

WASHINGTON STATE



UNIVERSITY

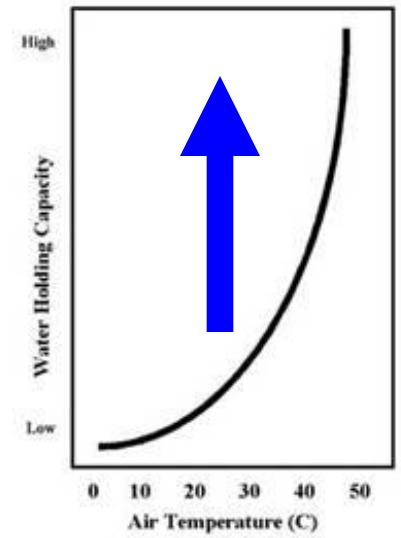
World Class. Face to Face.

Friend or Foe? Vine Nutrition Effects on Grape and Wine Quality

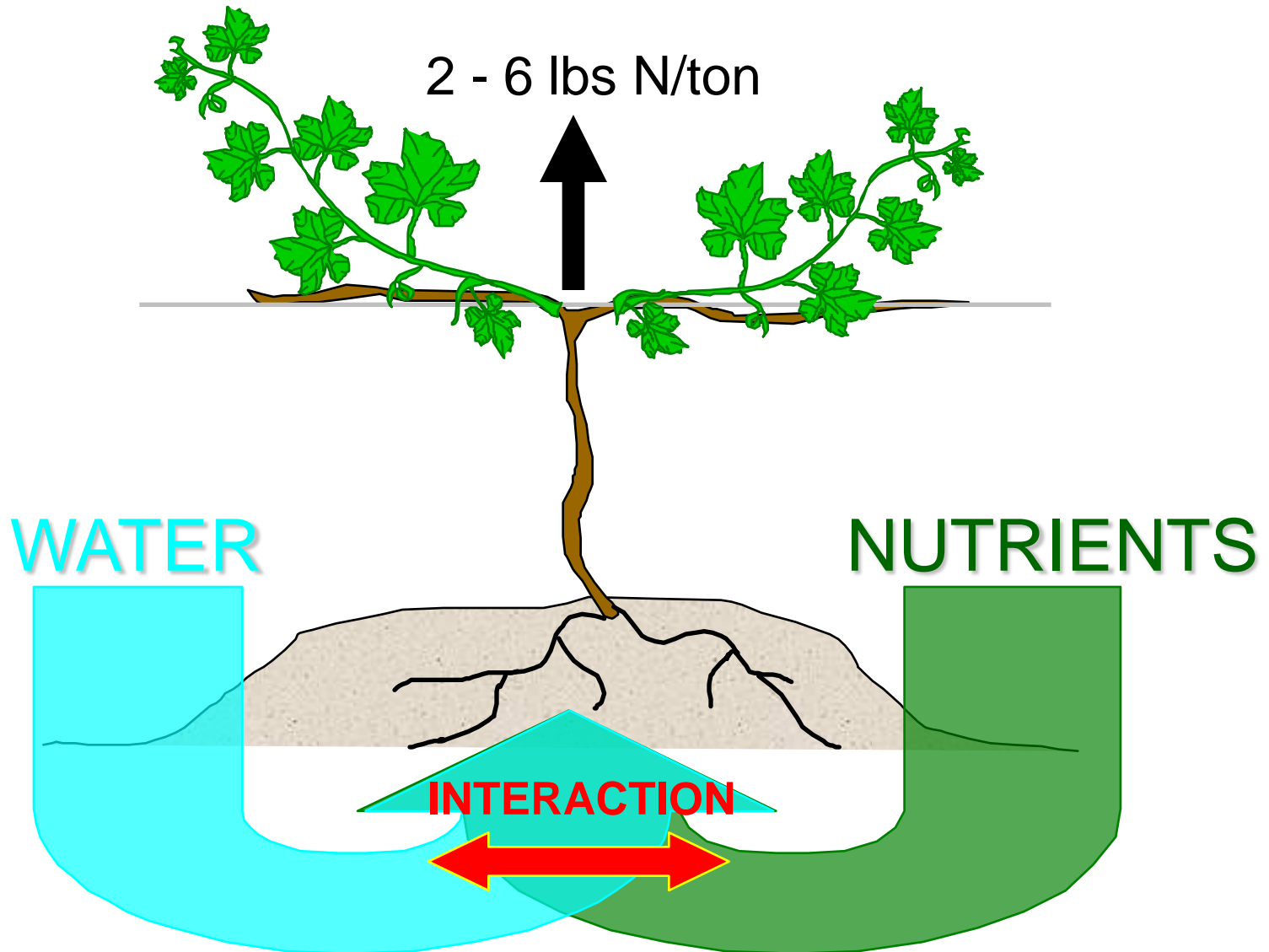


Location, location...

- Water and nutrients limit vine productivity
- Climate variation and change
- Amount and frequency of rainfall
- Evaporation (temperature)
- Spatial variation
- Soil water/nutrient holding capacity
 - Soil texture (loam/sand)
 - Rooting depth
 - Organic matter
 - pH
- Vine age/size



Ground rules



Nutrient availability and uptake

- Nutrients concentrated in surface soil
- Availability linked to soil water
- Large spatial/temporal variation
 - Roots grow in nutrient-rich zones
- Different nutrients in different locations (leaching: $\text{NO}_3^- \gg \text{K}^+ \gg \text{H}_2\text{PO}_4^-$)
 - Shallow roots: immobile nutrients
 - Deep roots: mobile nutrients
- Active uptake → Concentration
- Transpiration ↗ → Uptake ↗



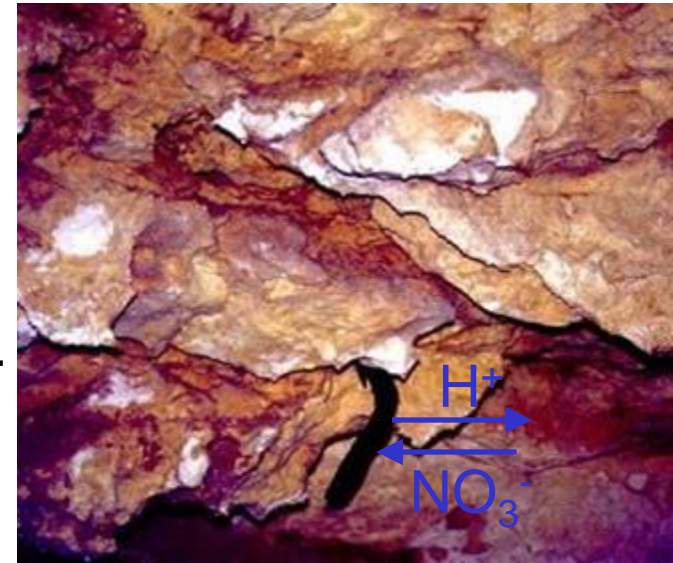
Nitrogen: What is it?

Chemical component of:

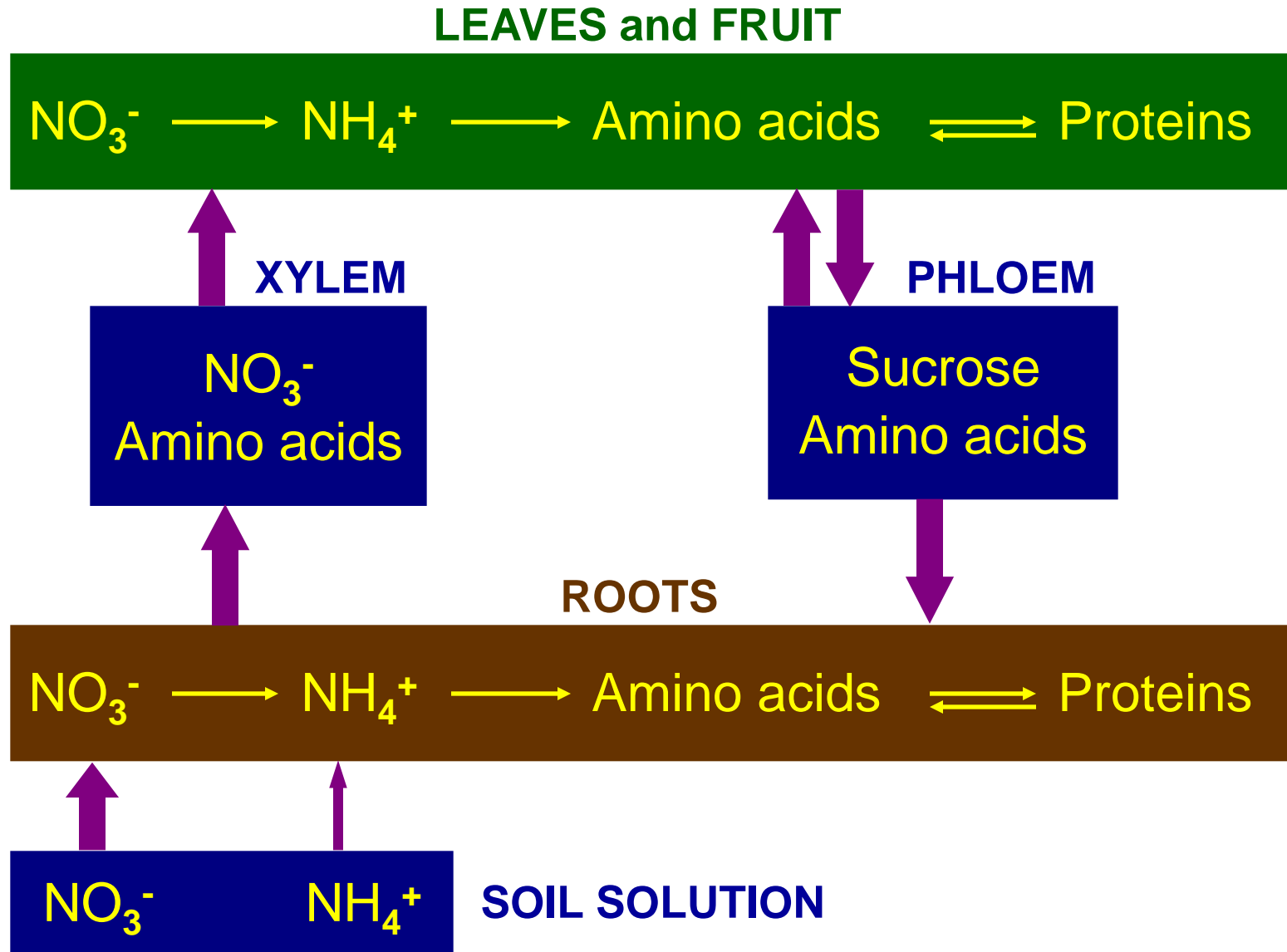
- Nucleic acids → DNA → Genes
- Amino acids → Proteins → Enzymes
- Chlorophyll → Light interception
- Hormones → Communication
- Secondary metabolites → Color, flavor

