



Strategies to Increase Calcium in Caneberry and Blueberry

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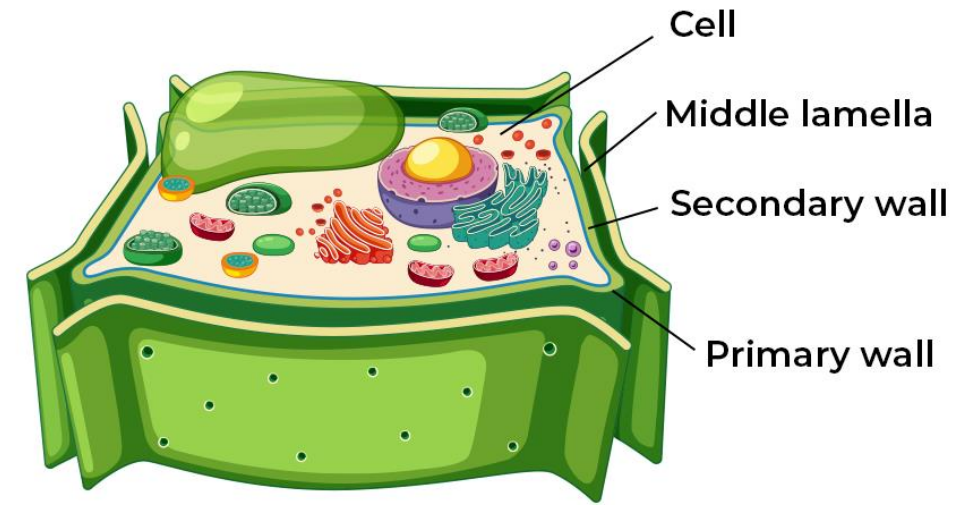
The Basics...



Calcium (Ca) - An Essential Nutrient

- Important for cell wall strength and membrane stability
- Associated with improved fruit quality (firmness), storability, and plant health
- Temporary deficiencies more common in low-transpiring organs (fruits)
- Nutrient antagonism can also reduce calcium uptake (e.g., Mg and K)

Calcium links pectins in middle lamella and influences cell wall rigidity

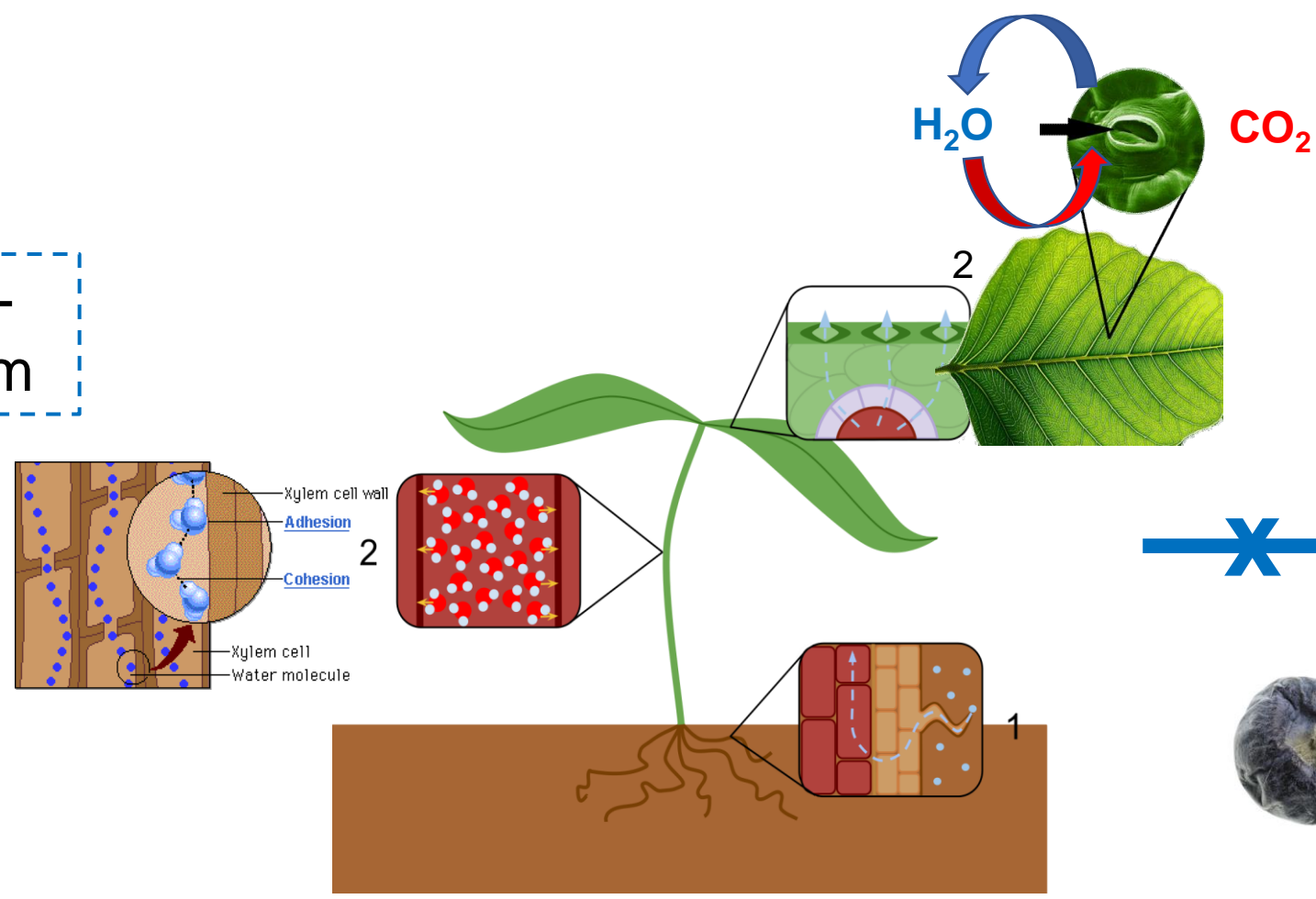




Mass Flow is Most Important for Uptake

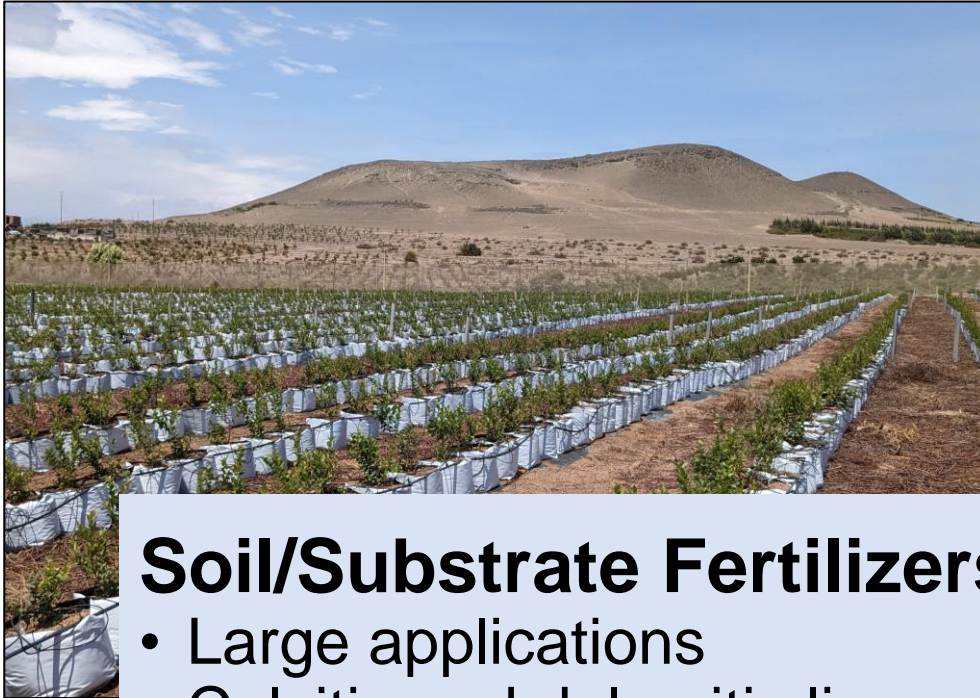
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$H_2O +$
calcium





