Grafting for Organic Heirloom Tomato Production

Cary L. Rivard, Ph.D.
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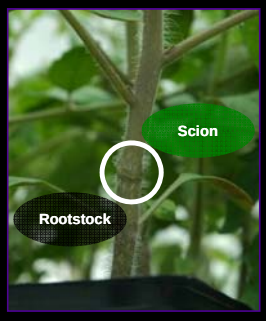
Great Plains Growers Conf.
www4.ncsu.edu/~clrivard

K-STATE Kansas State University Research and Extension

NC STATE UNIVERSITY

Top Row: Frank Louws, Chris Harlow, Cary Rivard, Steve Moore
Bottom Row: Mary Peet, Suzanne O'Connell, Josh Moore

Tomato Grafting



- First reports of vegetable grafting occurred in Asia in the 1920's.
  - Fusarium wilt of melon
- Popularized in Japan and Korea
  - Tunnel and Greenhouse production

Vegetable Grafting Worldwide

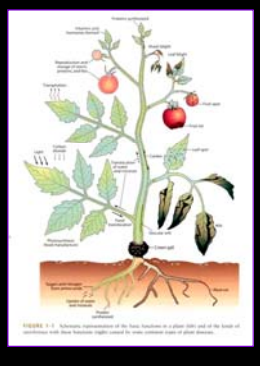
81% of Korean and 54% of Japanese vegetable production uses grafted plants

(Lee, 2003)

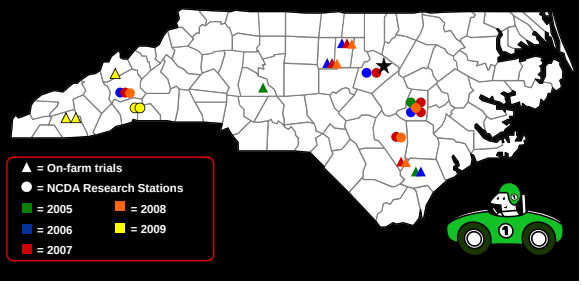
Photos courtesy of M. Peet (NCSU)

Benefits of Grafting

- Root function
  - Disease resistance against soilborne pathogens
  - Water and nutrient uptake
  - Nutrient assimilation and transport
  - Interface with soil ecosystem



- **Major soilborne diseases in NC.**
  - **Verticillium Wilt**
  - **Fusarium Wilt**
  - **Root-knot Nematodes**
  - **Southern Blight**
  - **Bacterial Wilt**



On-farm trials



Alex Hitt
Peregrine Farm

Ken Dawson
Maple Spring Gardens

Stefan Hartmann
Black River Organic Farm

On-farm participation
- Scion selection
- Cultural methods
- Harvest / data collection
- Feedback

University participation
- Rootstock selection
- Transplants
- Disease monitoring
- Nutrient and soil sampling
- Experimental design / analysis

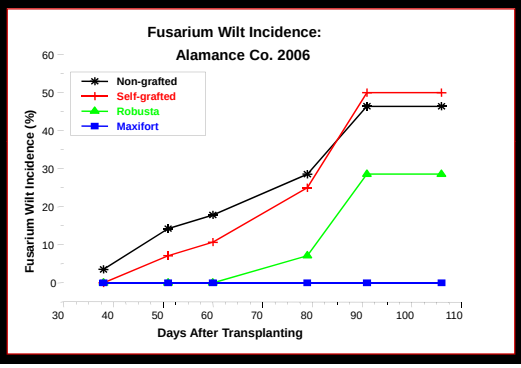
(Photos by Suzanne O'Connell, NCSU)

Fusarium Wilt

- Fusarium wilt is caused by *Fusarium oxysporum*.
  - Unilateral wilting
  - Yellowing of leaves
  - Browning of xylem



