



Hop Breeding in the 21st Century

The why, how, and impact of new hop variety evaluation and selection

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Yakima Chief Ranches



YAKIMA CHIEF Ranches



- ❖ Integrated crop management company which breeds and manages hops for the global brewing industry
- ❖ Started in late 1980s by the Perrault, Smith, and Carpenter families
- ❖ Focused on connecting world's finest brewers with family-owned hop farms



YAKIMA CHIEF RANCHES: VARIETY RELEASES



Ahtanum® Brand YCR 1
1997



Palisade® Brand YCR 4
2003



Warrior® Brand YCR 5
2000



Simcoe® Brand YCR 14
2000





HOP BREEDING COMPANY

YAKIMA CHIEF RANCHES, L.L.C. • JOHN I. HAAS INC.



YAKIMA CHIEF
Ranches



HAAS

BARTH-HAAS GROUP

- ❖ The YCR breeding program joined forces with the John I. Haas, Inc. breeding program to form Hop Breeding Company (HBC) in 2003.
- ❖ HBC's mission is to develop pest-resistant and disease-resistant hop brands with strong commercial qualities.
- ❖ HBC takes advantage of the combined resources of both companies and full integration of breeding efforts to be a hop breeding powerhouse.

HOP BREEDING COMPANY: VARIETY RELEASES



Citra® Brand HBC 394
2007



Sabro™ Brand HBC 438
2018



Mosaic® Brand HBC 369
2012



HBC 682
2018



Ekuanot® Brand HBC 366
2014



Talus™ Brand HBC 692
2020



Loral® Brand HBC 291
2016



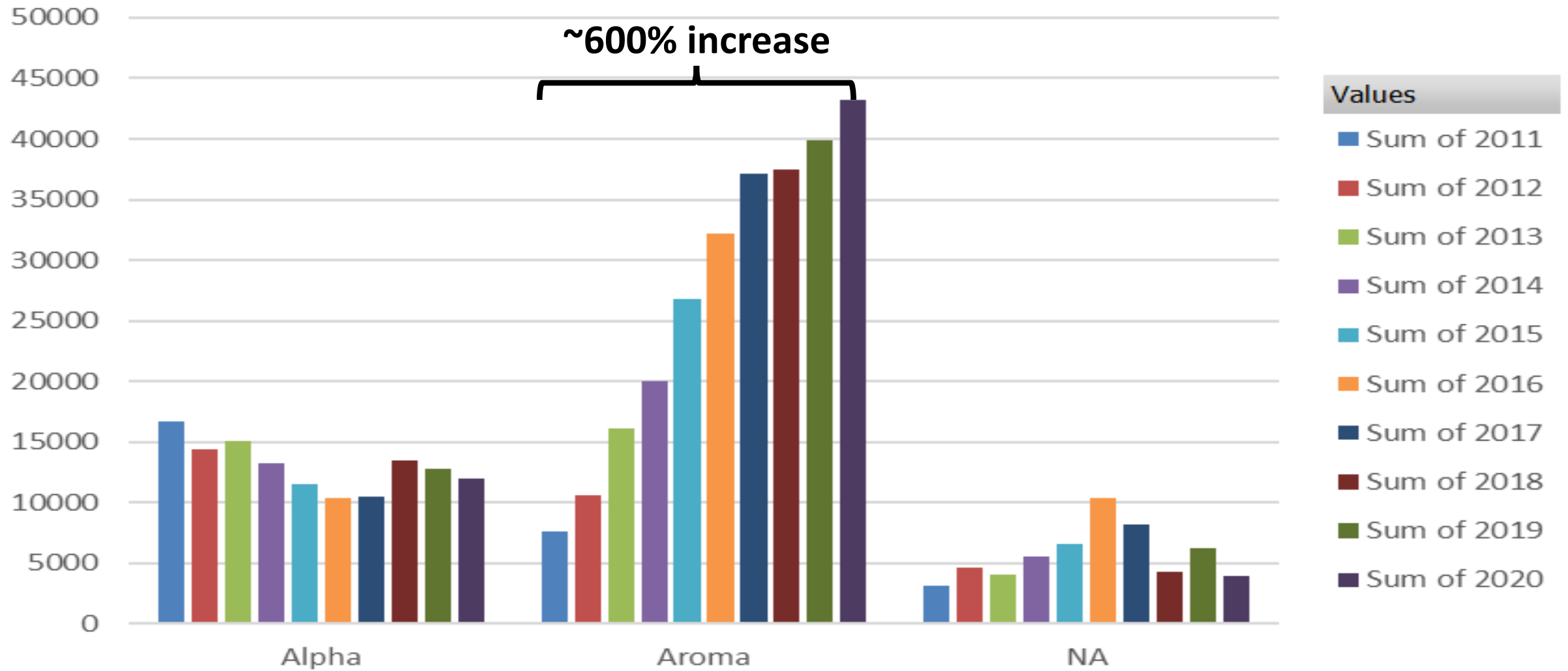
Coming soon...

Yakima Chief Ranches: Today



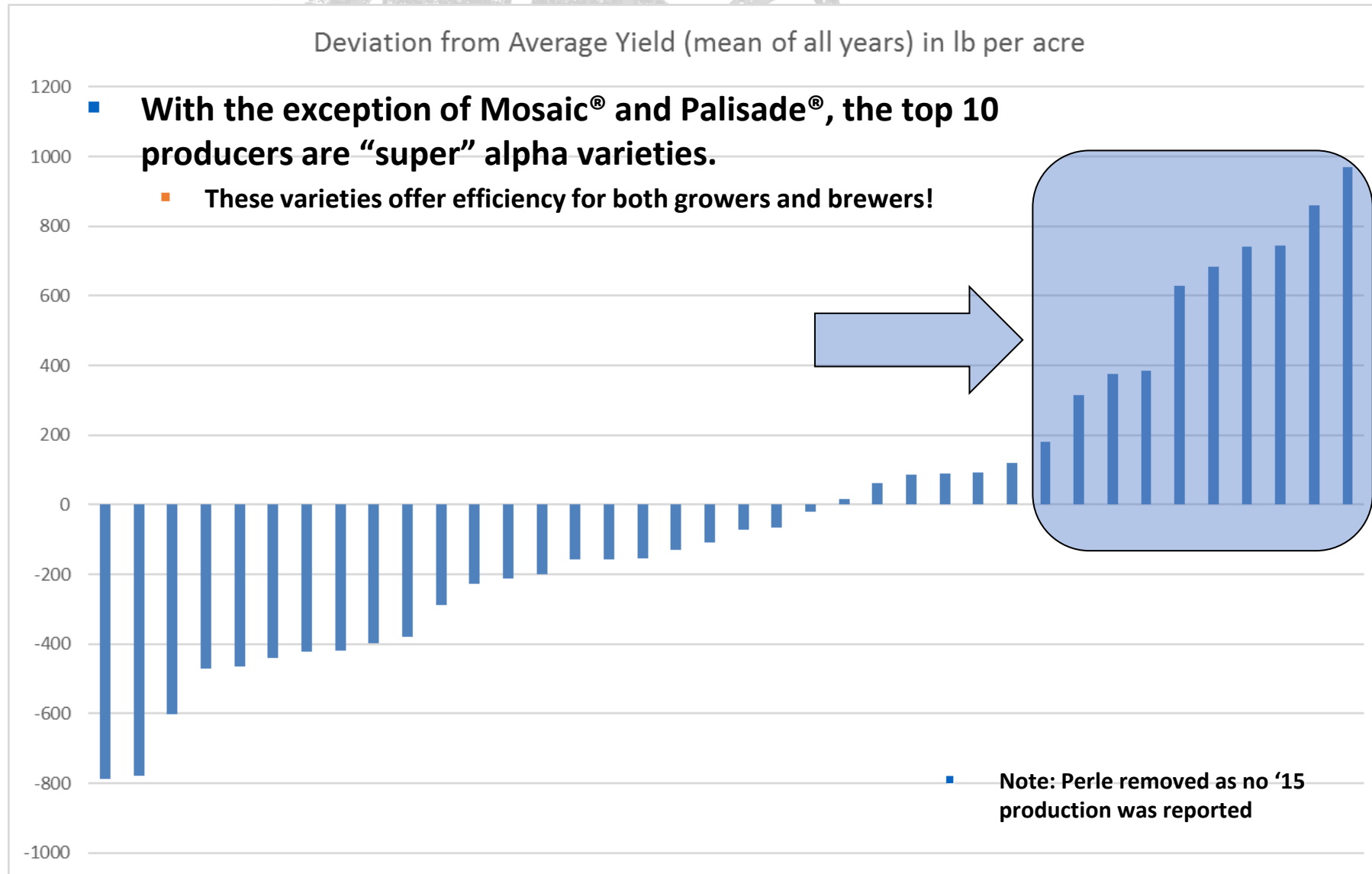
- New headquarters in Zillah, WA focused on clean plant propagation
 - 41,000 square feet of growing space
 - World-class research laboratory
 - Nanobrewery
 - Sensory lab
- Mission: Our purpose is to create, grow, and **protect** value for all within our footprint through developing first class hop varieties, **relentlessly pursuing quality**, and building meaningful relationships.

The Changing Hop Value Chain

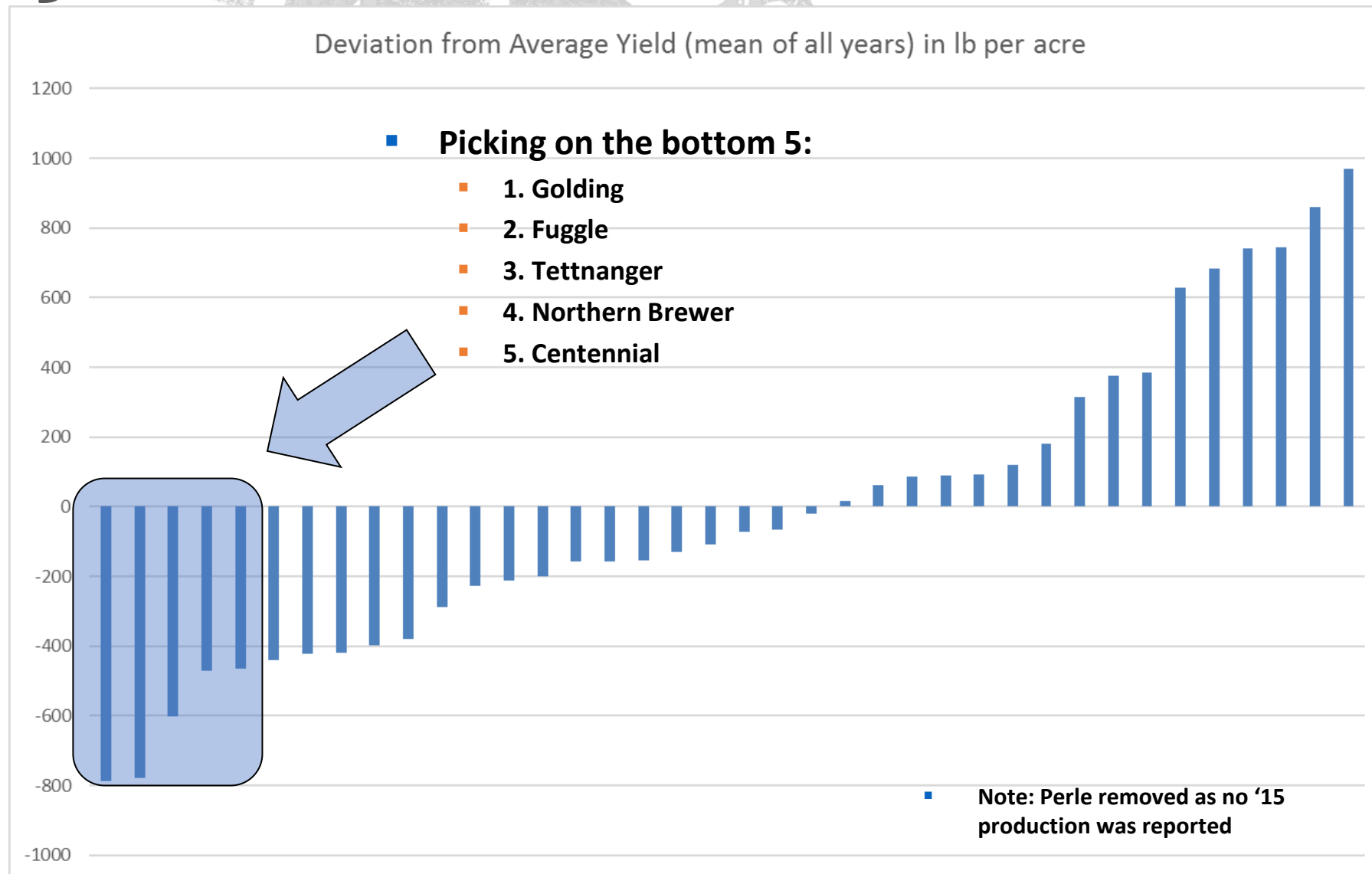


VARIETY TYPE ▾

Average Alpha Yields (deviation from mean)

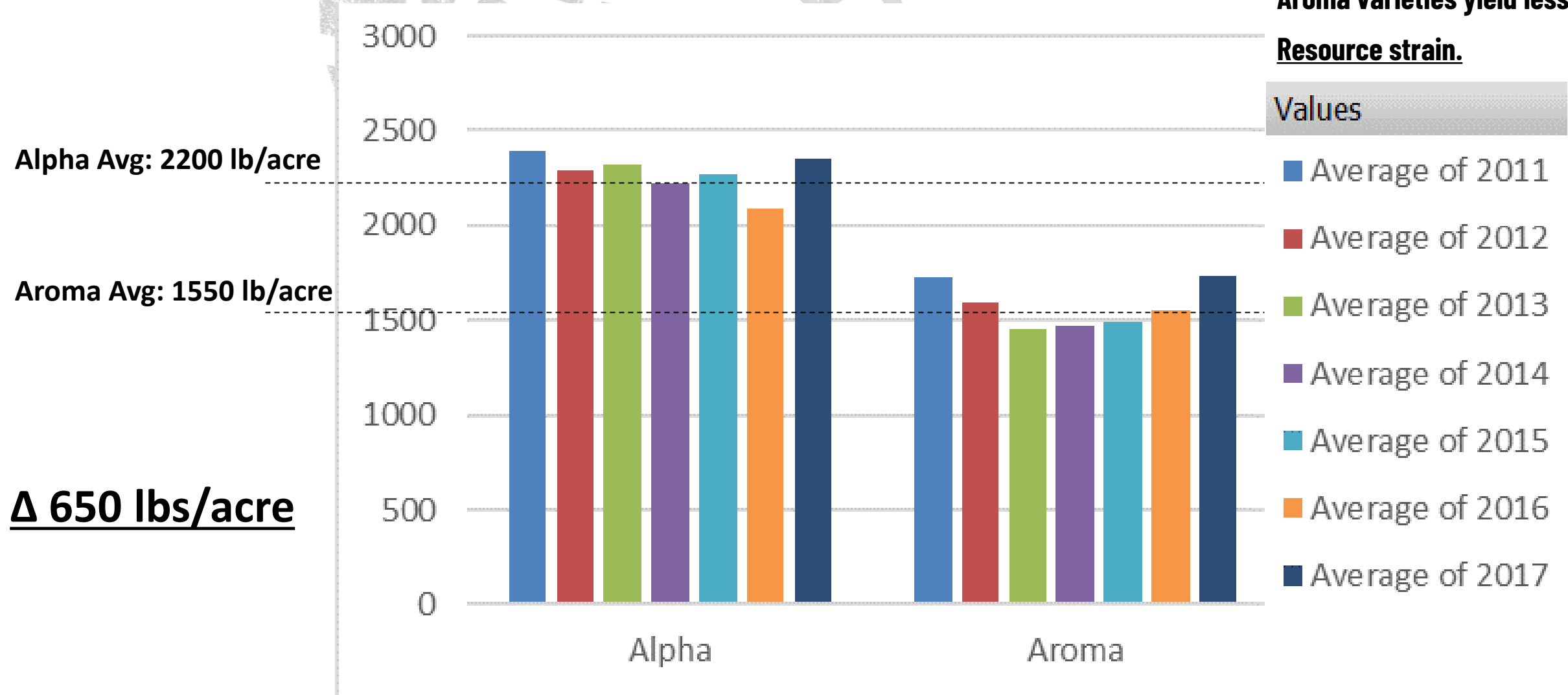


Average Aroma Yields (deviation from mean)



Alpha vs Aroma Yields

Aroma varieties yield less.
Resource strain.



Challenges: Biotic Stresses

Pests



Diseases

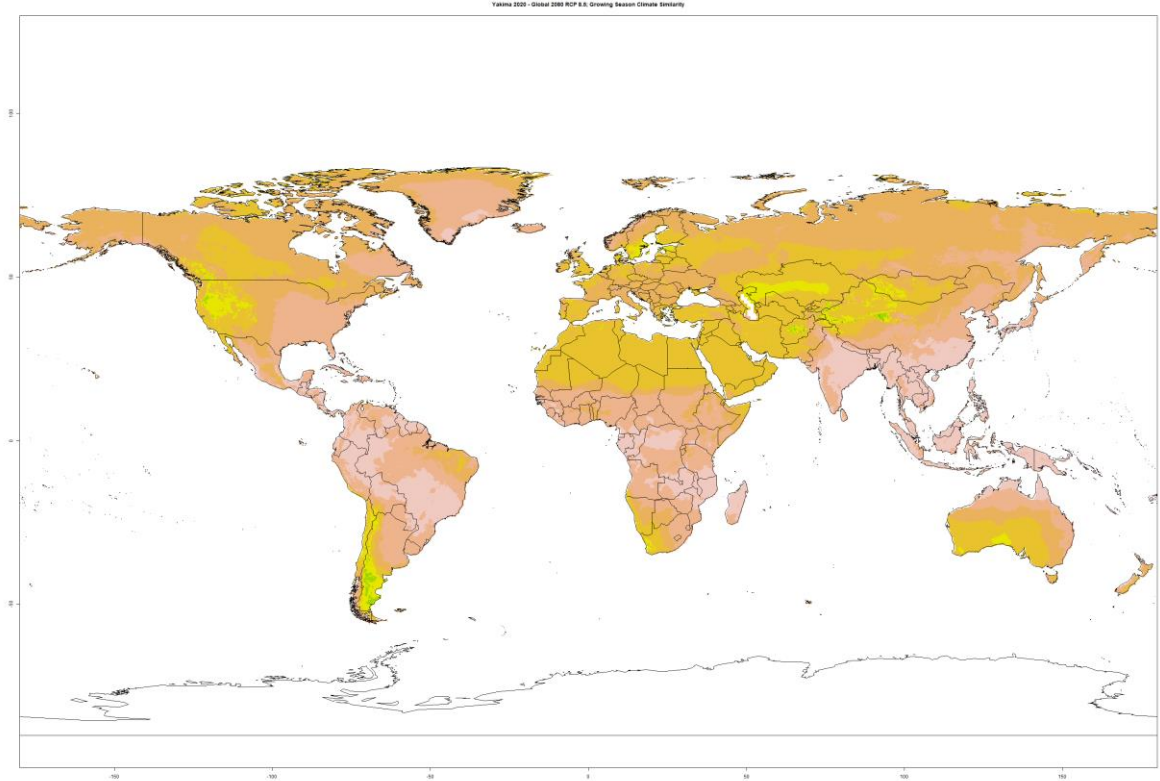
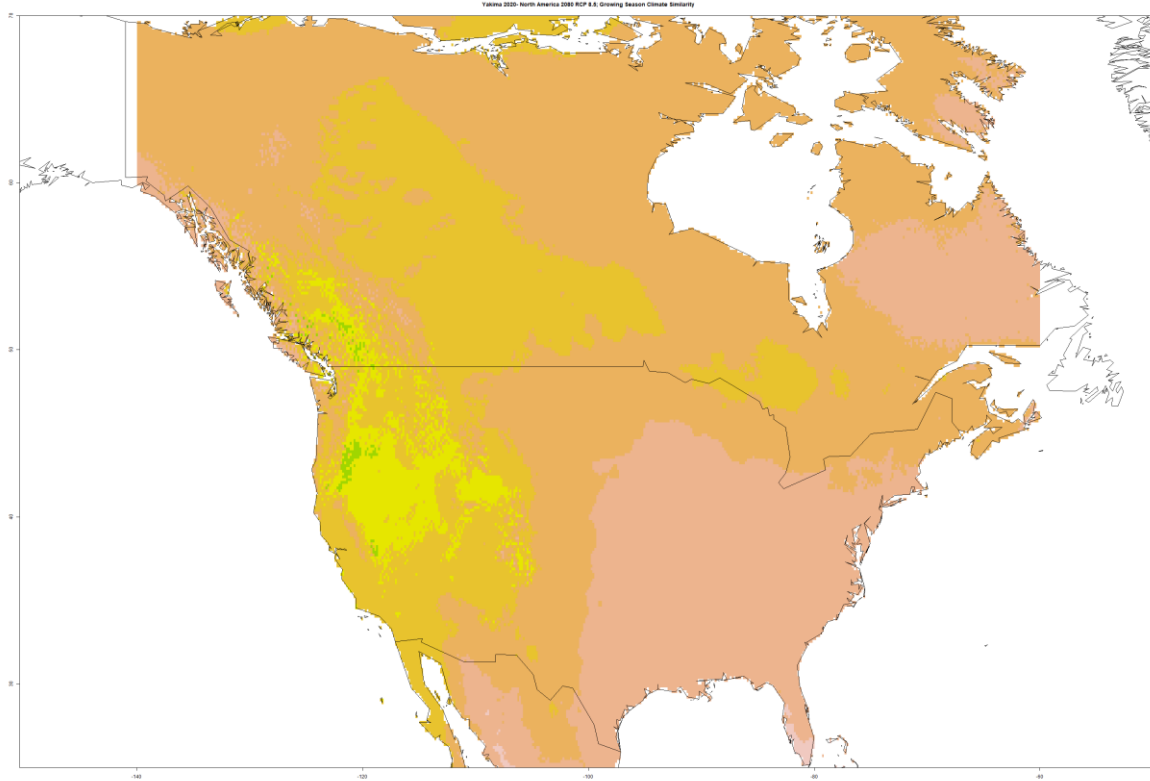


Viruses



Challenges: Heat and Drought Tolerance

2080

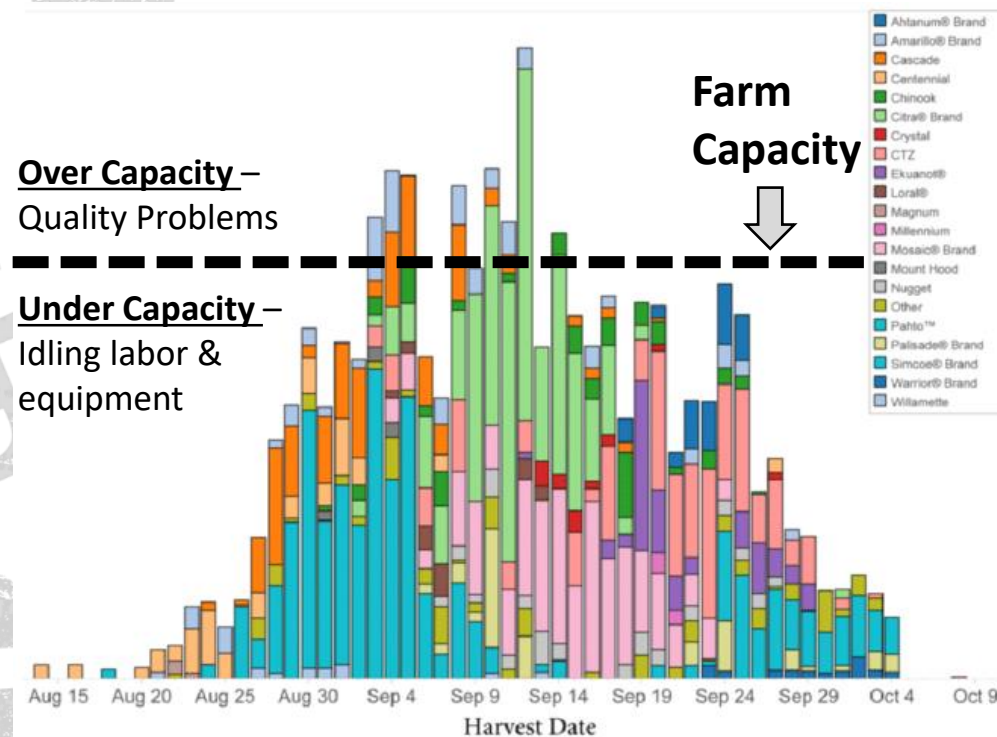


Challenges: Farm Inputs and Harvest Constraints



Over Capacity –
Quality Problems

Under Capacity –
Idling labor & equipment



Hop Breeding: Why is it necessary?

