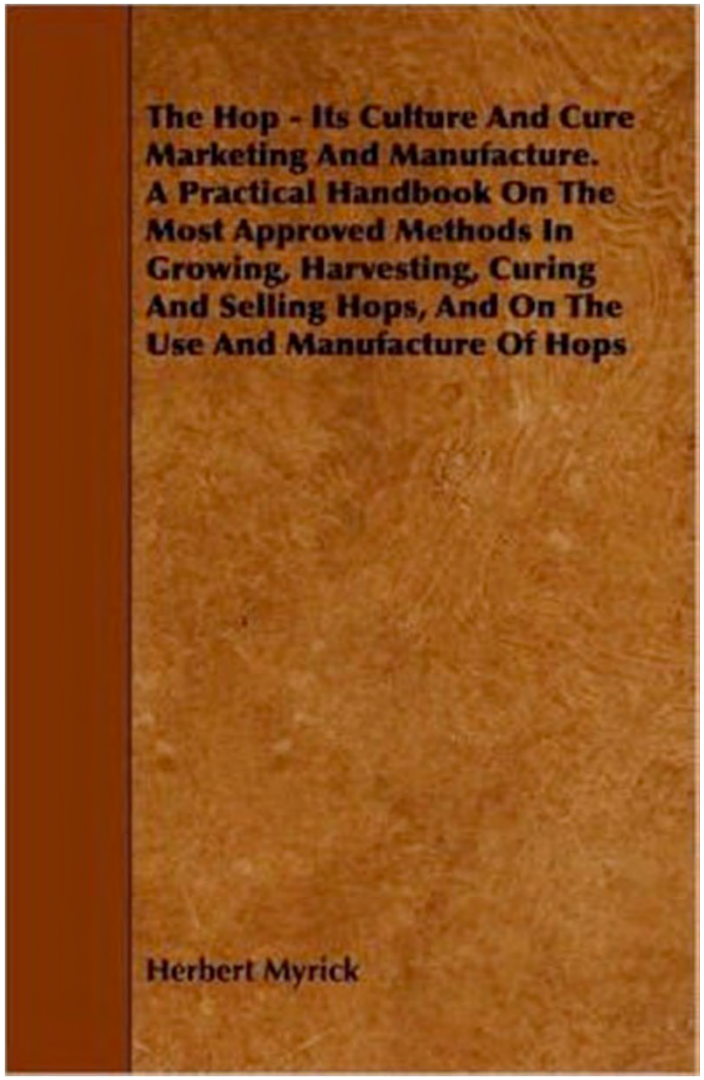


Under-drying

“When I opened up the package of Chinook, they smelled great. Sadly the same couldn’t be said for the Cascade. They were shipped in a large Mylar bag, which didn’t seem to be vacuum-packed or flushed with non-reactive gas. Probably no thanks to the three delivery attempts by UPS looking for a signature at the same time each day, the Cascade smelled like overripe hot chile peppers by the time I picked them up. They also seemed to contain excessive moisture”.

http://www.themadfermentationist.com/2013/10/north-carolina-malt-and-hop-ipa.html

The Hop; It's Culture and Cure, Marketing and Manufacture: A Practical Handbook. Herbert Myrick. 1899.



- Slack-scorched: hops dried at too high a temperature and not dried through. Burning them without drying them, so that while they have a scorched flavor, they may still sour or wet in cooling bin or bale. Often the fault of too many hops being on the kiln for it's capacity.