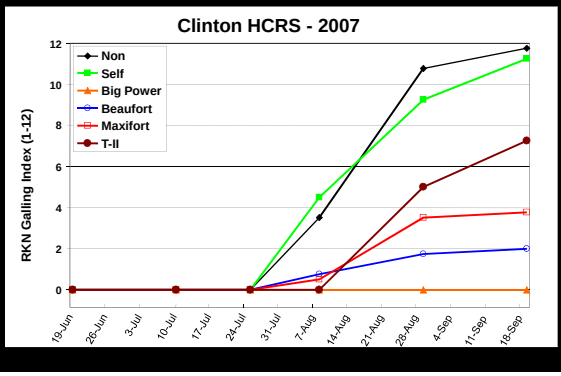
Fusarium Wilt



Root-knot Nematodes

- Root-knot Nematodes
  - *Meloidogyne spp.*
  - Root galls
  - Stunting and poor vigor
  - Prefer light soil


Root Knot Nematode



Root Knot Nematode

Root-knot nematode soil populations / 500 cc soil

	First Harvest	Terminal Harvest
Non-grafted	8357 D	1964 Y
Self-grafted	8751 D	1228 Y
Telone II	379 B	1260 Y
Big Power	77 A	40 Z
Beaufort	2680 C	2542 Y
Maxifort	3091 C	1251 Y

LSD based on P = 0.01

Disease Management

Rootstocks	TMV	Corky Root	Fusarium Wilt Race 1	Fusarium Wilt Race 2	Verticillium Wilt (r1)	Root-knot Nematode	Bacterial Wilt	Southern Blight
Beaufort *	R	R	R	R	R	MR	S	HR
Maxifort *	R	R	R	R	R	MR	S	HR
(Unreleased) *	R	S	R	R	R	R	HR	MR
TMZQ702 **	R	S	R	R	R	R	MR	MR
Dai Honmei ***	R	R	R	S	R	R	HR	MR
RST-04-105 ****	R	R	R	R	R	R	HR	MR
Big Power *****	R	R	R	R	R	R	S	HR
Robusta ******	R	R	S	R	R	S	S	?

R=Resistant , HR=Highly Resistant, MR=Moderately Resistant, S=Susceptible

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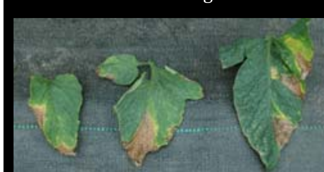
Cedar Meadow Farm

Verticillium Wilt

- ***Verticillium dahliae***
  - Loss of vigor
  - Wilting and leaf necrosis
  - Favored by cool wet weather
  - Race 2 prevalent in WNC
    (*Bender & Shoemaker, 1984*)
  - Reliance on fumigation



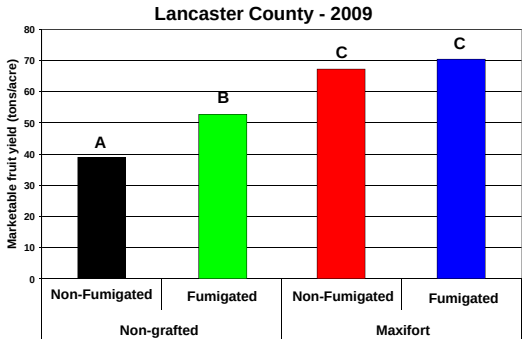
Cedar Meadow Farm

Research Objectives

- Can vigorous rootstock be used to manage verticillium wilt?
- How does grafting fit in with fumigation?
  - Additive or alternative
- Can we reduce economic constraints through cultural methods?
  - Plant spacing (2008)
  - Transplant costs (2009)

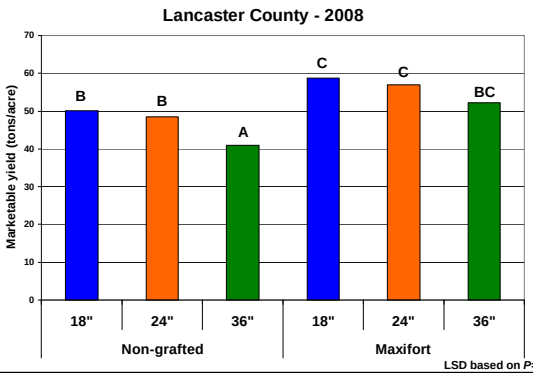
Kaitlin Dye (Summer 2008)
Photo Courtesy: Steve Groff

