Optimising Blueberry Nutrition

Physiological Mechanisms & Agronomic Implications

A scientific–industry synthesis

Dr Estelle Kempen · Delphy South Africa / Stellenbosch University

The useful question is not 'did the plant grow?'

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The commercial question is whether the nutrition programme improves fruit that reaches a premium market.

Every fertigation decision should be evaluated against measurable crop response.

Berry Size

Firmness

Harvest Timing

Pack-out Consistency

Postharvest Performance

For each change in fertigation, the guiding question should be: what crop response are we trying to buy — and how will we measure it?





Nutrition works through a chain, not a recipe

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Fertigation Input ▶ **Root-zone Condition** ▶ **Canopy Balance** ▶ **Fruit Development** ▶ **Marketable Quality**

A fertiliser programme succeeds only when the response it generates is commercially useful. This is why leaf values, vigour and yield must always be interpreted alongside harvest timing, fruit firmness and postharvest behaviour.

Measuring only vigour or EC is insufficient — connecting each step in the chain converts a fertiliser programme into production management.





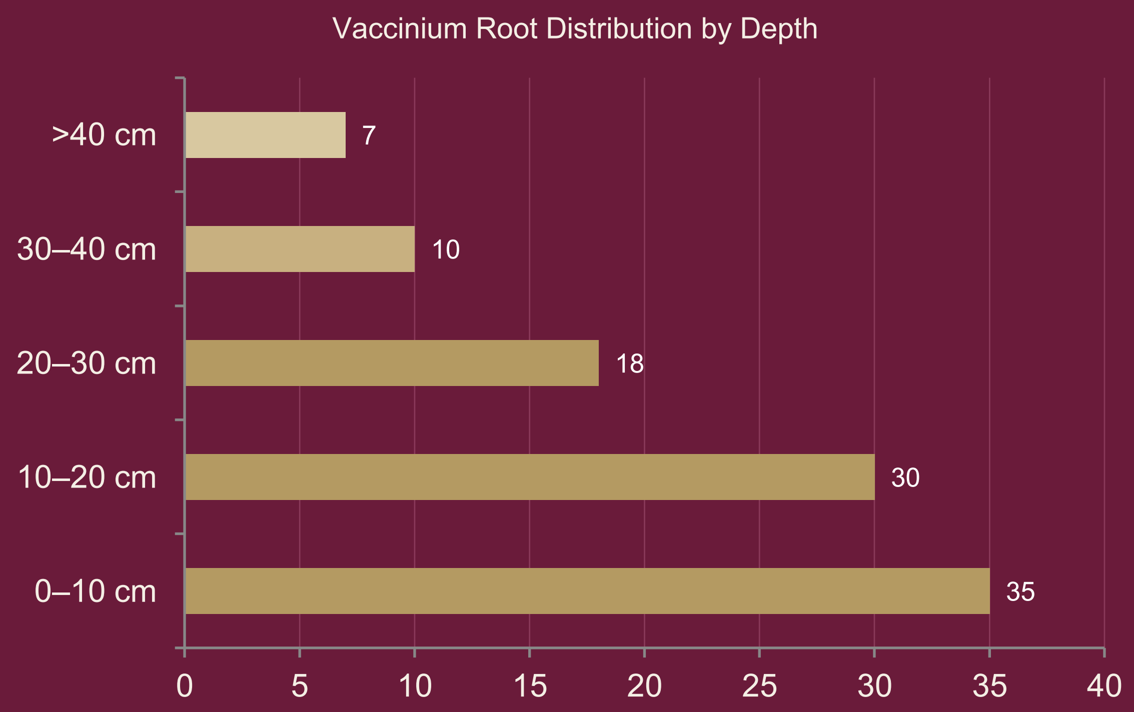
Blueberry nutrient uptake is shaped by an unusual root system

Key characteristics of Vaccinium root systems

- Very fine fibrous roots — no root hairs
- Shallow distribution: majority in top 20–40 cm
- Low root length density limits soil exploration
- High sensitivity to root-zone pH and EC
- Ericoid mycorrhizal fungi are critical for nutrient acquisition

Functional implications

- Cannot compensate for pH drift or salt stress by deeper rooting
- Mycorrhizae extend effective root surface — essential given absent root hairs



