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Securing Hop Quality Under Climate Change

KIRIN R&D DAY 2025

Institute for Future Beverages, Kirin Holdings Company, Limited

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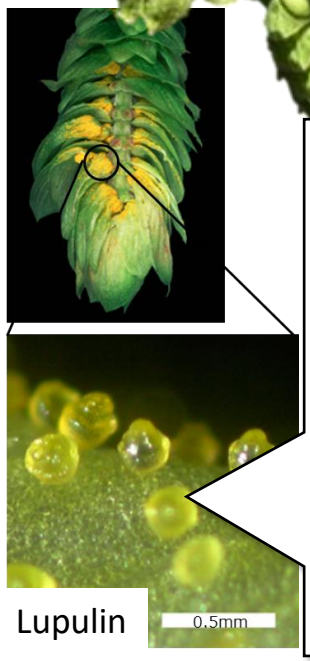
Hops are the soul of beer.

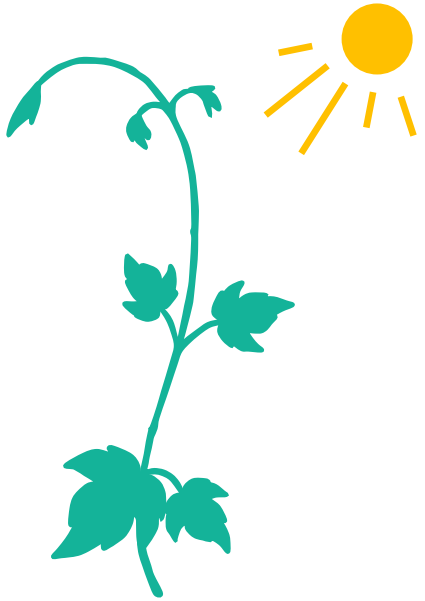
Hops play a central role in defining the aroma and flavor of beer.

1. Climate change is presenting challenges to hop quality and supply stability.
2. Rapid shifts in consumer preferences demand faster and more agile hop breeding.



Resins
- α-acid (humulones)
  - Key bittering components
- β-acid（lupulones）
  - Components that contribute to bitterness and stability upon oxidation

Essential oils
- Linalool
- Geraniol
- Myrcene
- Caryophyllene　etc…



1. Quality & Supply Stability:

Impact of Heat and Drought on Hop Yield and Quality

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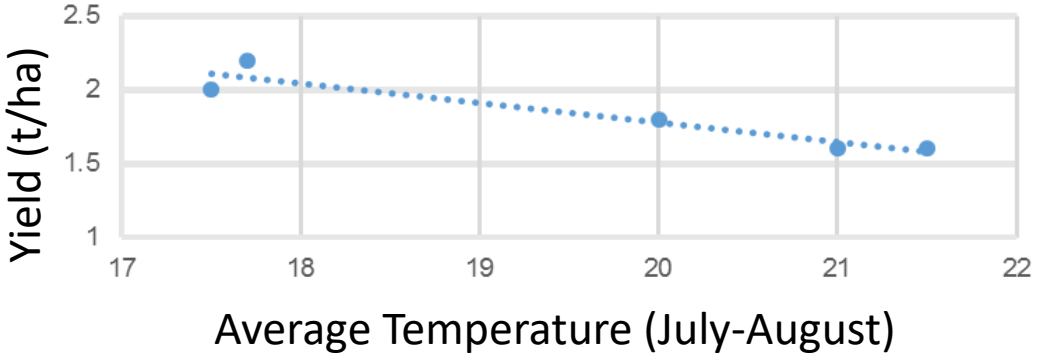
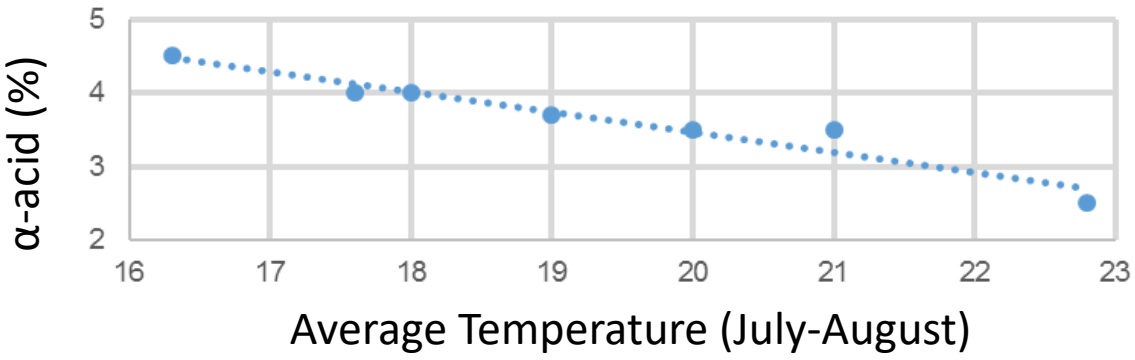
- Heat stress prior to harvest (June–August) reduces hop yield and lowers α-acid and aroma compound levels.
- These impacts are particularly pronounced in classical aroma and landrace varieties, such as Hersbrucker and Saaz.
- In 2022, average temperatures during June–August were ~1.5°C above normal, exceeding 19°C. In some regions and varieties, this resulted in ~20% yield losses and ~30% reductions in α-acid content, making 2022 an exceptionally poor harvest year.
- Model-based analyses integrating meteorological data with hop yield and quality projections indicate that, relative to the 1990s baseline, a temperature increase of about 1.4°C could by 2050 result in up to 20% lower yields and up to 30% lower α-acid content. (Martin *et al*, *Nat.commun.*, 2023)





