Managing nutrition in high density apple and sweet cherry

Denise Neilsen and Gerry Neilsen
Agriculture and Agri-Food Canada,
Pacific Agri-Food Research Centre,
Summerland, British Columbia, Canada

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Nutrient management in apple and cherry

- **compared with high density apple production little information is available for sweet cherry**

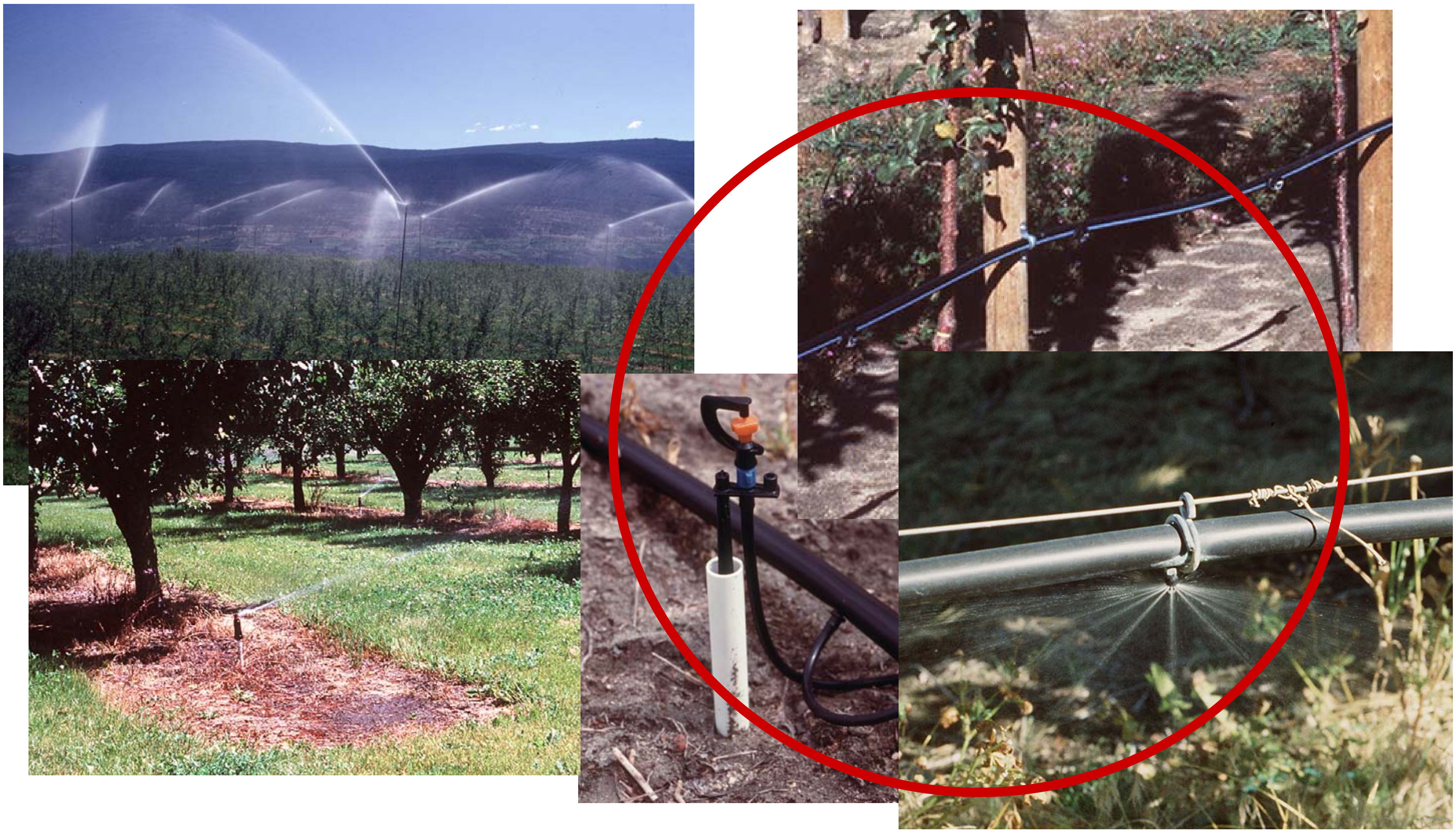
- **principles similar and can be applied to both**

Nutrition and water management are linked

water is

- **a solvent for nutrients in the soil and plant**
- **a transporting agent for nutrients to the root and within the plant**
- **irrigation management is the key to nutrient placement and retention in root zone**

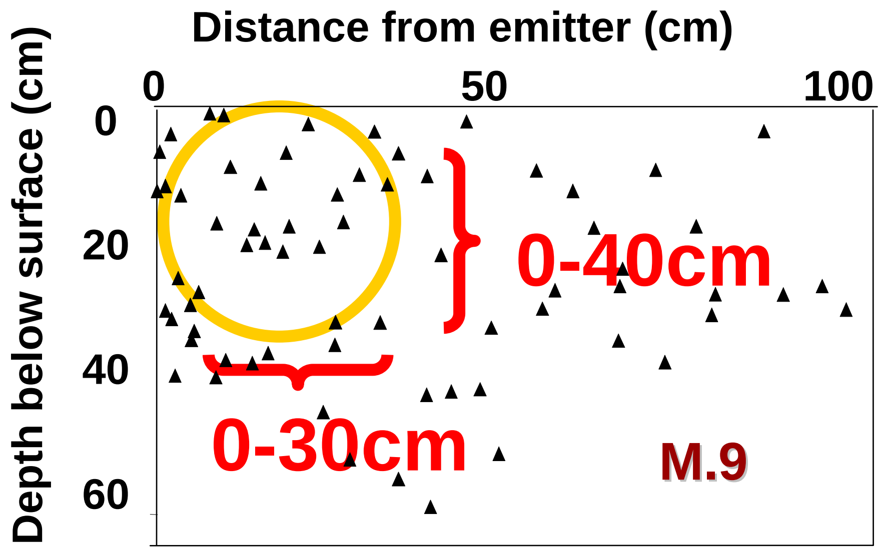
Increasing density - more water and nutrient management options

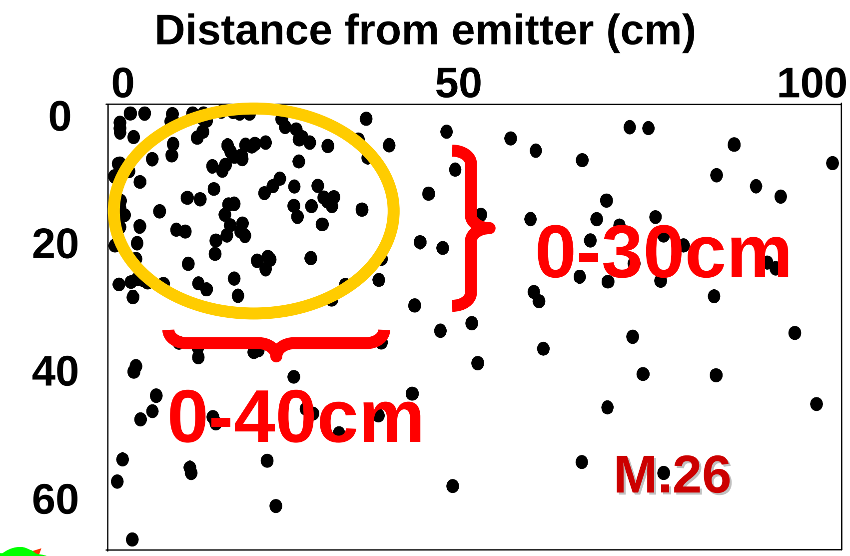


Nutrient Availability

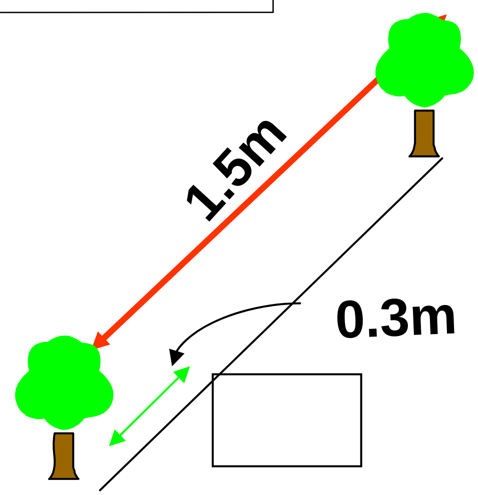
- Accessible to plant roots
- Timed to match demand
- Sufficient quantity

Root distribution under drip irrigation



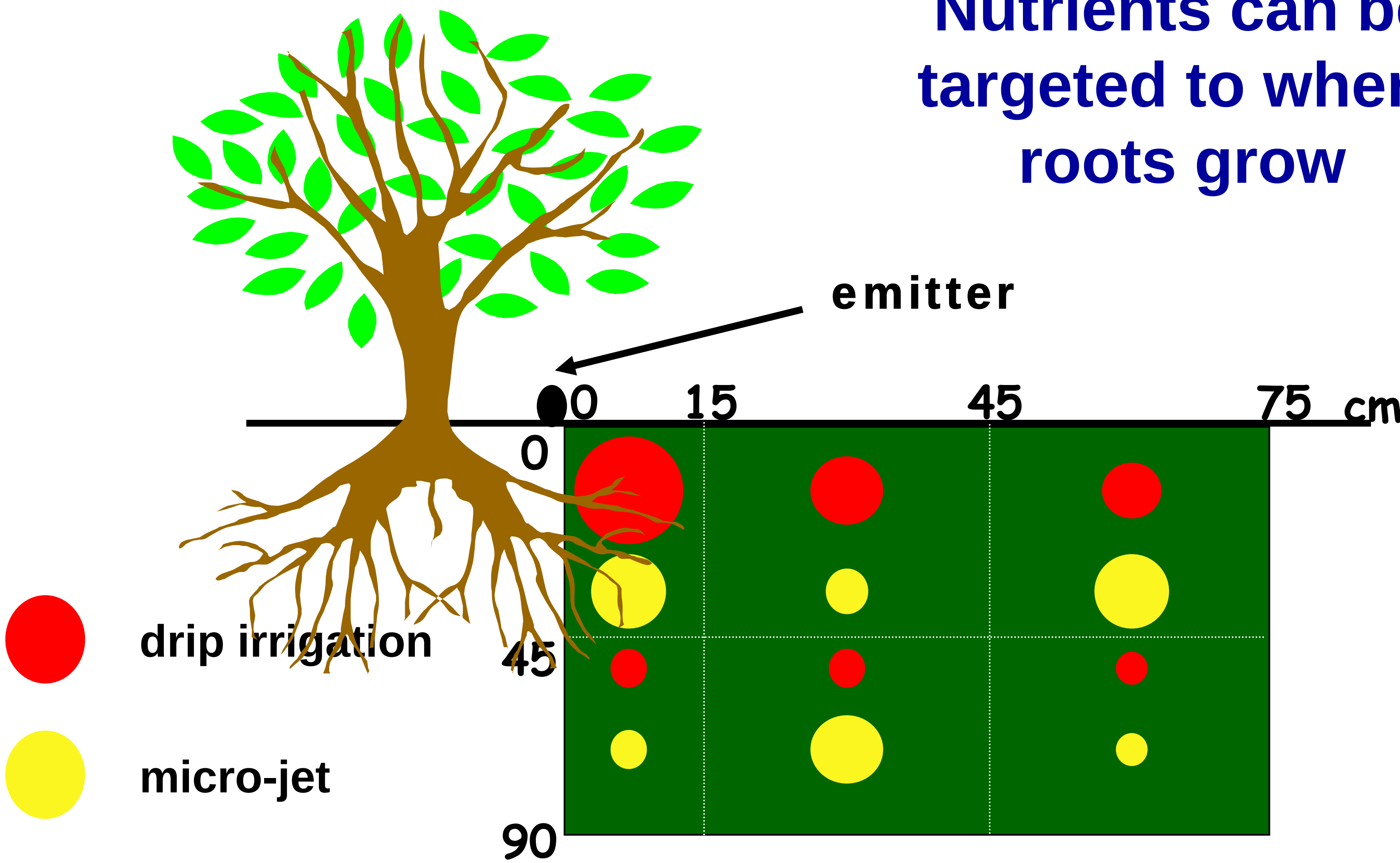


Neilsen et al. 1997
Can. J. Plant Sci. 77



Where roots grow

Nutrients can be targeted to where roots grow



Nutrient solubility and mobility

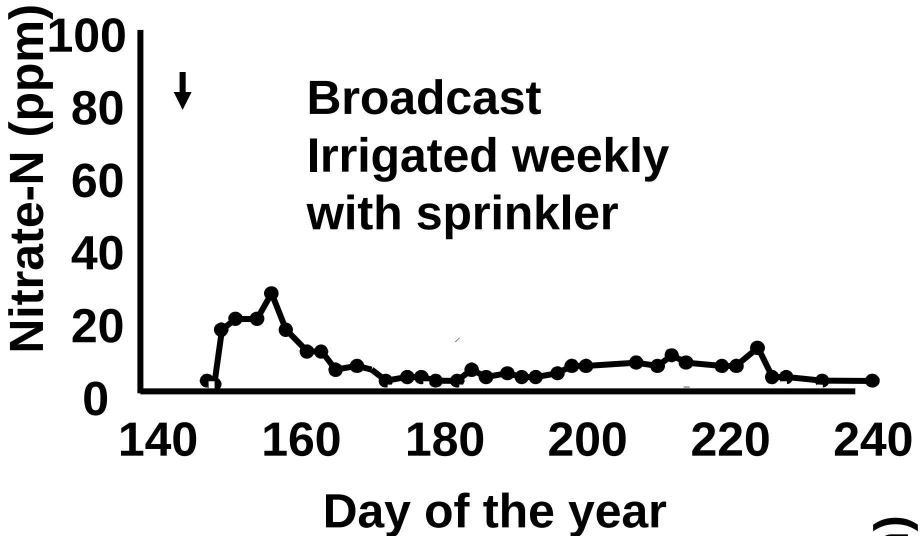
- **Mobile nutrients – N, B, Cl**
  - **remain dissolved in the soil solution**
  - **move by mass flow**
- **Moderately mobile nutrients – Ca, Mg, Na, K**
  - **remain dissolved in solution and are easily exchanged from soil particles**
  - **move by mass flow**
- **Immobile nutrients – K, P, Zn, Mn**
  - **fixed by soil**
  - **move by diffusion (occasionally mass flow)**

