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Soil Health for Tree Fruit: An International Perspective

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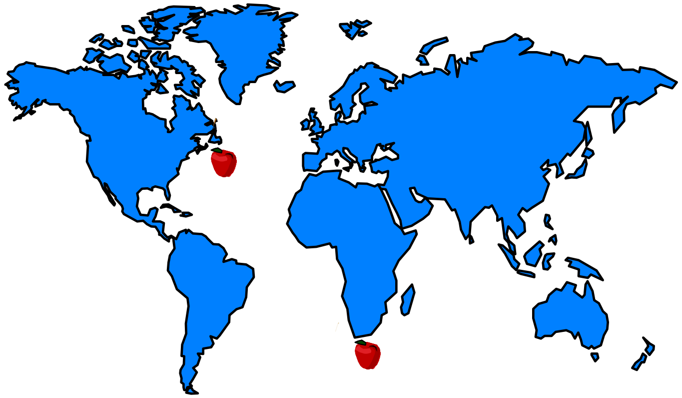
Keith Fuller
Soil Scientist
Atlantic Food & Horticulture Research Centre
Agriculture & Agri-Food Canada
Kentville, Nova Scotia
Keith.Fuller@agr.gc.ca

Canada

Contrasting Soil-Tree-Climate Associations



<u>Annapolis Valley, NS Lat. 45^0 N</u>

Maritime Climate

- **short, cool growing season**
- **non-irrigated orchards**
- **long, cold winters**
- **precipitation: 1150 mm**

<u>Western Cape, SA</u> Lat. 33^0 S

Mediterranean Climate

- **long, hot, dry growing season**
- **permanent irrigation systems**
- **short cool winters: insufficient chilling**
- **precipitation: 750 mm pa mostly winter**

Soil Health:

“ the capacity of soil to function as a vital living system, within ecosystem and land use boundaries, to sustain plant and animal production, maintain or enhance water and air quality, and promote plant and animal health.

Healthy soils are the ones which sustain biological productivity, store and cycle water and nutrients, decompose organic matter, inactivate toxic compounds, suppress pathogens, protect water quality and enhance catchment’s health.”

Doran, J. W. and Zeiss, M. R. 2000. Soil health and sustainability: managing the biotic component of soil quality. *Appl. Soil Ecol.*, ***15****, 3-11****.***

Three Soil Health Topics

1. SA and NS Approach to Drainage of Orchard Soils

What is an optimally drained soil?

- has the capacity to
gravity before oxyg
and root health

- for soils prone to w
that is achieved aft

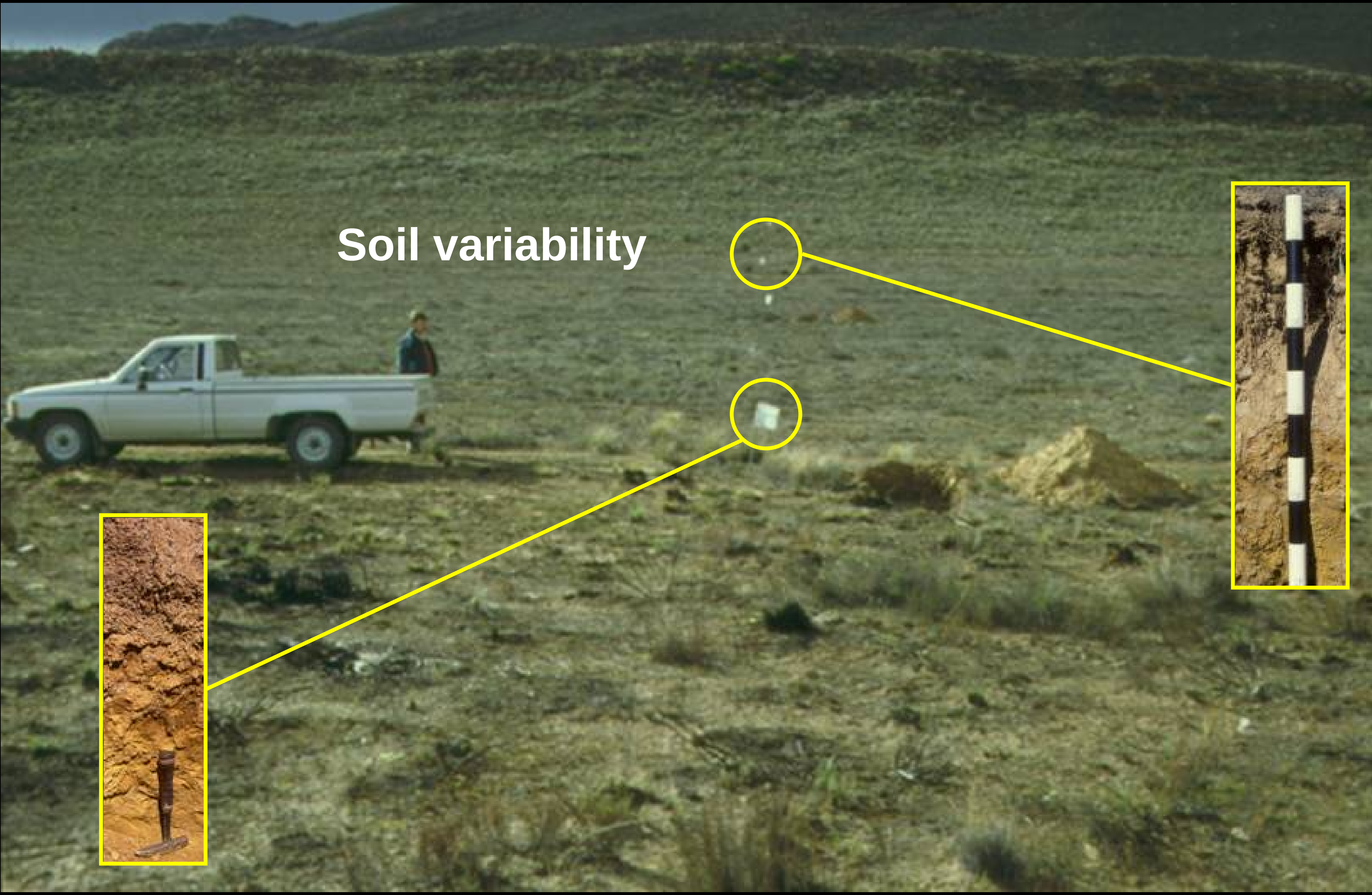
What are the spin-offs of improving soil drainage ?

- investment in soil health
  - > exchange of O_2 and CO_2 exchange
  - < production of anoxic gases: CO, NO
  - reduces risk of root diseases
  - soils less susceptible to compaction
  - improved nutrient uptake
  - < frost heaving (NS)
- improves trafficability
- greater tree uniformity
- earlier, higher production of quality fruit

Internal and External Drainage

Internal drainage: **refers to the net permeability of all soil layers in a profile**