Some of the hop varieties we rely on are particularly sensitive to heat and drought. Building a more climate-resilient supply system is therefore essential.

1. Quality & Supply Stability：

Impact of Declining Quality and Yield on Prices

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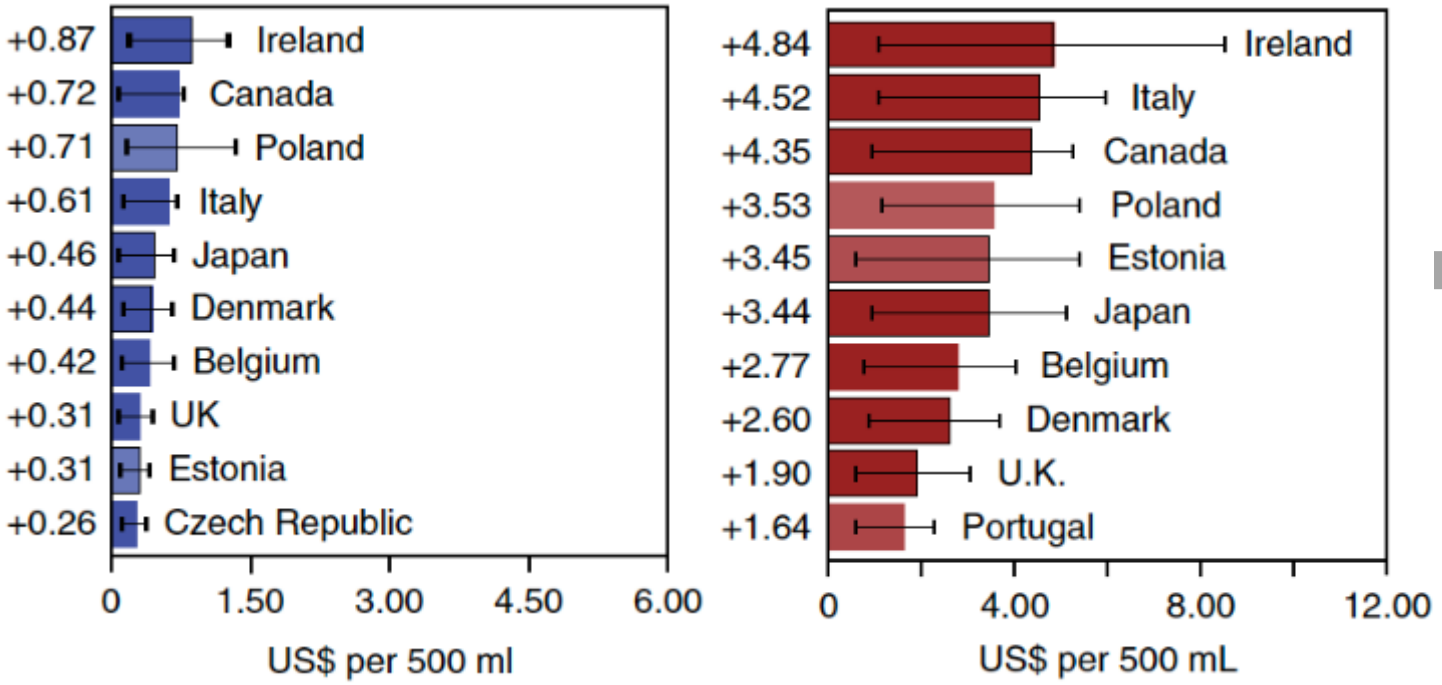
Projected Beer Price Impact from Climate-Driven Declines in Raw Material Yields



(Xie *et al*, *Nat Plant*, 2018)

Potential additional cost of approx.

