Development of Novel Hop Varieties

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Development of Novel Hop Varieties

- Basic hop info
  - Botanical
  - Crop development
- Impact of hop variety.
- Variety development
  - Why?
  - How?
  - Results

Humulus spp. Overview

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

(Neve 1991)

Hop Basics

- Dioecious (male and female plants).
  - Genetically complex.
  - Male-no commercial value
  - Female-Produces the valued strobiles, “cones”
- Annual above ground.
- Perennial below.
  - Allows for clonal propagation.
- Climbing bine requiring a support system.
- Photoperiod sensitive

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

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: well over 100 compounds, contribution to aroma.
    - Soft resins: beta acids, and the all important alpha acids.
  - Lupulin accounts for 20 – 50 % of cone weight.

Mature Female “Cones”

Male flowers at anthesis

Annual vs. Perennial Growth

- The above ground portion of the stem is annual.
  - Dies off at dormancy.
- The root is perennial, can survive low winter temps.
  - Requires a dormant period.
- The plant also produces rhizomes (below ground stems).
  - Buds become new spring growth.
  - Easily propagated from cuttings.

Clonal Propagation

- Propagation of hops purely vegetative
  - Root cuttings
  - Layering
  - Softwood cuttings
- Resulting plants genetically identical to parent material

Climbing Bines

- In the wild-usually found climbing on companion species.
  - In cultivation, trellis is used.
  - Typical Field Setup:
    - Trellis 18’ high
    - Plant spacing at 3.5’ x 14’ or 7’ x 7’.
      - Result is 889 plants per acre
    - Anchored twine is used to support plant growth.
- The vine wraps clockwise around string.
  - Function of phototropism and thigmotropism (Light and Touch).
- Rapid growth: The hop plant will grow a foot or more a day under ideal conditions. 18-25’ in a season.

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”

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.*

Varietal Impact

- Physiology and development are impacted by variety.
- Crop management is varietal dependant.
- There is a strong genetic x environmental interaction.
- The goal: Realize the maximum genetic potential.
- The problem: Maximum genetic potential cannot be reached in all environments.

The solution: Breeding varieties to match the environment and meet the industry needs.

- Breeding objectives based on the needs of all stakeholders.
  - Objectives meant to provide brewers with hops/hop products which enhance their brews, while being agronomically efficient.
  - Performance of a variety at every level, from the farm to the brewery, adds to the overall health of the industry and our environment.

How important is this?

- Hop Supply Chain: Each link on the supply chain affects subsequent links.
  - The efficiency of a hop has a corresponding impact on the chain.

Breeding Program

New Variety:

-Good yield

-Disease resistant

-Good quality

-Stores well

Farm

Cost/Acre

Yield

COST/UNIT

Handler

Cost

Storage

Pellet Recoveries

Extract Recoveries

Shipping

Brewery

Efficiency

Quality

Flavor

Cost

Sustainable Agriculture

Economic Viability

-Pursue cost efficiency
-Add value

Environmental Stewardship

-Follow applicable environmental laws.
-Practice sound chemical and water management.
-Ensure a safe, quality product for the customers.

Hop Breeding Scheme

Population Dynamics

Developing Objectives

- The hop trade consists of two distinct markets:
  - Alpha/Bitter
    - Processed hops.
    - Yield measured in Kg. Alpha per acre.
    - Typically high alpha varieties, increasingly aroma.
  - Aroma
    - Minimal processing.
    - Yield measured in lb. acre.
    - Typically aroma varieties, some high alphas.
- This is an important consideration when setting objectives.

Specific Objectives

- High yielding high alpha cultivars.
  - Super
  - Varietal
- High yielding aroma cultivars.
  - Improvements on the classics
  - Specialty / dual purpose
  - Organic
- Goal is to combine the above with:
  - Pest and disease resistance.
  - Good storage stability.
  - Desirable brewing characteristics (i.e. low cohumulone, specific oil components).