Nitrogen uptake and processing

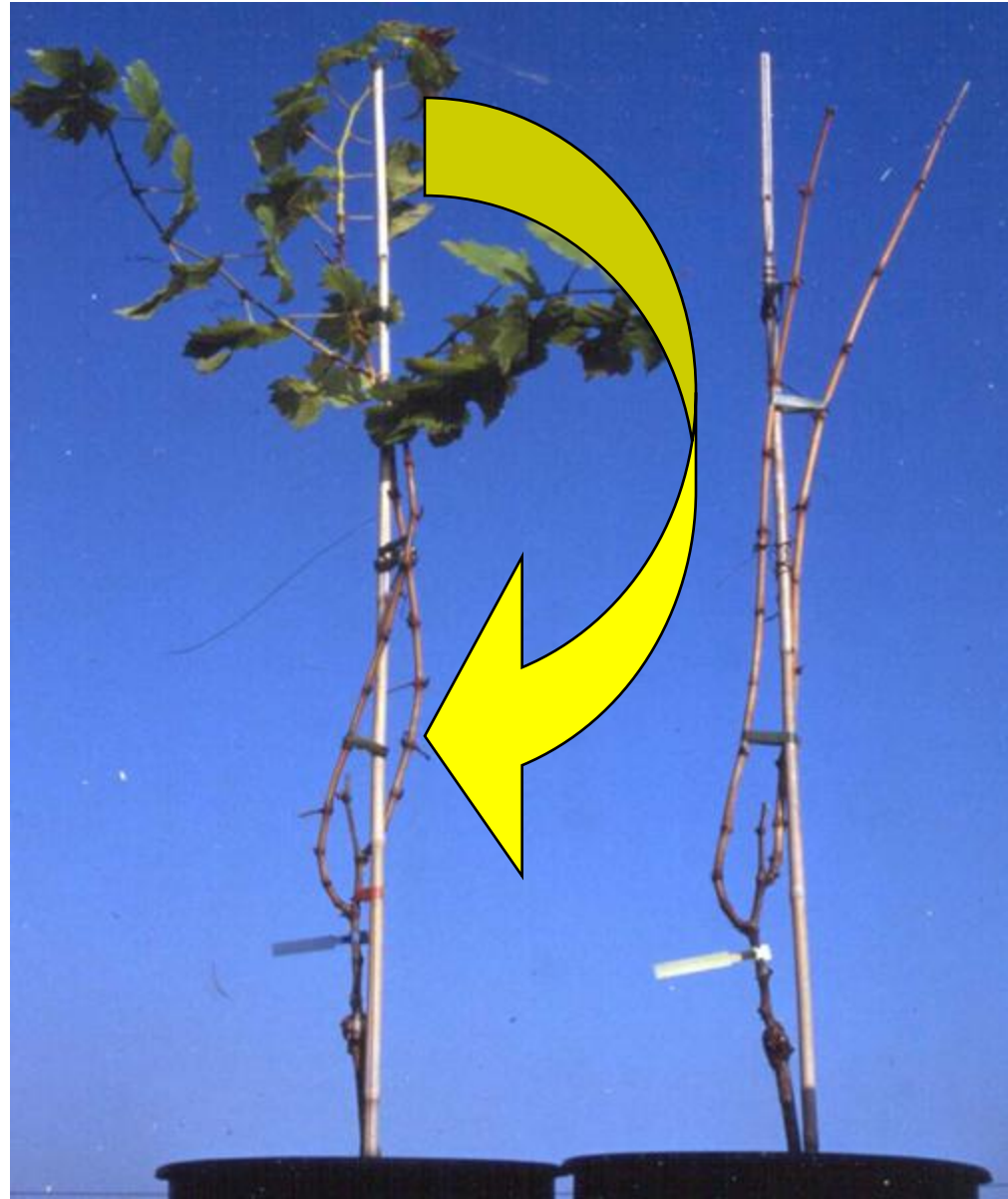
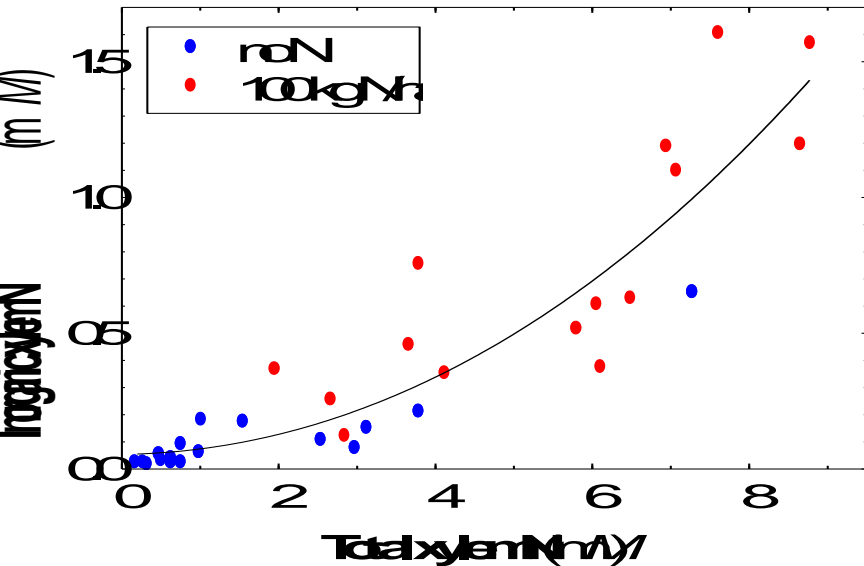
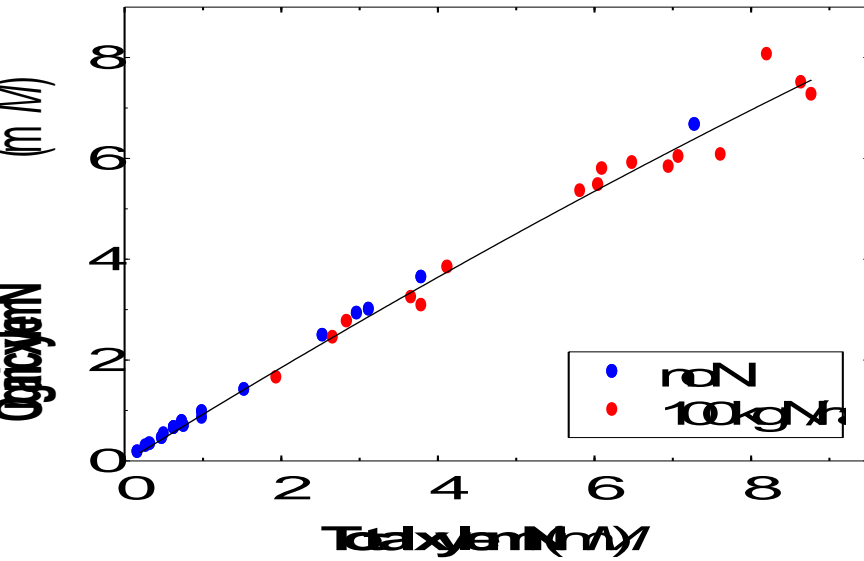
- N_2 in atmosphere (80%) useless for grapevines
- Mostly nitrate (NO_3^-) dissolved in soil water
- Soil water $[NO_3^-] \ll$ Tissue $[NO_3^-]$
- Active uptake via H^+ -ATP pump and H^+/NO_3^- cotransport
- Uptake requires **B** (for ATP pump)
- Assimilation requires **Mg²⁺**, **Mn²⁺** or **Co²⁺** (as GS cofactors) and carbohydrates → Expensive!
- Transport (xylem), storage (vacuole), or assimilation → Amino acids → Proteins



N uptake and assimilation



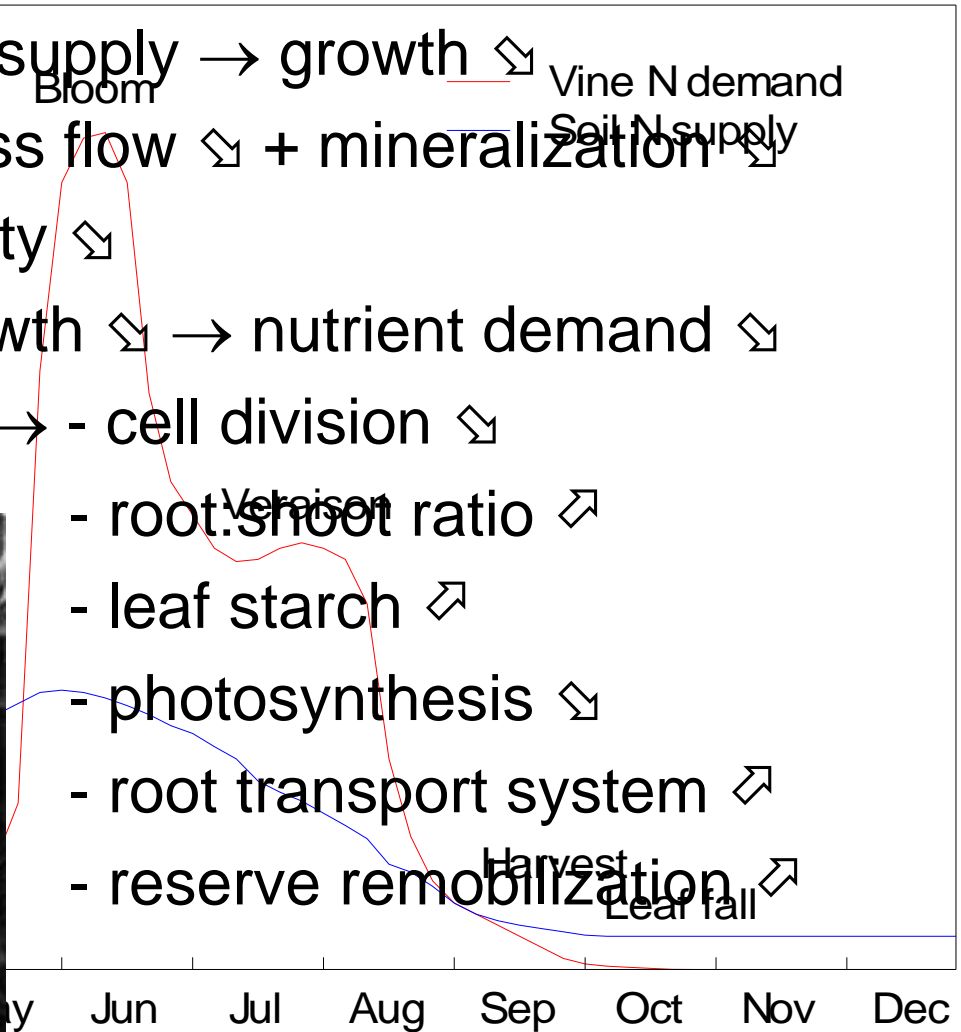
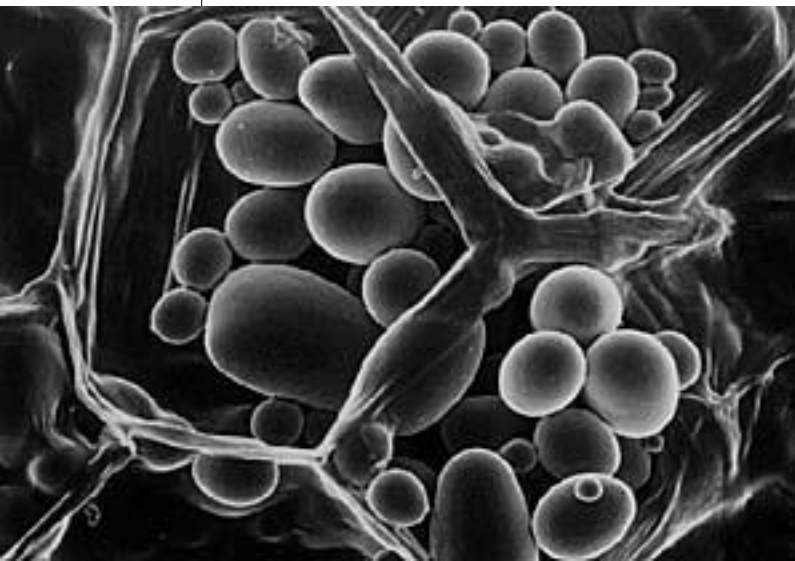
Roots pass surplus on to shoots