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

Dryer Types

- Bed

- Louvered

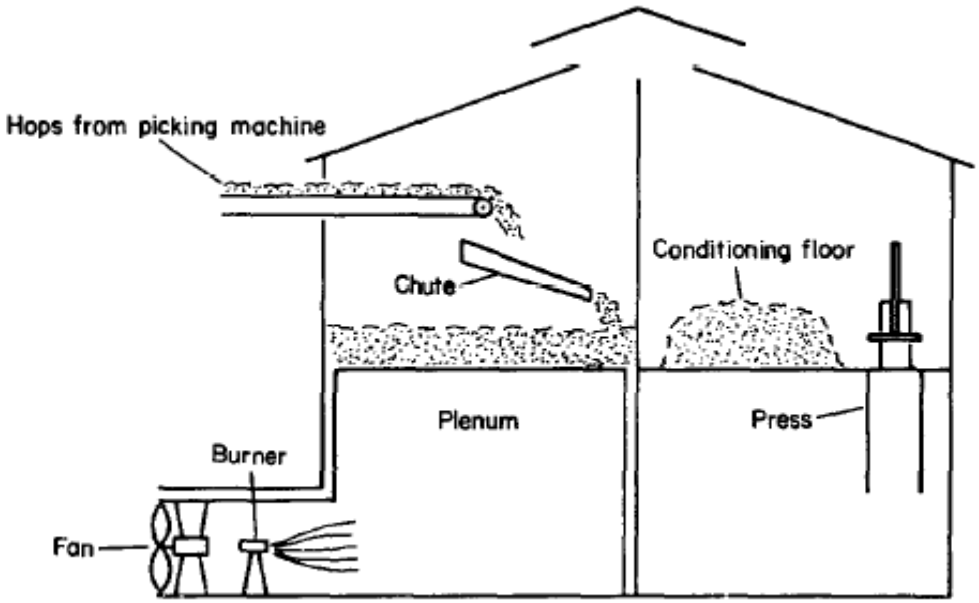


Fig. 1. Deep bed drier

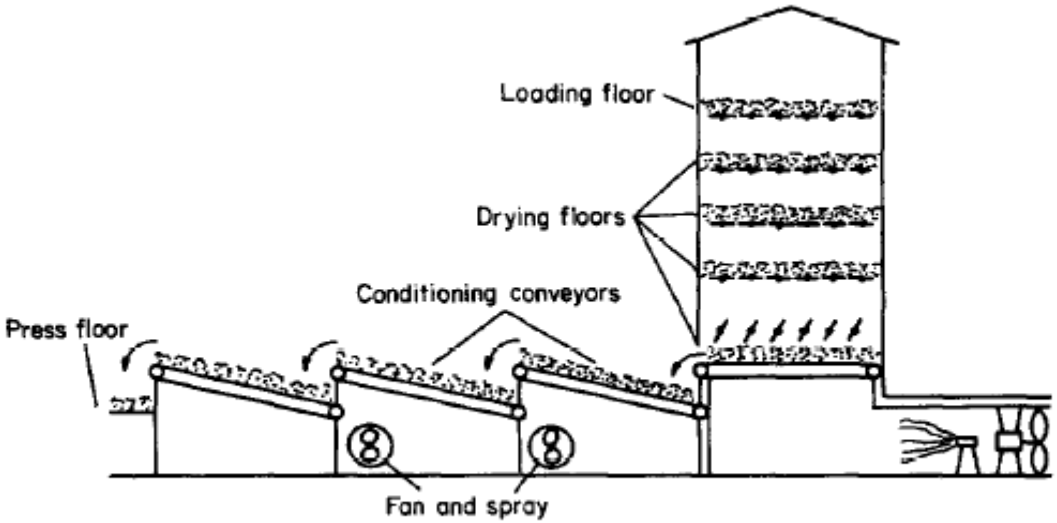
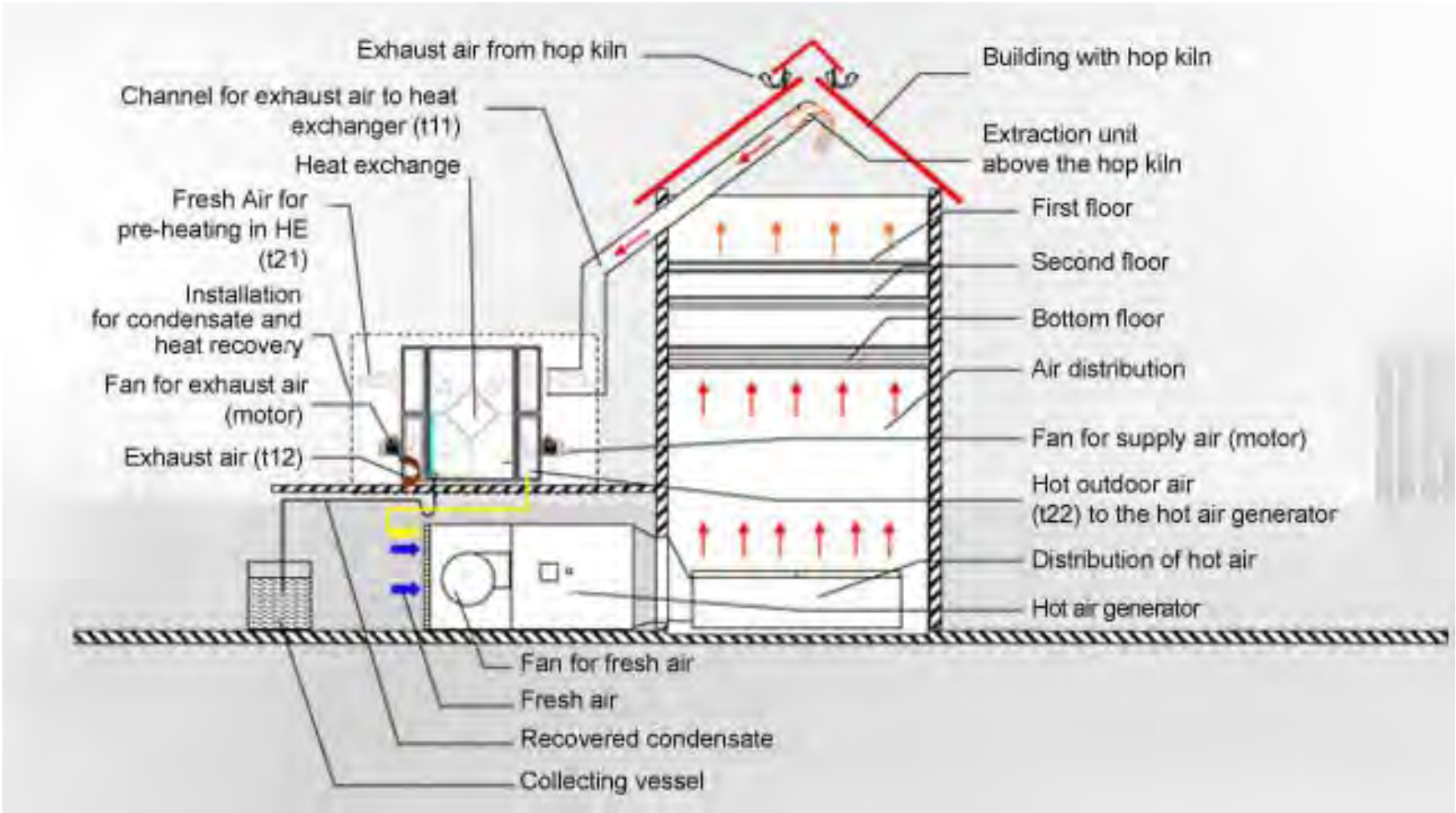


Fig. 2. Falling bed drier

Wolf-Modern system



Hydration

- *J. agric. Engng Res.* (1972) 17, 281-287
- Hop Drying-Unique Problems and Some Solutions
- S. M. HENDERSON*; G. E. MILLER JR.
- The quality of dried hops is determined from colour, texture, aroma, shatter, and lupulin colour and probably acid index. The relationship of these factors to drying conditions was considered.
- Hydration at the end of the drying period was found to unify the moisture content and reduce shatter in the baled material.
- Observations of temperature of parts of the hop were observed during drying and, from this, evidence indicated that higher programmed temperatures could probably be used during drying.
- Pressure air rate relationships were observed for guidance in drier design.