Cedar Meadow Farm



LSD *P = 0.05*

Cedar Meadow Farm



LSD based on *P=0.05*

Economics

Net returns of grafting ($/acre) : 2008

	Non-grafted*	Maxifort*	(Max-Std)
18" Spacing	$44,525	$47,366	$2,841
24" Spacing		$47,827	**$3,302**
36" Spacing		$45,533	$1008

Net returns of grafting ($/acre) : 2009

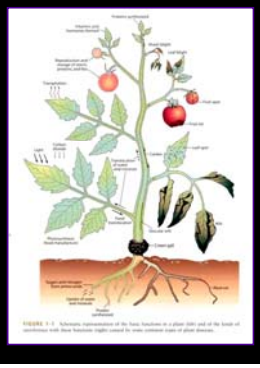
	Non-grafted*	Maxifort*	(Max-Std)
Fumigated	$47,739	$60,699	**$12,960**
Non-fumigated		$57,677	**$9,938**

* Values = Gross revenue – harvest costs – transplant costs

Selling price = $0.66 per lbs

Benefits of Grafting

- Root function
  - Disease resistance against soilborne pathogens
  - Water and nutrient uptake
  - Nutrient assimilation and transport
  - Interface with soil ecosystem



CEFS Research

2006 SR-SARE R&E Grant

- Compare production dynamics of tunnel vs field production.
  - Environment
  - Disease
  - Productivity
  - Economics
- Optimize cultural practices for high tunnels.
  - Nutrient / Fertility
  - Planting Date
- Investigate the role of grafting for open-field and tunnel production.
  - Beaufort
  - Maxifort
  - Nutrient uptake efficiency

'Cherokee Purple'

Beneficial habitat during 2008 growing season

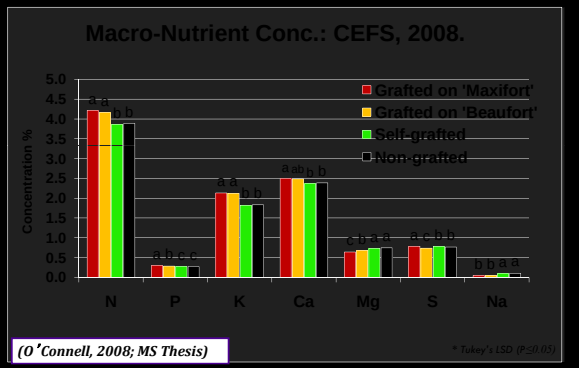
Cultural Management

- European string trellis in tunnels
- Stake-and-weave in field
- 4.5 ft row spacing