Parental Selection

- Remember- Hops are dioecious.
  - Distinct male and female plants.
  - Obligate out-crossers, cannot self pollinate.
    - High level of diversity (heterozygosity).
    - Hybrid vigor (Heterosis).
    - Seed propagation not possible.
  - Easily clonally propagated- traits can be “fixed” in single generation.
    - Each new variety results from a single plant.
      - Millions from one.

Crossing

Left: Collection of male flowers for isolation of pollen.
Above: Application of pollen to a bagged receptive female.

From Crosses to seedlings

Typically start with 20,000 – 50,000 genotypes in any given year.

Seedlings are screened in the greenhouse for Powdery Mildew, then planted to the field.

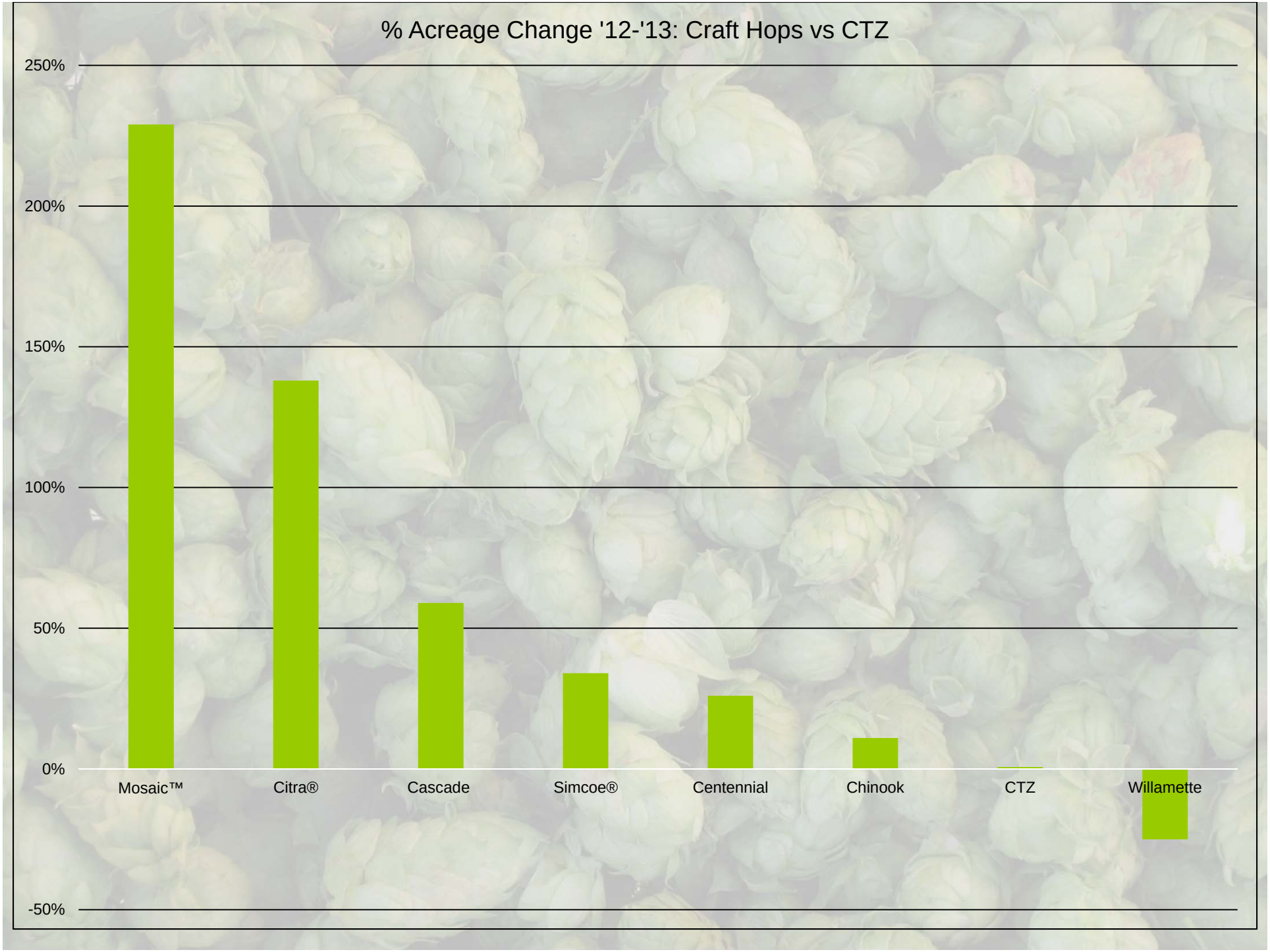
Typically eliminate 75 – 90% of the starting population.