External drainage: **refers to the position of the soil in the landscape**

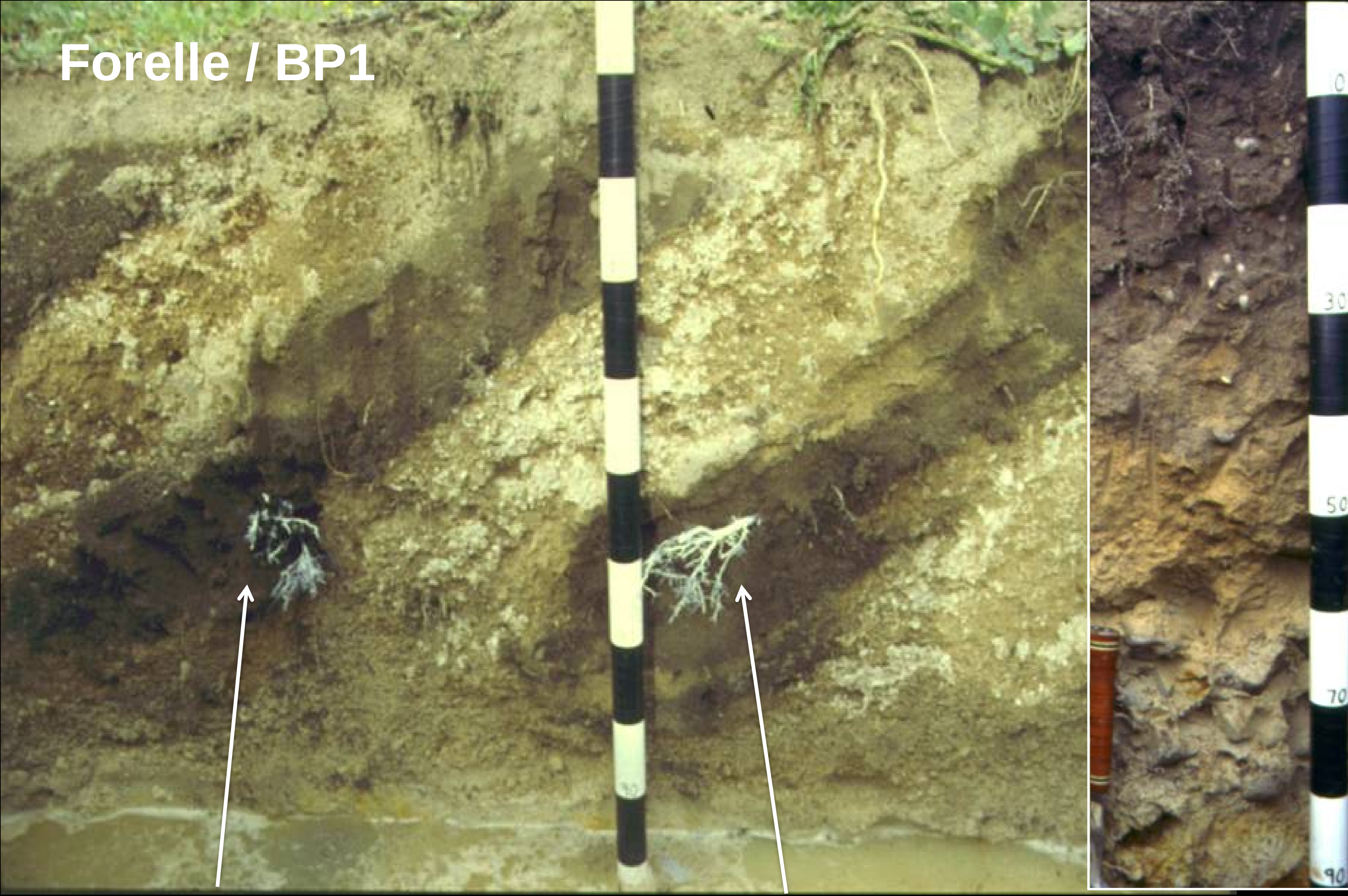

Soil variability

Considerations for Artificial, Sub-surface Drainage Systems:

- soil investigation
- **properties of the subsoil**
- **LT rainfall distribution patterns**
- **wettest year in 10**
- **classic “herring bone” design or selected drainage of wet areas ?**

- design: depth and spacing

Installing sub-surface drains



Healthy roots: cool soil temperatures; soil OM; sufficient moisture

Performance of Subsurface Drainage Systems for Orchards

Most critical period:	Post bloom
Weather	wettest year in 10
Rooting Zone:	60 cm
Saturated root zone:	150 mm water
Soil temp:	12 ^{o}C
DR of 2.5 mm hr^{-1}	60 hours
DR of 25 mm hr^{-1}	6 hours

Digging for facts is better than jumping to conclusions.

S<u>urface modification</u> for removal of excess water?

Syn: berms, ridges, landscaping

- shallow, wet soils with some slope to work with

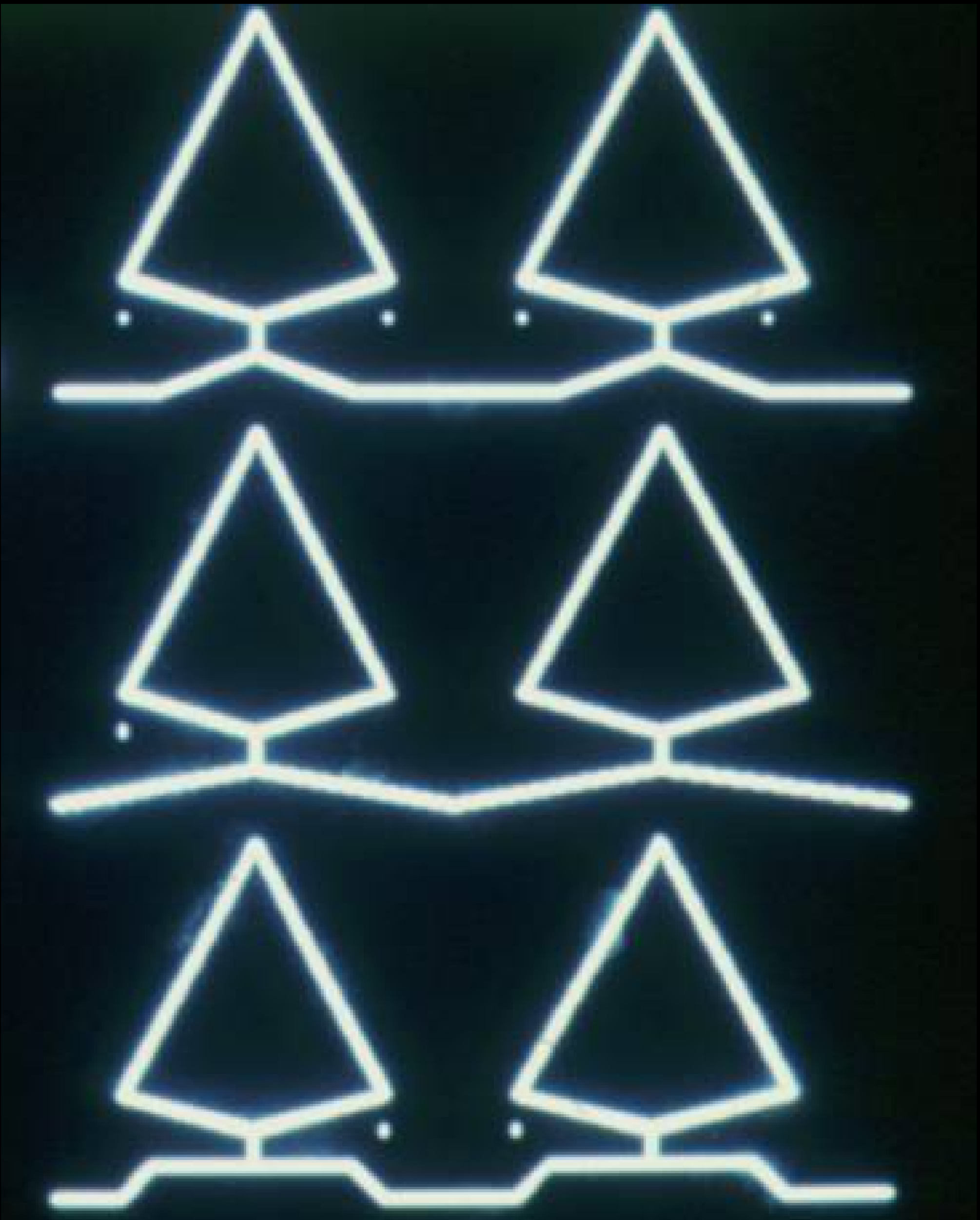
- investment in topsoil

- improves soil depth = “soil health”