Indicative distribution based on published Vaccinium root studies

Rhizosphere pH in blueberry systems is rarely stable

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1

Nitrogen form

NH_4^+ uptake → acidification | NO_3^- uptake → alkalinisation

2

Irrigation alkalinity

Bicarbonate loads of 1–4 meq L^{-1} often exceed the acidifying effect of fertiliser N

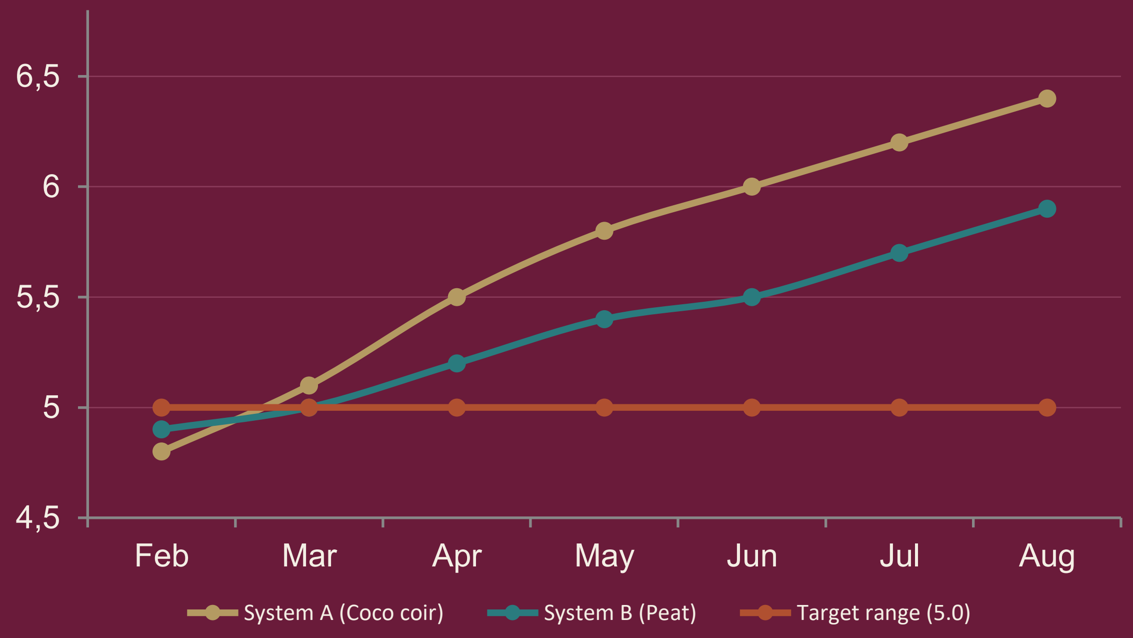
3

Substrate buffering

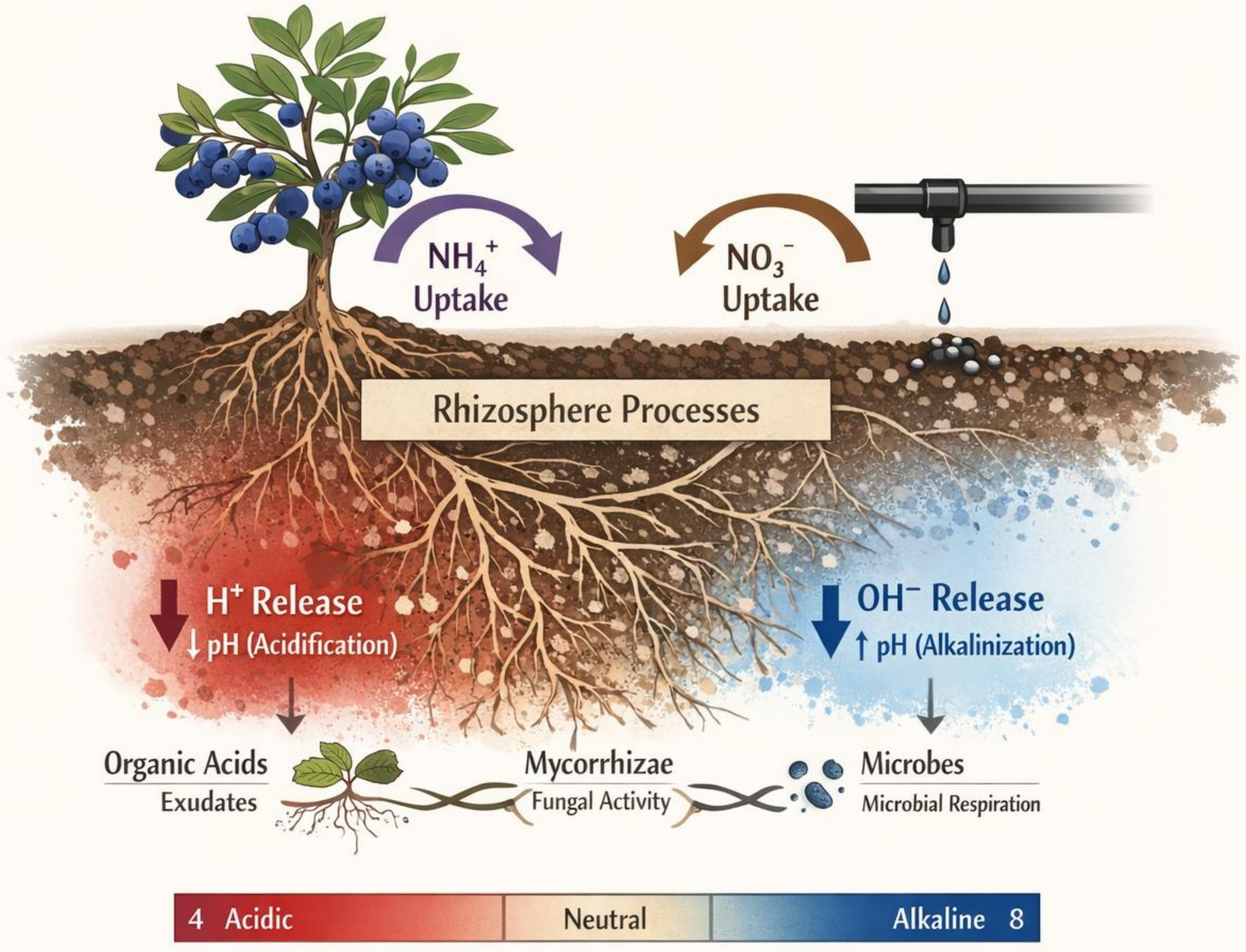
Peat: moderate | Coco coir: low | Sandy soil: very low