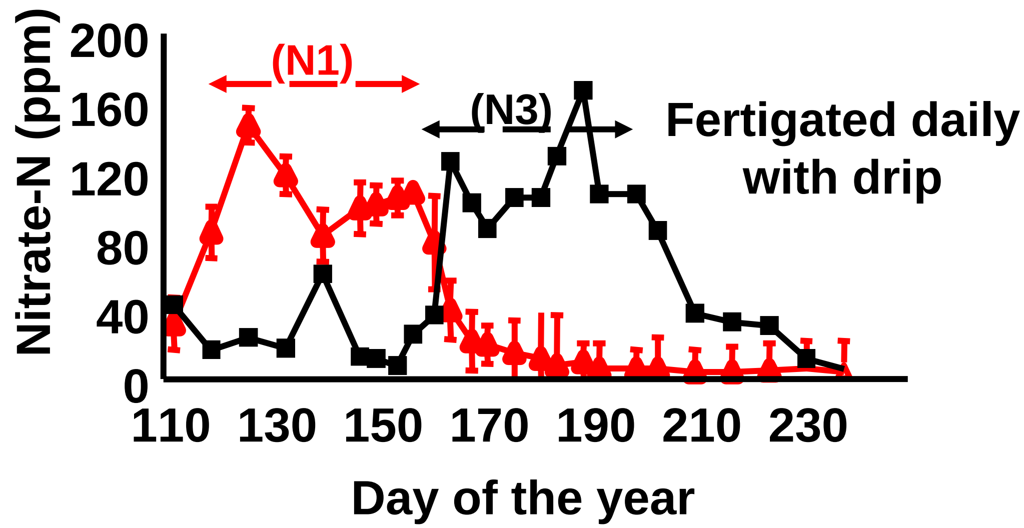
Mobile nutrients – N, B

Mobile nutrients

- Nitrogen
  - very mobile
  - allows flexibility in application
  - but difficult to control

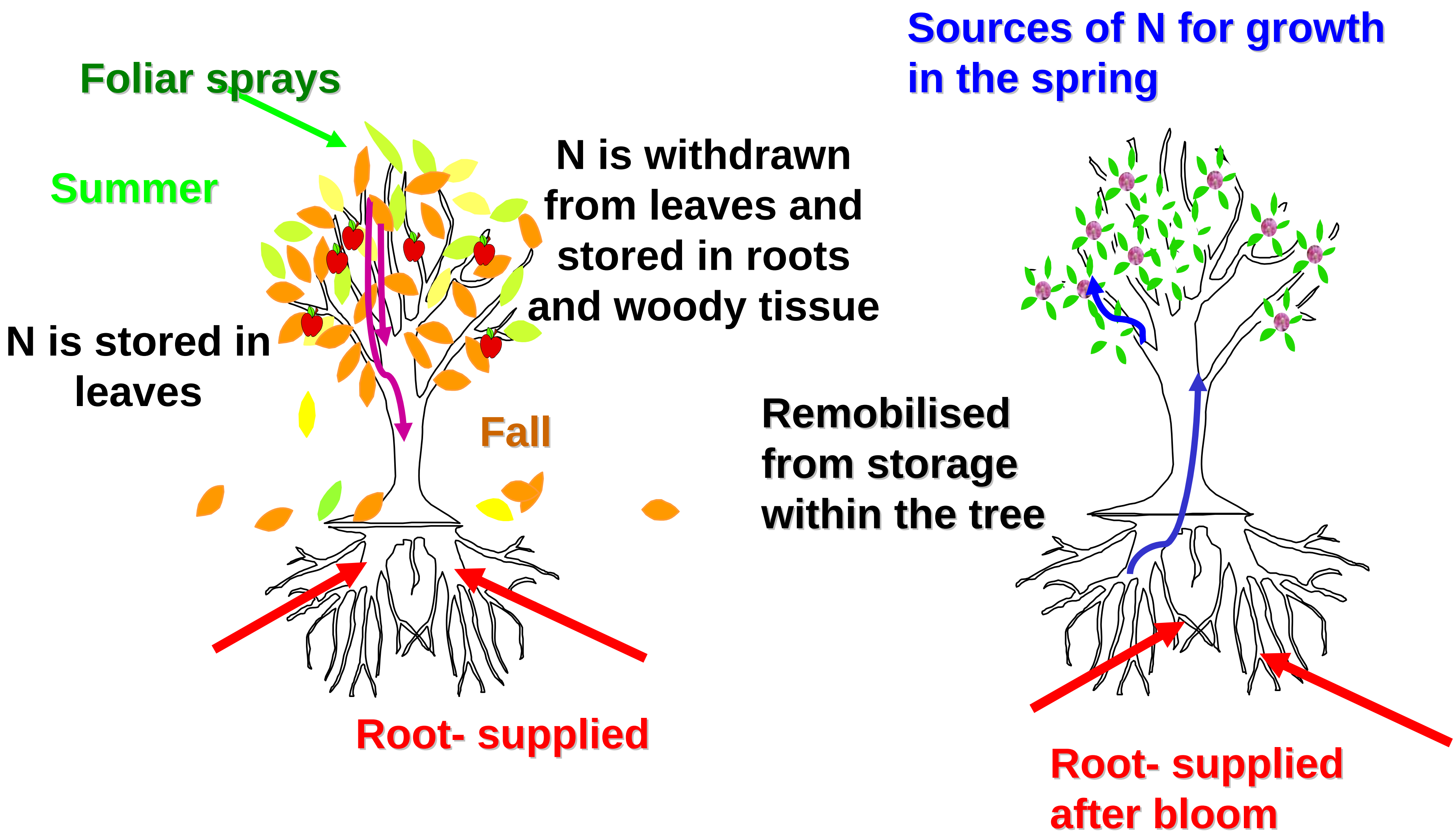
Control of soil N supply beneath drip emitter with fertigation





Neilsen et al. 1998
JASHS 123

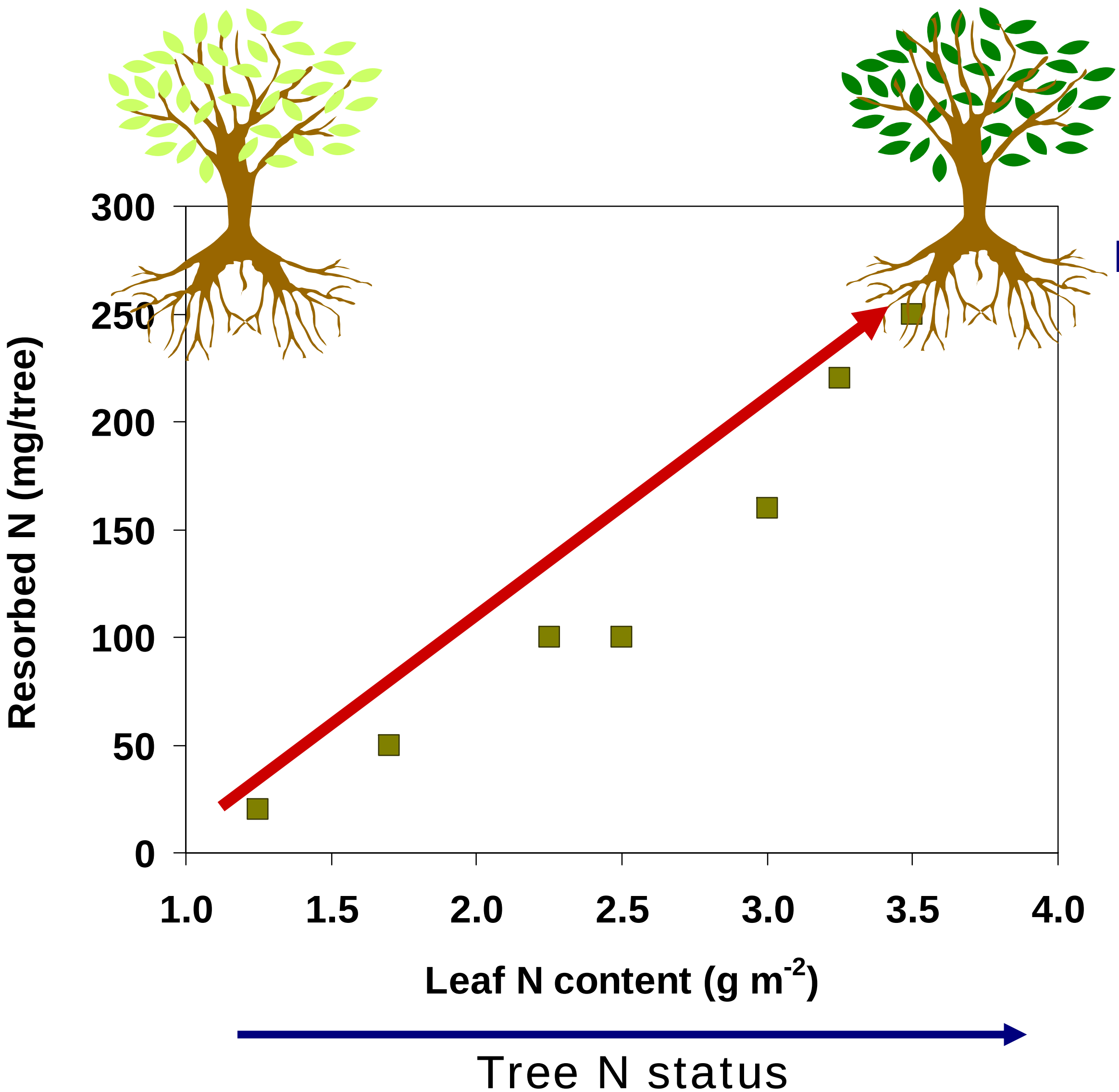
Timed to meet demand



Contribution of stored N to vegetative growth

Species	%	Reference
Walnut	88-92	Frak et al., 2002. Plant Phys. 130
Apple	18-92	Neilsen et al., 1997, 2001. Tree Phys. 17, 21
Peach	38-46	Tagliavini et al., 1998 Tree Phys. 18
Sweet Cherry	12-27	Grassi et al., 2002 Plant, Cell, Env. 25

