# BERRY CROPS PERFORMANCE IN A CHANGING CLIMATE

Dr. Pauliina Palonen
Dept. of Agricultural Sciences
University of Helsinki
Finland

# MAJOR BERRY CROPS IN FINLAND

- Strawberry, 4000 ha
  - 75 ha in tunnels
- Black currant, 2000 ha
- Raspberry, 380 ha
  - 40 ha in tunnels
- Blueberry, 115 ha
  - 3 ha in tunnels

# Yrjölän marjatila, Hämeenkyrö

# Astikkalan marjatila

eem GreeNeem
Neem GreeNeem
eeNe



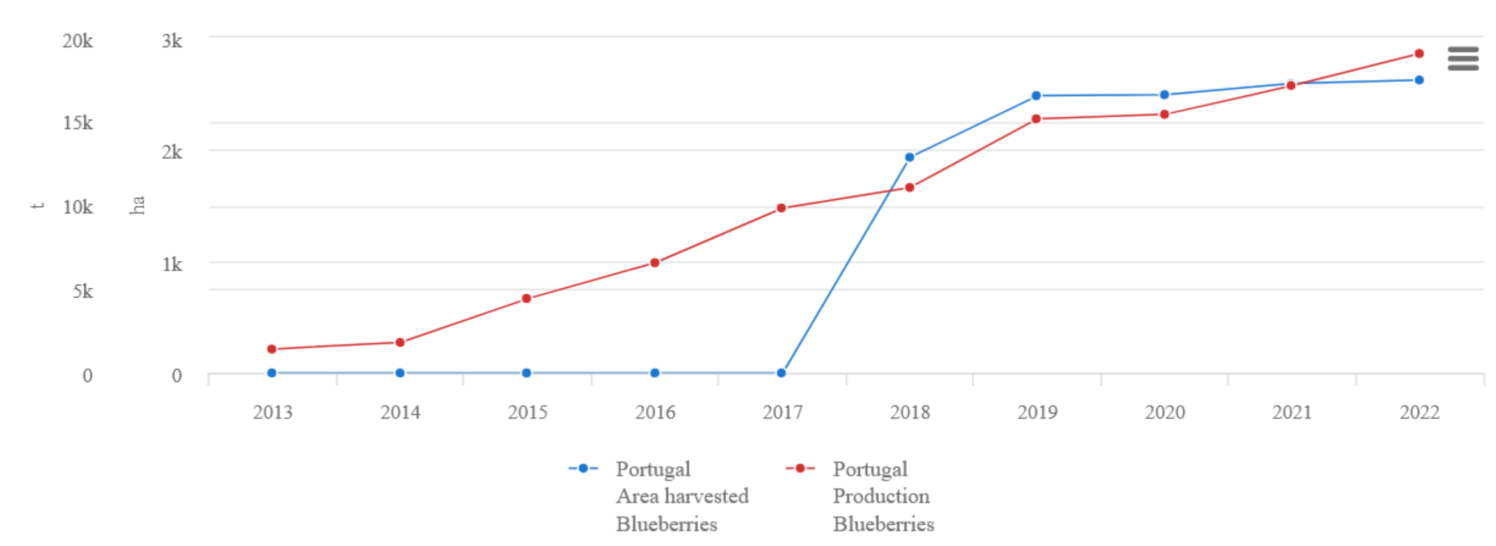


© vastavalo.net:678450 © vastavalo.net:678450

Joonas-harvester. www.rakennustempo.fi

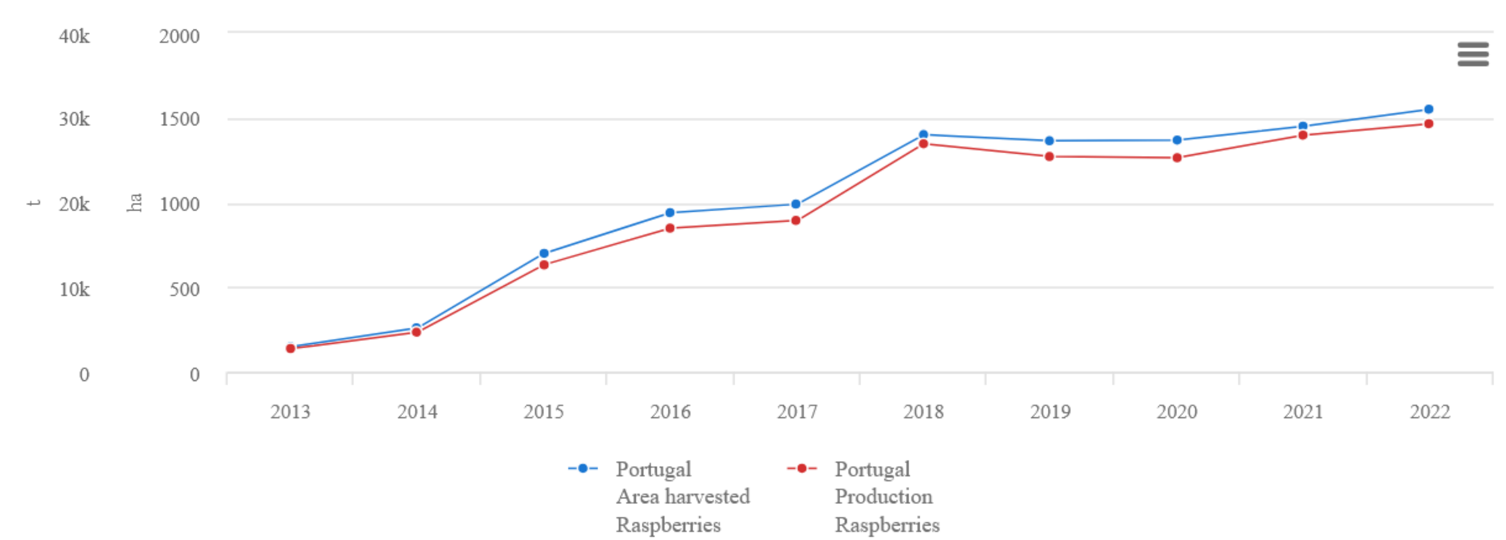
Production/Yield quantities of Blueberries in Portugal