Stable pH is an active management task. Monitor drainage pH regularly — pH drift of 0.5–1.0 units was observed in SA substrate systems despite constant fertigation recipes.

Observed pH Drift Over Season — Substrate Systems (SA)



Illustrative patterns based on SA substrate system observations



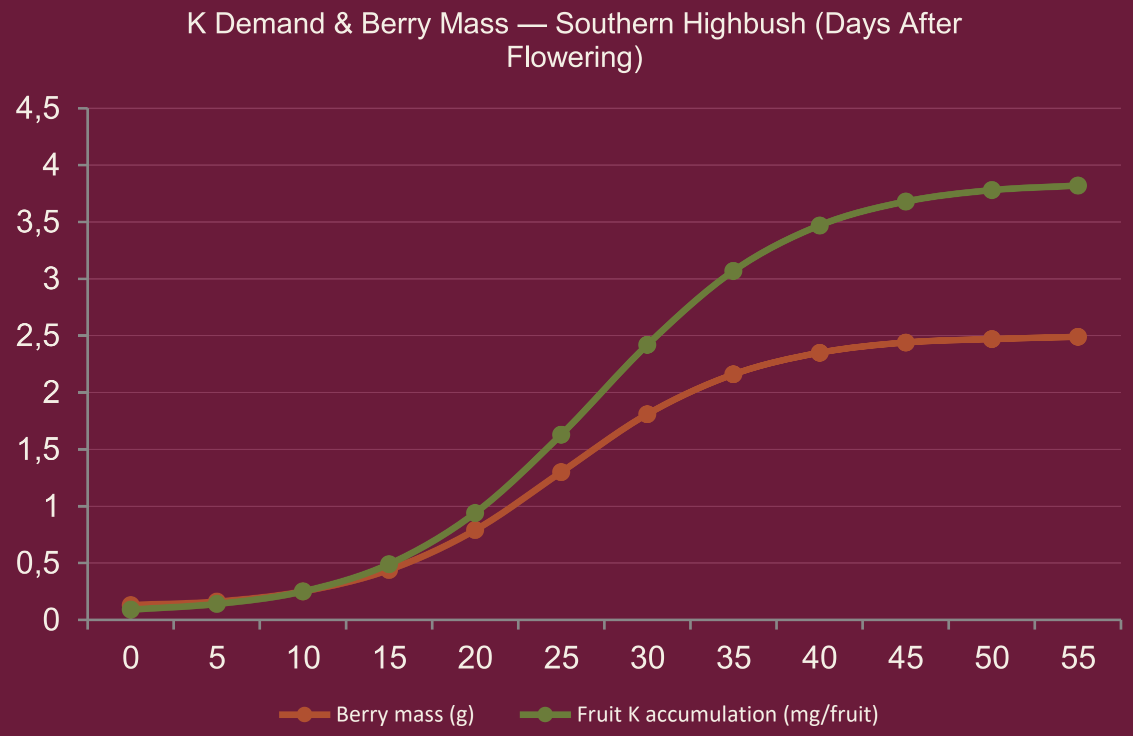
NH_4^+ Uptake
NO_3^- Uptake
Rhizosphere Processes
H^+ Release
↓ pH (Acidification)
OH^- Release
↑ pH (Alkalinization)
Organic Acids
Exudates
Mycorrhizae
Fungal Activity
Microbes
Microbial Respiration
4 Acidic
Neutral
Alkaline 8