¥2 billion per year

RCP: Representative Concentration Pathway
Climate scenarios that estimate future greenhouse gas emissions through the 21st century; higher values indicate higher emission levels.

Price increases in key hop varieties, such as Saaz and Hersbrucker, are directly driving higher costs and threatening business stability.

1. Quality & Supply Stability：

Conventional Approaches vs. Our Approach

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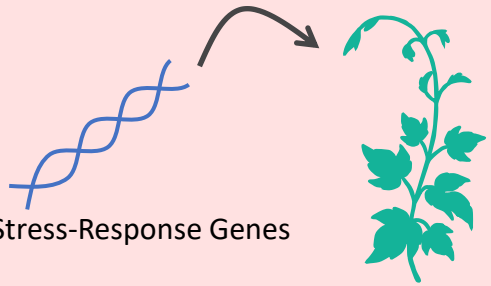
Genetic Modification & Genome Editing



Introduction of Stress-Response Genes

- Low efficiency of gene introduction in hops
- Limited market acceptance of genetically modified plants

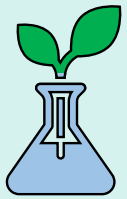
Conventional Breeding

Landrace Varieties × Stress-Tolerant Varieties

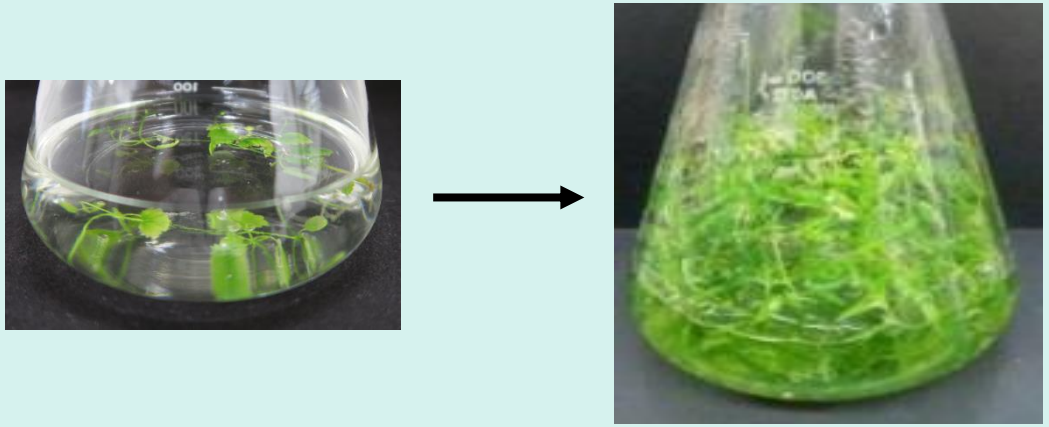
- Development takes a long time, typically 10–15 years.
- Challenges in retaining the original flavor of landrace varieties.

Heat Acclimation

Controlled mild-heat pre-treatment builds lasting heat tolerance in hop seedlings.



25°C (control 20°C) 6 weeks



- **Short development timeline**
- **Flavor preserved**
- **High market acceptability**