Value Chain: Each link on the supply chain affects subsequent links.

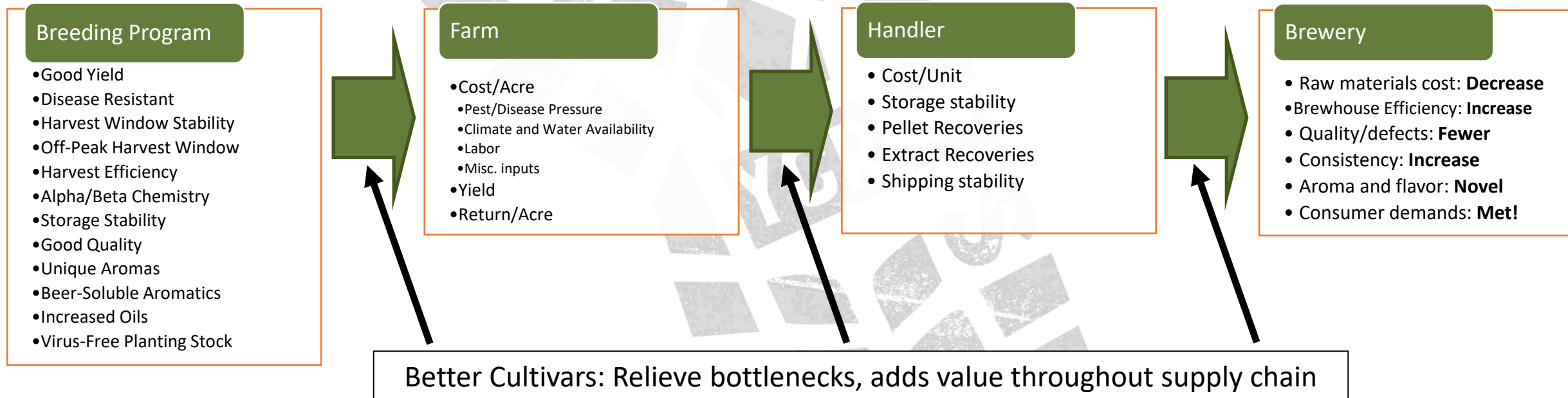
The efficiency of a hop has a corresponding impact on the chain.



Hop Breeding: Why is it necessary?

Value Chain: Each link on the supply chain affects subsequent links.

The efficiency of a hop has a corresponding impact on the chain.



Humulus lupulus: Botany Basics

Female flowers (“burrs”) at anthesis

Male flowers at anthesis

❖ Breeding Challenges:

- Dioecious (male and female plants)
- Males difficult to phenotype
- Genetically complex
- Obligate out-crossers, cannot self pollinate.
- High level of diversity (heterozygosity)
- Seed propagation not possible

❖ Breeding Benefits:

- Easily clonally propagated
- Traits can be “fixed” in single generation.
- Each new variety results from a single plant.



Hop Genetics

10 chromosomes, $2n = 20$

2 sex chromosomes

(X to autosome sex determination)

Means that something is on the X chromosome that is absent on Y which determines female and male morphology

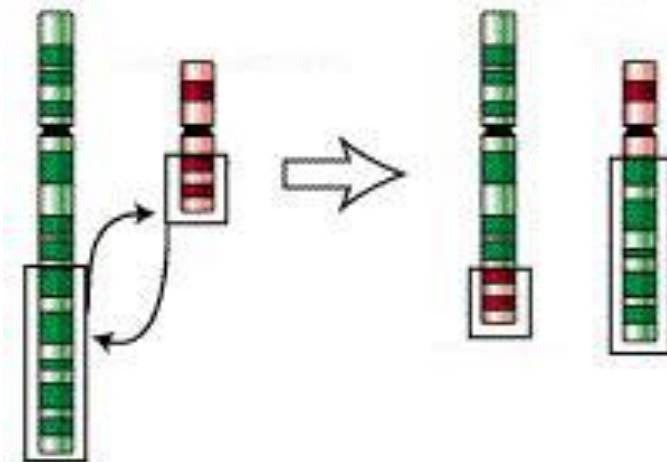
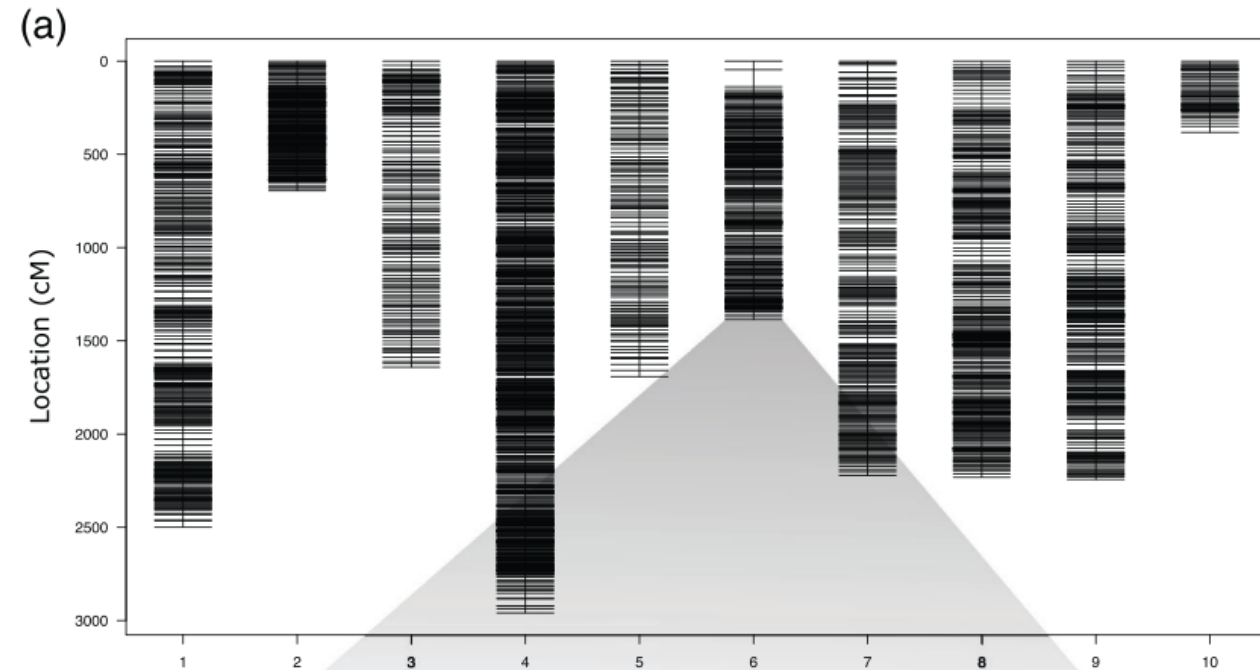
However, something on Y chromosome is thought to be essential for pollen fertility

Extreme heterozygosity: linkage drag

Non-mendelian linkage patterns between chromosomes: permanent translocation heterozygosity

Chromosomes are different sizes and contents in different varieties; causes reproductive incompatibility and infertility

See also: Cannabis sativa (10 chromosomes)



Crossing



Collection of male flowers for isolation of pollen.



Applying pollen to bagged female



Applying pollen to bagged female



Open pollination with pollen mix

Seedlings



Week-old hop seedlings



Greenhouse screening for Powdery Mildew



Low-trellis seedling yard

Single Hill & Advanced

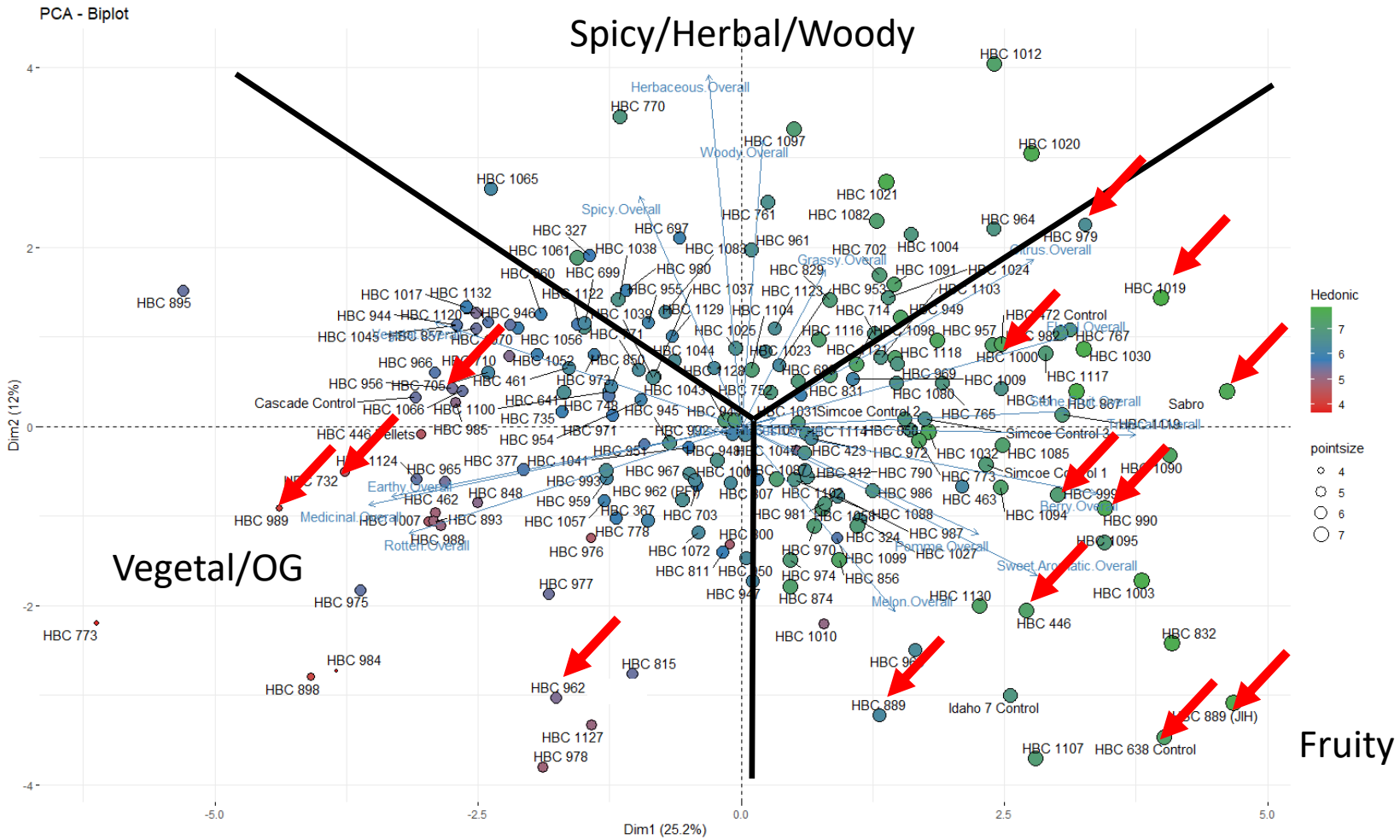


Taking Field Notes



Harvested single hill plant

Advanced Line Analysis: Hop and Beer Sensory



Advanced Line Analysis: Biochemistry

Variety	TotalOil	Pinenc	Myrcenc	Linaloc	Caryophyllenc	Farnesenc	Humulenc	Geranio	Methyl-butyl isobutyrate	Limonenc	Citral	Citronello
Ahtanum	2	0.86	61.99	0.36	7.77	0.18	12.92	0.23	0.56	0.28	0.22	1.17
Cascade	1.7666667	0.8033333	59.2233333	0.4466667	4.936666667	6.706666667	10.89	0.33	0.585	0.25	0.665	0.805
Centennial	2.3333333	0.906667	63.02	0.47	5.653333333	0.106666667	10.07	1.1066667	0.54	0.305	0.495	0.85
Ekuanot	4	0.55	39.82	0.34	10.05	0.03	17.25	0.29	1.91	0.15	1.92	3.84
HBC 472	1.575	0.505	36.7275	0.1925	28.8	5.1625	0.8475	0.245	2.6225	0.155	3.345	0.4025
HBC 520	1.8125	0.53	41.37625	0.195	22.3	0.1675	17.21625	0.02625	0.61	0.19375	1.8075	1.43125
HBC 522	2.3	0.45	36.95	0.64	8.44	0.52	13.18	0.05	0.09	0.12	1.12	3.36
HBC 630	2.475	0.67	43.7875	0.2525	13.1375	0.0775	17.6975	0.0875	1.5425	0.1775	1.92	1.1425
HBC 637	3.25	0.748333	50.581667	0.3966667	7.918333333	0.186666667	13.22833333	0.2533333	1.105	0.21	1.018	2.774
HBC 638	2.85	0.485	37.4275	0.295	10.9925	0.2	17.1475	0.17	1.2725	0.1475	1.52	3.5475
HBC 735	3.55	0.7375	54.035	0.3825	8.025	0.245	13.3925	0.945	0.623333333	0.2	0.63	2.31
Loral	3.15	0.745	59.805	1.075	5.17	0.095	16.57	0.41	0.535	0.195	0.27	0.875
Mosaic	2.3	0.9	62.8	0.5	3.87	0.13	10.51	0.42	1.26	0.26	0.13	0.68
Palisade	2.3	0.76	50.19	0.37	11.91	0.02	14.69	0.23	1.28	0.18	0.83	1.62
Sabro	2.68	0.806	55.982	0.402	11.76	0.574	11.996	0.798	1.955	0.28	0.9775	0.9125
Simcoe	2.1	0.69	49.28	0.44	9.24	0.09	16.77	0.87				
Talus	2.7	0.858333	52.696667	0.595	7.18	0.178333333	17.655	1.685	1.718333333	0.22166667	0.39	1.184

Hop Chemistry: Cascade GC Analysis

- | | |
|--------------------------------|--|
| 1. Hexanal | 16. Caryophyllene |
| 2. α -Pinene | 17. <i>trans</i> - α -Bergamotene + unknown |
| 3. Camphene | 18. <i>trans</i> - β -Farnesene |
| 4. 6-Methyl-5-hepten-2-one | 19. Humulene |
| 5. β -Pinene | 20. γ -Muurolene |
| 6. β -Myrcene | 21. γ -Selinene |
| 7. Cymene | 22. Geranyl isobutyrate |
| 8. <i>d</i> -Limonene | 23. β -Selinene |
| 9. β -Ocimene | 24. α -Muurolene |
| 10. <i>cis</i> -Linalool oxide | 25. α -Selinene |
| 11. Linalool | 26. γ -Cadinene |
| 12. Geraniol | 27. Calamenene |
| 13. Geranyl acetate | 28. Δ -Cadinene |
| 14. α -Ylangene | 29. Caryophyllene oxide |
| 15. α -Copaene | 30. Humulene oxide |

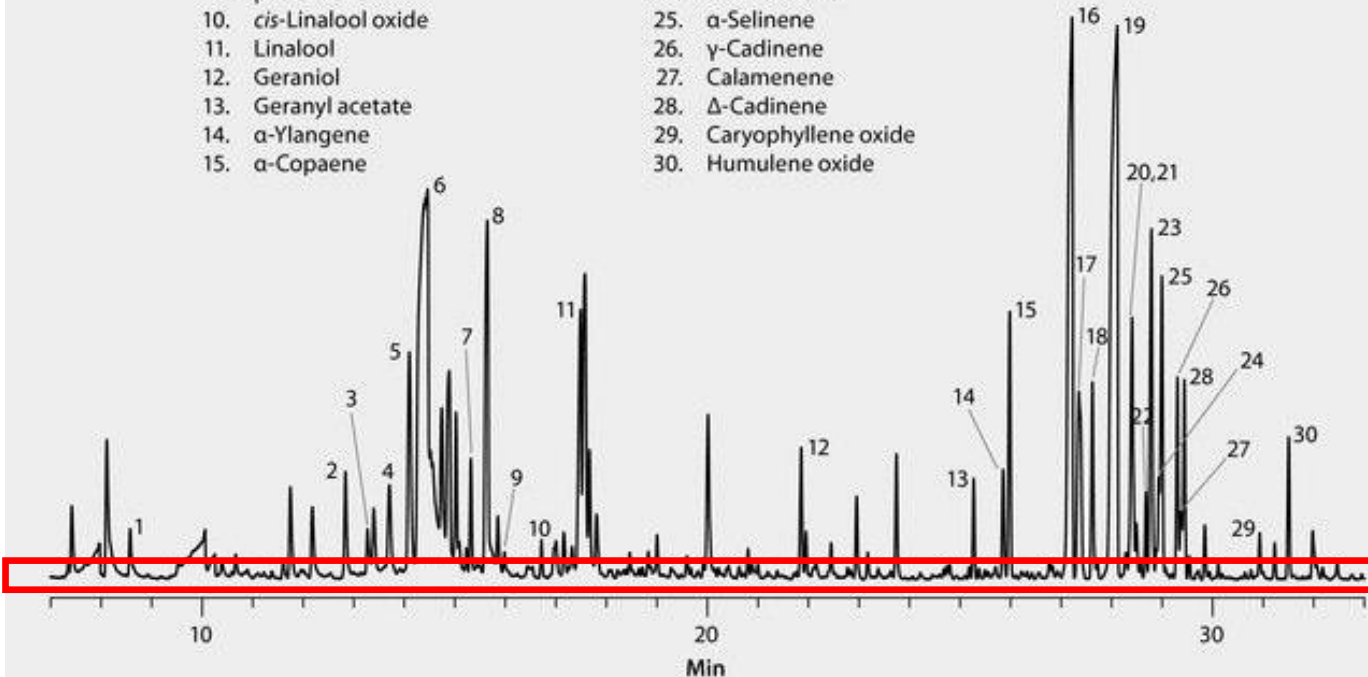
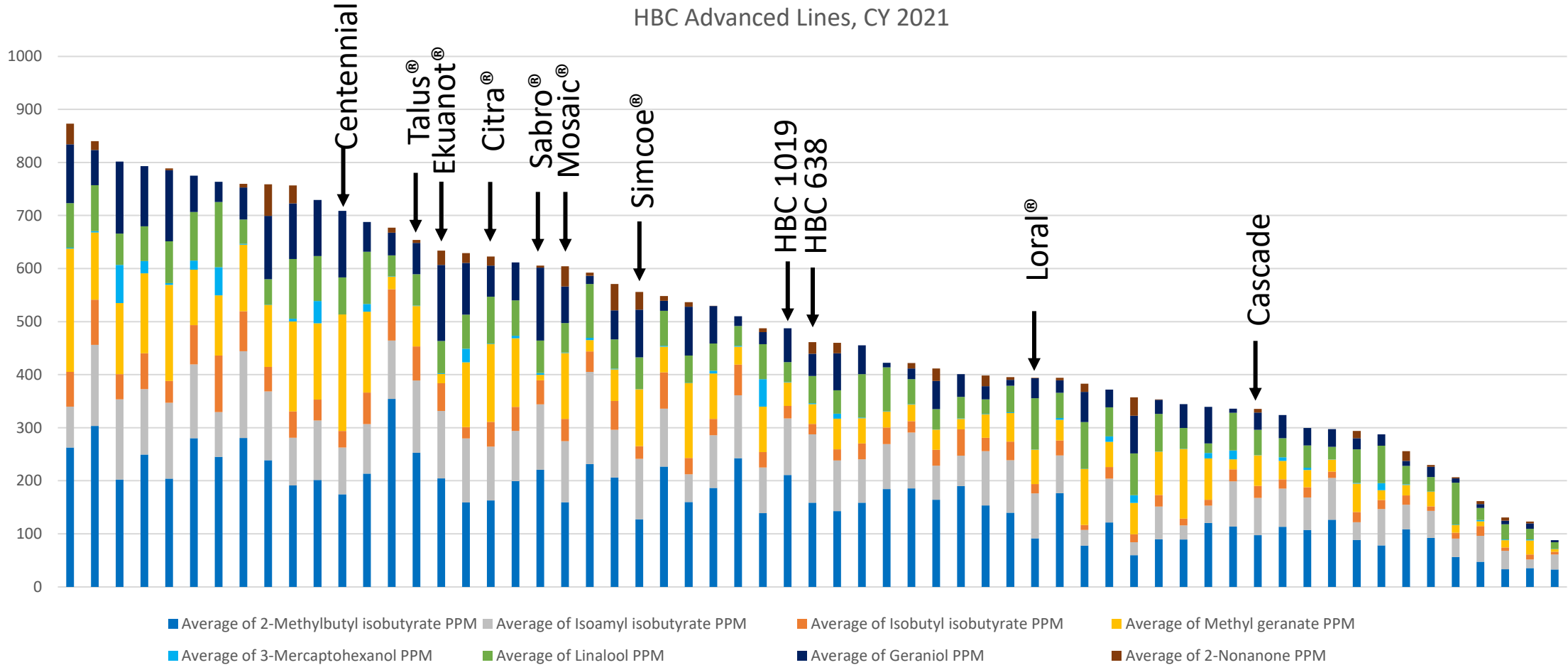


Table 3-3. Contents of hop-derived main odorants in beer hopped with 11 cultivars.

	Difference threshold value in beer ^c	US- SIM (2005)	US- SUM (2006)	US- APO (2006)	US- MIL (2006)	US- CAS (2006)	US- WIL (2006)	
4MMP (ng/L)	1.5	183.8	116.4	109.2	n.d.	16.9	n.d.	ppb
myrcene (μ g/L)	9.5	28.3	57.7	37.5	37.3	21.4	11.9	ppm
linalool (μ g/L) (ee %)	1.0 ^d , 1.7 ^e	95.5 (85.2)	87.9 (85.9)	73.4 (85.4)	84.7 (89.5)	56.9 (87.6)	64.6 (89.2)	ppm
geraniol (μ g/L)	4.0	58.5	59.1	33.3	23.2	82.8	11.7	ppm
ethyl 2-methyl -butanoate (μ g/L) (ee %)	1.2 ^e	2.04 (-93.9)	5.38 (-97.5)	9.78 (-97.7)	2.75 (-97.5)	0.80 (-92.2)	1.01 (-91.8)	ppm
ethyl 4-methyl -pentanoate (μ g/L)	1.0	0.60	2.39	2.23	1.93	0.41	0.35	ppm

Advanced Line Analysis: Beer "Survivables" Chemistry

HBC Advanced Lines, CY 2021



Variety Release!!!

...now what?

- ❖ After 8 - 10 years of evaluation, release is considered
 - Private varieties: PVP begins
- ❖ The work is far from over, success is dependent on:
 - Continued agronomic performance
 - Grower acceptance: usually short term
 - Brewer and consumer acceptance: long term
- ❖ Work doesn't stop at breeding:
 - Propagation and Expansion
 - Quality Management: Seed, harvest windows, farm practices
 - Virus free plants

HBC 1426: Queen of the Crop!

