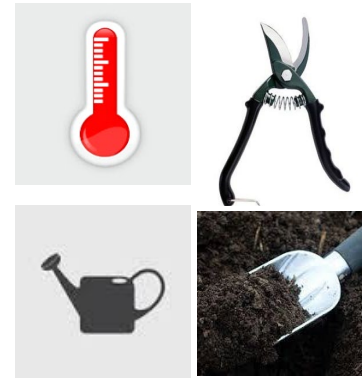
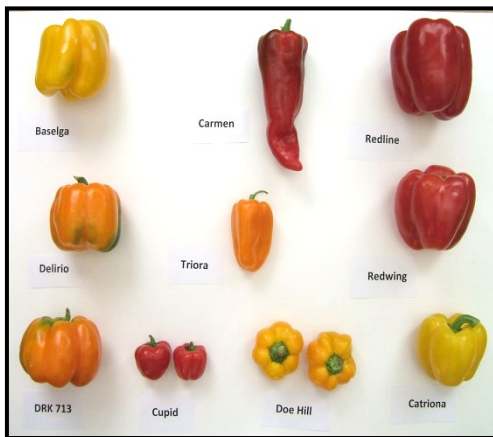


# Sweet Pepper, Grafted Tomato Demonstration and Greenhouse Tomato Production Monitoring

November 24, 2015 ACORN Conference



Presented by: Claude Berthélmé, NBDAAF Organic and Vegetable Production Specialist  
Charles Comeau, NBDAAF Crop Development Officer

# Overview of Presentation

- Project Background
- Coloured Sweet Pepper Variety Demonstration
  - Results, observations and assessment sheet
- Grafted vs Non-Grafted Tomato Demonstration
  - Results and observations
- Greenhouse Tomato Production Monitoring
  - Observations
- Important Things Learned in 2015
- Acknowledgements:

# Sweet Pepper, Grafted Tomato Demo and Tomato Production Monitoring

- Funded by Growing Forward 2 (Enabling Ag. Research and Innovation Prog.)
- Demonstration rather than adapted research (Great way to learn ...)
- Partnership between ACORN and NBDAAF
- As a result of the 2014 Quebec Vegetable Tour and the work done by Christine Villeneuve (MAPAQ).



# Sweet Pepper Demonstration

Intent:

- 1) Give growers an opportunity to grow some of the most productive coloured sweet pepper varieties (some already identified by QC Trials).
- 2) Provide opportunity for growers to do their own assessment.

A few details:

- 10 varieties (very large, large, medium, small and mini)
- Mostly new varieties for NB vegetable growers
- 8 collaborating farms
- Strawberry Hill Farm contracted to grow organic seedlings
- Grown in greenhouses and tunnels
- Transplanted in early to late June
- Plants were staked or weaved at most sites (no pruning)
- Project lead provided assessment sheets





High quality  
transplants





**Baselga**



**Carmen**



**Red Line**



**Delirio**



**Triora**



**Red Wing**



**DRO 713**



**Cupid**



**Doe Hill**



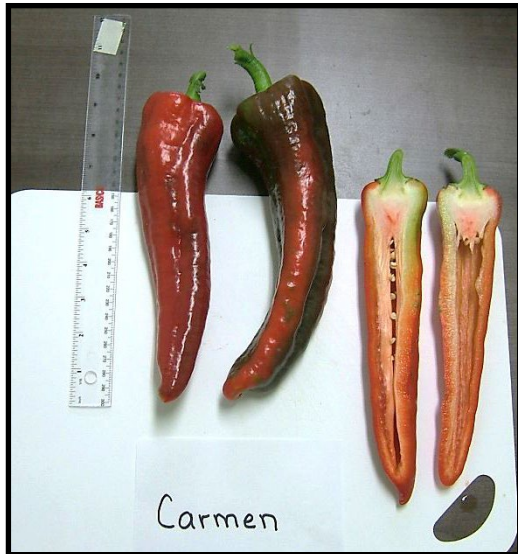
**Catriona**



# Five early to mid-season peppers:







# One of the two informal group tasting events



**EARI PROJECT- NBDAAF/ACORN Grafted Tomato and Coloured Sweet Pepper Demonstration (2015)**

**Crop assessment survey for coloured sweet peppers**

					Score: (2= very low, 4= low, 6= medium, 8= high, 10= very high)					
Variety	Earliness (early, mid, late)	Height of plants (cm)	Fruit shape ribbed, blocky, horn-shaped, triangular, pumpkin, oval	Fruit taste (sweet, bitter, sour, hot, etc)	Fruit attractiveness score	Fruit size uniformity score	Yield score	Proportion of marketable fruit score	Shelf-life score	Fruit taste score
<b>Carmen (regular red)</b>	Early	71-80	Bull-horn shaped	Sweet and flavourfull *	9	9	9	9	9	8*
<b>Red Wing (regular red)</b>	Late	66-80	Large blocky	Sweet	9	9	8	8	9	6
<b>Red Line (regular red)</b>	Late	60-70	Very large blocky	Sweet	9	7	8	8	9	6
<b>Catriona (regular yellow)</b>	Early-mid	60-67	Very large blocky	Sweet	9	9	9	8	7	7
<b>Baselga (regular yellow)</b>	Late	61-75	Large pumpkin "ribbed"	Sweet	7	8	8	9	8	6
<b>Delirio (regular orange)</b>	Late	60-81, variable	Large blocky	Sweet	9	8	7	7	8	6
<b>DRO 713 (regular orange)</b>	Mid	60-80 variable	Very large blocky	Sweet	8	7	7	8	8	7
<b>Cupid (mini red)</b>	Early	60-100, variable	Mini oval	Sweet *	9	8	8	9	9	8*
<b>Triora (mini-medium-orange)</b>	Early -mid	65-71	Med. triangle	Very sweet and flavourful *	9	9	9	8	9	9*
<b>Doe Hill (mini-yellow)</b>	Early	50-64, variable	Small pumpkin "ribbed"	Very sweet and flavourful *	7	7	8	7	9	9*

Data and observations from one year only. It is important to note that none of the collaborators have measured the exact yields. All scores are based on visual observations and taste.

\* Top 4 best tasting peppers based on two group tasting events

Seed suppliers: Johnny's Selected Seeds, Veseys Seeds, Seminova, Stokes Seeds, la société des plantes

Most varieties should be staked or supported

**EARI PROJECT- NBDAAF/ACORN Grafted Tomato and Coloured Sweet Pepper Demonstration (2015)**

**Crop assessment survey for coloured sweet peppers**

<b>Variety</b>	<b>Comments from growers and collaborators: disease incidence, insect damage, fruit size, colour uniformity, days to full maturity, other fruit characteristics, etc</b>
Carmen (regular red)	Heavy yield, thinning in early stages maybe beneficial, pick promptly or the fruit tips can go soft if in contact with ground. 153g/fruit, 8 and 17 fruits/plant, 40% lodging/1 site, need staking, hard to pick when loaded. 1 grower did not like taste.
Red Wing (regular red)	Huge fruit. Very interesting large and tasty fruit. 280g/fruit, 5 and 16 fruits/plant, 20% lodging/1 site, 14% wilt or rot/1 site.
Red Line (regular red)	Huge fruit bigger than Red Wing. <span style="float: right;">340g/fruit, 7 and 13</span> fruits/plant, less than 10% lodging/1site, need staking.
Catriona (regular yellow)	Amazing yellow colour. Pick promptly to avoid soft spots on fruit. A gone one. 233-250g/fruit, 7 and 10 fruits/plant, 7% wilt or rot/1 site, 0% lodging/1 site.
Baselga (regular yellow)	Thicker skin than Catriona. Lacked the consistent nice shape of Catriona. Fruits tended to be a bit shorter/rounder with more pronounced ribs than Catriona. 280-260g/fruit, 4 and 13 fruits/plant, 7% wilt or rot/1 site, 2/7 lodging/1site, may need staking.
Delirio (regular orange)	Fruit shape and size was nice, but the plants lack vigour. Plant height was variable. 167-300g/fruit, 6.5 and 17 fruits/plant, 50% lodging/1site, weak plants, may need staking.
DRO 713 (regular orange)	Fruit shape and size was nice, but not real a productive variety. 200-300g/fruit, 8.5 and 13 fruits/plant, 38% lodging/1 site, poor germination, weak seedlings, non-uniform seedlings, need staking.
Cupid (mini red)	Beautiful deep red. Very productive variety. This variety produce numerous fruits per plant. The height of the plants varied between sites. 37g/fruit, may need staking. Cupid and Doe Hill together make a nice mini pepper selection for selling in quarts.
Triora (mini-medium-orange)	Good yielder, medium size fruit, gorgeous orange. Did consistantly well on all sites. Top pick for one growers. 115g/fruit, no lodging with lots of fruit, 14 and 16 fruits/plant, need staking, pick promptly to avoid small cracks.
Doe Hill (mini-yellow)	Plants typically produce numerous small fruits. 77g/fruit, prone to wilt and rot in field conditions but did well under cover. Some plants failed during the middle of the season. No lodging with lots of fruits, 20 and 20 fruits/plant, no staking needed.

**\*Special thank you to Kirsten Livingstone, Strawberry Hill Farm**

# Sweet Pepper Demonstration

## Things learned:

- Productivity varied significantly amongst sites.  
Peppers are very sensitive to weather, soil fertility and irrigation (target yield in Quebec = 6 kg/m<sup>2</sup>, 2.8 to 5.2 to 7.3kg/m<sup>2</sup>, Villeneuve 2015)
- Most varieties require support.  
Simple weaving technique is fine (rebar + three levels of twine).
- Best to select early to mid season varieties for more productivity.
- Best to grow them in greenhouse or tunnels to encourage early ripening, reduce bacterial disease pressure and obtain higher yields.
- Transplants must be healthy and robust to ensure good yield

# Sweet Pepper Demonstration

## Things learned:

- Some growers preferred the medium size peppers (lower price per unit).
- Red Wing, Red Line, Catriona, DRO 713 are beautiful but maybe too large for some.
- Minis and medium size peppers are often sold in small containers. Growers tend to mix colours (i.e. cupid and Doe Hill)
- The taste testing events showed consistent results:  
**Top 5: Doe Hill, Triora, Carmen, Cupid and Catriona**

**Draft copies of the 2015 sweet pepper assessment sheet are available upon request.**

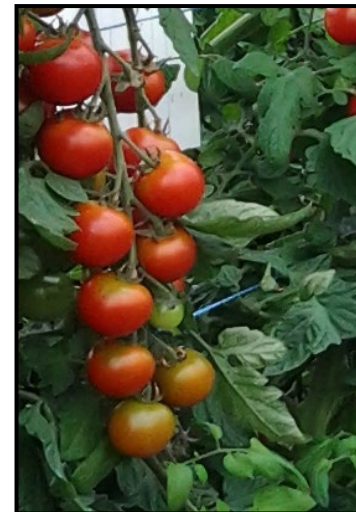
# Grafted Tomato Demo

Intent:

- 1) Allow growers an opportunity to grow grafted tomato plants
- 2) Allow growers to do their own assessment
- 3) Allow NBDAAF staff to get familiar with grafted tomato plants

A few details:

- 3 varieties: Frederik (beef), Sweet Heart (grape), Sakura (cherry)
- Frederik new to all
- Compare non-grafted to grafted (on Maxifort rootstock)
- 4 collaborating farms
- Schurman Family Farm contracted to grow organic seedlings
- Grown as usual: 3 sites with clips/strings & 1 weaved
- Grafted plants with twin heads
- Transplanted: May 20 to 26,
- Last harvest: early to mid-October
- Yields from 6 treatments recorded by growers ... merci!
- Grown in greenhouses (2) and high tunnels (2)



# 4 Types of Season Extension Infrastructures



Heated greenhouse



Caterpillar tunnel



Unheated greenhouse



Multi-bay high tunnel



# Grafted tomato plants with two heads

“Scion pinched above the cotyledons”



Scion “variety”

Over

Rootstock  
“Maxifort”