Soil/Substrate versus Foliar Fertilizers



Soil/Substrate Fertilizers

- Large applications
- Calcitic and dolomitic lime, gypsum, CAN, CN, CTS, chelated forms, etc.
- In substrate, add calcium sources before planting



Foliar Fertilizers

- Small, *supplemental* doses of water-based fertilizer
- Rapid absorption
- Feasible to tank mix
- CaCl_2 , $\text{Ca}_3(\text{PO}_3)_2$, CaO_3S_2



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Nutrient Uptake by Foliar Feeding

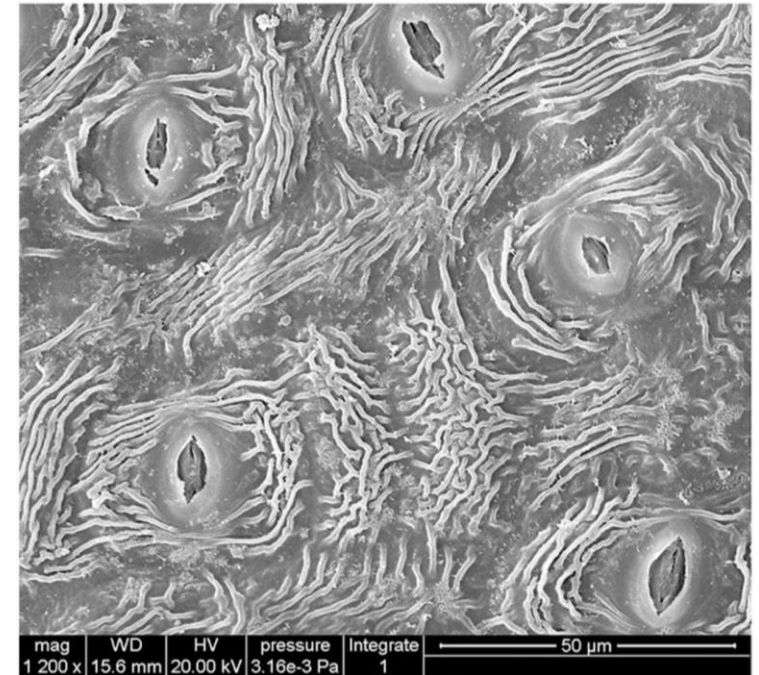
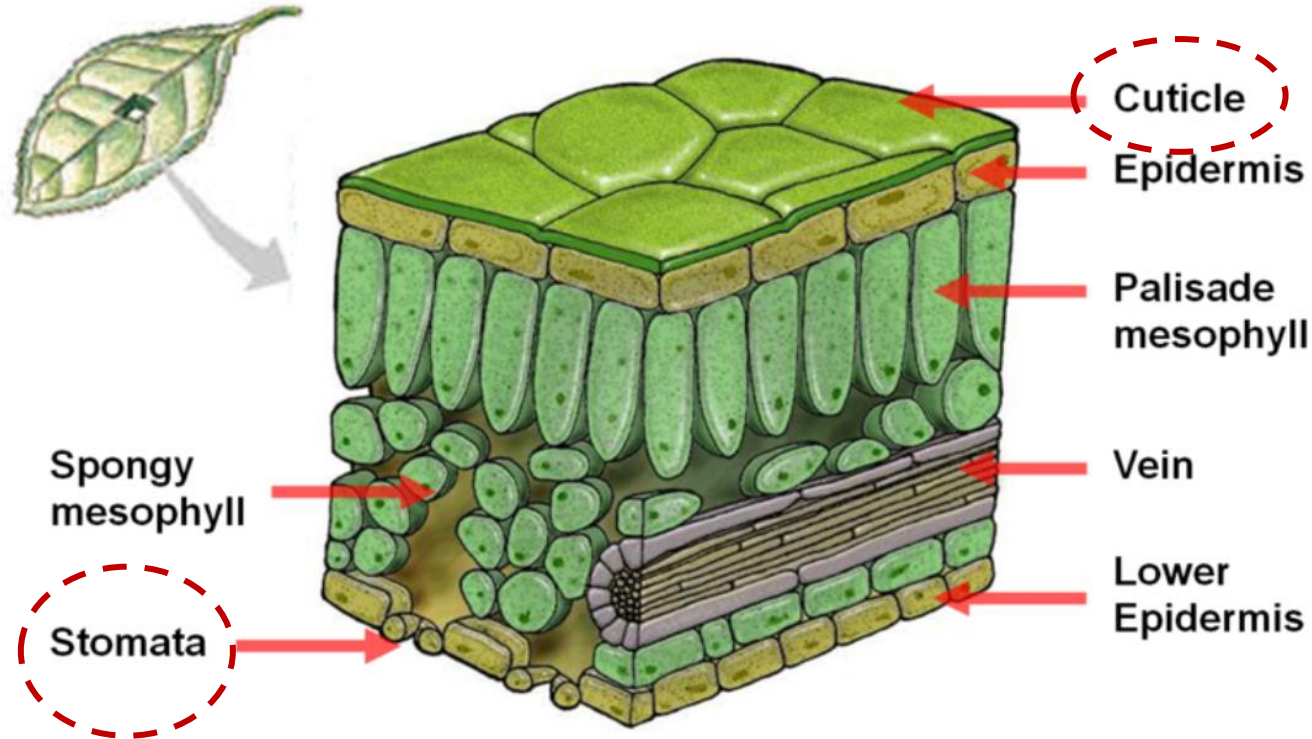
- Application of mineral nutrient(s) to canopy
- Research dates back to 1950s
- Mobility - needs to move to target tissue
- Tends to more effective for micronutrients (Zn, B, Cu)
- Macronutrients more challenging (N, P, K, **Ca**)