- enhances orchard uniformity

- often in conjunction with upslope cut-off drainage

Surface Modification for Removal of Surface Water



Model: Informal Landscape

Non irrigated orchards

Model: Formal Landscape

Non irrigated or drip irrigation

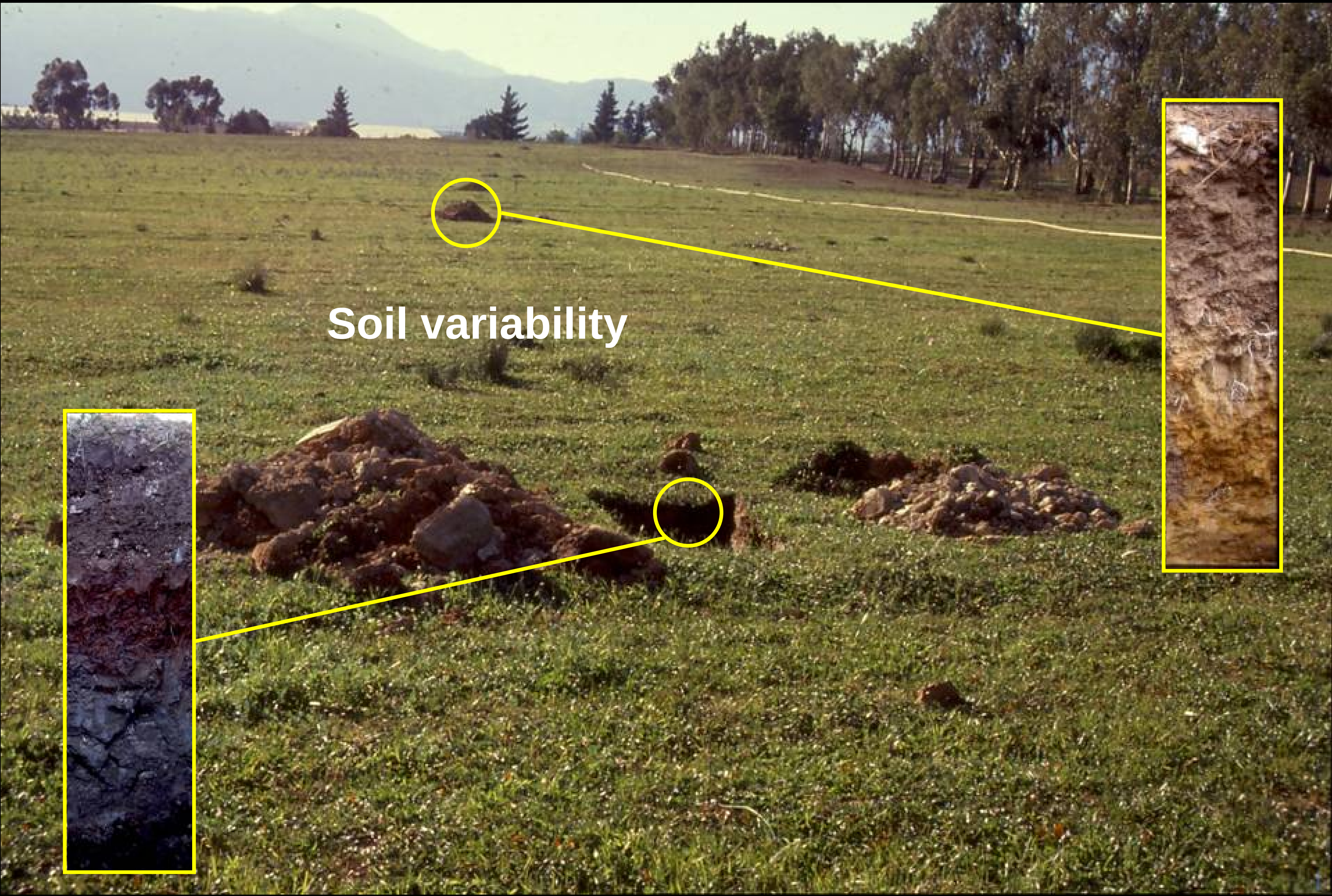
Model : Formal Table Top

Permanent micro-irrigation

Incorrect height to width ratio

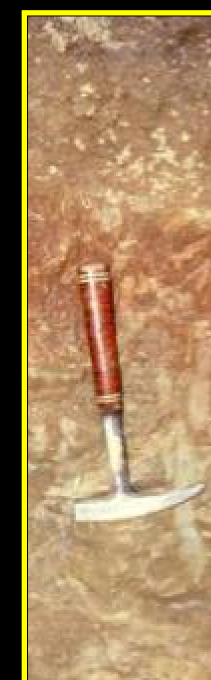
Problems with:

- **increases soil temp, ET**
- **difficult to irrigate**
- **impractical for equipment**


Soil variability


Reshaped surface to
improve drainage


Berm




Planting row

Ambrosia / B9 – Informal Landscaping


X
Don’t try to solve the
problem after
planting!

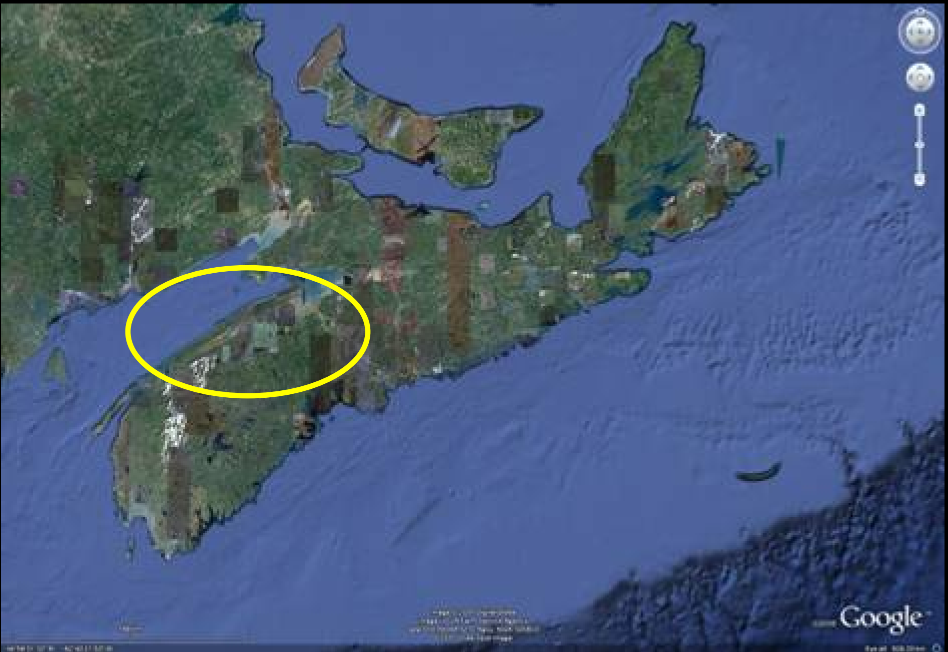
Western Cape – SA

Soils 30,000 + yrs old

> challenges with subsoil permeability

> emphasis on surface removal of water

Subsurface drainage; only selected situations



Annapolis Valley, Nova Scotia, CA

Soils < 10,000 yrs old: since last ice age

> fewer challenges with subsoil permeability

> emphasis on tile drainage (30 + % of all soils)

Surface modification in selected situations

Soil Health

2. Replant Disease: **a big challenge**

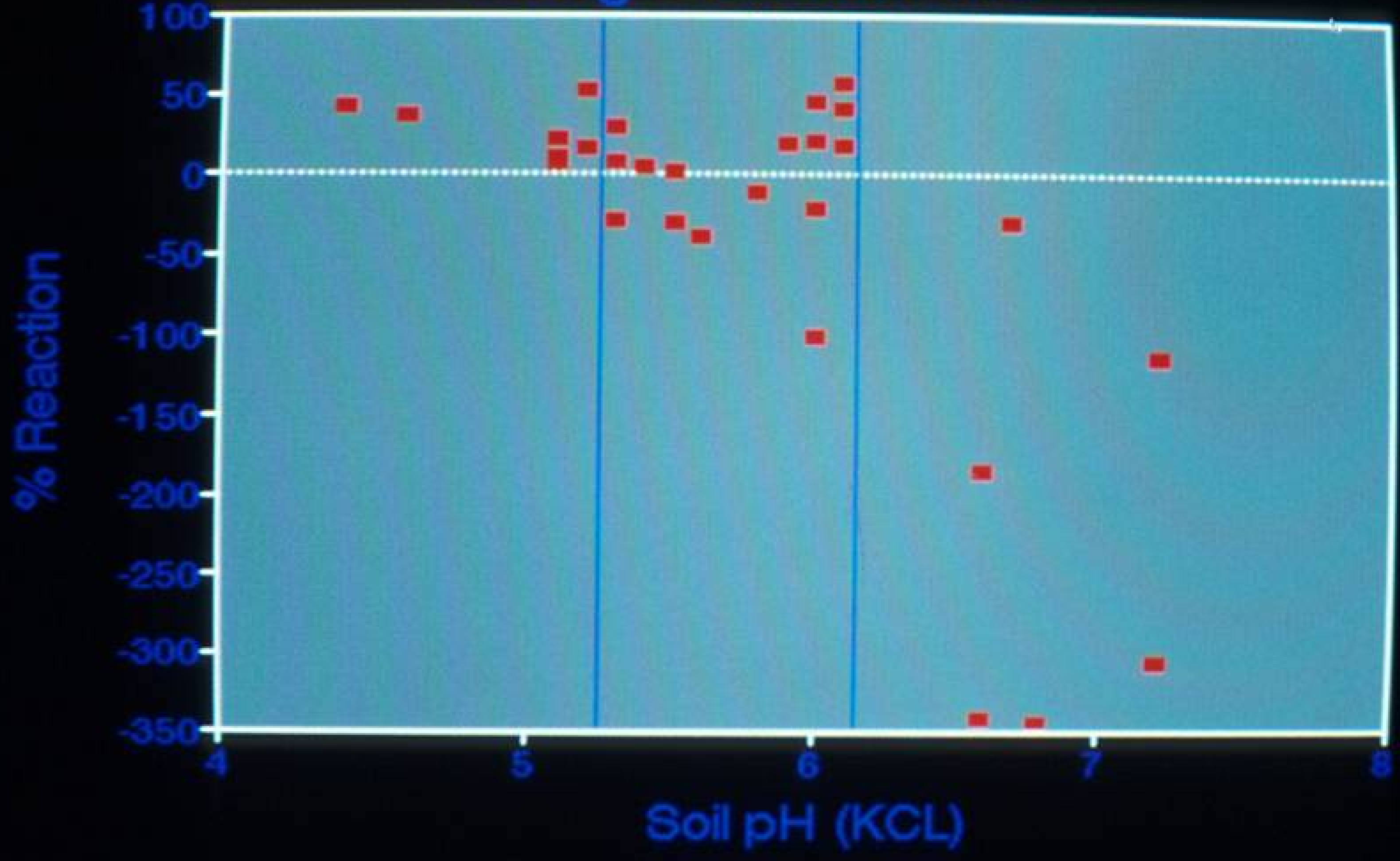

Greenhouse for running
replant bioassays


KOELFONTEIN
BLOK 54


Pasteurized
Control
BOPLAAS
BLOK 15B
APPELS
APPELS
KONTROLE
BEROOK


Non-fumigated
check

Effect of soil pH on the reaction to fumigation with MB



P deficiency


Soils Project 1999
Apple Replant Biotest
D. Nichols Topsoil
Untreated
D. Nichols Topsoil
Soils Project 1999
Apple Replant Biotest
Potting Mix
Untreated
Untreated replant soil
Sterilized replant soil
Untreated potting mix

HORTSCIENCE 45(11):1702–1707. 2010.