2013 - 2022




Production/Yield quantities of Raspberries in Portugal

2013 - 2022

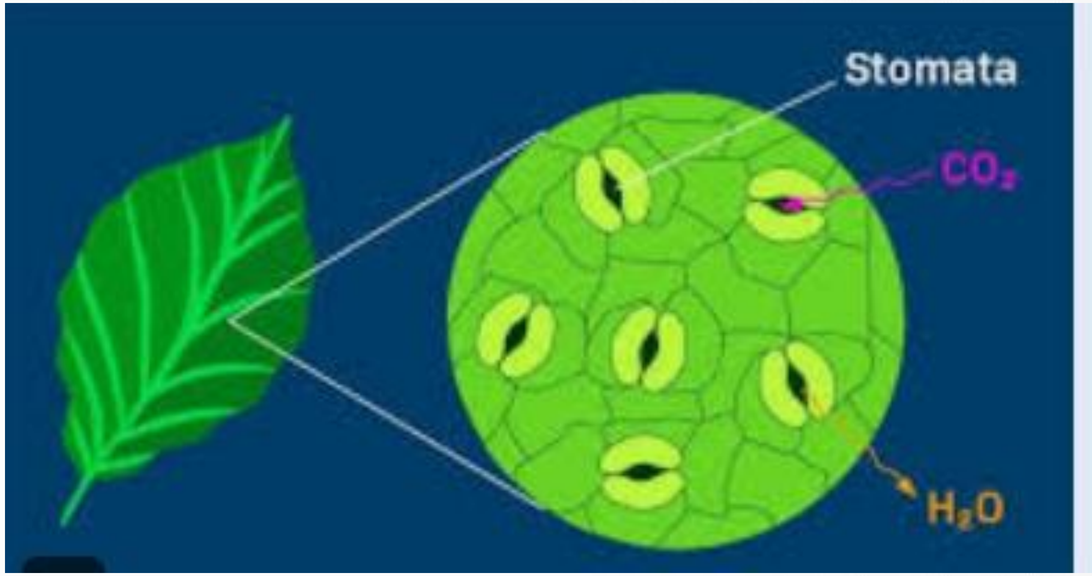


# UNDERSTANDING CLIMATE CHANGE

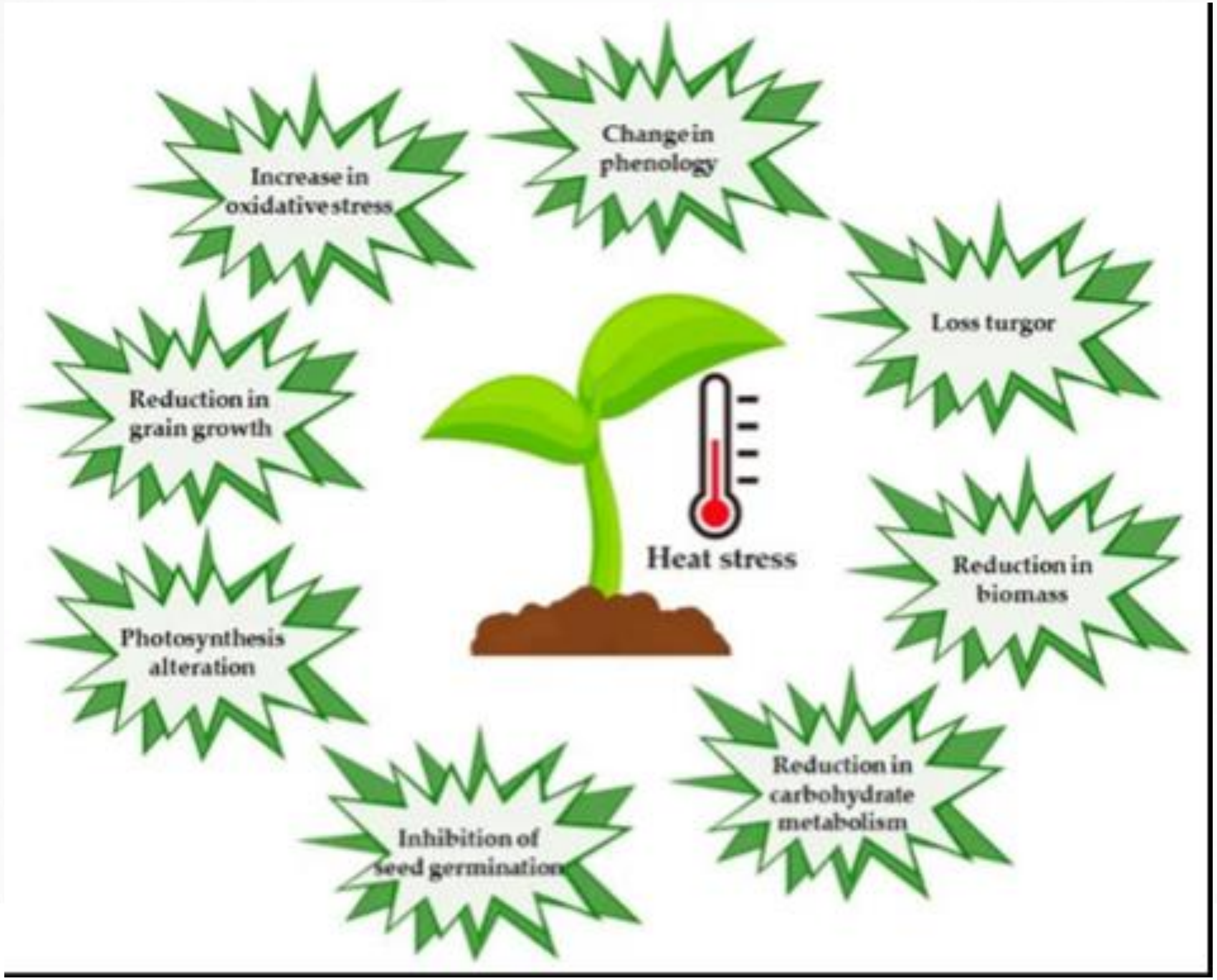
| Climatic element | Expected changes by 2050 | Impact |
|---|---|---|
| $CO_2$ | 360 ppm -> 450-600 ppm | Increased photosynthesis, reduced water use |
| Sea level rise | Rise by 10 to 15 cm | Coastal erosion, flooding, salinization of ground water |
| Temperature | Rise by few (?) degrees °C, winters warming more than summers, increased frequency of heatwaves | Faster and earlier growing seasons, crops moving north and to higher altitudes, heat stress, increased evapotranspiration |
| Precipitation | Seasonal changes | Drought, soil structure and workability, water logging, need for irrigation |
| Storms | Increased wind speed, more intense rainfall events | Soil erosion, damage to crops plants and cultivation structures |
| Extreme weather events | More frequently, unpredictable | |

# INCREASED $CO_2$

- More leaves or larger leaves
- Increased air $CO_2$ near the leaf balde -> decreased stomatal aperture, stomatal conductance and transpiration
- -> increased water use efficiency at leaf level
- Need to supply more water and fertilizers (N) because of increased growth and dry matter production



# IMPACT OF HIGH TEMPERATURE ON PLANT



# IMPACT OF RISING TEMPERATURES

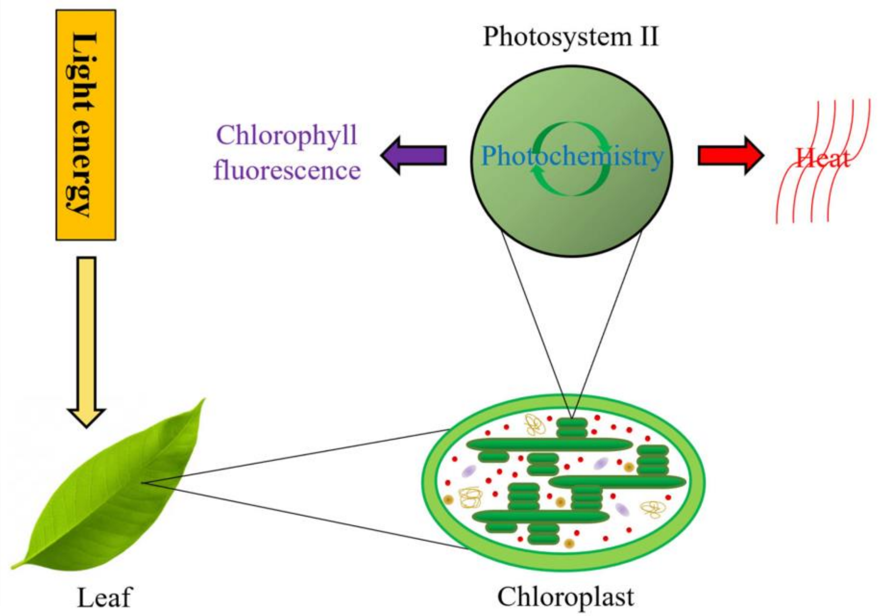
- Effects on berry crop phenology: flowering, fruiting, harvest times
- Although the accumulated heat sum increases, the crop may not be able to benefit from it, because the temperatures are supraoptimal
- The time for fruit formation is shorter -> impacts on fruit size?
- Most fruit ripen optimally at max. 35 °C
  - higher temperatures block the ripening process and suspend ethylene production in climacteric fruit
- Potential impacts on yield and quality

# IMPACT OF HIGH TEMPERATURE ON PLANT

At cellular level hgh temperatures disrupt the thermal stability of membranes and proteins

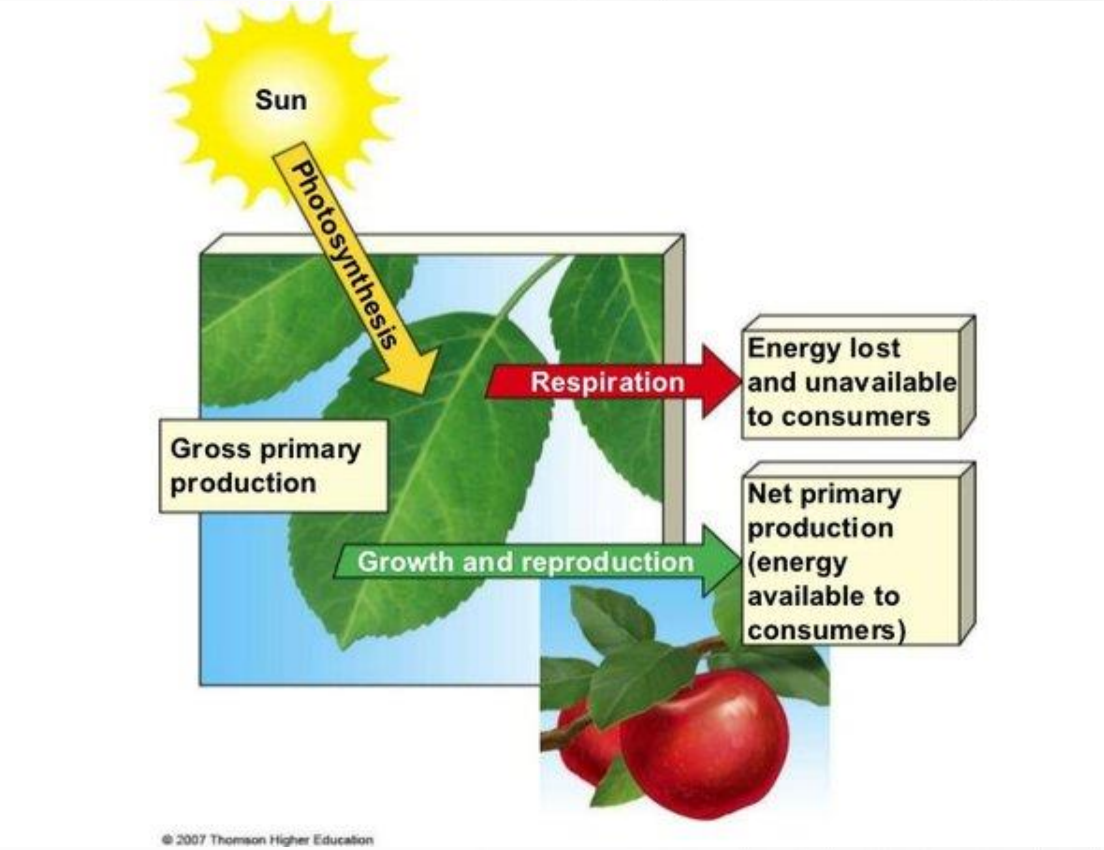
-> Ion leakage

-> Maximal quantum efficiency of photosystem II, Fv/Fm < 0.8 = stress!