Grafted plants with 2 heads



Scion should not be allowed  
to set roots





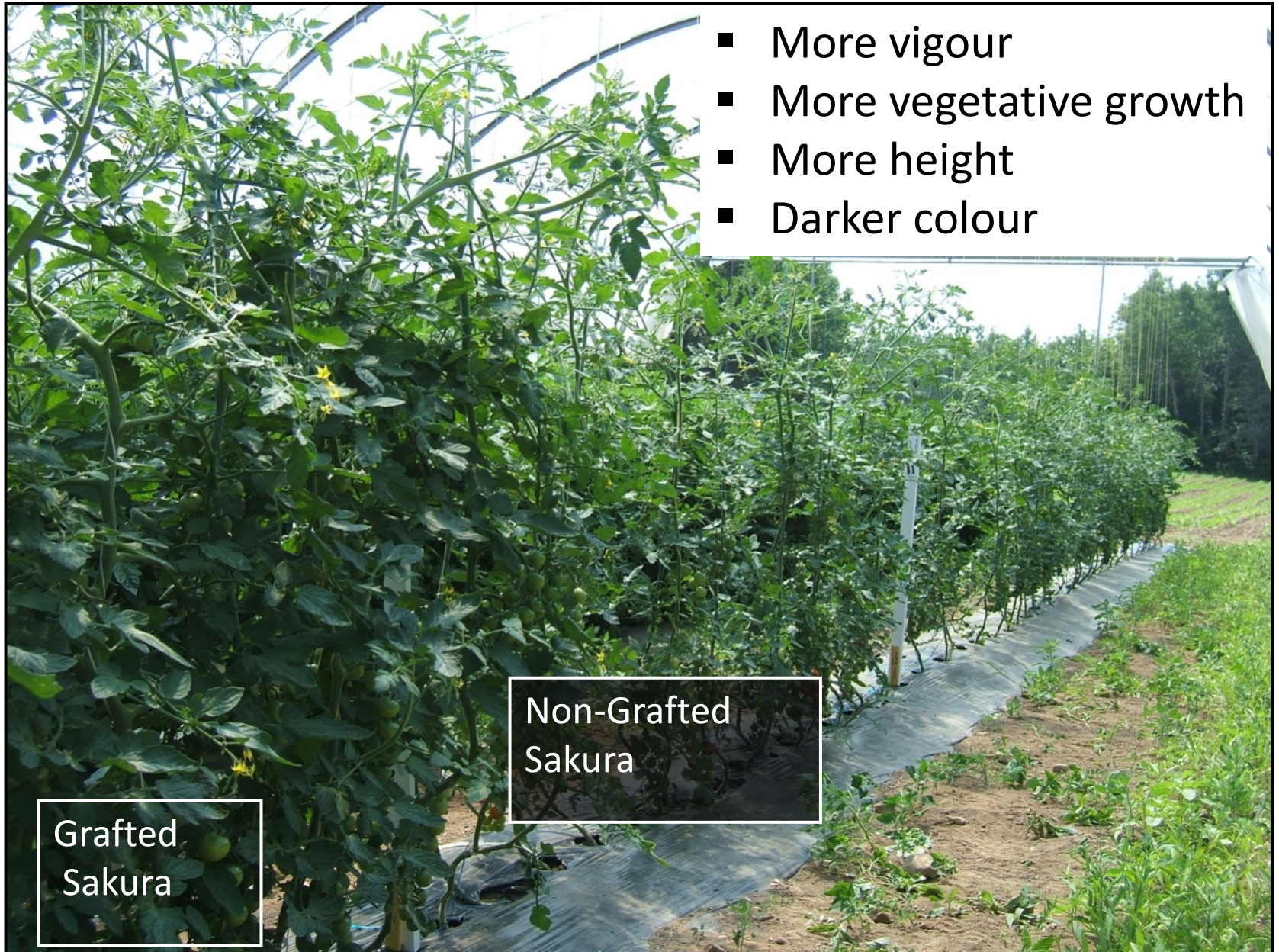
Home grown



Purchased grafted plants  
Lots of vegetative growth  
which may delay harvest



Ferme Pouce Vert Farm



- More vigour
- More vegetative growth
- More height
- Darker colour

Grafted  
Sakura

Non-Grafted  
Sakura



Frederik  
grafted

Frederik  
non-grafted

Nature's Route Farm



Grafted  
Sweet Heart

Non-grafted  
Sweet Heart

Ferme Pouce Vert Farm

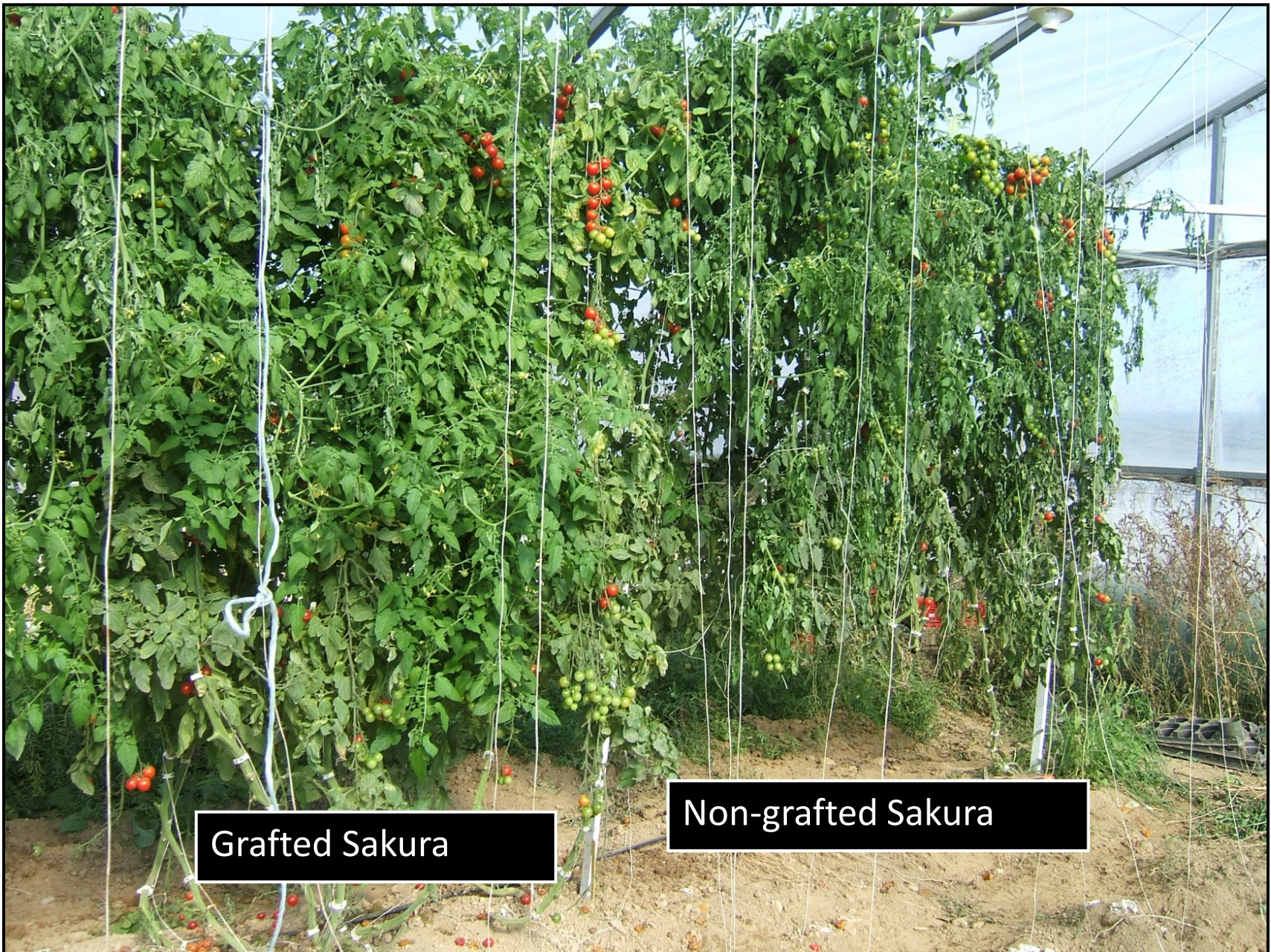




Non-grafted  
Frederik

Grafted  
Frederik

Nature's Route Farm



Grafted Sakura

Non-grafted Sakura

Strawberry Hill Farm



Non-grafted

Grafted



Nature's Route Farm

Table 1. Root systems of all treatments from the four sites



Treatment	Observation (size of root system)	Treatment ( <u>Maxifort</u> )
<b>Strawberry Hill Farm</b>		
Sweet Heart	=	Grafted
Sakura	<	Grafted
Frederik	<<	Grafted
<b><u>Jemseg River Farm</u></b>		
Sweet Heart	>/=	Grafted
Sakura	<	Grafted
Frederik	</=	Grafted
<b>Nature's Route Farm</b>		
Sweet Heart	<	Grafted
Sakura	<	Grafted
Frederik	<	Grafted
<b><u>Ferme Pouce Vert Farm</u></b>		
Sweet Heart	>/=	Grafted
Sakura	<	Grafted
Frederik	<	Grafted

Grafting Sakura and Frederik on Maxifort rootstock allowed for a more robust and healthier root system

# Something interesting about this site



Non-grafted plants



Grafted on Maxifort

More root growth (plenty of fine roots)

More root vigour

Healthier roots

One variety showed some corkroot disease, most likely caused by *Pyrenochaeta lycopersici* (1 site only)





Image from M. Tesfaendrias, NBDAAF



Grafted Plants

=

More growth

More vigour

Darker colour

More root vigour

Healthier and more powerful roots

Extended productivity

and

More yield ?