Response of ‘Honeycrisp_’ Apple Trees to Combinations of Pre-plant Fumigation, Deep Ripping, and Hog Manure Compost Incorporation in a Soil with Replant Disease

P**. Gordon Braun**, Keith D. Fuller, Kenneth McRae, and Sherry A.E. Fillmore

Agriculture and Agri-Food Canada, 32 Main Street, Kentville, Nova Scotia B4N 1J5, Canada


Replant Soil: Orthic Humo-Ferric Podzol
Birchleigh Farm, Nova Scotia

Bioassay for Replant Disease:
-apple seedlings grown in greenhouse
- significant response to pasteurization of soil
- ARD root pathogens *Pythium* and *Cylindrocarpon* sp. isolated


Compost
used

Deep ripping

Replant Site:

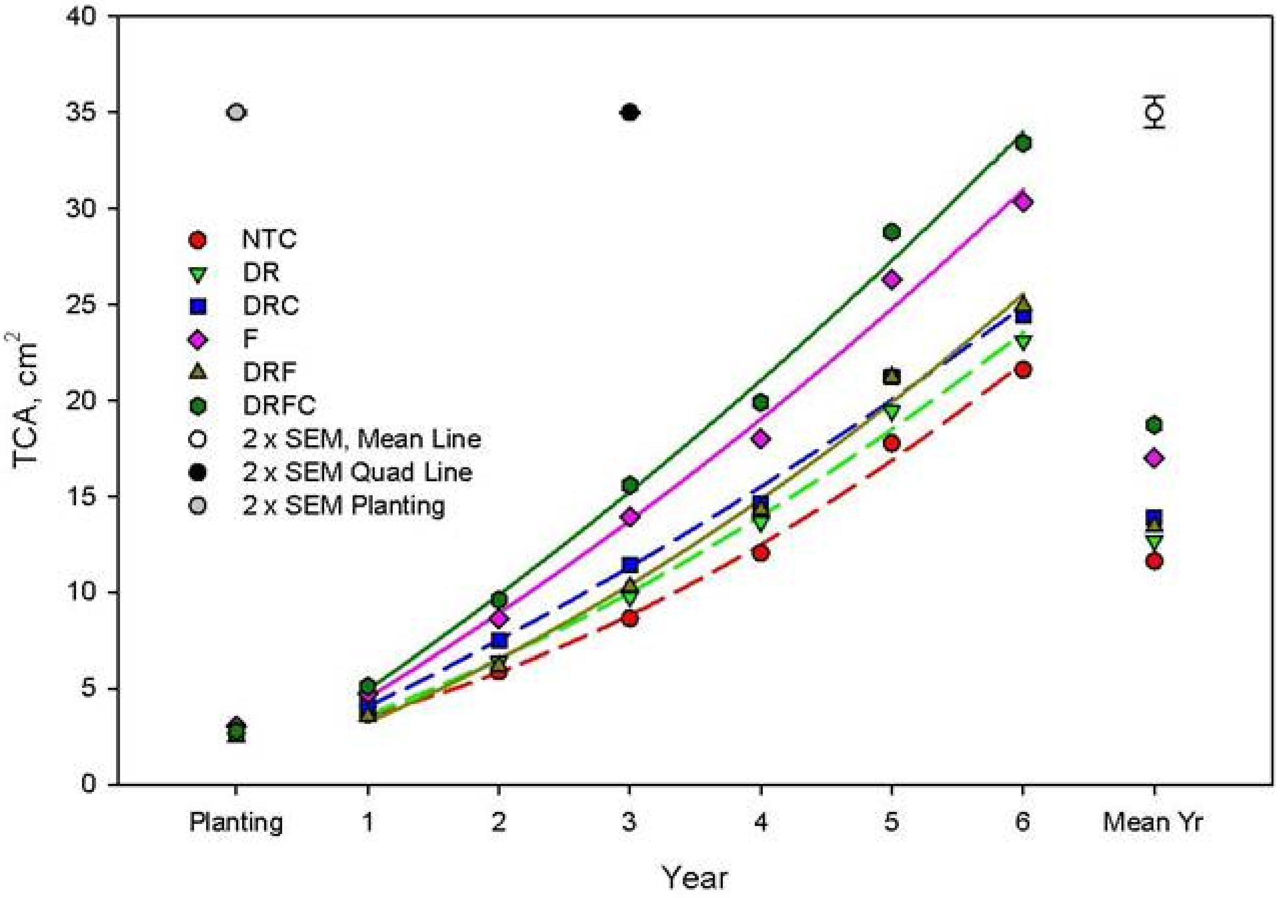
1. Apple production since 1942
2. Old trees removed summer 2001
3. Land plowed down: fall 2001
4. Treatments established: fall 2002
5. Honeycrisp® / M4 planted spring 2003

Replant Treatments:

1. Control
2. Fumigation: Telone C17 @ 280 L per ha
3. Deep ripping
4. Deep ripping + fumigation
5. Deep ripping + compost incorporation
6. Deep ripping + fumigation + compost inc.

Fumigation

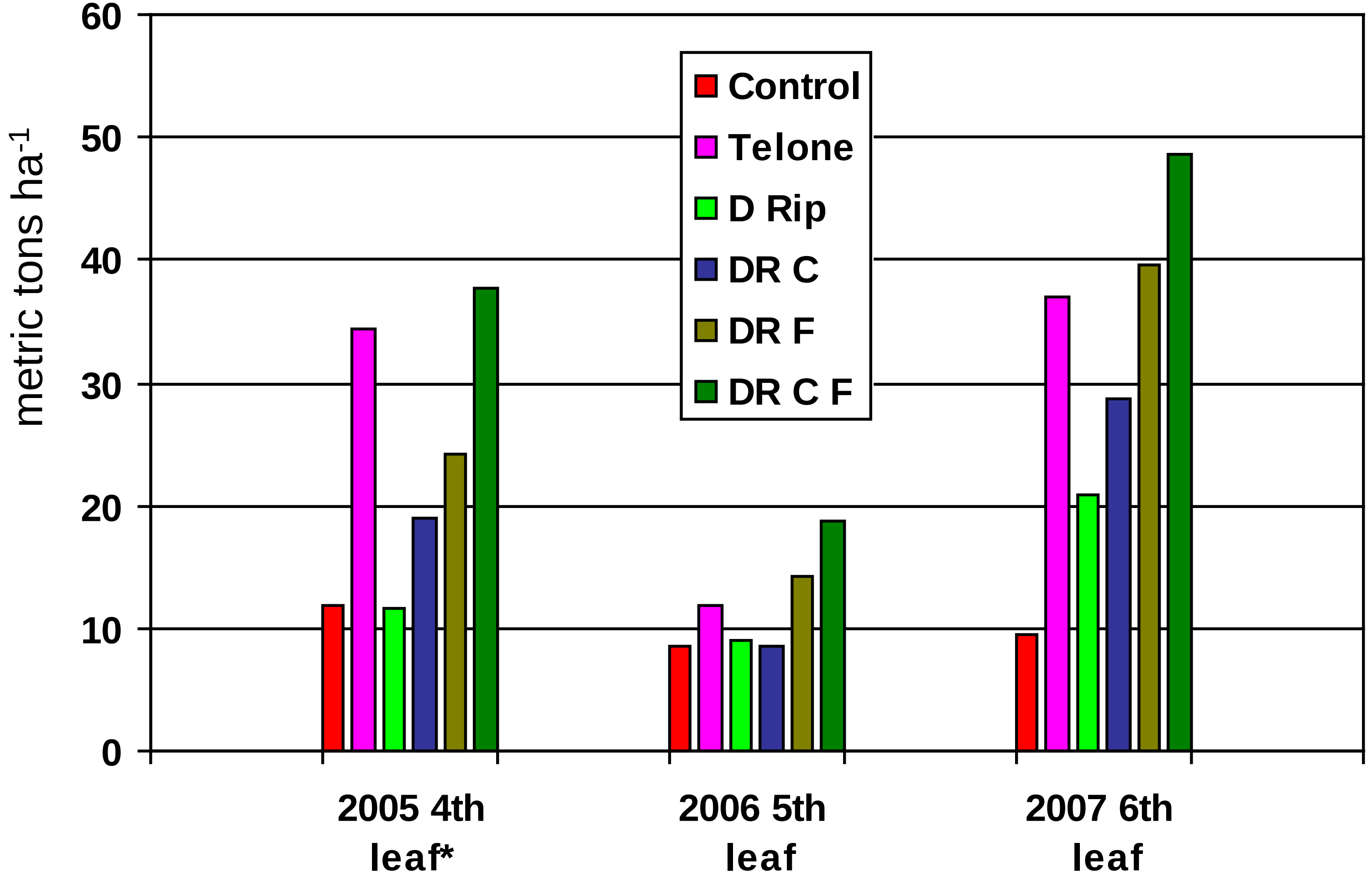
Growth Response of Honeycrisp / M4 to Replant Treatments

