

Growing Hops in Southern California – UCCE

Economics – Feasibility – **Botany** – **Cultural Practices** – **Pest Control** – Harvest



June 21-22



*Paul Vossen
UC Cooperative Extension*

Humulus spp. Overview

- Family:
Cannabaceae
 - *Cannabis*
 - *C. sativa*
 - *Humulus*
 - *H. japonicus*
 - *H. yunnanensis*
 - *H. lupulus*



(Neve 1991)

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Hop Basics (*Humulus lupulus*)

- Climbing perennial (bine) with storage roots
- Dies back winter – regrows from crown in spring
- Growth and flowering influenced by daylength
- Male & female flowers on separate plants
- Only female plants grown (males rogued out)
- Seeds are “undesirable” – add weight
- Plant flourishes with good nutrition & water
- Susceptible to many diseases and insects
- Flowers – “cones” with many scales in clusters
- Lupulin: yellow granular oily resin = flavor
- Resin acids: Alpha & Beta = bitterness
- Oils: volatile aromatics

Long Lived Perennial



Numerous Bines Climbing



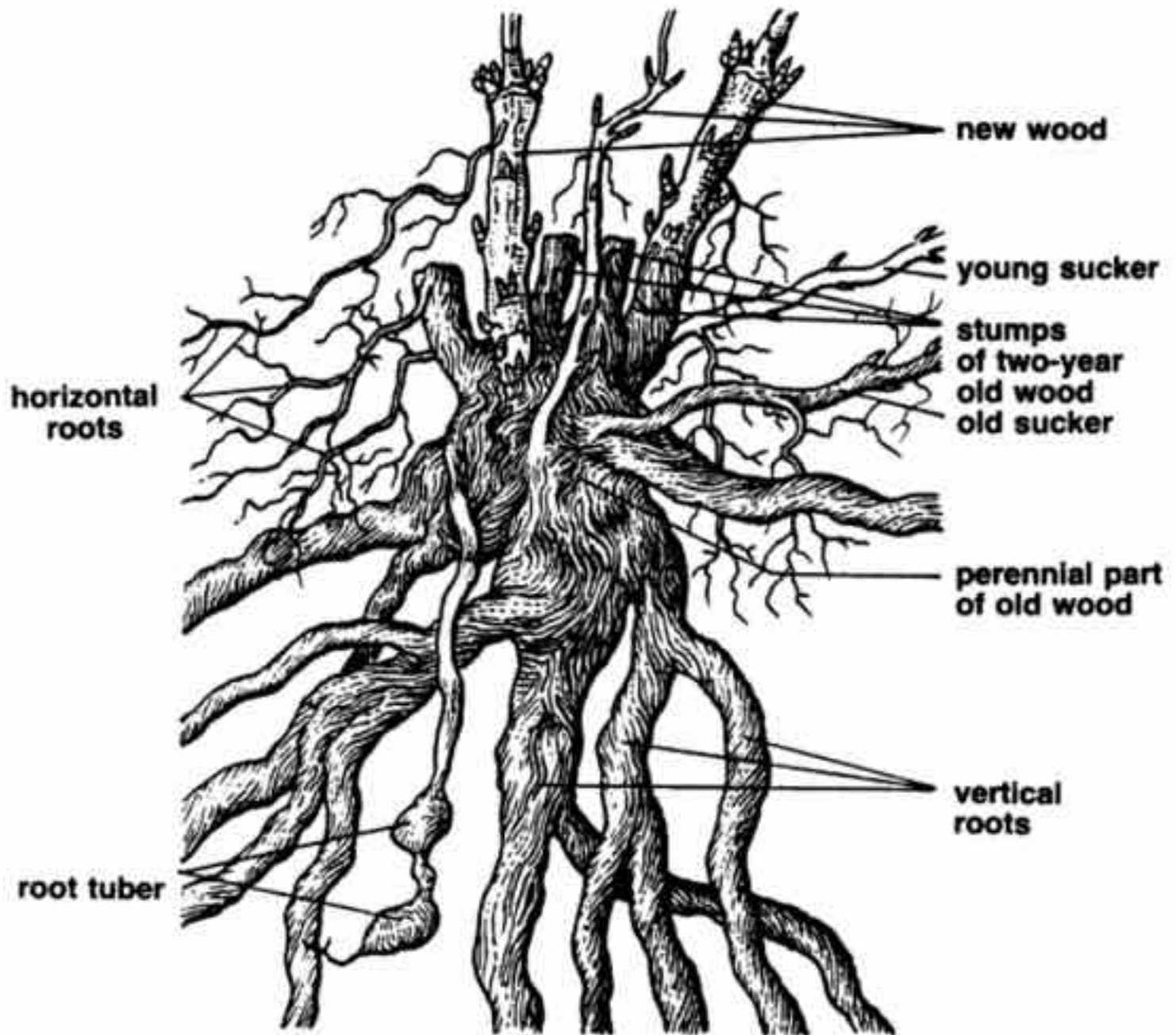


Fig. 2. Underground part of hop plant.

Humulus lupulus

- “Hops”
- Dioecious, perennial, climbing vine
- Indigenous to the Northern Hemisphere
 - Origins in Europe:
 - *H. lupulus* var. *lupulus*
 - Origins in Asia (mainly Japan):
 - *H. lupulus* var. *cordifolius*
 - Origins in North America:
 - *H. lupulus* var. *pubescens*
 - *H. lupulus* var. *neomexicanus*
 - *H. lupulus* var. *lupuloides*

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Dioecious Plants

- Separate male and female plants
- Commercial value derived from the strobiles or “cones” of the female plant
- Male plants utilized only for hybridization
- Pollination results in:
 - Unwanted seeds
 - Increased cone size