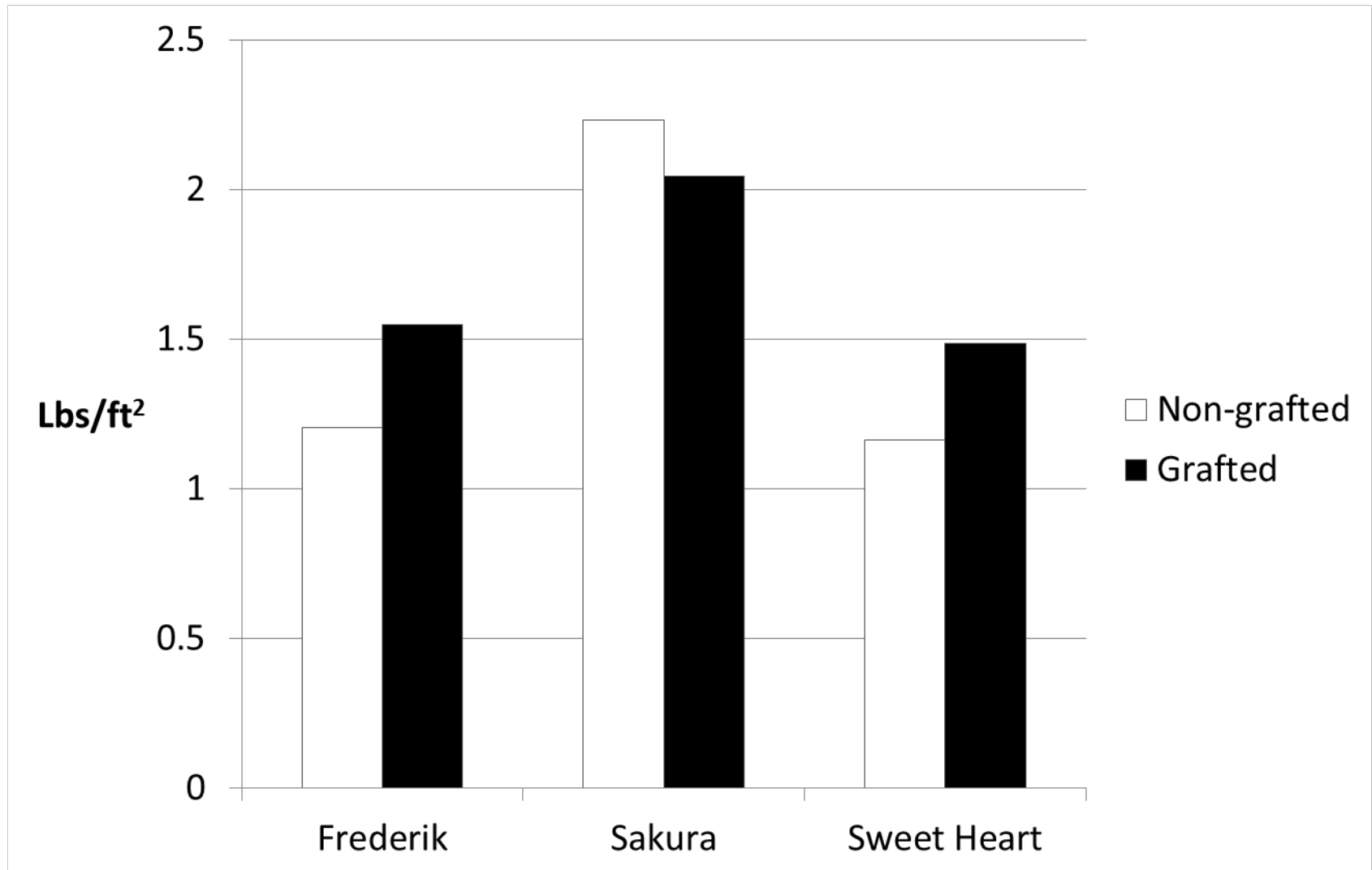
# SHF yield results

Heated greenhouse



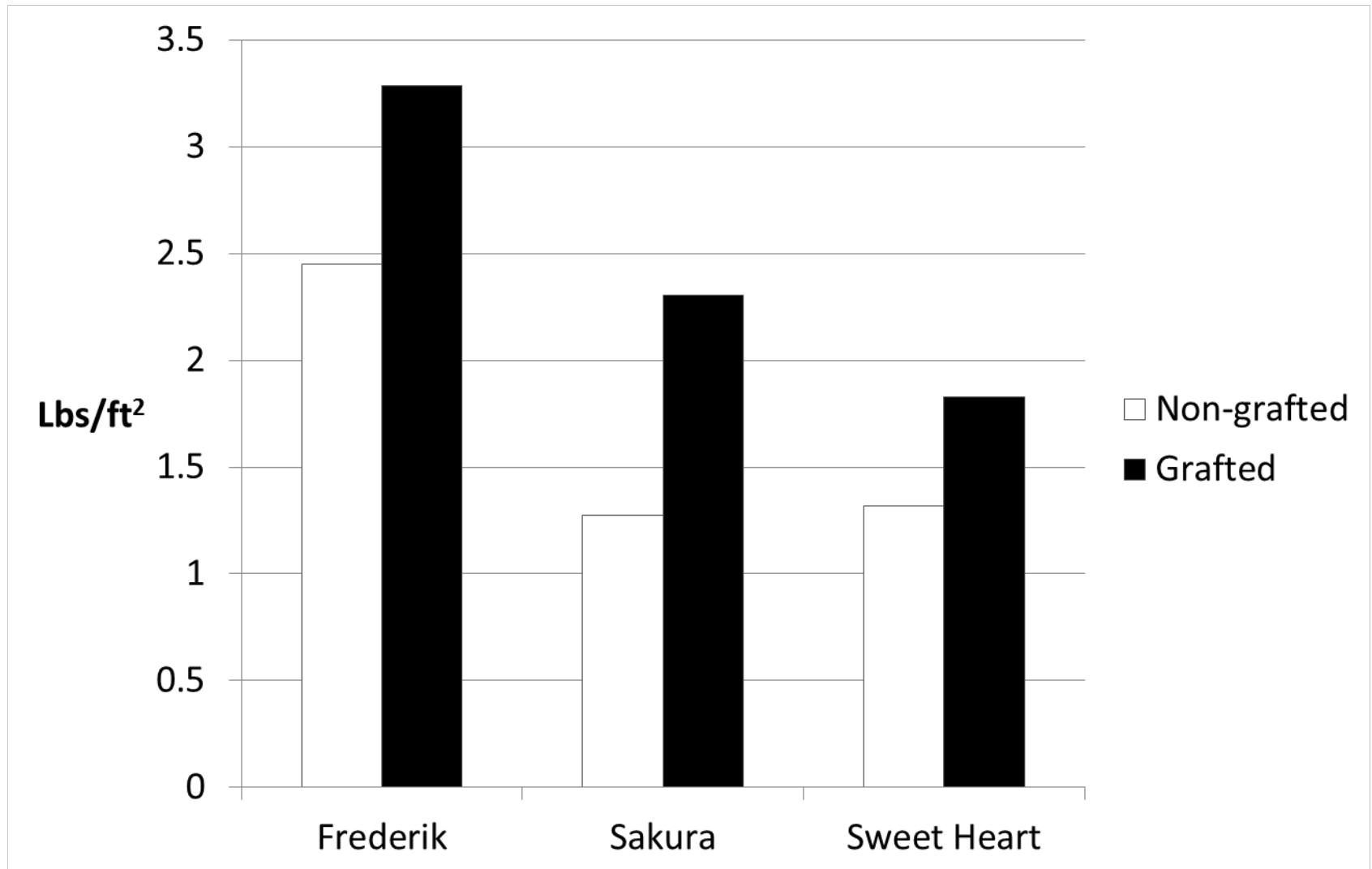
# JRF yield results

Caterpillar tunnel



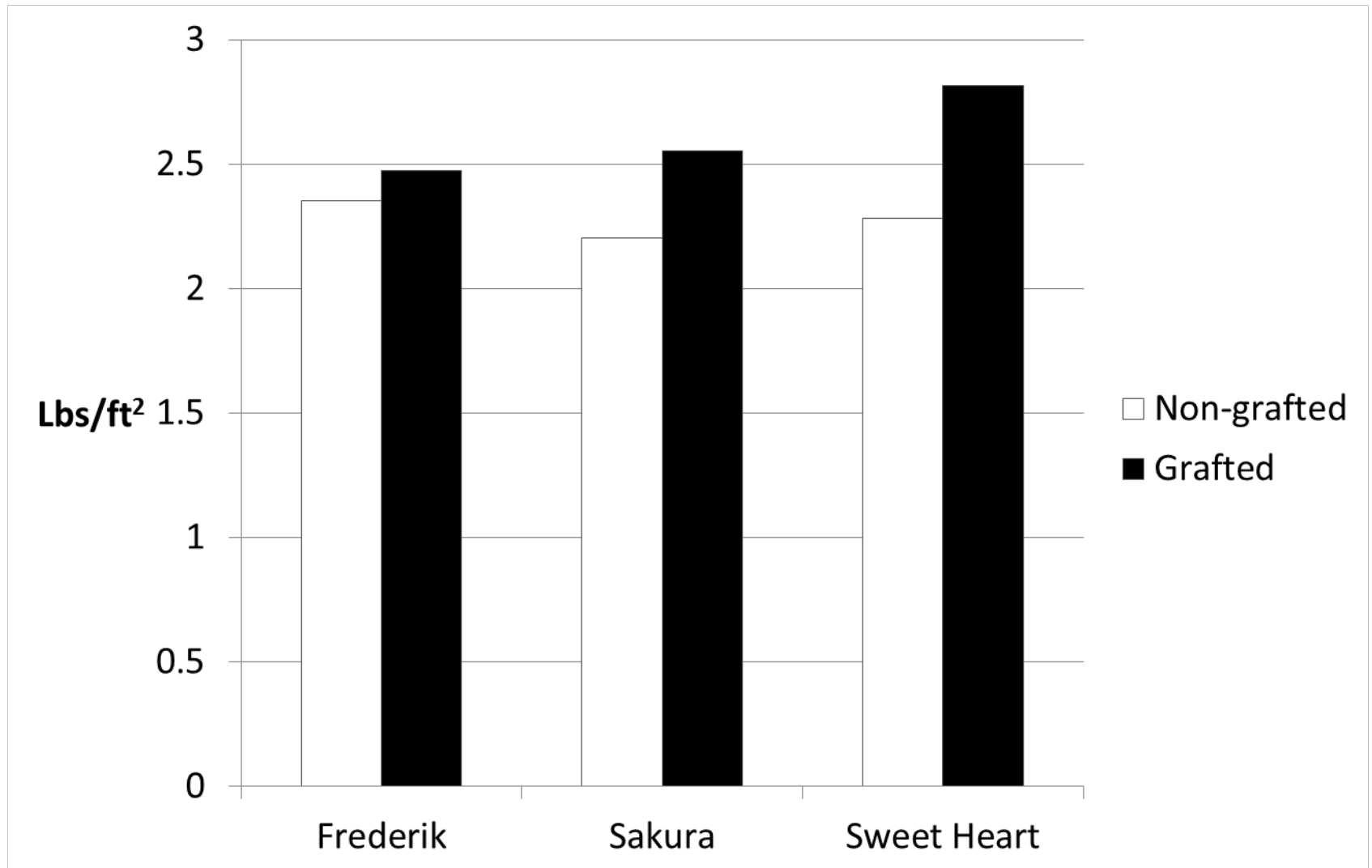
# NRF yield results

Unheated greenhouse



# FPV yield results

High tunnel



# Tomato Production Monitoring



Intent:

- 1) Monitor the tomato production on 4 NB farms
- 2) Allow growers to work with tools used to monitor soil fertility, air temperature, and irrigation
- 3) Allow NBDAAF staff to get familiar with monitoring tools so they can develop expertise and provide recommendations to growers

A few details:

- Monitored soil fertility via Standard Soil Tests (1), Greenhouse Soil Tests (2) and Leaf Tissue Tests (3).
- Monitor temperature via thermocouples (indoor/outdoor thermometers)
- Monitor irrigation practices via water meters, tensiometers and visual observations.

# 4 Types of Season Extension Infrastructures



Heated greenhouse



Caterpillar tunnel



Unheated greenhouse



Multi-bay high tunnel

# Soil Fertility Monitoring via Basic Soil Testing

Standard Soil Analysis: What's in the soil, ...  
Must be done before planting.



Sample Information		Soil Test Values and Ratings (Ratings are based on P and K, not P205 and K2O - see comments for conversion factor)								
Lab Sample #	Field Number	Organic Matter (%)	pH	Phosphate P <sub>2</sub> O <sub>5</sub> (ppm)	Potash K <sub>2</sub> O (ppm)	Calcium Ca (ppm)	Magnesium Mg (ppm)	Boron B (ppm)	Copper Cu (ppm)	Salt mS/cm
1	SHF (Tomatoes)		5.8	600 H+	280 H+	1550	133	.7	2.8	
2	JRF (Tomatoes)		6.3	585 H+	235 H+	1761	127	.4	1.2	
3	NRF (Tomatoes)		7.6	532 H+	584 H+	3875	422	5.1	8.6	
4	FPV (Tomatoes)		7.9	837 H+	143 H	3197	115	1.3	.6	

Lab Sample #	Field Number	Zinc Zn (ppm)	Sulfur S (ppm)	Manganese Mn (ppm)	Iron Fe (ppm)	Sodium Na (ppm)	Aluminum Al (ppm)	Lime Index	Nitrogen N (%)	Nitrate-N NO <sub>3</sub> -N (ppm)
1	SHF (Tomatoes)	5.8	58	31	272	91	1378	6.7		
2	JRF (Tomatoes)	2.9	16	31	212	20	1270	6.9		
3	NRF (Tomatoes)	4.5	505	82	108	175	978	7.6		
4	FPV (Tomatoes)	2.2	18	39	157	42	1261	7.9		

L: Low    L: Low    M: Medium    M+: Above Medium    H: High    H+: Very High

Sample Information		To convert HECTARES into ACRES multiply by 2.47			To convert T/HECTARE into T/ACRE multiply by 0.45			To convert Kg/Ha into lbs/ACRE; multiply by 0.9		
Lab Sample #	Field Number	Field Size (Ha)	Crop to be grown	pH 5.5	pH 6.0	pH 6.5	Nitrogen N	Phosphate P, O	Potash K, O	Required Applications (Kg/Ha)
1	SHF (Tomatoes)		Mixed Vegetables			2	120	90	90	
2	JRF (Tomatoes)		Mixed Vegetables				120	90	90	
3	NRF (Tomatoes)		Mixed Vegetables				120	90	90	
4	FPV (Tomatoes)		Mixed Vegetables				120	90	90	

Lab Sample #	Field Number	% P/Al	Ratio Ca/Mg	M a n	S o d	CEC (Meq/100g)	Base Saturation					Total % Base Saturation
							% K	% Mg	% Ca	% H	% Na	
1	SHF (Tomatoes)	19.01	12 : 1	0	0	13	4.4	8.2	57.6	26.8	2.9	70.2
2	JRF (Tomatoes)	20.11	14 : 1	0	0	12	4.3	9.1	75.6	10.3	.7	89.0
3	NRF (Tomatoes)	23.75	9 : 1	0	0	25	5.0	14.1	77.8		3.1	96.9
4	FPV (Tomatoes)	28.99	28 : 1	0	0	17	1.8	5.5	91.7		1.0	99.0

## Soil Analysis Report

5/15/2015

PROJECT EARI-14-091  
CLAUDE BERTHELEME  
NBDAAF PO BOX 6000  
FREDERICTON, NB  
E3B 5H1

PEI Analytical Laboratories  
PEI Department of Agriculture and Forestry  
23 Innovation Way  
PO Box 2000, Charlottetown, PEI, C1A7N8

Fax: (902) 368-6299  
Telephone: (902)620-3300



Client: 5889  
Accession: 21911  
Samples Reported: 5/12/2015  
Samples Received: 5/7/2015



# Basic Soil Test Results (spring)

Farm	Organic Matter (%)	pH	Phosphate (ppm)	Potash (ppm)	Calcium (ppm)	Magnesium (ppm)	Boron (ppm)	Copper (ppm)	Zinc (ppm)
SHF	4	5.8	600 (H+)	280 (H+)	1550	133	0.7	2.8	5.8
JRF	5.7	6.3	585 (H+)	235 (H+)	1761	127	0.4	1.2	2.9
NRF	4.9	7.6	532 (H+)	584 (H+)	3875	422	5.1	8.6	4.5
FPV	3.7	7.9	837 (H+)	143 (H)	3197	115	1.3	0.6	2.2