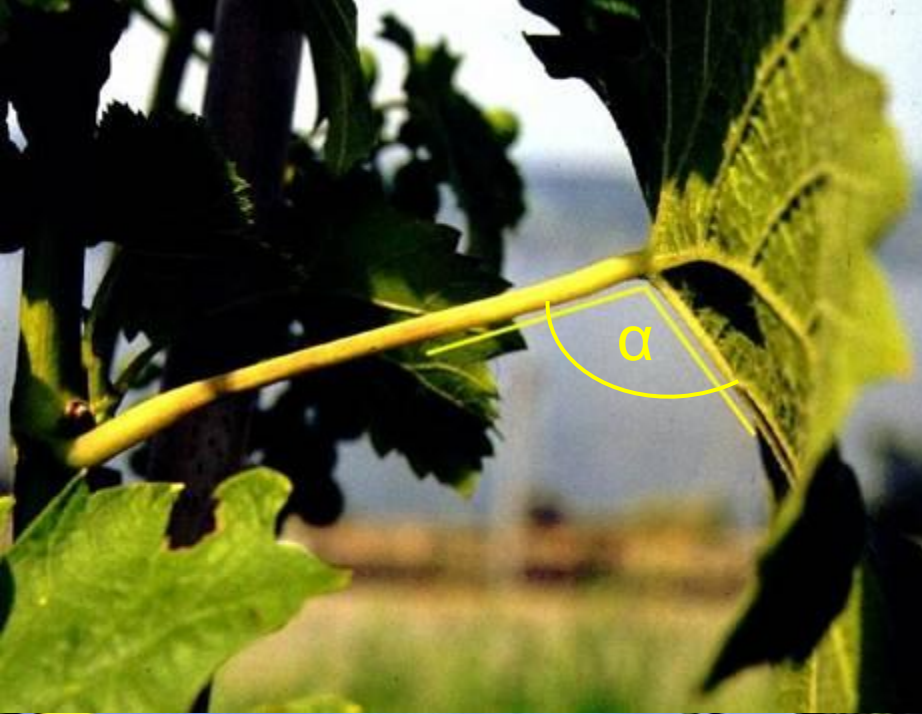
Growth and nutrient status

- Growth drives nutrient uptake

- Insufficient nutrient supply → growth ↘
- Water deficit → mass flow ↘ + mineralization ↘
- → nutrient availability ↘
- Water deficit → growth ↘ → nutrient demand ↘
- Nutrient deficiency → - cell division ↘



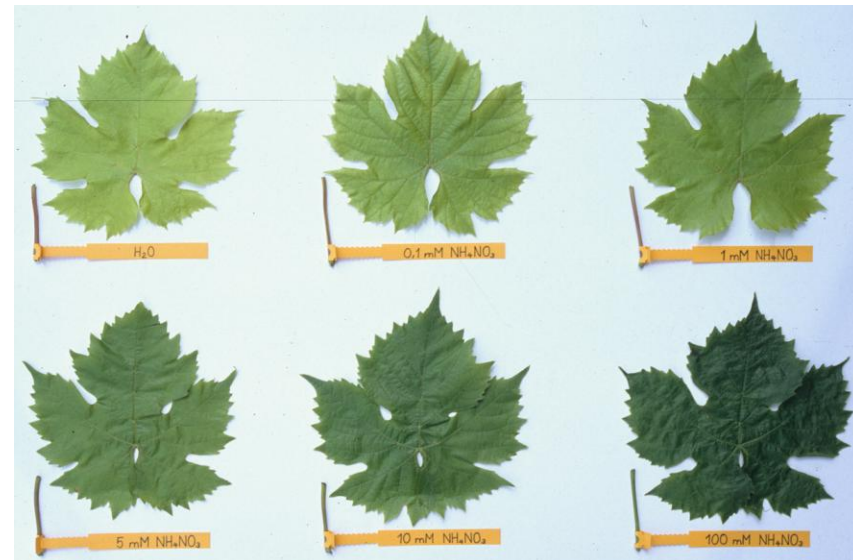
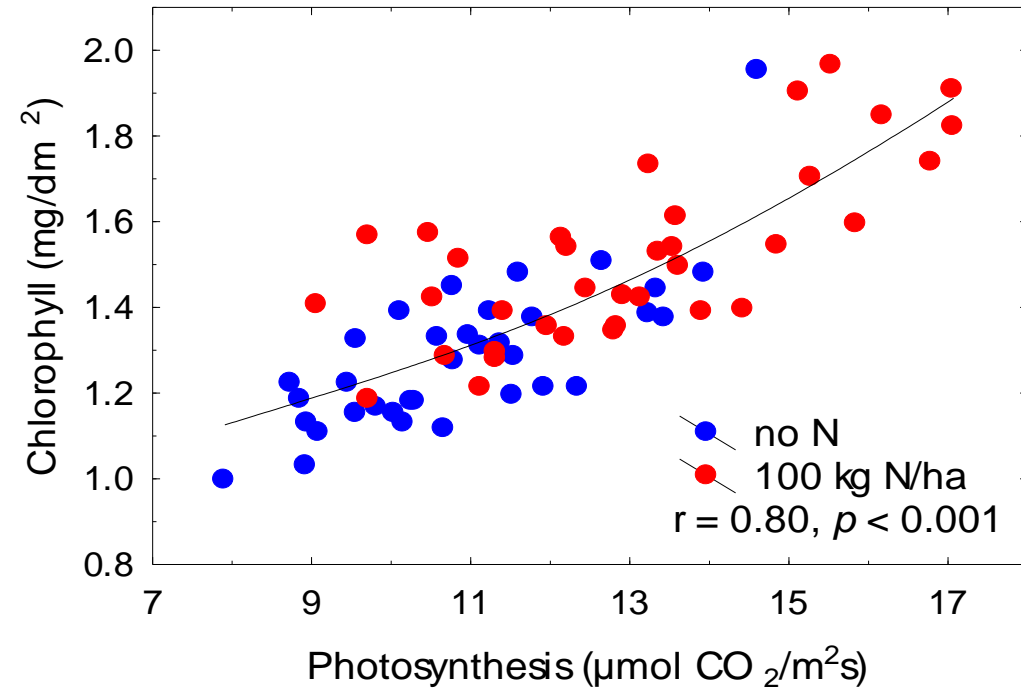
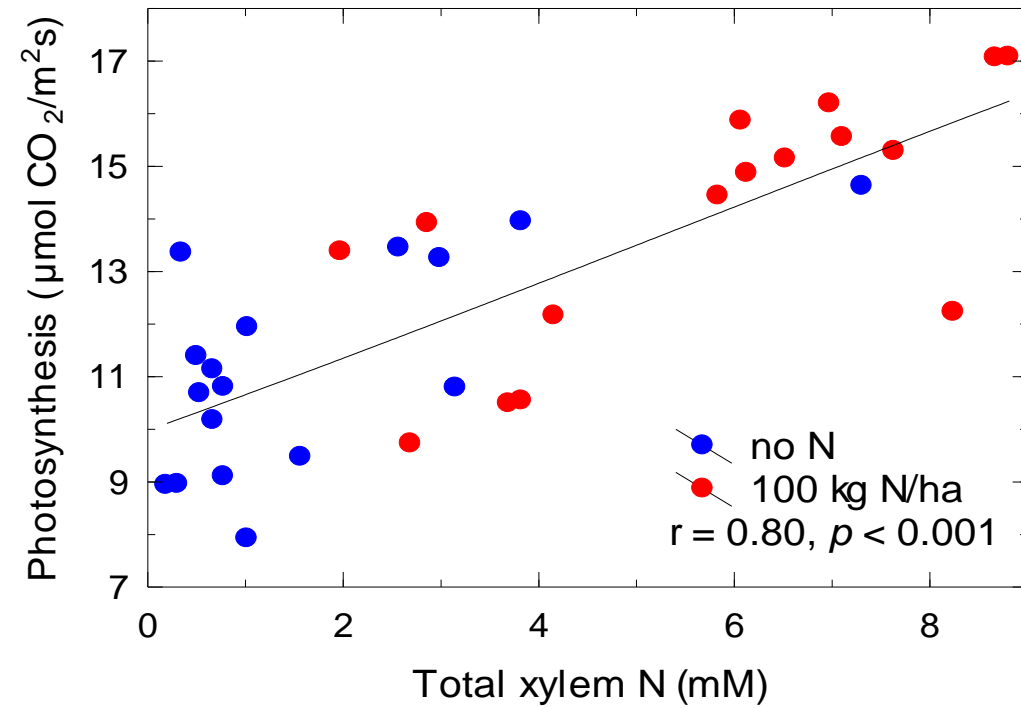
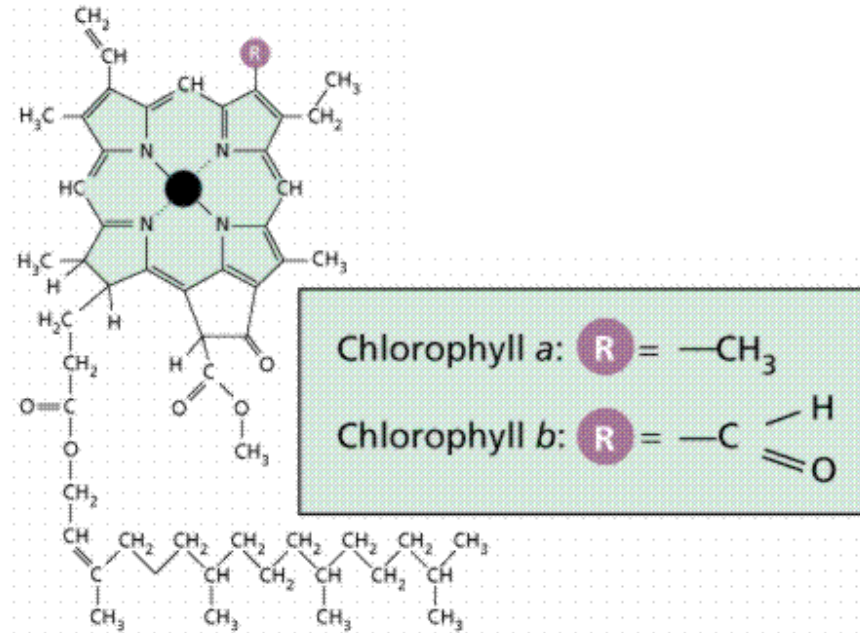
- root:shoot ratio ↗
- leaf starch ↗
- photosynthesis ↘
- root transport system ↗
- reserve remobilization ↗