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Male Flowers

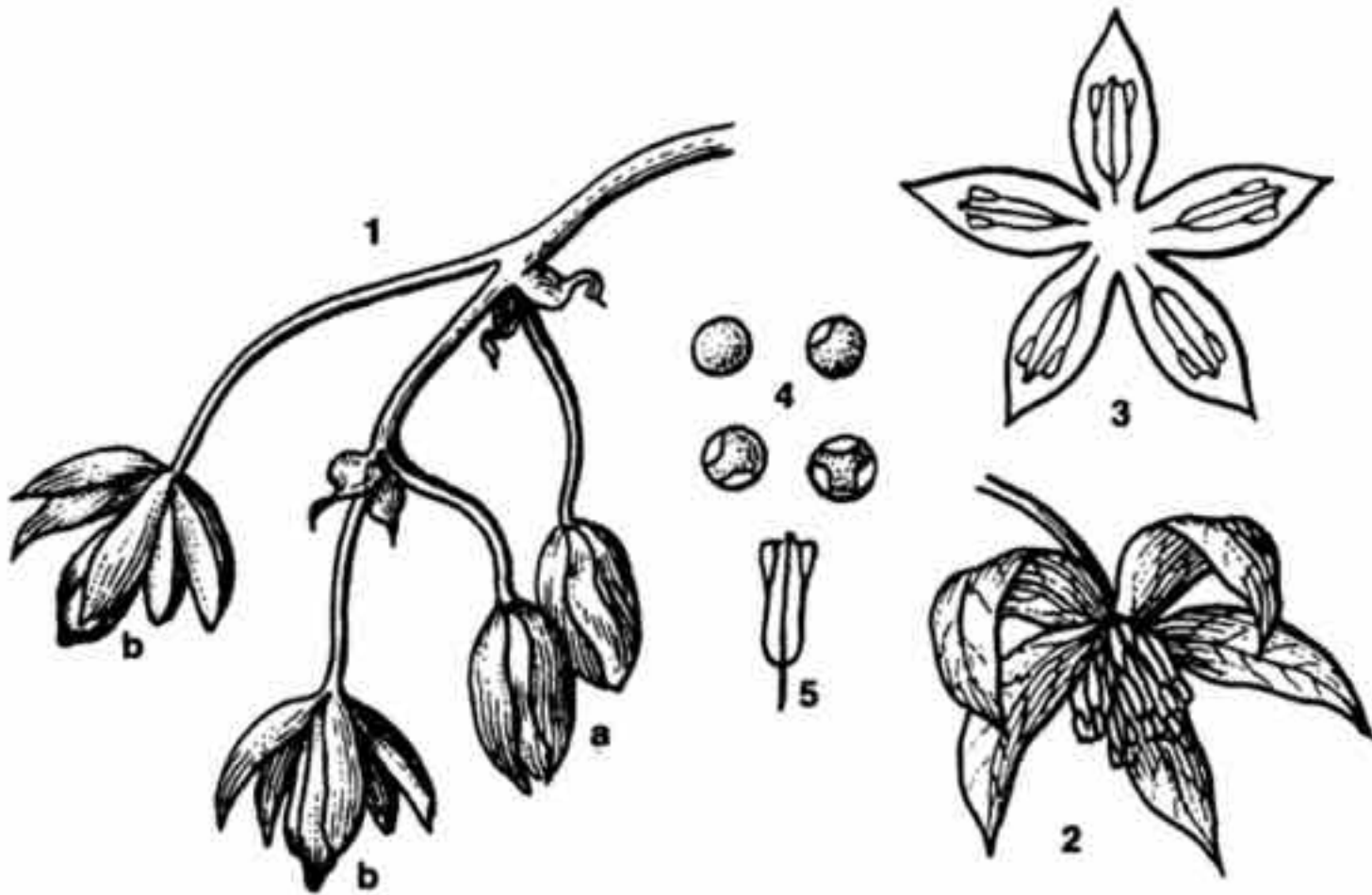


Fig. 20. Male inflorescence (1) with buds (a) and flowers (b), open flower (2) and flower diagram (3), pollen grains (4), anther (5).

Male Flowers



Perrault Breeding Program



New Variety Evaluation



The “Cones”

- These are the manufacturing unit of the commercial hop plant.
 - The cones contain lupulin glands (actually modified vine hairs).
 - These glands contain the chemistry we are after:
 - Essential oils: over 300 compounds, contribution to aroma.
 - Soft resins: beta acids, and the all important alpha acids.
 - Lupulin accounts for 20 – 30 % of cone weight.

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Photoperiod Sensitive

- Hops are a short day plant.
 - Under a critical number of light hours - floral initiation.
 - Also node dependant.
 - Over the critical amount, vegetative growth.
 - In shorter day areas, flowering occurs as soon as the node requirement in met-yield not maximized.
 - In longer day areas-vegetative growth is maximized prior to shortening days of mid to late summer.
- Results in defined “Production Stages”

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**Reaches the top
laterals form
Flowering starts**



Female Flowers

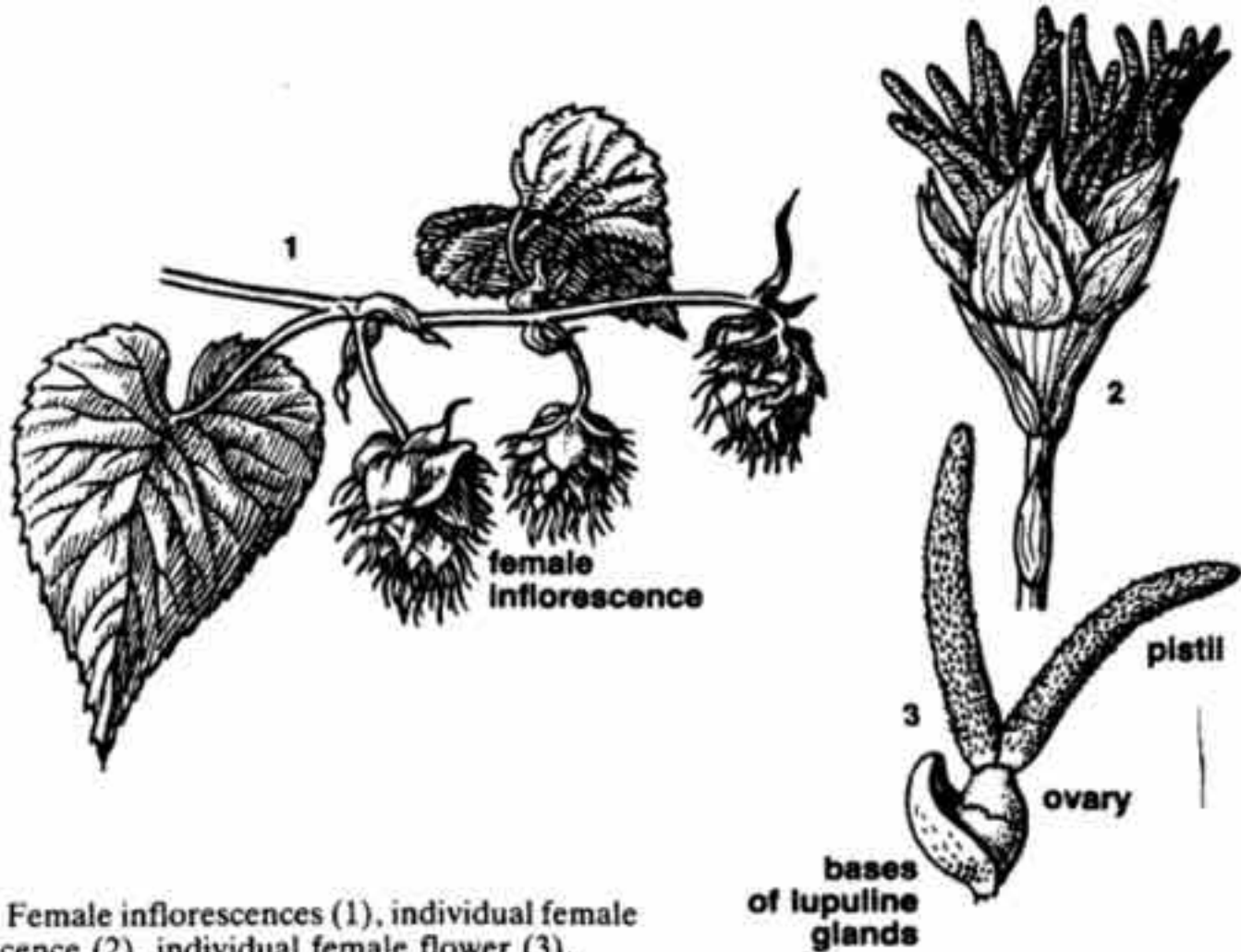


Fig. 21. Female inflorescences (1), individual female inflorescence (2), individual female flower (3).

Female Flowers



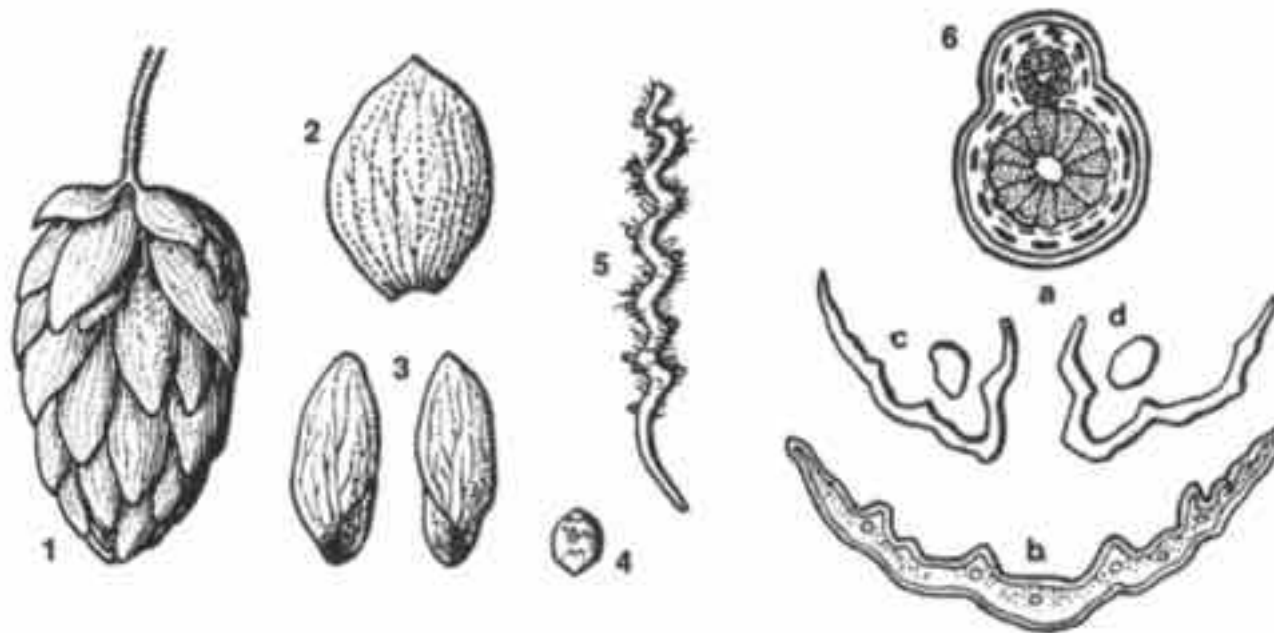


Fig. 23. Cone and its parts: 1 – cone, 2 – covering bract, 3 – true (involucral) bracts, 4 – achene, 5 – cranked axis, 6 – cross section of a cone | a – cranked axis, b – covering bract, c – true (involucral) bracts, d – achenes|.