Potassium is the dominant cation accumulated in blueberry fruit

Physiological roles of potassium in fruit

- Osmotic regulation driving cell expansion
- Maintenance of fruit turgor pressure
- Activation of enzymes in carbohydrate metabolism
- Facilitation of phloem loading and sugar transport

Trade-off: excessive K supply may reduce Ca uptake via cation competition → softer fruit. K:Ca balance matters as much as absolute K level.







Calcium delivery to blueberry fruit is physiologically constrained

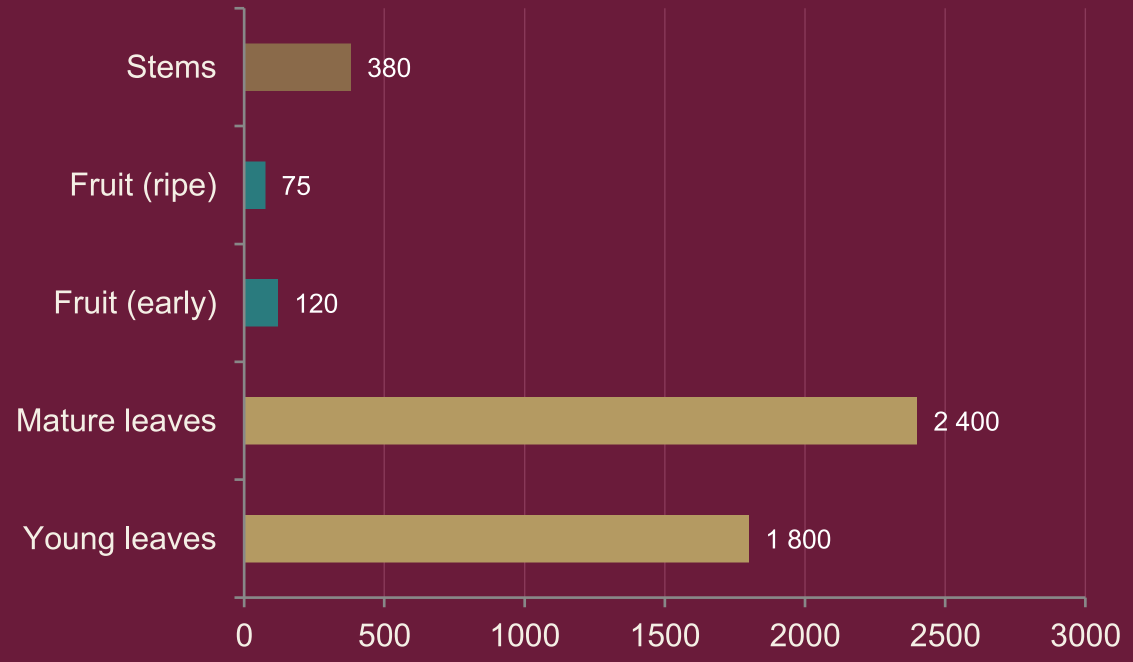
Key characteristics of Ca transport

- Ca moves primarily through the xylem transpiration stream
- Ca has very low phloem mobility
- Fruit transpiration rates are relatively low — limiting xylem-driven delivery to fruit