N Deficit

- Root growth ↗
→ Drought susceptibility ↘
- Shoot growth ↘↘
- Photosynthesis ↘
→ Energy overload
→ Chlorophyll ↘
→ Carbohydrates ↗
→ Anthocyanins ↗
- Leaf senescence
→ Nutrient recycling

Photosynthesis





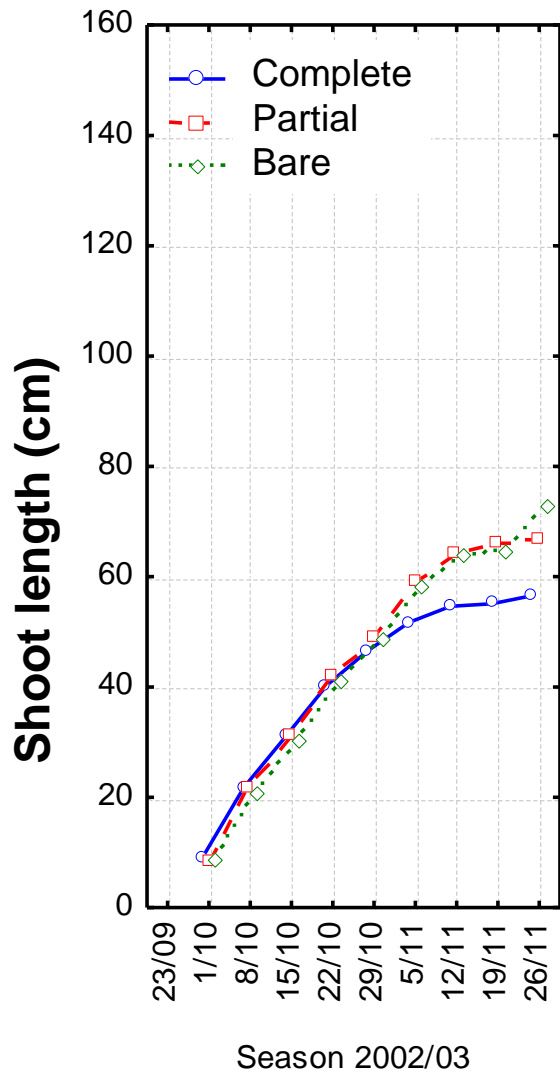
K Deficit

- Root growth (↗) (K → cell expansion)
- Shoot growth ↘
- Photosynthesis ↘
- Sugar export (phloem flow) ↘
→ Ripening, reserves ↘
- Berry 'shrivel' (?)
- Xylem sap flow ↘
- Leaf senescence
→ Nutrient recycling

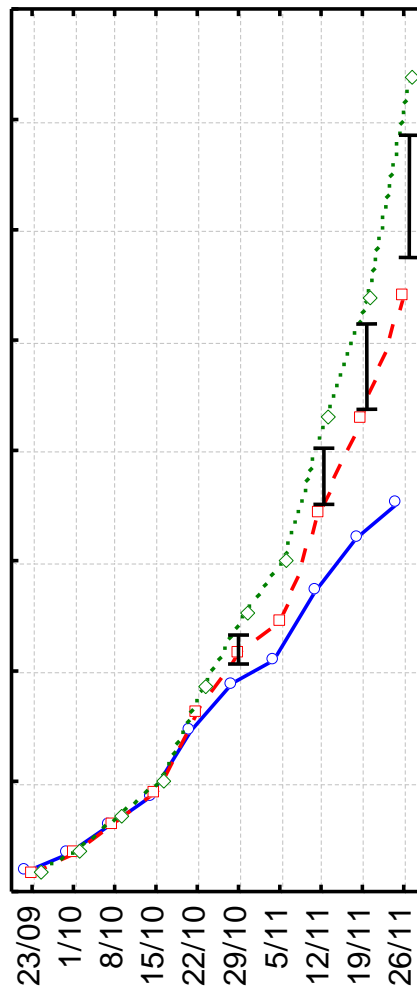
P Deficit

- Root growth ↗ (shallow), ↘ (deep)
→ Drought susceptibility ↗
- Mycorrhiza → P supply ↗
- Shoot growth ↘↘ (laterals)
→ Carbohydrates ↗
- Photosynthesis ↘
→ Energy overload
→ Anthocyanins ↗
- Mg transport in xylem ↘
→ Mg deficiency symptoms
- Leaf senescence
→ Nutrient recycling

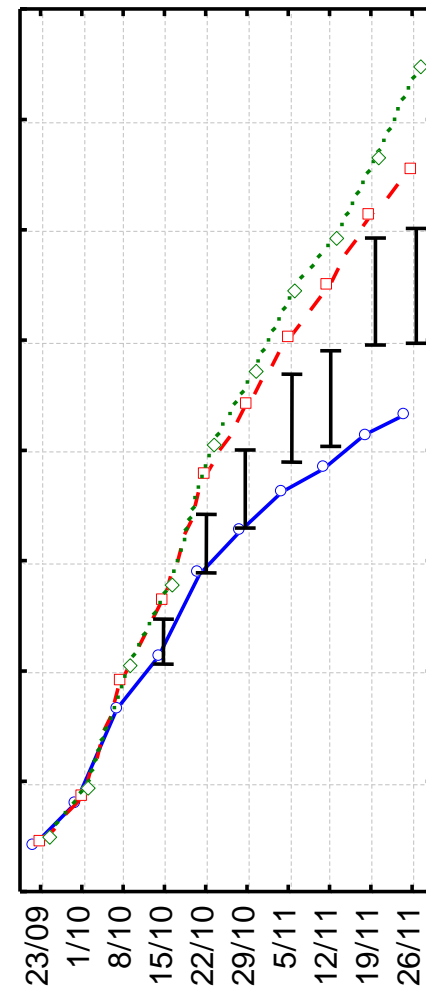




Season 2002/03



Season 2003/04



Season 2004/05

Wagga Wagga

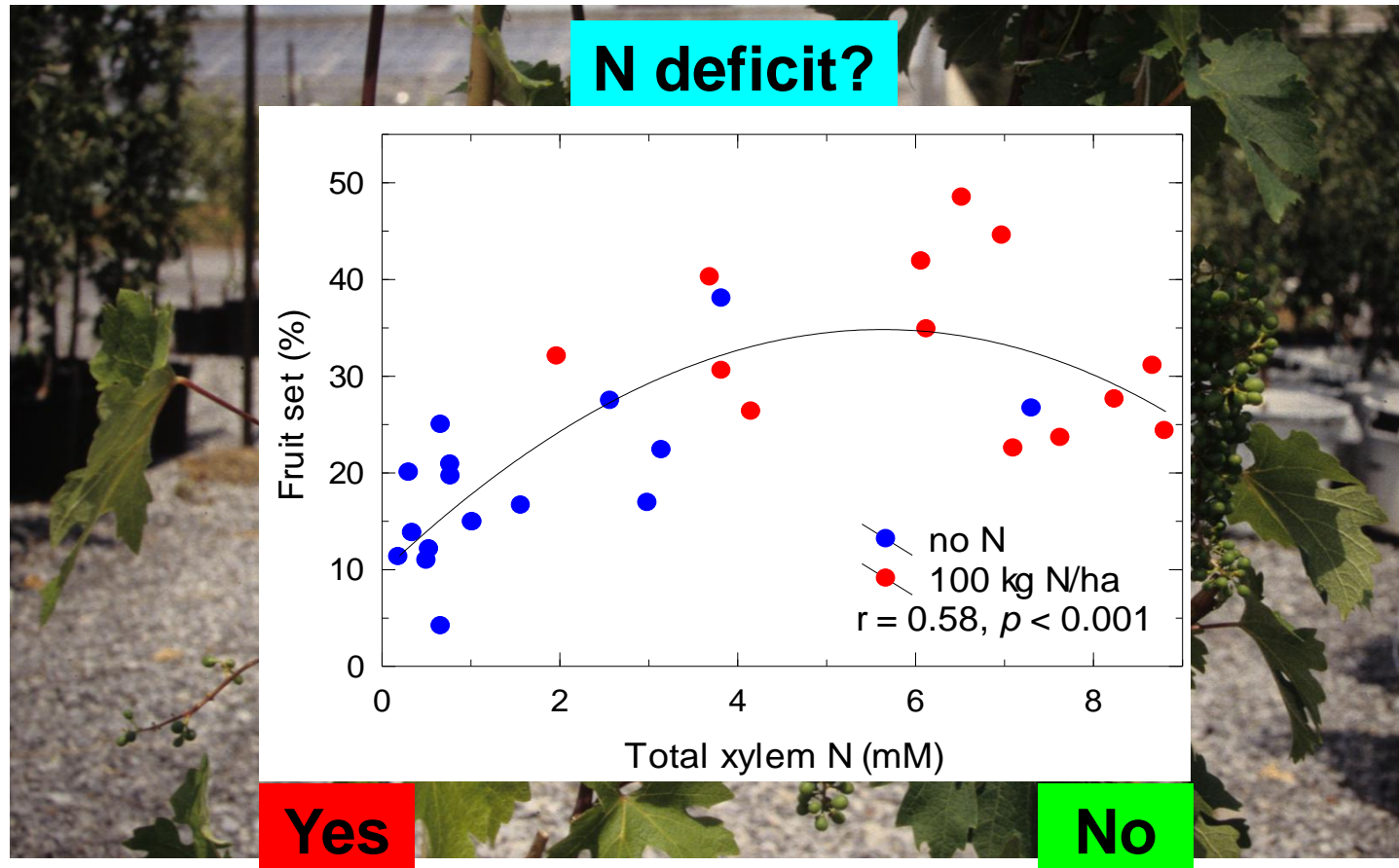
Use but beware of competition!