TABLE 14 Percentage of components in dry matter of hop cones

Component	Percentage of total				
	Wildner (1938)			Bulgakov (1954)	Rybáček (1963)
	min.	max.	average		
Rachis	5.20	5.90	5.60	5.98	4.40
Axis	6.10	7.30	6.70	6.36	6.68
Bracteoles and bracts	66.90	69.40	68.20	66.85	69.31
Lupuline glands	19.20	19.80	19.50	19.81	19.61
Total			100.00	100.00	100.00

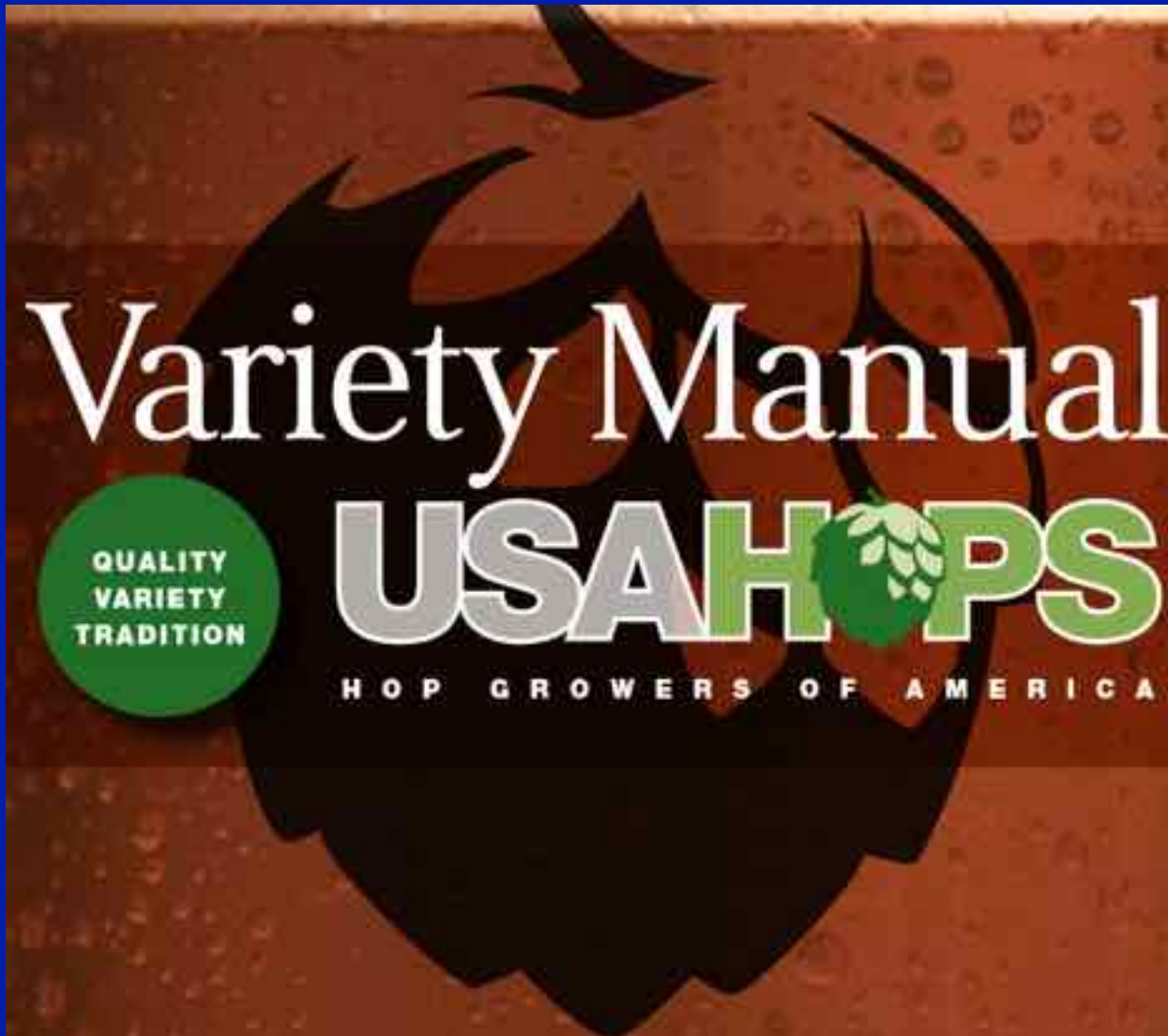
Developmental Physiology of the Hop Plant (or Production Stages)

- The hop plant goes through numerous stages of growth throughout the year.
 - Each stage has its own unique characteristics.
 - Therefore each stage of growth requires its own unique management scheme.
- Main Stages of Growth
 - Dormancy
 - Spring regrowth
 - Vegetative Growth
 - Reproductive Growth
 - Preparation for Dormancy

Comments on Development

- The stages of hop plant growth need to be understood to properly manage the crop.
 - Each stage is unique, thus unique management requirements.
- Yield is already being determined as early as April and May.
- To complicate things further: *Much of this is variety dependant.*