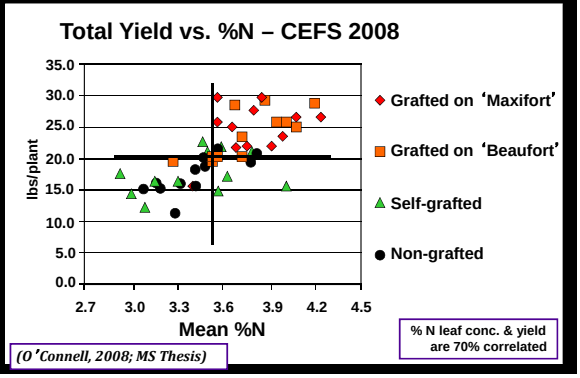
Twin leader in tunnel

Stake-and-weave in field

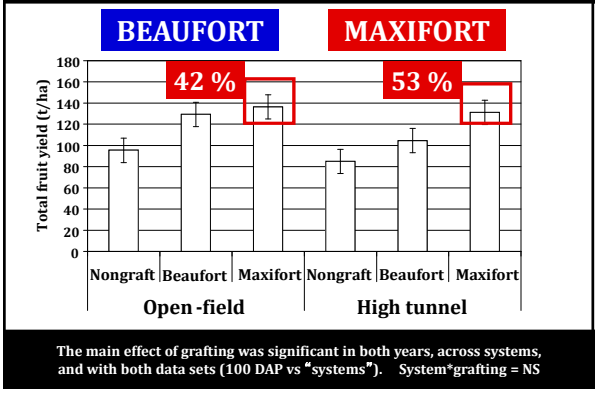
Grafting Effects - Nutrients



Grafting Effects

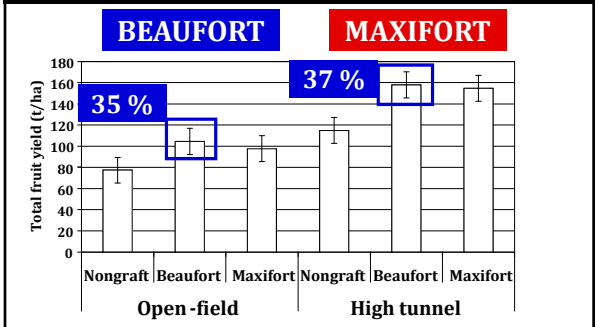


Grafting Effects - 2007



The main effect of grafting was significant in both years, across systems, and with both data sets (100 DAP vs "systems"). System*grafting = NS

Grafting Effects - 2008



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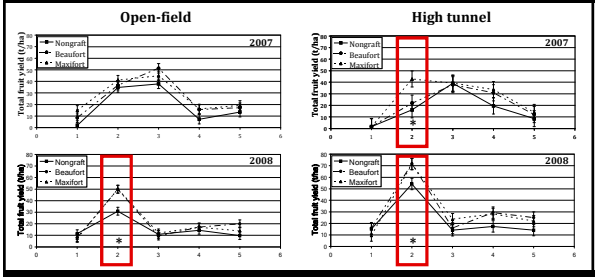
Grafting Effects - Yield



- Bi-weekly harvest data was collected into five bins.
  - Last bin was the final (terminal) harvest
  - Previous four were equivalent divisions of the harvest season
    - Each interval = 3 weeks in the tunnel or 2 weeks in the open-field

Economics

Gross Revenue ($/plant) : 2008

	Non-grafted	Beaufort	Maxifort
Open-field	$28.51	$38.52	$36.00
High tunnel	$42.35	$58.21	$57.04

*at $2/lb

Gross Revenue ($/plant) : 2008

	Non-grafted	Beaufort	Maxifort
Open-field	$42.77	$57.78	$54.00
High tunnel	$63.53	$87.32	$85.56

*at $3/lb

Conclusions

- Grafting provides a site-specific management tool for soilborne disease.
  - Disease diagnosis and rootstock selection are critical.
- Use of rootstocks may increase yield through added vigor and nutrient uptake.
- Cultural management may reduce economic constraints.
  - Planting density
  - Pruning/training
  - Fertility

Grafting at NC State

Novelties

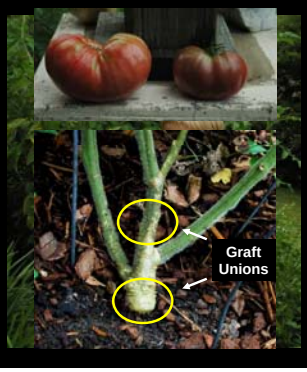


Photo Courtesy: M. Peet (USDA-NIFA)

Tube Grafting


Grafting
for Disease Resistance in Heirloom Tomatoes

Grafting is a simple technique that growers can use to increase soilborne disease resistance in tomatoes without chemical fumigants or pesticides.

Heirloom tomato cultivars lack genetic disease resistance and are particularly susceptible to epidemics in the field. Growers interested in this niche market, however, are not willing to give up the high-quality fruit that they deliver. Grafting can be used to unite the soilborne disease resistance and enhanced vigor of hybrid tomato cultivars with the high fruit quality of heirloom varieties.