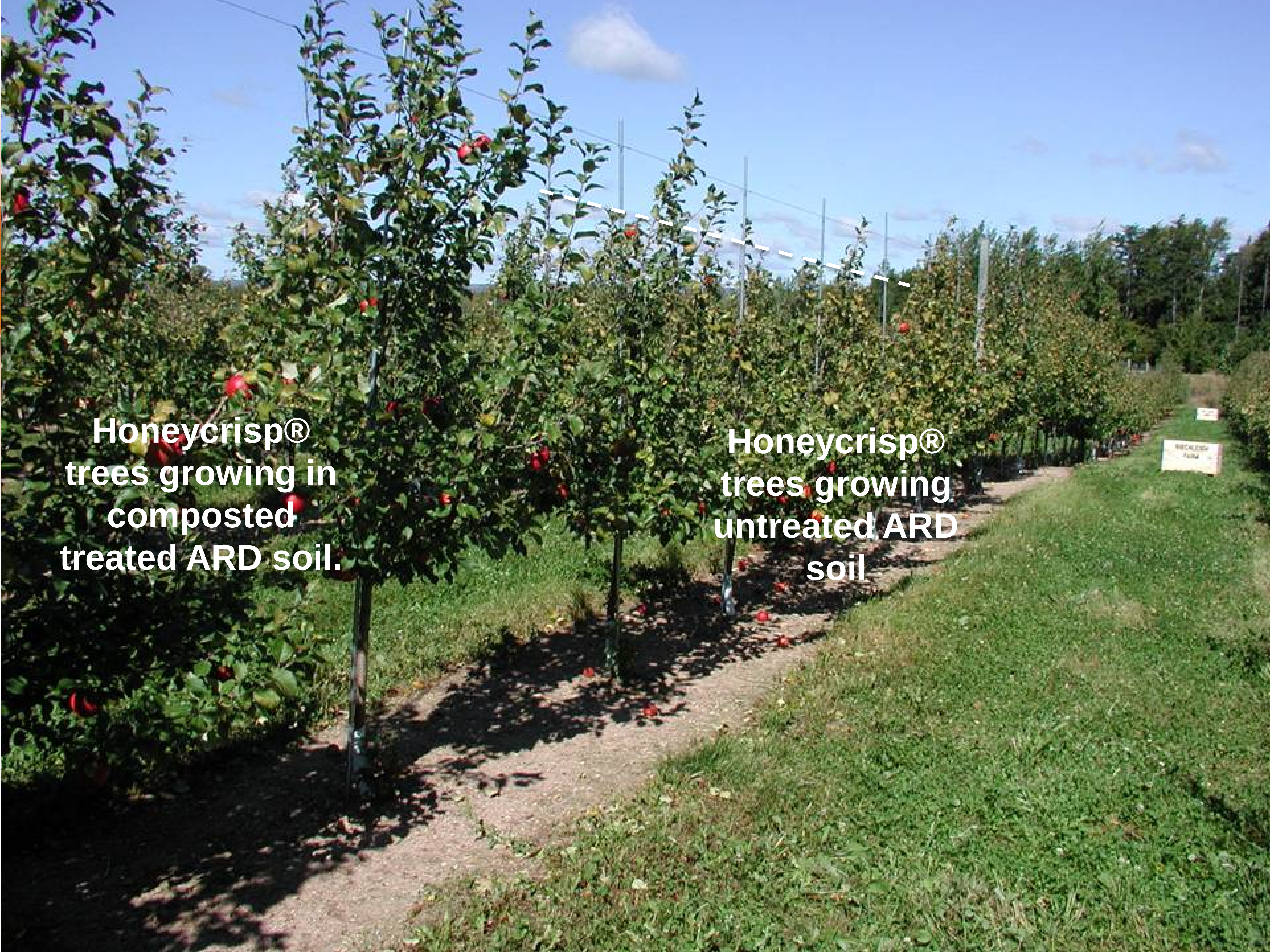


Reference:

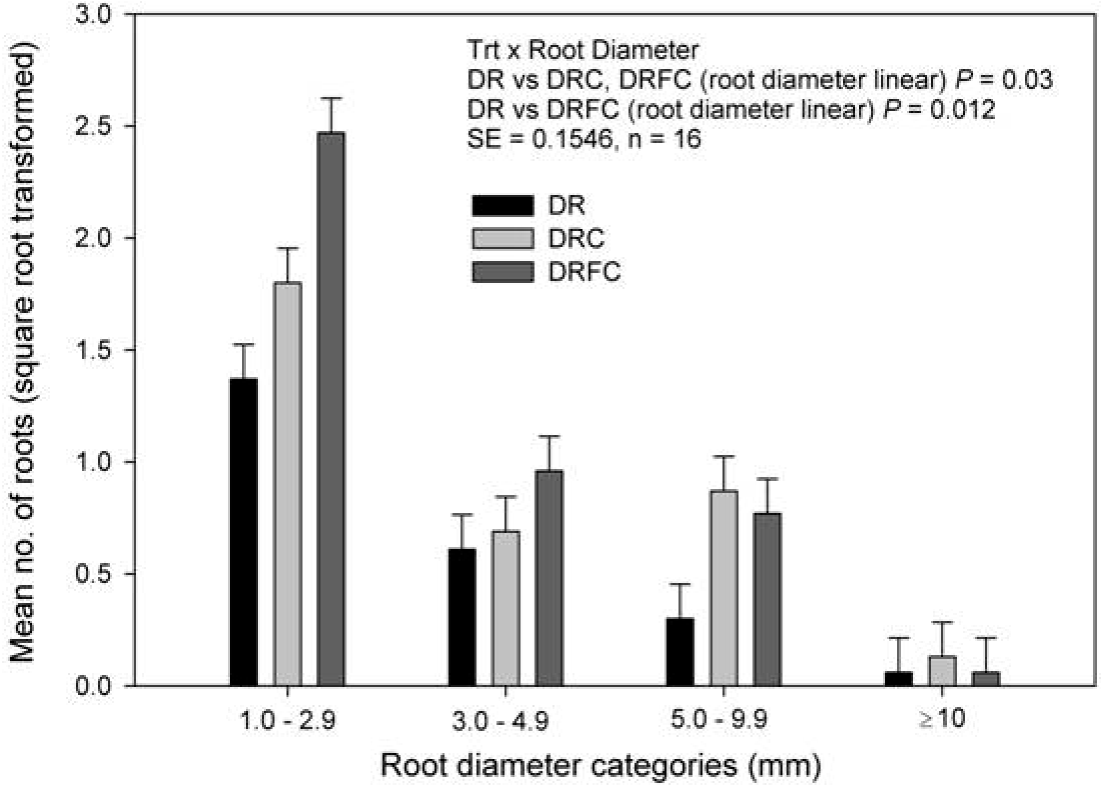
Braun, G, Fuller, K.D., Fillmore, S.A.E., McRae, K. 2010. Response of 'Honeycrisp®' Apple Trees to Combinations of Pre-plant Fumigation, Deep Ripping, and Hog Manure Compost Incorporation in a Soil with Replant Disease. *HortScience 45(11):1702–1707.*

Yield of Honeycrisp® / M4 in Response to Replant Treatments with compost




Honeycrisp® trees growing in composted treated ARD soil.
Honeycrisp® trees growing untreated ARD soil

Effect of deep ripping, fumigation and compost on root numbers in the 80 cm of soil



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Compost suppression of soil borne diseases*

- production of antibiotics or fungitoxins by microbial populations in compost

- destruction or absorption of phytotoxins by compost or the organisms it supports

- improved plant nutrition and vigour

- induced systemic resistance by microbes in compost

- successful competition for nutrients by compost supported micro-organisms

- parasitism of pathogens by compost supported microbes

- beneficial changes to the physical characteristics of the soil

- beneficial changes to soil pH / salt concentration

* Noble, R., and Coventry, E. 2005. Suppression of soil-borne plant diseases with composts. A review. Biocontrol Sci. Technol. 15: 3-20.