# IMPACT ON FRUIT QUALITY

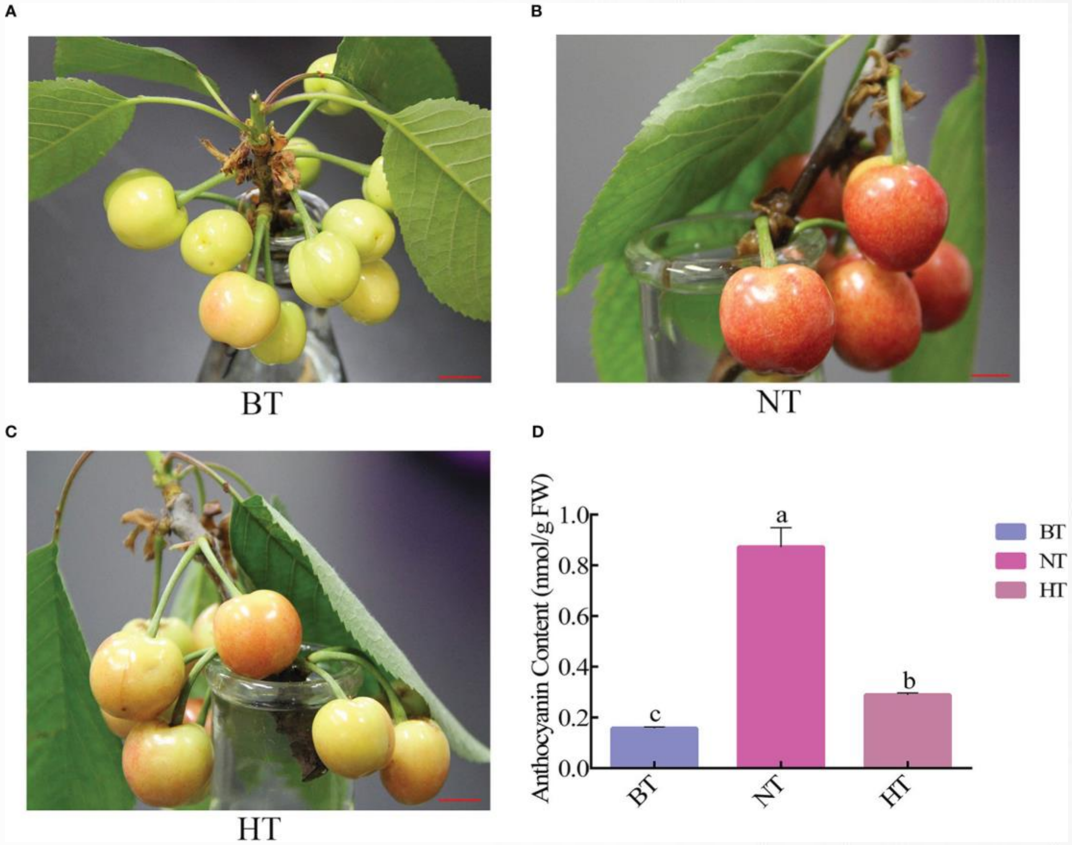
- Ratio of photosynthesis and respiration
  - At moderate temperature 15 °C ~ 10
- High night temperature -> increased maintenance respiration of fruit, degrading photoassimilates -> less dry matter and poor organoleptic quality
- Higher temperature combined with elevated $CO_2$
  - -> Decrease starch, sugars, proteins, and some minerals




https://www.mrgscience.com/uploads/2/0/7/9/20796234/main-qimg-26aec98be22a434b1123139be13ea433-lq_orig.jpeg

# IMPACT ON FRUIT QUALITY

- Cool nights favor anthocyanin production
- High temperature during fruit ripening may repress anthocyanin accumulation:
    - (B) normal temperature 14°C night / 24°C day.
    - (C) high temperature 24°C night / 34°C day




Tan et al. 2023. Frontiers in Plant Sci.
https://doi.org/10.3389/fpls.2023.1079292

# RASPBERRY AND BLACKBERRY

- Heat is the major challenge for expansion of production
- Photosynthesis optimal usually below 20 °C in raspberry
- Blackberry more adapted to heat than raspberry

- High temperature impacts floral initiation and development in peak summer months in primocane rasperry cultivars
- High temperatures during bloom may hinder bee pollination and / or pollen tube growth -> small crumbly fruit
- Heat during fruit development and ripening -> crumbly, dry, and less flavorful berries.

- Heat and drought -> browning of leaf edges, or entire leaves closest to the tip
- Water shortage hinders nutrient uptake -> nutrient deficiency symptoms

Photos: Mintenko, A. www.gov.mb.ca

# RASPBERRY AND BLACKBERRY

- Shading for a short period prior to fruit ripening
- UV-absorbing plastic or shade net

Fig. 3.2 White drupelet disorder in 'Apache' blackberry. (Photo Absalom Shank)

Fernandez et al. 2018

Damaged fruit with 'white drupelet disorder' in 'Heritage' raspberries during development.