Farm	Sulfur (ppm)	Manganese (ppm)	Iron (ppm)	Sodium (ppm)	Aluminium (ppm)	Ca/Mg ratio	CEC (Meq/100g)	Total % Base Saturation
SHF	58	31	272	91	1378	12:1	13	70.2
JRF	16	31	212	20	1270	14:1	12	89
NRF	505	82	108	175	978	9:1	25	96.9
FPV	18	39	157	42	1261	28:1	17	99

# Soil Fertility Monitoring via SME Testing

## Greenhouse Soil Test:

- Nutrients that are more readily available (Saturated Media Extract)
- If needed, should be done throughout the season

**Greenhouse Analysis Report**  
6/16/2015

CLAUDE BERTHELEME  
C.P 6000  
FREDRICKTON, NB  
E3B 5H1

*PEI Analytical Laboratories*  
*PEI Department of Agriculture and Forestry*  
*23 Innovation Way*  
*PO Box 2000, Charlottetown, PEI, C1A7N8*

*Fax: (902) 368-6299*  
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Client: 5518  
Accession: 872  
Samples Reported: 6/15/2015  
Samples Received: 6/12/2015

Lab #	Client Sample ID	Crop	Soluble Salt (mS/cm)	pH	Available Nutrients in Parts per Million (ppm) on Greenhouse Media Extract						
					Nitrate-N	Phosphorous	Potassium	Calcium	Magnesium	Sulphate	Chloride
1	SHF	Tomatoes	5.23	7.0	601.8	1.272	196.1	570.7	108.2	212.6	139
2	JRF	Tomatoes	1.692	8.0	146.8	1.161	20.94	83.55	14.02	45.48	34.8
3	NRF	Tomatoes	5.46	7.9	287.8	.7572	200.9	647.1	191.8	1511	298.7
4	FPV	Tomatoes	7.46	7.3	684.4	.3574	157.5	899.2	75.32	53.68	661.2

# Saturated Media Extract (SME) greenhouse soil test results

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	<b>Soluble salt (mS/cm)</b>		<b>pH</b>		<b>Nitrate-N (ppm)</b>		<b>Phosphorous (ppm)</b>	
<b>Farm</b>	<b>June</b>	<b>July</b>	<b>June</b>	<b>July</b>	<b>June</b>	<b>July</b>	<b>June</b>	<b>July</b>
<b>SHF</b>	5.2	3.4	7.0	7.2	602	386	1.3	0.9
<b>JRF</b>	1.7	1.8	8.0	8.0	147	187	1.2	1.0
<b>NRF</b>	5.5	1.9	7.9	8.1	288	63	0.8	0.5
<b>FPV</b>	7.5	2.4	7.3	7.9	684	216	0.4	0.3

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	<b>Potassium (ppm)</b>		<b>Ca (ppm)</b>		<b>Mg (ppm)</b>	
<b>Farm</b>	<b>June</b>	<b>July</b>	<b>June</b>	<b>July</b>	<b>June</b>	<b>July</b>
<b>SHF</b>	196	61	571	402	108	78
<b>JRF</b>	21	13	84	131	14	21
<b>NRF</b>	201	18	647	311	192	62
<b>FPV</b>	158	17	899	281	75	26

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# Saturated Media Extract (SME) greenhouse soil test results

Farm	Soluble salt (mS/cm)			pH			Nitrate-N (ppm)			Phosphorous (ppm)		
	June	July	Trend	June	July		June	July		June	July	
SHF	5.2	3.4	↓	7.0	7.2	↑	602	386	↓	1.3	0.9	↓
JRF	1.7	1.8	↑	8.0	8.0	–	147	187	↑	1.2	1.0	↓
NRF	5.5	1.9	↓	7.9	8.1	↑	288	63	↓	0.8	0.5	↓
FPV	7.5	2.4	↓	7.3	7.9	↑	684	216	↓	0.4	0.3	↓


Farm	Potassium (ppm)			Ca (ppm)			Mg (ppm)		
	June	July		June	July		June	July	
SHF	196	61	↓	571	402	↓	108	78	↓
JRF	21	13	↓	84	131	↑	14	21	↑
NRF	201	18	↓	647	311	↓	192	62	↓
FPV	158	17	↓	899	281	↓	75	26	↓

Very High
High
Optimum
Acceptable
Low

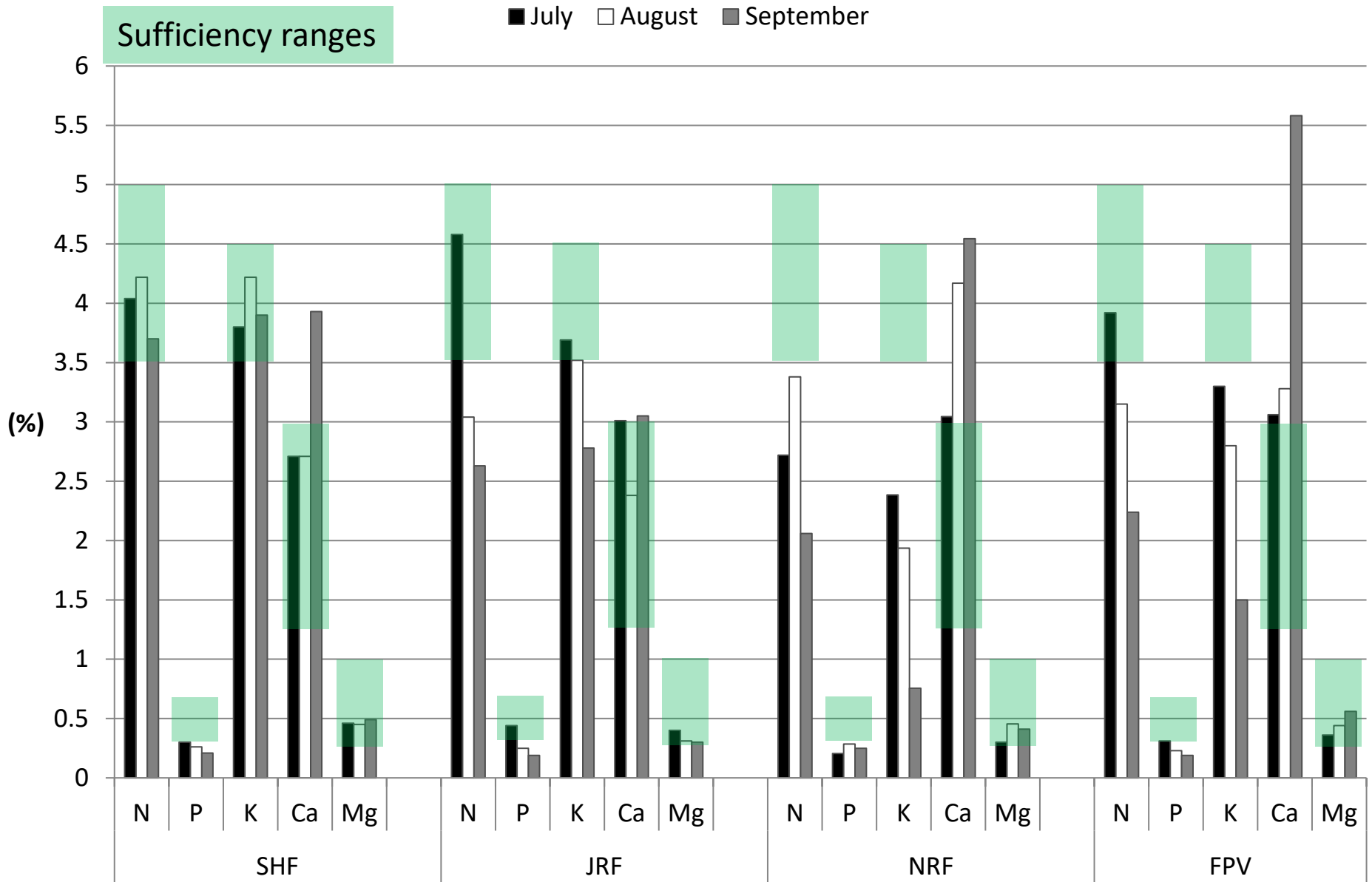
# Soil Fertility Monitoring via Tissue Testing

## Tomato leaf tissue testing:

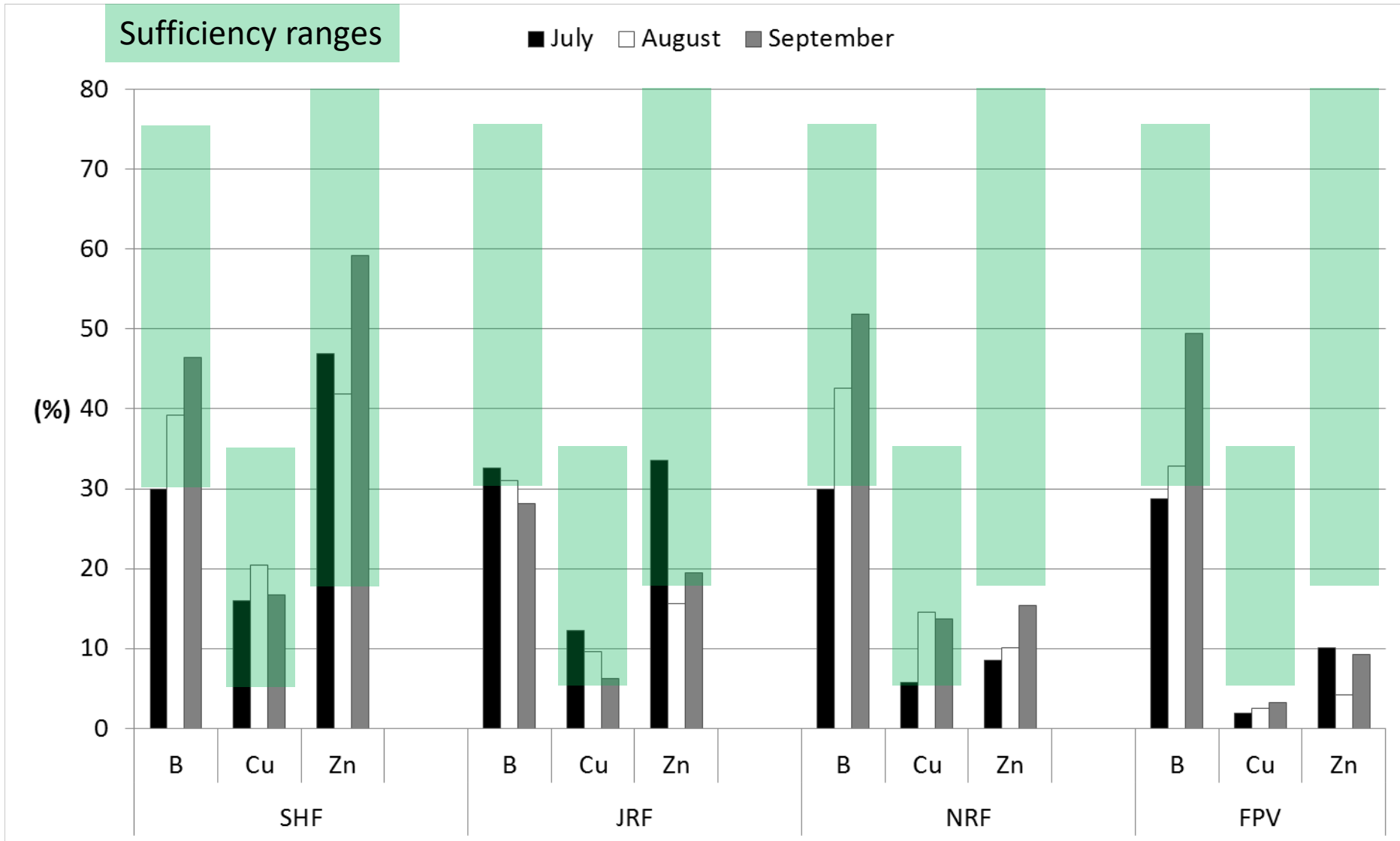
- Nutrients that the crop was able to uptake from the soil
- If needed, should be done throughout the season