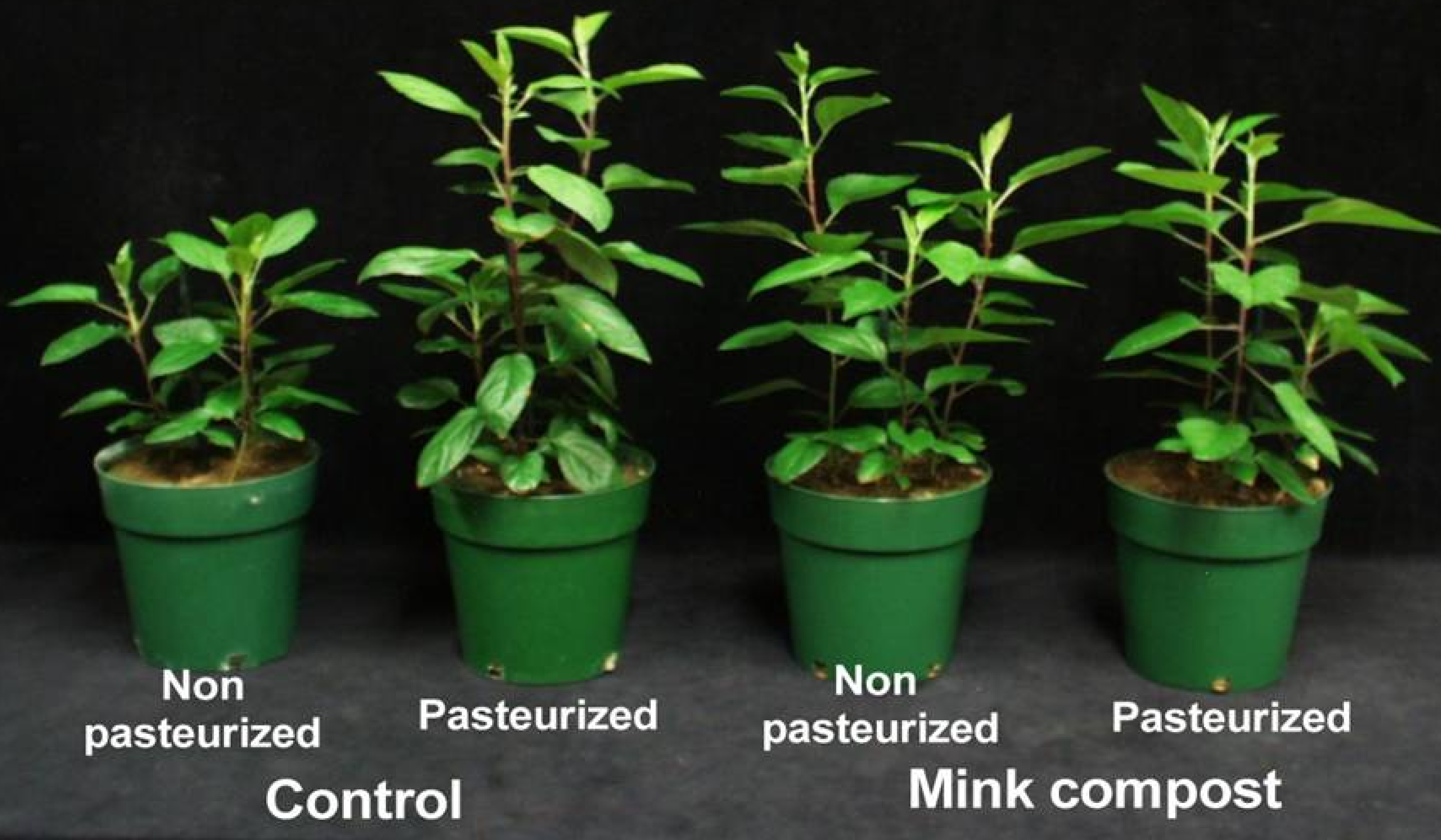
Other observations

- symptoms of “Honeycrisp® chlorosis” were more pronounced in control trees when compared with trees receiving compost

- trees in the control site were still visibly smaller after 6 years and had not filled allotted space

- severity of the disease at this site generally fits the prognosis that ARD is more pronounced on coarse textured mineral soils with average to low OM and the likely hood of moderate to severe levels of drought stress

Biological remediation of Apple Replant Disease with composts and animal wastes



Summary of Research and Field Experiences with Replant Disease in SA and NS

- a major re-establishment issue in both industries ... apples and pears
- Greenhouse: hundreds of replant soil tests 1993 – 2004: replant disease always present
- Green house: best growth response in replant tests on soils with low pH – worth pursuing
- Field: many replant sites fumigated with an observational control – almost always a good response
- Field: observations generally showed more severe replant symptoms on coarse textured soils with average to low soil OM and moderate to severe drought stress
- Viable alternatives to broad spectrum fumigants: currently none

Soil Health

3. Nitrogen Utilization Efficiency: Soil Health Indicator

Studies in N use efficiency and water quality in Annapolis Valley orchards

Fuller, K.D., Embree, C.G., and MacLeod J.A. 2001. Orchard removal effects nitrate discharge from tiled land. ***Acta Horticulturae, No. 564: 285-294.***

- **MacSpur / MM107 and MM111**
- **400 trees per ha**
- **orthic gray-brown-luvisol**
- **tile drained orchard**
- **3.4 % OM**
- **grassed orchard floor, only broadleaf herbicides**

Std pruning / thinning practices

Methodolody: Nitrogen Applications and Mulching for MacSpurr

1. Permanent under-canopy mulch
   - 2.4 x 2.4 m sq per tree
   - 5 kg per tree per pa (5 cm)

2. Nitrogen applications
   - hay mulch each spring
   - 5 kg hay per tree (1.2 % N)
   - equiv: 24 kg N ha^{-1}
     +
   - 150 g AN / tree to mulched area
   - equiv. to 20 kg N ha^{-1}
     =

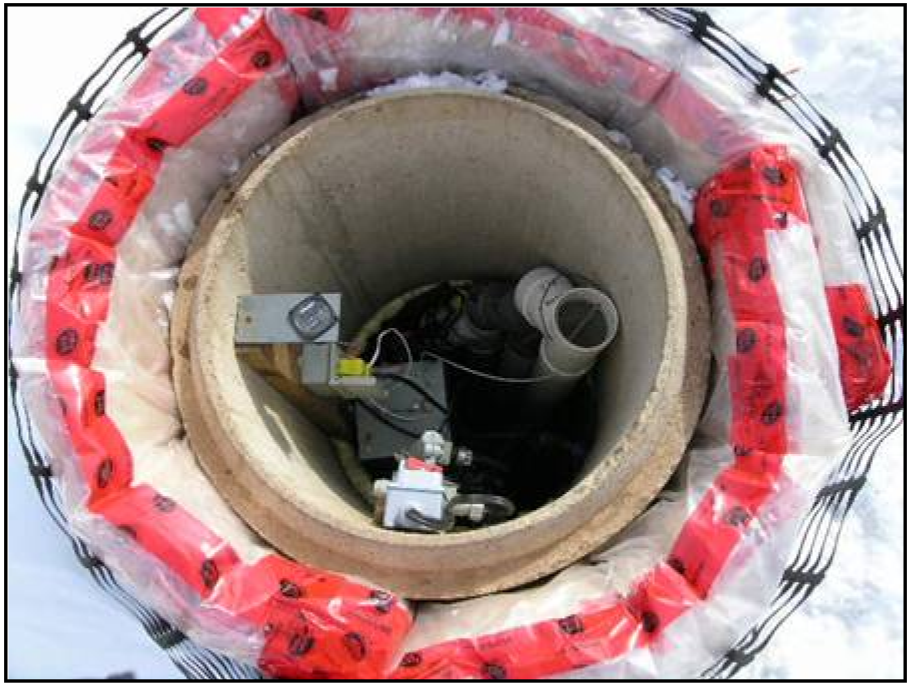
Total: 44 kg N ha^{-1} each spring

3. Grassed orchard floor

4. Broadleaf herbicides to eliminate N fixation.

Methodology : N leaching

- tile drainage system to collect leachate
- continuous monitoring of flow
- collection of composite water samples
- calculation of nitrate loading (kg N ha^{-1})