Hop Varieties

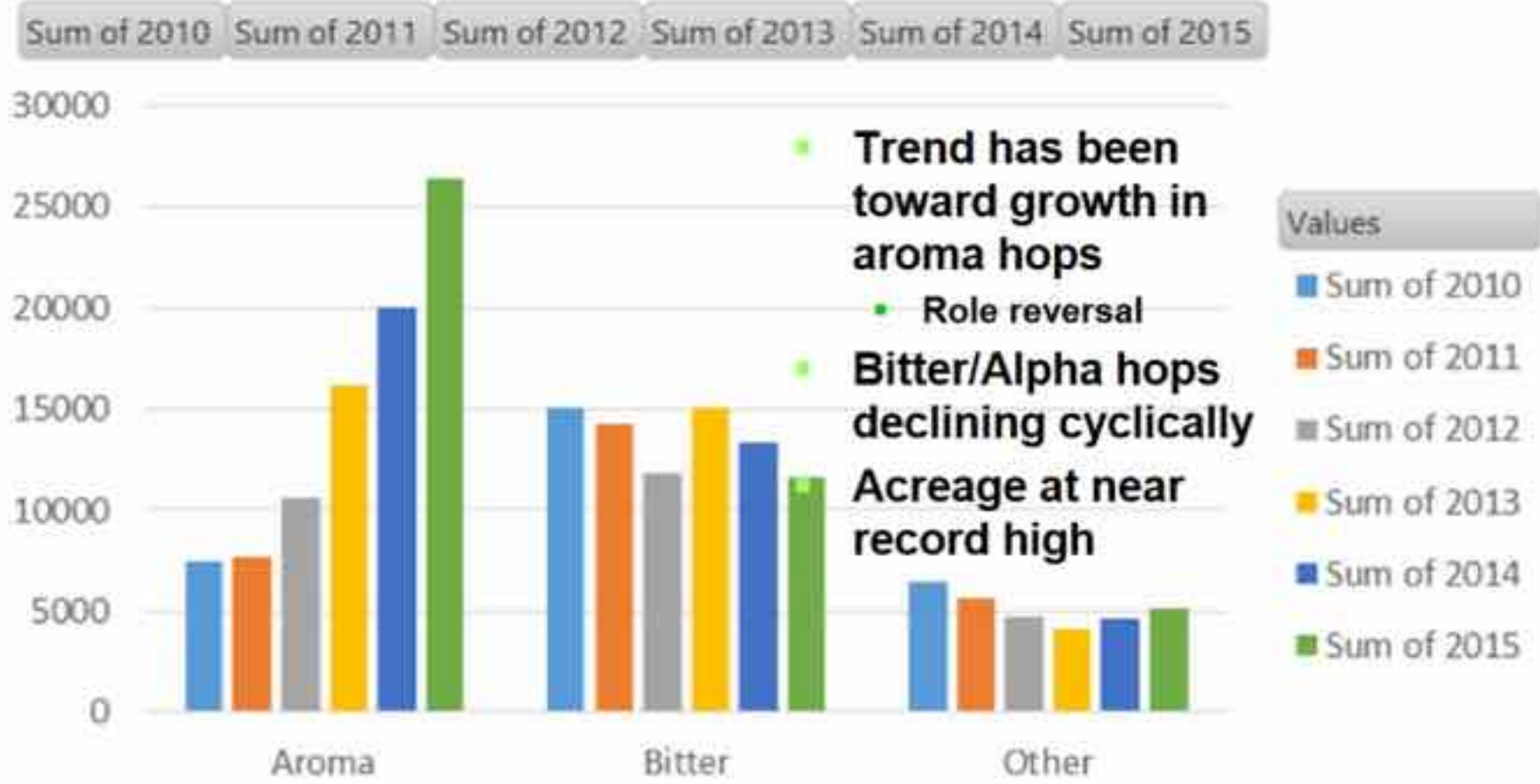


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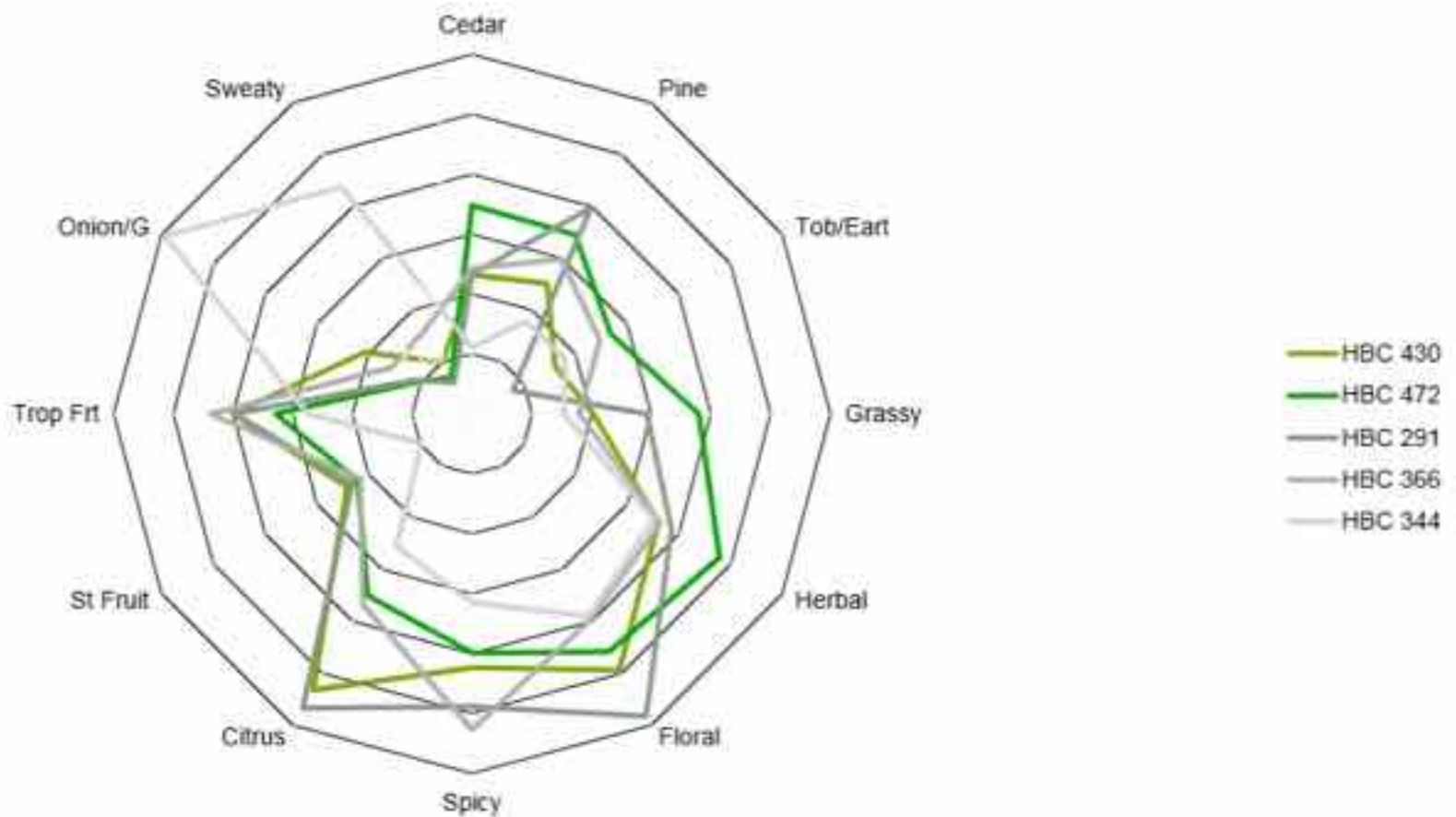
Select
Botanicals

Brewers

Acreage Trend: aroma versus alpha



Aromatic Variability



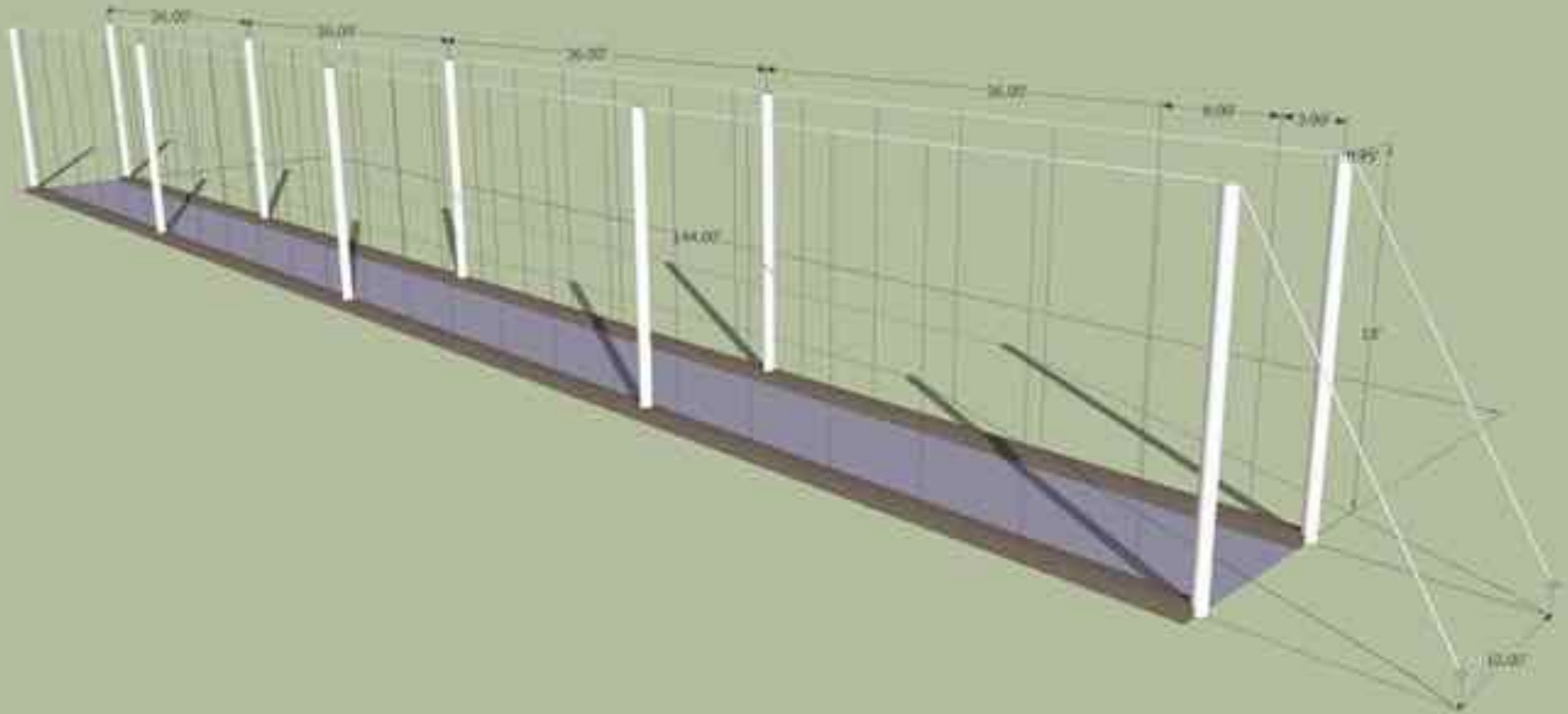
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Land Preparation