Pathway of Foliar Nutrients

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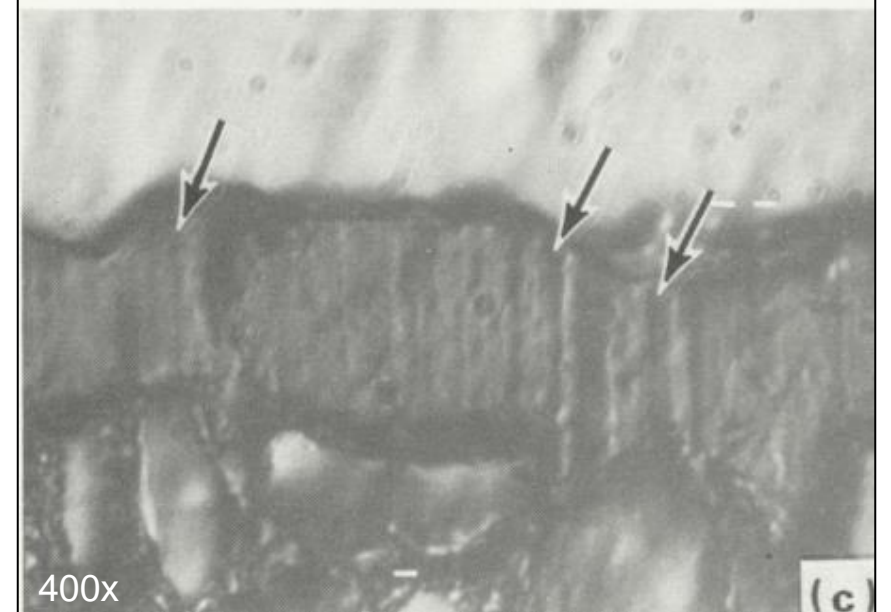
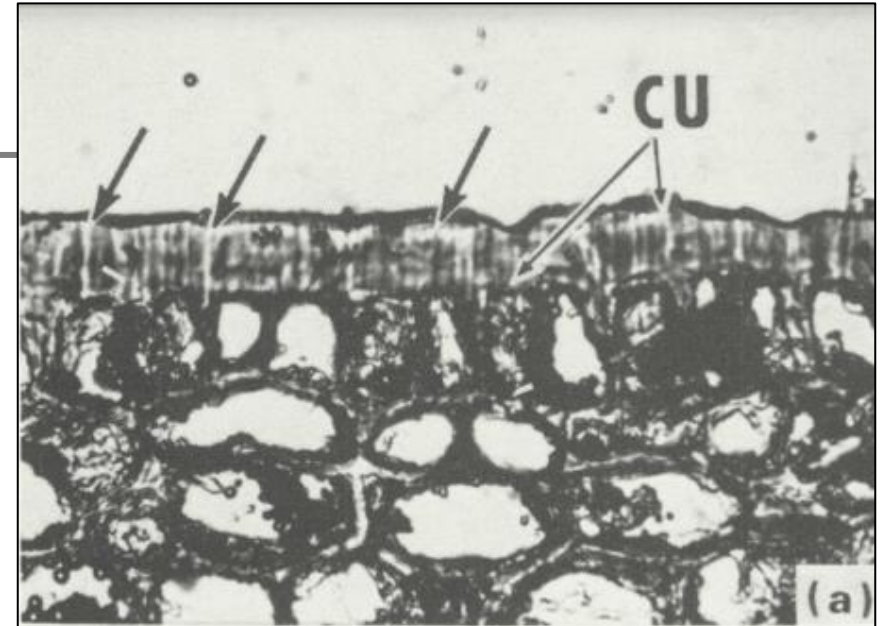
Wu et al. (2022) *Frontiers in Plant Sci.*

Nutrients must pass through cuticle and/or stomata before entering plant tissues



Cuticular Pores

- Cuticular pores allow some nutrients passage into leaves and fruits
- Cuticular pores are narrow (<1 nm) and negatively charged
- Small, slightly positively charged nutrients more easily transported into tissue

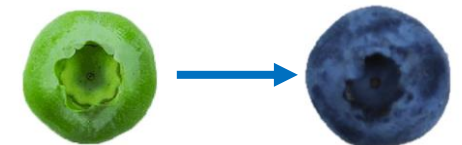
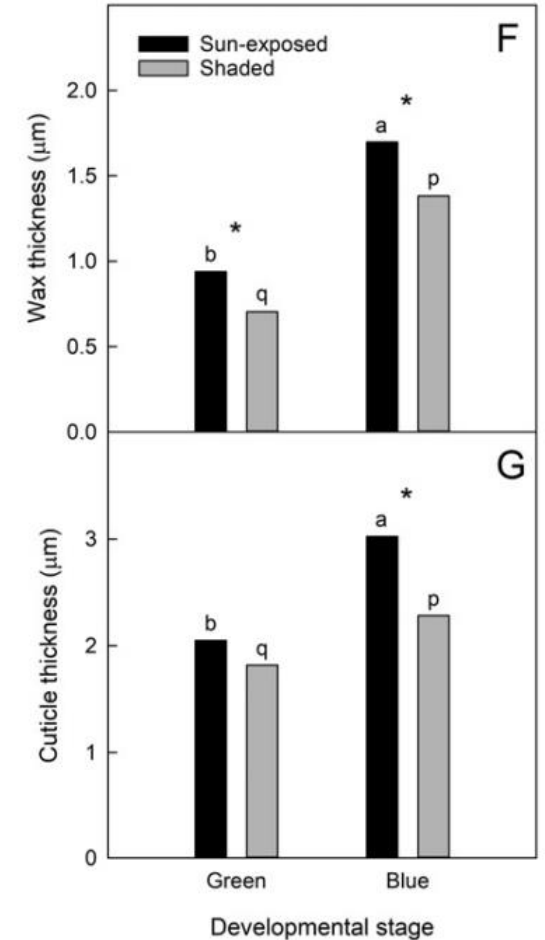
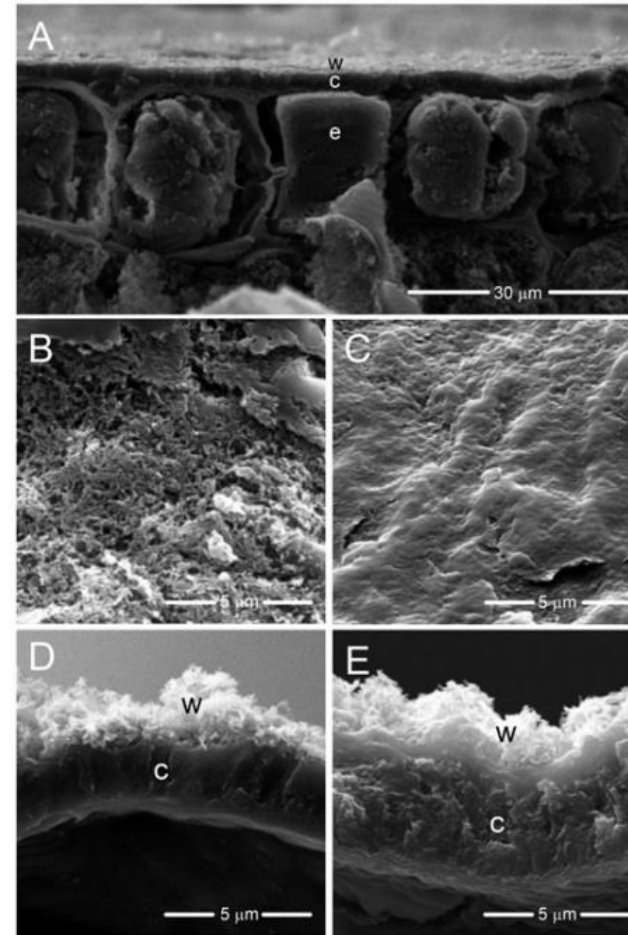




Blueberry Fruit Cuticle

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- Thickens as berries ripen
- Thicker on sun-exposed fruits
- Barrier to foliar fertilizers
- Foliar fertilizers targeting fruits should be applied early, shortly after flowering and until color change