Methodology : N removal by crop

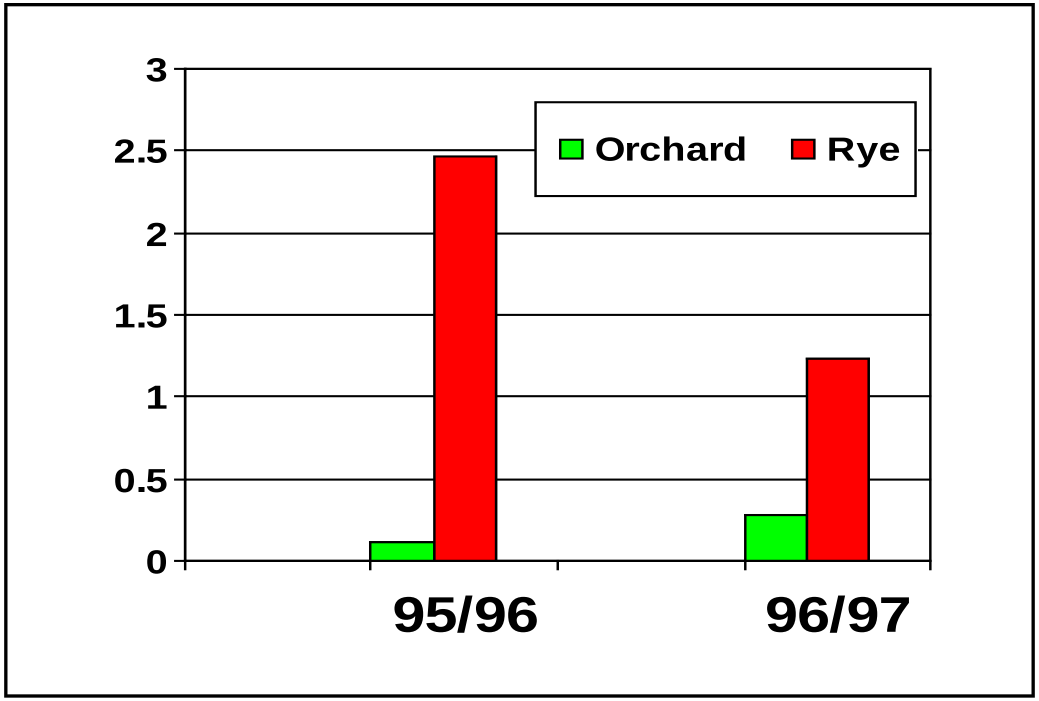
- harvesting of fruit (fresh + drops)
- calculation of yield
- use of industry norms for fruit N content
- calculation of N removal from system

Results: N removal by crop

- production: 40 metric tons ha^{-1}
- N removal: 16. 8 kg N ha^{-1}
- vs applied: 44 kg N ha^{-1}

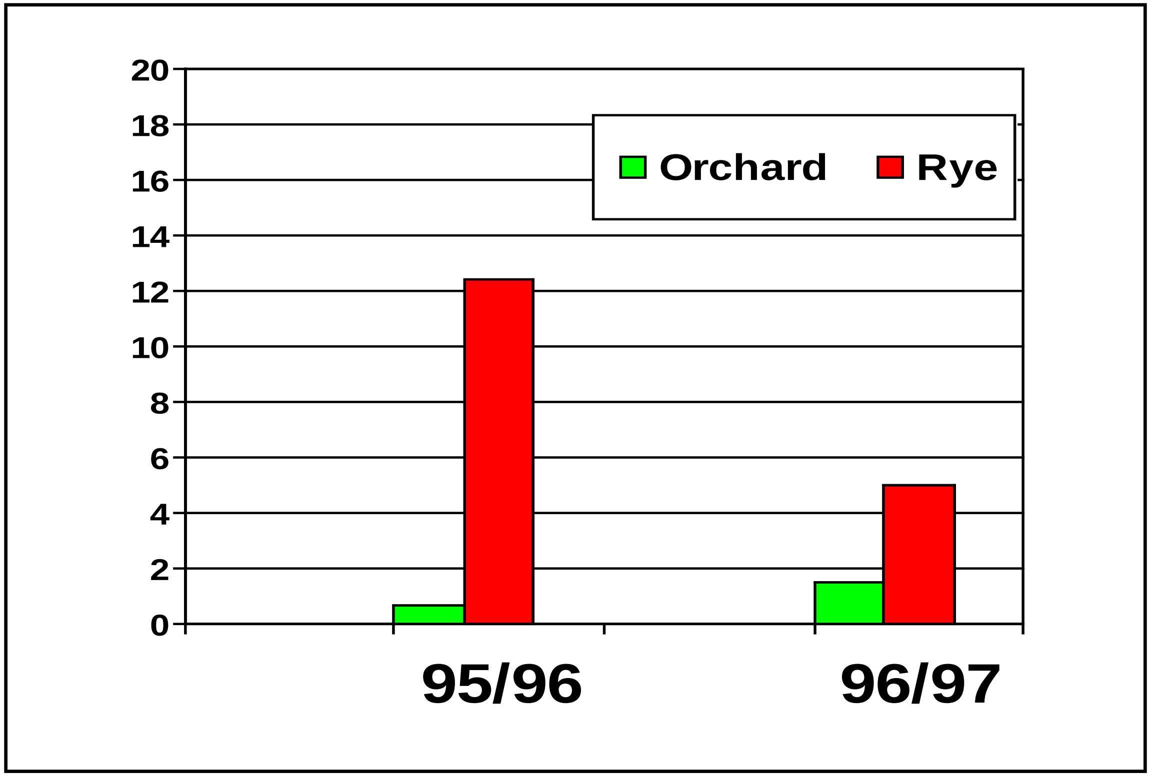
Results : tile NO3-N concentrations

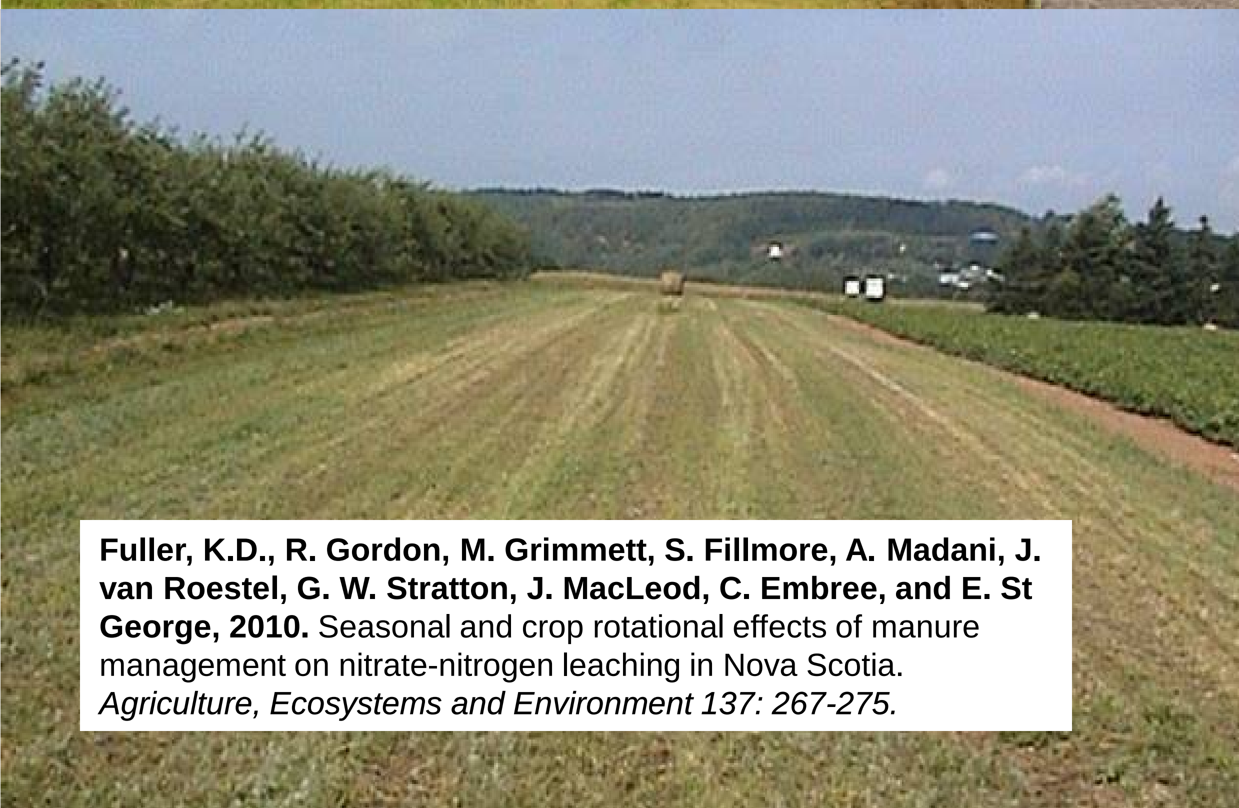
- fall, winter and spring periods
- > 30 composite samples each drainage season
- 0.5 – 2.0 mg NO3-N L^{-1}
- << drinking water standard : 10 mg N L^{-1}