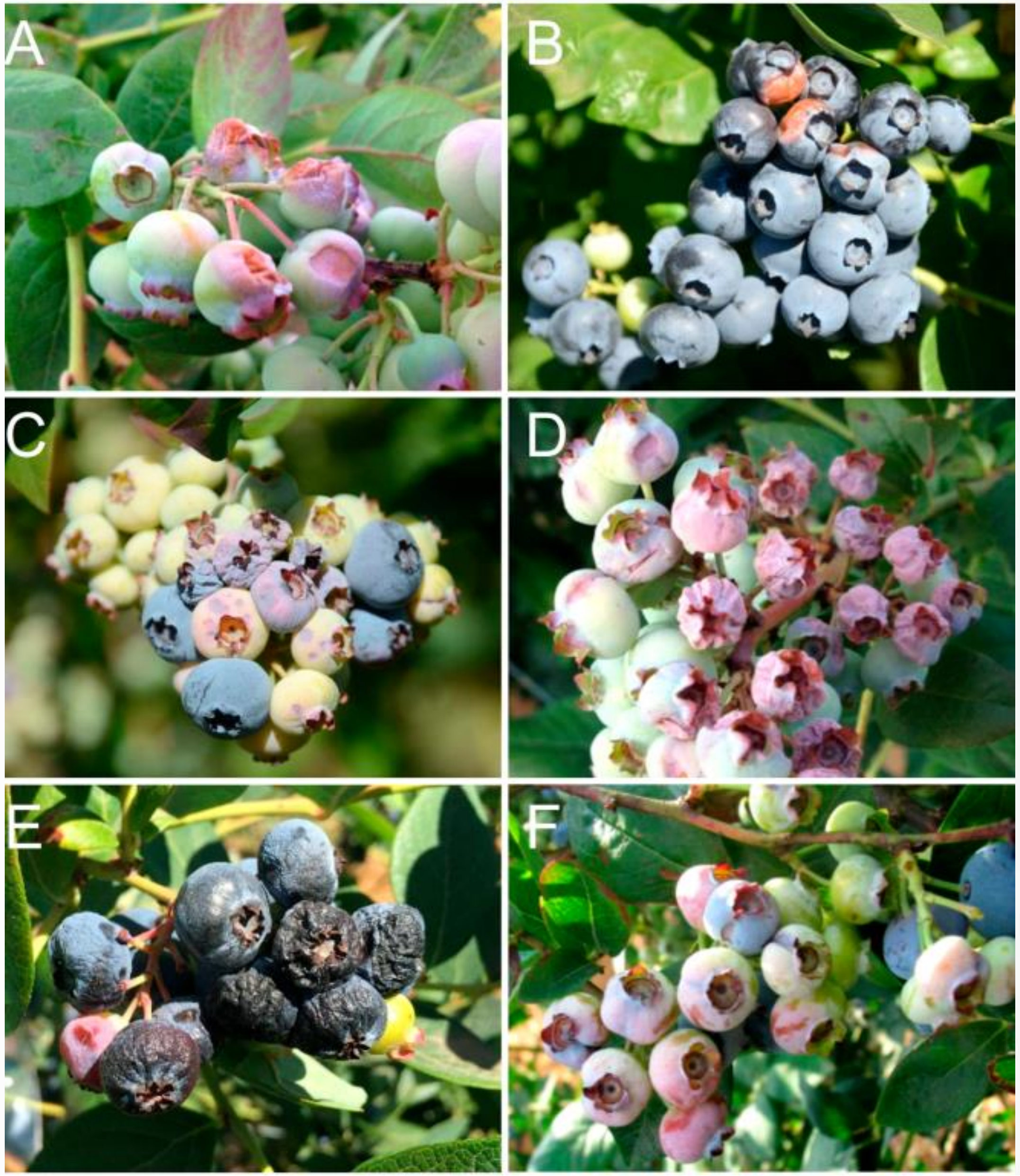
Contreras et al. 2024. Acta Hort. 1396

# RESPONSE OF BLUEBERRY CULTIVARS TO HEAT

- Optimal temperatures 20 to 25 °C
- SHB more tolerant to heat than NHB
- Optimal temperature for photosynthesis 18-26 °C for ’Jersey’, 14-22 °C for ’Bluecrop’ (Moon et al. 1987)
- 30 °C temperature reduced photosynthesis of NHB cultivars by 22-51 % (Hancock et al. 1992)
  - ’Jersey’, ’Elliott’, and ’Rubel’ suffered less than ’Spartan’, ’Bluejay’, and ’Patriot’
- ’Ozarkblue’ and ’Jubilee’ perform well in in hot summers (Trehane, 2004)
- Temperature up to 40-45 °C -> photosynthetic system damaged in ’Brigitta’, but was OK in ’Sharpblue’ and ’Duke’ (Chen et al. 2012)

# HEAT AND BLUEBERRY

- Sun-exposed berries
  - May be 11 to 12 °C warmer than air
- More in the upper portions of canopy
- Symptoms of heat damage in northern highbush blueberry:
  - (A, B) necrosis,
  - (C) spotting,
  - (D, E) shriveling or wrinkling,
  - (F) poor coloration and smaller berries.
- Shorter storage life
  - Above 32 °C during maturation -> soft fruit and wax susceptible to loss

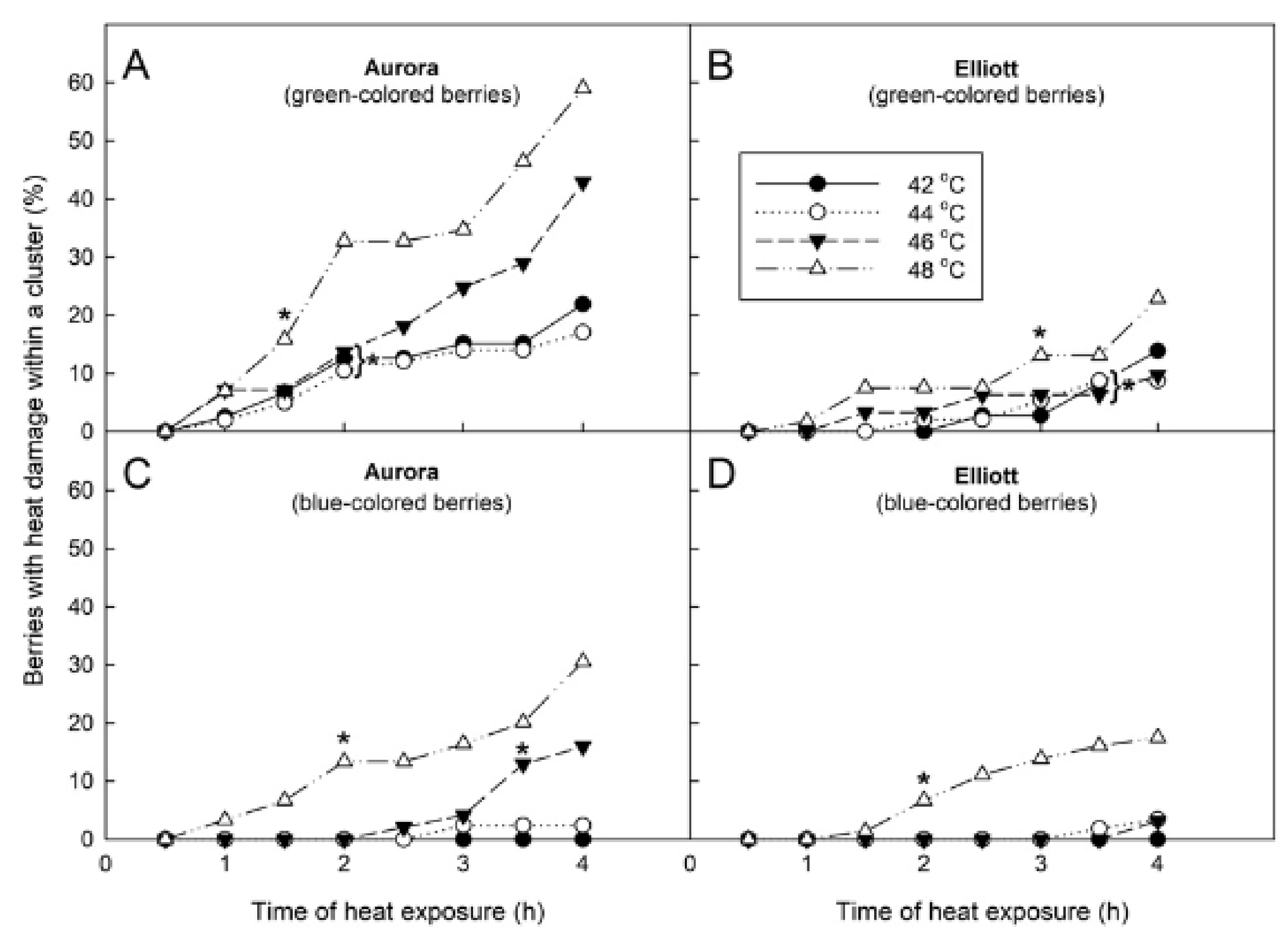



Yang et al. 2029. HortScience 54. Photo by Davib Bryla

# RESPONSE OF BLUEBERRY CULTIVARS TO HEAT

- Green stage more susceptible than blue stage
  - Damage appeared within 2 to 3.5 h at 42 to 46 °C

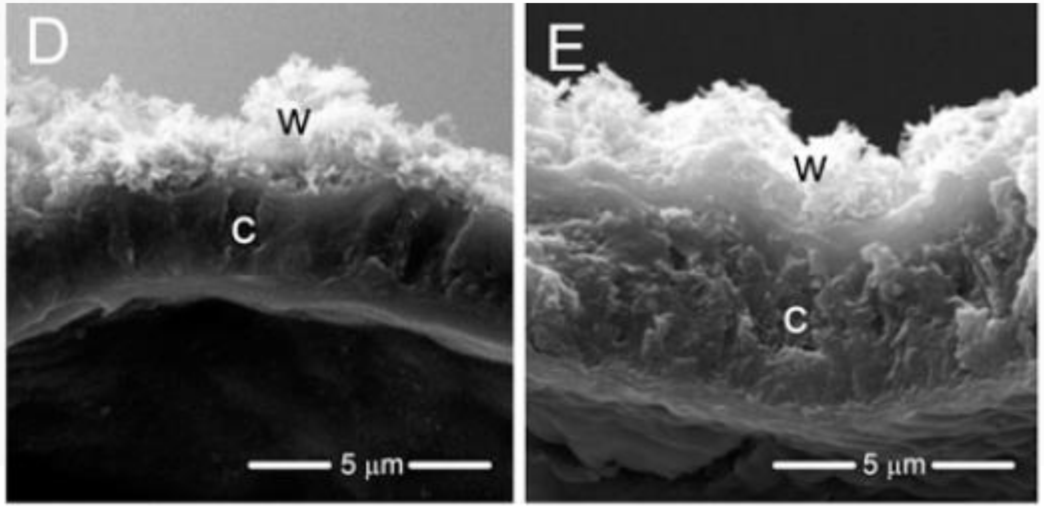
- Blueberry fields should be cooled at > 32 °C during green fruit stages and > 35 °C during fruit ripening

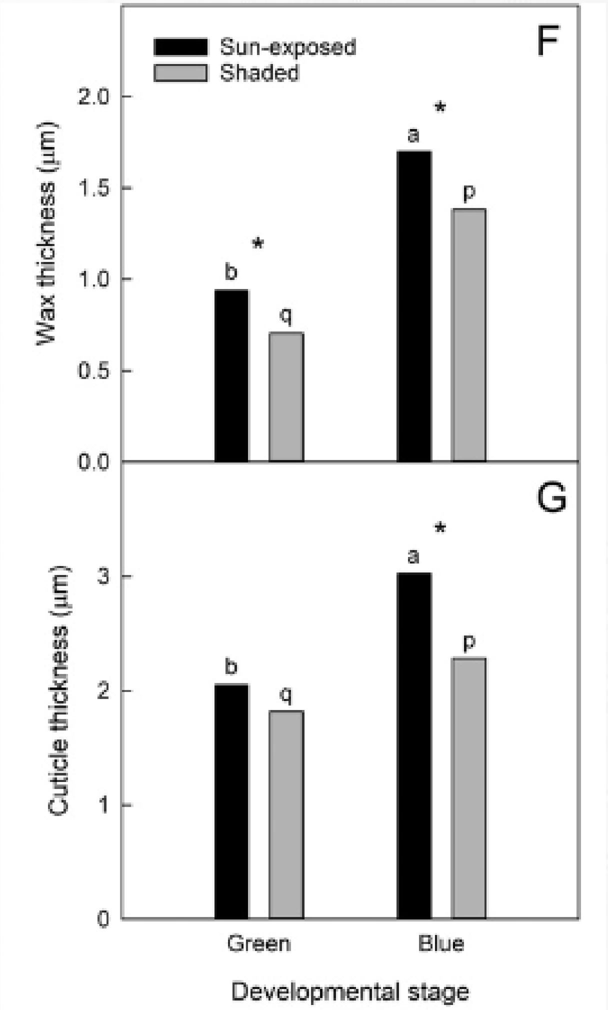



Yang et al. 2029. HortScience 54.