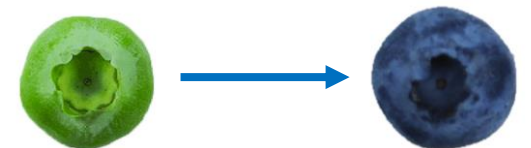
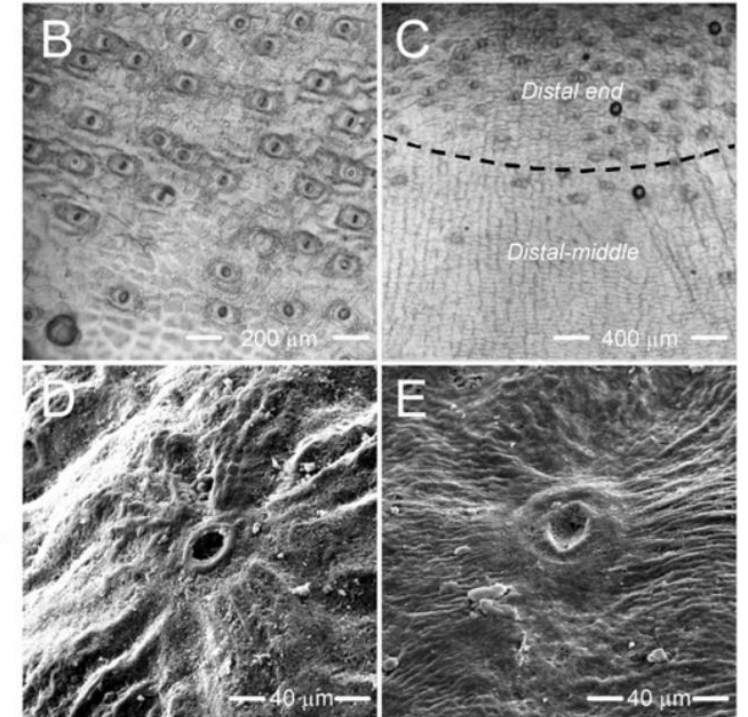
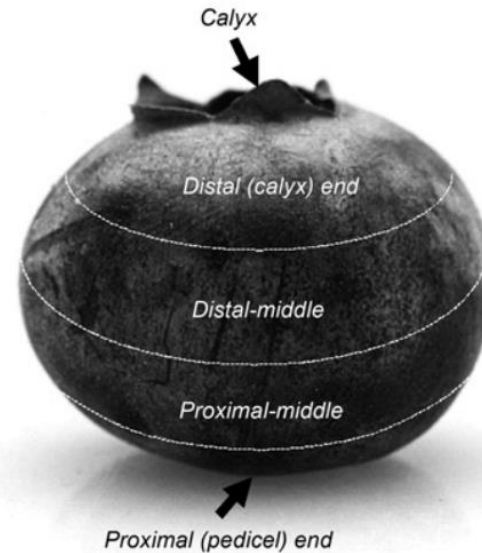




Blueberry Fruit Stomata

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- Early green stage → stomata are wide-open, near distal end, little wax along guard cell
- Color change → stomata completely covered with wax





Raspberry Fruit Cuticle and Stomata

- Fruit surface less well characterized
- Epidermal hairs on fruit surface
- Receptacle may impact movement of nutrients into fruit more than external features of drupelets



'Meeker', white bar = 400 μ m

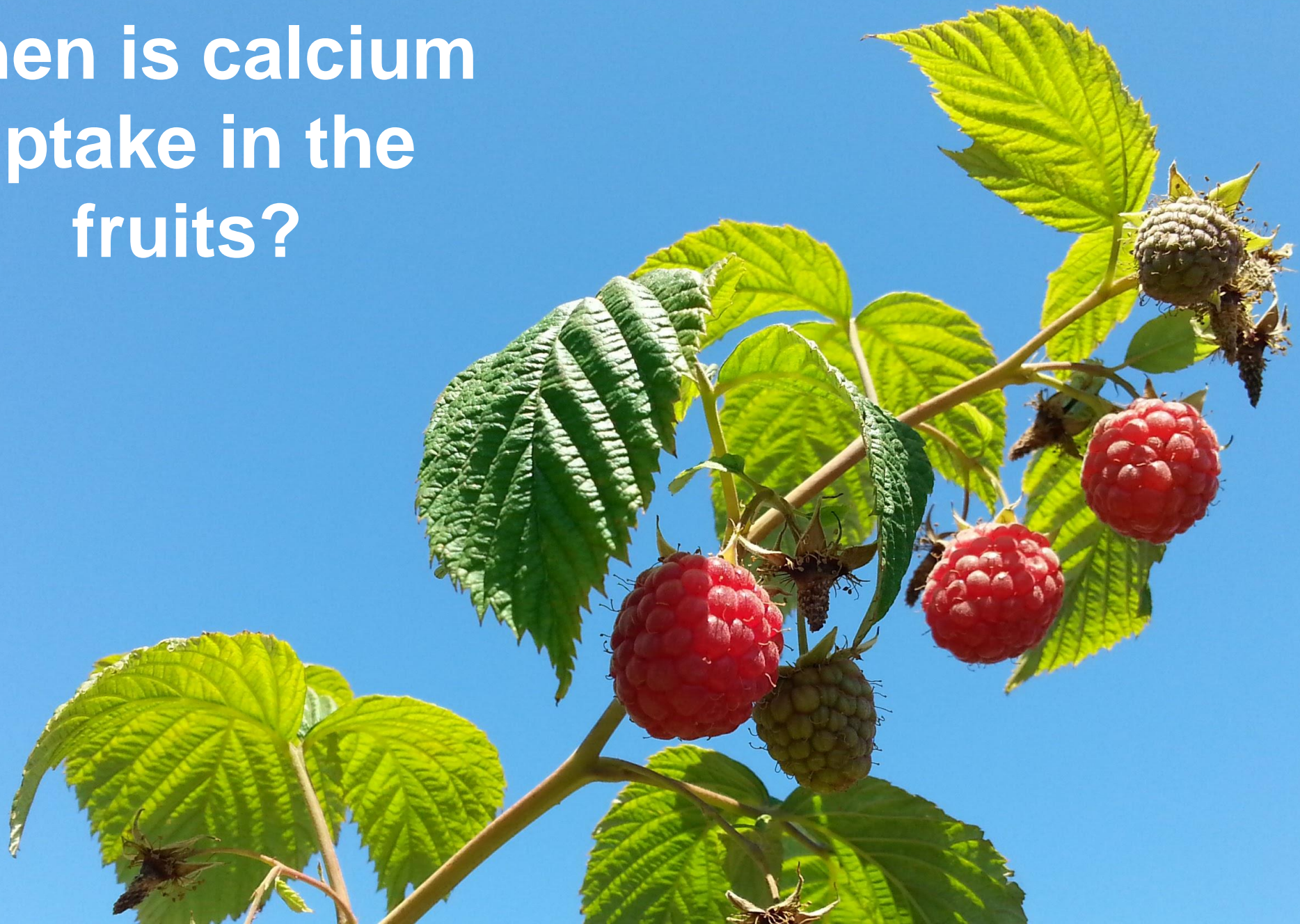
Research



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When is calcium uptake in the fruits?