Consequences for blueberry fruit

- Inherently low Ca accumulation in berries
- Strong dependence on early-season Ca supply
- Late-season foliar Ca sprays have limited impact on internal fruit Ca
- Even improved Ca formulations rarely raise internal fruit Ca due to physiological immobilisation

Ca Distribution Across Plant Tissues (Indicative)



Compiled from Vaccinium Ca distribution literature ranges

Protect firmness before harvest — it cannot be recovered

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Ca for fruit firmness

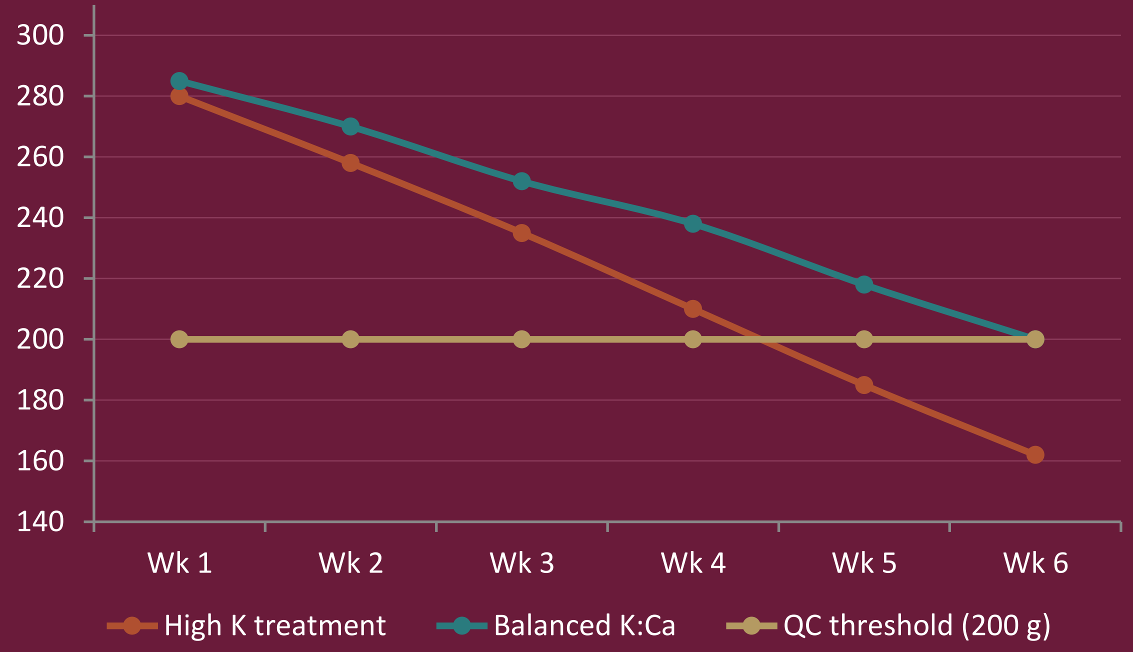
- Stabilises cell wall pectin structure
- Strengthens middle lamella between cells
- Improves membrane stability and reduces leakage

High K supply increases vegetative and fruit sink strength, which may reduce Ca allocation to fruit — the critical firmness mineral.

Management actions

- Time K supply peaks to match berry expansion; reduce K late season
- Maintain adequate Ca in fertigation from early fruit set
- Monitor K:Ca ratio in leachate as a real-time signal

Firmness Decline Over Harvest Season (g force)



Conceptual illustration based on published firmness decline patterns (Moggia et al., 2017)