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: hoppenin@uvm.edu
Phone: 802 524 6501

NW CROPS & SOILS PROGRAM

UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

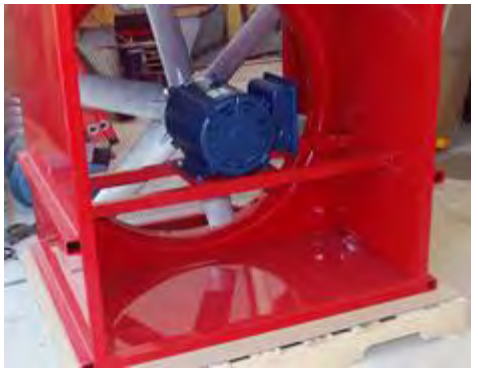
Modular Hop Oast

UVM Extension helps individuals and communities put research-based knowledge to work. Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the United States Department of Agriculture. University of Vermont Extension, Burlington, Vermont. University of Vermont Extension, and U.S. Department of Agriculture, cooperating, offer education and employment to everyone without regard to race, color, national origin, gender, religion, age, disability, political beliefs, sexual orientation, and marital or familial status. Any reference to commercial products, trade names, or brand names is for information only, and no endorsement or approval is intended.

Small scale indoor batch style

- “indoor batch style drying unit capable of 1/3-1/2 acre batch sizes, depending upon depth of hops.”
- Designed with subdivisions for drying multiple varieties
- Fan pulls air down
- Plans-$250
- Fan $3800

BINE Dryer



Two Stages

1. Ambient air-fan pulls ambient air until cone moisture is 20-25%
2. Conditioned air-dryer isolated from ambient air and conditioned to lower relative humidity ("begin conditioning the air using dehumidifiers, desiccants, air conditioning, etc. Avoid large open spaces like barns, etc.")

*Drying times-depend upon temperature and humidity

*High humidity areas- 3 to 4 days to complete stages 1 and 2.