Results : nitrate loading

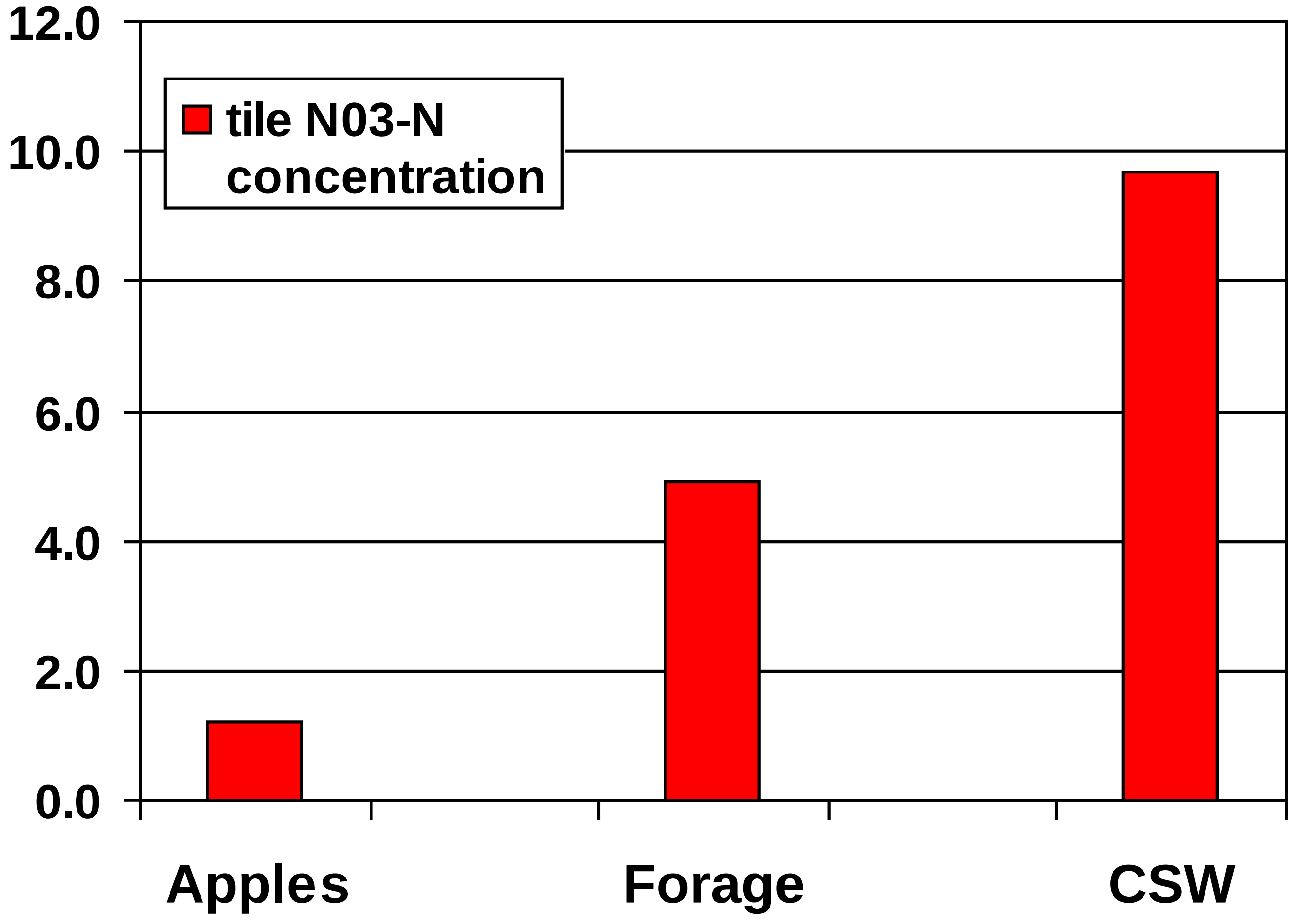
- < 2 kg N ha^{-1} annually
- most during the dormant season
- approximately 5 % of applied N



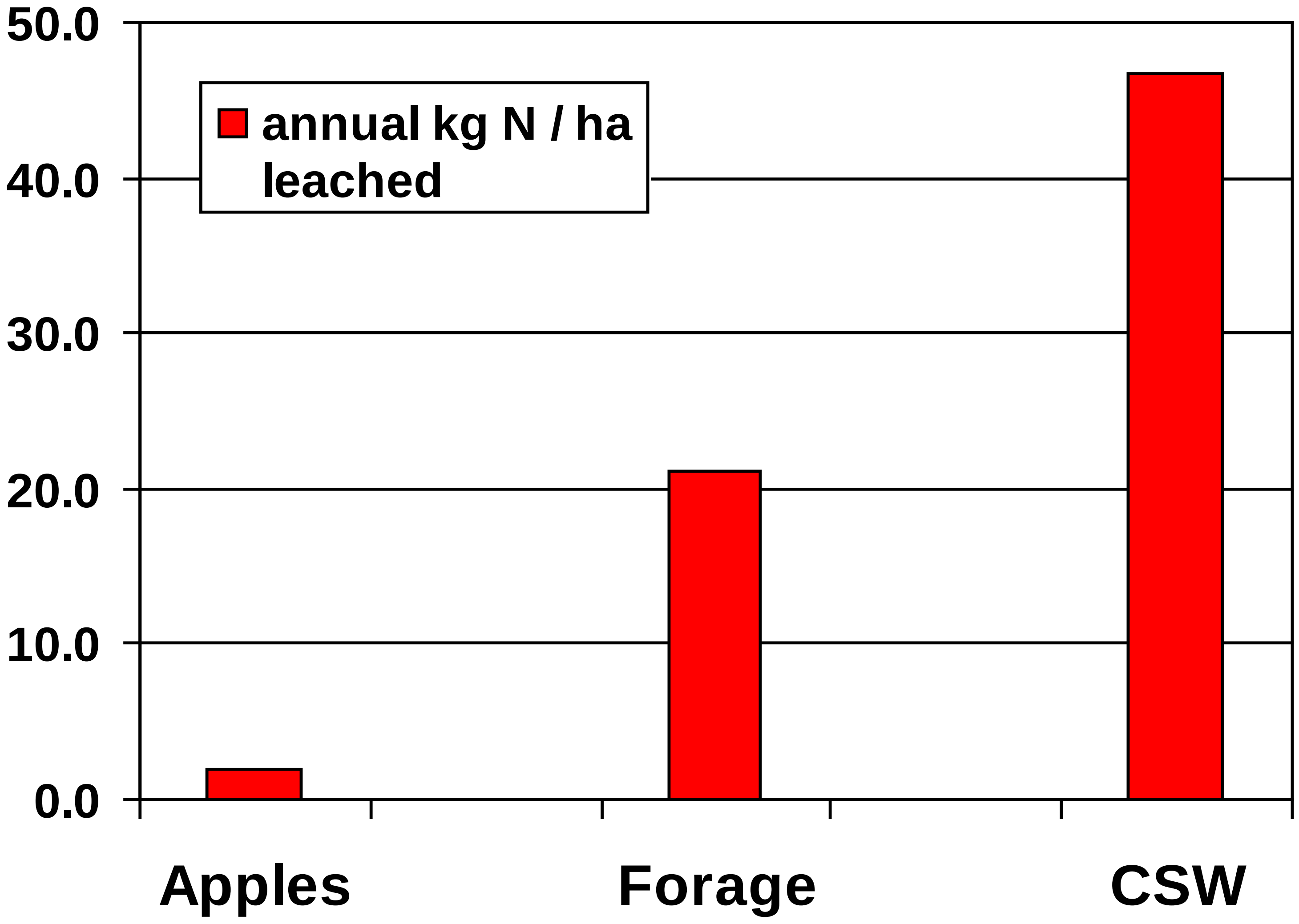


Fuller, K.D., R. Gordon, M. Grimmett, S. Fillmore, A. Madani, J. van Roestel, G. W. Stratton, J. MacLeod, C. Embree, and E. St George, 2010. Seasonal and crop rotational effects of manure management on nitrate-nitrogen leaching in Nova Scotia. *Agriculture, Ecosystems and Environment 137: 267-275.*

Lysimeter



12.0
10.0
8.0
6.0
4.0
2.0
0.0
tile N03-N concentration
Apples
Forage
CSW



50.0
40.0
30.0
20.0
10.0
0.0
annual kg N / ha leached
Apples
Forage
CSW

Possible reasons for high N utilization

- berms: more topsoil under the canopy
- application of hay mulch: builds soil C, stores N, gradual release
- orchard is a no-till / extreme reduced till system
- optimal rooting environment under the much
- > branching of root system
- > higher than normal root density
- > higher % utilization of N, only 5% lost by leaching

= approximately 5 % of applied N

= <u>SOIL HEALTH</u>

Comments on N utilization efficiency in orchards

South Africa | **Nova Scotia**

Soil OM content:

1 - 3 % vs **2 – 4 %**

Leaching potential:

750 + 500 mm vs **1150 mm**

Ave. Annual Temperature:

15^{o}C vs **8 ^{o}C**

Thank You !