<u>Plant Tissue Report</u> 7/8/2015		PEI Analytical Laboratories PEI Department of Agriculture and Forestry 23 Innovation Way PO Box 2000, Charlottetown, PEI, C1A7N8 Fax: (902) 358-6299 Telephone: (902) 620-3300			Prince Edward Island CANADA 
BERTHELEME, CLAUDE NBDAAF PO BOX 6000 FREDERICTON, NB E3B 5H1		Client: 5518 Accession: 3444 Samples Reported: 7/7/2015 Samples Received: 7/3/2015			
Analysis Performed*	Lab #: 3444-1	Lab #: 3444-2	Lab #: 3444-3	Lab #: 3444-4	
	Field: SHF Type: Tomatoes	Field: JRK Type: Tomatoes	Field: NRFSG Type: Tomatoes	Field: NRFSNG Type: Tomatoes	
<i>Sufficiency Range</i>					
Nitrogen %	3.5 - 5.0	4.04 OK	4.58 OK	3.28 L	2.16 L
Phosphorus %	0.3 - 0.65	0.30 OK	0.44 OK	0.24 L	0.17 L
Potassium %	3.5 - 4.5	3.80 OK	3.69 OK	2.67 L	2.10 L
Calcium %	1.3 - 3.00	2.71 OK	3.01 OK	3.62 H	2.47 OK
Magnesium %	0.35 - 1.00	0.46 OK	0.40 OK	0.32 L	0.28 L
Boron ppm	30 - 75	29.90 OK	32.60 OK	33.60 OK	26.30 L
Copper ppm	5 - 35	15.97 OK	12.32 OK	8.18 OK	3.35 L
Zinc ppm	18 - 80	46.90 OK	33.60 OK	10.40 L	6.60 L

# Tomato Leaf Tissue Analysis (cv. Sakura)

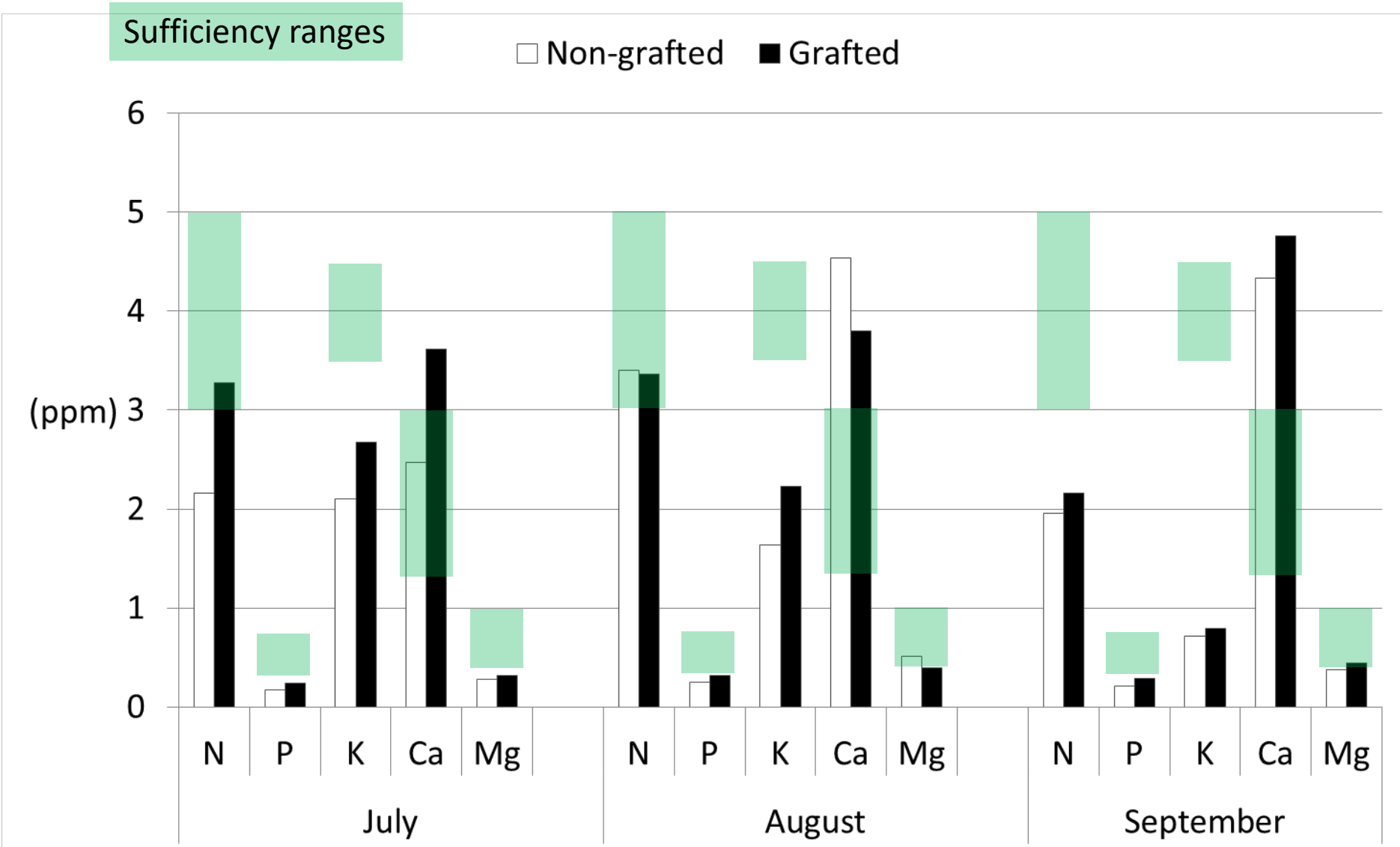


# Tomato Leaf Tissue Analysis (cv. Sakura)

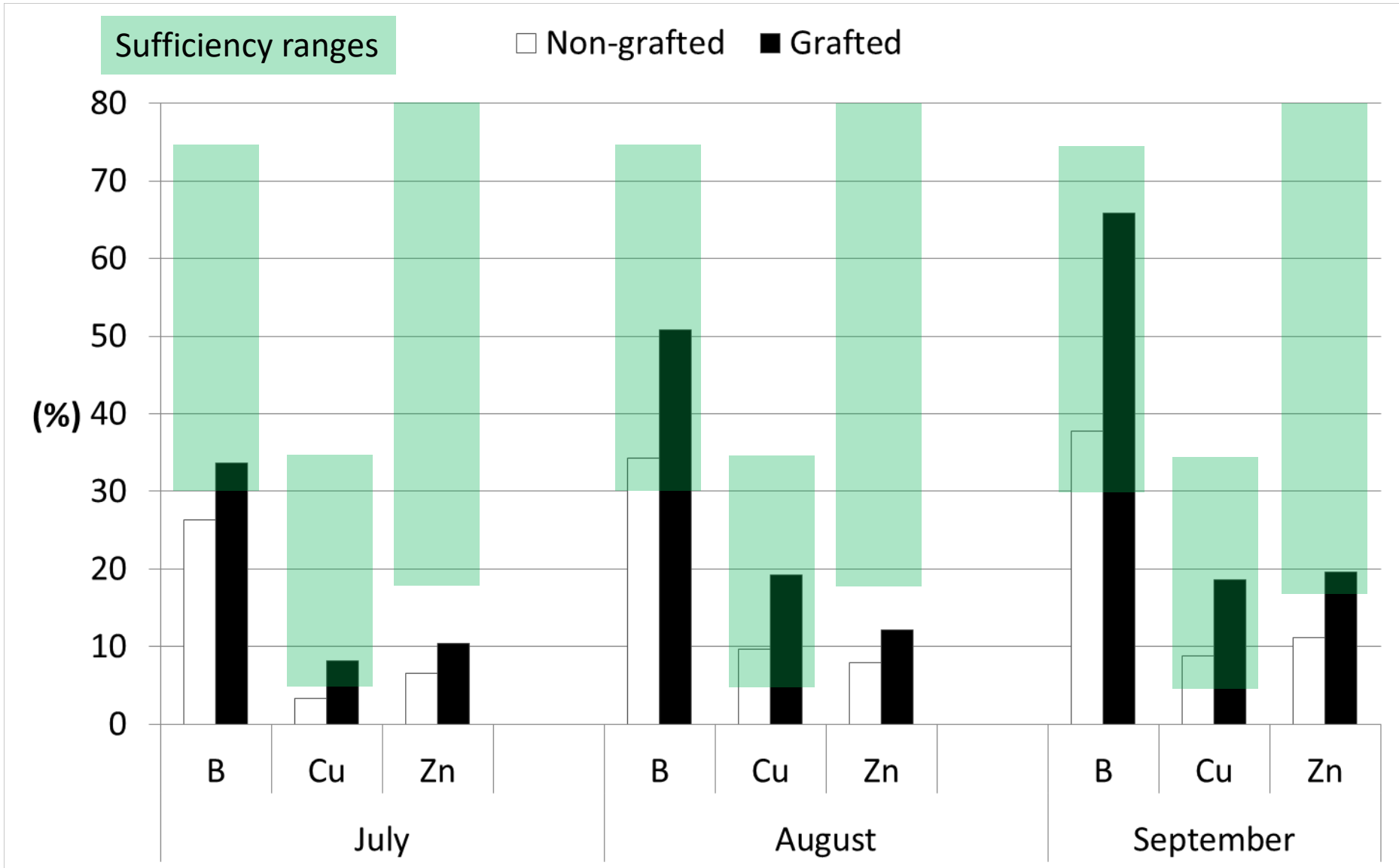




# Tomato Leaf Tissue Analysis (cv. Sakura)



# Tomato Leaf Tissue Analysis (cv. Sakura)



# Air Temperature Monitoring via Thermocouple: Indoor/Outdoor



Heated greenhouse



Caterpillar tunnel



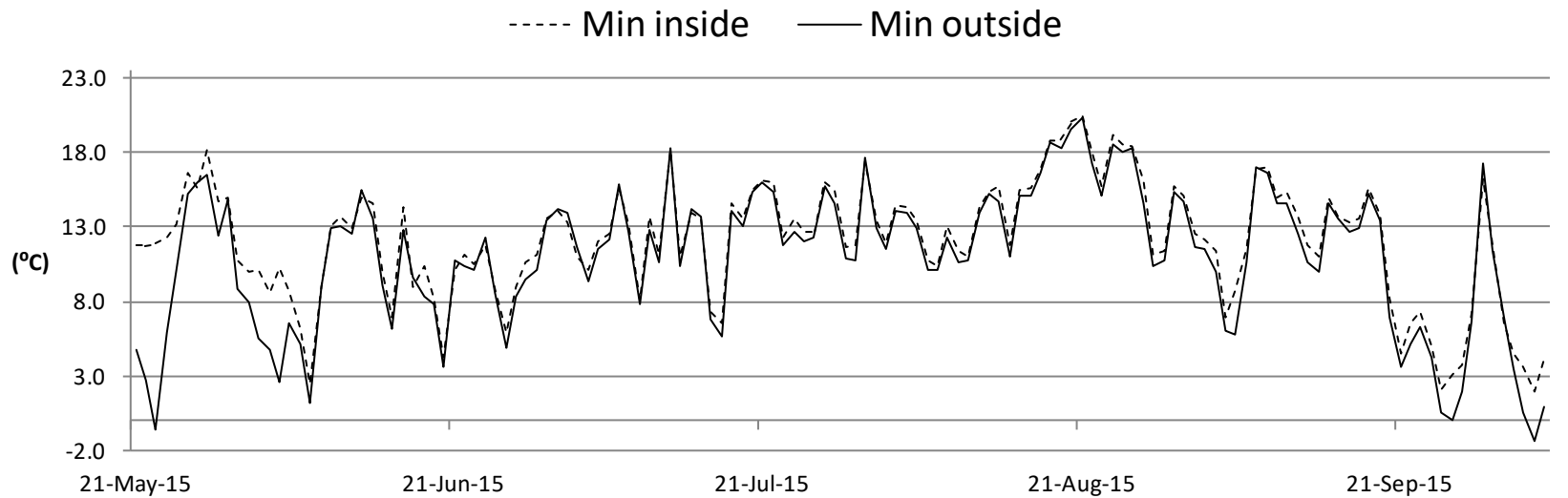
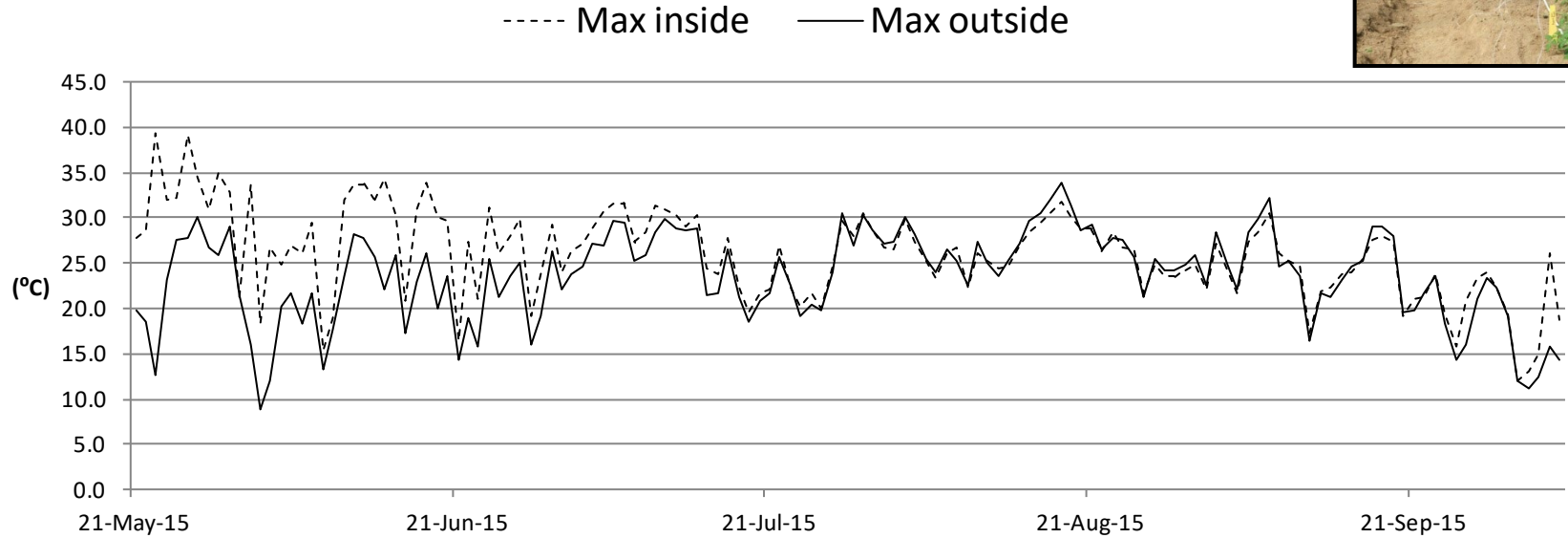
Unheated greenhouse