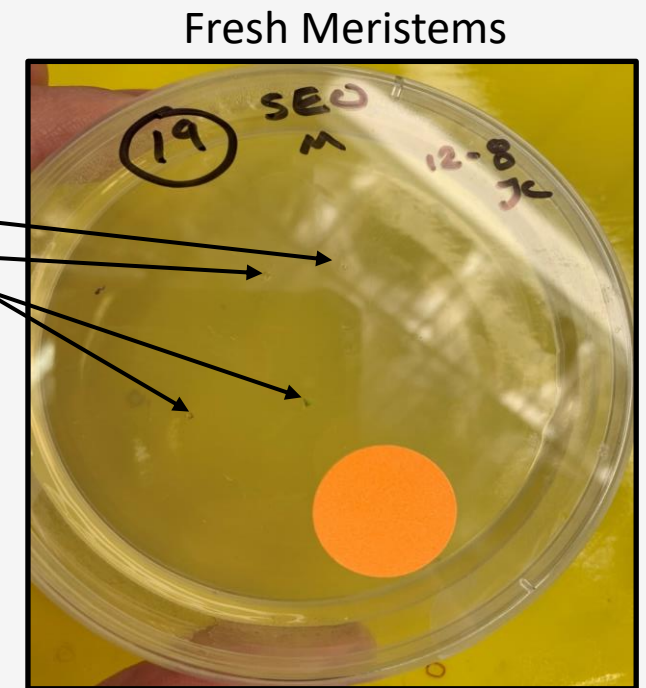
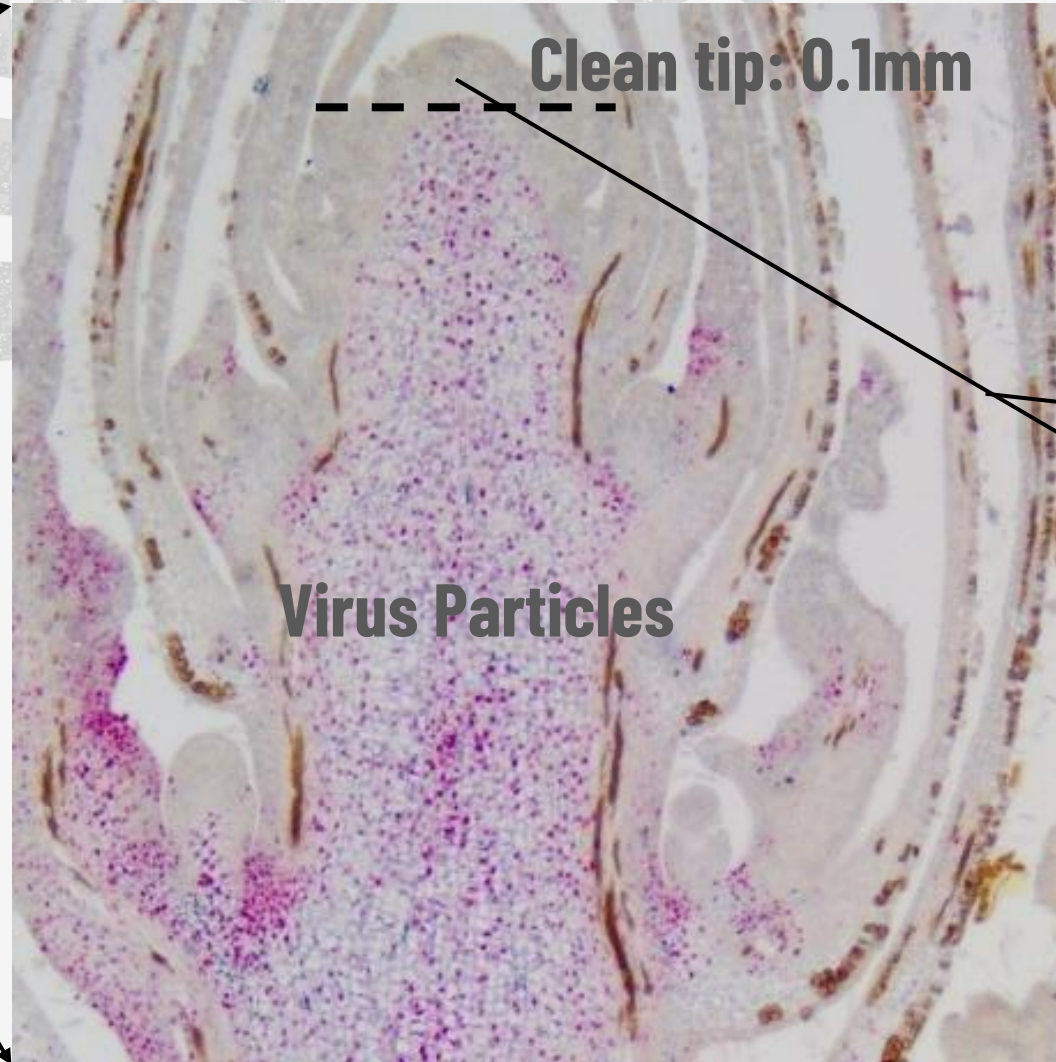


Example: Virus effects on yield and quality

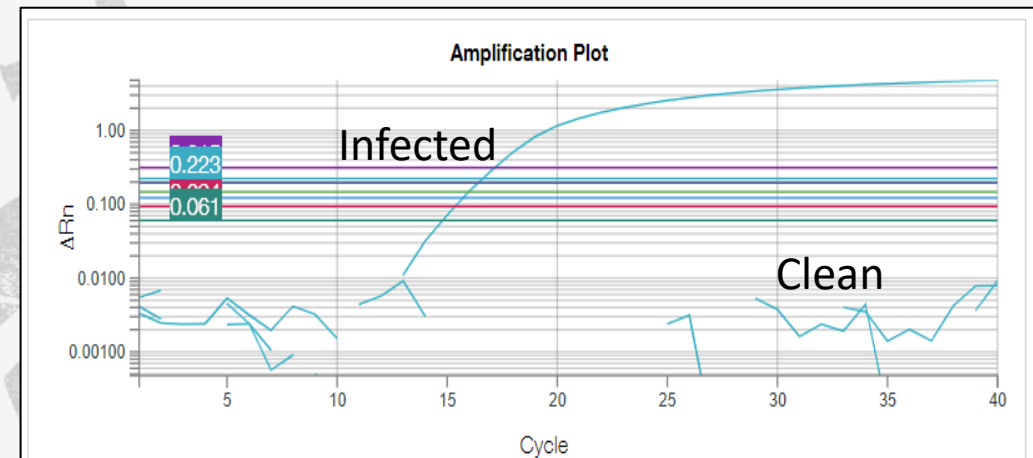
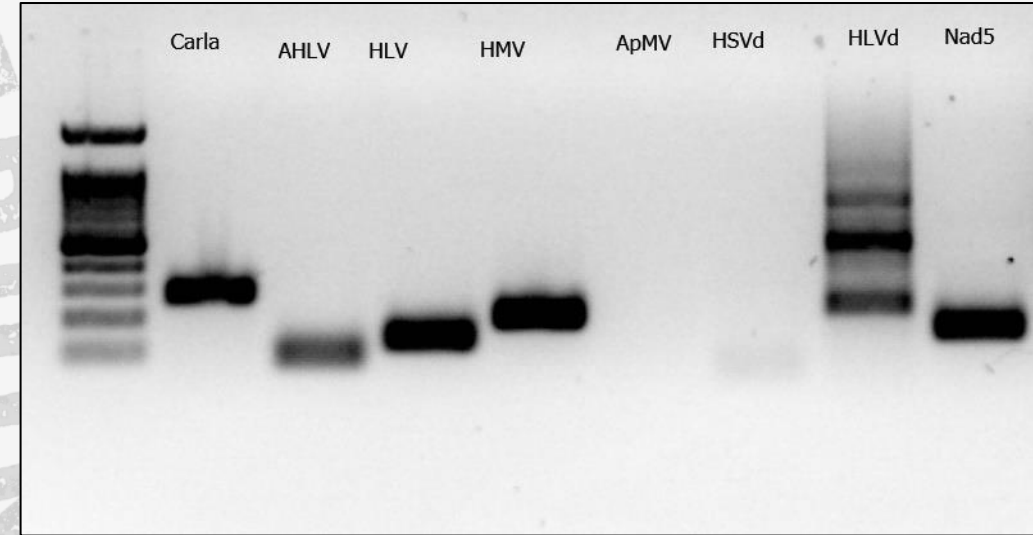
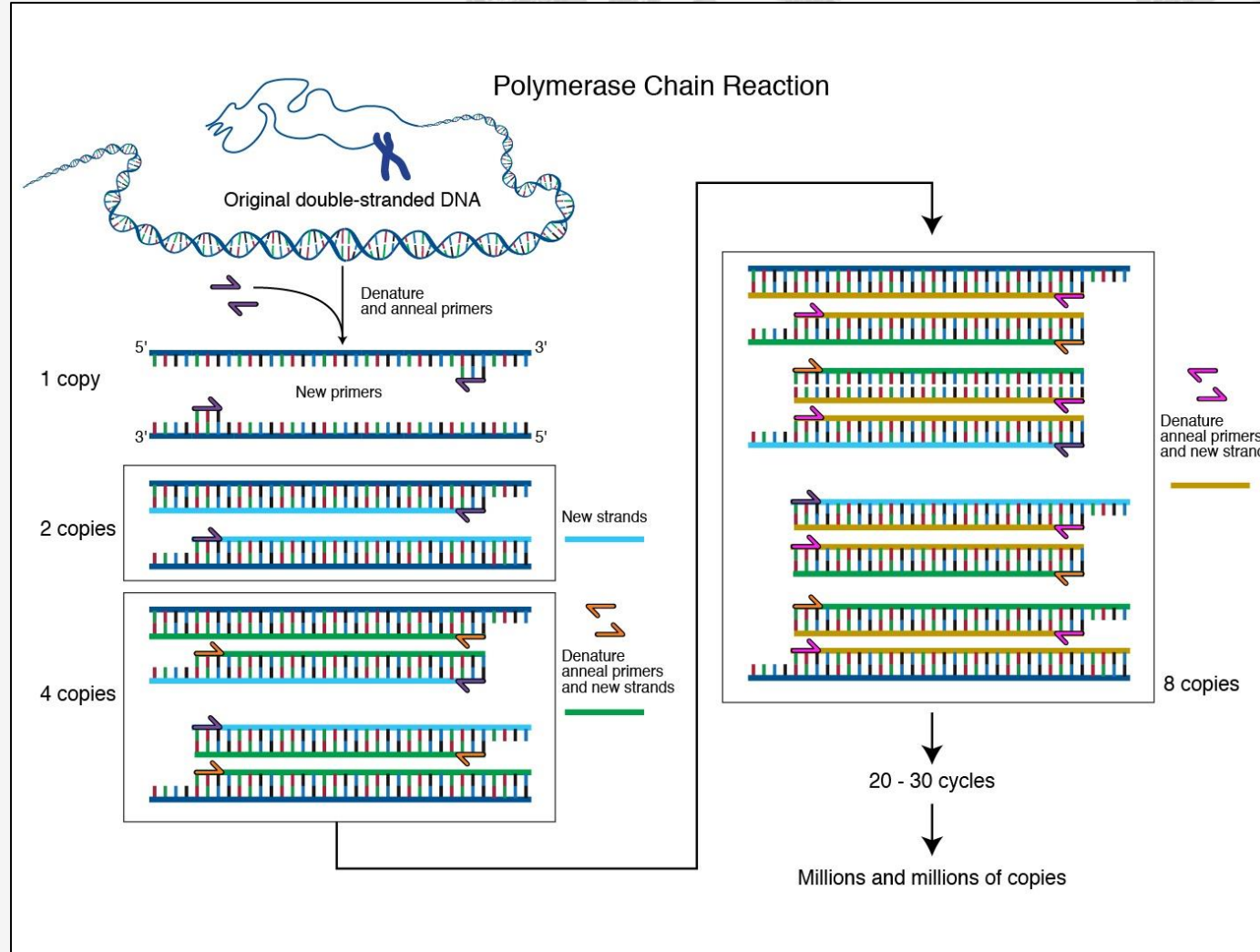
	Saaz	Sladek	Premiant	Agnus	Omega	Northdown	Challenger
Yield	-19%				-0.37	ND	-11%
alpha	-32%	-28%	-15%	-9%	-31%	-0.15	-11%
beta	3%	16%	-3%	-10%	0.3	0.19	8%
coh	5%	-7%	-5%	2%	0.1	-0.05	
col	-1%	0%	2%	1%	-0.01	-0.01	
XH	-23%	-23%	-21%	-4%			
oils	-4%	-25%	-15%	-11%	0.15	0.18	
monoterpenes	18%	-11%	-2%	0%			
ketones	-22%	-21%	-40%	5%			
esters	-6%	-21%	5%	13%			
epoxides	56%	115%	-16%	36%			



Clean Plants: Meristem Therapy



How do we test for viruses?



Tissue Culture: Clean Plant Propagation

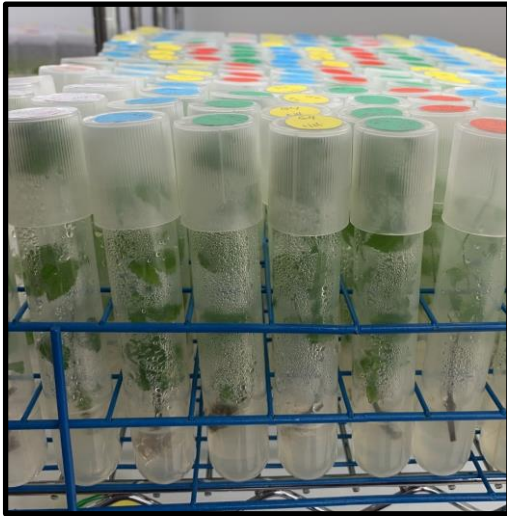
Tissue Culture Propagation

Tissue Culture Growth Chamber



Clean Hop Propagation

G1



Tissue Culture
Mother Stock
10's

**Individual
Testing**

G2



Tissue Culture
Propagation
10,000's

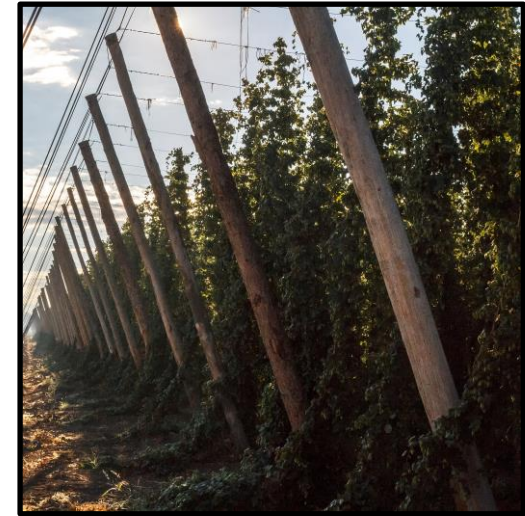
Audits

G3-5



Greenhouse
Propagation
100k-millions

Hop Yard

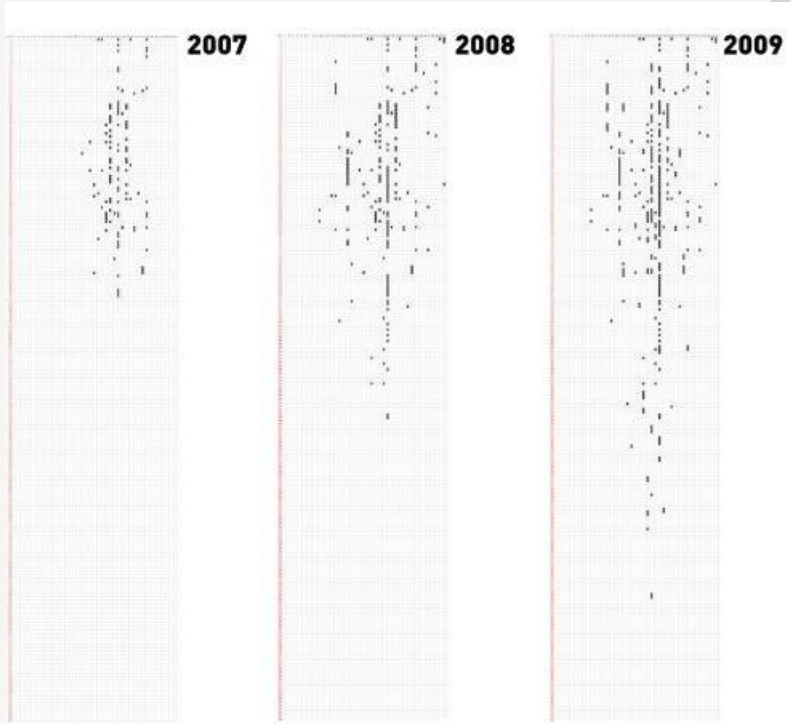


Field
NO repropagation

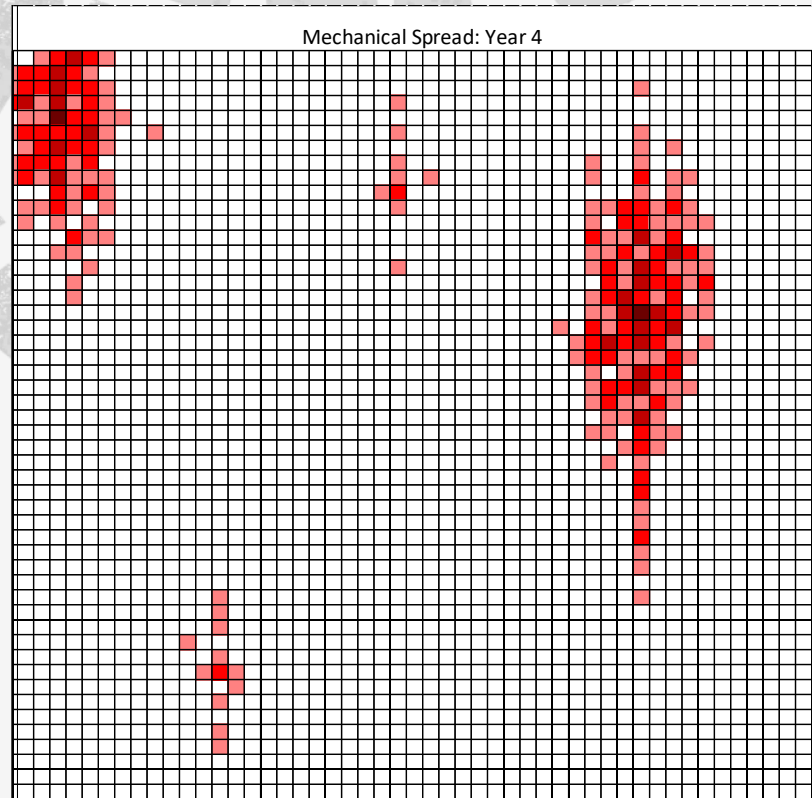
Monitoring

The difference of clean plants

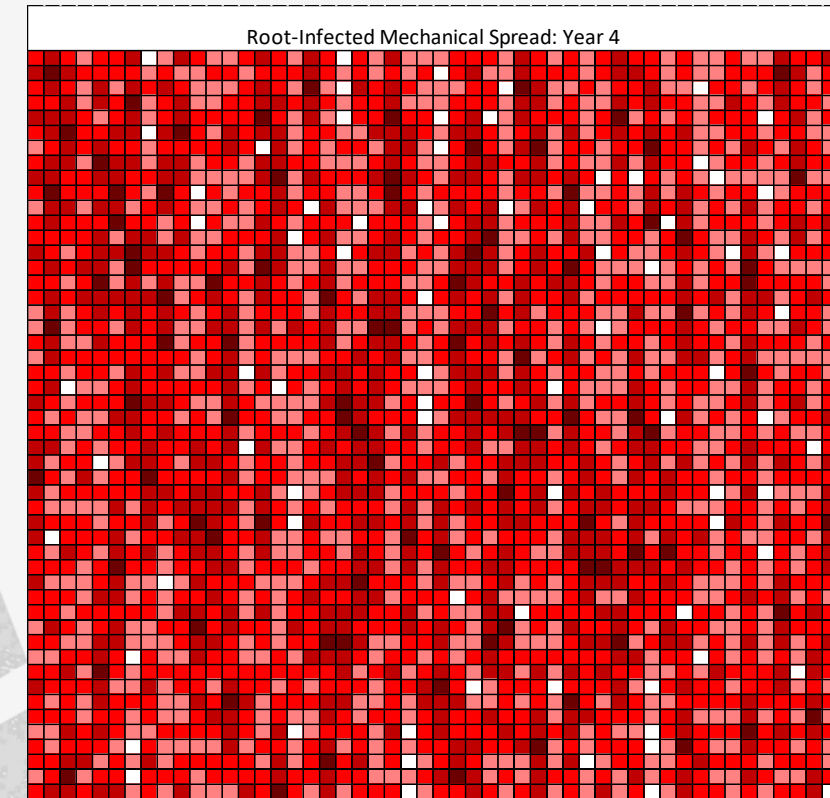
Spread Pattern of Plant Viruses in the Field



Replant with Clean Plants



Replant with Rhizome Starts from 3rd year field



Exaggeration for illustrative purposes

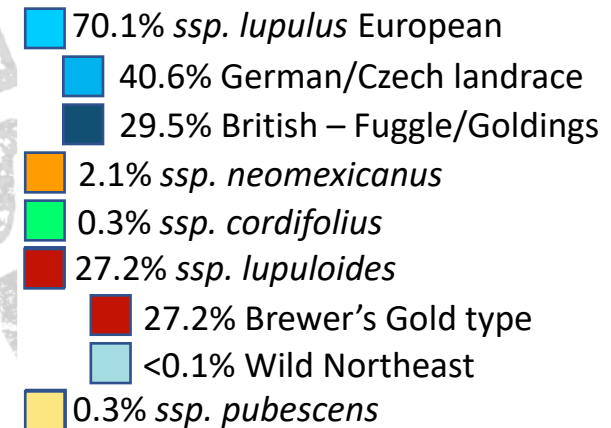
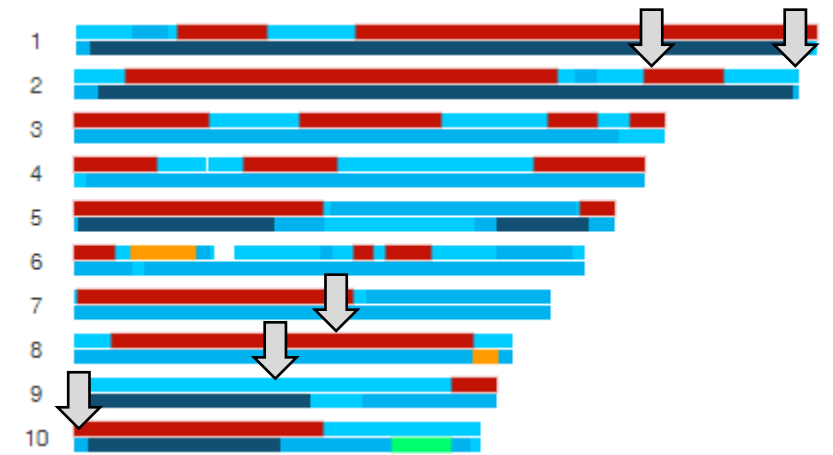
Future Trends in Hop Breeding

❖ Marker assisted selection

- Alpha
- Yield
- Oil
- Disease resistance

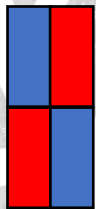
❖ Genetic Diversity – Novel Traits from wild germplasm

- Heat/drought tolerance
- Pest/disease tolerance
- Novel aromatics
- ?????