-4 days for 1/3 acre is a long time

-12 days to dry 1 acre

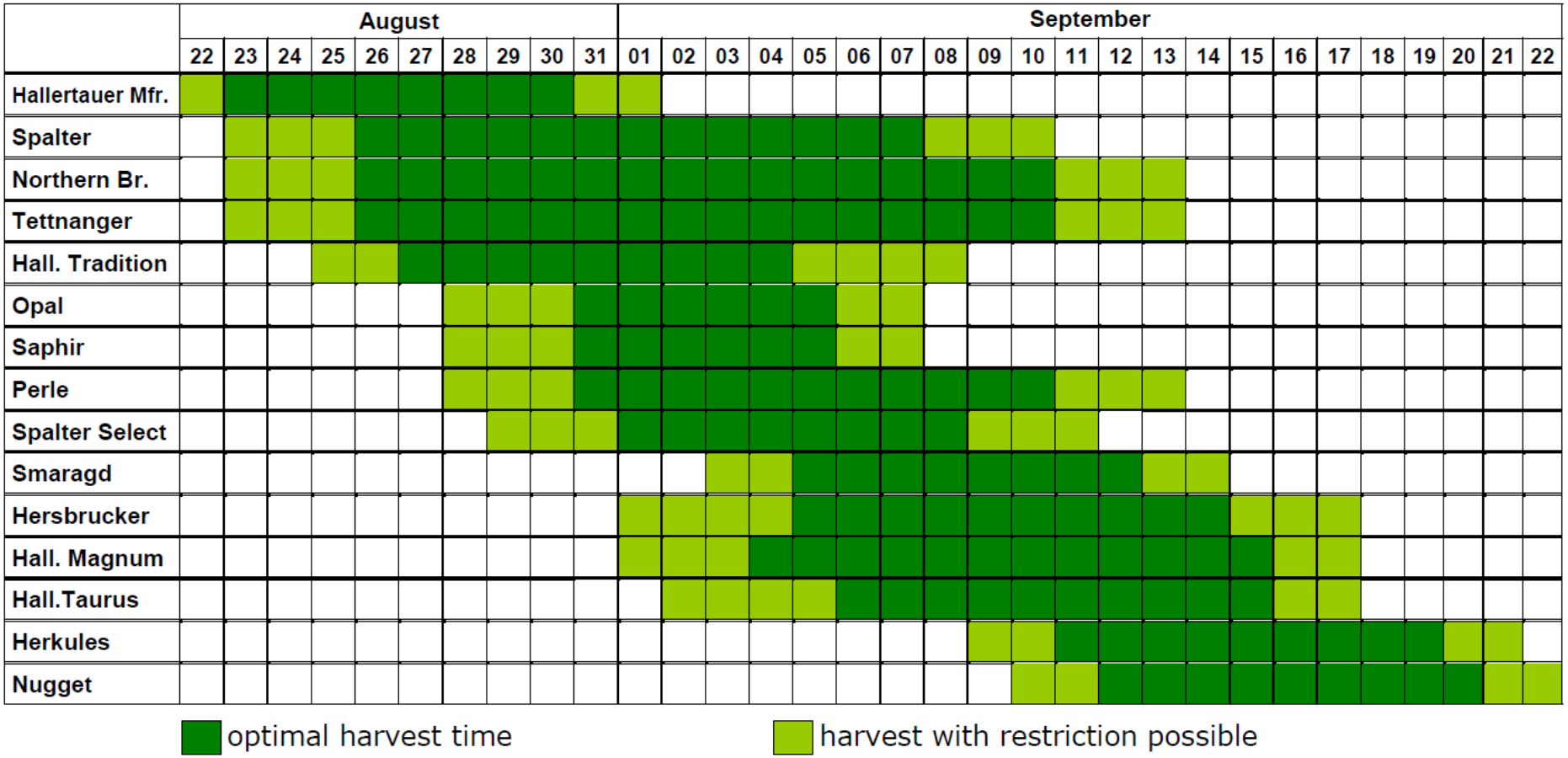
LfL Pflanzenbau

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



Smaller Scale

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©

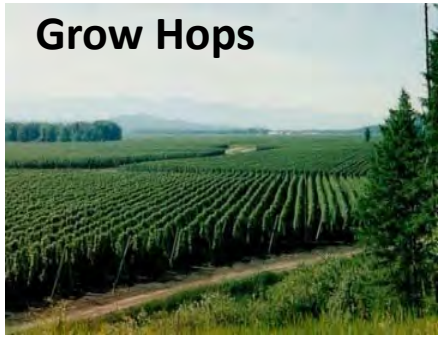

ithinkaboutbeer.com©

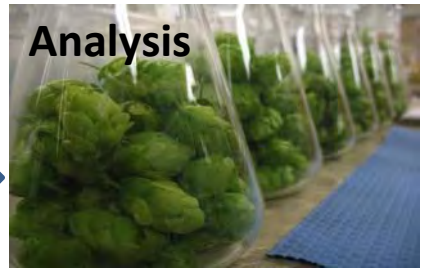
How to dry to 8-10% Moisture?