Cultivar Release: Year 11

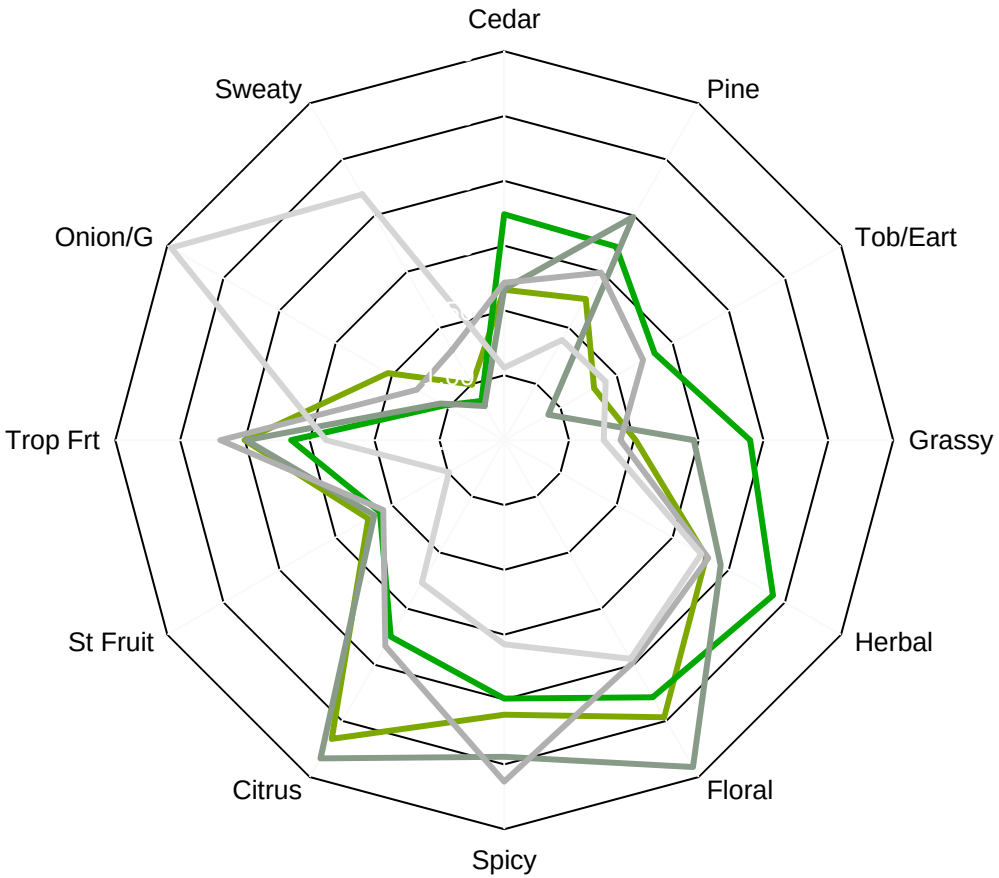
- After 8 - 10 years of evaluation, release is considered.
  - Private varieties: PVP begins.
- The work is far from over, success is dependant on:
  - Continued agronomic success.
  - Grower acceptance, usually short term.
  - Brewer acceptance, long term.