Marker Assisted Selection: Principles

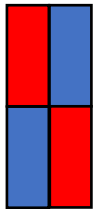
Trait 2 SNP
Trait 1 SNP



Trait 1 Carrier
Trait 2 Carrier



Trait 2 SNP
Trait 1 SNP



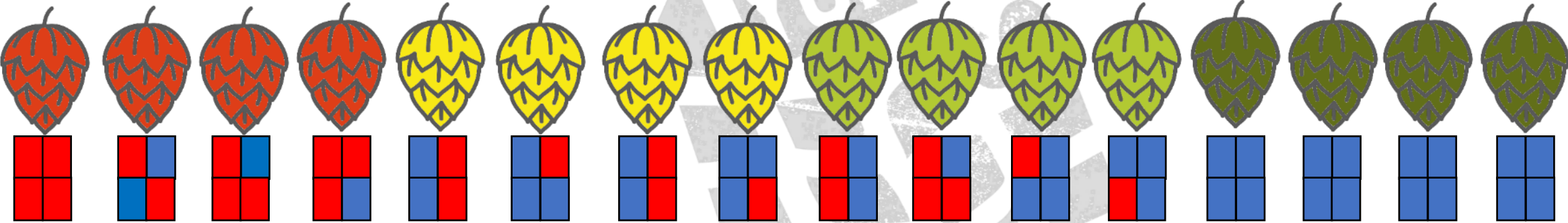
Trait 1 Carrier
Trait 2 Carrier

Neither Trait

Trait 1 ONLY

Trait 2 ONLY

Both Traits

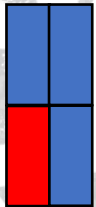


Marker Assisted Selection:

Increasing the odds of success

Which male to use?

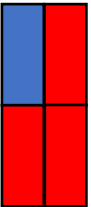
↓
Educated
Guess



×



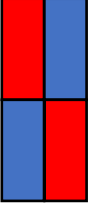
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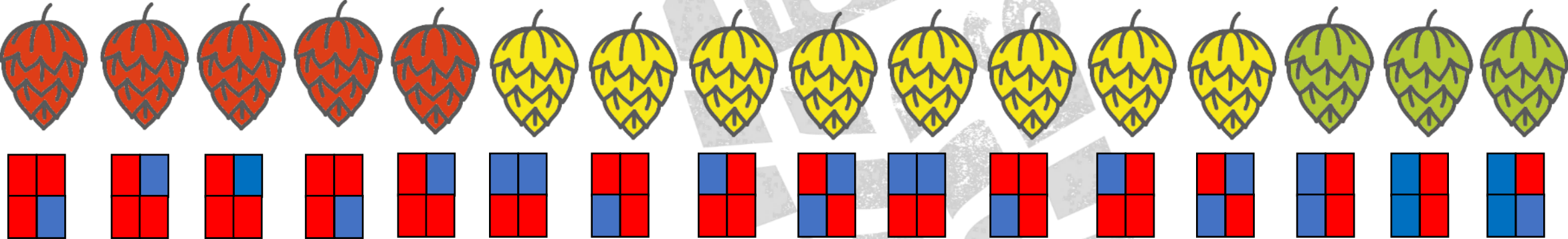


Moderate Cone
Good Aroma

Bad Cones, Bad Aroma

Moderate cones, poor aroma

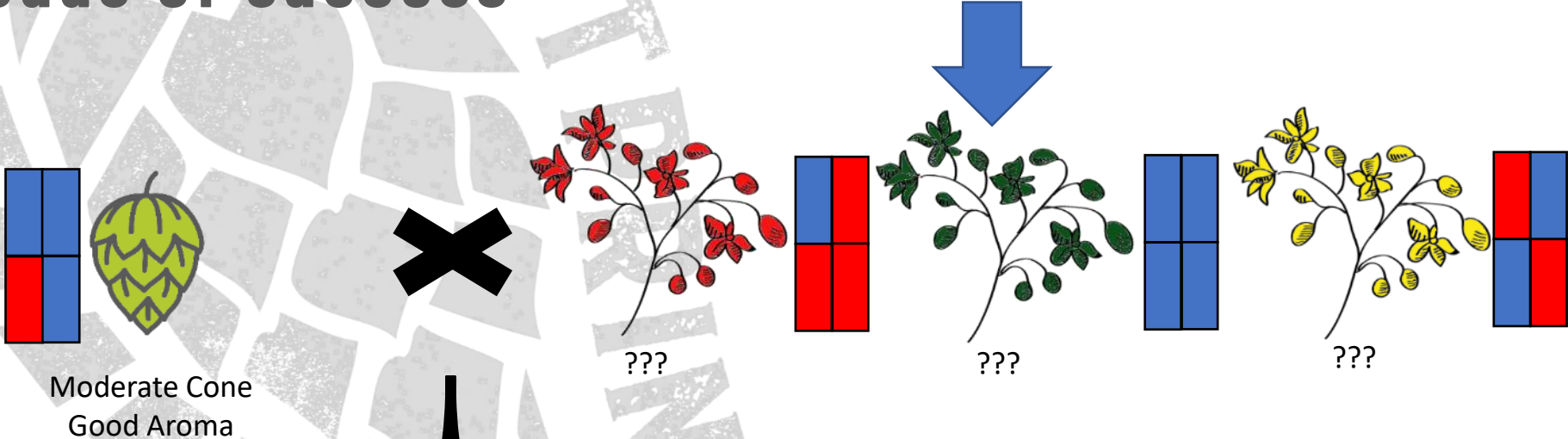
Good Cones
poor aroma



Marker Assisted Selection

Increasing the odds of success

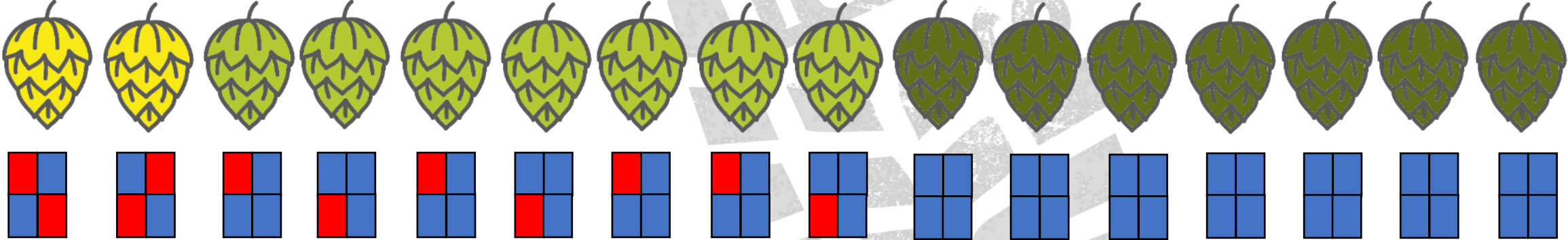
Which male to use?



Moderate cones
poor aroma

Moderate cones
Good aroma

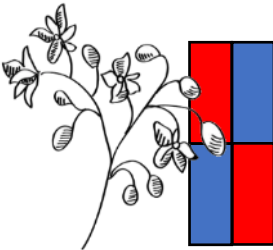
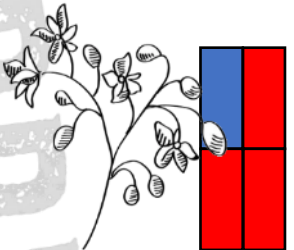
Good Cones
Good Aroma



Marker Assisted Selection

Genomic Prediction

Which male to use?



Moderate Cone
Good Aroma

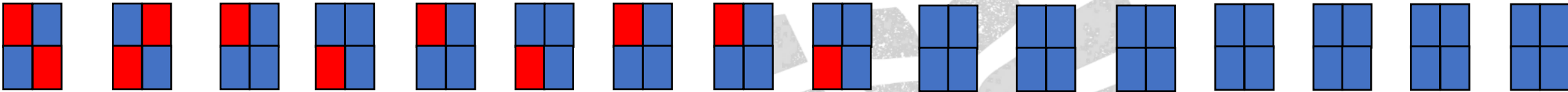
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???

Eliminate at seedling stage; RESOURCE DRAIN

Keep desirable genotypes; Focus Labor and Resources



Marker Assisted Selection

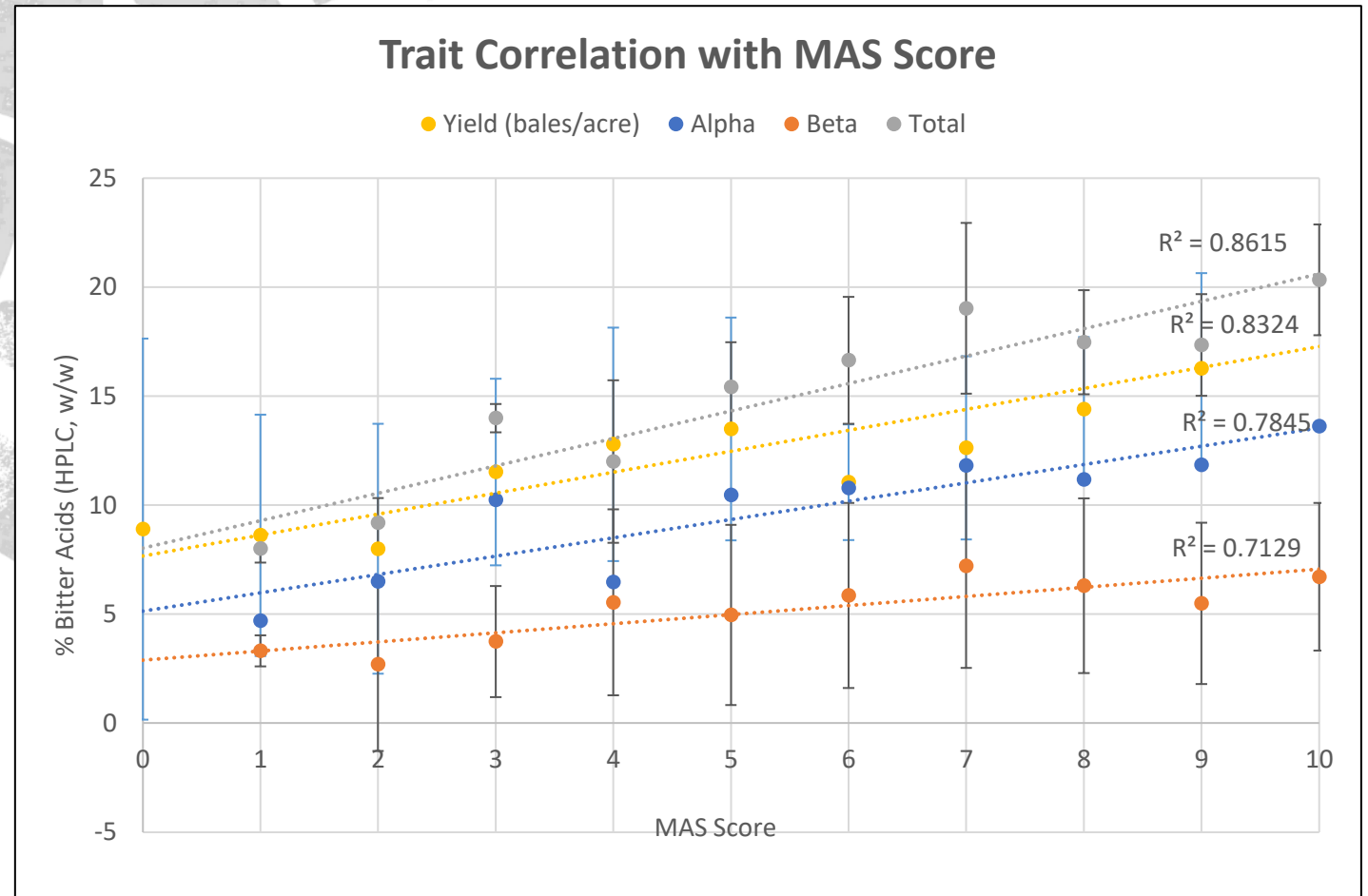
Polygenic Traits: QTL's

Assist in parental selections

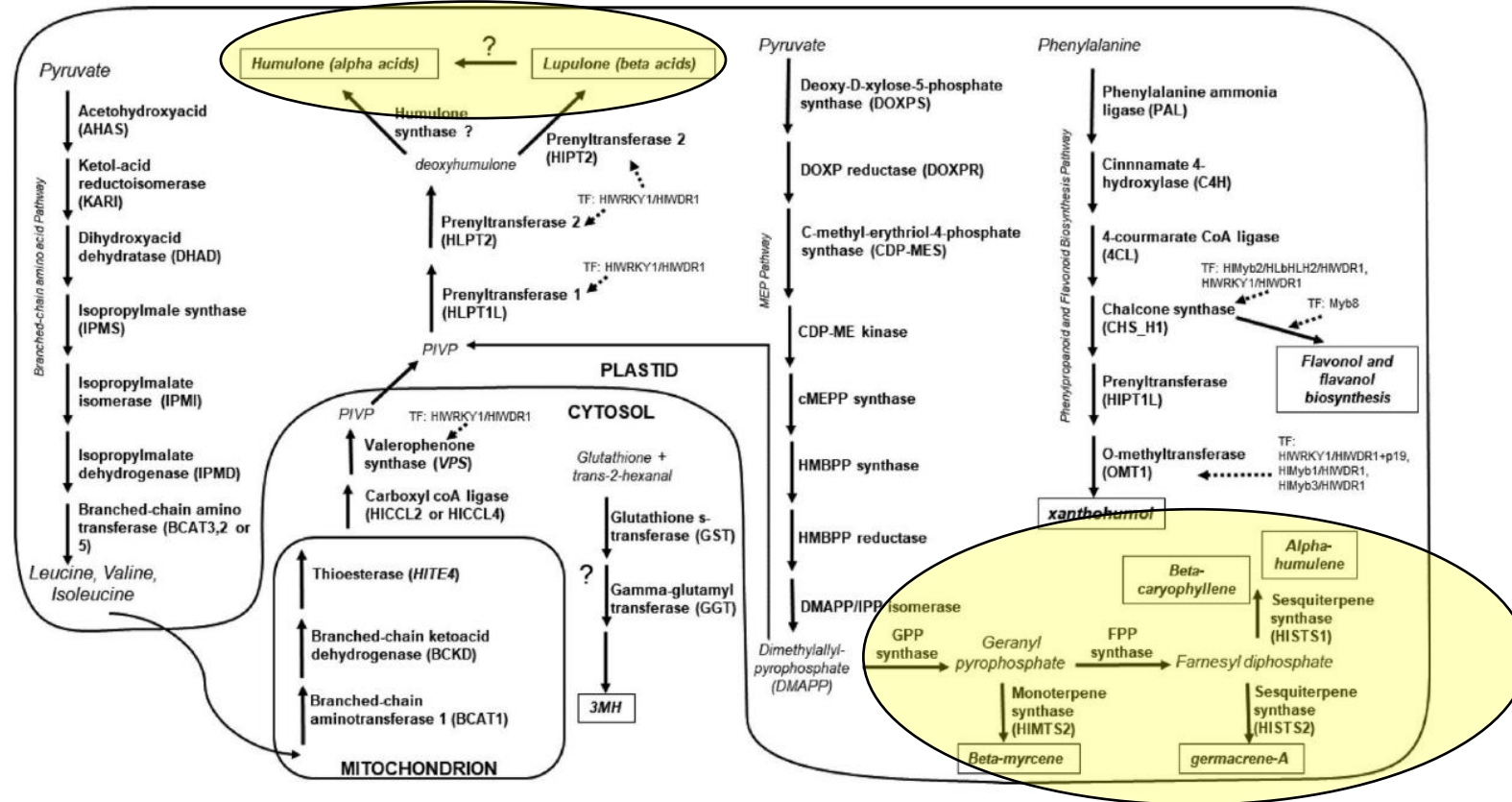
- Male phenotypic prediction
- Heterosis potential

Predict performance of seedlings

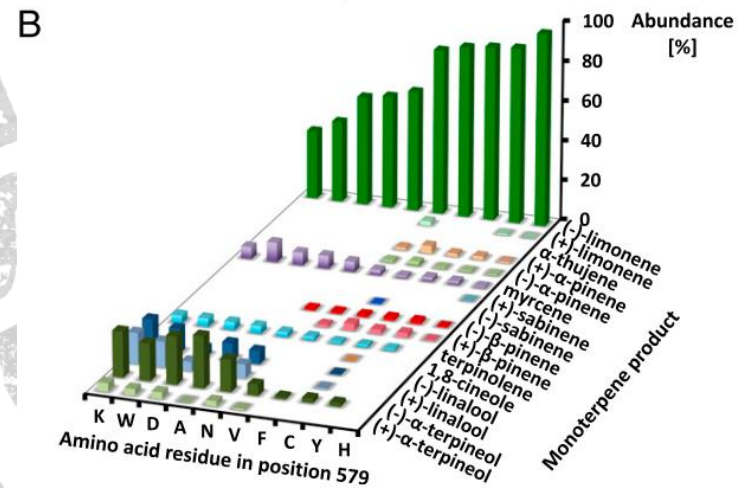
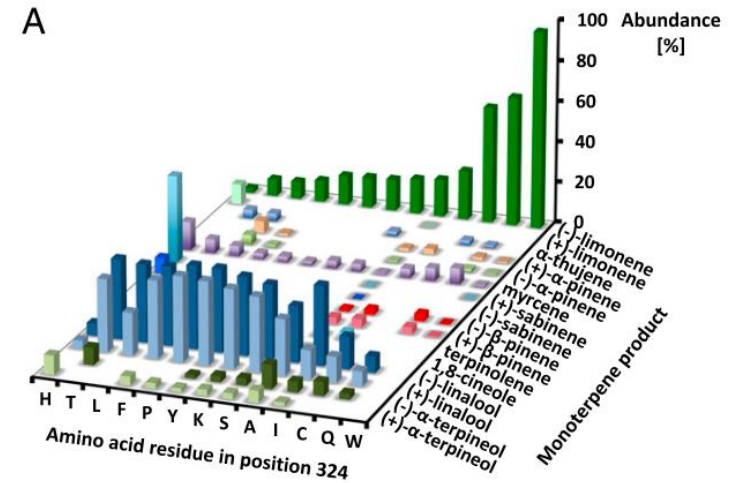
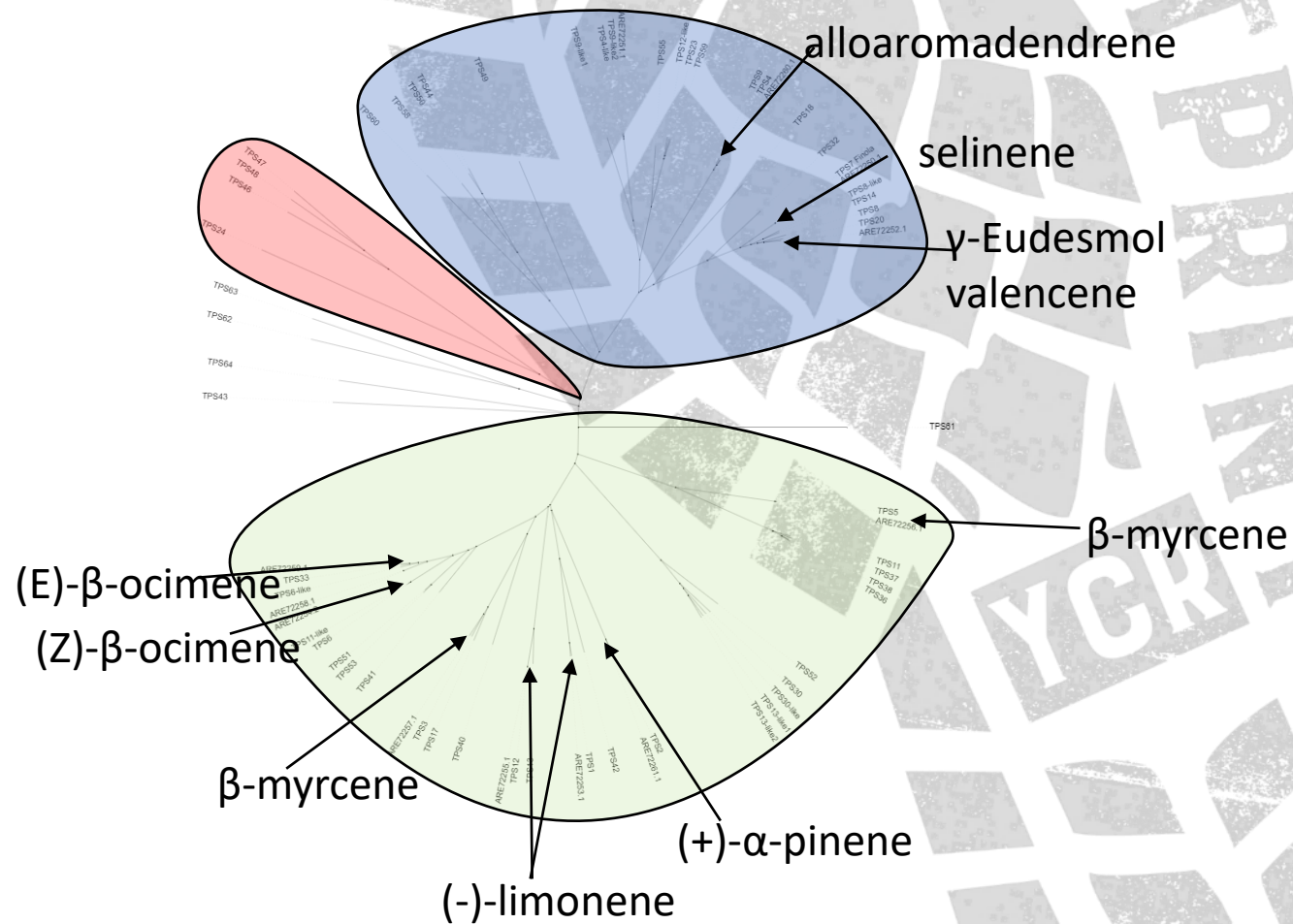
- Faster, more stringent early selections
- Screen larger numbers of higher-quality candidates
- Bypass Single Hill stage of breeding program



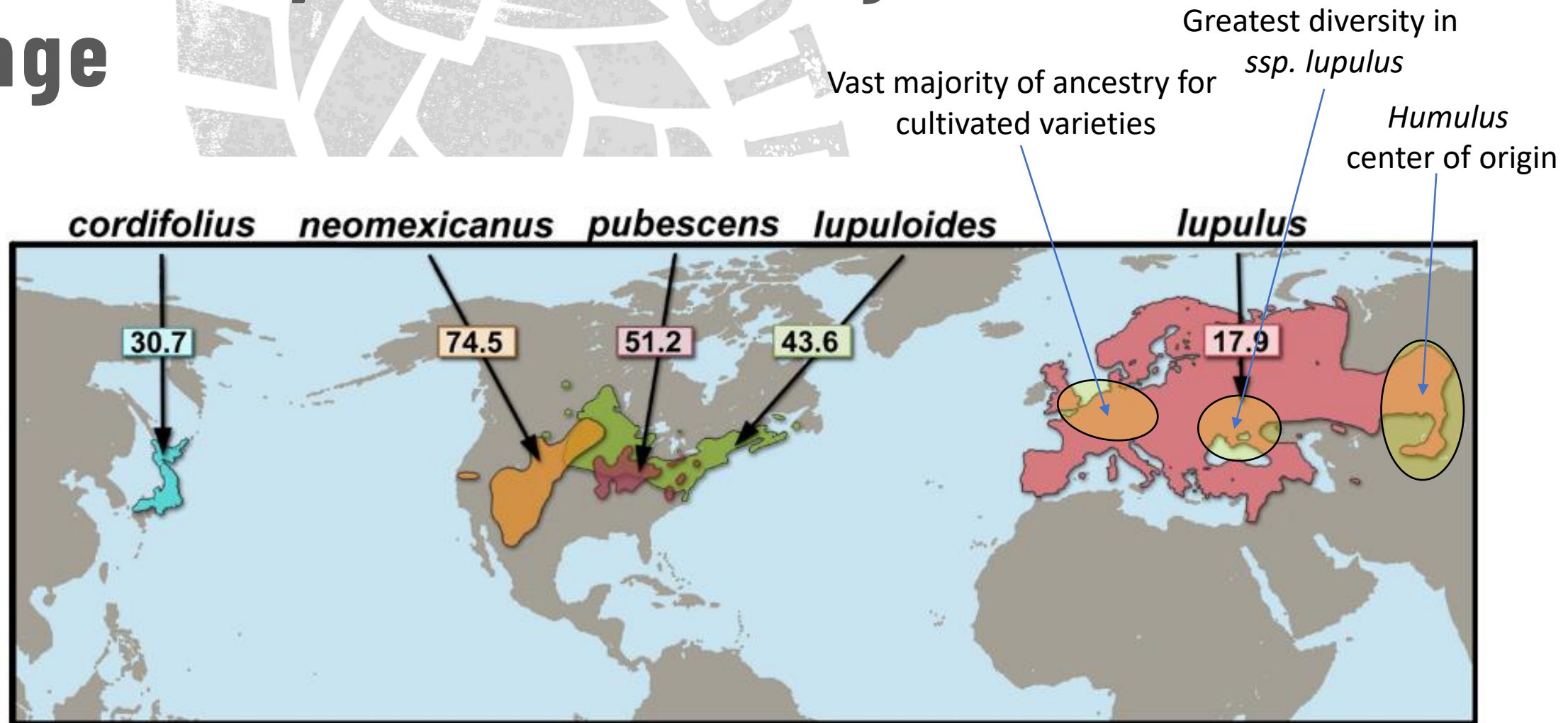
Example: Bitter Acid Genetics



Example: Terpene Biosynthesis



Humulus lupulus: Diversity and Natural Range



Wild Germplasm

H. lupulus ssp. lupuloides

- ❖ Varieties: Brewers Gold, Bullion, Bramling Cross, Cluster
 - ❖ In the pedigrees of most modern hops
- ❖ Traits: High alpha and resin, unique “American” aroma