Grafting: An Old Technology with a New Technique

Grafting vegetables to manage soilborne

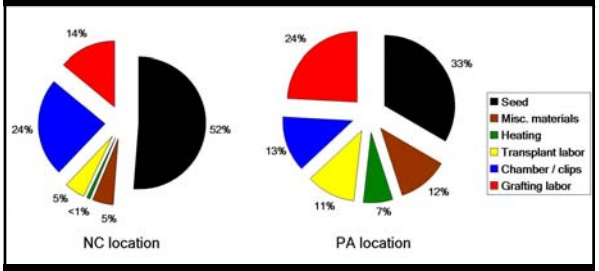
Grafting has been used in the horticultural industry for woody species, such as apples and grapes, for centuries. The first use of vegetable grafting to reduce soilborne disease occurred in the early 1900s to diminish fusarium wilt on watermelons. More recently, this technique has been used in plant production systems when the genetic trait for disease resistance in a crop is closely linked to a negative quality, such as small fruit size. For example, grafting is often used to reduce bacterial wilt (caused by *Ralstonia solanacearum*) in tomatoes. This disease complex is particularly dif-

Disclaimer

- No Recipe for Success
- Principles
  - Production
  - Uniformity
  - Water Stress
  - Sanitation
  - Re-acclimation

Propagation Costs

- Proportion of added costs
  - e.g. seed costs (%) = ($SEED_{graft}$ - $SEED_{non}$) / ($TOTAL_{graft}$ - $TOTAL_{non}$)

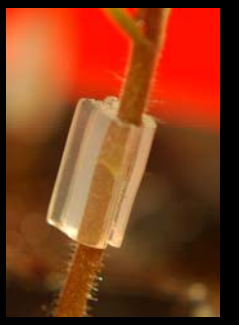


$0.46 / plant **$0.74 / plant = Added cost**

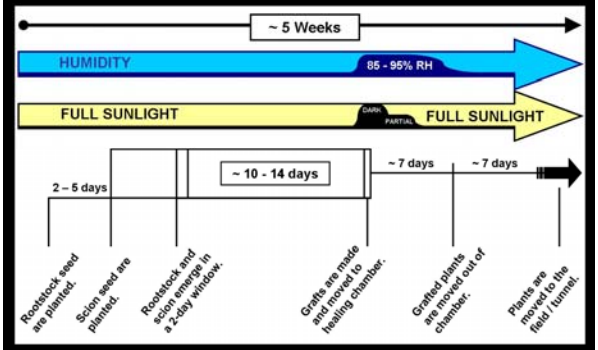
(Rivard et al., 2010)

Tube Grafting

- The advent of "tube-grafting" or "Japanese top-grafting" has become the most popular for tomato.
  - Seedlings are grafted at 2-4 leaf stage.
  - High Throughput
    - A person can make ~ 1000 grafts/day
    - Grafting robots can make 700 grafts/hr.



Timeline



Seeding / Transplant Production

- Uniformity is key
  - Germination period
  - Substrate
  - Transplanting / Sowing
- Rootstock and scion
- Numbers
- Healthy Transplants
- Healing Chamber

Tube Grafting Technique

- Size:
  - 2-4 leaves
  - 1.5-2.0 mm stem diameter
  - Sorting
- Temperature can be manipulated to compensate for size differences.
- Timing is critical.

Tube Grafting Technique

- Preparing for surgery…
  - Make sure plants are not water or nutrient stressed.
  - Have a clean working area.
    - Disinfect hands, tools, and grafting clips.
  - Carry out grafting indoors
  - Be in close proximity to healing chamber.

Tube Grafting Technique

- Angle of cut
- Clip attachment
- Scion insertion
- Provide good contact between the rootstock and the scion.