1. Quality & Supply Stability：

A Breakthrough Solution - Heat Acclimation

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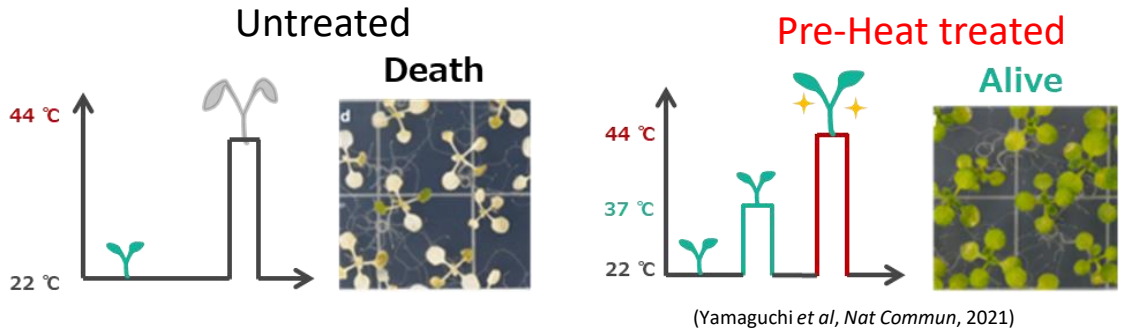
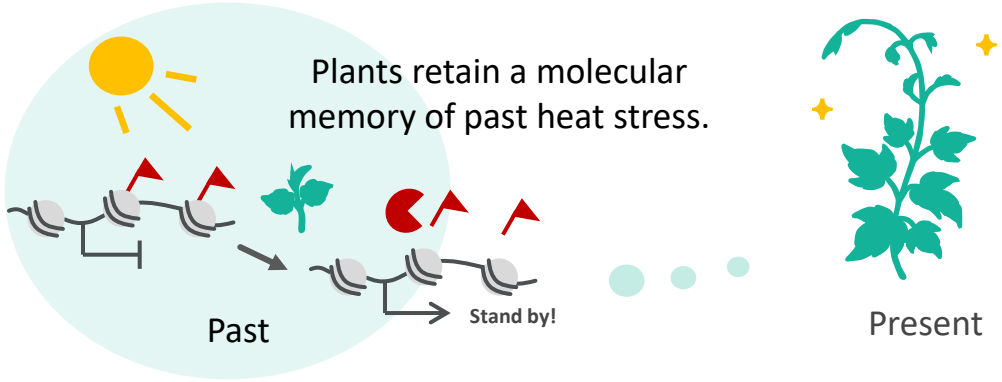
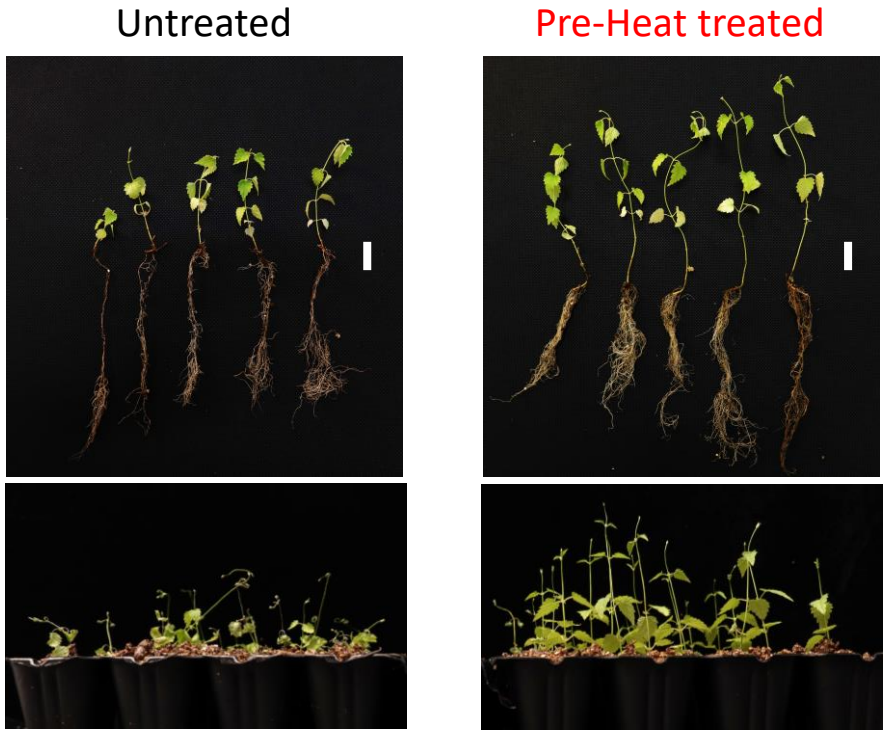
In model plants, mild heat pre-exposure enables survival under later heat stress (heat acclimation).



(Yamaguchi *et al*, *Nat Commun*, 2021)



Does the same mechanism apply to hops?



Pre-Heat treatment improved hops' tolerance to both heat and drought in lab tests.