Stress and yield

- Vegetative growth vs. reproductive growth
 - Time of nutrient deficit important
 - Budbreak – bloom
 - Bloom – fruit set
 - Cell division – cell expansion
 - Pre-veraison – post-veraison
- The later a stress occurs, the smaller its effect on yield

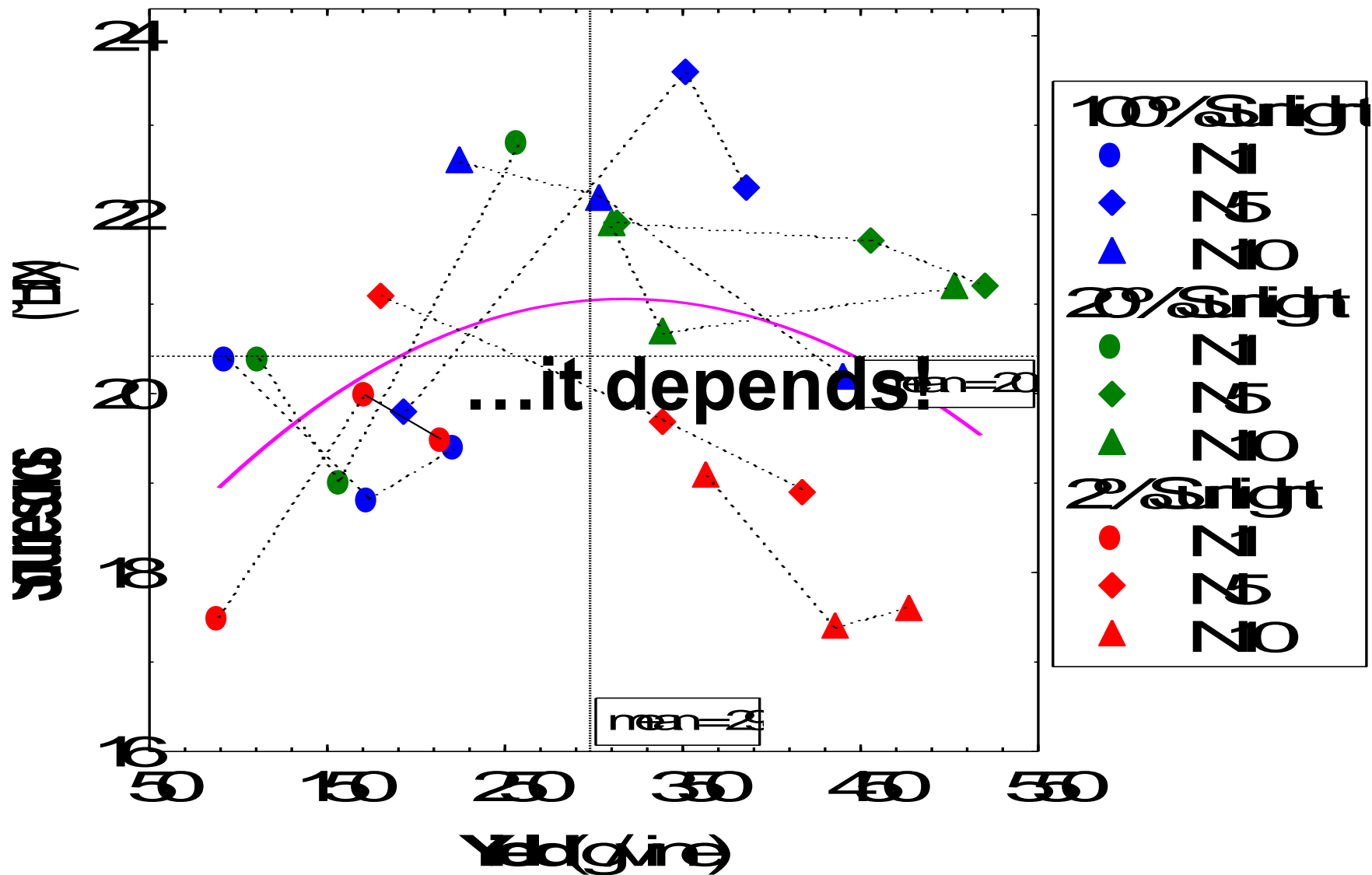


Early stress → Poor fruit set



- N, K, P, Ca, Fe, B, Zn, Cu, Mo, ..., and salinity
- Often 'hens & chicks' (especially Zn, Mo, B)
- Nutrient stress also exacerbates water stress

How much N to apply?

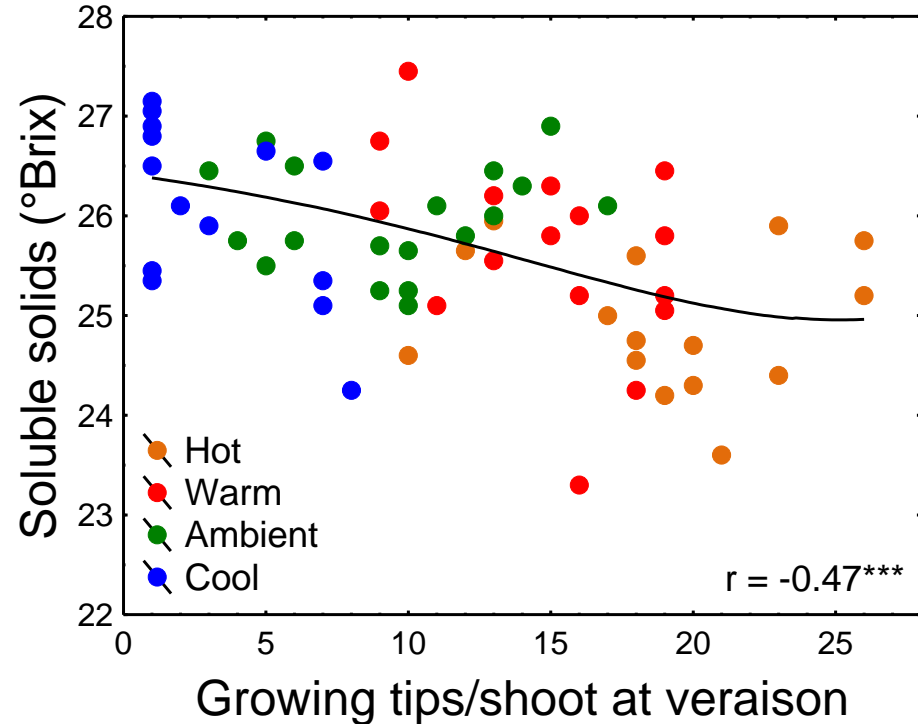
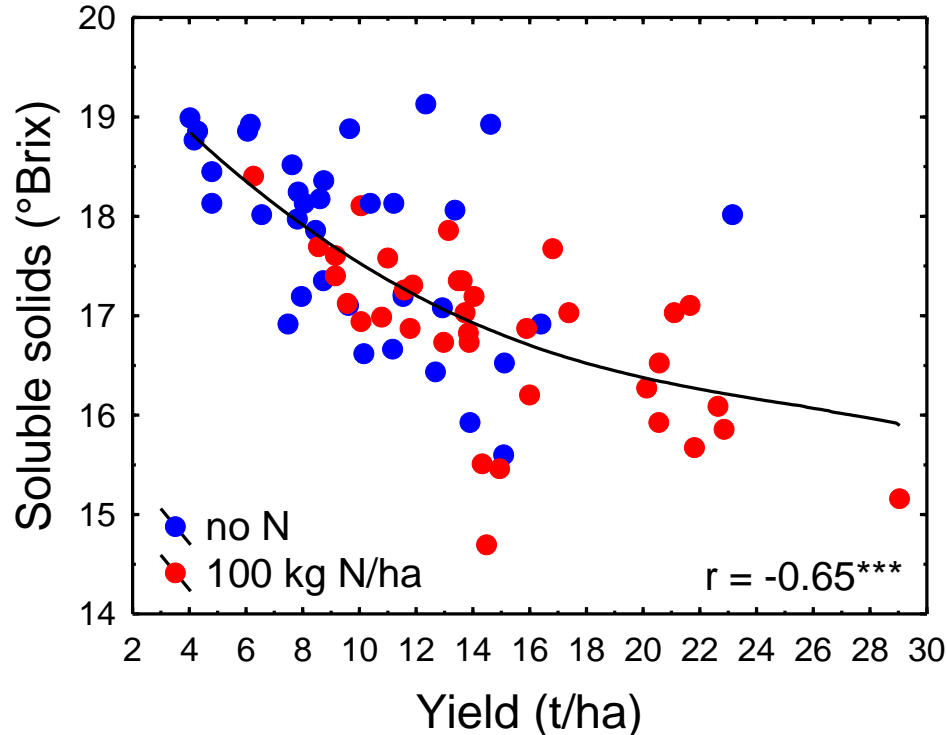


N and fruit quality

- **RDN** (Regulated Deficit Nutrition):
 - Berry size \Downarrow (unless fruit set \Downarrow)
 - Sugar (\Uparrow - \Downarrow)
 - Malate \Downarrow (less production)
 - Tartrate (?)
 - K^+ \Downarrow
 - pH \Uparrow (?)
 - Amino acids (arginine!) \Downarrow
 - Phenolics (anthocyanins, flavonols...) \Uparrow
 - Flavors (\Uparrow - \Downarrow)
- Post-veraison berries remain responsive to N