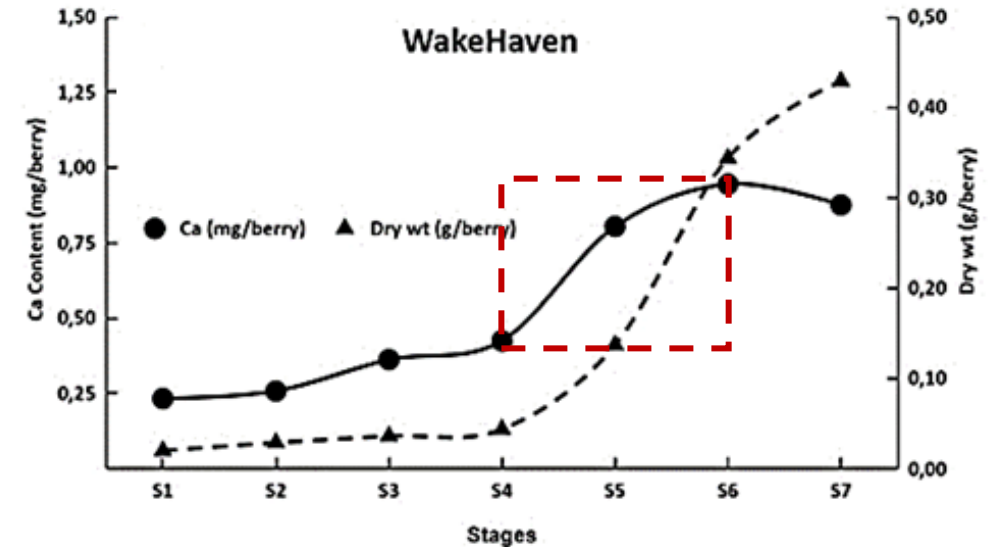
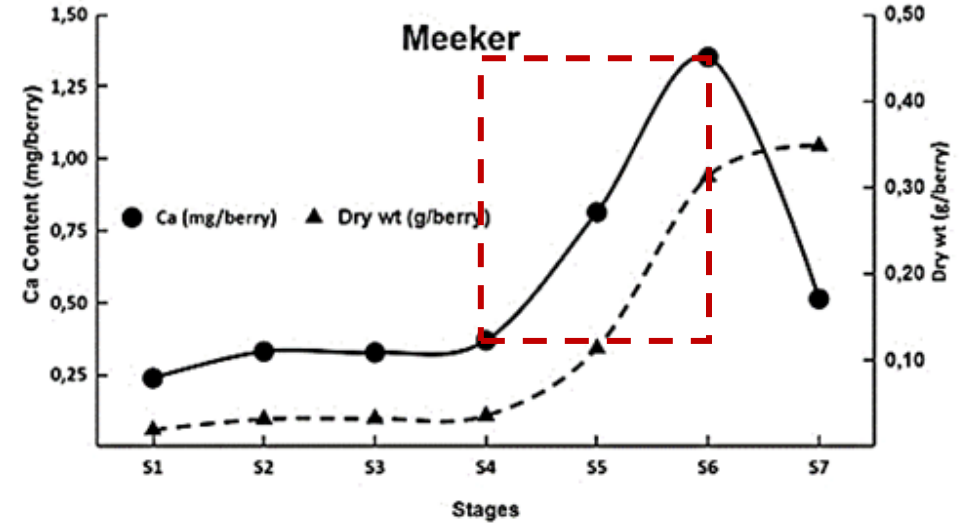
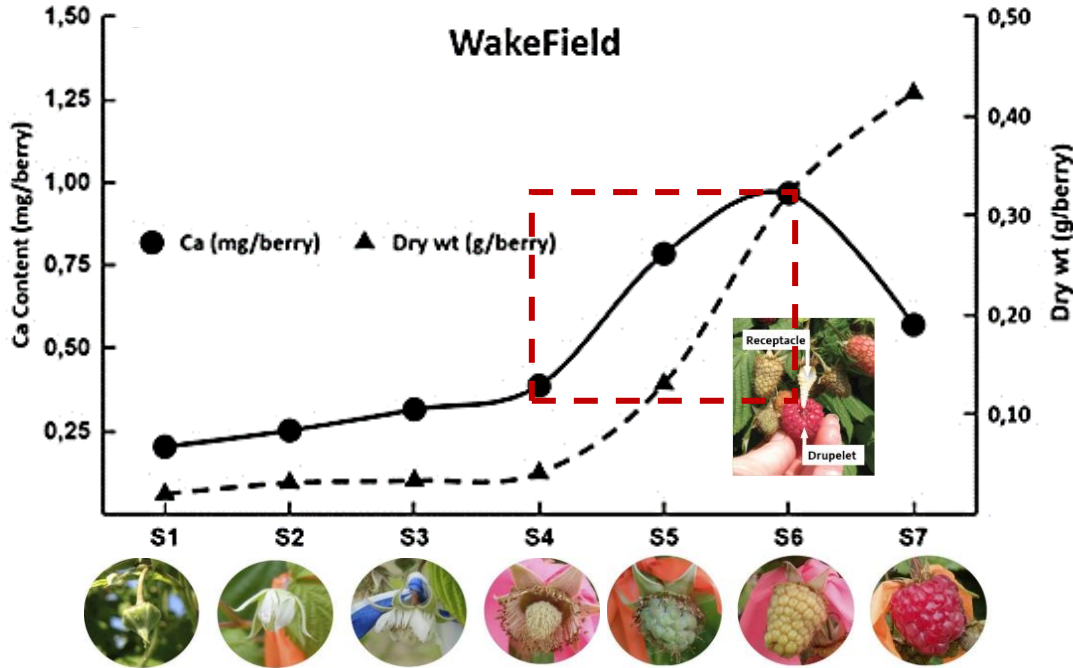




Calcium Uptake in Raspberry



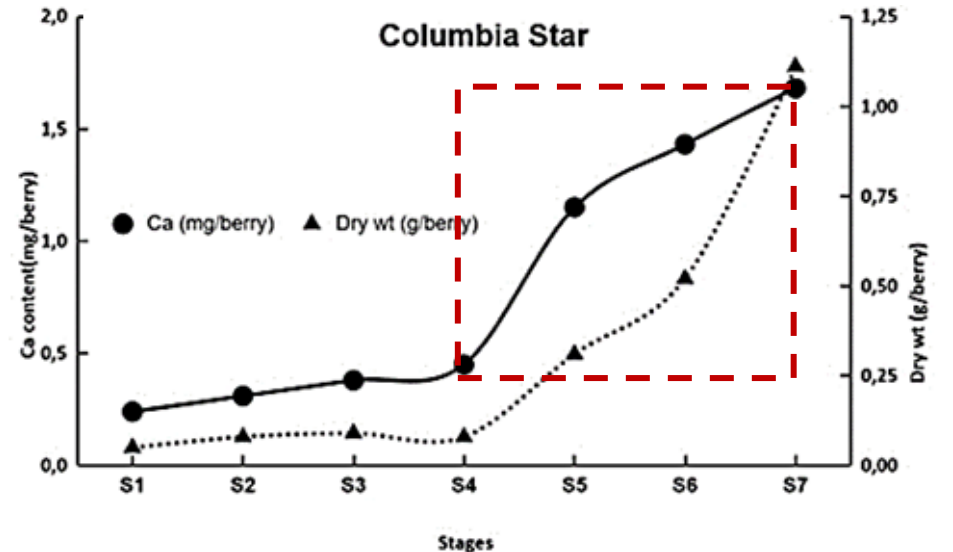
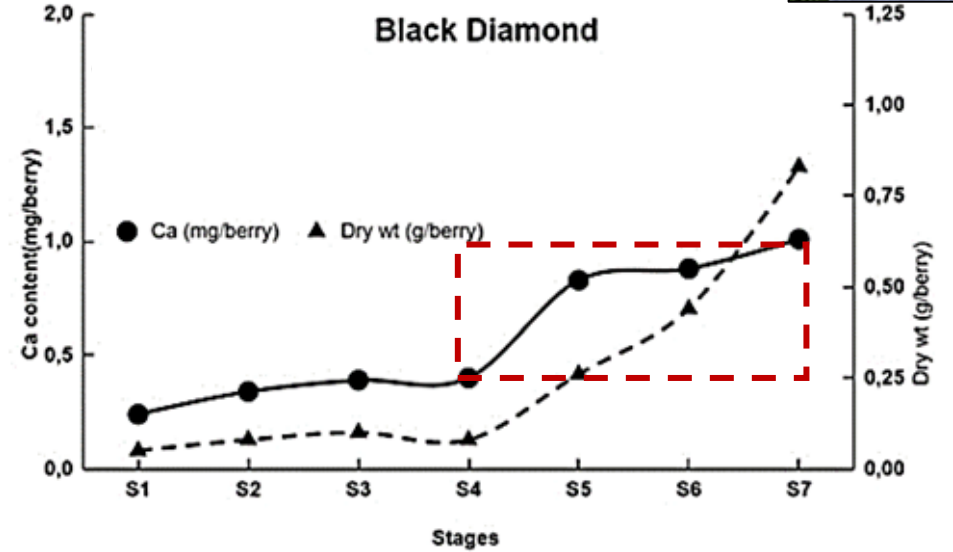
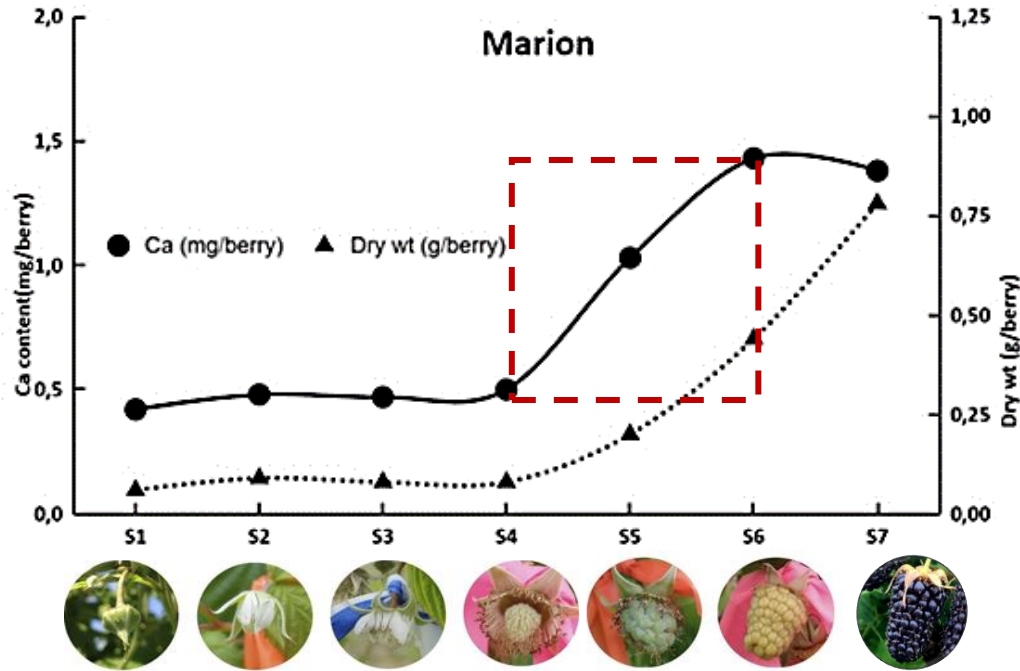
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- Peak period of uptake between half-developed (S4) and immature fruit (S6)
- Declines at mature stage (S7) due to loss of receptacle, except for 'WakeHaven'