Life in the Chamber

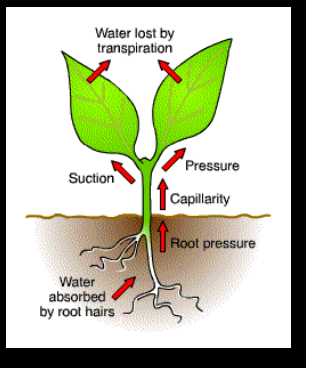
- During the healing process, the plant has to form callus tissue and reconnect vascular bundles within the stem.

Life in the Chamber

- By altering the plant's physical environment, we can offset the functional effects that this trauma has incurred, and give the plant time to heal itself…

Life in the Chamber

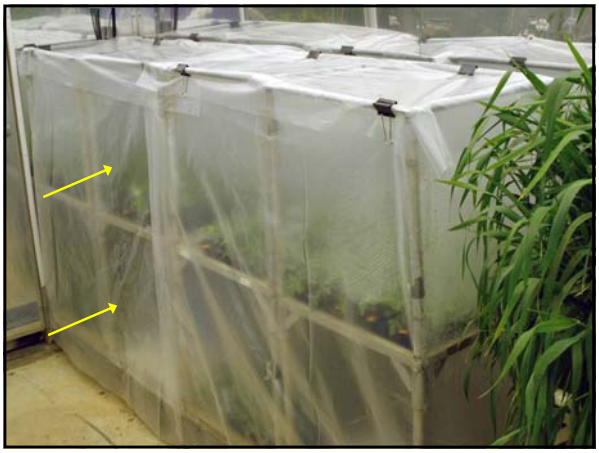
- Objectives of the healing chamber
  - Reducing water stress by slowing the transpirational stream.
    - Humidity
    - Light
    - Temperature
  - Keep temperature fairly constant and between 75 and 80 degrees F.



Life in the Chamber

- **Regulate humidity**
  - Cool-water vaporizers
  - Passive humidifiers
  - No warm-water vaporizers
  - No misters PLEASE
  - Overhead watering

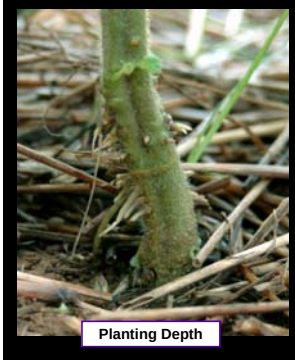
- Regulate light & humidity in the chamber



Life in the Greenhouse

- 7-10 days in the Greenhouse
  - Hardening off
  - Overhead Watering
  - The Clip
  - Transportation

Life on the Farm



Planting Depth

Suckering

Early Tomato Production

Life on the Farm

NON-GRAFTED

MAXIFORT

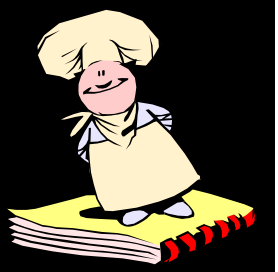
Life on the Farm

Twin leader for European string trellis

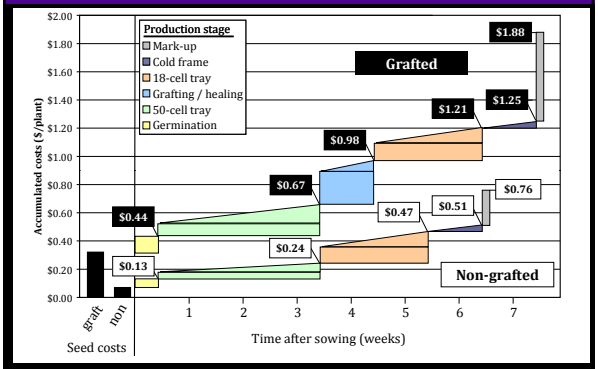
Twin leader for stake-and-weave

Review

- Uniformity of seedlings
- Timing
- Patience
- Sanitation
- Careful observation
- Water management
- Cultural Management



Propagation Costs



(Rivard et al., 2010)