We are evaluating whether these benefits can also be reproduced under field conditions.

1. Quality & Supply Stability：

Field Results of Heat Acclimation Treatment

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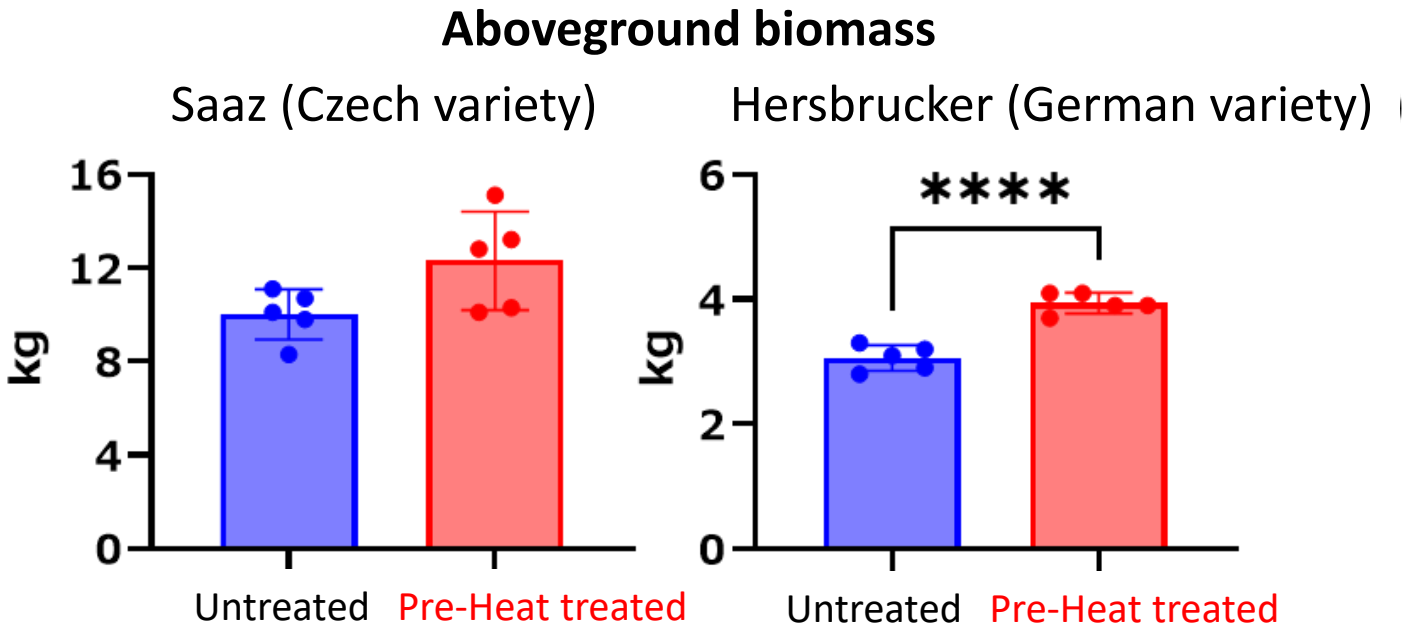
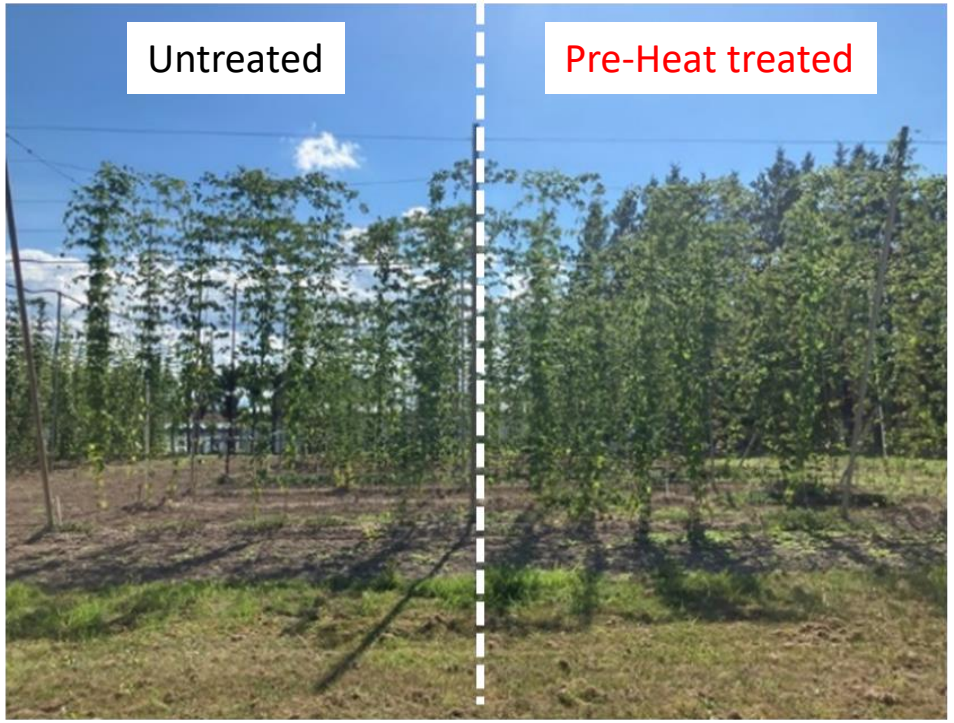
Are the effects reproducible in the field and sustainable over time?