Multi-bay high tunnel

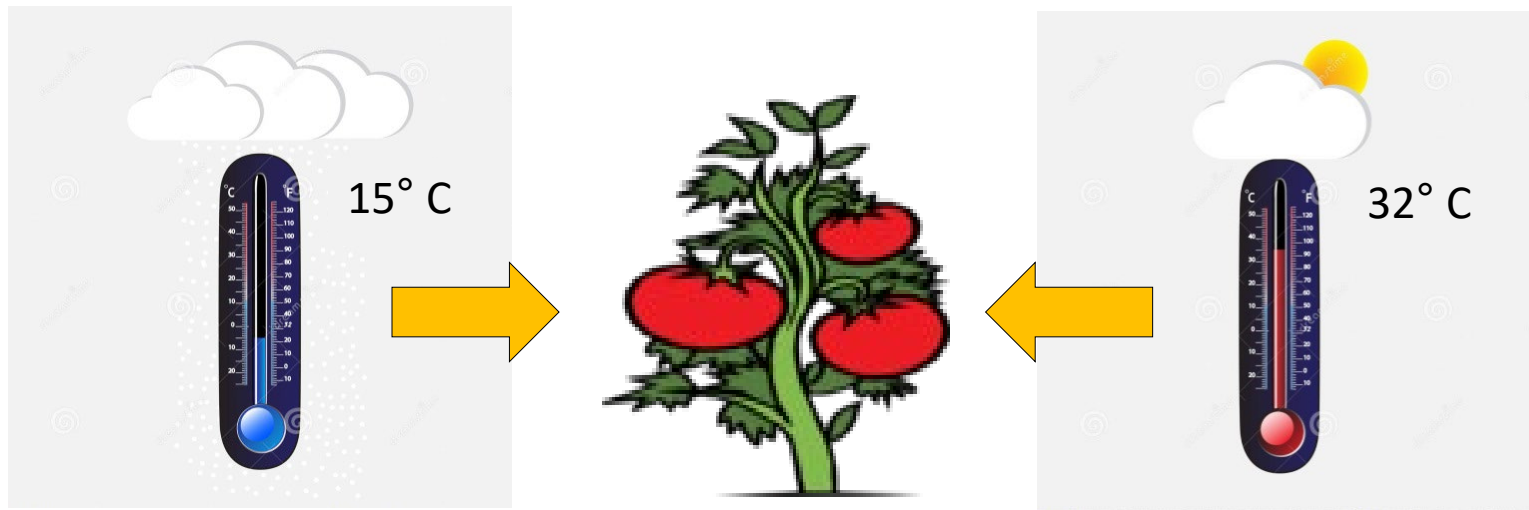
# SHF Temperature trends

## Heated Greenhouse



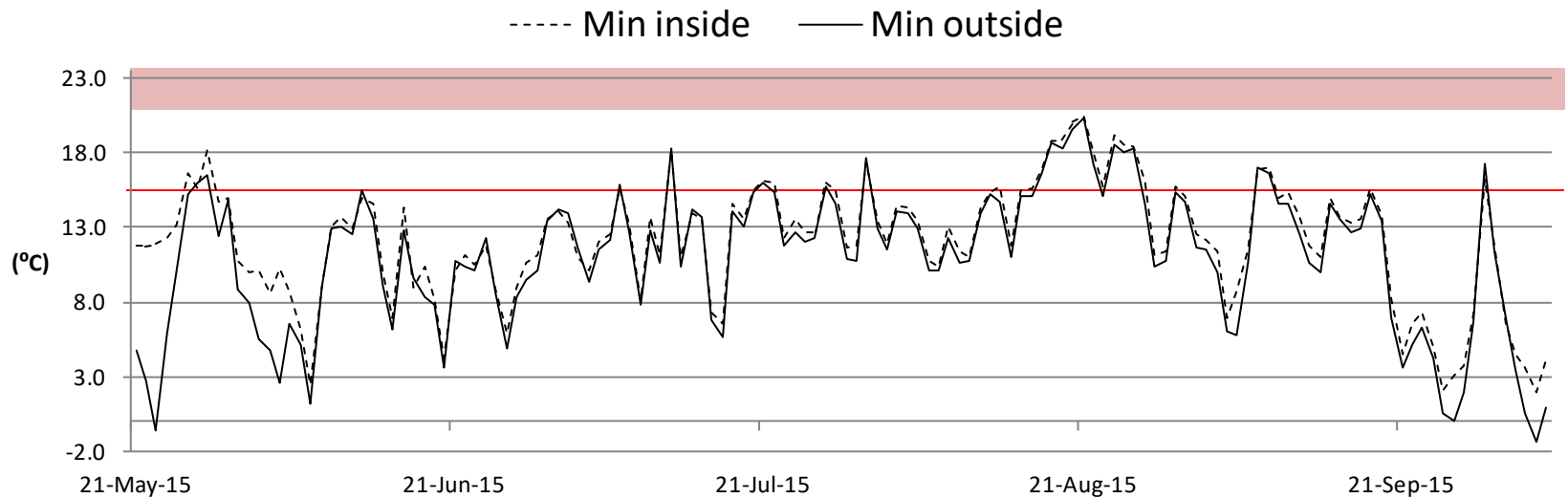
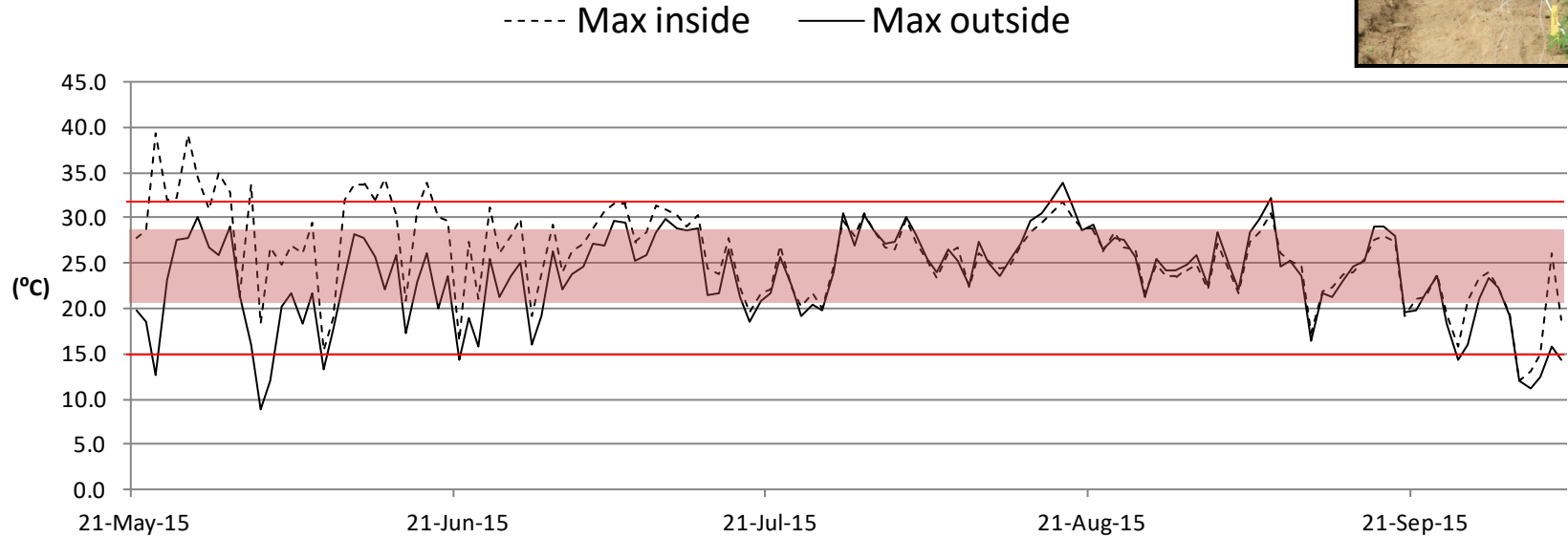
# Air Temperature (1 m) Monitoring via thermocouple: Indoor/Outdoor

- Preferred ambient temperature for greenhouse tomato production much tighter than : 15-32° C



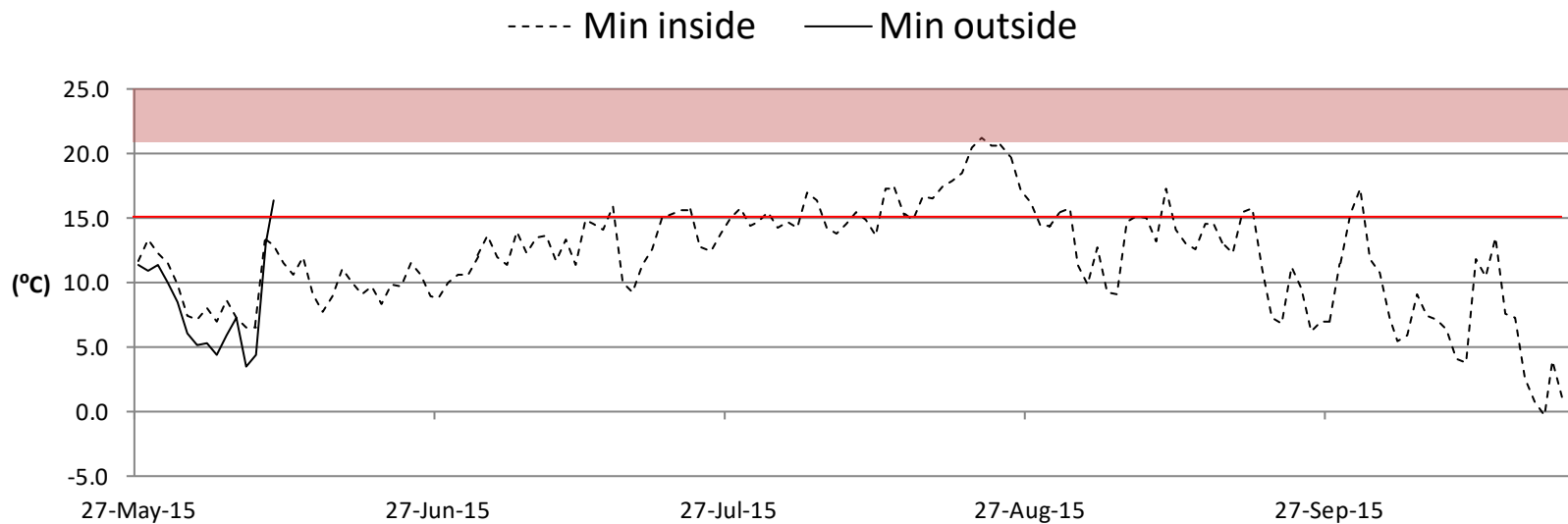
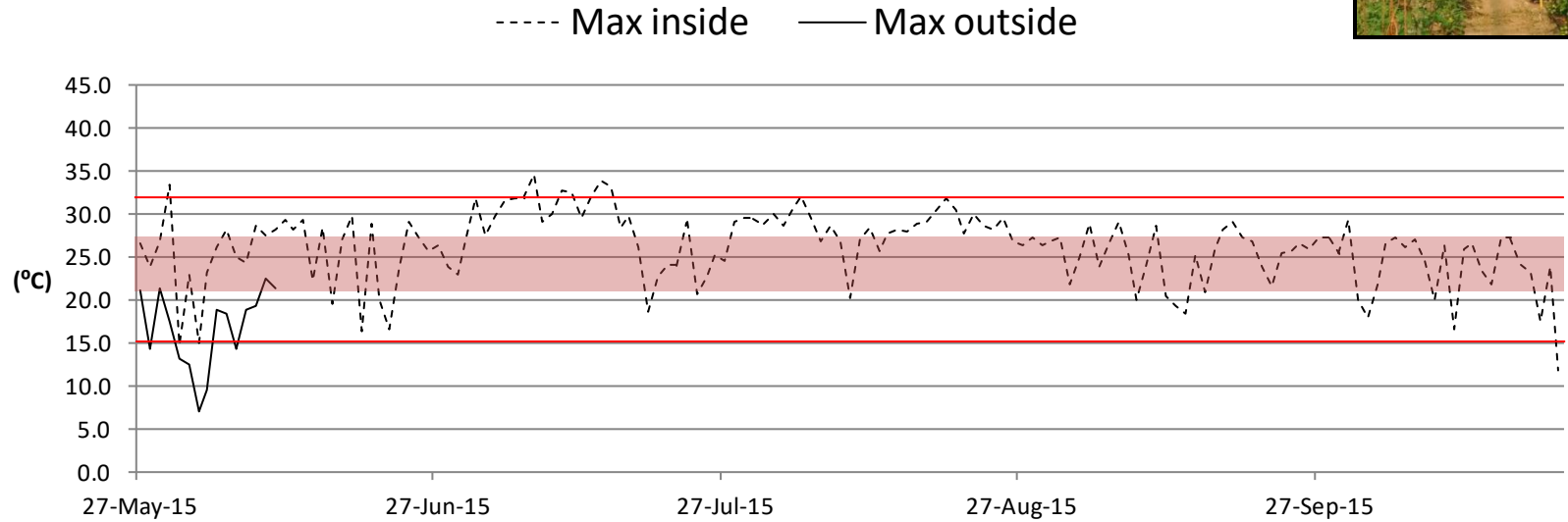
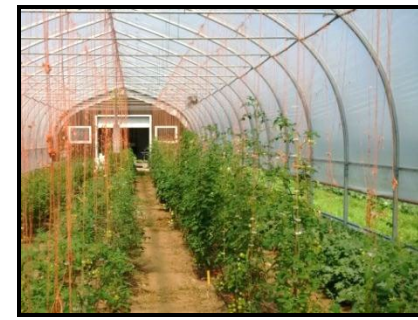
# SHF Temperature trends