H. lupulus ssp. neomexicanus

- ❖ Varieties: Target, Comet, Bitter Gold, El Dorado, Progress, Pioneer, Boadicea, First Gold, Sunbeam, Millennium, Chelan, Lotus™, Sabro®, Talus®, Zappa™, Medusa....
- ❖ Trait: Unique aroma, late harvest, pest, drought, and heat tolerance – e.g. Target

H. lupulus ssp. cordifolius

- ❖ Varieties: Boadicea
- ❖ Traits: Aphid resistance

Categories

Aroma efficiency

Public "C" hops – better yielding alternatives to Cascade, Centennial

HBC 522

HBC 637

HBC 638

Nobles

HBC 1134

Alpha efficiency

HBC 695, HBC 930, HBC 948, HBC 950, HBC 951, HBC 962, HBC 1213,

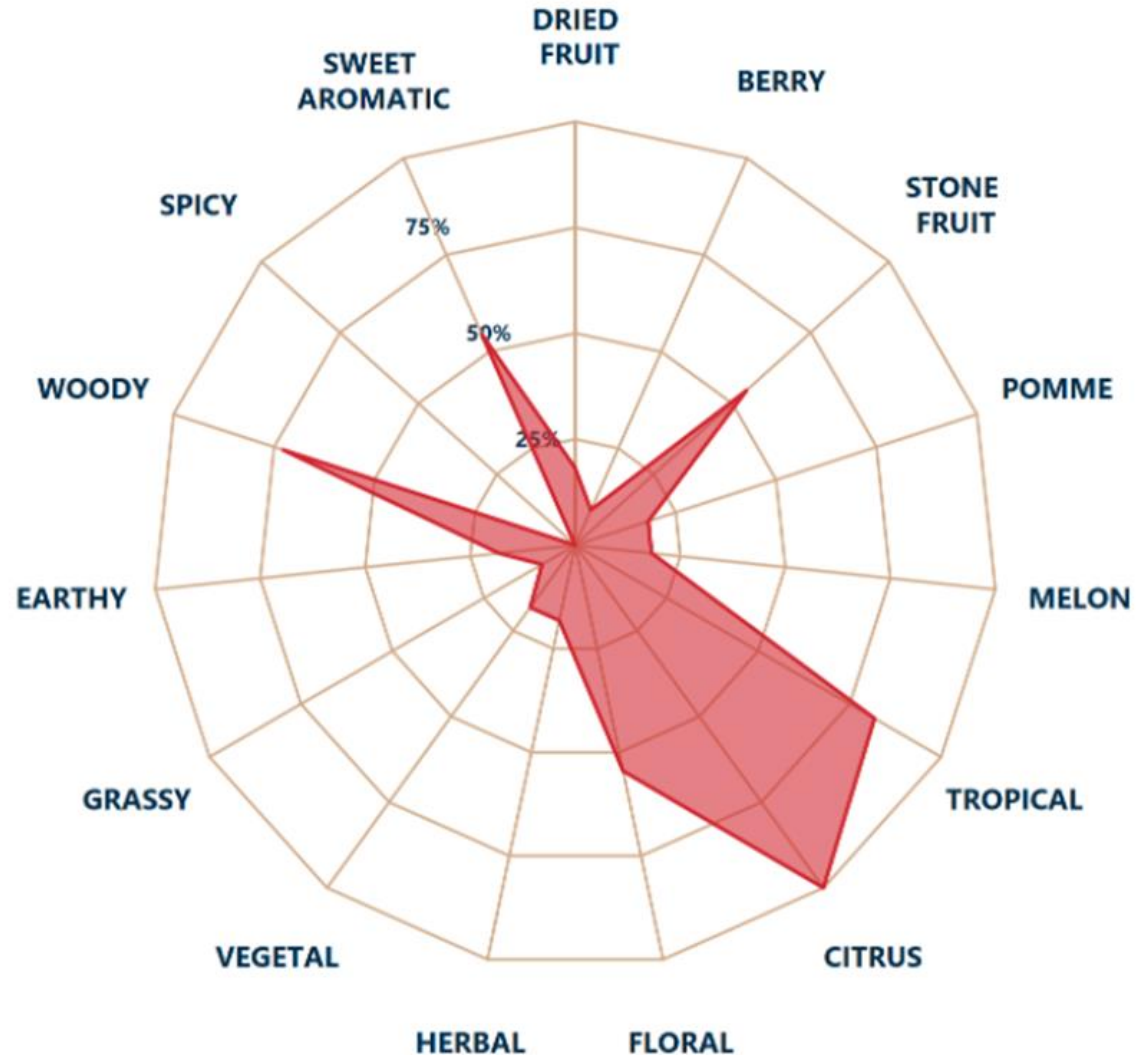
Specialty Aroma

Chasing new flavors!

HBC 446, HBC 586, HBC 630, HBC 735, HBC 889, HBC 989, HBC 990, HBC 1019

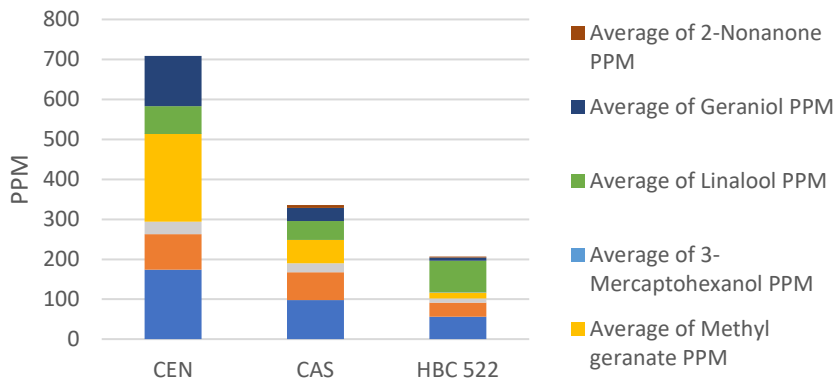
HBC 522: Concept, "Cascade"-type

Mean Productivity Metrics		
Alpha:	11.6	UV - % of cone weight
Beta:	4.5	UV - % of cone weight
Cohumulone:	24.8	% of cone weight
Total Oil:	2.30	ml/100g hops
Storage:		
Maturity:		
Yield:	2648	lb./acre



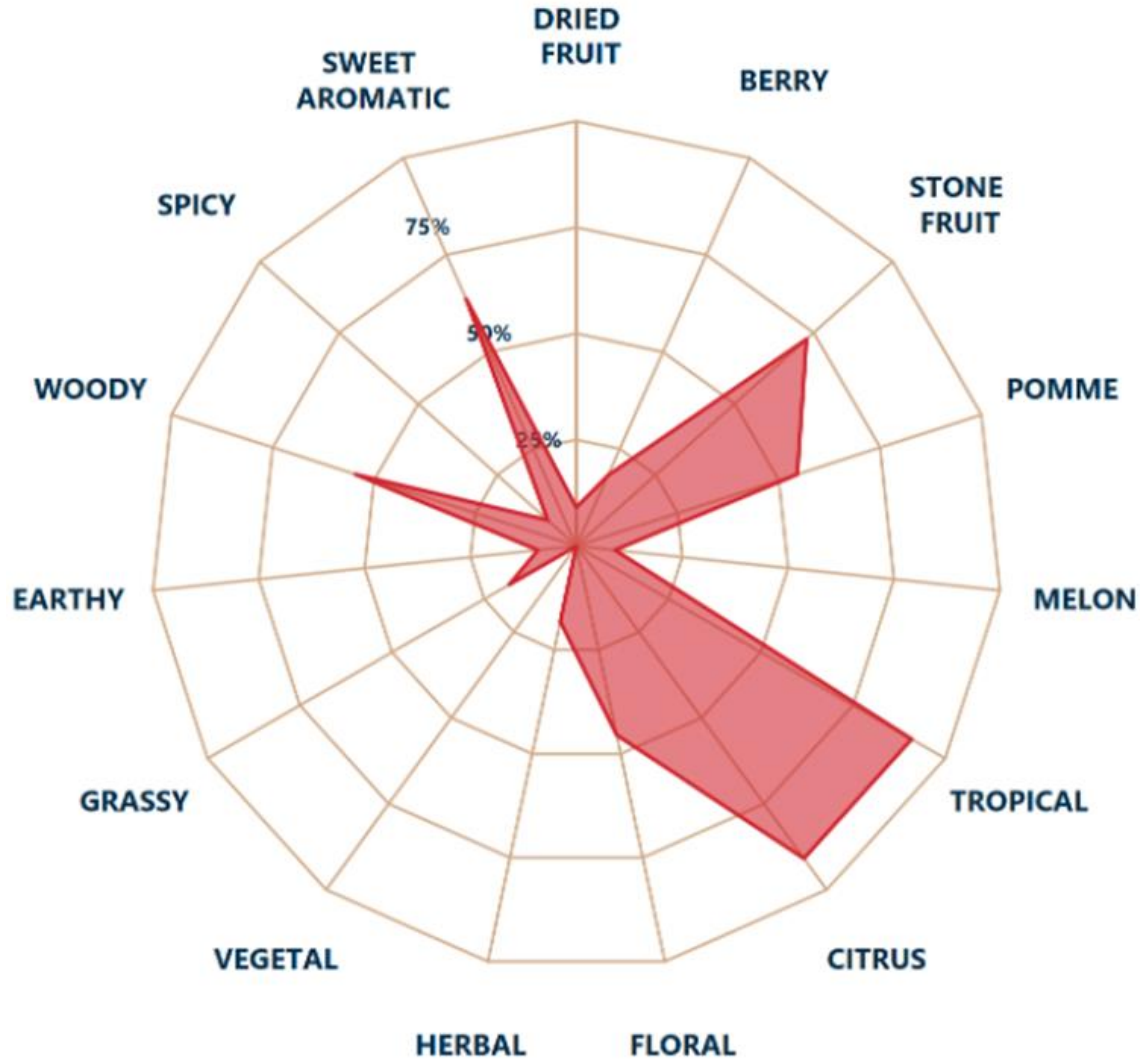
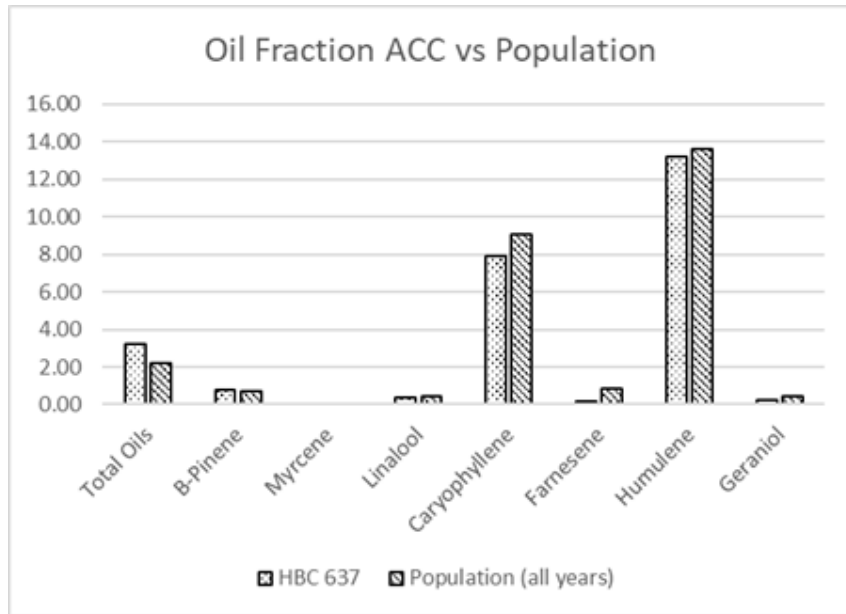
Attribute	HBC 522
LEMON	45.45%
GRAPEFRUIT	36.36%
BUBBLEGUM	27.27%
HONEY	27.27%
PEACH	27.27%
PINE	27.27%
ROSE	27.27%
CEDAR	18.18%
DRIED APRICOT	18.18%
GUAVA	18.18%
SOAPY	18.18%
TOBACCO	18.18%

HBC 522



HBC 637: Elite, "Cascade"-type

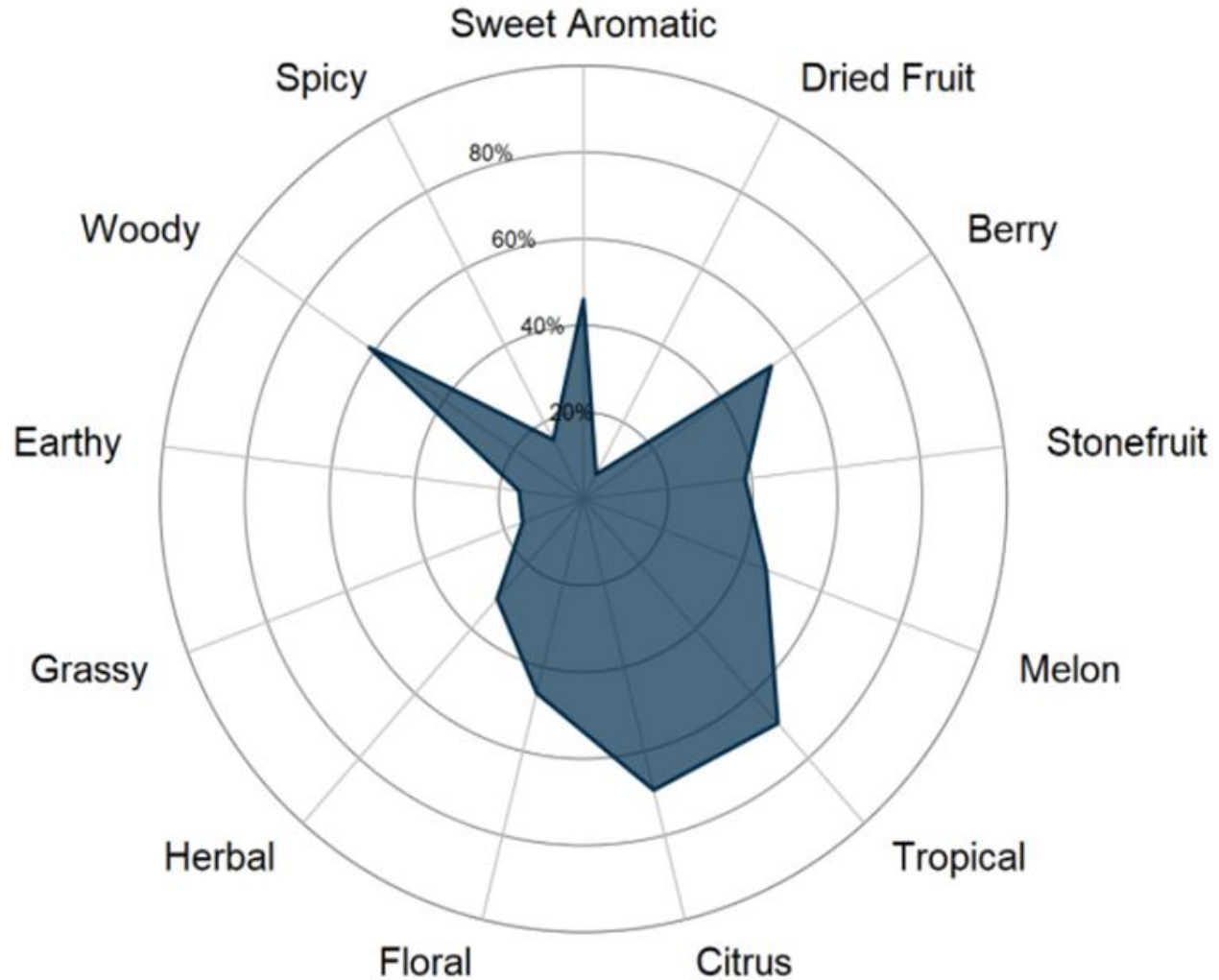
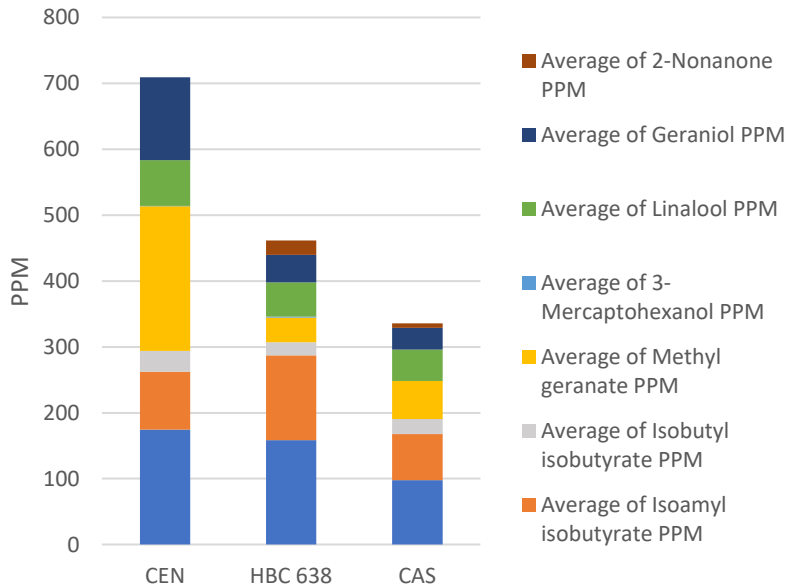
Mean Productivity Metrics		
Alpha:	14.1	UV - % of cone weight
Beta:	6.5	UV - % of cone weight
Cohumulone:	30	% of cone weight
Total Oil:	3.25	ml/100g hops
Storage:	poor	>30% loss, 6 month common
Maturity:	late	>9/20
Yield:	2449	lb./acre



Attribute	HBC 637
ORANGE	45.45%
APPLE	36.36%
PINE	36.36%
BUBBLEGUM	27.27%
MANGO	27.27%
PEACH	27.27%
SOAPY	27.27%
APRICOT	18.18%
GREEN GRASS	18.18%
LEMON	18.18%
PASSION FRUIT	18.18%

HBC 638: Concept, "Centennial"-type

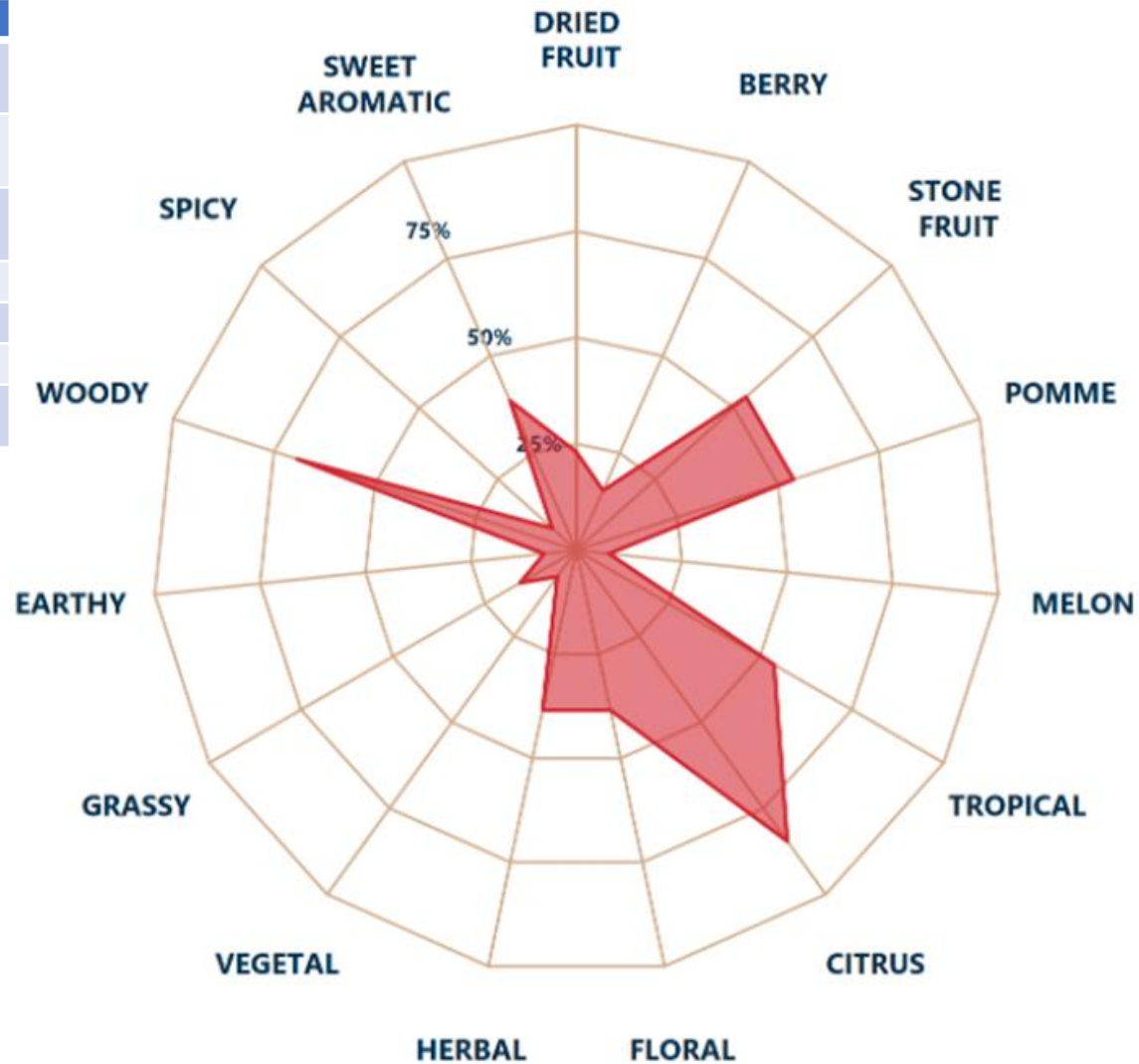
Mean Productivity Metrics		
Alpha:	13.8	UV - % of cone weight
Beta:	4.9	UV - % of cone weight
Cohumulone:	29.5	% of cone weight
Total Oil:	2.85	ml/100g hops
Storage:	excellent	
Maturity:	very late	
Yield:	2185	lb./acre