Calcium Uptake in Blackberry



- Similar trend as raspberry
- Some uptake between immature (S6) and mature (S7) stages
- Uptake greatest in 'Columbia Star'

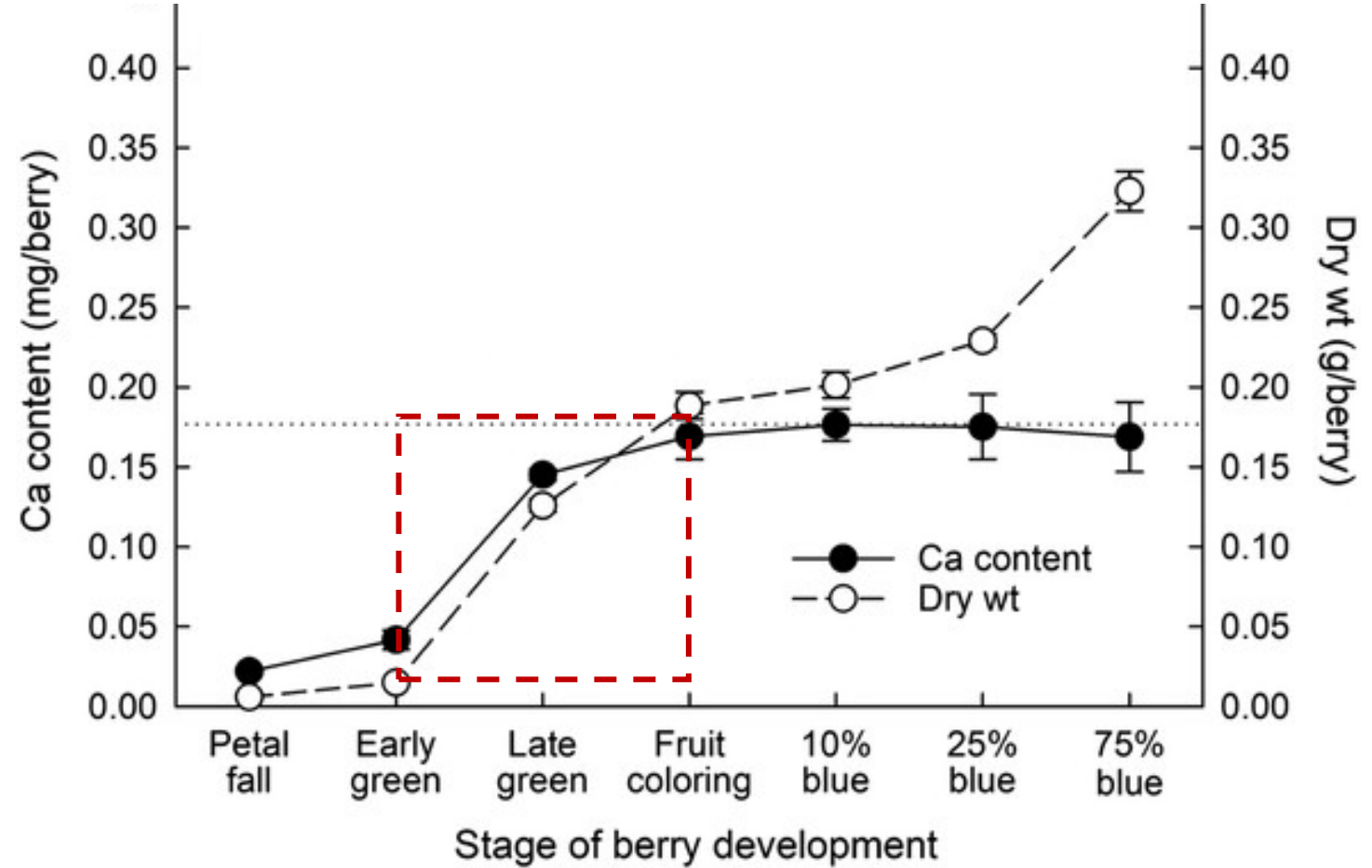




Calcium Uptake in Blueberry



- Peak period of calcium uptake is early green to fruit coloring stages
- Overlap fertilizer applications with peak uptake periods