Aboveground biomass





- **Heat acclimation reduced early-stage environmental stress in field trials.**
- **This helped maintain plant growth, indicating potential yield stability.**
- **The benefits were observed to persist for up to three years.**

Future Plan:

- Evaluate reproducibility in overseas field trials.
- Investigate application to other crops (joint research with FANCL).

FANCL

2. Accelerating Hop Breeding：

Rapidly Evolving Trends and Technical Challenges

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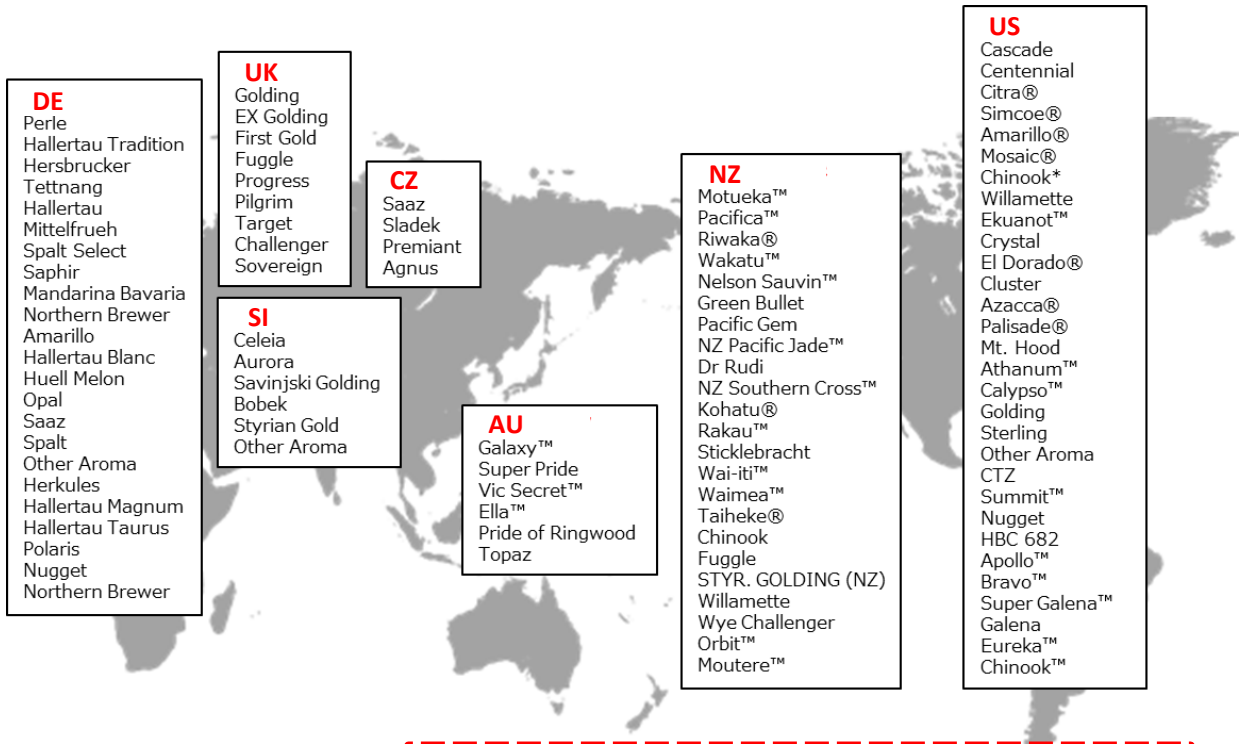
- Diversifying consumer preferences are driving demand for a wider range of hop varieties.
- Brewers are increasingly required to respond quickly to changing flavor trends.