## Heated Greenhouse



# NRF Temperature trends

## Unheated greenhouse

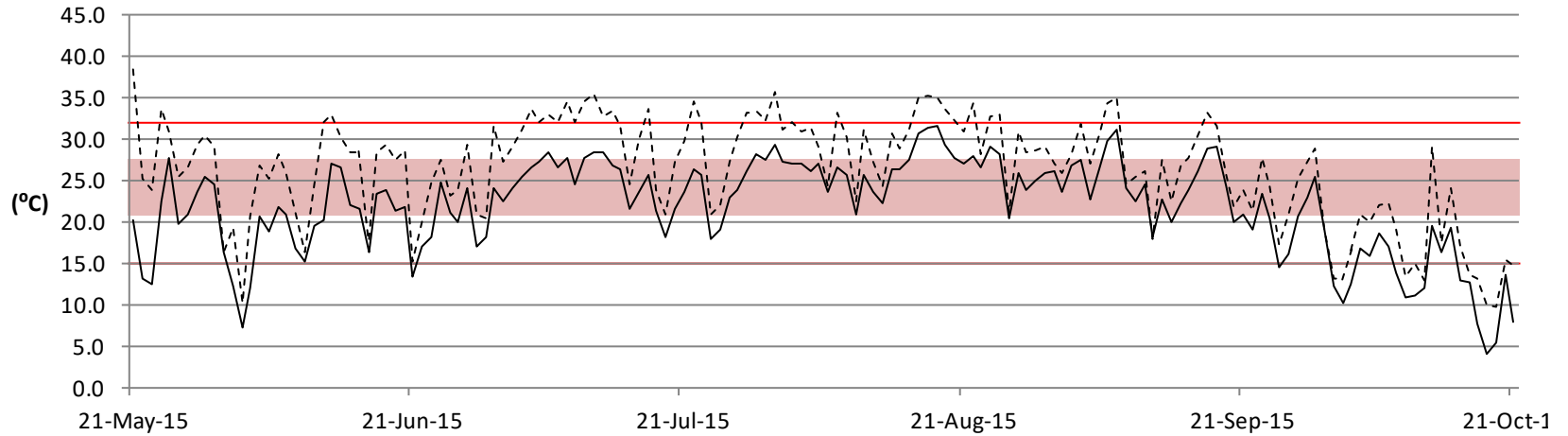


# JRF Temperature trends

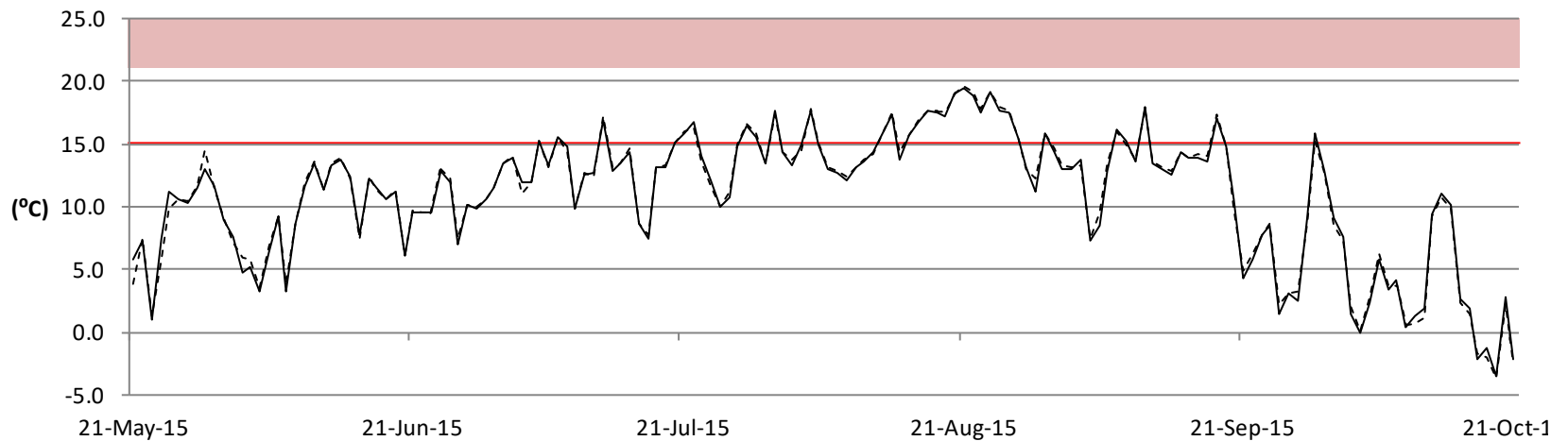
## Caterpillar tunnel



----- Max inside    — Max outside



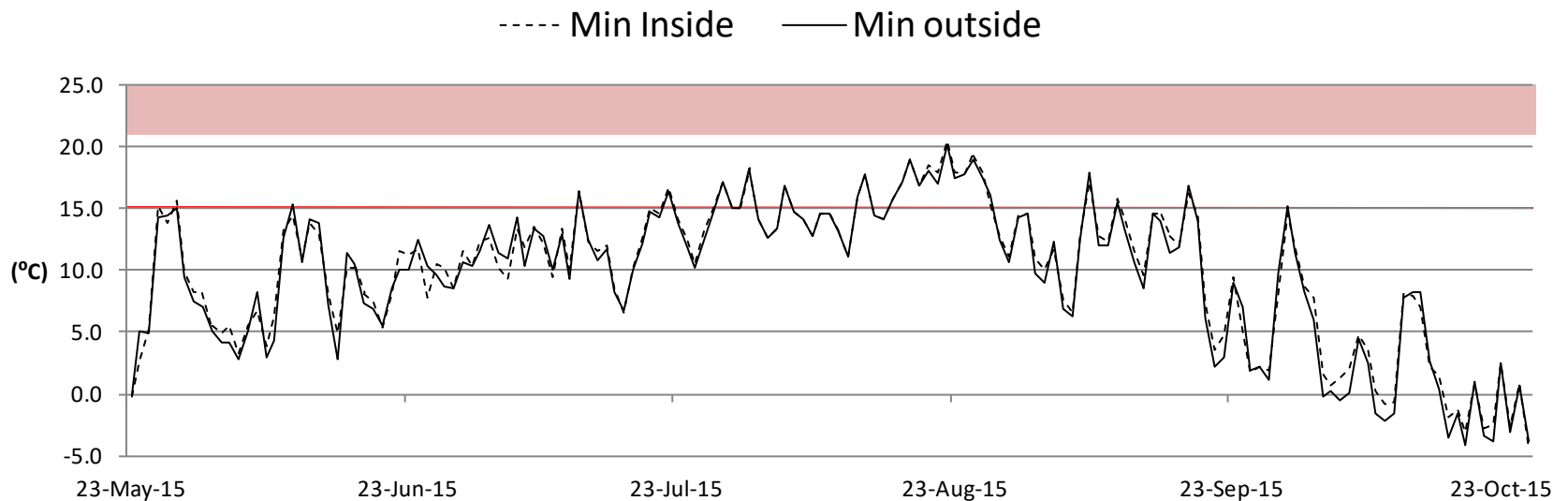
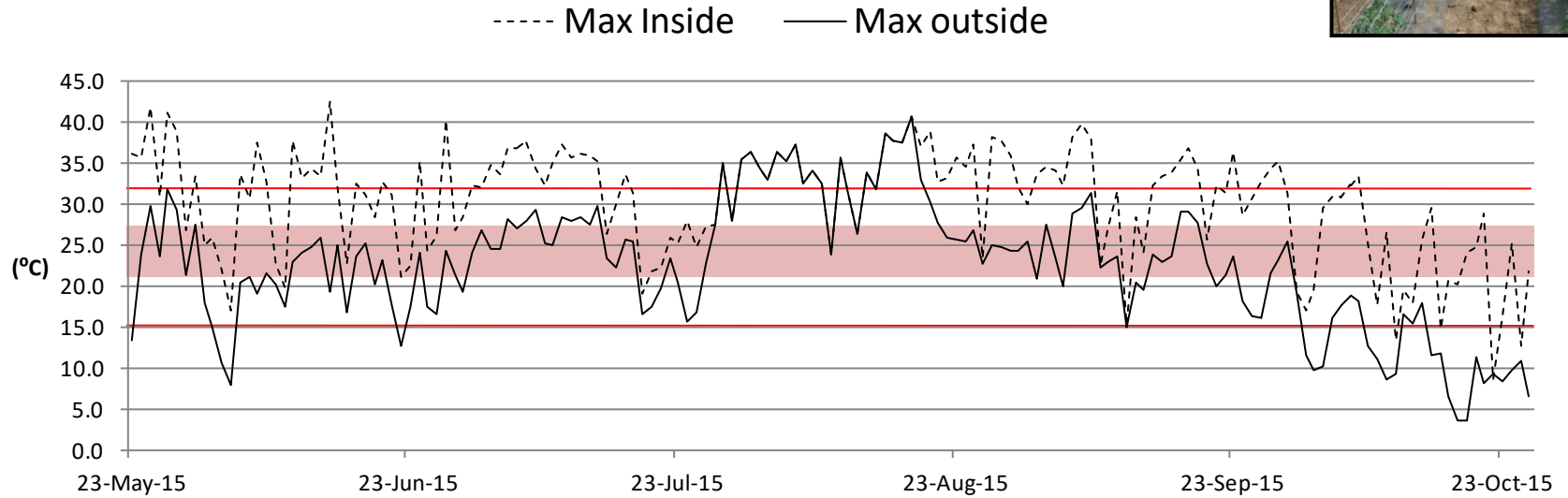
----- Min inside    — Min outside





# FPV Temperature trends

## Multi-Bay High Tunnel



# Irrigation

- Crops grown in greenhouses and tunnels must be irrigated
  - Typically through drip systems