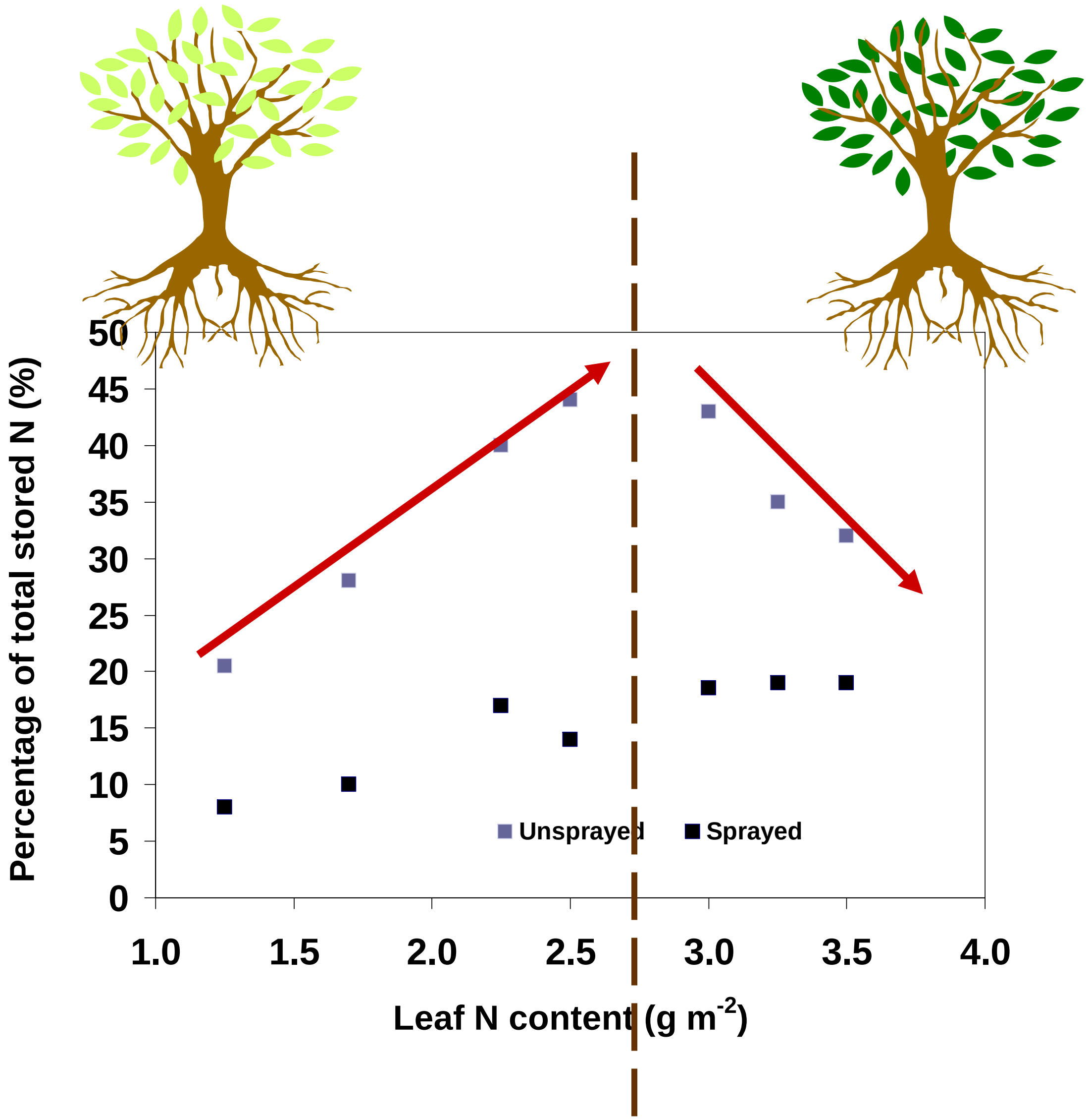
Leaf N moves into storage in the fall



- As tree N status increases the amount of N moved into storage increases

Re-drawn from Cheng et al., 2002 J. Hort. Sci &Biotech 77

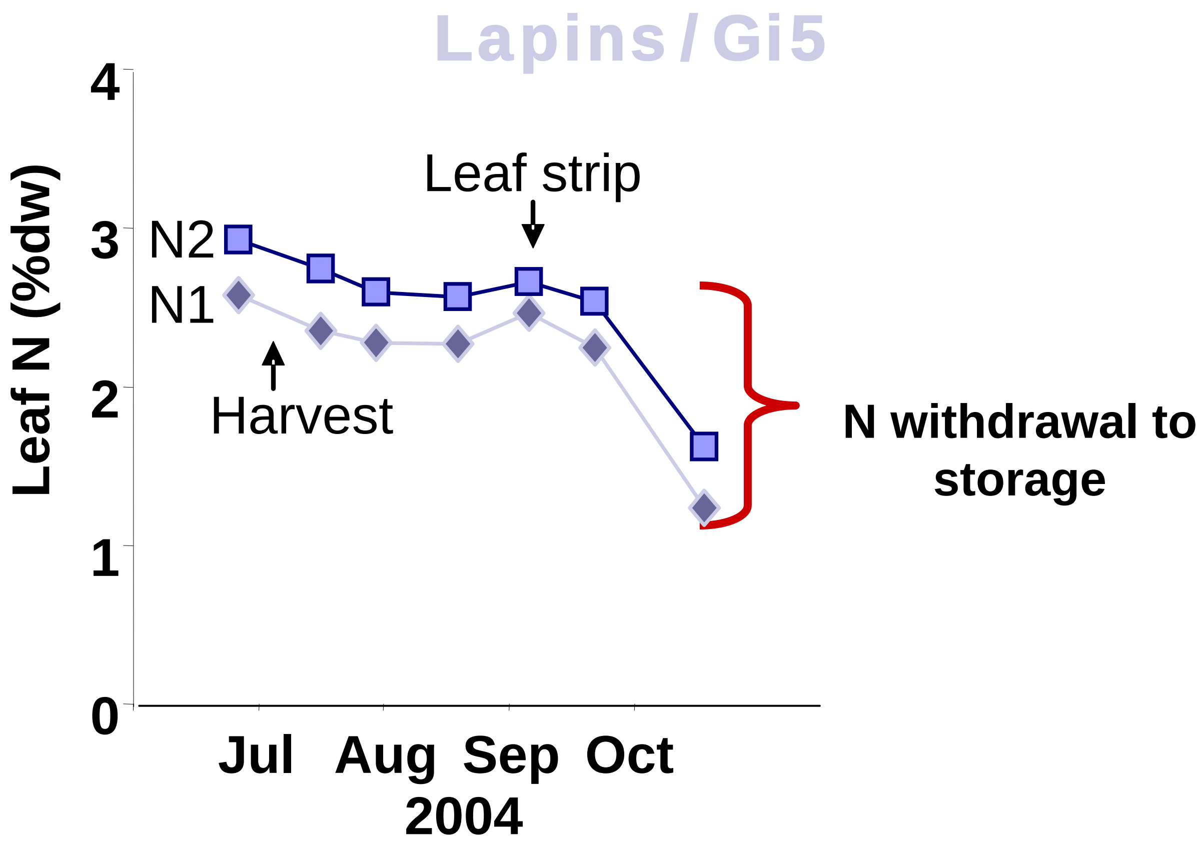
Fall applied foliar urea



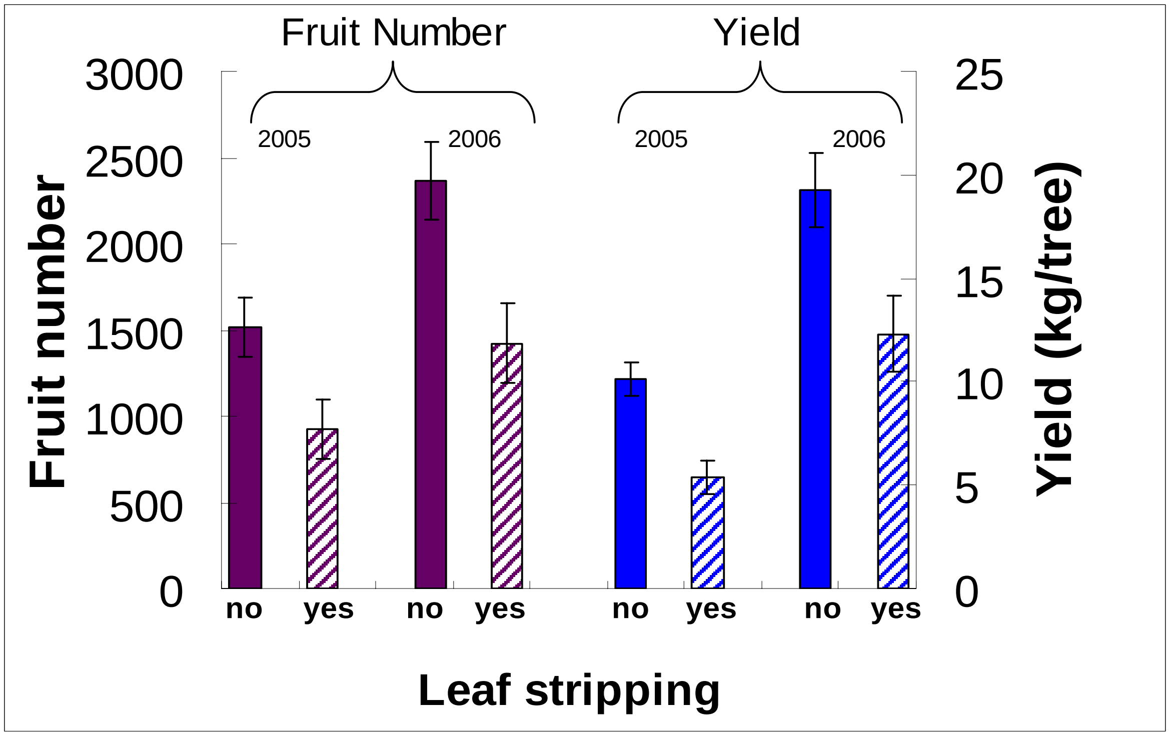
- In trees with low leaf N, fall urea applications may increase N storage for growth next year
- In high N trees foliar urea is not necessary

Re-drawn from Cheng et al., 2002 J. Hort. Sci &Biotech 77

Contribution of winter storage N to tree performance in sweet cherry

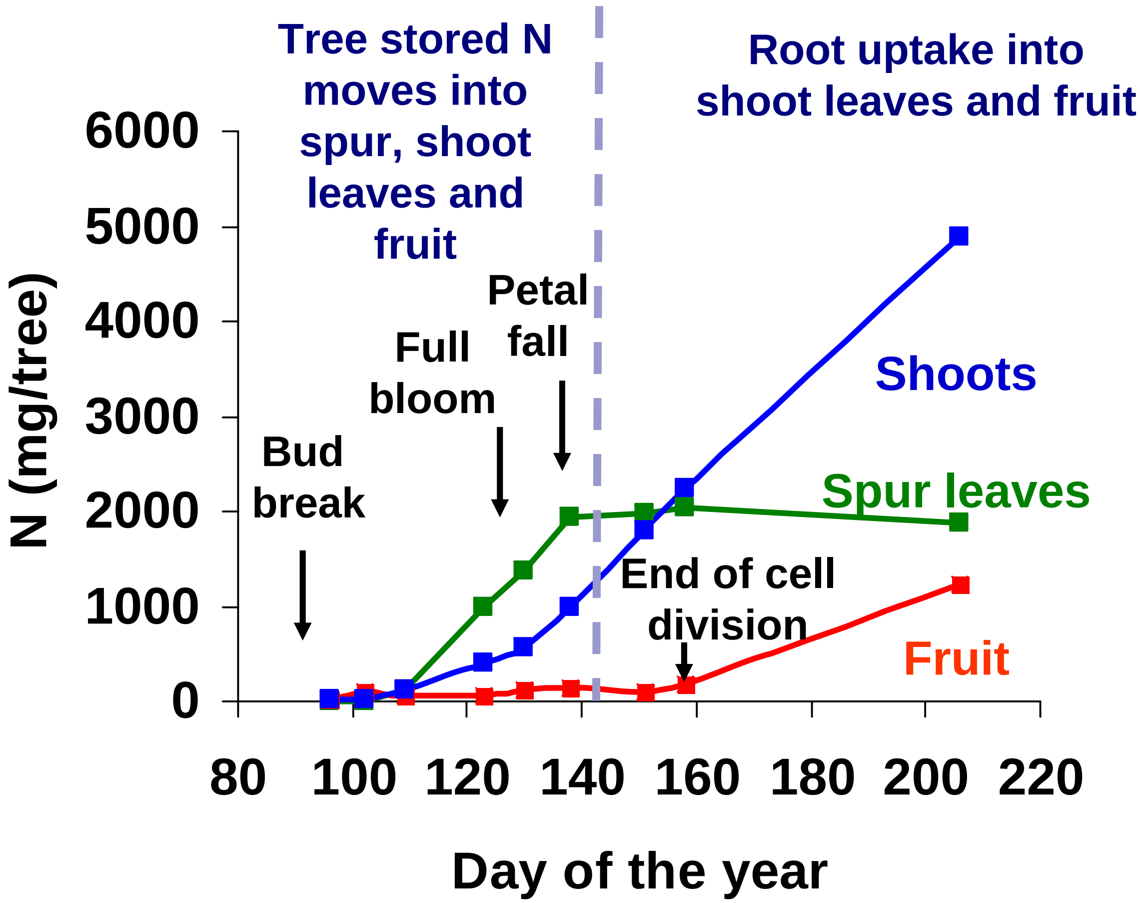


Contribution of winter storage N to tree performance in sweet cherry



- leaf stripping decreased fruit number & reduced yield
- fruit development highly dependent on stored N
- leaf stripping did not affect shoot leaf development (data not shown)
- shoot growth more dependent on current season supply

Timing of N demand for growth in apple in relation to phenology



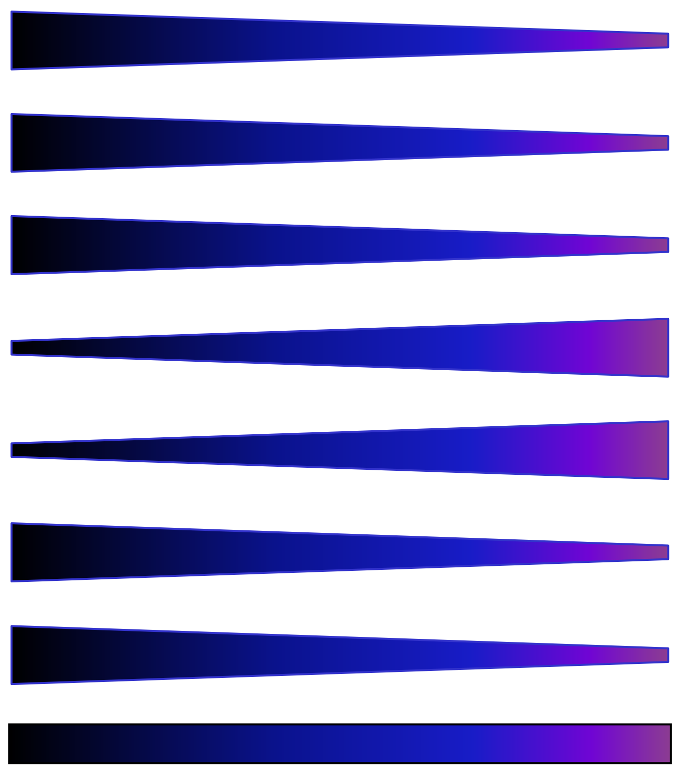
- Before full bloom leaf growth (spur leaves) supported by remobilized N
- Root uptake occurs mainly after bloom to support shoot and fruit growth
- N inflow into fruit occurs mainly after cell division

Guak et al. 2003, J. Exp. Bot 54
Neilsen et al., 2006 Acta Hort 721

Effect of timing of N applications on fruit for Gala/M.9 over 3 years

N applications weeks after bloom: 0-4 | 4-8 | 8-12

Response



	Significant (number of years)
Bloom	1
Yield	1
Size	1
SS	2
Malic acid	2
SS/Malic acid	2
Starch	3
% red	Not significant

Nitrogen amount - removal in fruit and senescent leaves of apple trees

	g/tree	kg/ha*
Golden Delicious/M.9 first year	2.7	8.9
Gala/M.9 third year	6.5	21.7
Elstar/M.9 fourth year	10.2	34.0
Gala/M.9 sixth year	12.3	41.0

•assumes a tree density of 3300 trees/ha (1336 trees/acre)

Neilsen et al. 2002
HortTechnology 12

Nitrogen requirements for sweet cherry

- **most soils cannot supply sufficient N**
- **classic N deficiencies seen (pale, small leaves, leaf drop)**
- **recommend 2.2-3.4% leaf N**
- **~50-130 kg N/ha recommended**
  - **high rate on sandy soil**
  - **low rates in soils with high organic matter**

Hanson and Proebsting 1996 *in* 'Cherries crop production and physiology' (eds. Webster & Looney)

Lapins/Gisela.5 N treatments

Fertigation treatments

N (8 weeks post full bloom)