# RESPONSE OF BLUEBERRY TO HEAT

- Berry damage due to wax layer melting on berry surface
- Wax and cuticle layers thicker on sun-exposed berries
    - Cultivars with thicker wax layer more resistant?
    - Breeding, management practices?




Yang et al. 2029. HortScience 54.

# HOW TO COPE WITH HEAT?

- Over-canopy sprinkler system
- Using tunnel plastic that lowers temperature
- Shade structures
  - Use shade cloth or other structures to protect plants from extreme heat and sun exposure.
- Reflective mulch materials that can help reduce soil temperatures around the plants?
- Seasonal adjustment
  - Modify planting and harvesting times to align with new climate patterns.

# KAOLIN CLAY TO PROTECT FROM SUNBURN AND HIGH TEMPERATURES


Roussos, 2024.
https://doi.org/10.3390/encyclopedia4010036

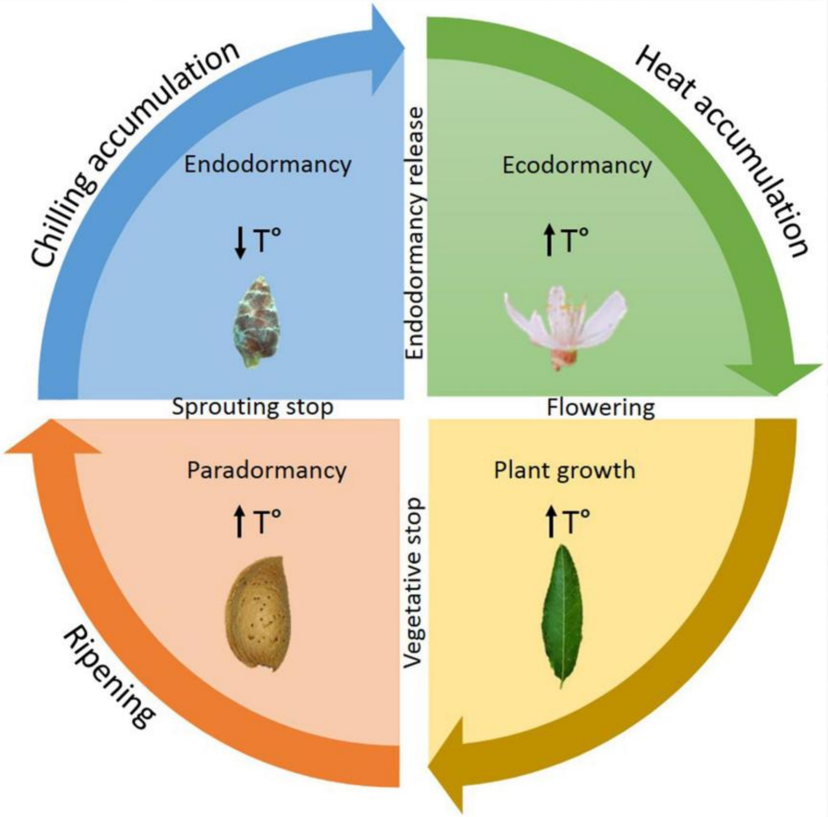
https://www.phillyorchards.org/2015/05/04/kaolin-clay-sprays-for-fruit-trees/

# INCREASING TEMPERATURE AND DORMANCY

- The ability to tolerate fluctuating winter temperatures.
- Raspberry has adapted by having high chilling requirements
- Blueberry cultivars very diverse in chilling requirement
- Inadequate chilling -> poor and prolonged flowering period -> decreased yield

Adaptation to low chill environment:

- Cultivar selection (breeding)
- Dormancy avoidance (defoliation)
- Manipulation of microclimate, cooling
  - irrigation, water sprinkling, colored shade nets
- Chemicals
  - hydrogene cyanamide, e.g. Hi-Cane, Dormex®, Erger®, Syncron®, mineral oil




Guillamón et al. 2022. Frontiers in Plant Sci. https://doi.org/10.3389/fpls.2021.812621

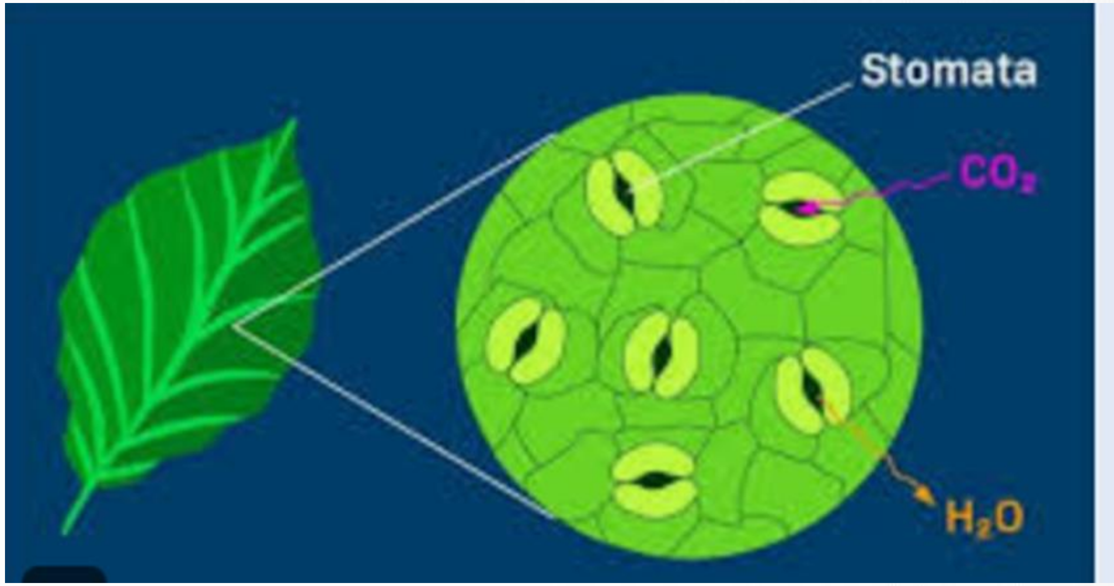
# ALTERED PRECIPITATION PATTERNS

- Changes in rainfall distribution and intensity
- Implications for irrigation and water management
- Risks of drought and excessive rainfall -> fruit cracking
  - In blueberry mainly because of absorbed water through the skin, but also via root system uptake, although less

https://msfruitextension.wordpress.com/wp-content/uploads/2015/06/watersplitberry2015.jpg

# ALTERED PRECIPITATION PATTERNS

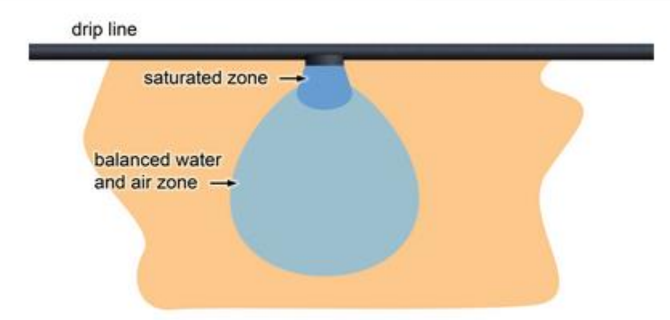
- Water deficit -> stomatal closure -> plants stops growing
- Water is extremely important during fruit growth
    - Water deficit -> decreased fruit size



# WATER MANAGEMENT

- Efficient irrigation practices and water conservation methods
- Recycling of irrigation water
- Rainwater harvesting
- Regulated deficit irrigation methods for berry crops?
  - Irrigation reduce at selected phenological stages to control vegetative growth without compromising fruit yield