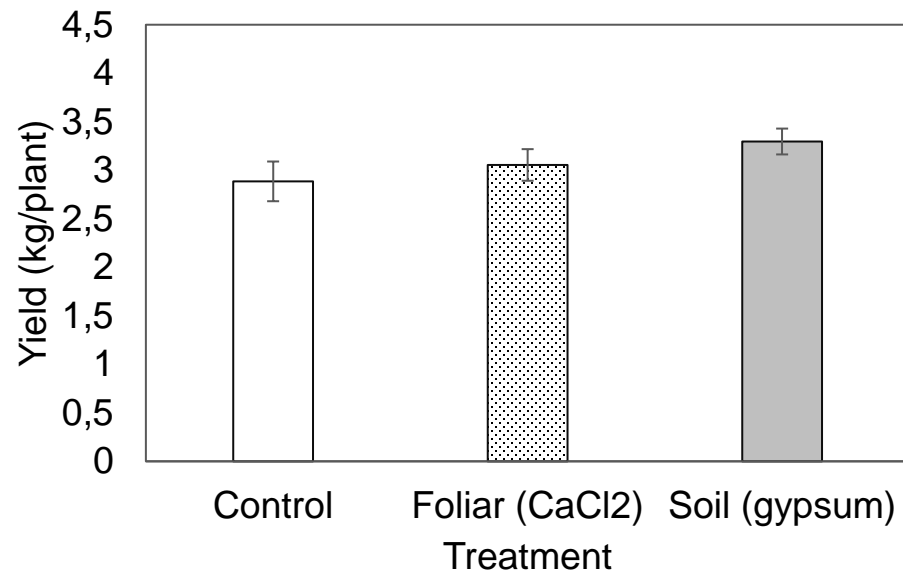


Fertilizer Trials



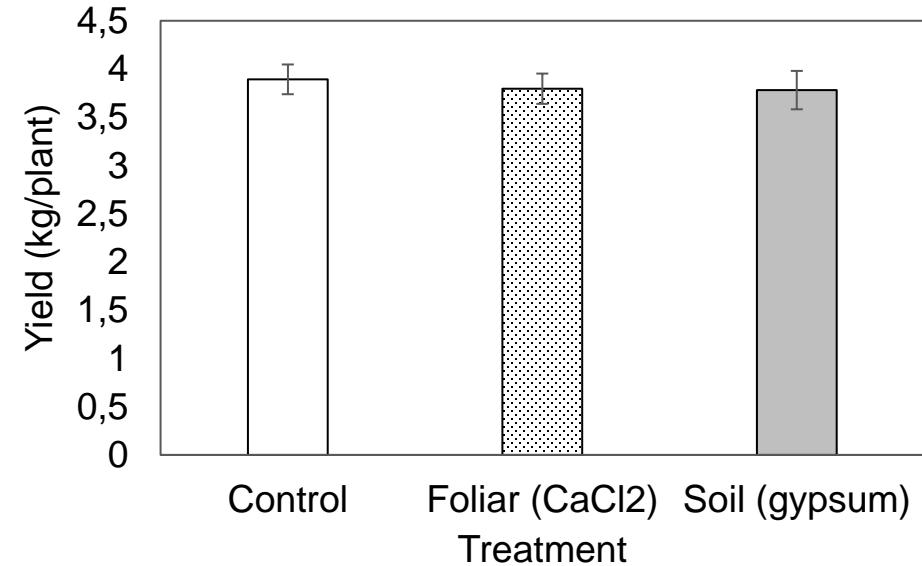
Raspberry Yield and Fruit Quality Unaffected

'Meeker'



15 harvests in 2024

'Kulshan'



15 harvests in 2024

Yield and fruit quality (not shown) was the same across all treatments in both years



Receptacle versus Fruit Calcium



- No treatment effects on fruit calcium concentrations
- Receptacle contained greater calcium than fruits
- Only 'WakeHaven' receptacles differed by treatment in 2023 (foliar > gypsum > control)

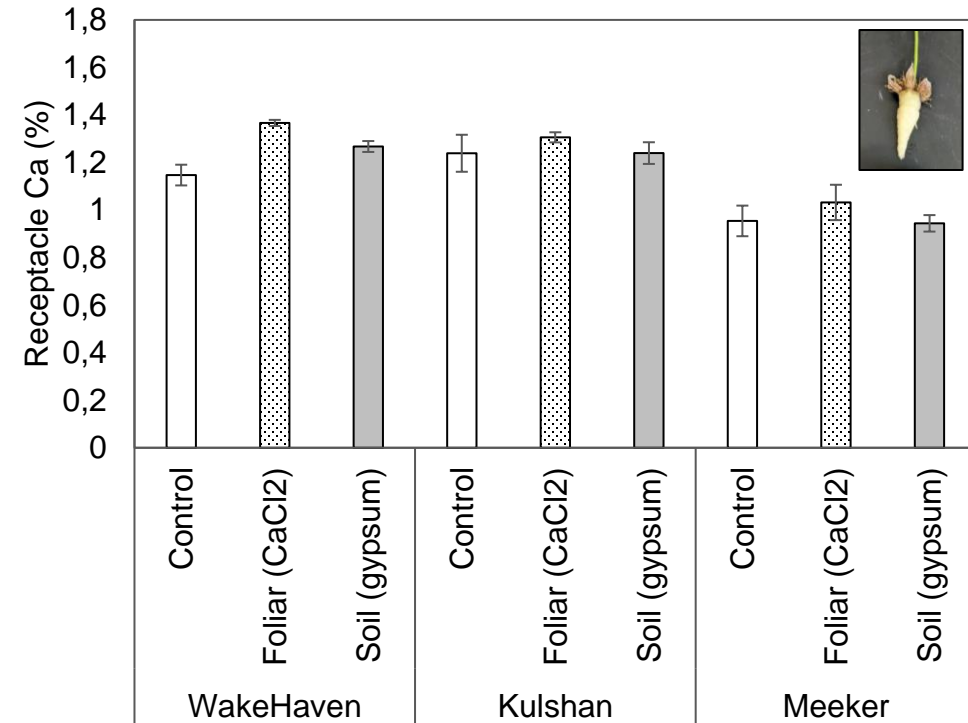
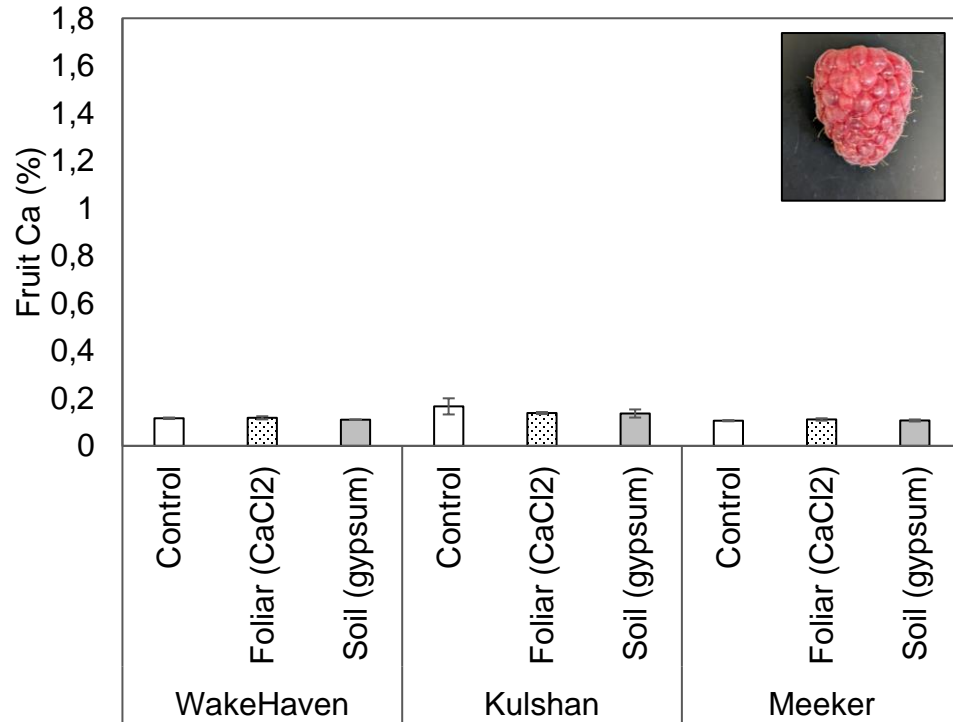
'WakeHaven'

Treatment	Calcium (%)	
	Fruit	Receptacle
Foliar (CaCl ₂)	0.12	1.37 a ^z
Soil (gypsum)	0.11	1.27 b
Control	0.12	1.15 c
p-value	0.408	0.001

^zLetters of difference, with different letters within a column denoting significant differences ($\alpha=0.05$).