1. Low (42 ppm) ~63 kg/ha

2. Medium (84 ppm) ~126 kg/ha

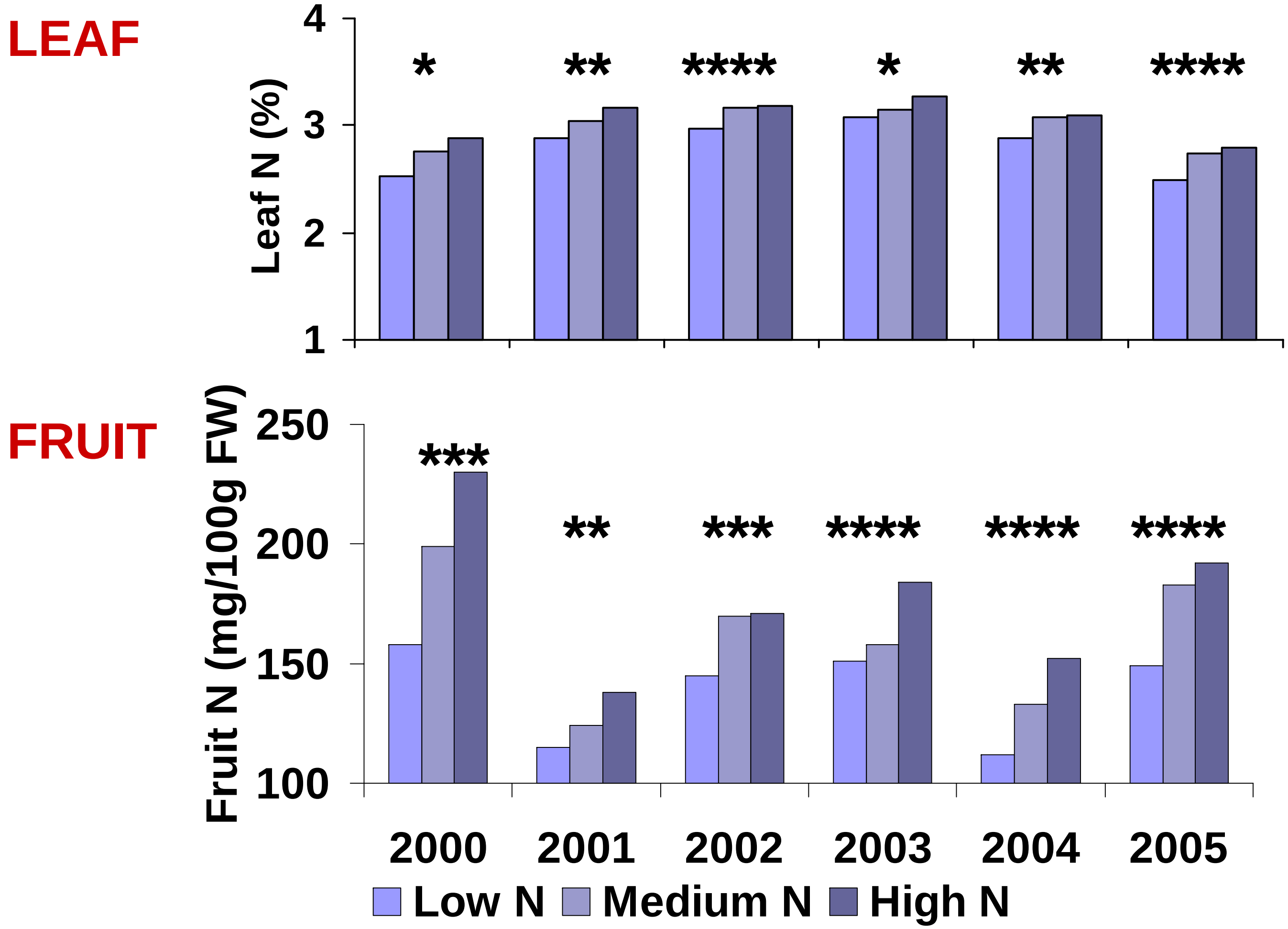
3. High (168 ppm) ~ 254 kg/ha

Broadcast treatments

5. Broadcast N at bloom (75 kg ha-1, 2m strip)

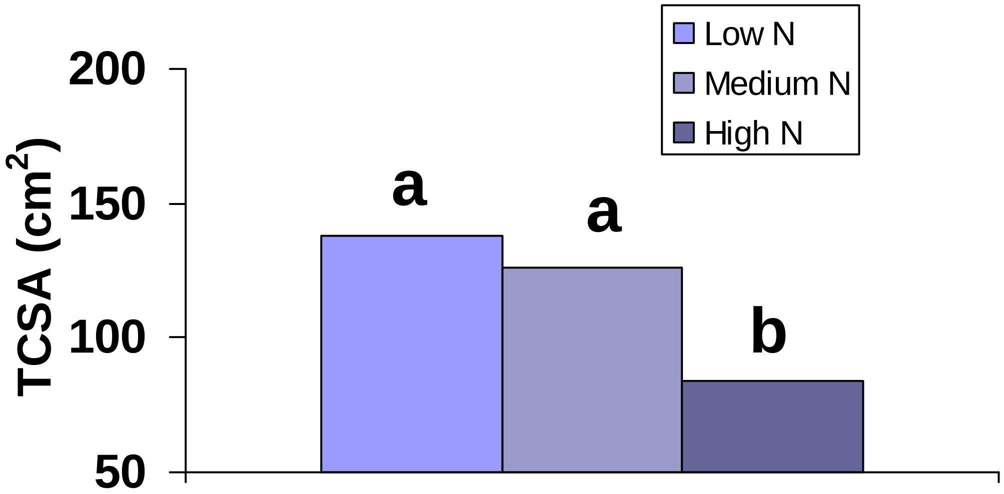
6. Broadcast at bloom plus post- harvest fertigated N (med. rate, 4 weeks, August)

Leaf and fruit N - Lapins/Gisela 5



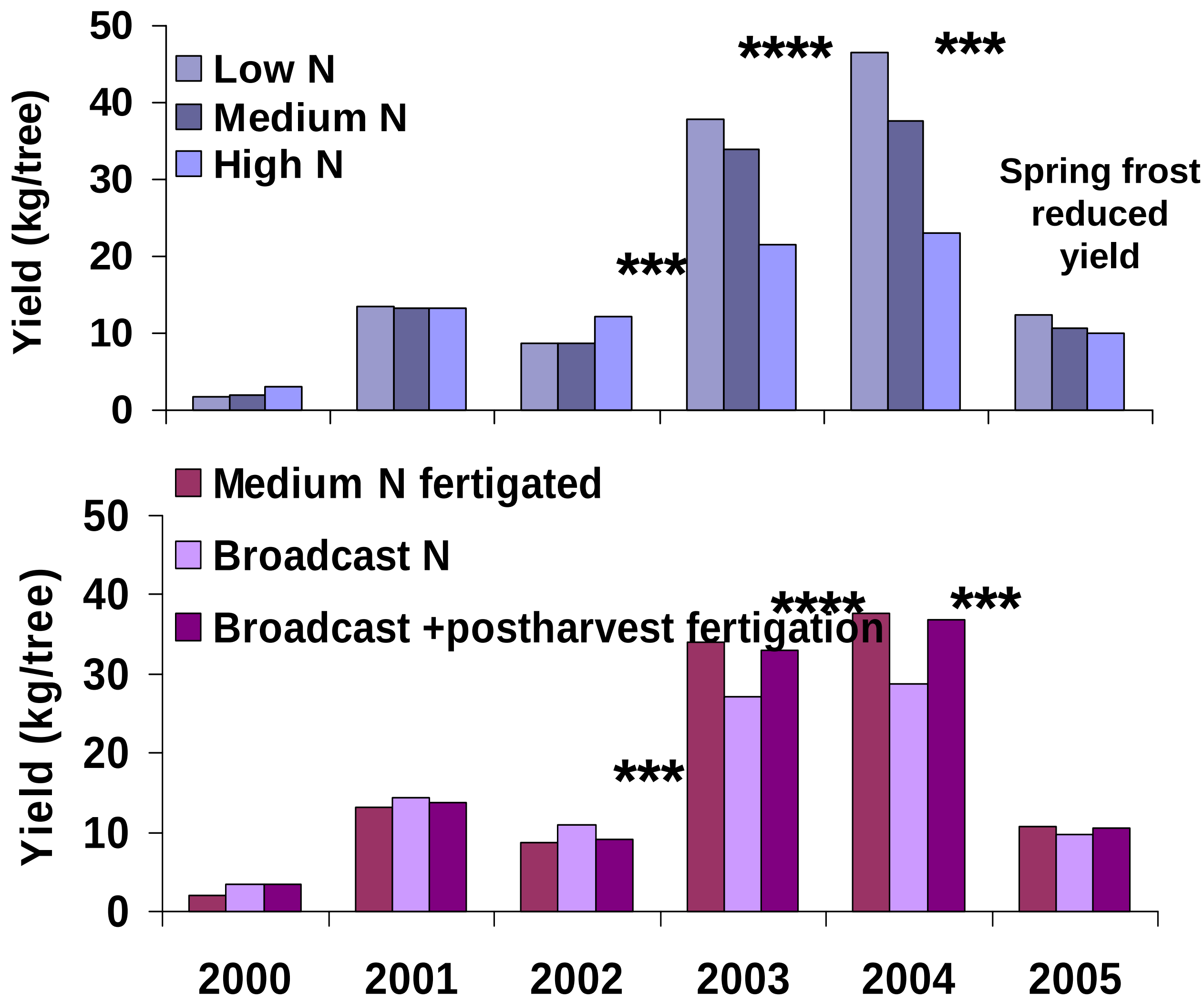
- high N increased leaf and fruit N concentration
- large crop in 2004 reduced N concentration in fruit

Tree growth - Lapins/Gisela 5



- **But high N decreased tree growth**

Tree yield - Lapins/Gisela 5



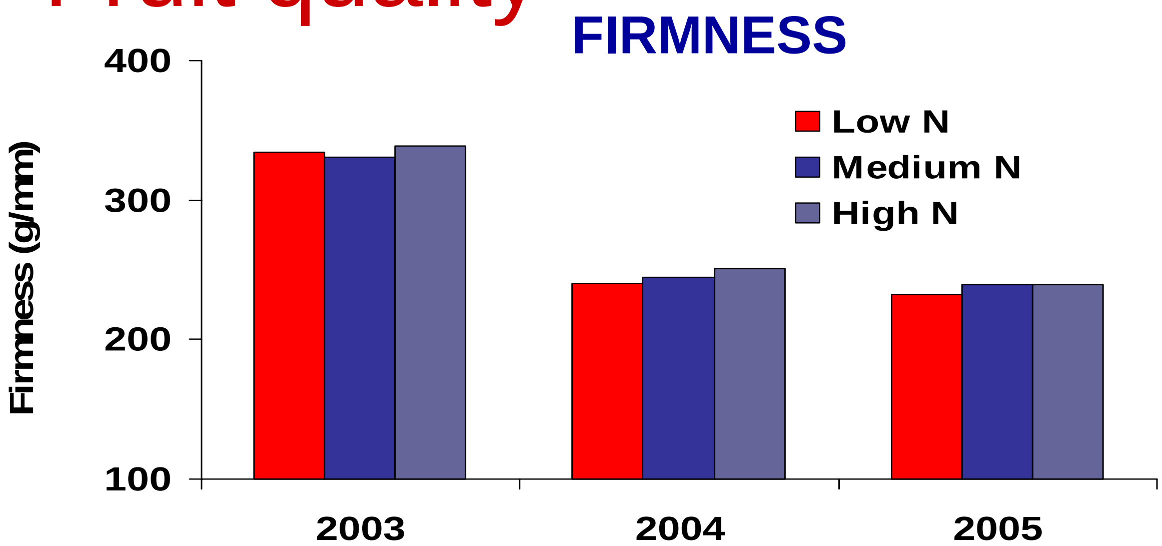
- high N inputs do not necessarily lead to high yields
- fertigated N improved yield compared with broadcast N

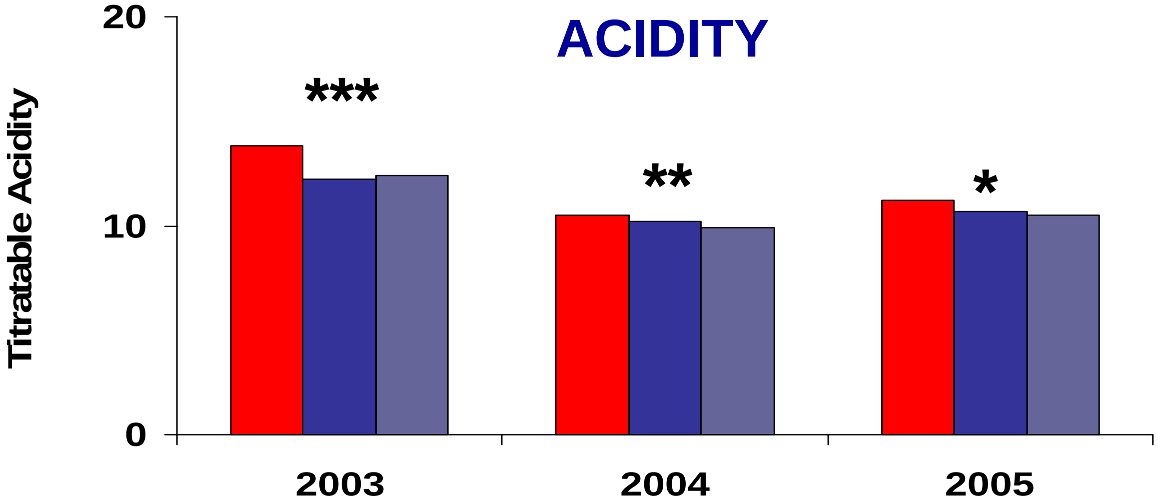
Fruit size (g/fruit)

N rate	2000	2001	2002	2003		2004	2005
				UT	T		
Low	12.6	11.0	10.0	11.0	11.4	9.7	14.9
Medium	12.0	10.0	9.0	10.0	9.8	10.1	14.4
High	12.3	9.6	9.0	8.1	8.6	9.4	13.8
	ns	*	*	*		ns	****