Larger berries frequently show lower Ca concentration — the dilution effect

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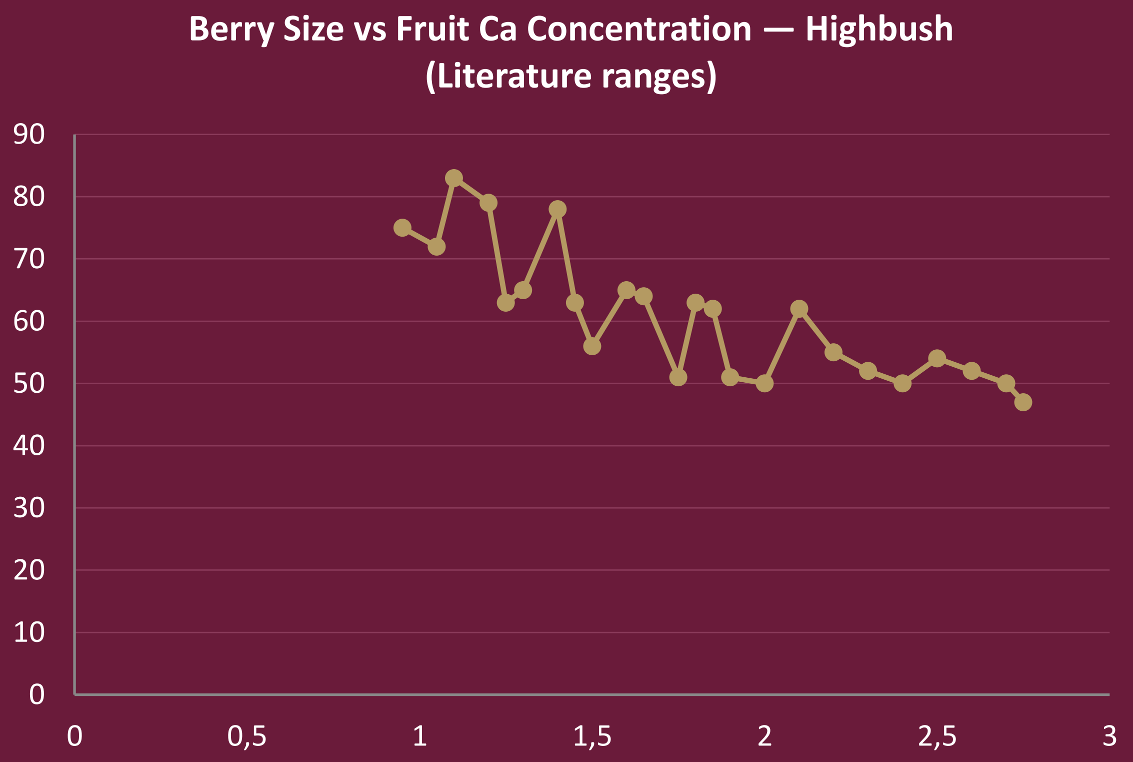
During rapid berry expansion, fruit volume increases faster than Ca can accumulate. This dilution effect is most pronounced for Ca and Mg, already present at low baseline concentrations.

Berry expansion → Rapid volume ↑ → Dry matter lags → **Ca concentration diluted**

- Low fruit Ca is not always caused by inadequate Ca supply — rapid expansion is often the primary driver
- Strategies maximising berry size may inadvertently reduce Ca concentration and increase postharvest softening risk
- Interpret fruit Ca data in context of berry size and growth rate



Plant vigour is a diagnostic signal, not the production target

Higher N consistently increases vegetative growth — but maximum vigour is not the same as optimum performance.

What N increases

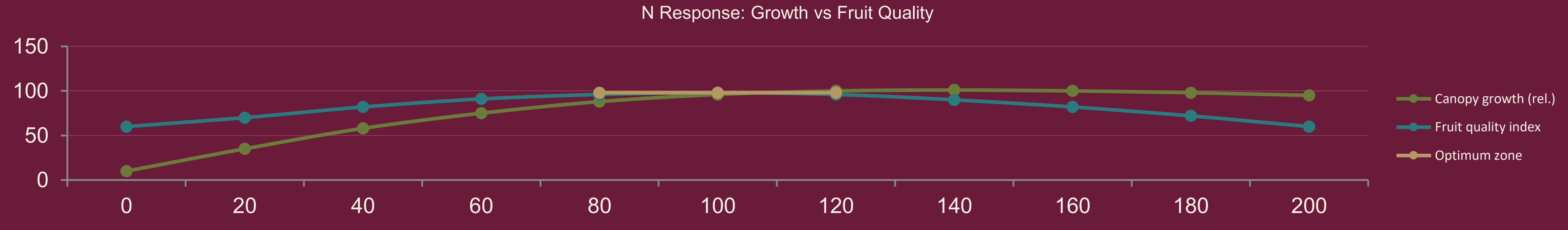
- Shoot growth & canopy density
- Vegetative sink strength
- Nutrient uptake capacity
- Canopy development speed

What N may reduce

- Harvest timing predictability
- Berry size at high rates (Fang et al., 2020)
- Relative fruit quality at extreme rates
- Ca allocation to fruit

Optimum target

- Balanced canopy, efficient resource use
- Earlier harvest window
- Marketable fruit size & firmness
- Reduced vegetative competition



How should we manage NH_4^+:NO_3^- balance?