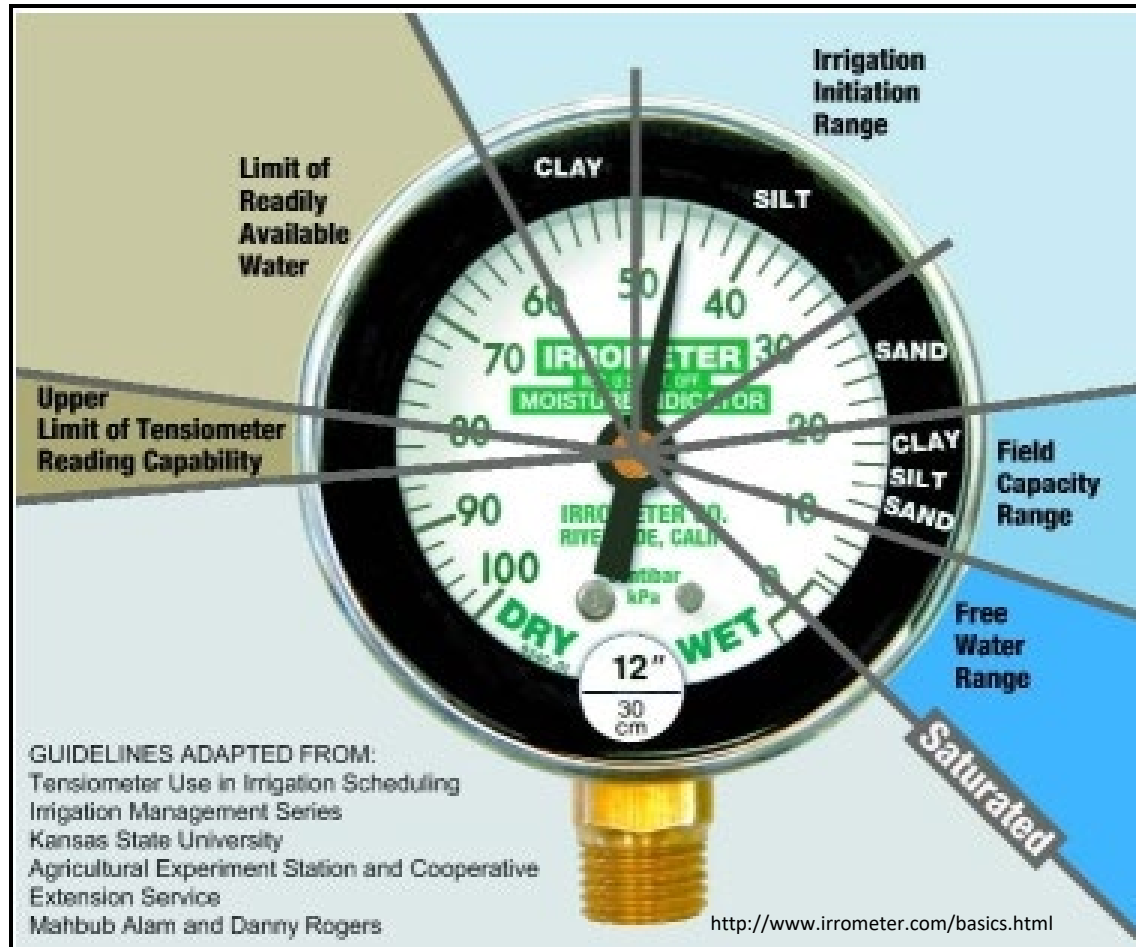
# Traditional irrigation monitoring tools



Tensiometers: Tools that measure the soil water tension or “availability of water”

- Soil saturated with water: 0-10 centibar
- Soils that are too dry (most soils): 60 + centibar
- 2-3 tensiometers per farm: 4-6 in. deep/9-12 in. deep





- **0-10 Centibars** = Saturated soil
- **10-30 Centibars** = Soil is adequately wet (except coarse sands, which are beginning to lose water)
- **30-60 Centibars** = Usual range for irrigation (most soils)
- **60-100 Centibars** = Usual range for irrigation in heavy clay
- **100-200 Centibars** = Soil is becoming dangerously dry for maximum production. Proceed with caution!

## Watermark Sensors: Measures soil water tension

Our other option is the [WATERMARK Sensor](#), which is a calibrated, indirect method of measuring soil water tension. These "Granular Matrix Sensors" electronically read the amount of moisture absorbed through a special "granular matrix", or mix of precisely composed materials. This special mix buffers the sensor against the effects of different salinities and ensures a much longer life than traditional "gypsum blocks". The readings are calibrated to reflect the same values that would be generated by a Tensiometer. These sensors are maintenance free and can be left in the ground permanently, with an expected life of 5+ years. WATERMARK sensors require very little power to read and integrate perfectly with electronic systems for data logging or telemetry.



<http://www.irrometer.com/basics.html>



Water meters:

A tool that measures the amount of water used

# Irrigation:

- Spaghetti emitters are often not suitable for in-ground organic tomato production
- Single drip line per bed not suitable for organic greenhouse tomato production

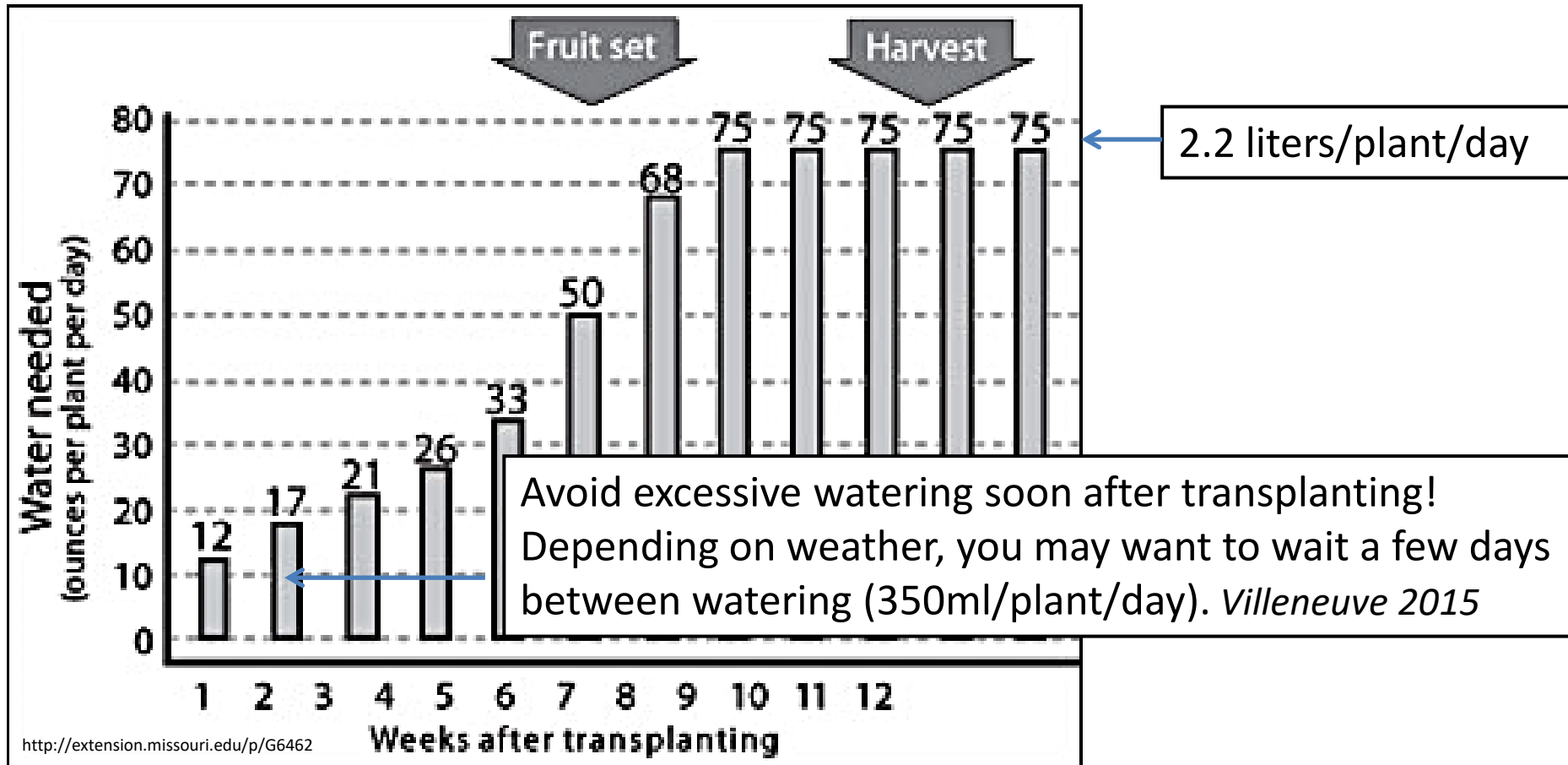


Too many dry zones = poor watering uniformity  
Not good for tensiometers  
Not good for soil biological activity  
Not good for mineralization



Need to lift the plastic and dig a little

- Water requirement in high tunnel production in Missouri





- White on black plastic mulches provides weed suppression, reflective colour and reduces water evaporation from soil.
- This also keeps the soil moisture uniform and at a level that is conducive to soil biological activity = **improved mineralization!**



- High production organic greenhouse systems:  
4 drip lines with low output emitters per bed



- A good irrigation strategy should involve a period of irrigation (1 or more cycles) but also a period of aeration



Organic fertilizers left on the surface are not effective. When possible they should be incorporated into the soil and watered immediately to encourage breakdown and mineralization.

The drip lines should be covered with white on black plastic to create a moist environment to stimulate surface mineralization.



Multiple drip lines covered with white on black plastic

- Enhanced surface biological activity
- Better moisture uniformity through the full width of the bed
- Better root distribution through the full width of the bed

More drip for more food, especially in organic production, *Christine Villeneuve 2015*

# Irrigation for greenhouse/tunnel tomatoes

Things we learned:

- Tensiometers work well if the irrigation setup is well designed
- Spaghetti emitters are often not suitable for in-ground organic production
- 1 to 2 drip lines per bed often not enough
- Emitter spacing should not be too far apart (12 inches apart or less)
  
- Typically, busy diversified vegetable growers under irrigate
- Watering cycles are too long and not frequent enough
- More water when the crop is in full production ... Temp and Sun ↑
- Avoid irrigating in late afternoon and evening

**Irrigation is very important to organic growers who rely on the soil biological activity to mineralize plant nutrients.**

# Take home messages in 60 seconds

## ■ Sweet peppers

- Improve peppers yields by selecting early to mid-season varieties and by growing them in greenhouses and tunnels  
Earlier ripening and less bacterial disease pressure (target 6 kg/m<sup>2</sup>)
- Irrigation and fertilization programs critical for optimal pepper yields
- Need healthy and robust transplants
- Conduct your own variety trials under your growing conditions

## ■ Grafted tomatoes

- The grafted Frederik and Sweet Heart seem to outperform the non-grafted plants by 10 to 50%
- Grafted plants may offer more vigour, more resistance to soilborne diseases, more yield (in most conditions) and will extend the growing season
- Consider grafted tomato plants once your greenhouse/tunnel production management is adequate (fertility, irrigation, pruning, ...) ???

# Take home messages in 60 seconds

## ■ Tomato Production Monitoring

- Need to improved fertilization program to meet target yield  
Target organic yield: 20 Kg/m<sup>2</sup> (4.1 lbs/ft<sup>2</sup>)  
May need to add soil amendments/fertilizers during the growing season  
Potassium often over-looked
- Need to consider effective irrigation equipment and improve watering practices
- Plastic over the drip lines will reduce evaporation and encourage surface biological activity (important if you plan to split N applications)
- Tensiometers are very good tools when the irrigation system is well designed
- Need to increase the ventilation of the high tunnels during hot summer days to avoid excessive heat
- Adding minimal heat in early and late season can extended the season ...

# Acknowledgements

- Growing Forward 2 - Enabling Agriculture Research and Innovation Program
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- Jemseg River Farm: Michael Carr
- Nature's Route Farm: Kent Coates, Lisa Archambault and Fanny Legacy
- Ferme Pouce Vert: Roger and Jean-Louis Richard
  
- Gore Farm, Pumpkin Lady Farm, Les serres à Eugène, Villeneuve Family Farm
  
- Seed Supplier: Hélène Valois, Seminova
- Transplant Suppliers: Schurman Family Farm and Strawberry Hill Farm





**Thank you**

## Appendix 1

Table 1. Amount of nutrients applied and available to the tomato crop

Farm	Nitrogen (Kg/ha of avail. N)	P <sub>2</sub> O <sub>5</sub> (Kg/ha)	K <sub>2</sub> O (Kg/ha)
SHF	182	151	165
JRF	196	112	96
NRF	107+	92	223
FPV	244	122	261+
General recommendation (indeterminate tomatoes)	140-200	100-190	200 +