Receptacle versus Fruit Calcium



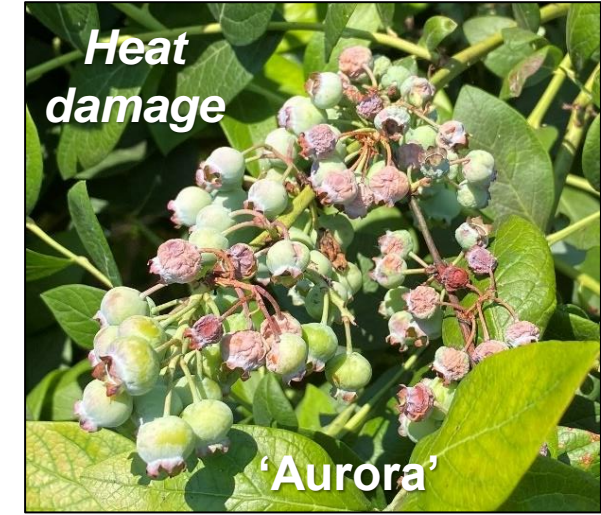
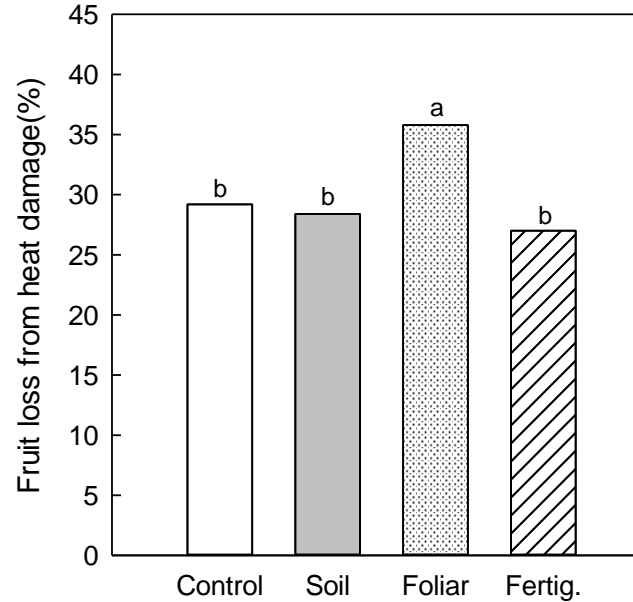
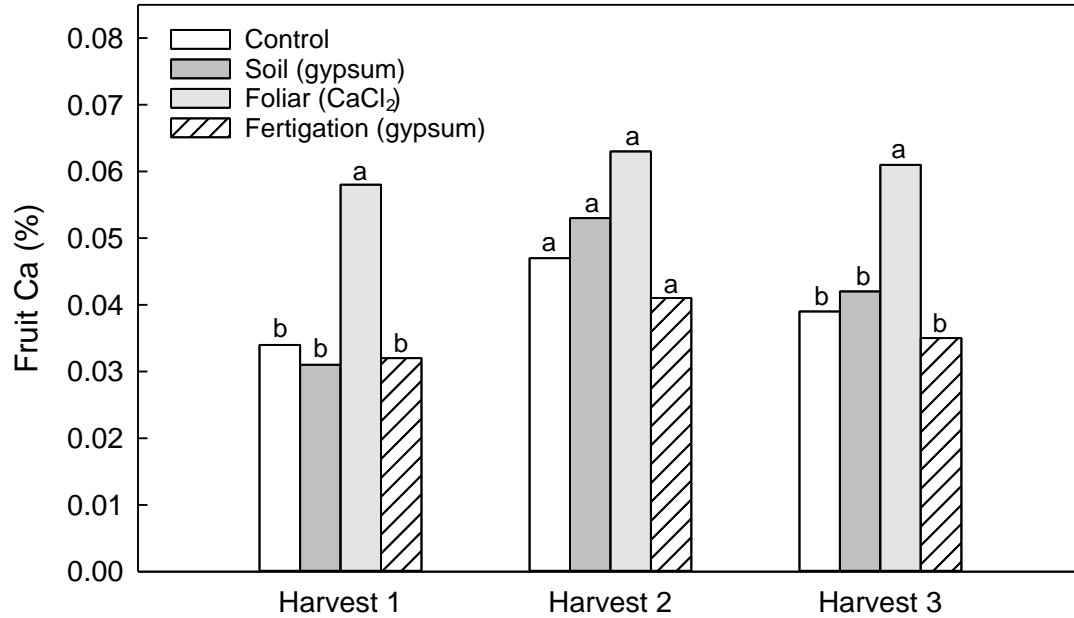
Receptacles had 10x more calcium than fruits, indicating isolation events are limiting allocation of calcium from receptacles to drupelets



Blueberry Calcium Research



'Aurora'



- Fruit calcium concentrations and firmness higher with foliar applications of CaCl₂ in 'Duke', 'Bluecrop', and 'Aurora'
- Yield and quality loss with foliar calcium → greater heat damage in 'Aurora' and residue formation



Foliar Calcium – Mixed Results

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Timing of Foliar Calcium Sprays Improves Fruit Firmness and Antioxidants in “Liberty” Blueberries

[T. E. Lobos](#) , [J. B. Retamales](#), [A. Luengo Escobar](#) & [E. J. Hanson](#)

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Not Bot Horti Agrobo, 2012, 40(2): 163-169



The Impact of Foliar Application of Calcium Fertilizers on the Quality of Highbush Blueberry Fruits Belonging to the ‘Duke’ Cultivar

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HORTSCIENCE 52(3):382–387. 2017. doi: 10.21273/HORTSCI11612-16

Foliar Calcium Applications Do Not Improve Quality or Shelf Life of Strawberry, Raspberry, Blackberry, or Blueberry Fruit

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HORTSCIENCE 30(5):977–978. 1995.

Preharvest Calcium Sprays Do Not Improve Highbush Blueberry (*Vaccinium corymbosum* L.) Quality

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Conclusions

- Repeated, high rates of calcium foliar fertilizer applied during periods of fruit uptake with a surfactant can increase fruit concentrations and firmness in blueberry (no effects seen in raspberry)
- Potential drawback → yield and fruit quality losses due to increased heat damage, salt deposits, and phytotoxicity
- Moving calcium from the receptacle to drupelets is a barrier in raspberry
- Foliar calcium fertilizer programs likely have negligible to no impacts on yield and fruit quality so long as plants are within sufficiency ranges
- Growers should focus on balanced soil/media nutrient applications with calcium, staying within sufficiency ranges for all nutrients to avoid imbalances, and selecting cultivars with desired fruit quality and storability traits

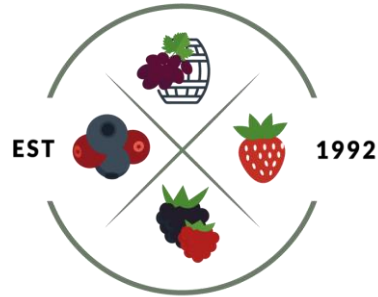




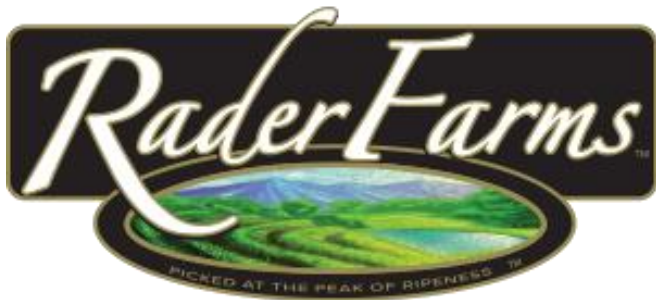
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Northwest Center
FOR SMALL FRUITS RESEARCH



WSU Small Fruit Horticulture Lab



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Thank you! Questions?



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