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Blueberries are acid-loving plants, but the ammonium:nitrate ratio should be managed as a production tool — not assumed from generic 'prefers ammonium' rules.

N Form Pattern	Reported Response	Technical Relevance
More NH_4^+ dominant	Can advance flowering/fruit set in some studies	Useful for timing; monitor root-zone pH carefully
Balanced NH_4^+:NO_3^-	Promoted growth, nutrient uptake and fruiting in controlled work	Potentially a useful benchmark for substrate systems
More NO_3^- dominant	Can support shoot extension or sugar accumulation in some contexts	Response is cultivar-, medium- and climate-dependent

A 'blueberry prefers ammonium' rule is too crude for modern SHB substrate production. Manage total N level, N form and timing as a combined lever. Source: Anwar et al. (2024); Arias et al. (2024).

How much nutrition do Southern Highbush blueberries actually require?

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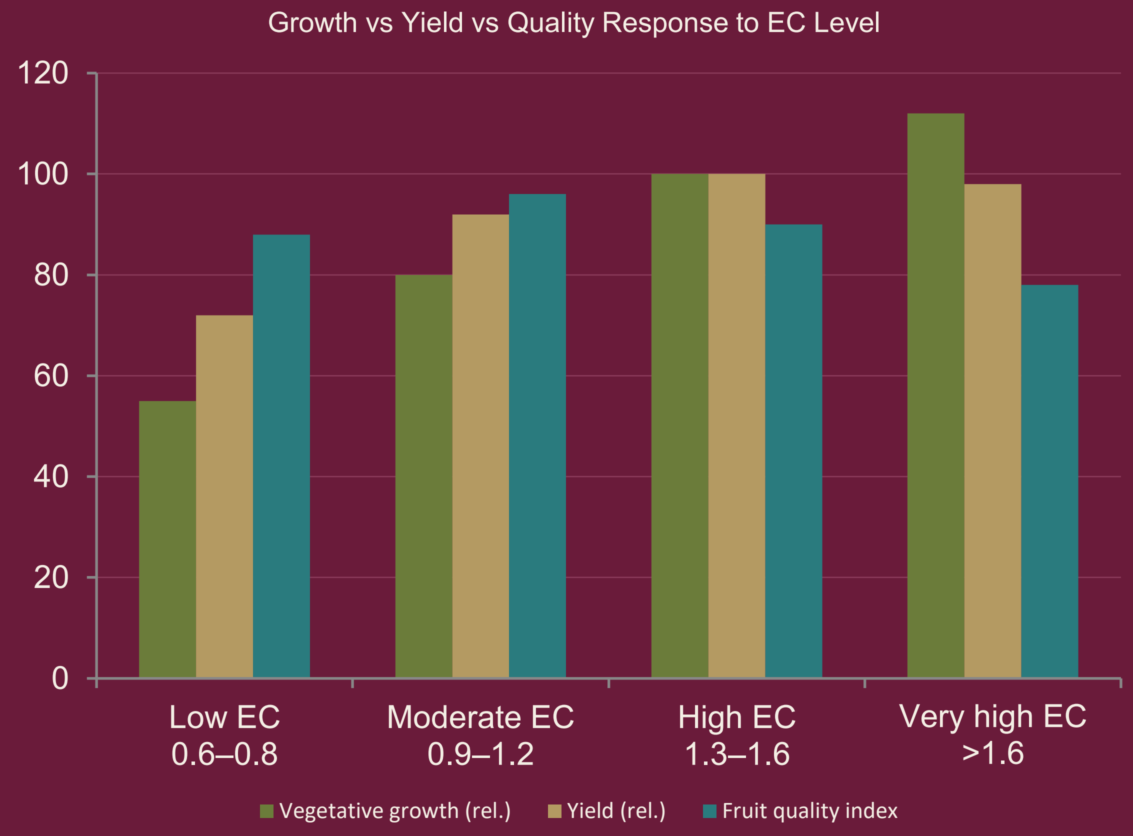
Despite widespread fertigation use, optimal supply levels remain debated. Commercial observations show high variation between programmes — with excessive vegetative growth common in high-N systems.