WSU Cost Study 2010
Disc, subsoil, plow/rototill,
springtooth 2X = \$150/a

Hop Trellis ~ \$3,000



2010 Yakima WA Cost Study (per acre)

- 60 poles + 10 anchor poles (12' x 28')
- Holes, anchor material, cable, wire, staples

Poles, cables, wires, dead-men



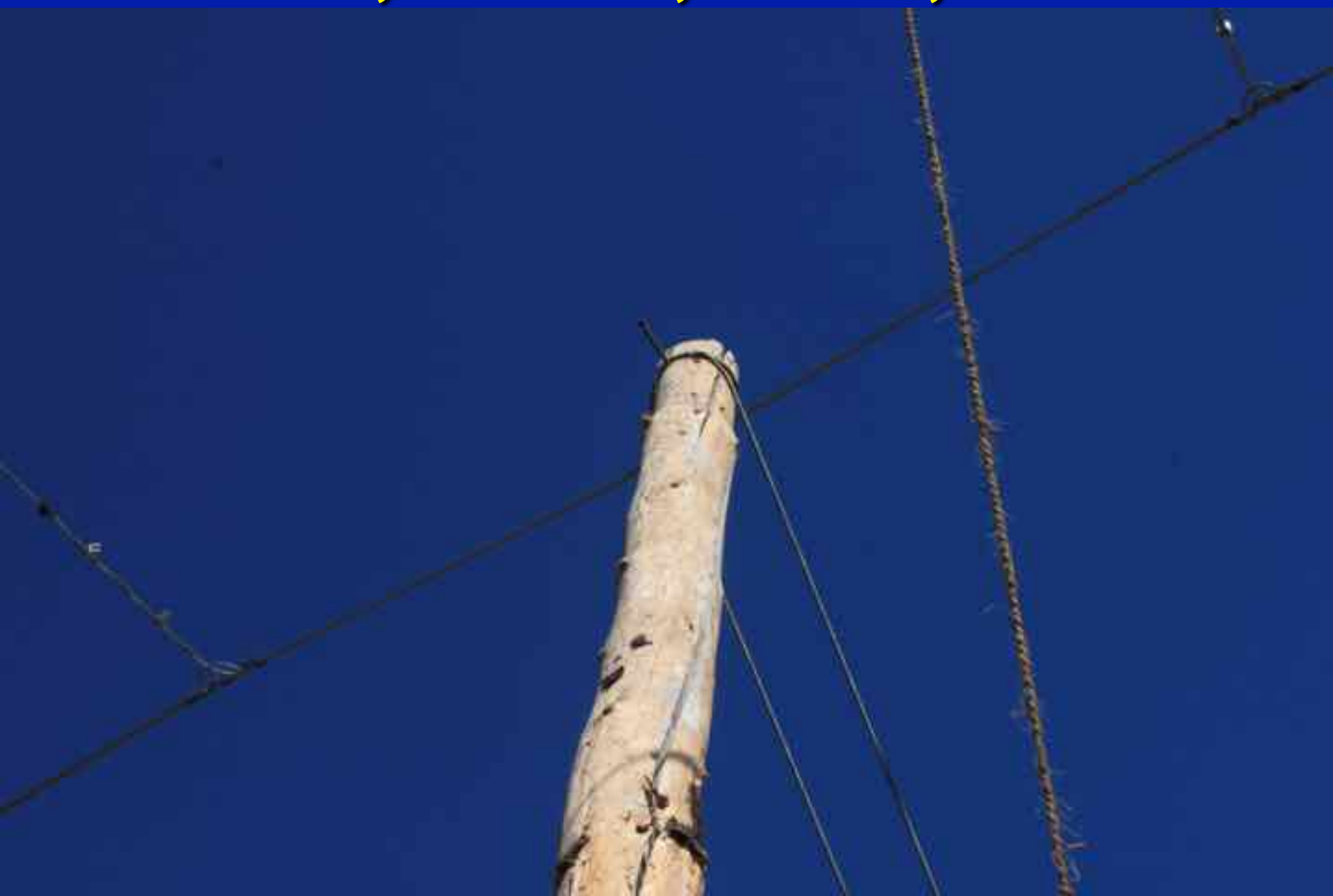
Poles



Poles soaked in preservative



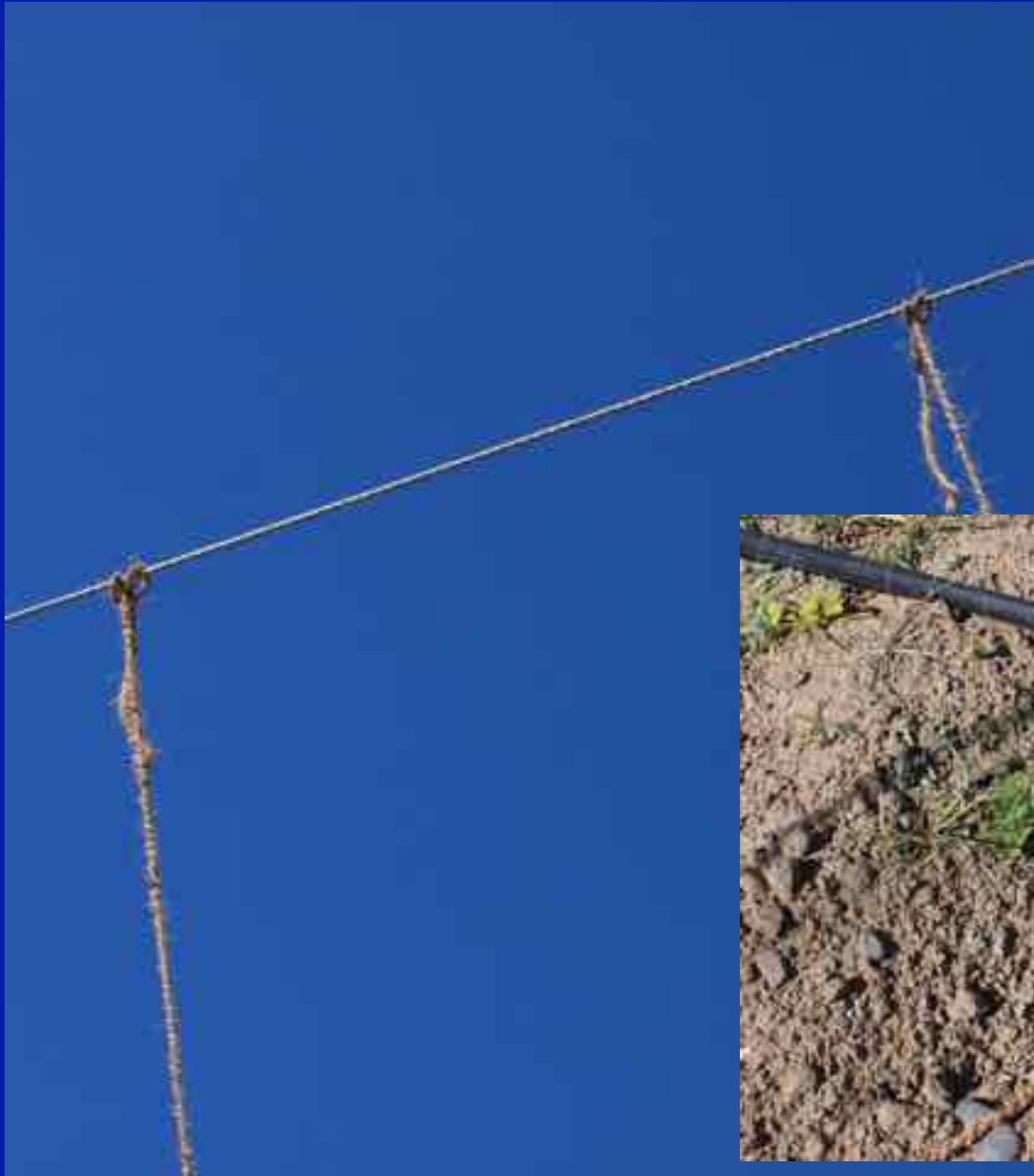
Poles, cables, wires, twine



Tall carts



Cables, twine, hopclip



Growing hops

- Site: full sun & well drained soil
- Spacing 2-5' in row – 7-14' between rows
- Yakima: 3.5' x 12' = 1,037 crowns/acre
- Plant ~ 4,000 roots/acre (3-4 per hill)
- 22' Poles: 60-130/acre + 10 anchor poles (12' x 28')
- Buried 3-4 ft. with DM anchors (+ - cement)
- Drip irrigation system (~ \$1,500/acre)
- Prune crown in late winter/early spring
- Train 2 vines/string – 4-6 per crown
- 50% yield year 1 – 80% year 2 – 100% year 3
- Fresh yield: 65-80% H₂O ~ 4-6,000 lbs/acre

Training vines onto twine



**WSU Cost Study 2010
4,000 roots @ \$0.20 each
\$800/acre**

Training vines onto twine



Training vines onto twine



Training vines onto twine



Minimal Weed Competition



Hop Irrigation

- Ideal: base on Evapotranspiration (ET)
 - Drip irrigate every day from May to harvest
 - Increase or decrease hours/day based on temp.
- General: 20-30"/season (minus soil H₂O)
 - Loam holds 2"/ft. rooting depth
 - 20-30" = 543,000 to 814,000 gallons/season
 - Hops tolerate drought, but stress ↓ production
- Critical Times: spring growth & flowering



A photograph of a soil bank, likely a cross-section of a hillside or embankment. The soil is light brown and shows signs of erosion with vertical cracks. Numerous tree roots are exposed, extending horizontally and diagonally across the face of the soil. At the top of the bank, there are some small trees and a utility fence with several vertical posts. The sky is clear and blue.

**Soil ~ 2 ft. deep underlain by
impervious clay**

Soil holds ~ 2"/ft. = 4 inches of water

Seasonal Water Requirement

April - October (30 yr. average in inches) (Sonoma County)