- Biostimulants

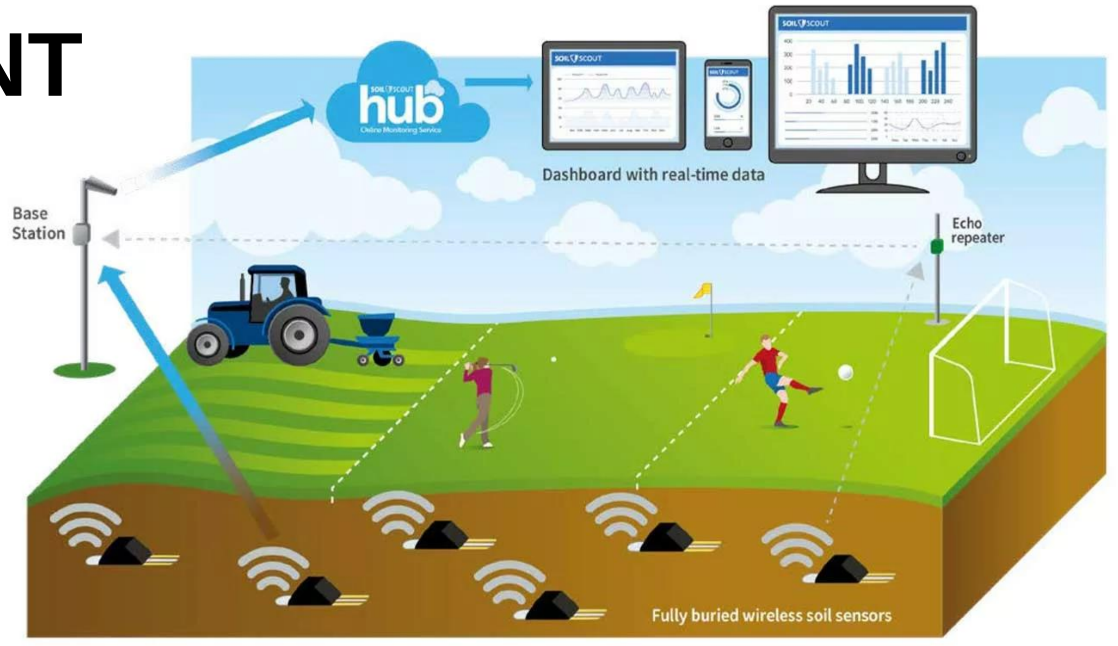



Maxijet microsprinklers for blueberry

# WATER MANAGEMENT

- Soil moisture sensors to monitor and manage water usage more effectively.

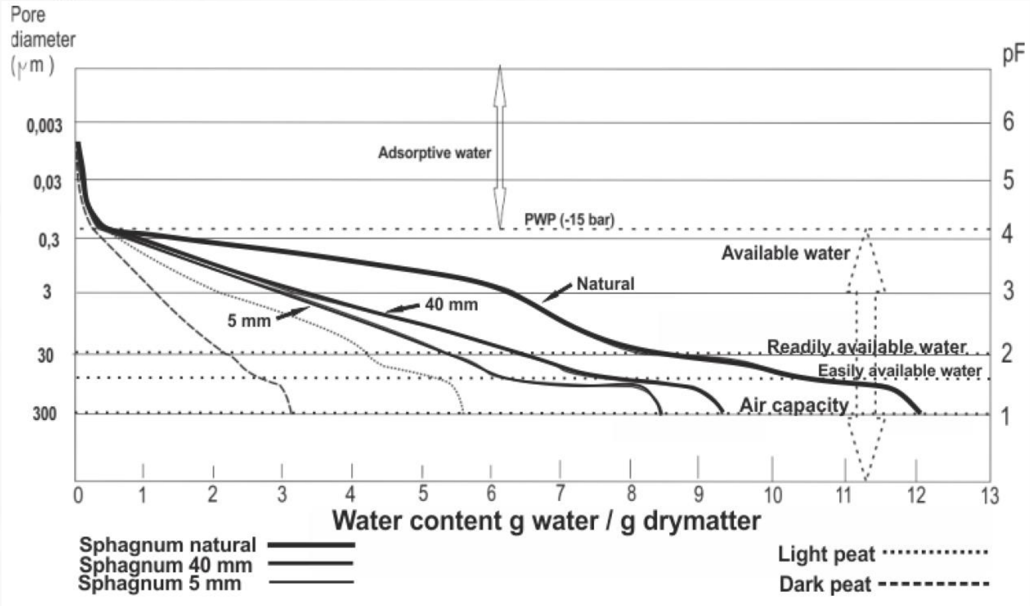
- Windbreaks: to protect plants from strong winds, which can cause physical damage and increase evaporation.




SOIL SCOUT

# WATER MANAGEMENT

- Choice of substrate to increase water retention
  - E.g. *Sphagnum* moss has a greater water retention capacity than peat

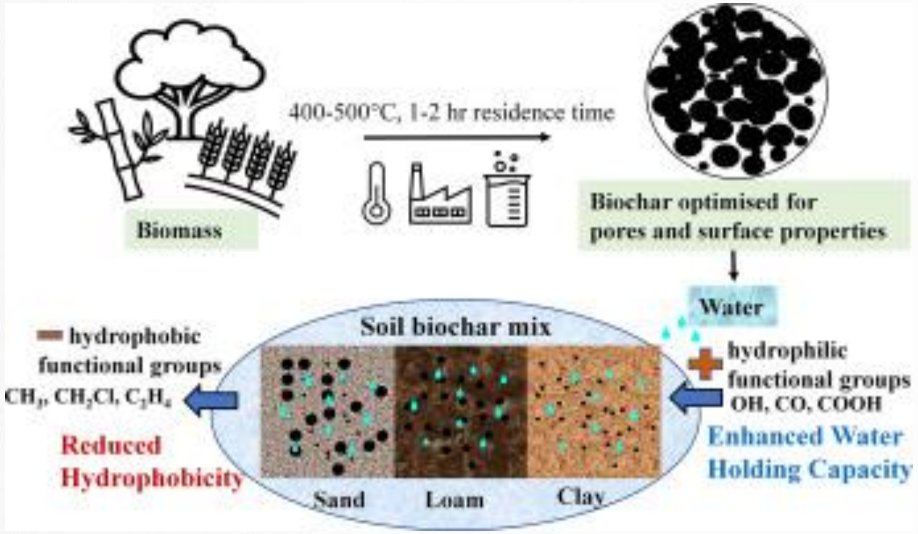



Kämäräinen et al. 2018. Mires and Peat

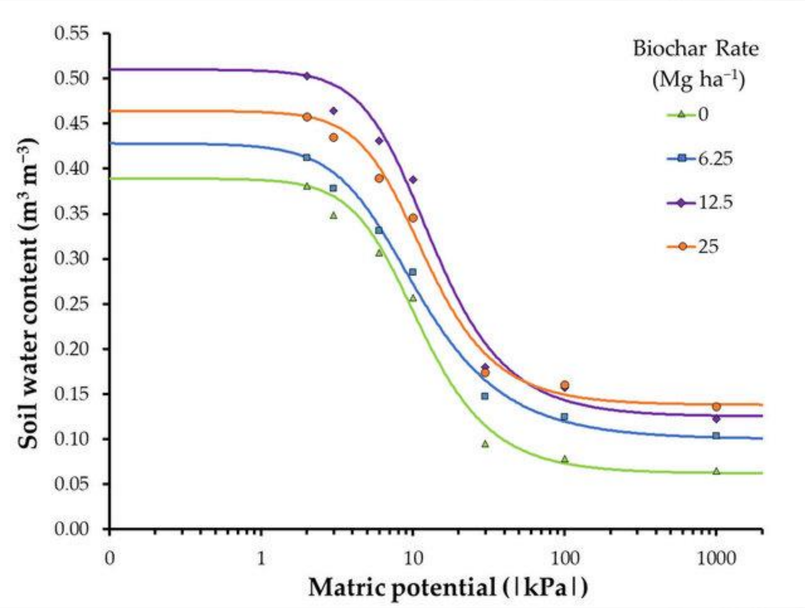

Puutarha&Kauppa 2016

# WATER MANAGEMENT

- Importance of soil health: structure, fertility, organic matter
- Techniques for improving soil moisture retention
  - Mulching
  - Biochar




Adhikari et al. 2022.
https://doi.org/10.1016/j.scitotenv.2022.158043




Carvalho et al. 2020. Agriculture

# INCREASED EXTREME WEATHER EVENTS

- Frequency of heatwaves, storms, and frosts
- Direct and indirect effects on berry crops
- Mitigation strategies and resilience building
- Staggered planting
  - Plant in stages to spread out the risk of adverse weather conditions affecting the entire crop.