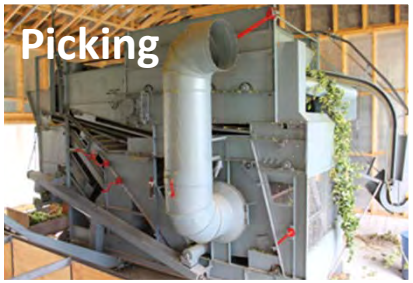
- University of Vermont Extension

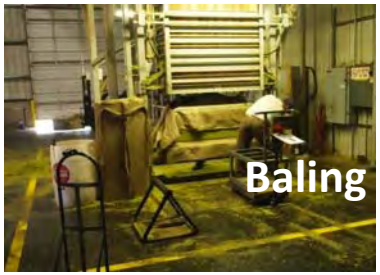
Hop Harvest Moisture Calculator

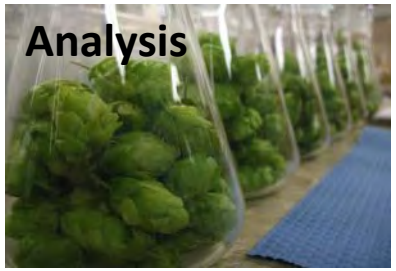
Hop Value-Chain











Hammer Mill & Pelletizer

Marketing/Sales

Whole cone

Pellets

VII. 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.”

Transported by conveyor belt to floor

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.

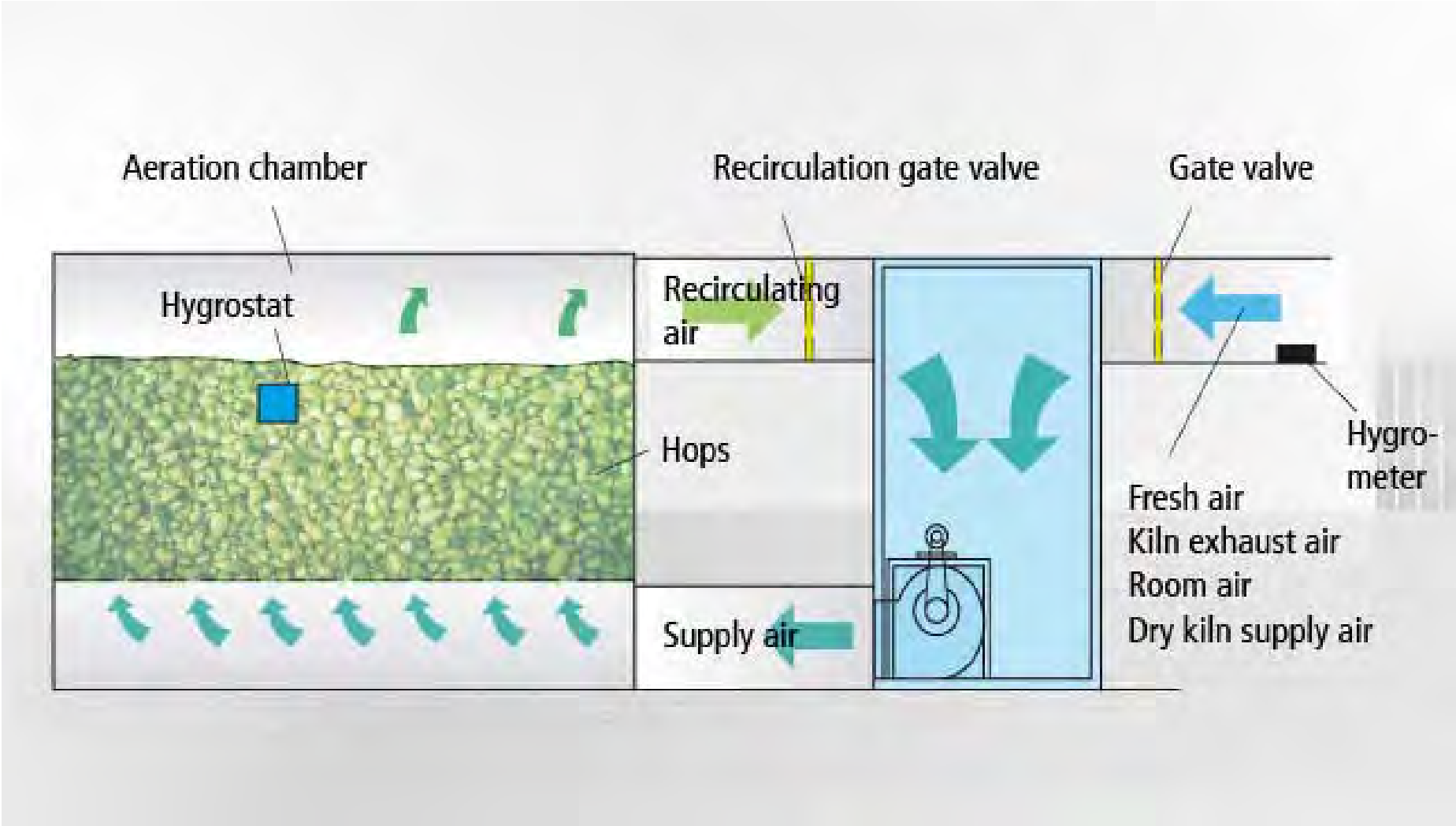
High relative humidity- moisture content of cones in the outer layer of the heap increases and such cones have a reduced sparkle and there is a change from the original colour after pressing.