	<u>Marine</u>	<u>Coastal Cool</u>	<u>Coastal Warm</u>
April	2.8	4.0	4.5
May	2.9	5.8	6.9
June	2.8	5.6	7.0
July	3.4	6.1	7.9
August	3.1	5.2	6.8
Sept.	3.1	4.4	5.7
Oct.	<u>3.1</u>	<u>3.3</u>	<u>3.7</u>
TOTAL	21.2	34.4	42.5

Plant - USE RATE

How Much Water Plants Use

Evapo - Transpiration (ET)

- Evaporation from soil surface = 10%
- Transpiration = 90% cooling of the leaves



Hop Irrigation *(Santa Rosa ET)*

			May	June	July	August	Sept.	Oct.
		ET _o inches/day	0.17	0.20	0.20	0.19	0.14	0.10
		ET _c inches/day	0.13	0.15	0.15	0.14	0.11	0.08
Size	ft ²	Plant age	gallons per plant/ day	gallons per plant/ day	gallons per plant/ day	gallons per plant/ day	gallons per plant/ day	gallons per plant/ day
4	ft ²	new	0.6	0.8	0.8	0.7	0.5	0.4
9	ft ²	young	0.7	0.9	0.9	0.8	0.6	0.4
25	ft ²	mature	2.0	2.4	2.4	2.2	1.7	1.2
40	ft ²	mature	3.2	3.8	3.8	3.5	2.7	2.0
43,560	ft ²	1 acre solid cover	3,456	4,168	4,139	3,784	2,885	2,037

Hop Irrigation

- Spaced 3x14 ft. (40 ft²)
- Cool spring = 3 gal/plant/day
- Warm summer = 4 gal/plant/day

- Spaced 2x12 ft. (24 ft²)
- Cool spring = 2 gal/plant/day
- Warm summer = 2.5 gal/plant/day

**Hop roots will grow in the entire rooting zone
Most roots are in the top 2-3 feet**

Hop Nutrition Requirements

- Nitrogen: ~ 100-150 lbs. per acre (needs to be in the soil available by end of May)
- Phosphorous: ~ 0-60 lbs. per acre (if soil analysis is >60 ppm = not needed)
- Potassium: ~ 80-160 lbs. (K_2O) (if soil analysis is >200 ppm = not needed)
- pH: 5.0 to 7.0 = no problems (6.0 is perfect)
- Ca, Mg, Mn, Lime: soils above 5.7pH = nothing needed (ratio of 3Ca:1Mg = good)

Hop Organic Nutrition

cover crops, compost, concentrates



Tilled in large biomass of legumes



Till in 3-5 tons/acre in the fall

*CalPhos
or similar
product*



*Feather or
fish meal*

Primary Hop Pests

- Downy Mildew
 - Powdery Mildew
 - Virus-viroids
 - Spider Mites
 - Aphids
-
- Many miscellaneous
Secondary pests



Hop Diseases - PREVENTION

Sanitation:

- Remove or compost all overwintering plant material
- Trim up lower leaves and side shoots
- Reduce humidity