Low ~ 63 kg/ha; Medium ~126 kg/ha; High ~ 254 kg/ha

Fruit quality



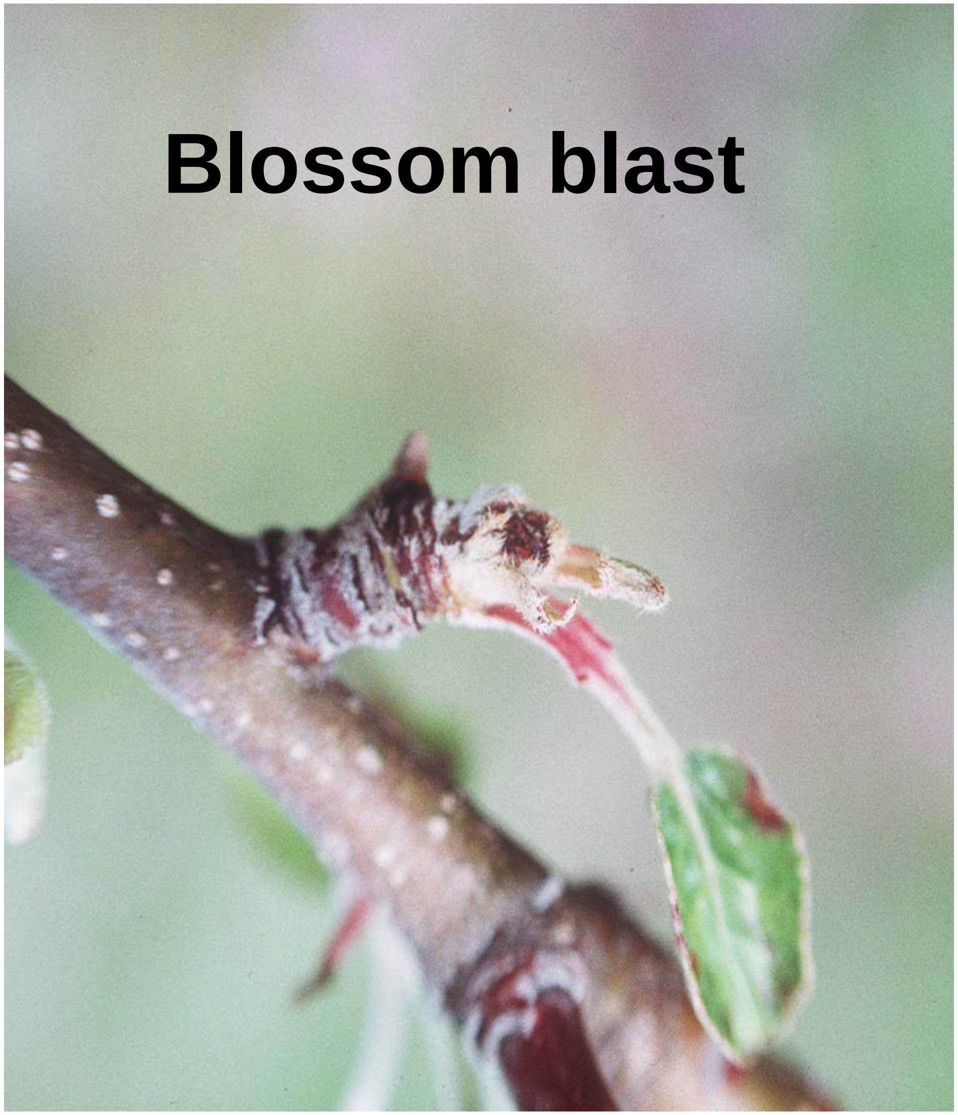


- Nitrogen treatments had no effect on firmness or sweetness (data not shown)
- But high N fruit was less acid

Mobile nutrients – N, B

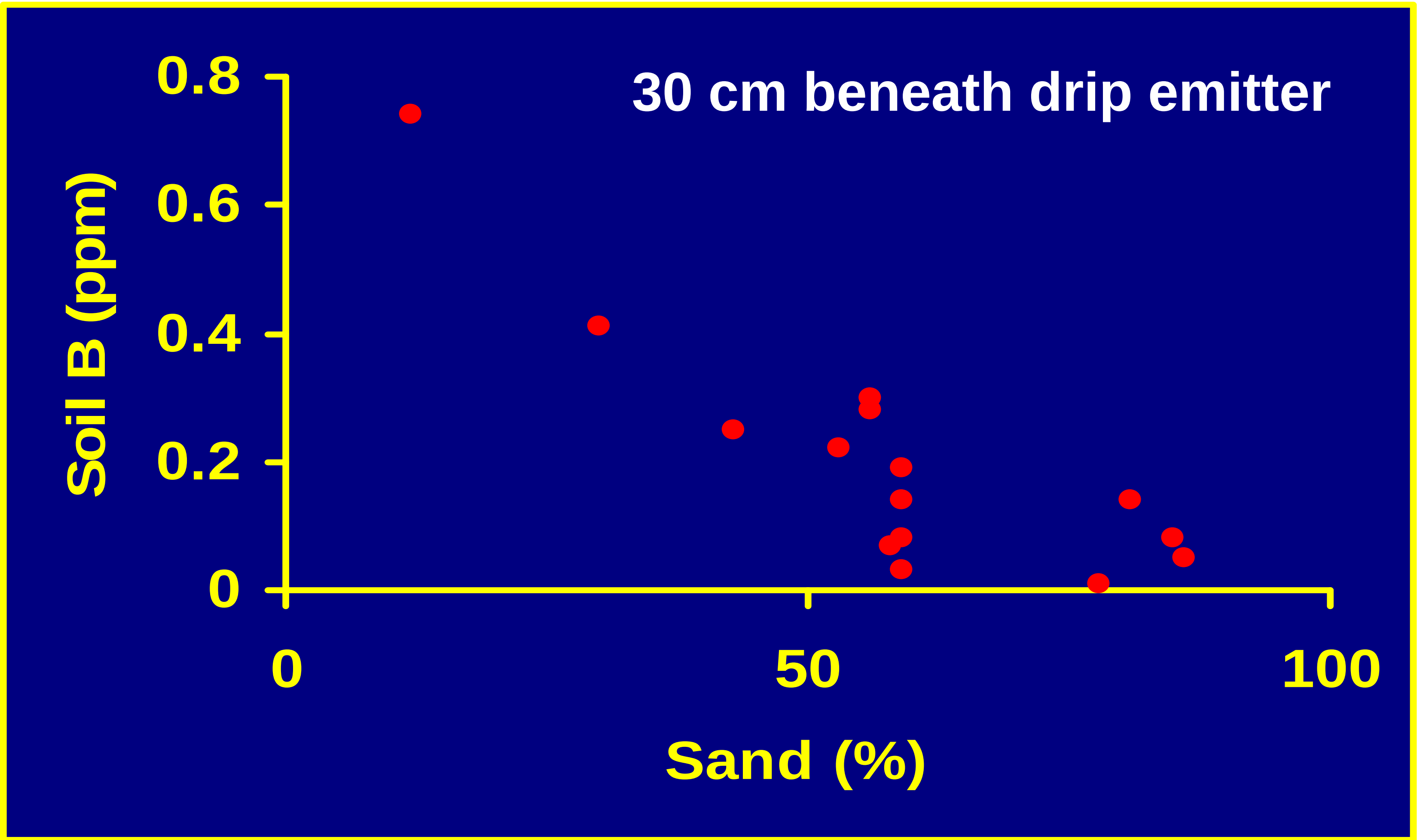
- Boron
  - very mobile
  - Narrow range between sufficiency and deficiency