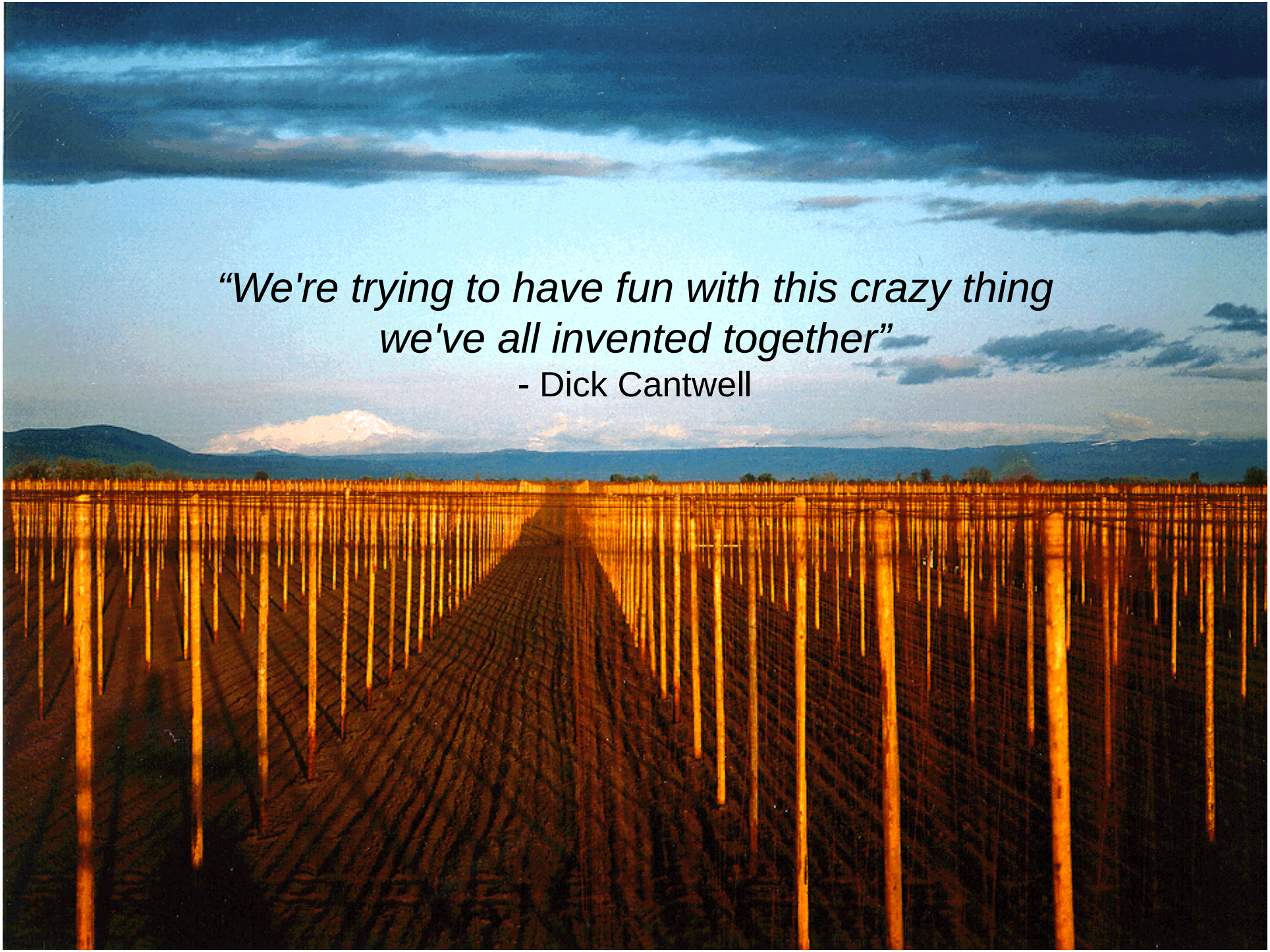
Future Trends in Hop Breeding

- Molecular research
  - Marker assisted selection
  - Gene mapping
  - Gene functionality
- Non-brewery usage
- Continuing conversion to new varieties
  - Driven by disease pressure, storage issues, basic economic pressures, and continued growth in craft brewing.
  - Increases focus on AROMA


% Acreage Change '12-'13: Craft Hops vs CTZ
250%
200%
150%
100%
50%
0%
-50%
Mosaic™
Citra®
Cascade
Simcoe®
Centennial
Chinook
CTZ
Willamette

Aromatic Variablity




“We're trying to have fun with this crazy thing we've all invented together”
- Dick Cantwell