Attribute	HBC 638 - DH
Lemon	46.2%
Pine	30.8%
Bready	23.1%
Bubblegum	23.1%
Cantaloupe	23.1%
Mango	23.1%
Passion Fruit	23.1%
Pineapple	23.1%
Rose	23.1%
Apple	15.4%
Cedar	15.4%
Cherry	15.4%
Cherry Blossom	15.4%
Clove	15.4%
Grapefruit	15.4%
Jasmine	15.4%
Orange	15.4%
Peach	15.4%
Strawberry	15.4%
Tea Tree	15.4%
Vanilla	15.4%
Watermelon	15.4%

HBC 1134: Elite, Noble-type

Mean Productivity Metrics		
Alpha:	10.7	UV - % of cone weight
Beta:	4.0	UV - % of cone weight
Cohumulone:	27.97	% of cone weight
Total Oil:	2.70	ml/100g hops
Storage:	TBD	TBD
Maturity:	Early-mid	
Yield:	12	Est. bales/acre



Attribute	HBC 1134
LEMON	61.54%
APPLE	38.46%
GRAPEFRUIT	38.46%
PEACH	38.46%
PINE	30.77%
CEDAR	23.08%
MANGO	23.08%
ORANGE	23.08%
APRICOT	15.38%
BANANA	15.38%
HONEY	15.38%
PEAR	15.38%
ROSE	15.38%

*No data available for oil profile

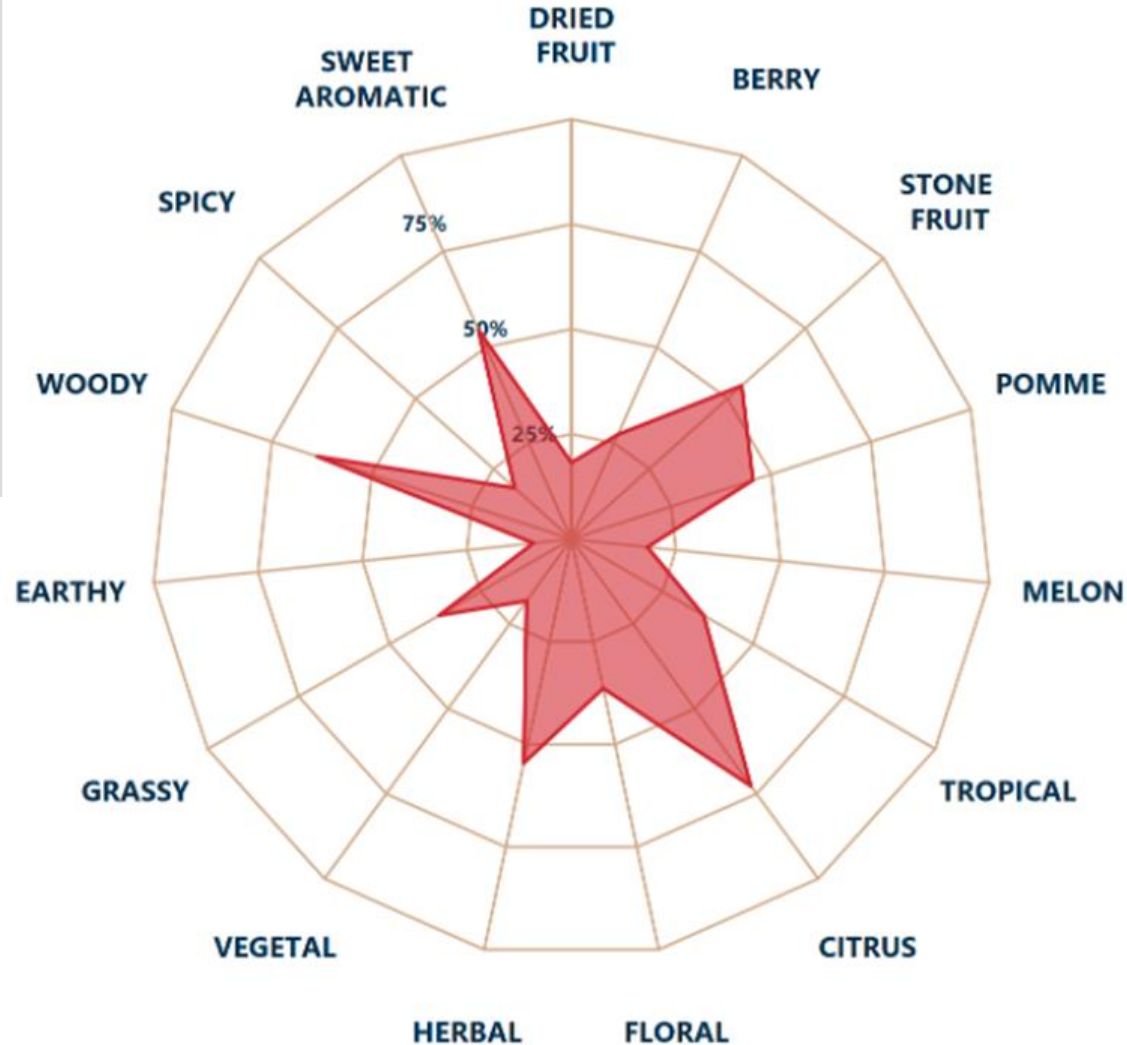
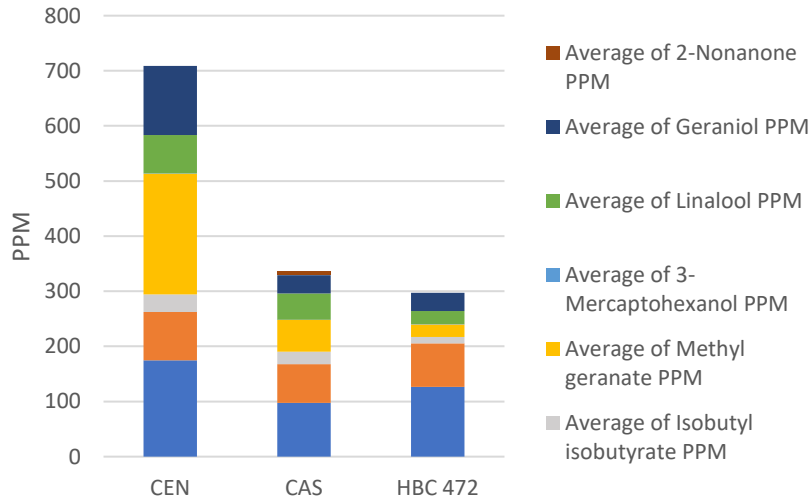
HBC 472 Concept, Specialty Aroma



HBC 472

CITRUS, COCONUT, HERBAL, WOODY

Alpha:	9-12%
Beta:	7-9%
CO_H:	40-45%
Oil:	1-3 mL/100g



Attribute	HBC 472
CEDAR	36.36%
HONEY	27.27%
APPLE	18.18%
CHERRY	18.18%
GREEN TEA	18.18%
GUAVA	18.18%
HAY	18.18%
LEMON	18.18%
ORANGE	18.18%
PEACH	18.18%
PEAR	18.18%
PINE	18.18%
THYME	18.18%

HBC 586: Concept, Specialty Aroma

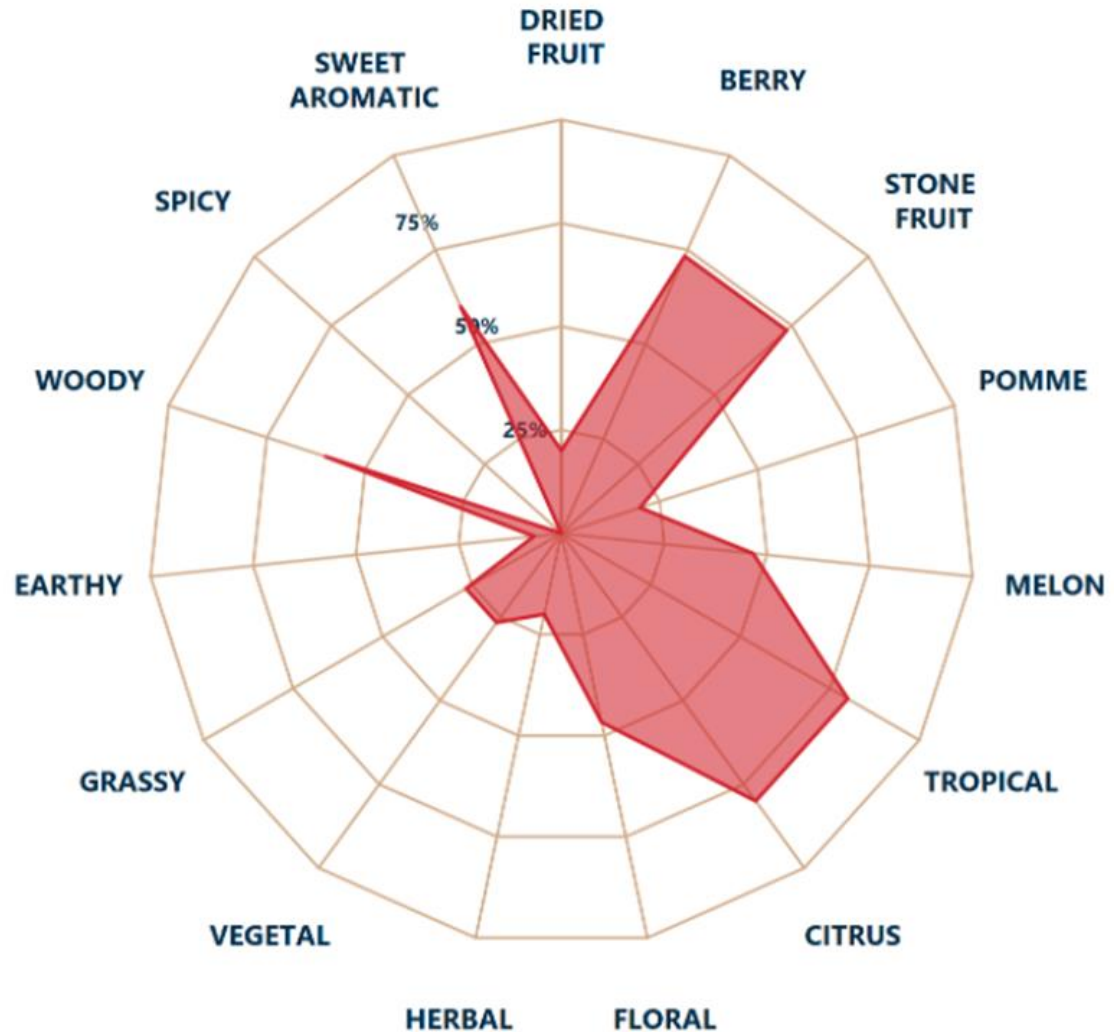
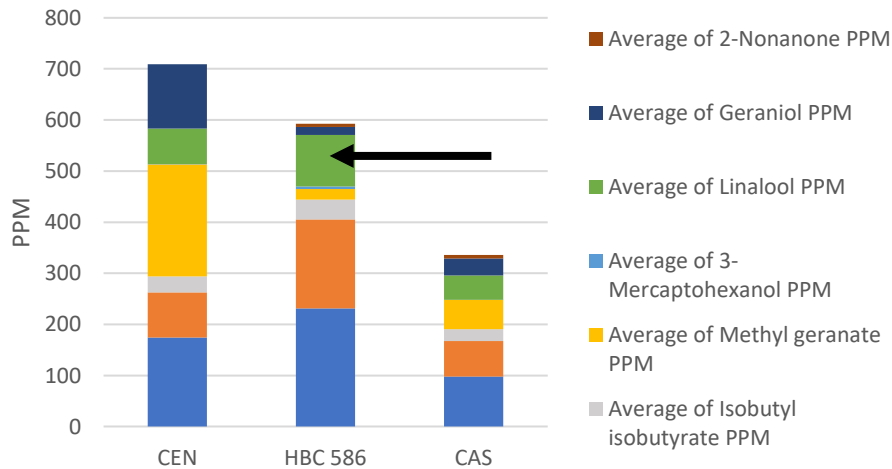


HBC 586

CITRUS, STONE FRUIT, TROPICAL, WOODY

Alpha:	11-14%
Beta:	7.5-8.5%
CO_H:	35-40%
Oil:	2.5-4.5 ml/100g

HBC 586



Attribute	HBC 586 - DH
Mango	53.8%
Peach	46.2%
Pine	46.2%
Pineapple	46.2%
Bubblegum	38.5%
Grapefruit	38.5%
Honeydew	38.5%
Strawberry	38.5%
Orange	30.8%
Apricot	23.1%
Bready	23.1%
Honey	23.1%
Passion Fruit	23.1%
Vanilla	23.1%
Apple	15.4%
Banana	15.4%
Cantaloupe	15.4%
Cedar	15.4%
Cherry	15.4%
Green Grass	15.4%
Green Pepper	15.4%
Guava	15.4%
Lemon	15.4%
Pear	15.4%
Raspberry	15.4%
Rose	15.4%

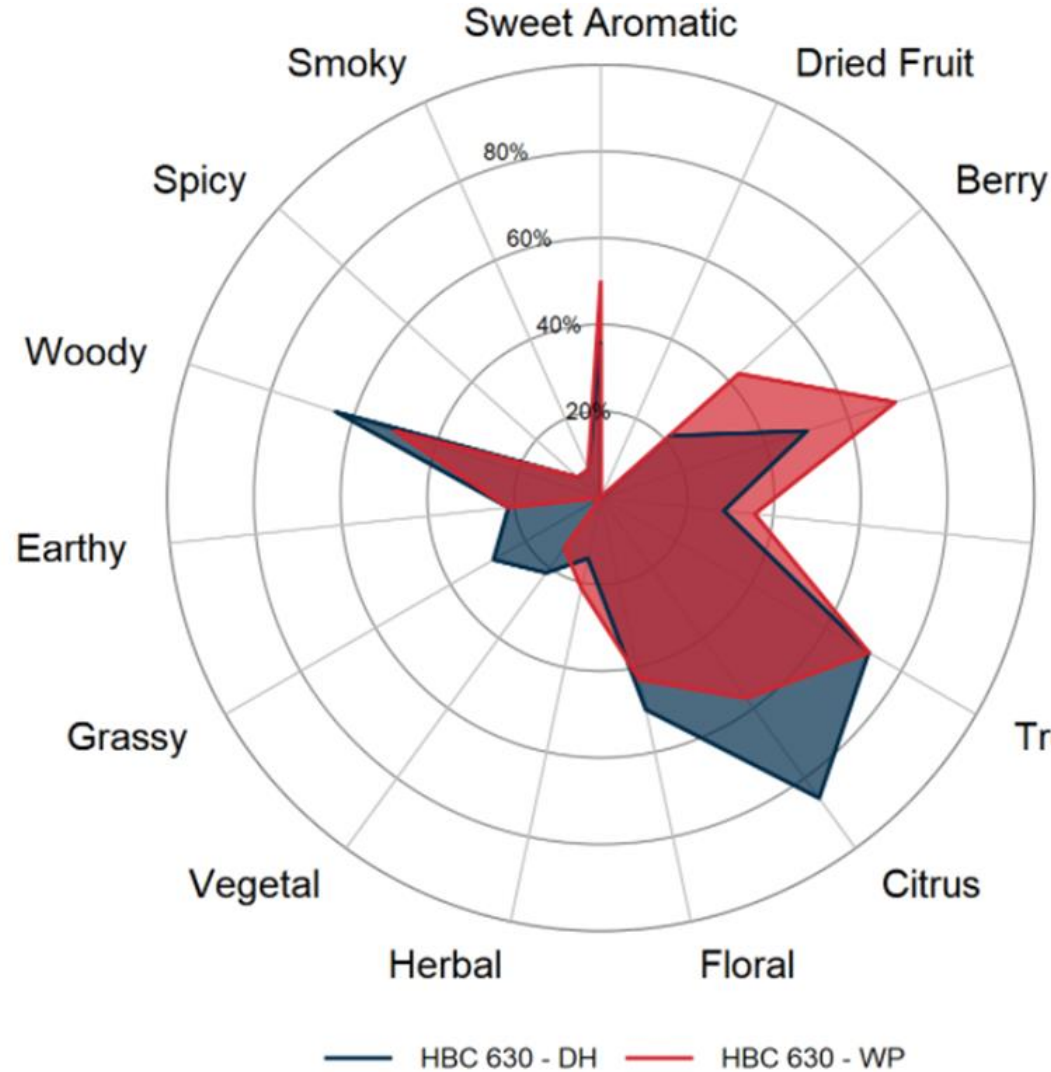
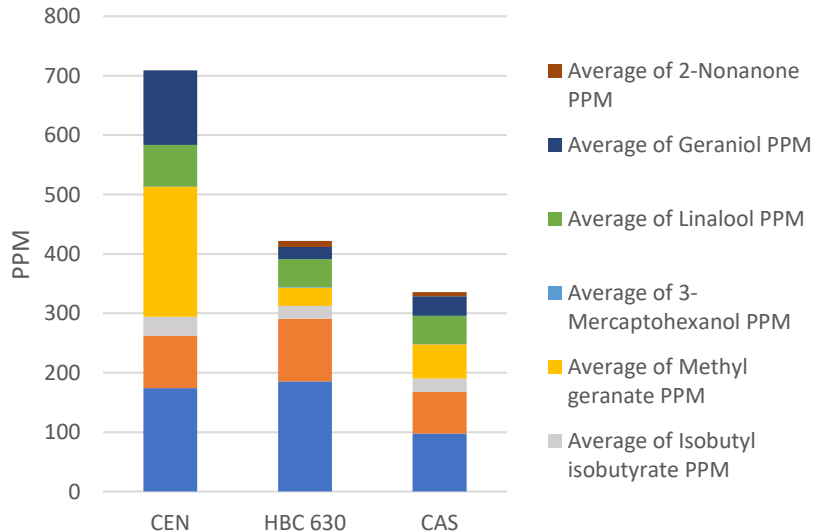
HBC 630: Concept, Specialty Aroma



HBC 630

BERRY, CITRUS, STONE FRUIT, SWEET AROMATIC, T...

Alpha:	13-15%
Beta:	5-7%
CO_H:	20-25%
Oil:	1.5-3 mL/100g

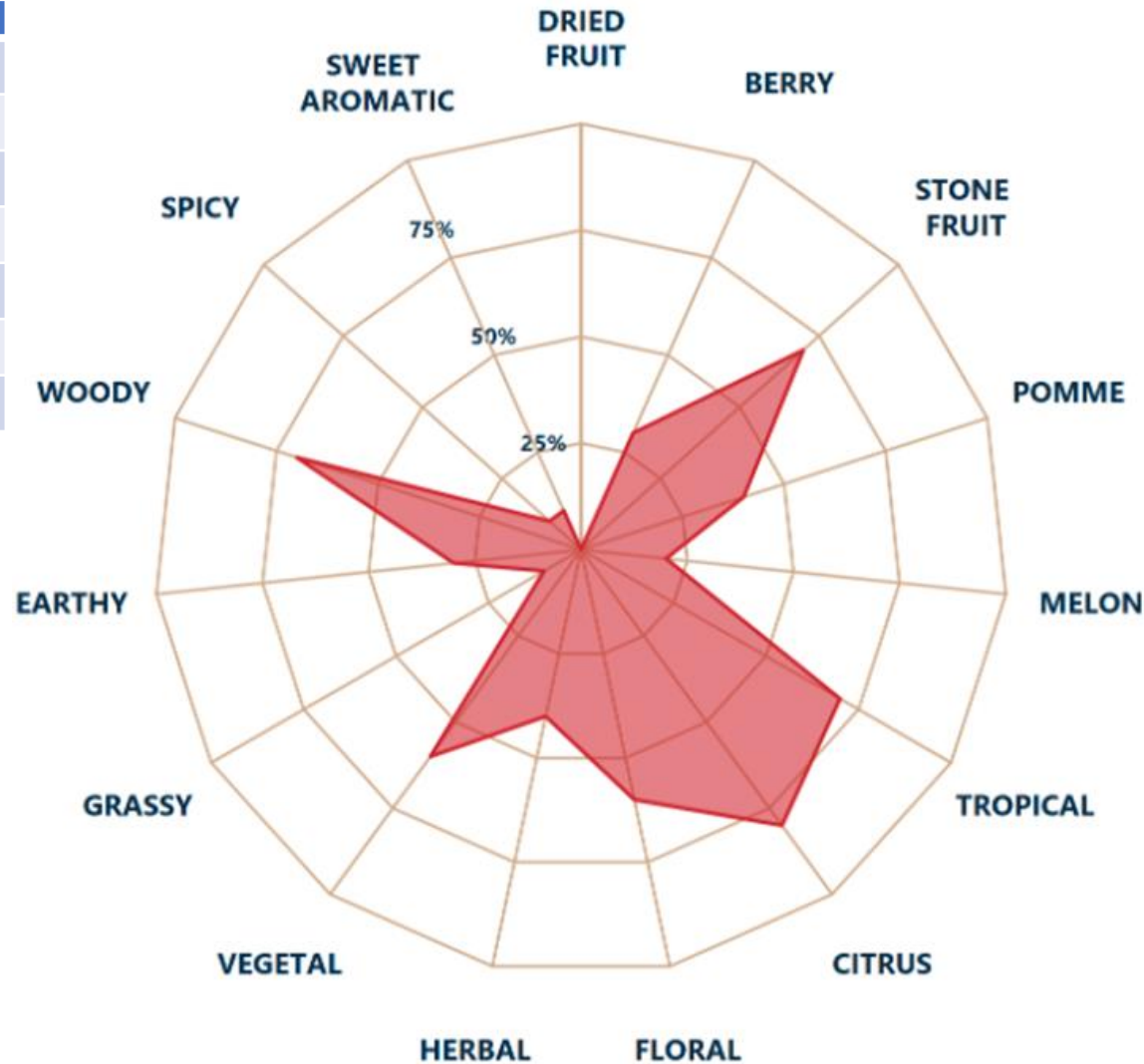
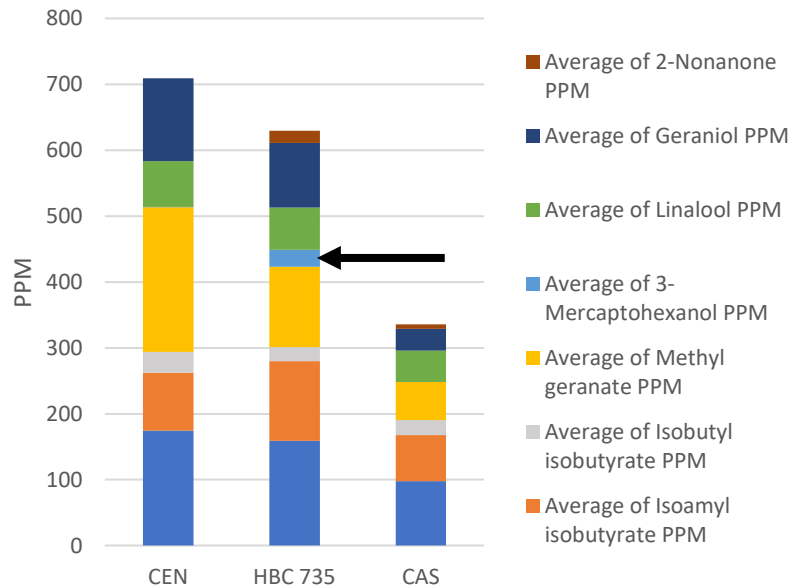


Attribute	HBC 630 - WP
Lemon	35.7%
Banana	28.6%
Honey	28.6%
Orange	28.6%
Peach	28.6%
Pear	28.6%
Honeydew	21.4%
Pine	21.4%

Attribute	HBC 630 - DH
Peach	35.7%
Grapefruit	28.6%
Mango	28.6%
Orange	28.6%
Pineapple	28.6%
Cedar	21.4%
Green Grass	21.4%
Lemon	21.4%