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*

Automatic Conditioning Plants



VIII. 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.”

UVM Hop Baler (5-10 lb.)

Hops Baler 2.0 Project
Mentor: Dr. Mike Rosen
Clients: UVM Extension
By: Ryan Rzepka, Yuri Hudak, and John Repucci

The UNIVERSITY of VERMONT EXTENSION

Disclaimer

VERMONT
AGENCY OF AGRICULTURE, FOODS & MARKETS

USDA
United States Department of Agriculture
National Institute of Food and Agriculture

Actual Budget:

Quantity	Item and Supplier	Unit Price ($)	Total Price ($)
2	McMaster HDPE Polyethylene, 3/8" Thick, 48" X 48"	87.47	174.94
1	McMaster Fully Keyed 1045 Steel Drive Shaft, 3/4" OD, 3/16" Keyway Width, 36" Length	42.88	42.88
2	McMaster Fully Keyed 1045 Steel Drive Shaft, 3/4" OD, 3/16" Keyway Width, 24" Length	33.23	66.46
1	McMaster Steel Standard Key Stock, 3/16" X 3/16", 12" Length	2.74	2.74
8	McMaster Black-Oxide Steel Set Screw Shaft Collar, 3/4" Bore, 1-1/4" Outside Diameter, 9/16" Width	1.26	10.08
1	Clews Machining (Crank Wheel)	350	350
1	McMaster FDA Compliant Neoprene Rubber, 1/8" Thick, 12" x 24", 55A Durometer	32.32	32.32
2	McMaster Steel 20 Degree Pressure Angle Spur Gear, 16 Pitch, 32 Teeth, 2" Pitch Diameter, 3/4" Bore	33.54	67.08
1	McMaster Impact-Resistant UHMW Polyethylene Tube, 1-3/8" OD X 3/4" ID, 1' Length	7.87	7.87
6	McMaster Cast Iron Base-Mounted Steel Ball Bearing, Set-Screw Lock, for 3/4" Shaft Diameter	39.08	234.48
2	McMaster Steel 20 Degree Pressure Angle Spur Gear, 16 Pitch, 80 Teeth, 5" Pitch Diameter, 3/4" Bore	77.37	154.74
1	McMaster Steel 20 Degree Pressure Angle Spur Gear Rack, 16 Pitch, 1/2" Face Width, 1/2" Height, 6' Length	64.46	63.46
1	Sears Clear Food Grade Silicone Sealant	8.35	8.35
1	ULine 24X24 6MIL POLYBAG 200	140	140
	Queen City Steel		153.00
	Aubuchon Hardware		25.00
	West Marine		45.00
		Total Price	$1578.4

Our clients assigned us a budget of $2000 and we were able to complete the project with a reasonable final price. Most of our parts were bought from the McMaster-Carr online store and Queen City Steel. Our most expensive item, the crank wheel, was outsourced to Clews Manufacturing and cost $350. Initially we just wanted them to roll the outside handle of the

UVM Hop Baler (15-20 lb)

HOW TO BUILD A
HOPS BALER
WITH A LOG SPLITTER

By Ian Pfeiffer and Brian Pinand

The UNIVERSITY of VERMONT EXTENSION

USDA
United States Department of Agriculture
National Institute of Food and Agriculture