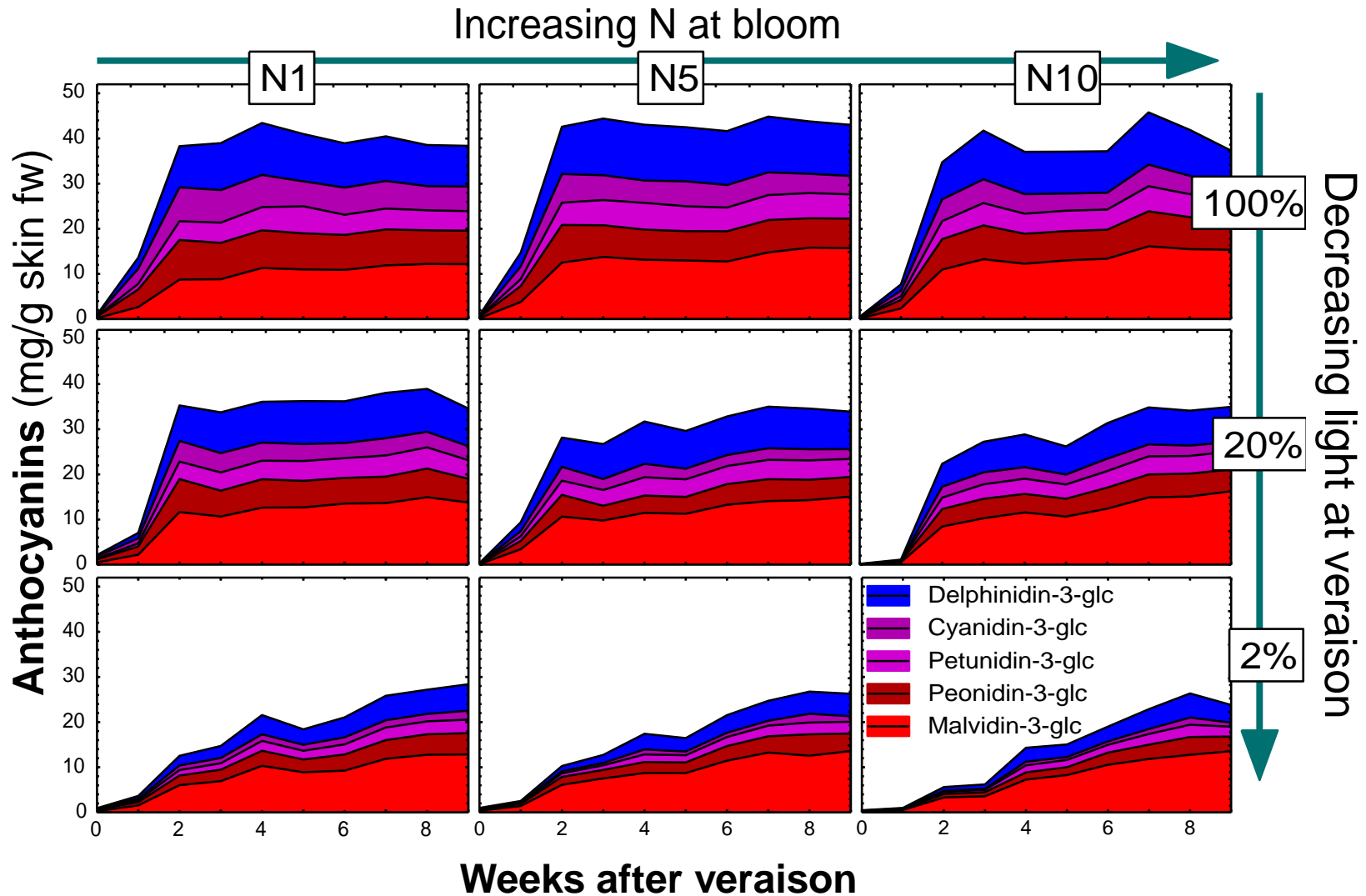


N: Moderation is a virtue



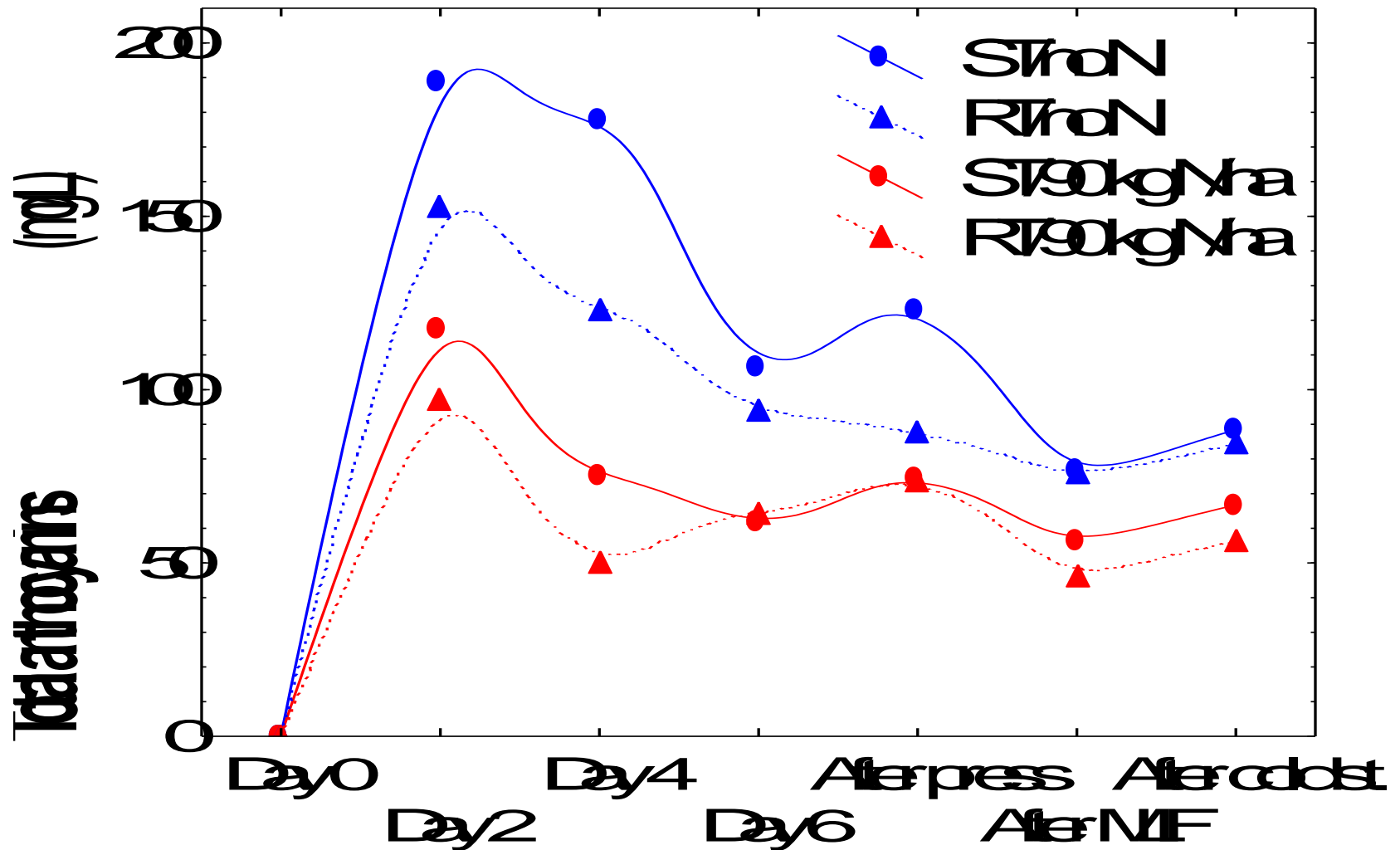
- More N → Higher yield
- More N → More lateral shoot growth, denser canopy
- Growing shoot tips compete with fruit → Delayed ripening
- N suppresses secondary metabolism (phenolics)
- N (and S) enhances volatile thiol precursor production

How to get poor color



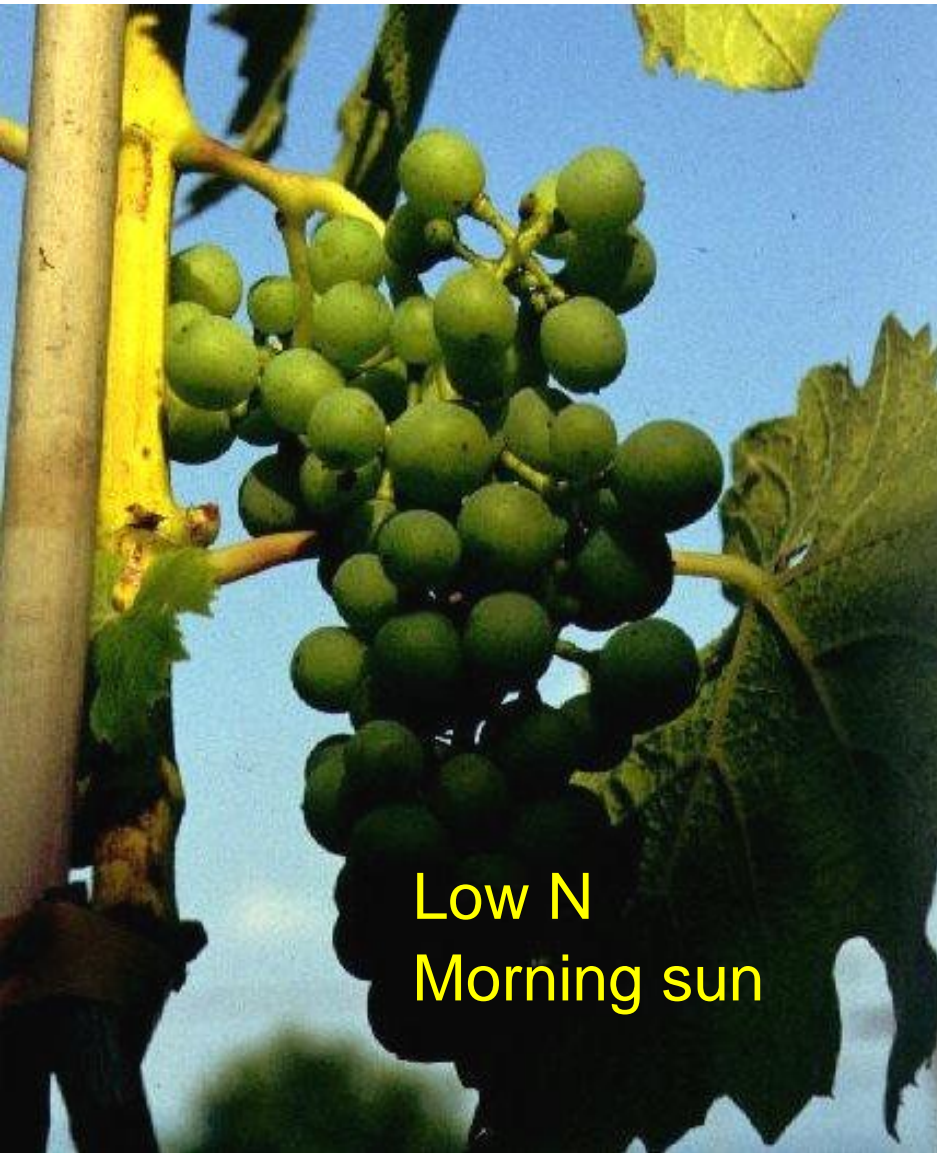
Worst case: High bloom-N + clouds during ripening

Going from bad to worse



Not possible to solve high-N problems with hedging

Exposure: Too much of a good thing?