HBC 735: Elite, Specialty Dual-Purpose

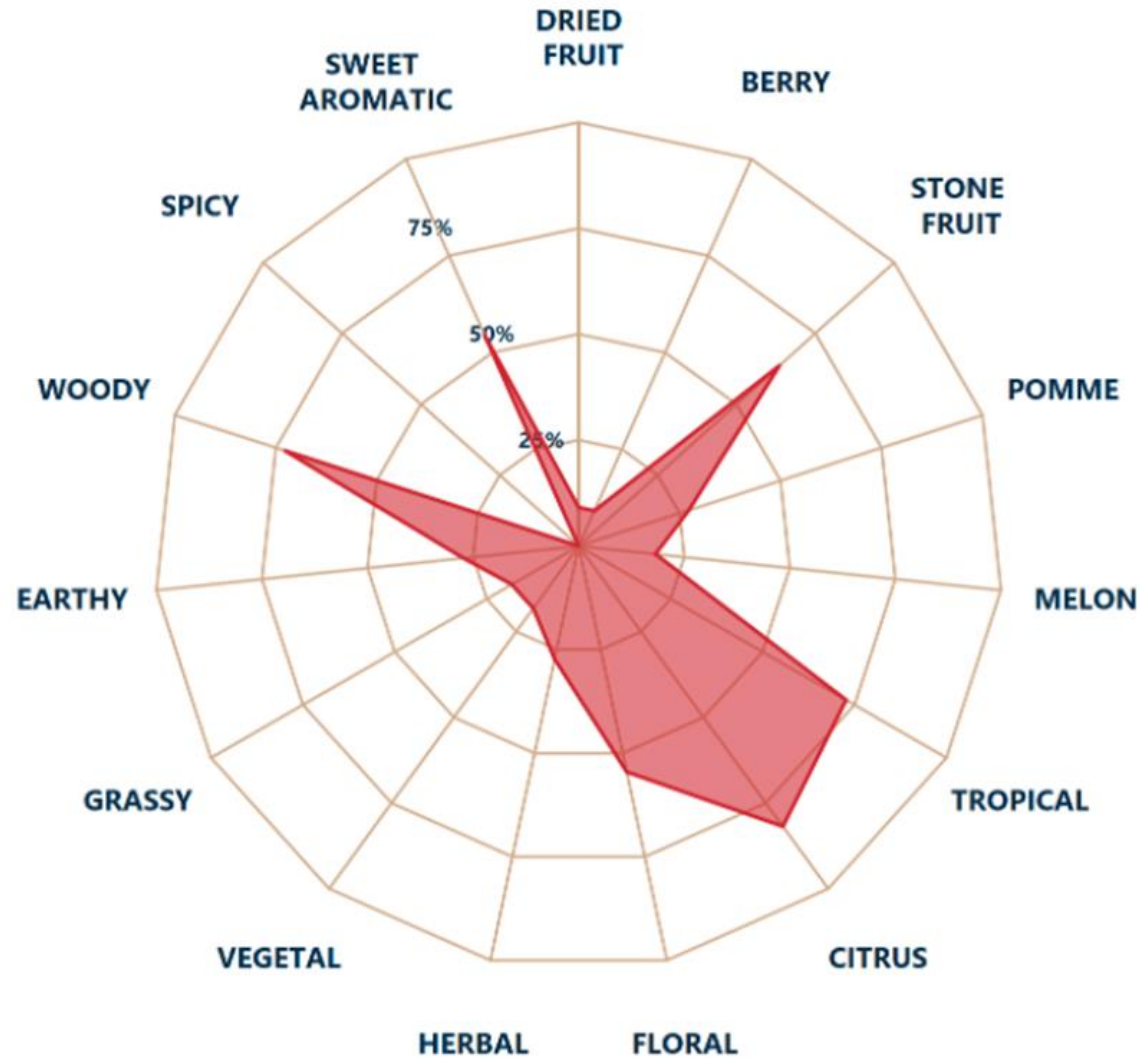
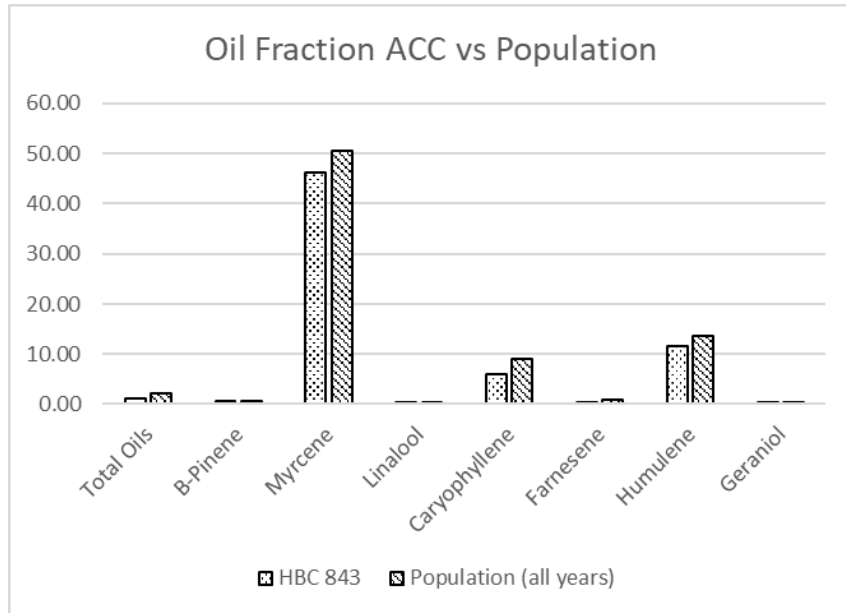
Mean Productivity Metrics		
Alpha:	15.2	UV - % of cone weight
Beta:	6.4	UV - % of cone weight
Cohumulone:	26.5	% of cone weight
Total Oil:	3.60	ml/100g hops
Storage:	poor	
Maturity:	late	
Yield:	3136	lb./acre



Attribute	Outcross HBC 735
LEMON	30.00%
PEACH	30.00%
ROSE	30.00%
TEA	30.00%
APPLE	20.00%
CABBAGE	20.00%
GRAPE	20.00%
GRAPEFRUIT	20.00%
MANGO	20.00%
ORANGE	20.00%
PEAR	20.00%
PINE	20.00%
PINEAPPLE	20.00%
SAWDUST	20.00%

HBC 843: Elite, Specialty Dual-Purpose

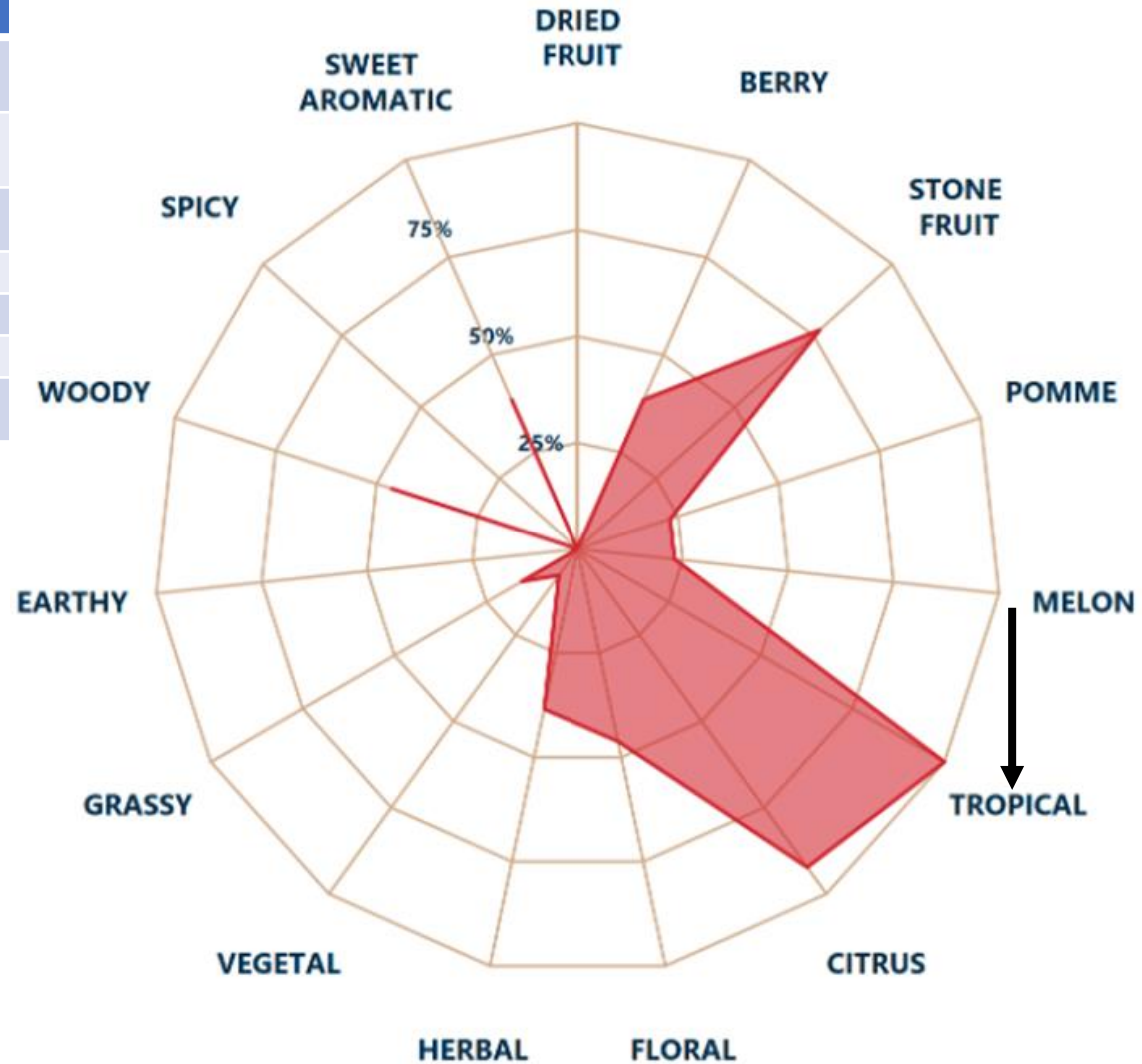
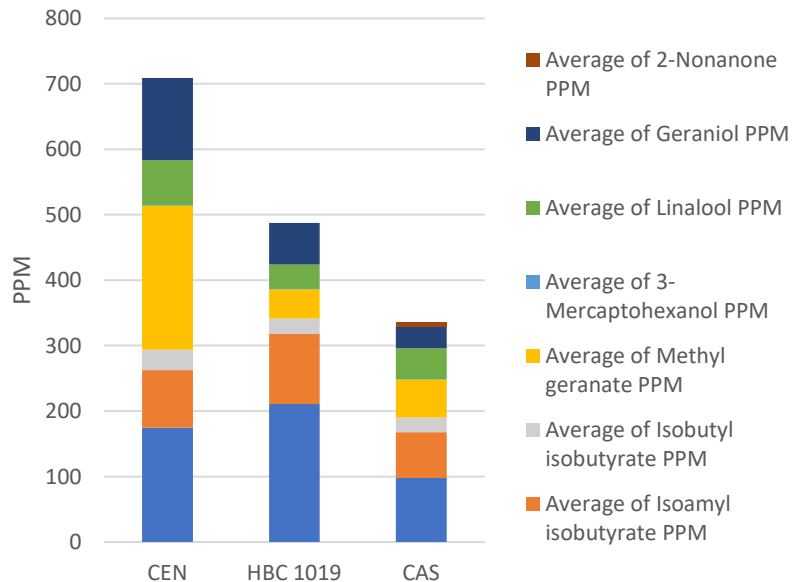
Mean Productivity Metrics		
Alpha:	15.1	UV - % of cone weight
Beta:	4.5	UV - % of cone weight
Cohumulone:	27.5	% of cone weight
Total Oil:	1.20	ml/100g hops
Storage:	good	< 25% alpha loss, 6 months common
Maturity:	late	post 9/25
Yield:	3167	lb./acre



Attribute	HBC 843
CEDAR	36.36%
LEMON	36.36%
HONEY	27.27%
MANGO	27.27%
ORANGE	27.27%
ROSE	27.27%
APPLE	18.18%
APRICOT	18.18%
CHERRY	18.18%
GRAPEFRUIT	18.18%
GREEN GRASS	18.18%
GUAVA	18.18%
PEACH	18.18%
PINE	18.18%
PINEAPPLE	18.18%
SOAPY	18.18%
TOBACCO	18.18%

HBC 1019: Concept, Specialty Aroma

Mean Productivity Metrics		
Alpha:	10.7	UV - % of cone weight
Beta:	4.0	UV - % of cone weight
Cohumulone:	27.97	% of cone weight
Total Oil:	2.70	ml/100g hops
Storage:		
Maturity:		
Yield:	12	Est. bales/acre

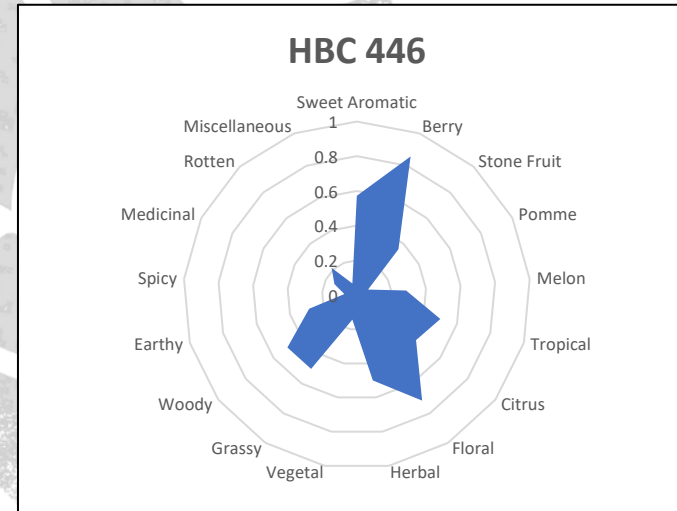


Attribute	HBC 1019
PEACH	69.23%
MANGO	53.85%
ORANGE	53.85%
LEMON	46.15%
PINE	30.77%
PINEAPPLE	30.77%
CANTALOUPE	23.08%
CREAMY	23.08%
APPLE	15.38%
CEDAR	15.38%
COCONUT	15.38%
GRAPE	15.38%
GRAPEFRUIT	15.38%
GREEN TEA	15.38%
GUAVA	15.38%
HONEY	15.38%
LYCHEE	15.38%
PASSION FRUIT	15.38%
SOAPY	15.38%

New Elite Lineup CY2023

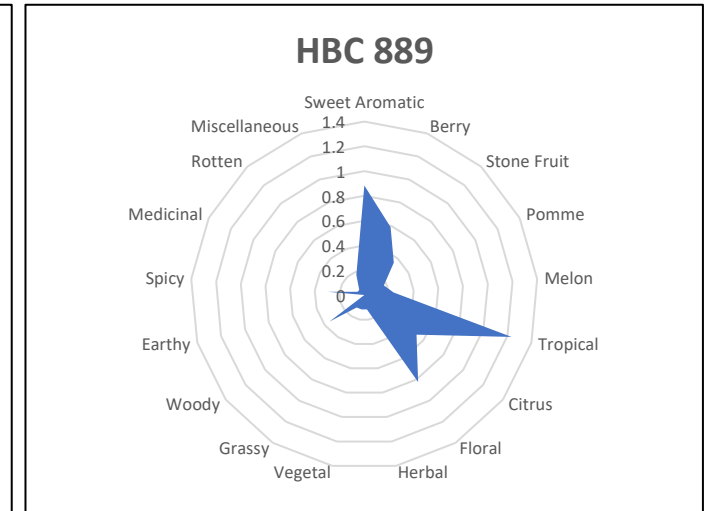
❖ HBC 446

- ❖ Sweet, red berry, fruit punch, floral
- ❖ Neomexicanus line



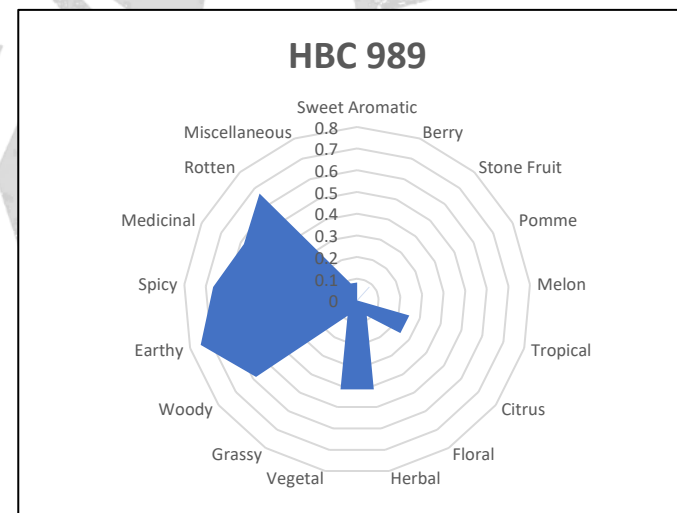
❖ HBC 889

- ❖ "Pink", white wine, tropical



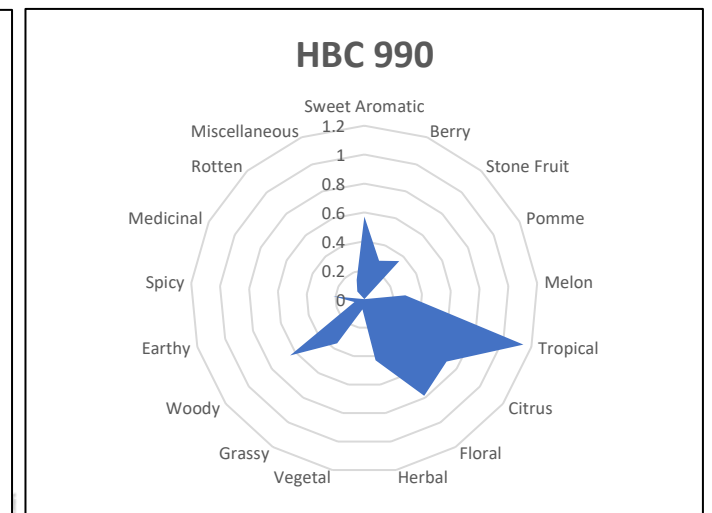
❖ HBC 989

- ❖ Fruity, pine, earthy, spicy
- ❖ Huge yield



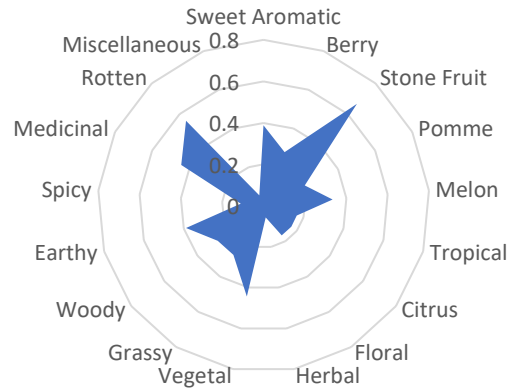
❖ HBC 990

- ❖ Citrus, floral, tropical
- ❖ Huge yield

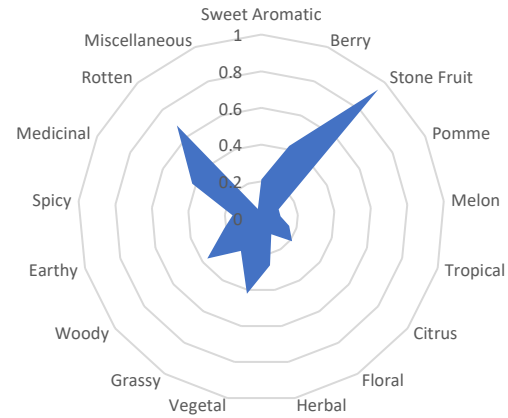


CY2023: expanded yield trials

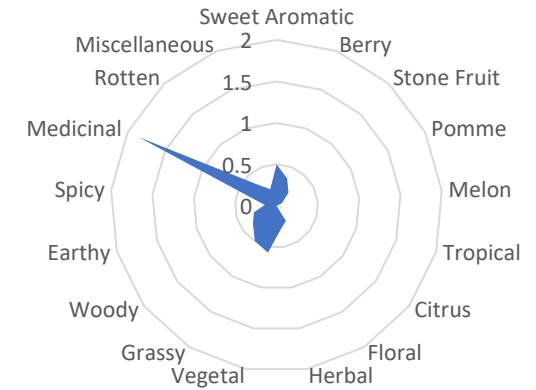
HBC 367



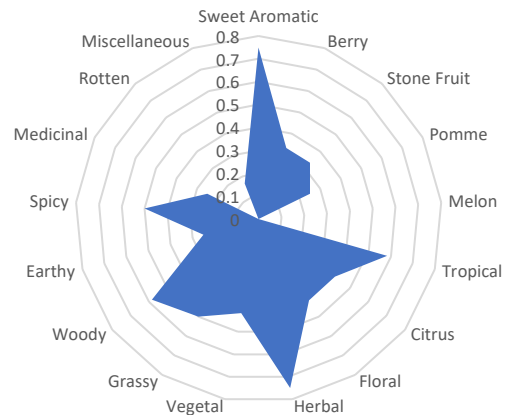
HBC 703



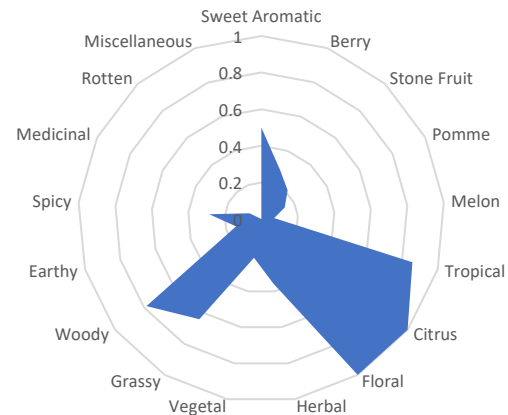
HBC 732



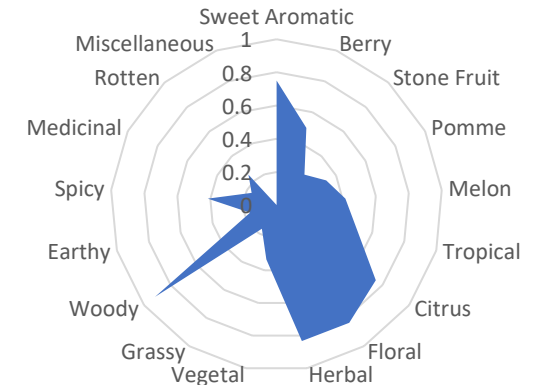
HBC 773



HBC 867



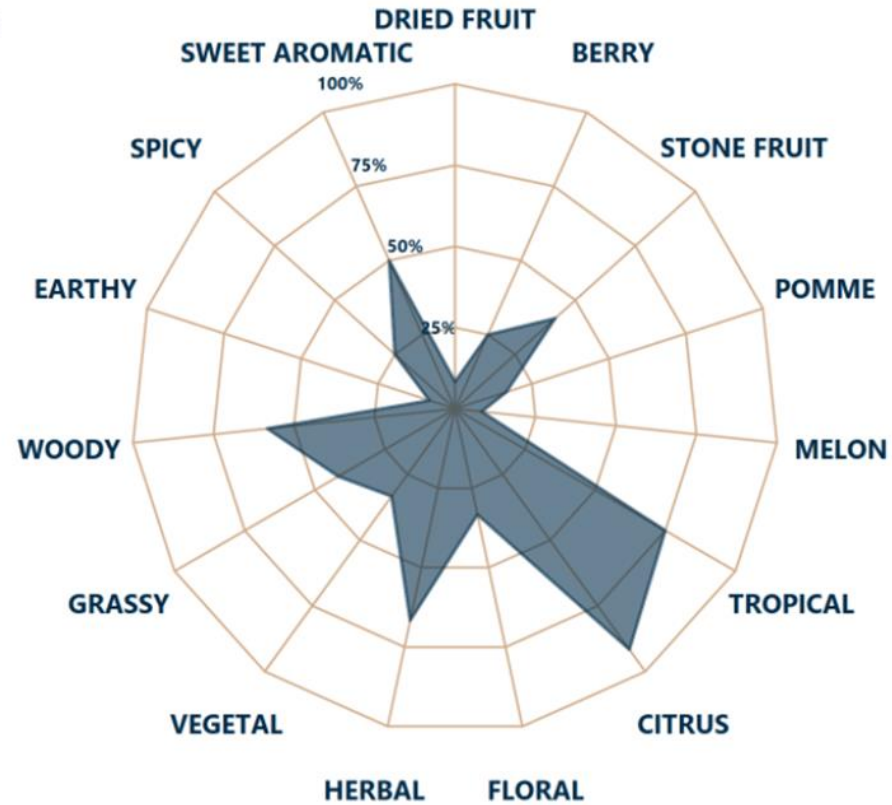
HBC 979



HBC 990 (Elite, CY2023)

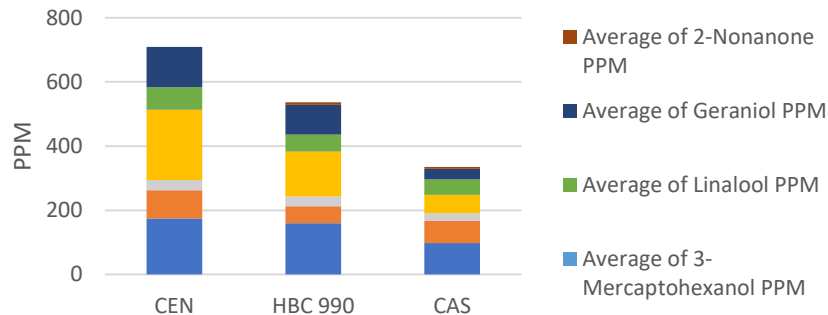
Mean Productivity Metrics		
Alpha	11.1	HPLC- % of cone weight
Beta	3.45	HPLC- % of cone weight
Cohumulone	32.5	% of alpha
Total Oils	2.55	ml/100g hops
Storage	Very good	
Maturity	Mid-late	9/20-9/25
Yield	19.9	Bales/acre (est.)