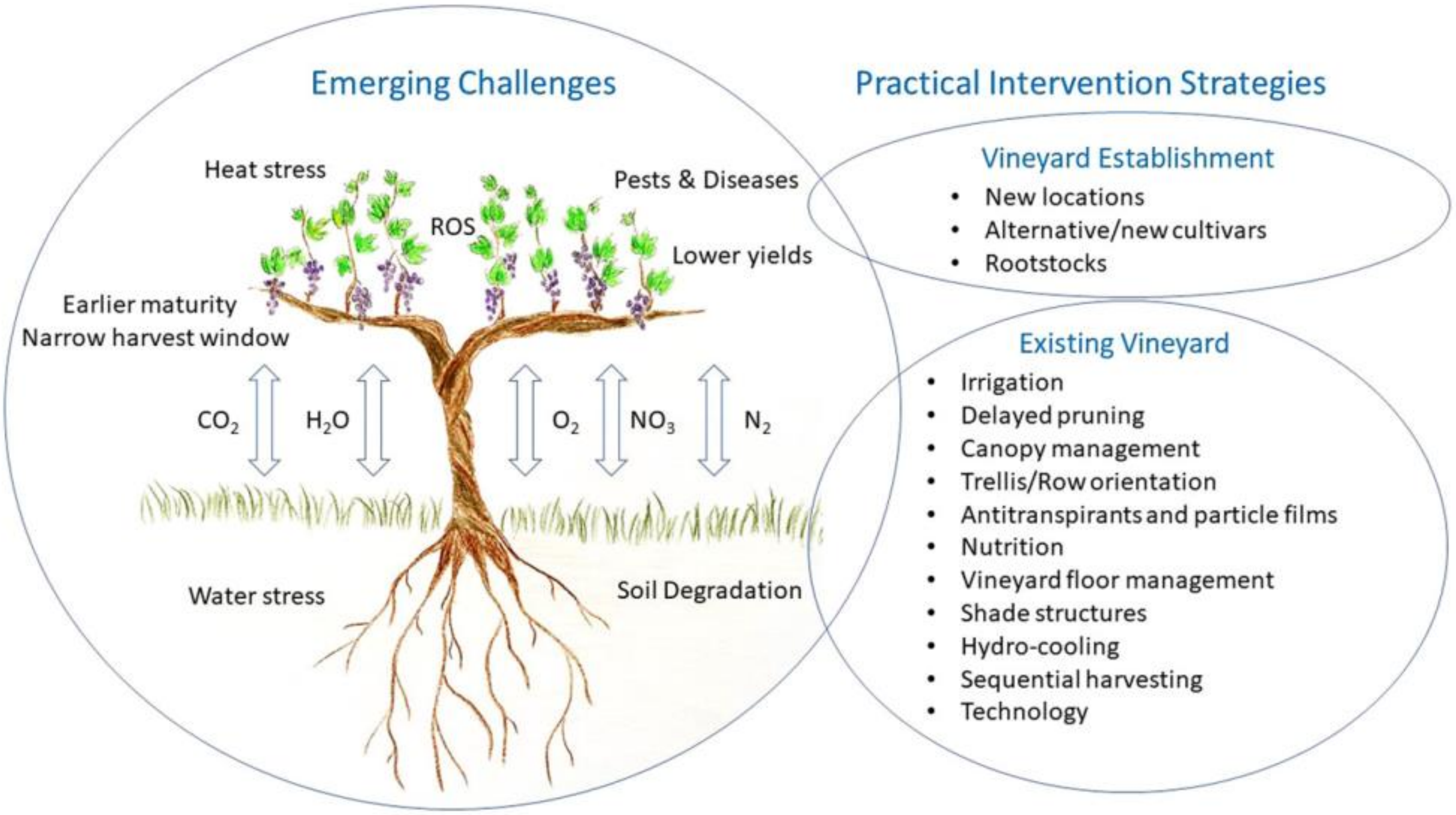
https://www.researchgate.net/publication/336197580_High_Tunnel_Production_Guide_for_Raspberries_and_Blackberries

# MANAGING PEST AND DISEASE PRESSURE

- Climate change effects on pest and disease dynamics
  - New pests introduced
  - Faster reproduction of current pests
- Integrated pest management (IPM) strategies
  - Choice of chemicals for plant protection decreasing
  - Resistance issues with current chemicals
  - Have to combine biological + mechanical + chemical plant protection strategies

# DEVELOPING RESILIENT VARIETIES

- Breeding for climate resilience: drought, heat, pest resistance
  - Role of biotechnology, traditional and new breeding methods
- Public breeding programs?




Rogiers et al. 2022. Front. Plant Sci. https://doi.org/10.3389/fpls.2022.1094633

# WHAT TO DO?

1. Select climate-resilient varieties
- temperature fluctuations, drought, and disease.

2. Optimize irrigation practices
- Drip irrigation
- Soil moisture sensors
- Rainwater harvesting

3. Enhance soil health
- Organic matter
- Cover crops
- Mulching

4. Implement shade structures and windbreaks

5. Integrated Pest Management (IPM)

6. Adjust planting and harvesting schedules
- Seasonal adjustment
- Staggered planting

7. Protect against frost and other extremes

8. Diversify crops to spread risk and increase resilience.

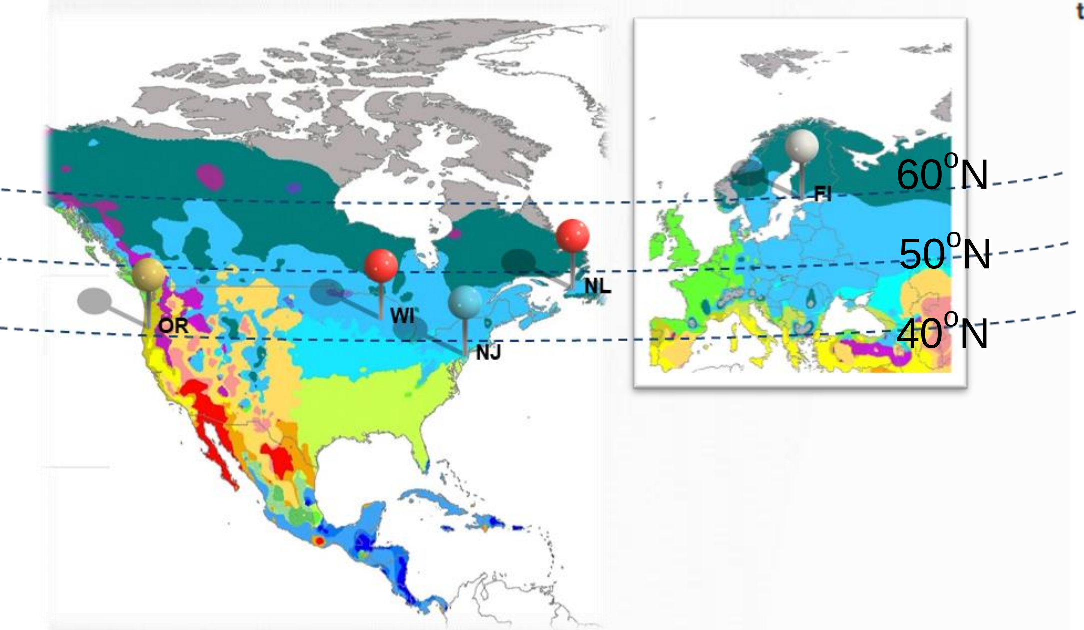
9. Monitor and adapt
- Climate data: Stay informed about local climate trends and projections.
- Adaptation plans: Be prepared to adapt management practices based on new information

# *VACCINIUM MACROCARPON* IN USA

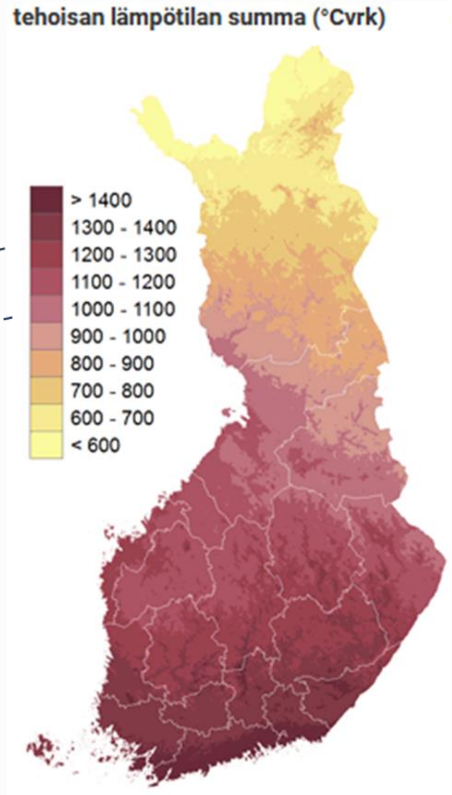
Michigan 22. May, 2017

https://upload.wikimedia.org/wikipedia/commons/thumb/b/b4/Cranberrys_beim_Ernten.jpeg/250px-Cranberrys_beim_Ernten.jpeg

# *VACCINIUM MACROCARPON* IN FINLAND?




Peel ym. 2007 Hydrol. Earth Syst. Sci.