Boron deficiency

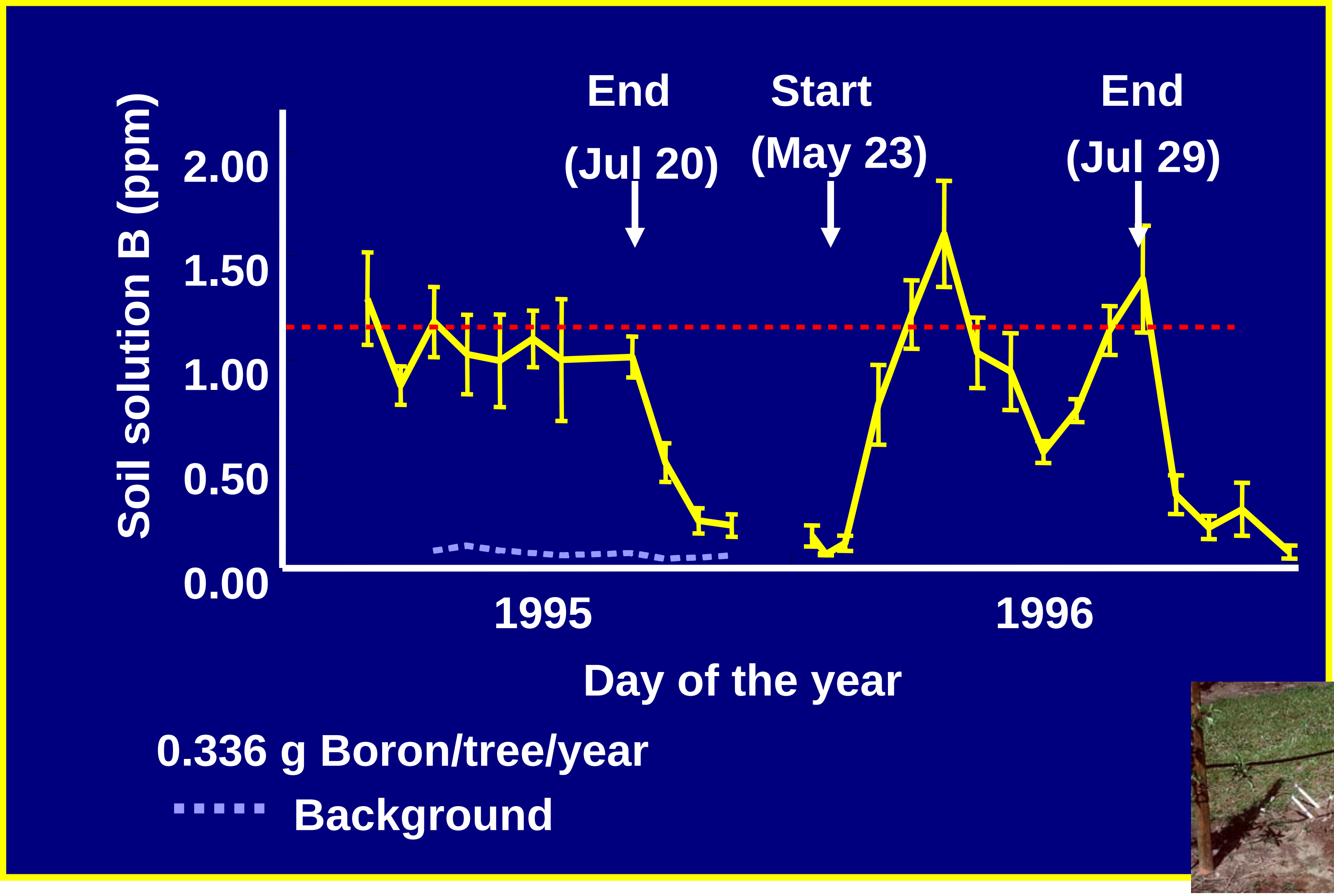


Surface cracking

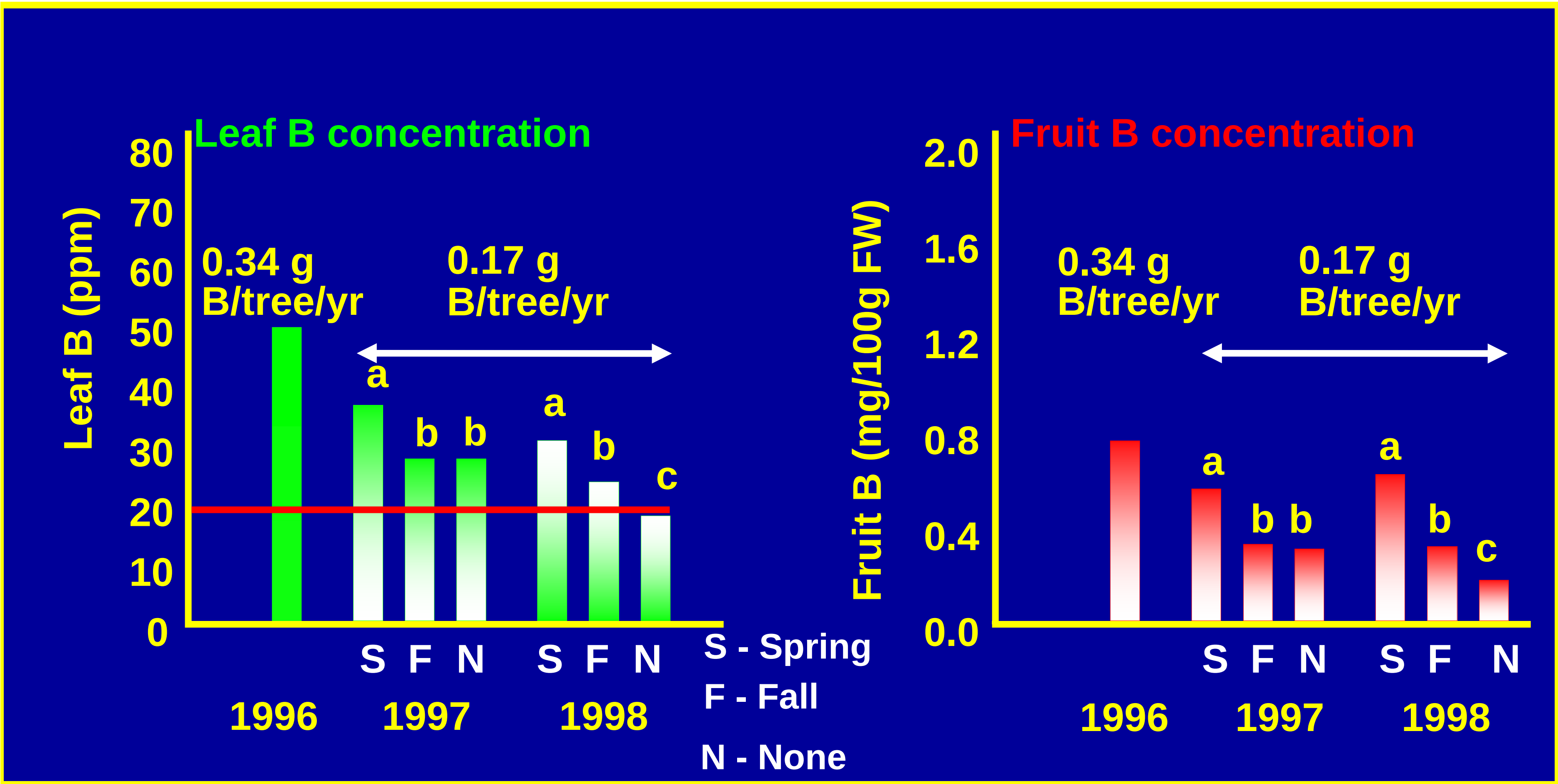
Soil boron- effect of soil texture



Soil solution boron



Leaf and fruit B concentration in response to application method



Neilsen et al. 2004
Can. J. Plant Sci. 84

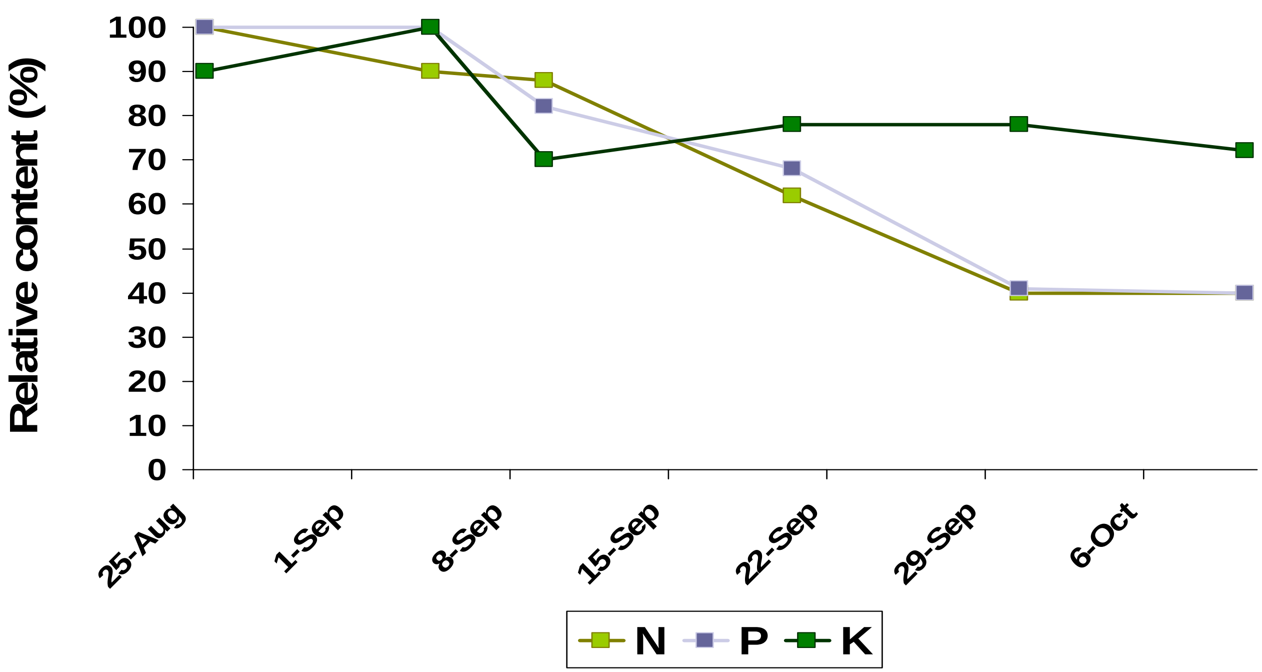
Lapins/G.5 - B

- Deficiency level <20ppm leaf B
- 2003 overall average = 28.7ppm
  - drip treatment = 21.5 ppm
- 2004 overall average = 29 ppm
  - drip treatment = 22.1 ppm

Immobile nutrients

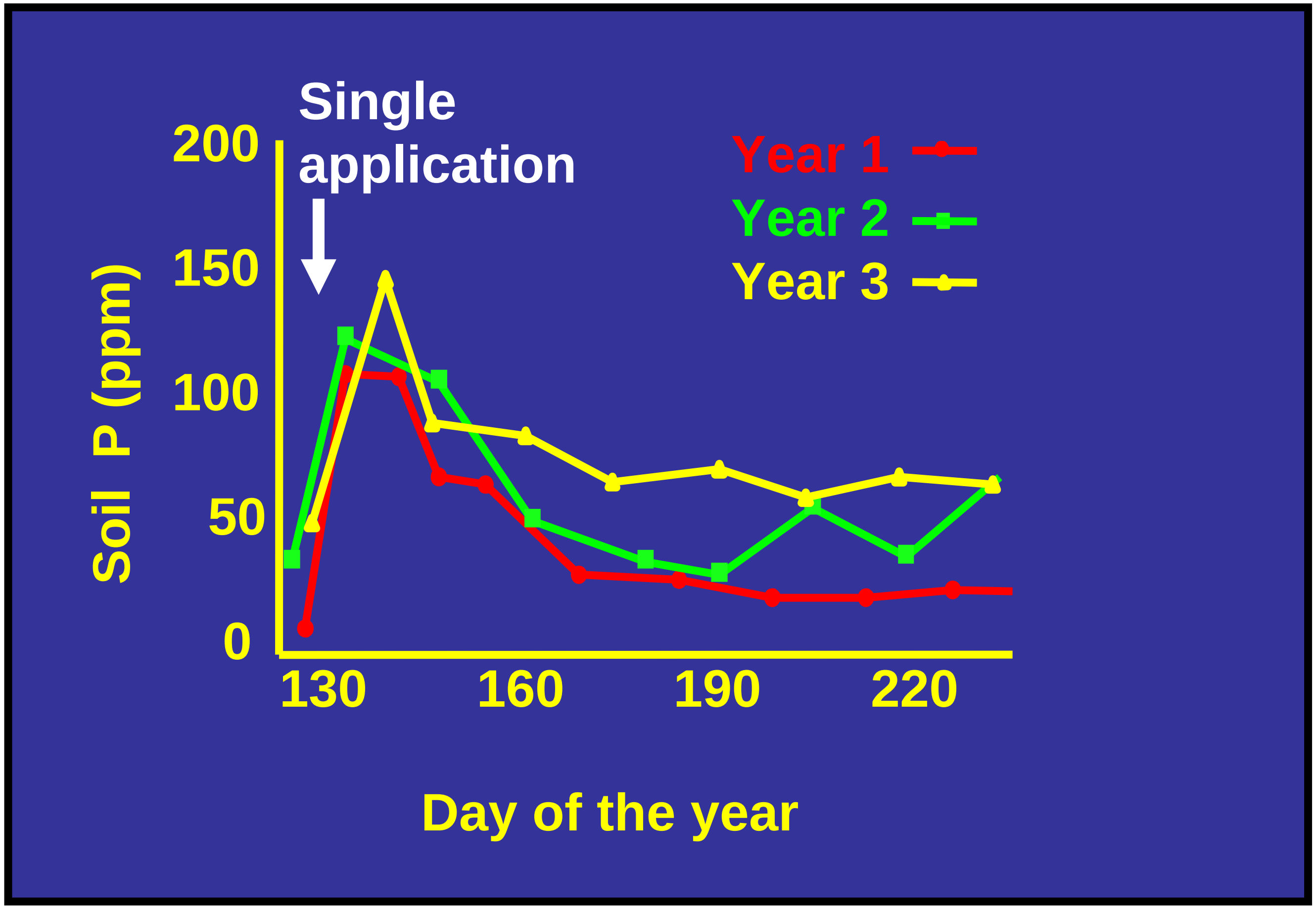
- Phosphorus and potassium
  - immobile
  - much less information available on internal cycling and uptake patterns than N
  - Spatially targeted applications required

Resorption of major nutrients from poplar leaves in Fall



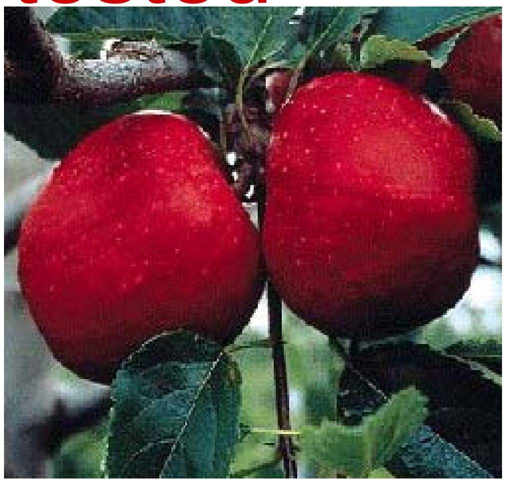
Redrawn from Keskitalko et al., 2005 Plant Physiol. 139

Fertigated phosphorus in apple (drip irrigation)



Neilsen et al. 1999
HortTechnology 9

P fertigation trial- five apple cultivars tested



Gala

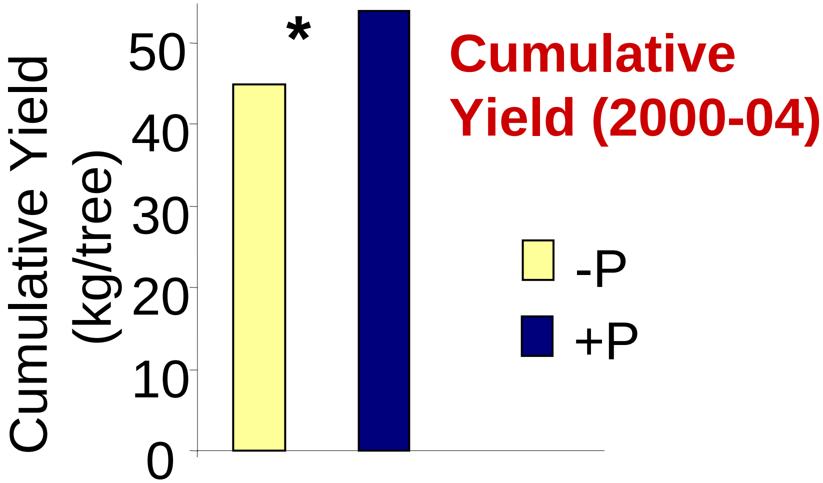
Cameo

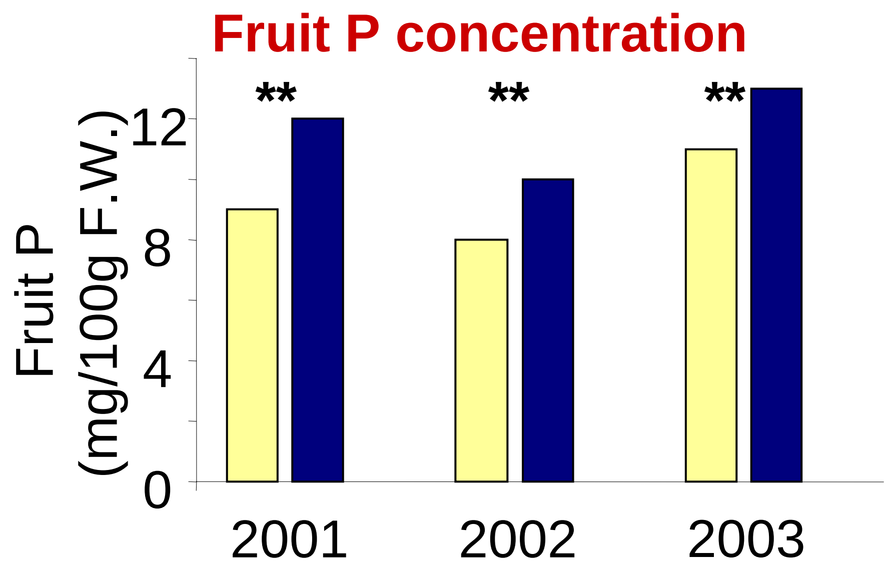
P fertigated at 20g/tree one week after full bloom

Fuji

Silken

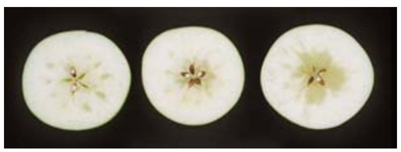
Phosphorus effects on fruit production - 5 apple cvs/M.9





- Phosphorus additions are effective when targeted to the roots through fertigation

Phosphorus effects on fruit quality- 5 apple cvs/M.9



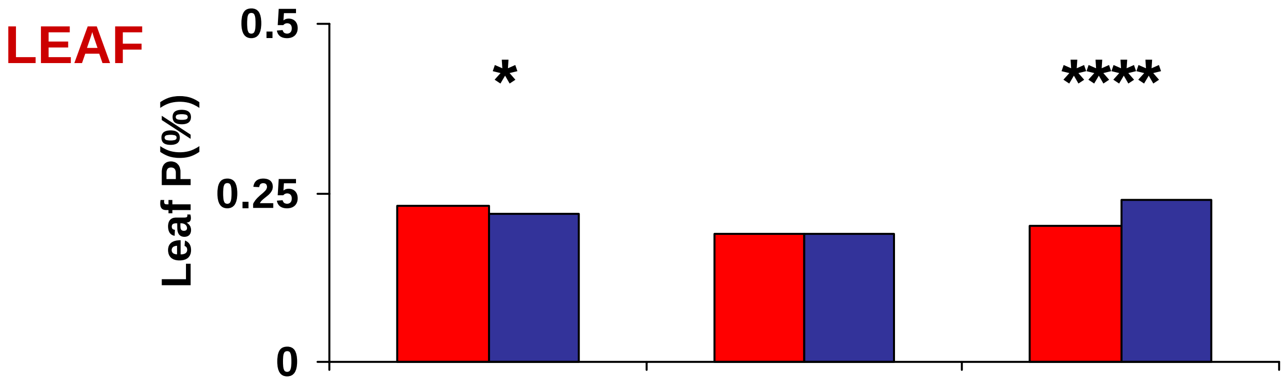
Year	Statistically significant effect on qu
200	all cultivars
	s, all cultivars
2003	aces, all cultivars
	membrane leakage Silken
2004	increased soluble solids, all cultivars