◆ HBC990 (n=12)



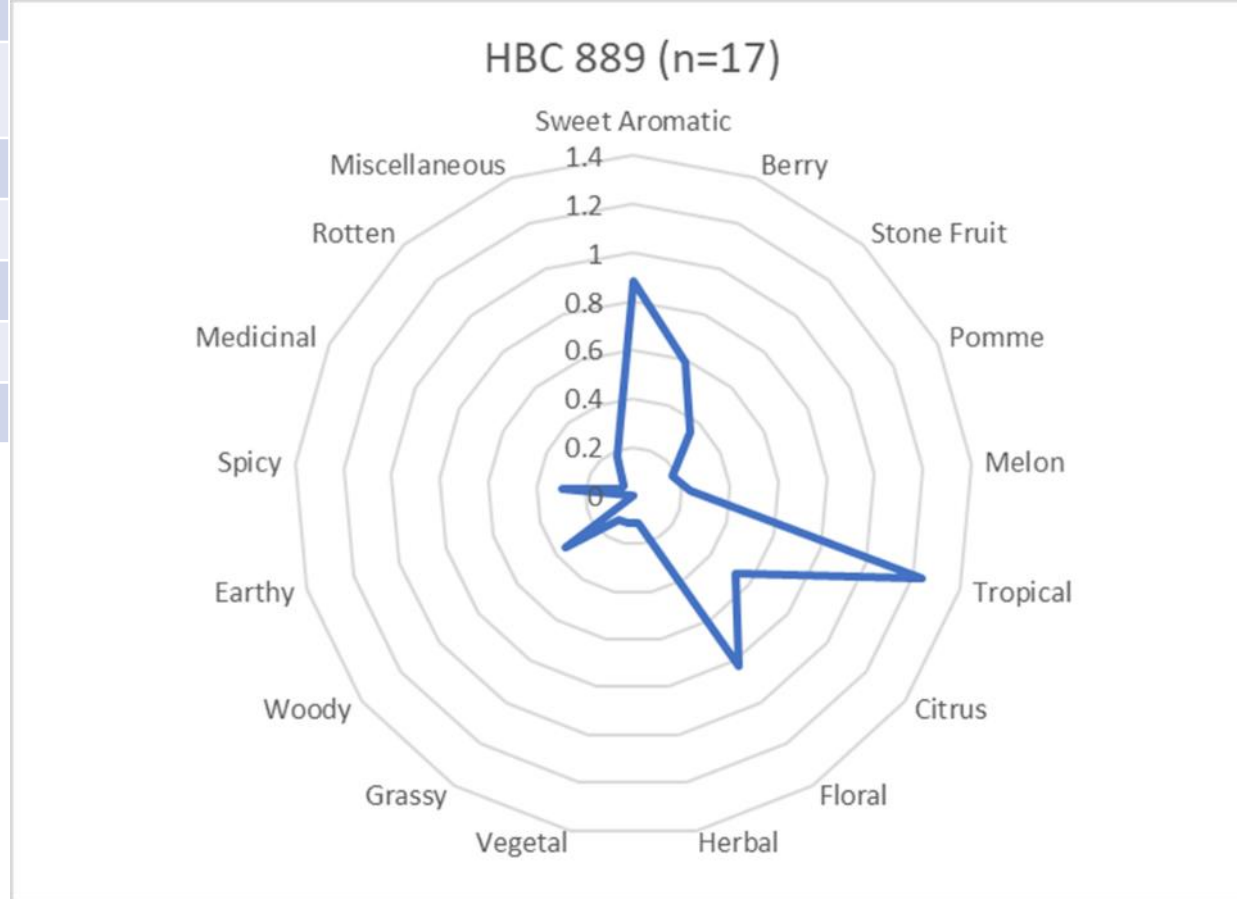
Attribute	HBC 990
Fruity	0.428571
Pine	0.357143
Tropical	0.285714
Geranium	0.285714
Guava	0.285714
Bubblegum	0.285714
Sweet Aromatic	0.214286
Tangerine	0.214286

HBC 990



HBC 889 (Elite, CY2023)

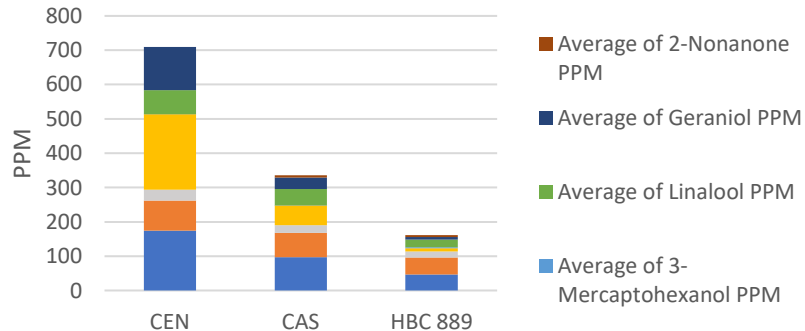
Mean Productivity Metrics		
Alpha	10	HPLC- % of cone weight
Beta	4.425	HPLC- % of cone weight
Cohumulone	35.23	% of alpha
Total Oils	1.25	ml/100g hops
Storage	Moderate-Fair	
Maturity	Late	9/17-9/25
Yield	10.3	Bales/acre (est.)



Attribute	HBC 889
Floral	0.444444
Bubblegum	0.411765
Banana	0.352941
Vanilla	0.277778
Berry	0.277778
Fruity	0.235294
Pineapple	0.235294

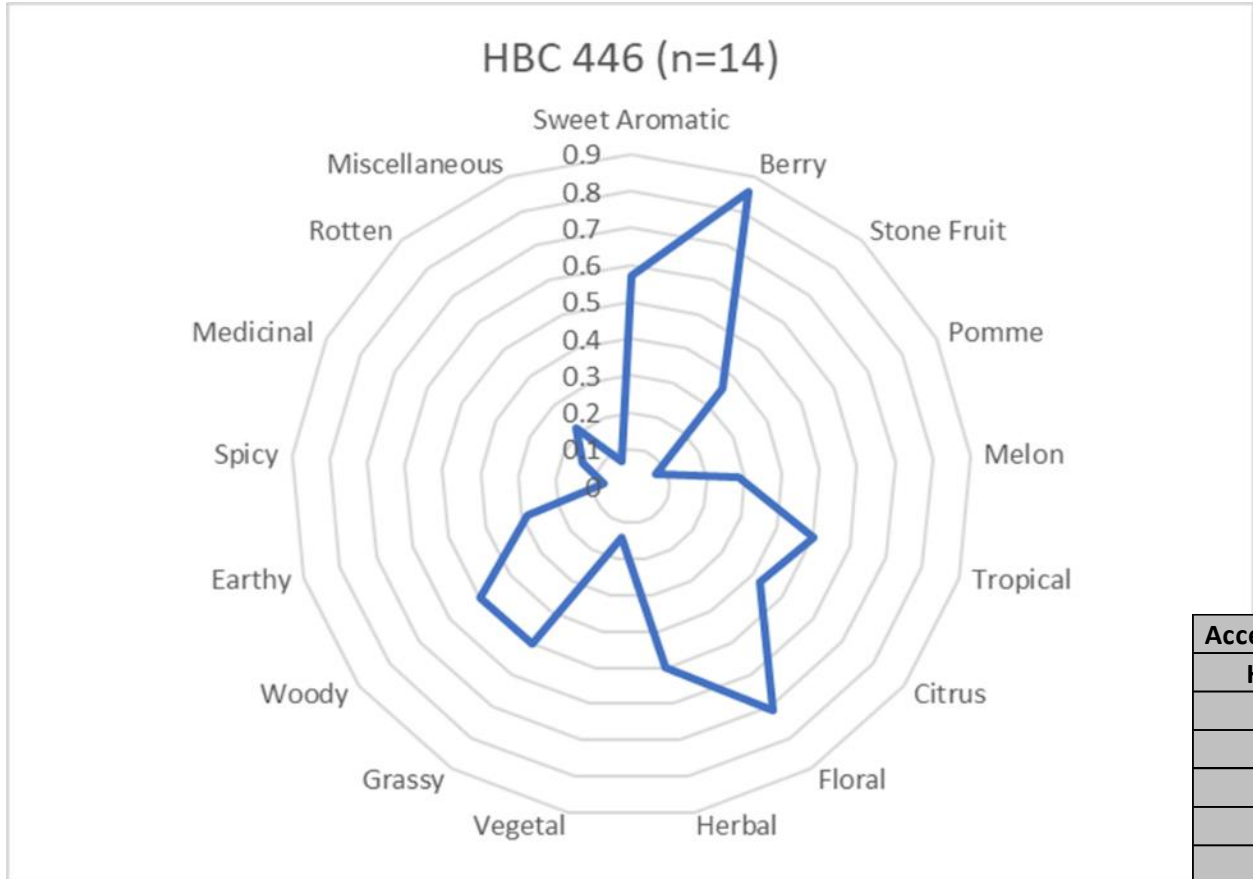
AccessionNumber	HBC 889
HPLCAlpha	10
HPLCBeta	4.425
CoH	35.225
TotalOils	1.25
Pinene	0.7475
Myrcene	36.91
Linalool	0.2875
Caryophyllene	7.415
Farnesene	7.3925
Humulene	17.3975
Geraniol	0.125
A-Pinene	0.06
Methyl-butyl isobutyrate	0.94
Limonene	0.16

HBC 889



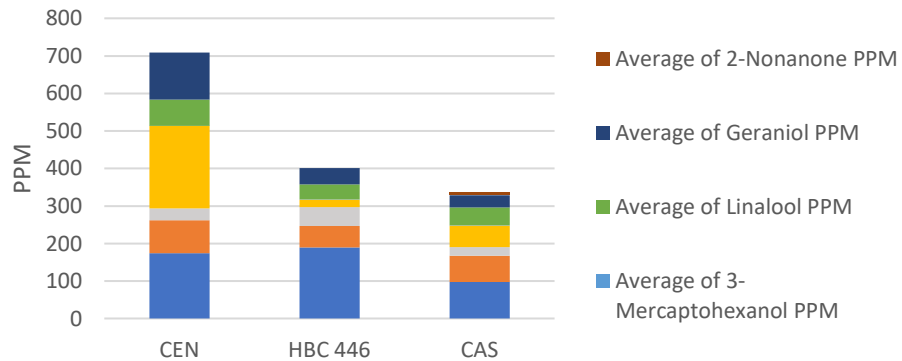
HBC 446 (Elite, CY2023)

Mean Productivity Metrics		
Alpha	4.72	HPLC- % of cone weight
Beta	3.4	HPLC- % of cone weight
Cohumulone	47.3	% of alpha
Total Oils	1.0	ml/100g hops
Storage	Fair	
Maturity	Late	9/20-10/1
Yield	15.7	Bales/acre (est.)



Attribute	HBC 446
Fruity	0.5
Sweet Aromatic	0.357143
Rose	0.214286
Citrus	0.214286
Cherry	0.214286
Strawberry	0.214286
Hay	0.214286

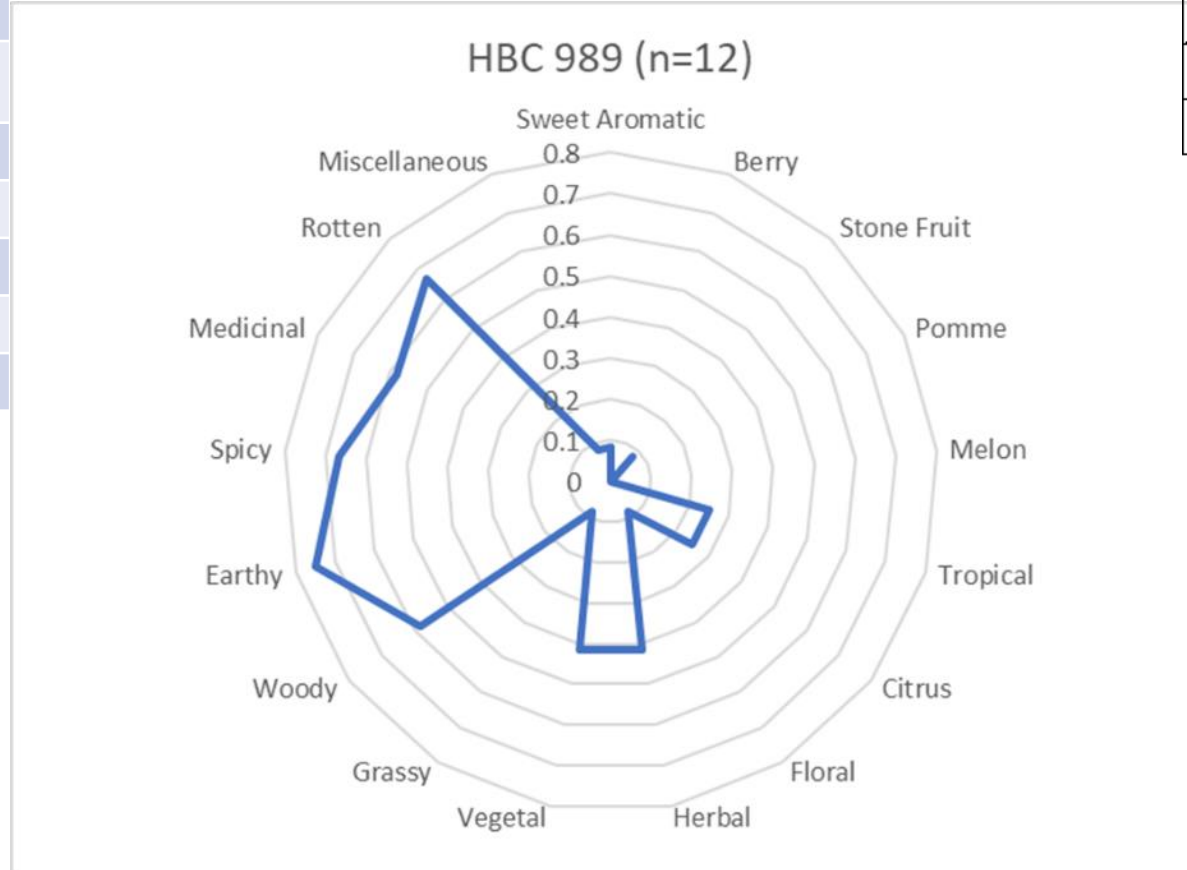
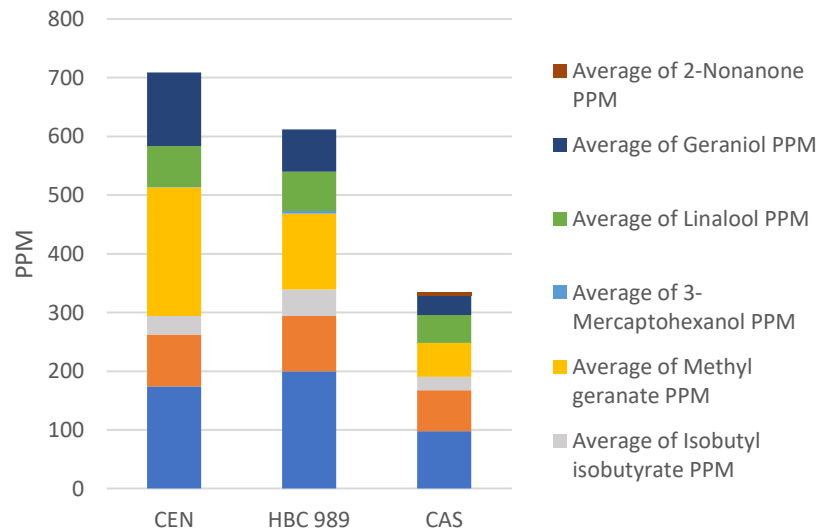
HBC 446



AccessionNumber	HBC 446
HPLCAalpha	5.7
HPLCBeta	3
CoH	47
TotalOils	
Pinene	0.67833
Myrcene	40.5
Linalool	0.30833
Caryophyllene	7.3
Farnesene	0.11166
Humulene	22.7533
Geraniol	0.43166
A-Pinene	0.09333
Methyl-butyl	

HBC 989 (Elite, CY2023)

Mean Productivity Metrics		
Alpha	10.05	HPLC- % of CW
Beta	3.65	HPLC- % of CW
Cohumulone	32.55	% of alpha
Total Oils	1.1	ml/100g hops
Storage	Very good	
Maturity	Late	9/26-9/29
Yield	23.6	Bales/acre (est.)



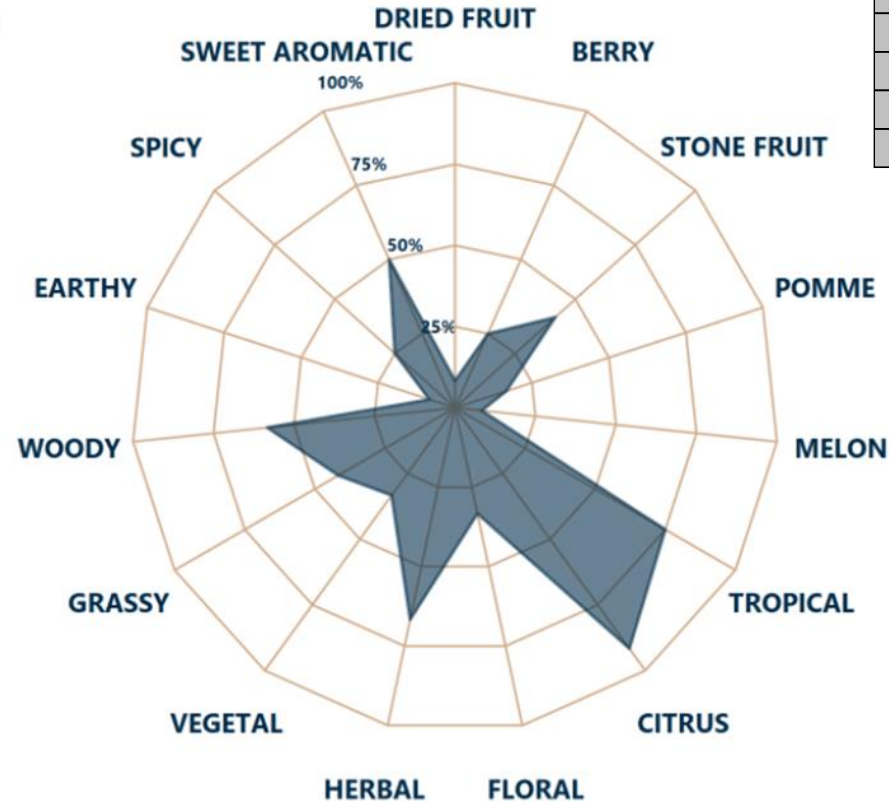
Attribute	HBC 989
Cream	0.25
Citrus	0.166667
Herbaceous	0.166667
Tobacco	0.166667
Earthy	0.166667

AccessionNumber	HBC 989
HPLCAAlpha	10.05
HPLCBeta	3.65
CoH	32.55
TotalOils	1.1
Pinene	0.6
Myrcene	45.2
Linalool	0.35
Caryophyllene	6.345
Farnesene	0.15
Humulene	19.055
Geraniol	0.875

HBC 990 (Elite, CY2023)

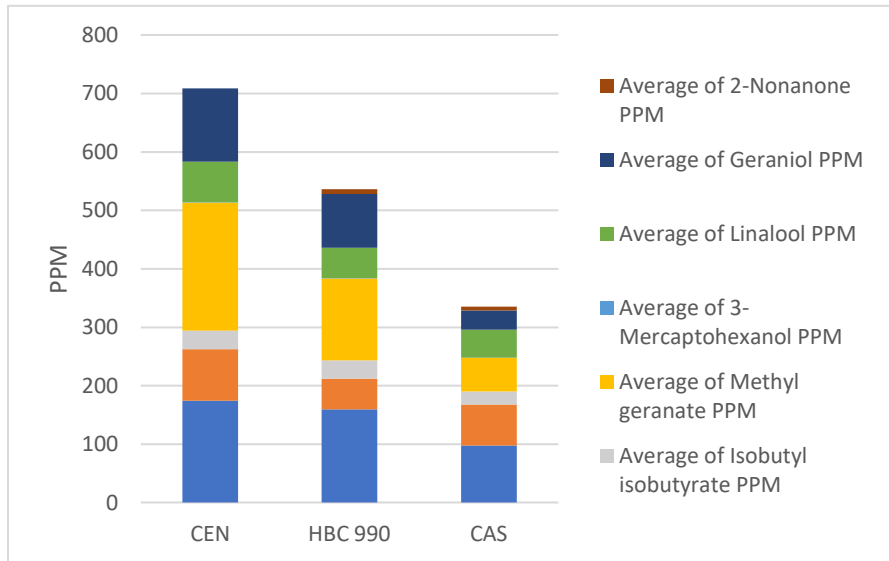
Mean Productivity Metrics		
Alpha	11.1	HPLC- % of CW
Beta	3.45	HPLC- % of CW
Cohumulone	32.5	% of alpha
Total Oils	2.55	ml/100g hops
Storage	Very good	
Maturity	Mid-late	9/20-9/25
Yield	19.9	Bales/acre (est.)

◆ HBC990 (n=12)



AccessionNumber	HBC 990
HPLCAlpha	11.1
HPLCBeta	3.45
CoH	32.5
TotalOils	2.55
Pinene	0.76
Myrcene	56.285
Linalool	0.315
Caryophyllene	7.13
Farnesene	2.17
Humulene	17.7
Geraniol	0.635

Attribute	HBC 990
Fruity	0.428571
Pine	0.357143
Tropical	0.285714
Geranium	0.285714
Guava	0.285714
Bubblegum	0.285714
Sweet Aromatic	0.214286
Tangerine	0.214286





Questions?