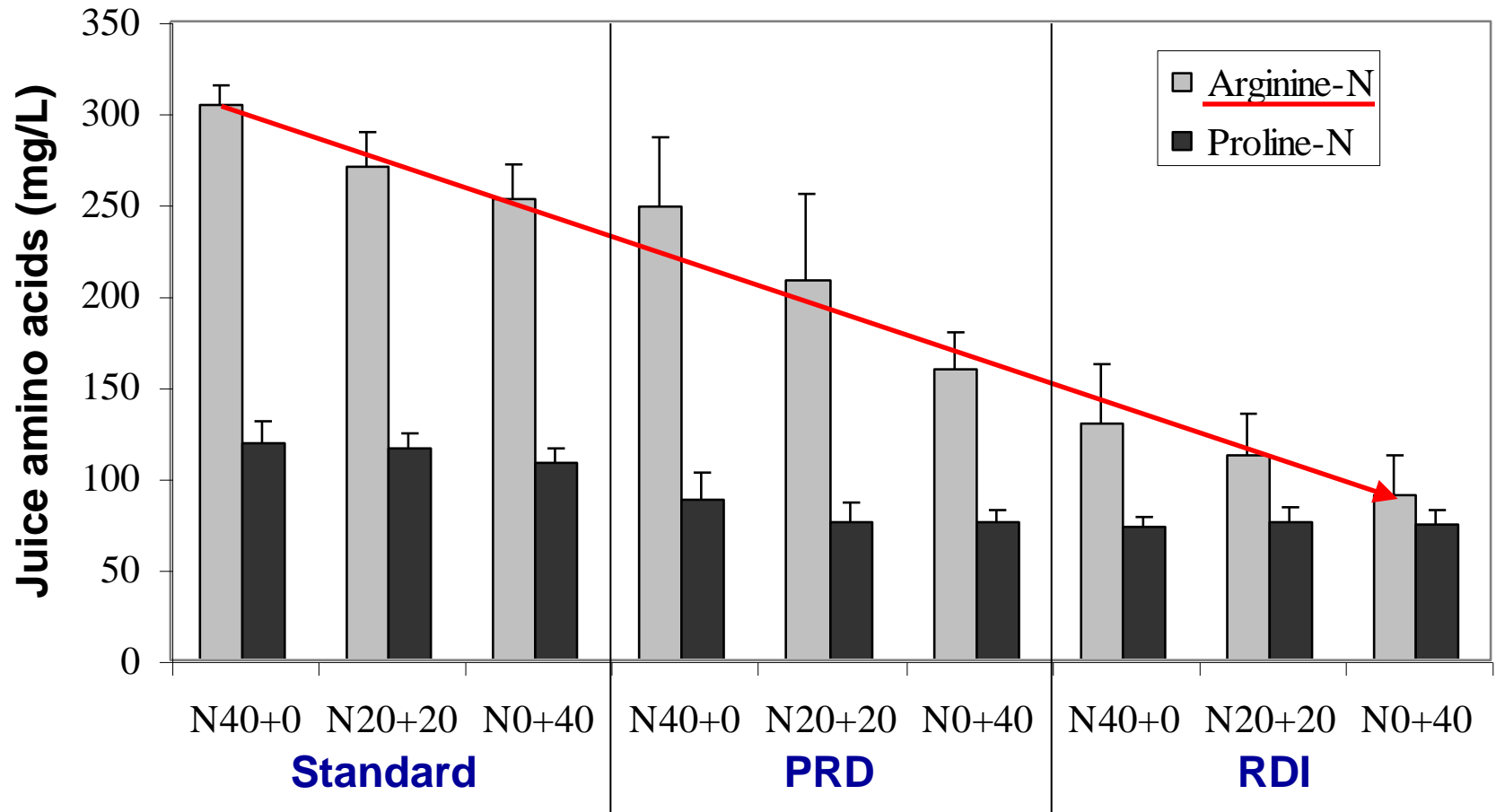
Low N
Morning sun



High N
Afternoon sun

N suppresses flavonol production

Nutrition and deficit irrigation



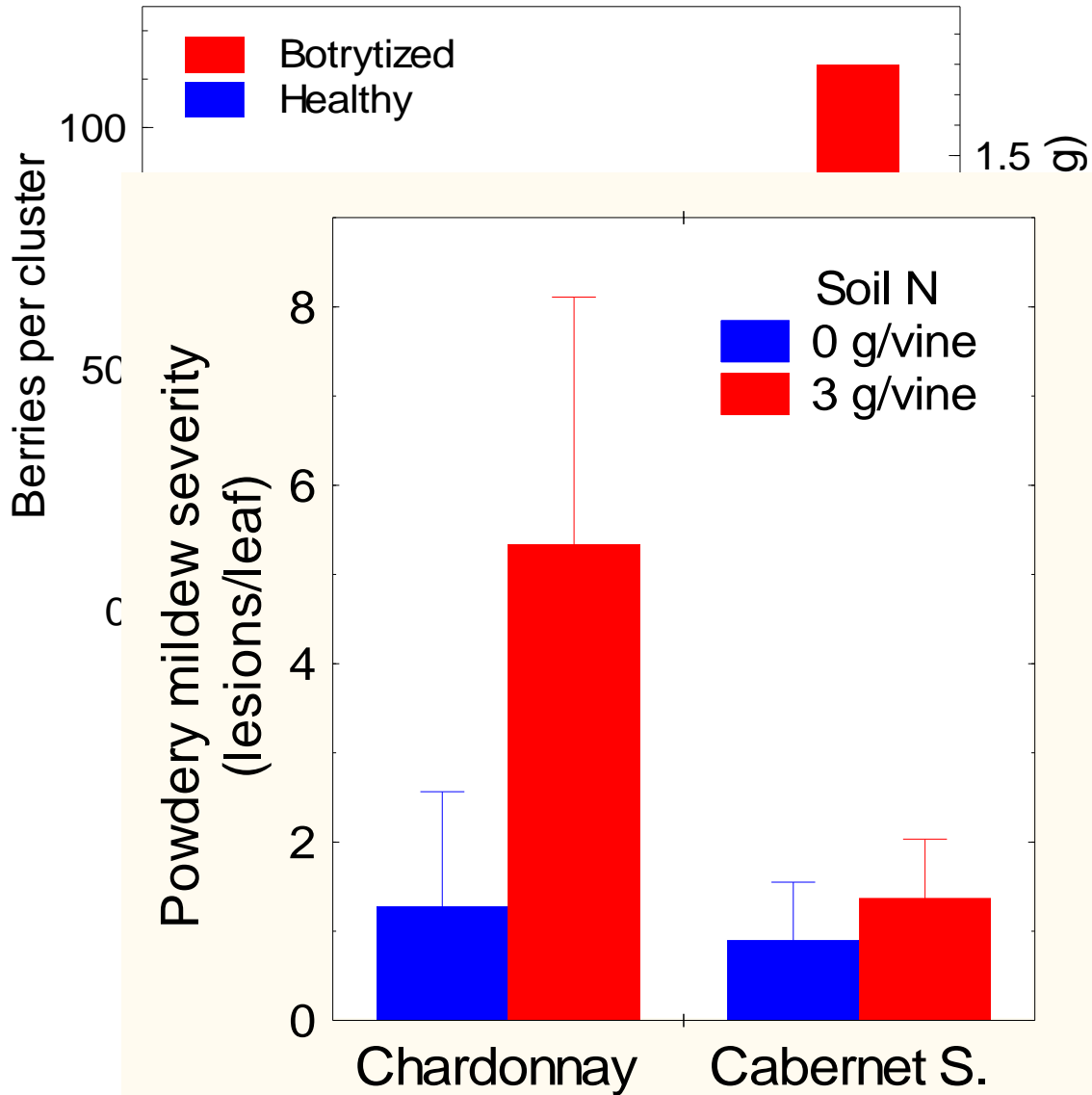
- Food for **yeast**: More N needed with water deficit
- Post-harvest N only with long post-harvest period
- Veraison N as good as bloom N for YAN

The Whites vs. the Reds

- Berry size and sun exposure less important for white grapes (phenolics → astringency, bitterness!)
- Moderate N supply maximizes aroma potential
 - Precursors of volatile thiols (mercaptans)
 - ‘Blackcurrant’, ‘passion fruit’, ‘grapefruit’, (‘skunk’!)
- Low N → Low YAN (<150 mg/L) → Sluggish/stuck fermentation → H₂S (‘rotten eggs’!)
- More N may delay ripening
 - Acid/flavor retention (advantage in hot seasons)