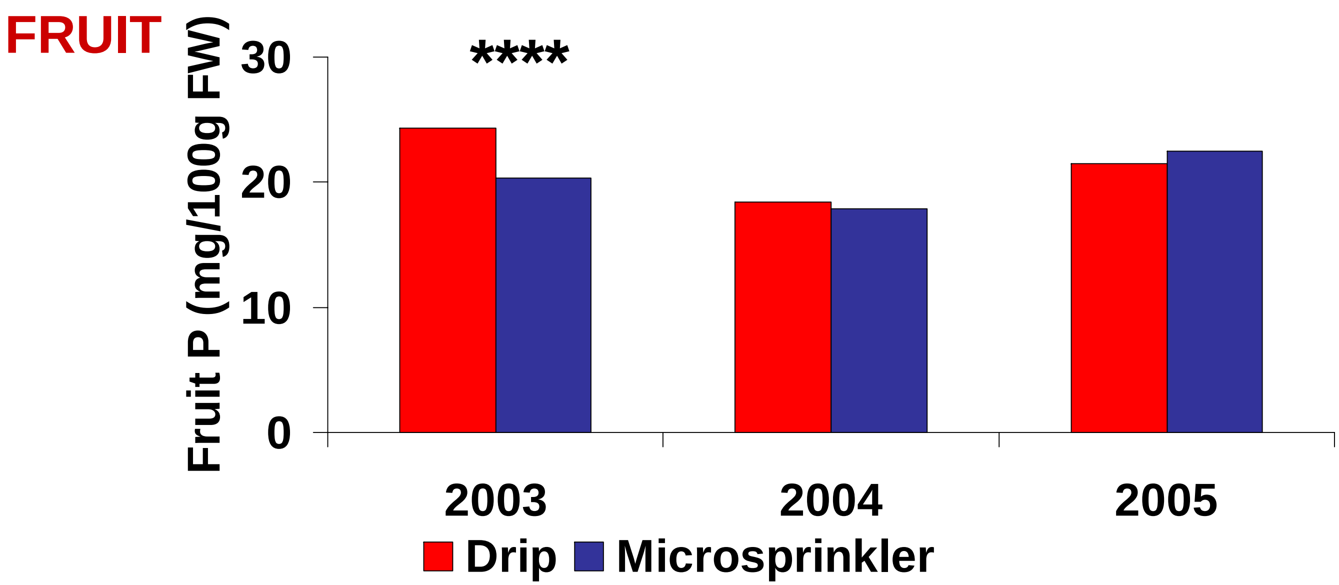
Phosphorus increases the stability of cell walls

Lapins/Gisela.5 P and K treatments

- **Fertigated through micro-sprinkler with medium N rate**
- **Annual P (20g/tree, end April)**
- **Annual K (14-31g/tree, 4 weeks, June)**

Leaf and fruit P - Lapins/Gisela 5

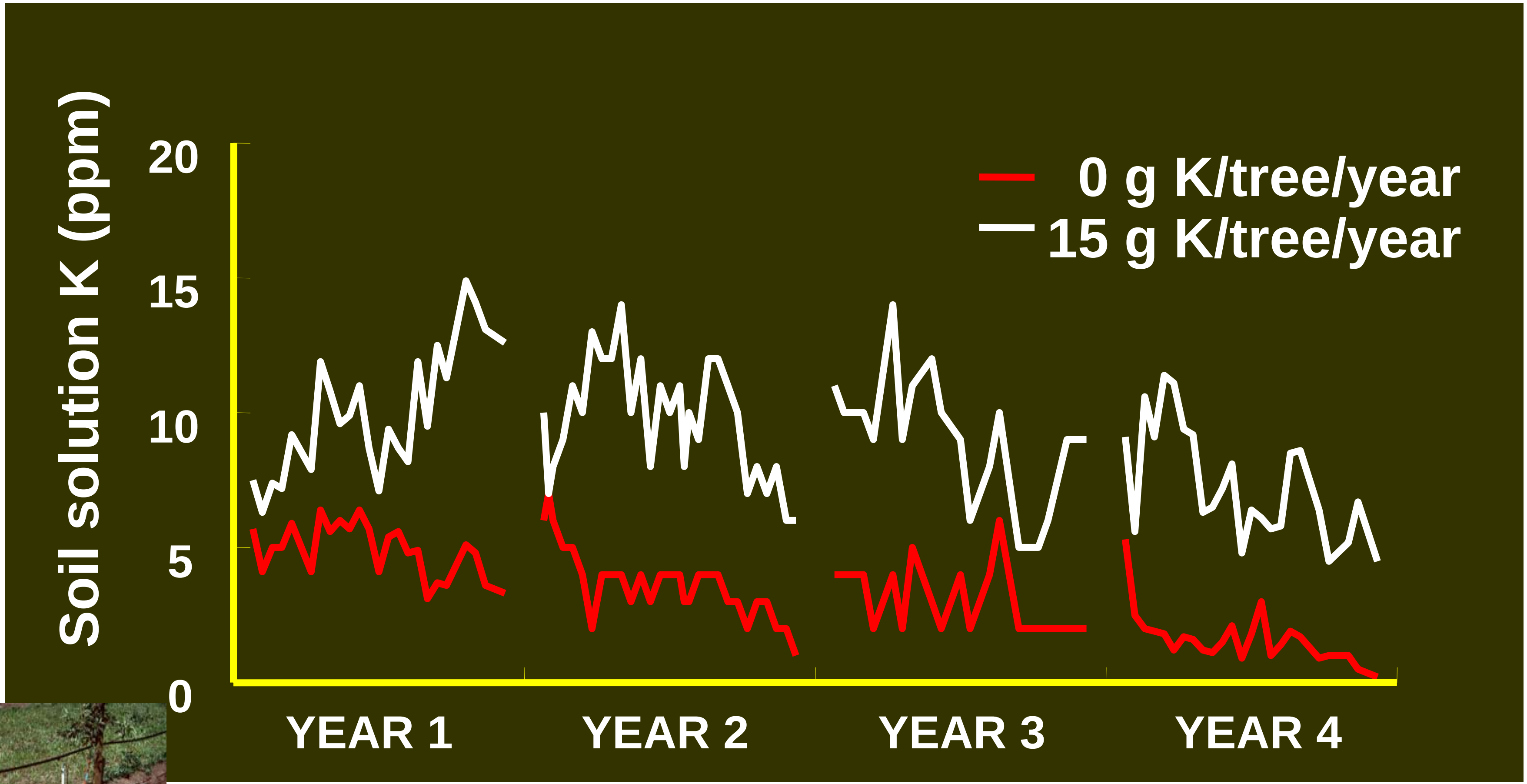




- P fertigation did not affect growth or nutrient conc. (data not shown) leaves and fruit
- irrigation effects inconclusive
- P fertigation using drip may be more useful than P fertigation with microsprinkler

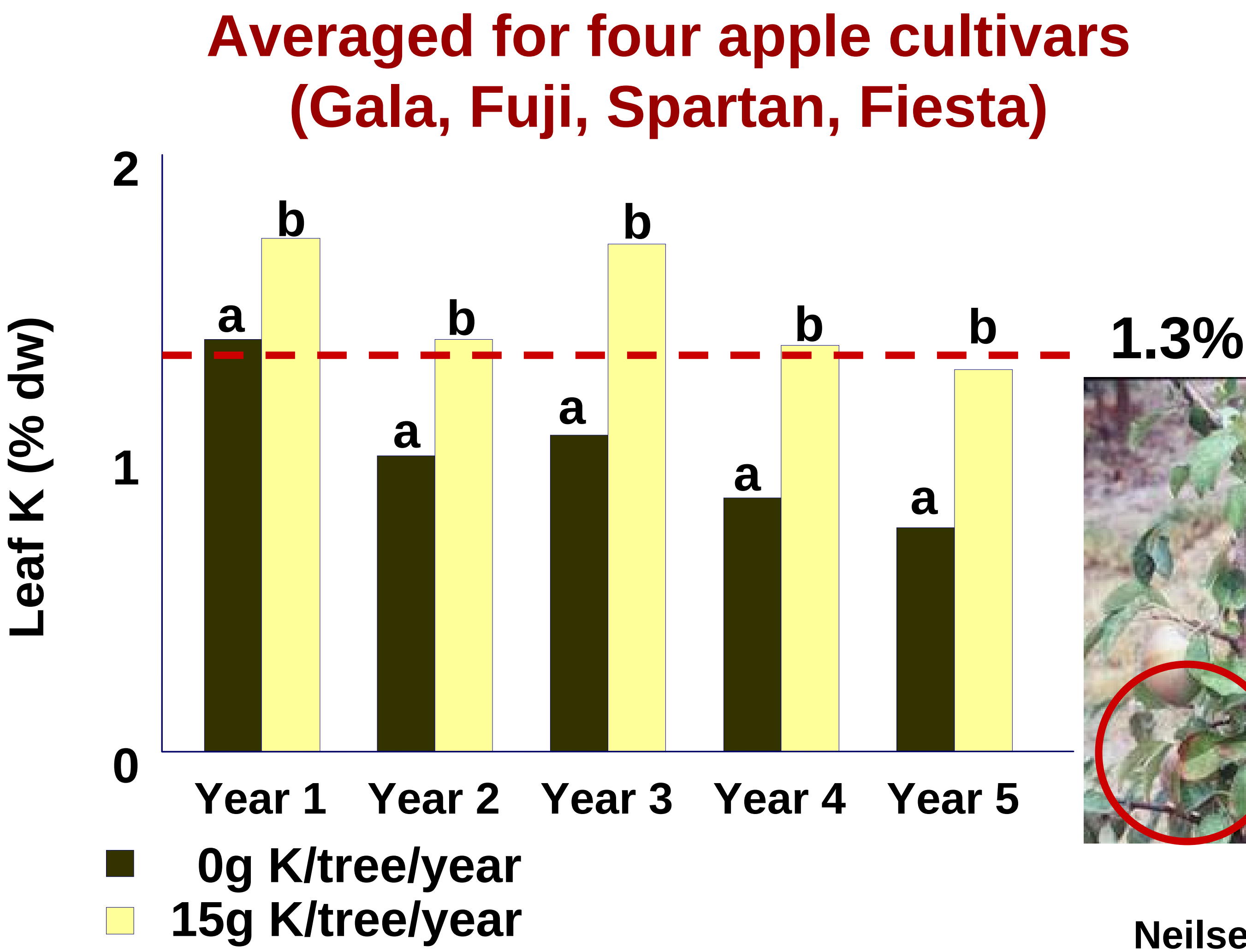
- Potassium
  - Management options

Soil solution K concentration in response to fertigation under drip



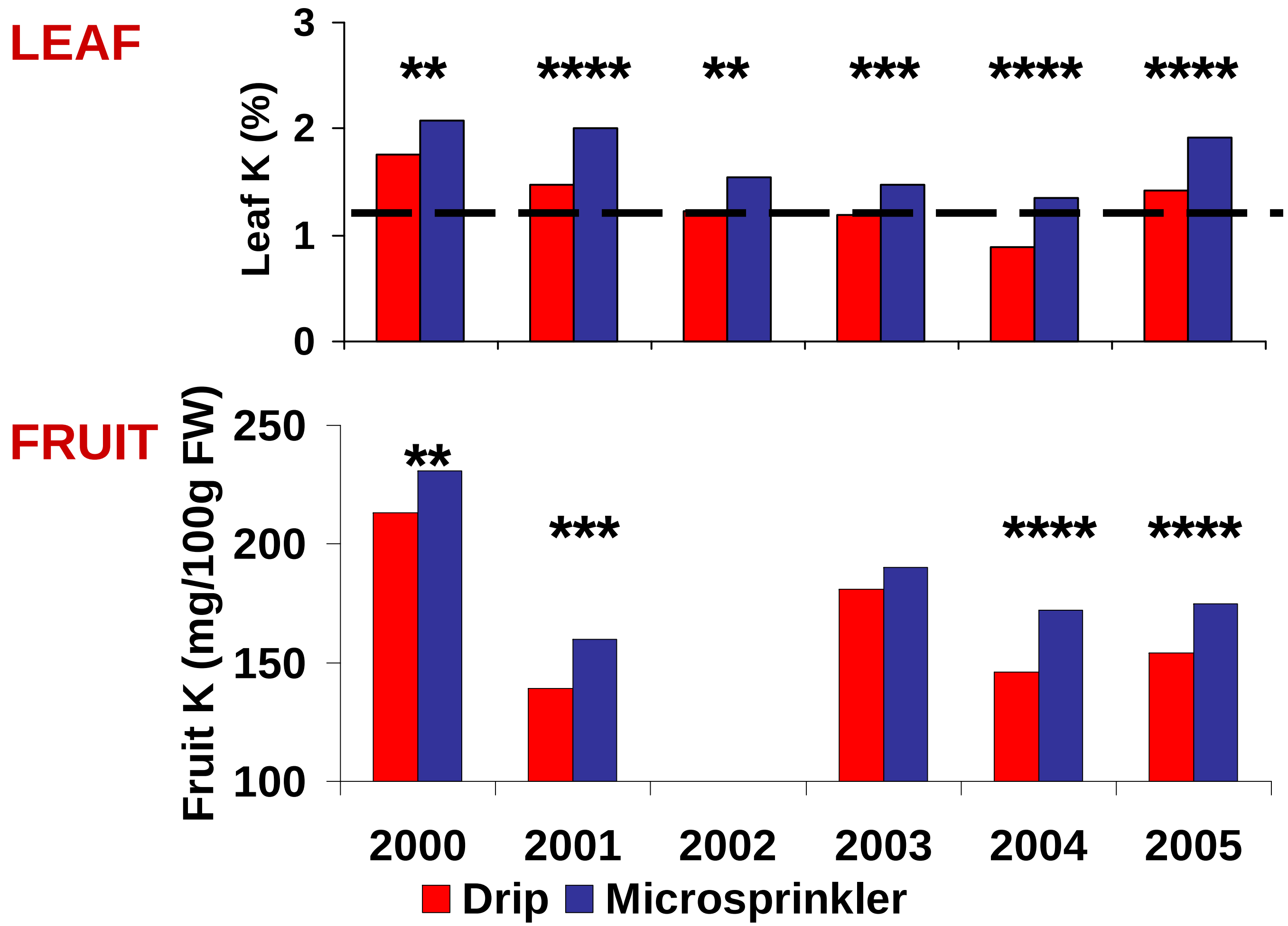
Neilsen et al. 2004 JASHS 80

Effect of fertigated K on leaf K concentration



Neilsen et al. 2004 JASHS 80

Leaf and fruit K - Lapins/Gisela 5



- K fertigation (microsprinkler) did not affect leaf or fruit K conc. (data not shown)
- Leaf and fruit K are reduced under drip irrigation, likely due to soil K leaching
- Low crop in 2005, reduced overall demand for K