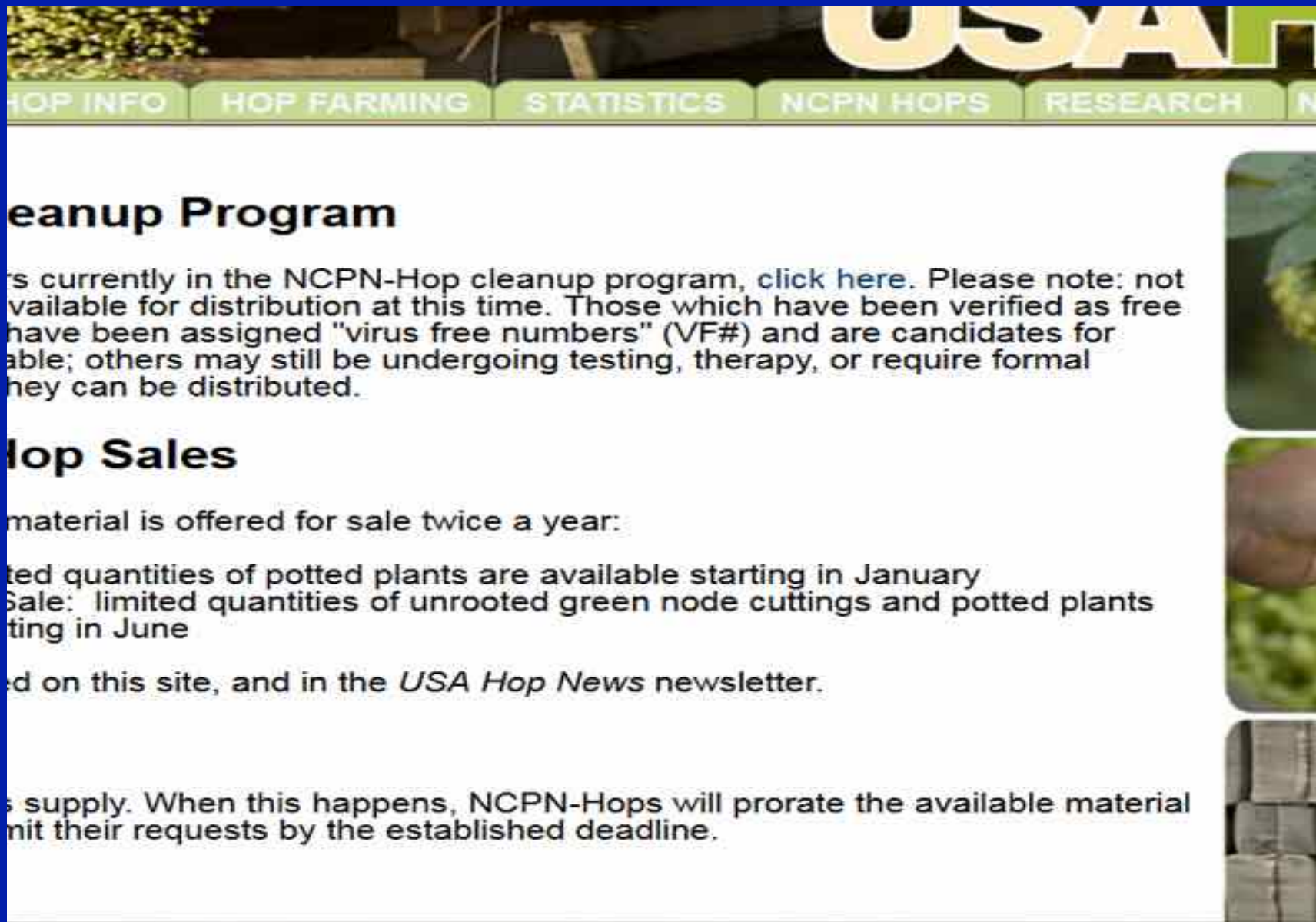
Hop Latent & Apple Mosaic Virus

Stunts growth and
dramatically reduces cone set

Control: plant certified
virus free plants



Hop Assn. Certification Program



The image shows a screenshot of the USA Hop website. At the top, there is a navigation menu with the following items: HOP INFO, HOP FARMING, STATISTICS, NCPN HOPS, RESEARCH, and N. The main content area features a section titled "Cleanup Program" with text explaining the NCPN-Hop cleanup program and providing a link for more information. Below this is a section titled "Hop Sales" which describes the availability of potted plants and unrooted green node cuttings. The text is partially obscured by a blue vertical bar on the left side of the image.

Cleanup Program

ers currently in the NCPN-Hop cleanup program, [click here](#). Please note: not available for distribution at this time. Those which have been verified as free have been assigned "virus free numbers" (VF#) and are candidates for sale; others may still be undergoing testing, therapy, or require formal they can be distributed.

Hop Sales

material is offered for sale twice a year:

ted quantities of potted plants are available starting in January
Sale: limited quantities of unrooted green node cuttings and potted plants
ting in June

ed on this site, and in the *USA Hop News* newsletter.

s supply. When this happens, NCPN-Hops will prorate the available material
mit their requests by the established deadline.

Downy Mildew can ruin the crop



P. Mildew can ruin the crop



Healthy



Diseased

**Critical
Control
Period**

**3 weeks
during early
cone
development**

WA P. Mildew infection examples

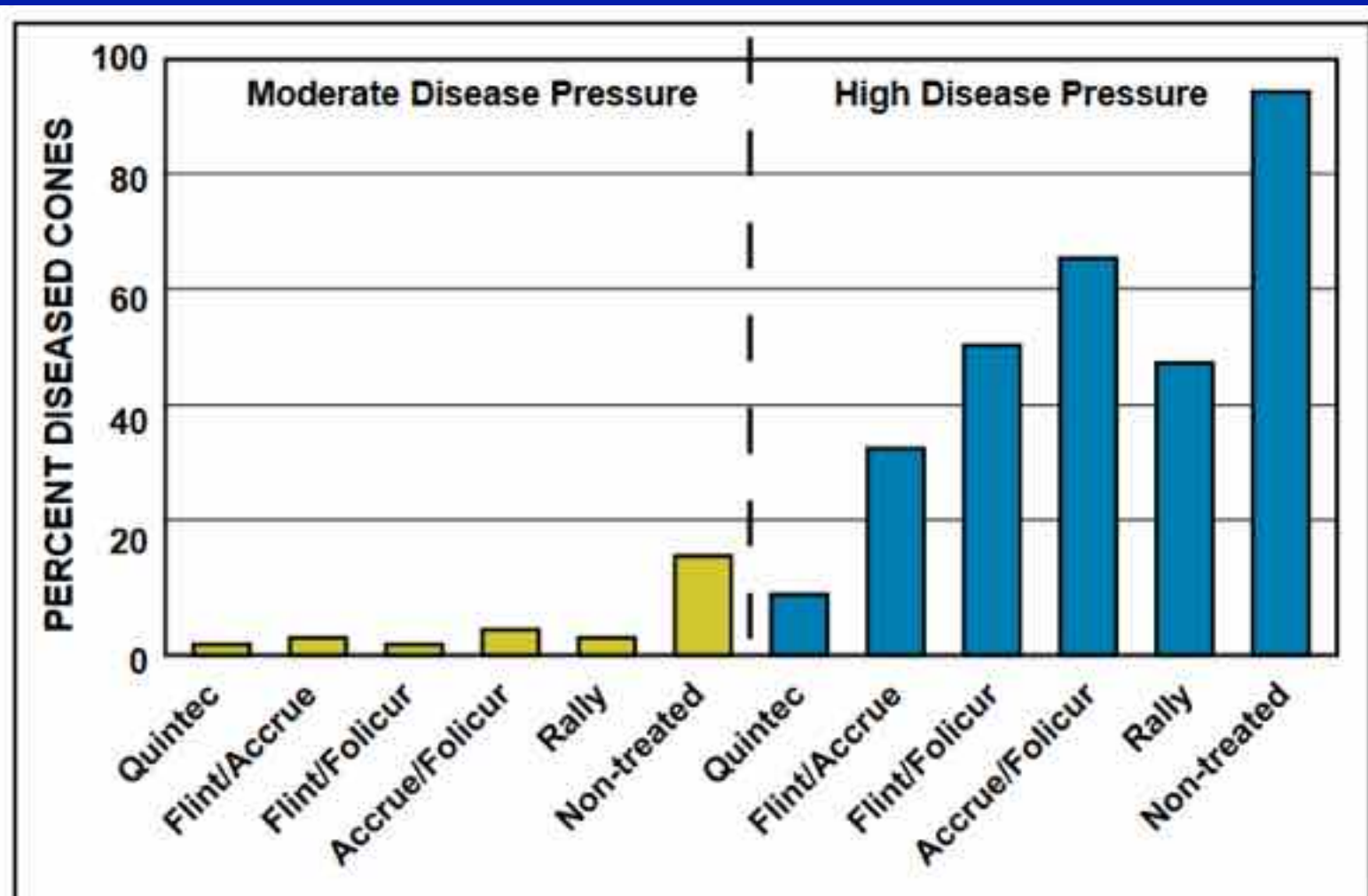


Figure 38. Efficacy of powdery mildew fungicides under moderate and high disease pressure in Washington. Notice that most fungicides provide acceptable control when disease pressure is moderate.

Powdery Mildew



Control:

- Sanitation
- Mod. fertilization
- Mod. irrigation
- Timely fungicide applications

Hop Diseases

(Resistant Varieties)

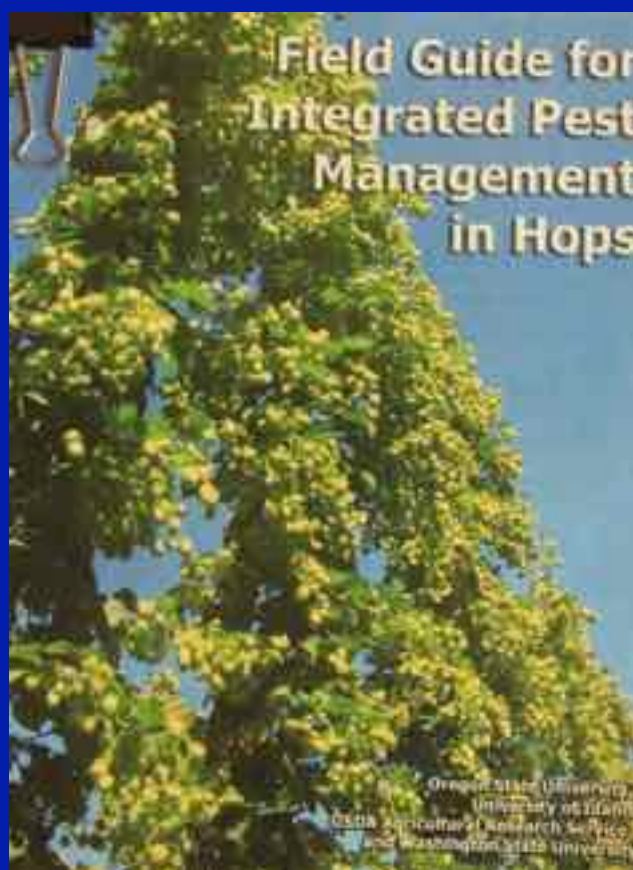


Table 2. Disease Susceptibility and Chemical Characteristics of the Primary Public Hop Varieties Grown in the U.S.