VERMONT
AGENCY OF AGRICULTURE, FOODS & MARKETS

Mechanical German RB-60 Presses / Balers


NO SMOKING
NO FUME

From Shelhammer and Sharp

Table 3: Relationship between hop packaging and crushed lupulin glands

Type of bale	Dimension cm	Bulk weight kg/m^3	Degree of crushed lupulin glands % relative
Farmers' bales	80 x 120	85	< 1 %
40 kg rectangular bales	60 x 60 x 120	93	< 1 %
60 kg rectangular bales	60 x 60 x 120	139	< 1 to 3 %
80 kg rectangular bales	60 x 60 x 120	185	> 20 %
US bales	76 x 52 x 150	155	> 10 %

Forster, A. The quality chain from hops to hop products. In *48th IHGC Congress, Canterbury, Barth-Haas Research & Publications (http://www. barthhaas. com)*; 2001.

HOPUNION LLC

Recommendations

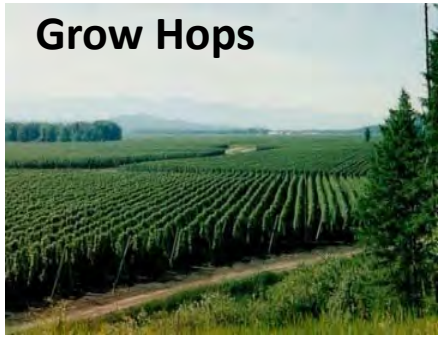
Packaging: Whole Hops are sold in the following quantities:

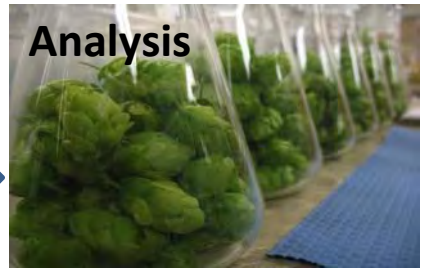
Bales (US Bales = 200 lbs / Import bales = 120 lbs)
½ Bales (US = 100 lbs / Import = 60 lbs)
¼ Bales (50 lbs, vacuum sealed and nitrogen flushed)
Mini-bales (13 lbs, vacuum sealed and nitrogen flushed)

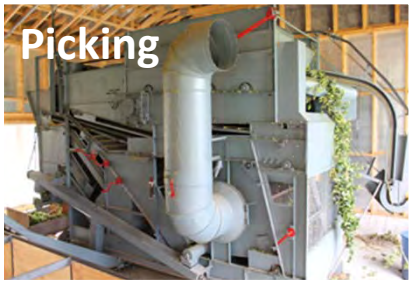
Storage and Best By Recommendations: For maximum protection of bitterness potential and aroma, whole hops should be stored in temperatures below 35°F. Vacuum sealing the whole hops with an inert gas in a laminated plastic/aluminum foil pouch will drastically reduce the rate of oxidation and is recommended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

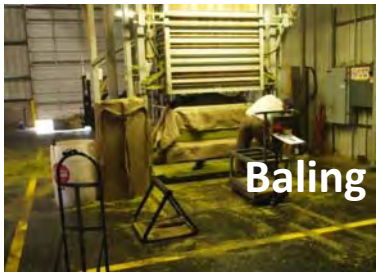
Harvesting, drying, conditioning, and baling video-WOLF

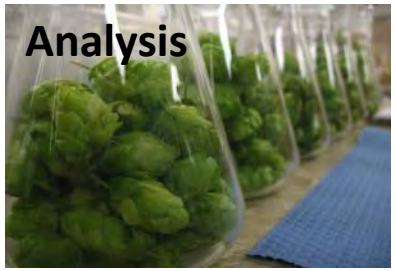
Hop Value-Chain











Hammer Mill & Pelletizer

Marketing/Sales

Whole cone

Pellets