Nutrient management and soil quality

Consequences of fertigating with NH_4^+ based fertilizers

Soil chemical changes in 20 orchards (3-5 years old) receiving drip irrigation and fertigation

	pH	Ca	Mg (ppm)	K	B
Alley	7.0	1235	144	211	0.97
Beneath emitters	6.2	911	114	88	0.19
Significance	***	**	**	**	****

*,**,***,****, significantly different at $p<0.05$, 0.01, 0.001, 0.0001

Effects of mulches and composts

Long –term compost/ mulch trial. Soil property changes over 7 years

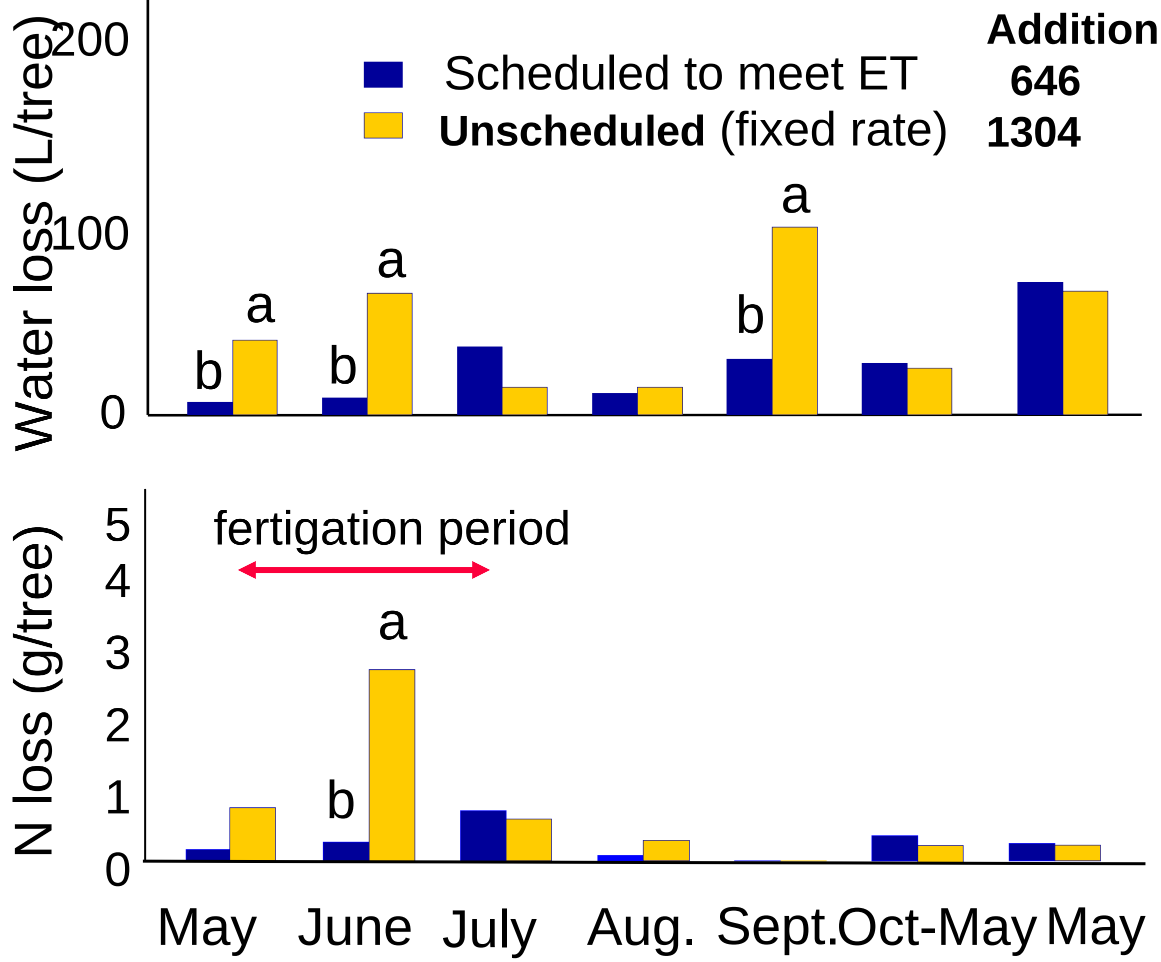
Treatment	Total C (%)	Total N (%)	Extractable P (ppm)
Check	1.0c	0.10bc	40b
Biosolids (GVRD)	1.9a	0.18a	205a
Paper Mulch	1.3bc	0.12b	26b
Black plastic	0.9c	0.09c	29b

Neilsen et al. 2003. Can. J. of Soil Sci. 83:131-137

Water and nutrient management are linked

- **Retention of nutrients in the root zone for as long as possible will improve nutrient use efficiency**
  - fertilizer applications are timed to meet tree demand
  - water applications are scheduled to meet evaporative demand

Loss of water and N beneath the root zone in response to irrigation scheduling

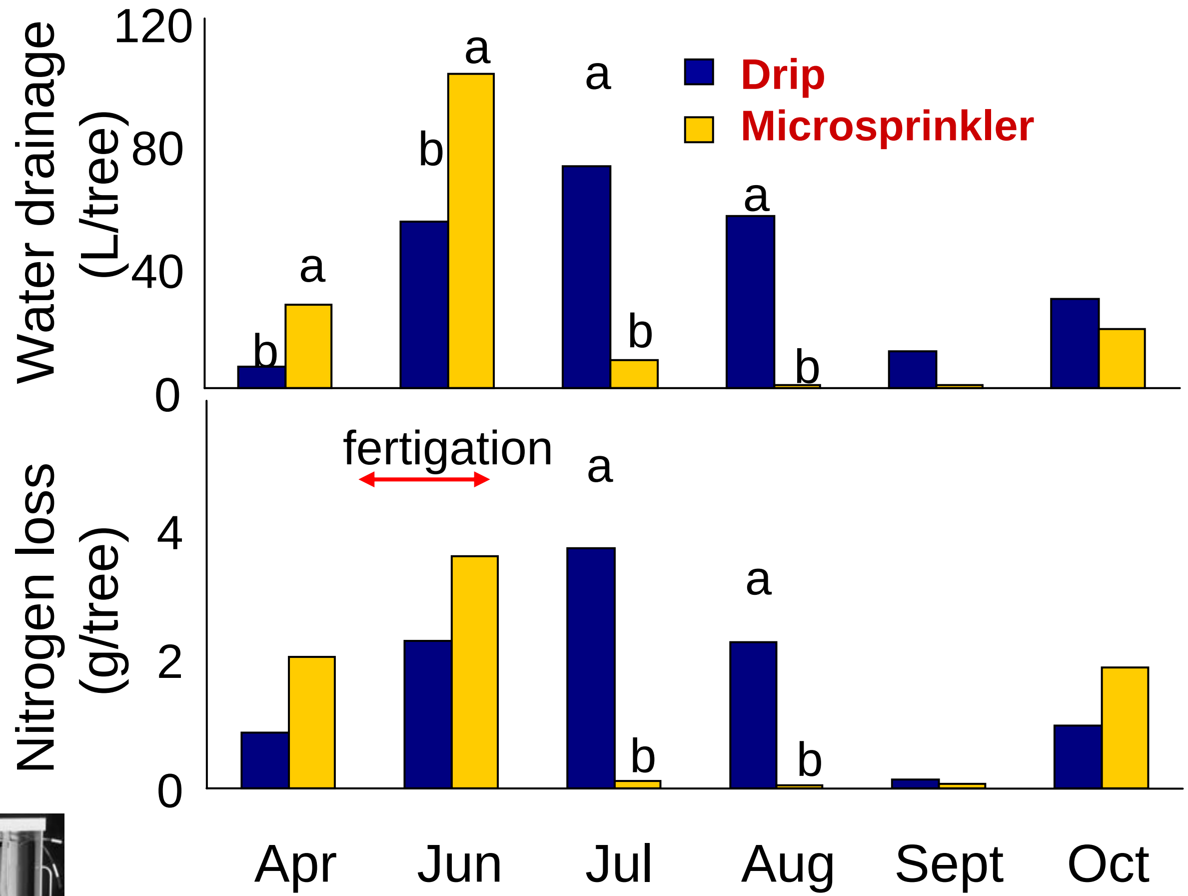


	Water/tree (L)	
	Addition	**Loss**
Scheduled to meet ET	**646**	**168**
Unscheduled (fixed rate)	**1304**	**286**

- **water and N losses related during fertigation period**
- **water losses high under unscheduled irrigation during periods of low ET**

Neilsen et al. 2002
HortTechnology 12

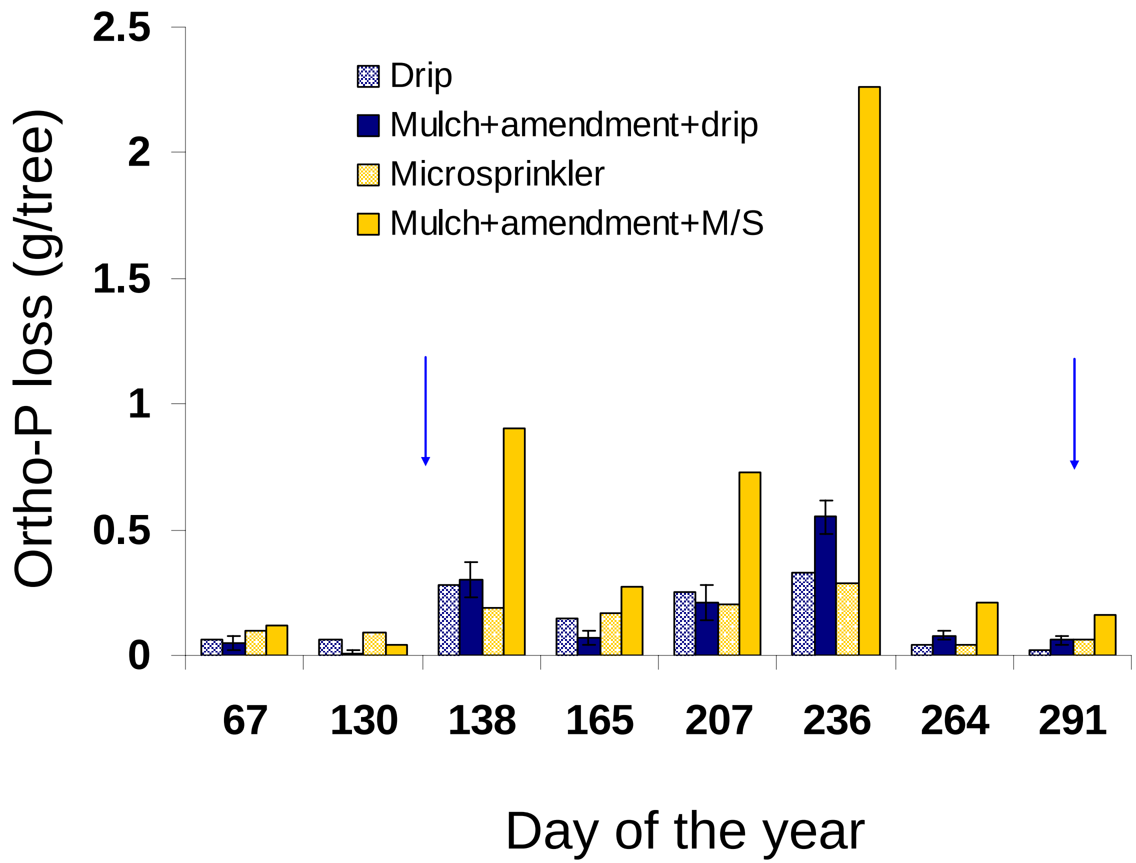
Seasonal water & N loss beneath the root zone in response to irrigation type



- N losses follow water drainage closely
- Losses under drip higher during periods of high ET (mid-summer)
- Water replacement rate too high for soil storage capacity

Timing of P leaching in response to irrigation system and compost

- P susceptible to leaching under compost
- Movement as Organic P?
- Over-application of water in micro-sprinkler plot, day 236, increased P losses.



Conclusions

<u>Mobile nutrients</u>

- **Water management (scheduling, irrigation method) and timing of N application determines the retention of N in the root zone and availability.**
- **Aided by improved understanding of tree N cycling and time of root uptake**
- **Fertigation allows precise timing of N additions and is more effective than broadcast applications**
- **Very high N applications, may be detrimental to production**
- **B deficiency more prevalent in sandy soils and can be managed by fertigation –with care**

Conclusions

Less mobile nutrients

- **Fertigation may improve the mobility and effectiveness of P applications, but only with drip irrigation**
- **Drip irrigation, may cause soil K leaching and reduce availability – K fertigaiton through drip can offset this**
- **Fertigating K through microsprinkler does not improve K uptake**
- **Size controlling rootstocks may take be more susceptible to K deficiency**
- **P leaching may occur when organic amendments are used**

Financial support

- **International Dwarf Fruit Tree Association**
- **Washington Tree Fruit Research Commission**
- **Okanagan Kootenay Cherry Fruit Growers Association**
- **Agriculture and Agri-food Canada Matching Investment Initiative MII**

Thank you

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