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 Mittelfruh	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
Spaizer	Aroma	S	MS	S
Spaizer 36	Aroma	S	MS	S
Spalter	Aroma	S	R	MR
Stirling	Aroma	MS	MR	U
Teamaker	Aroma	MR	MR	S
Tetthanger	Aroma	MS	MS	S
Tolhurst	Aroma	S	S	U
U.S. Tetthanger	Aroma	MS	MS	S
Vanguard	Aroma	S	S	U
Willamette	Aroma	MS	MR	S

Hop Downy & Powdery Mildew

- PM favored by rapid plant growth
- Both like mild temperatures (47-82°F)
- Both like high humidity
- DM likes 24 hours of wetness
- Not the same as PM of grapes

Hop Insects

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Arthropod and Slug Pest Management

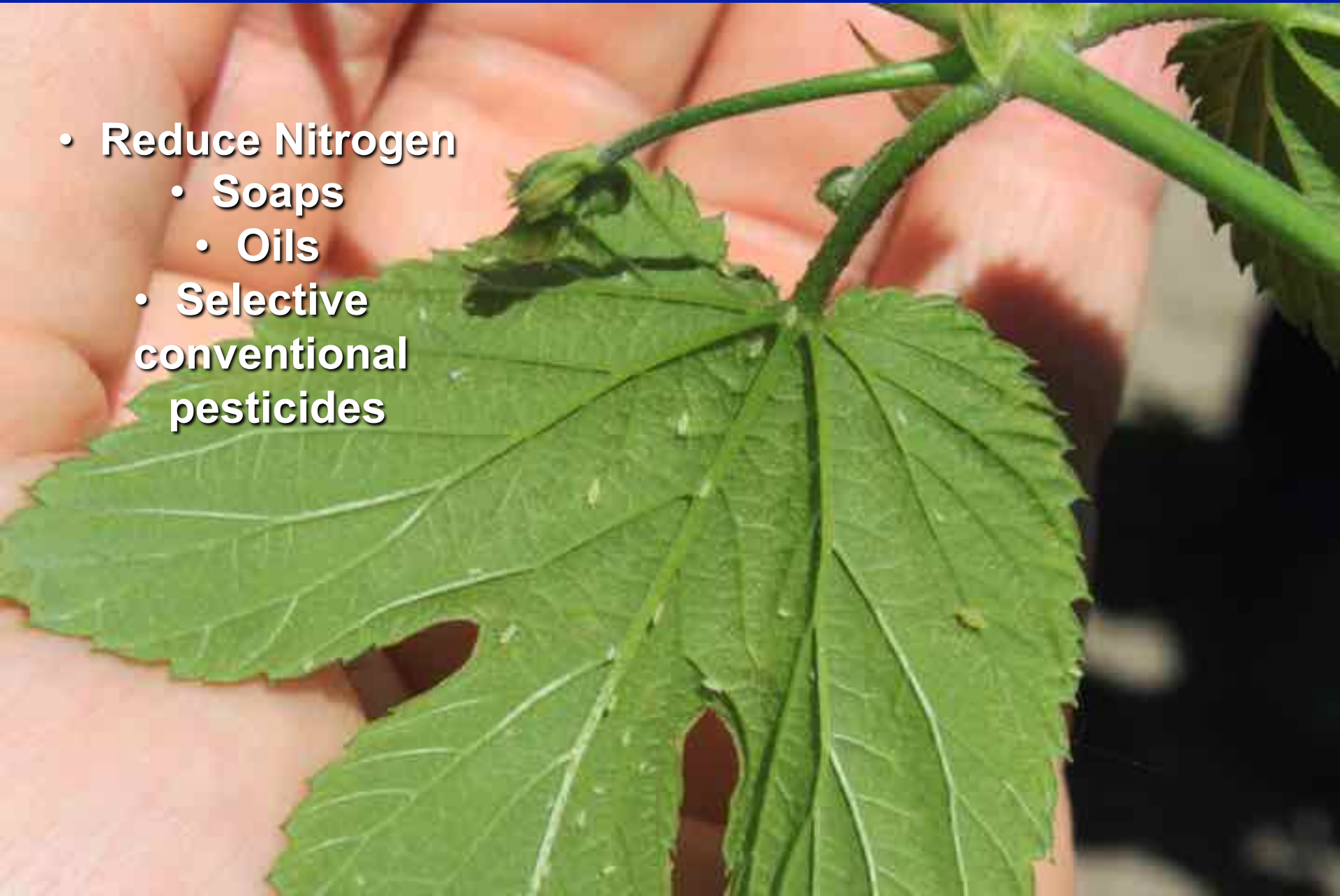
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Aphids

- Reduce Nitrogen
 - Soaps
 - Oils
- Selective conventional pesticides



Spider mites

- Monitor weekly for economic threshold
- Reduce Nitrogen
 - Reduce Dust
- Selective miticides
 - Avoid using conventional insecticides that kill natural enemies





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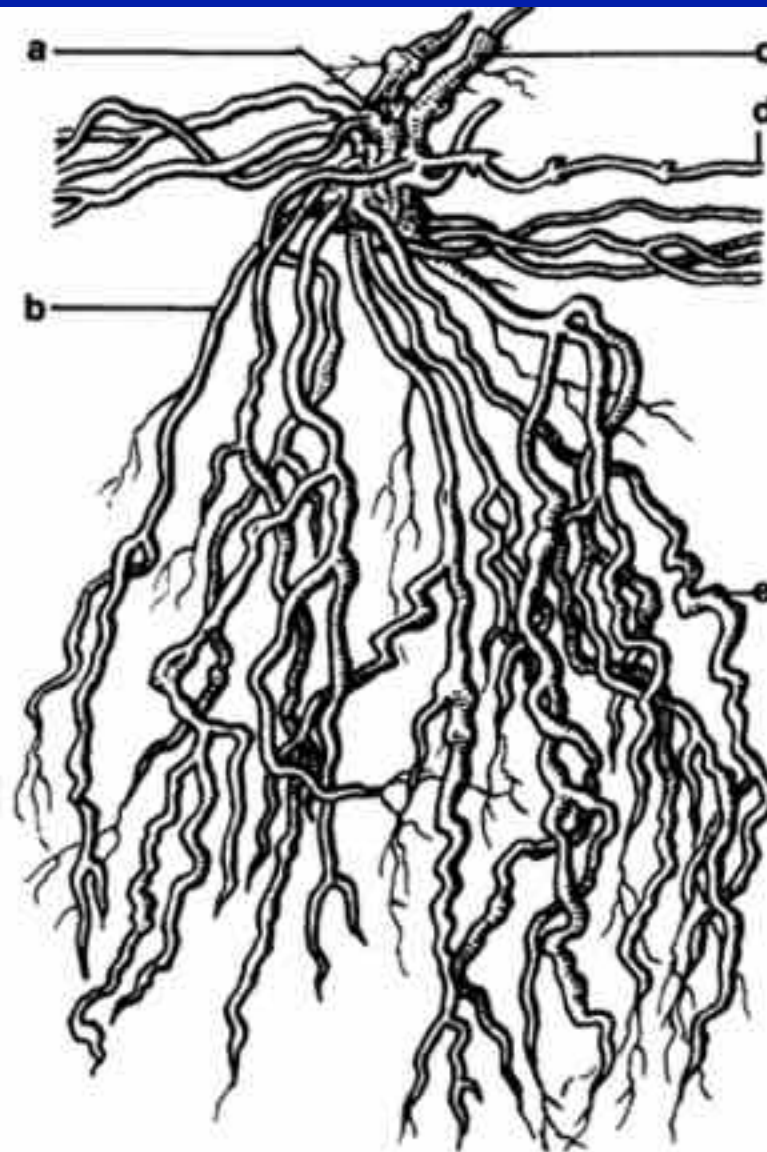


Fig. 9. Displacement of vertical roots: a – old wood, b – vertical roots, c – new wood, d – suckers, e – root tubers.