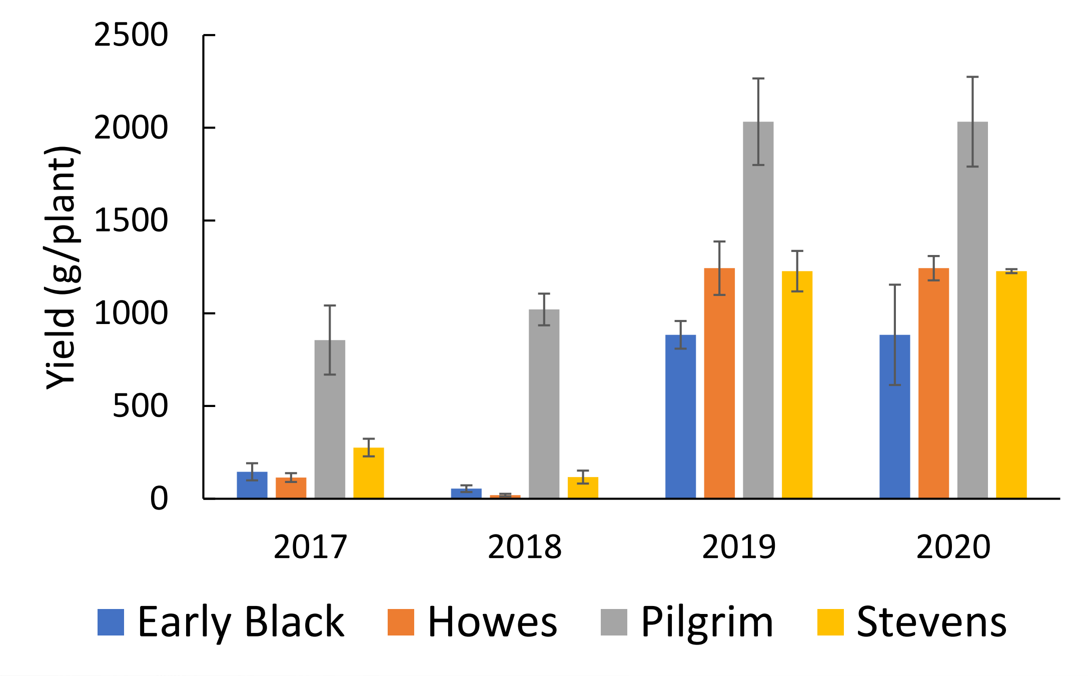

- Growing season extended by 15 days in the last 50 years (Irannezhad & Kløve 2015) and
- The effective heat sum increased by 150 GDD since the 1950's (Spinoni et al. 2015)
- High tunnel berry production has become a major practice

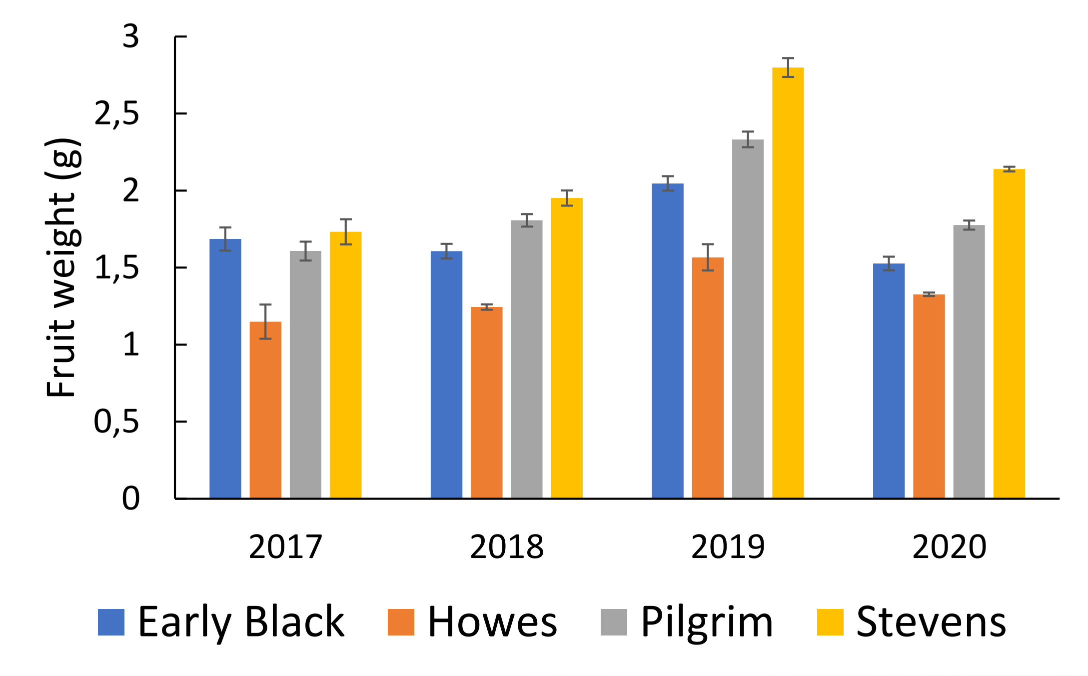
# High tunnel soilless table-top production of cranberry in the Northern conditions

- Is it (economically) feasible at 60 °N? Or even at 70 °C?
- How do the Northern light conditions (photoperiod, spectrum) affect growth, cropping and berry quality of cranberry?
- Do the North American cultivars possess adequate winter hardiness for our conditions? Especially their roots?

# Cranberry yield in a high tunnel

- Forest nursery peat, slow release fertilizer, drip irrigation
- No major pests or diseases
- Excellent shelf life of tunnel grown cranberries; > 6 months at +3 °C



# FIELD DAY IN VIIKKI 7.10.2022

# Pruning practices of cranberry in substrate culture
M.Sc. Leila Karami

- Timing of pruning
- Severity of pruning
  - ➢ Vegetative growth, yield, berry quality

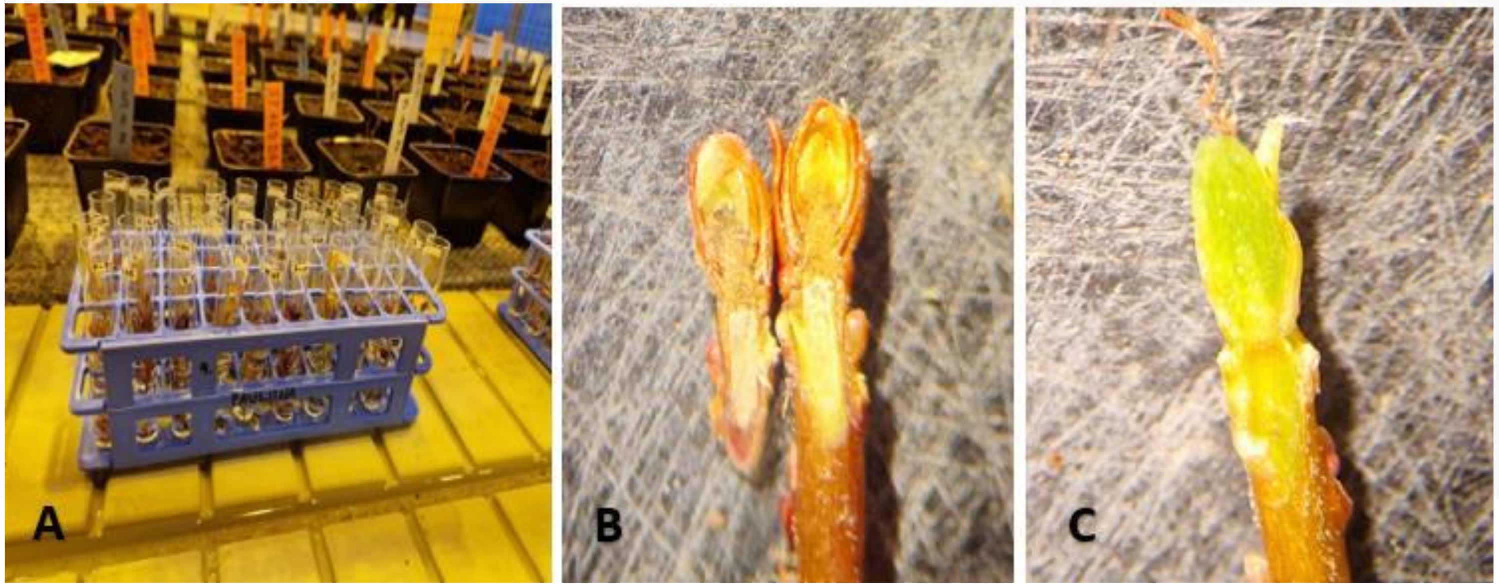
- Fruit thinning in individual uprights
  - ➢ Berry quality (size, °Brix, color, anthocyanins)
  - ➢ Allocation of dry matter, return bloom

# Fertilization of cranberry in substrate culture M.Sc. Jonna Pärssinen

- What is the nutrient demand of cranberry in substrate culture?
- The effect of biochar supplement in substrate on nutrient demand, yield and berry quality?
- The possibility of using *Sphagnum* moss as a substrate for cranberry as a replacement for peat?
- The effect of substrate and fertilization on winter hardiness of cranberry?

- Sphagnum moss, forest nursery peat
- Biochar, biochar + urea
- Slow release fertilizer, different levels

# Frost hardiness of cranberry cultivars



# Future

- Farm trials initiated in 2024
- Cost analysis, profitability calculation
- Picking?
- Novel cranberry products?
- Marketing?