There are already around 400 hop varieties available as of 2025.

Challenges in Hop Breeding

- Hop breeding is a slow and highly time-intensive process.
- Development is constrained by weather, pests, and seasonal variability.
- Breeding requires specialized expertise and large cultivation space.

Solution

- Indoor hop cultivation combined with proprietary plant technologies.
- A controlled, year-round breeding platform independent of external conditions.
- Enables faster development and more efficient selection of superior varieties.

2. Accelerating Hop Breeding：

Indoor Hop Cultivation

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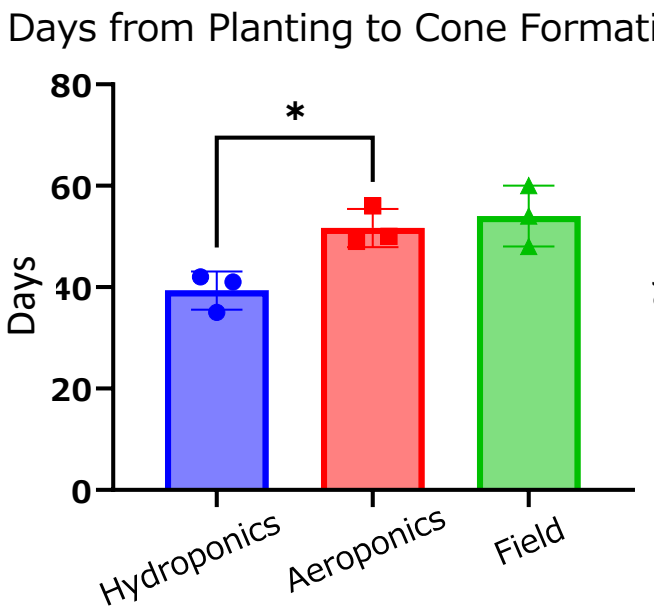
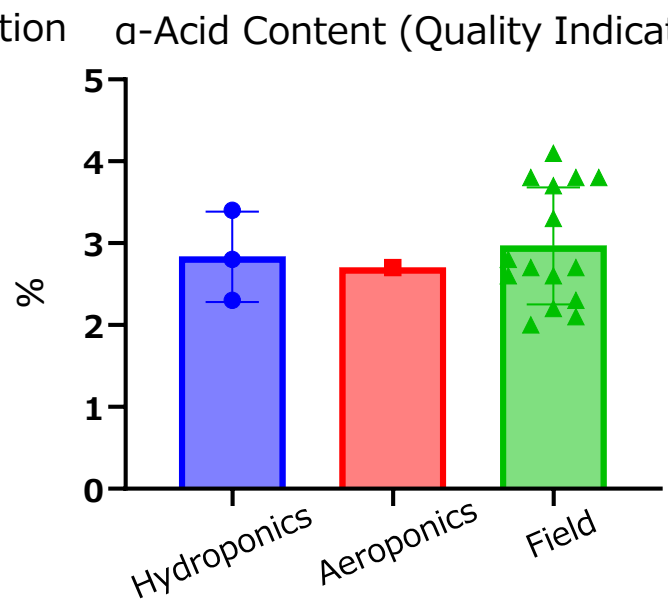
To speed up proprietary hop breeding and research on climate resilience, Kirin has launched a joint project with the startup CULTA to develop indoor hop cultivation technology.





- Indoor cultivation shortened the growing period by approximately one month compared with outdoor fields.
- Hops of comparable quality to field-grown hops can now be produced year-round, whereas outdoor cultivation is typically limited to a single harvest each summer.

This platform enables faster breeding cycles and accelerates research on climate change adaptation.

Summary

Protecting & Advancing the Soul of Beer

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Hops are fundamental to beer quality and a key driver of Kirin's long-term business value.

Quality and Supply Stability

Heat Acclimation

Protecting existing varieties to avoid cost increases

Accelerated Hop Breeding

Indoor Cultivation

Accelerating breeding research to create new value-adding varieties

Driving Business Growth Through Advanced Hop Cultivation—the Soul of Beer