- Relatively modest EC values are commonly used commercially
- Moderate EC treatments often match yields of higher EC
- Higher input does not proportionally translate to improved fruit quality
- Excessive vegetative growth frequently observed in high-N programmes

Region	Typical EC (mS cm^{-1})
Chile	~0.9–1.4
Spain	~0.8–1.3
South Africa	**often <1.2**



Can productivity be maintained with lower fertiliser inputs?

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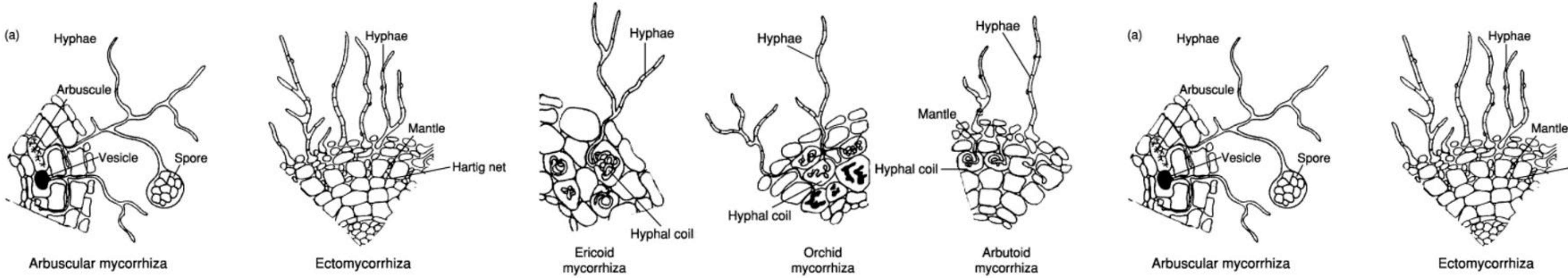
Ericoid mycorrhizal fungi offer a route to reducing fertiliser dependency — but the yield–quality trade-off must be managed carefully.

What ericoid mycorrhizae can do

- Improve N acquisition from organic and inorganic sources
- Enhance phosphorus uptake
- Extend functional root surface area — compensating for absent root hairs
- Partially compensate for reduced nutrient availability under low EC

Evidence from local trials

- Low EC + mycorrhiza treatments showed similar growth and yield to controls in local trials
- Fruit quality parameters were slightly lower under reduced supply in some trials
- Berry size, firmness and postharvest quality remain sensitive to nutrient supply level
- Biological acquisition may allow input reduction, but yield–quality balance remains critical



Evaluating nutrition by crop response — a five-step framework

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1 **Define the target response**

Earlier harvest, stronger canopy, firmer fruit, or better pack-out — before changing the programme

2 **Track the root-zone**

EC, pH, drainage fraction, moisture and irrigation uniformity — not just the feed recipe

3 **Sample by crop stage**

Leaf and fruit analysis aligned with phenological windows, not only calendar dates

4 **Link nutrition to fruit outcomes**

Firmness, size, soluble solids, acidity and defect rates per harvest week

5 **Interpret by cultivar type**

Contrasting harvest windows between cultivar types may not respond identically to the same programme

Where the evidence is still insufficient for confident local recommendations

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The current evidence supports the principle of targeted nutrition, but a robust South African decision basis for nitrogen programmes requires further local work.

N level	N form	Crop stage
Cultivar type	Ca status	VPD risk

Research needed

Local evidence linking N level and form to phenology, harvest distribution, calcium status, VPD exposure and postharvest quality under substrate-grown SHB conditions.

The goal is not another fertiliser recipe — it is a field-ready interpretation system for steering Southern Highbush blueberries toward the right fruit at the right time.

The most useful nutrition programme is the one that produces the right fruit at the right time.

Thank you

Questions and discussion welcome

Dr Estelle
estellekempen@sun.ac.za