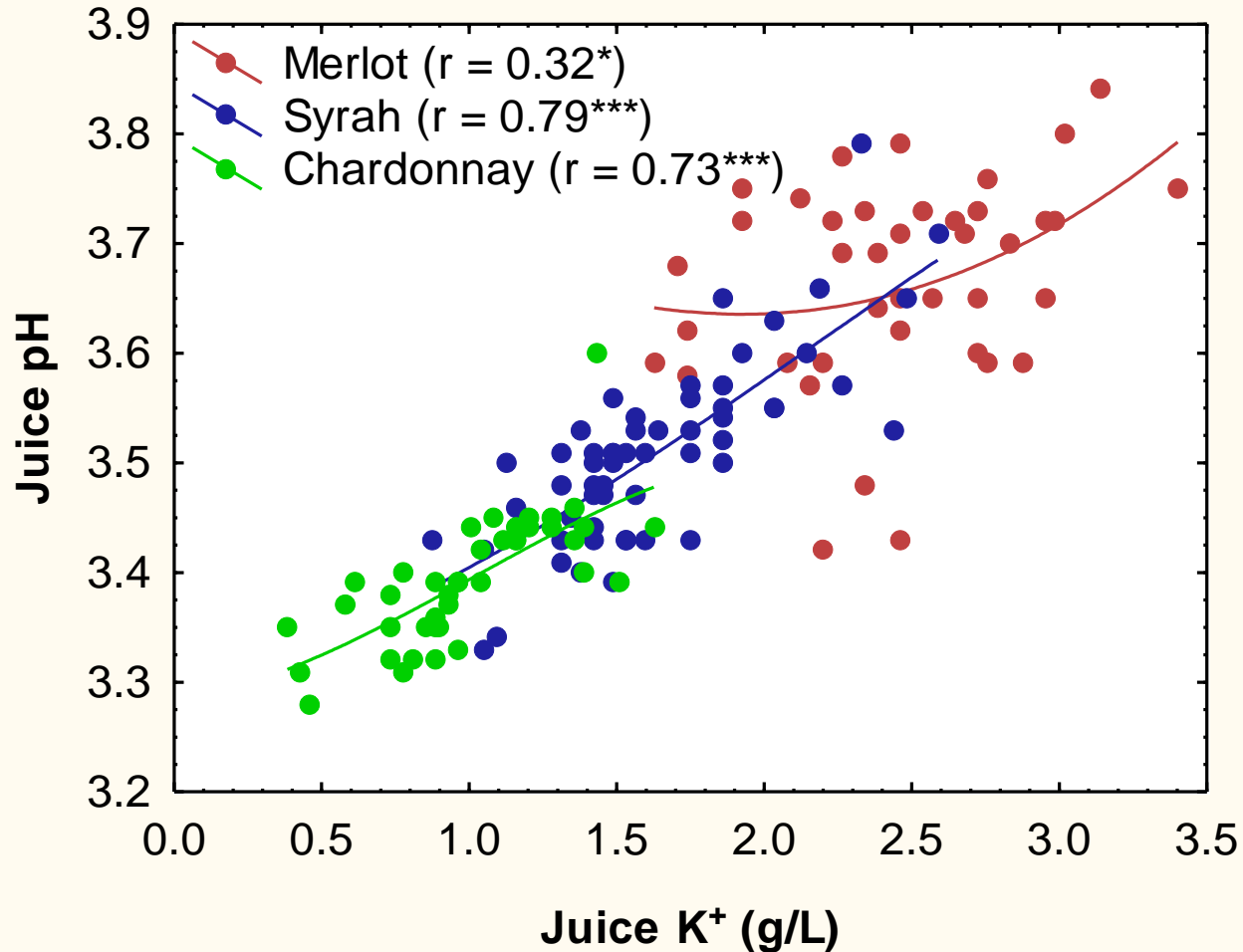
High N → Disease susceptibility



***Botrytis*: What is the problem?**

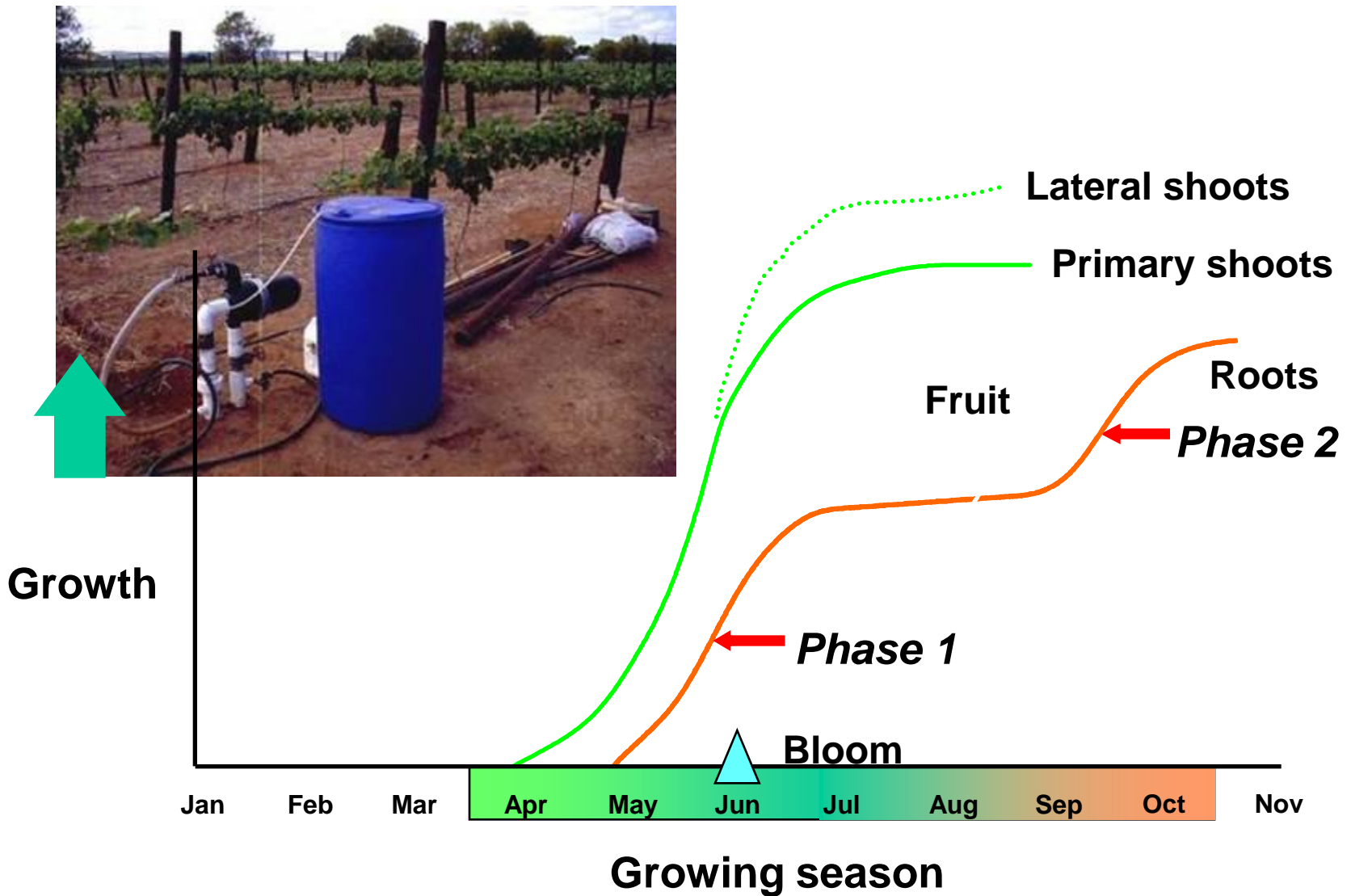
- *Botrytis* destroys berry cell integrity (membrane rupture)
→ Mixing of cell components
- *Botrytis* secretes laccase = 'nasty' form of PPO
(stable at low pH, high temperature (>120°F), ethanol)
→ Oxidizes phenolics
(hydroxycinnamates, anthocyanins, tannins)
- Oxidation products (quinones) oxidize other compounds
(ascorbate, SO₂)
- Worse in grapes with high hydroxycinnamate and low glutathione (S transport & storage form) contents
→ Control *Botrytis*, avoid mechanical damage, N and S deficiency or excess, (late) overexposure!

K: The pH conundrum

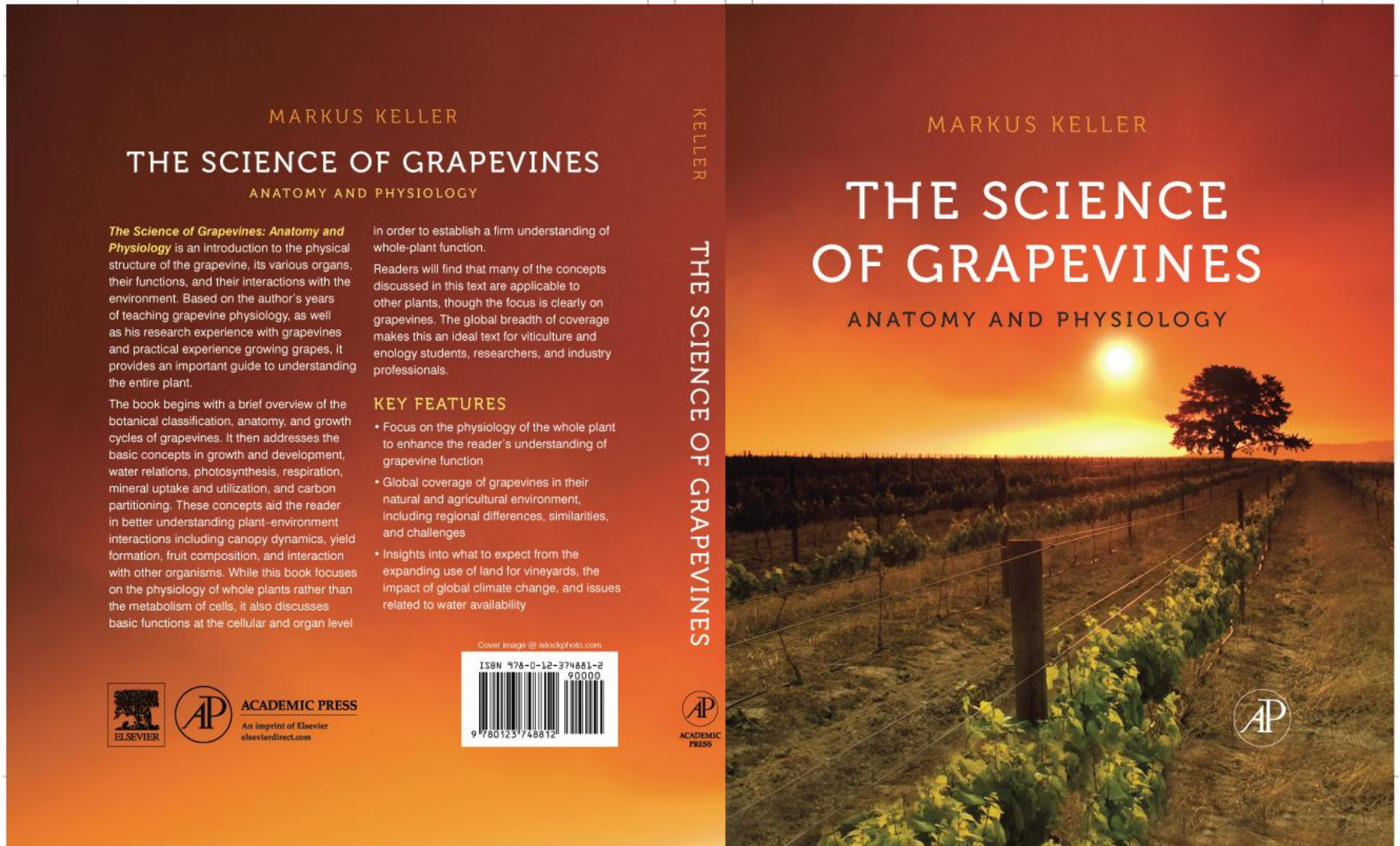


- Juice and wine pH is sensitive to K
- Juice pH is not very responsive to soil K (→ More malate)
- High soil pH may lead to lower juice pH (→ Ca)

When to apply nutrients?



The good news: It's in the book!



MARKUS KELLER

THE SCIENCE OF GRAPEVINES

ANATOMY AND PHYSIOLOGY

The Science of Grapevines: Anatomy and Physiology is an introduction to the physical structure of the grapevine, its various organs, their functions, and their interactions with the environment. Based on the author's years of teaching grapevine physiology, as well as his research experience with grapevines and practical experience growing grapes, it provides an important guide to understanding the entire plant.

The book begins with a brief overview of the botanical classification, anatomy, and growth cycles of grapevines. It then addresses the basic concepts in growth and development, water relations, photosynthesis, respiration, mineral uptake and utilization, and carbon partitioning. These concepts aid the reader in better understanding plant-environment interactions including canopy dynamics, yield formation, fruit composition, and interaction with other organisms. While this book focuses on the physiology of whole plants rather than the metabolism of cells, it also discusses basic functions at the cellular and organ level

in order to establish a firm understanding of whole-plant function.

Readers will find that many of the concepts discussed in this text are applicable to other plants, though the focus is clearly on grapevines. The global breadth of coverage makes this an ideal text for viticulture and enology students, researchers, and industry professionals.

KEY FEATURES

- Focus on the physiology of the whole plant to enhance the reader's understanding of grapevine function
- Global coverage of grapevines in their natural and agricultural environment, including regional differences, similarities, and challenges
- Insights into what to expect from the expanding use of land for vineyards, the impact of global climate change, and issues related to water availability

Cover Image @ istockphoto.com

ISBN 978-0-12-374881-2



ACADEMIC PRESS

An imprint of Elsevier
elsevierdirect.com



ACADEMIC PRESS

MARKUS KELLER

THE SCIENCE OF GRAPEVINES

ANATOMY AND PHYSIOLOGY



www.amazon.com/Science-Grapevines-Anatomy-Physiology/dp/012374881X