GRAFTING TOMATOES AS AN IPM TOOL TO MANAGE SOILBORNE DISEASES

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A multi-tactic approach to manage soilborne diseases has been implemented in NC and surrounding regions. In addition to evaluation of non-ozone depleting fumigants to assist growers as they transition from methyl bromide formulations, multiple programs have also explored the potential of grafting as an IPM tool to manage economically limiting soilborne diseases and to improve yield and/or fruit quality. Grafting has increased exponentially in many parts of the world and the First International Conference on Grafting of Vegetables was held in Viterbo, Italy with over 180 scientists, educators and practitioners in attendance from 22 different countries (http://www.grafting2011.com/). This paper highlights some summary data from North Carolina and also introduces a USDA funded program where multiple institutions will work together with industry to further explore the potential of grafting of solanaceous and cucurbit crops in the USA.

Multiple on-farm (in part through the USDA Area-Wide Program) and research station experiments have been conducted in NC since 2005. Our goal has been to evaluate the potential of using select rootstock to manage the major soilborne diseases encountered in high tunnel, open field, organic and conventional tomato production systems. Disease problems vary in each ecological zone (Table 1). In general, selecting the correct rootstock that matches the known soilborne disease problem(s) resulted in higher yields, sometimes dramatically. Increased fruit quality was observed, especially fruit size in most experiments. In many cases, grafting provided yield advantage even in the absence of identifiable soilborne pathogens but not in all cases, depending on the rootstock selected and type of production system. For example, in one optimized organic system, yield advantage was not noted, whereas in other systems a vigorous rootstock increased net profits. Several experiments were complimented with a partial budget analysis to determine the impact of grafting on net profits.

We have compiled a preliminary table (Table 2) that summarizes the efficacy against soilborne diseases evaluated in NC experiments or the known efficacy of the rootstock against specific pathogens according to published literature.

Finally, to explore the interest and potential of using grafted cucurbit and solanaceous crops in the USA, multiple institutions, companies and growers have formed a USDA-funded specialty crop research initiative. The initiative includes 4 major objectives, and each objective is led by a multi-disciplinary team of researchers, extension personnel, private experts and/or practitioners (Table 3). Institutional leaders from the 6 cooperating universities and one USDA-ARS station are also listed (Table 4). Each institution will involve multiple personnel in each state to advance the stated objectives. For more information, interested parties should contact the relevant institutional leader.

Table 1: The relative importance of soilborne tomato diseases in each ecological zone and the demonstrated or potential use of grafting to manage that disease based on on-farm and research station research results.

Pathogen	ECOLOGICAL ZONE: Coastal Plain	Piedmont	Mountains	Graft Potential
Fus. oxy. f.sp. *lycopersici race 0 or 1* (formerly race 1&2)	4	4	4	5
Fus. oxy. f.sp. *lycopersici race 2* (formerly race 3)	1	2	4	3
Meloidogyne incognita (Root knot)	5	3	1	4
Phytophthora capsici	3	3	3	1
Pseudomonas corrugata	2	2	3	?
Pythium sp.	2	3	3	?
Ralstonia solanacearum (race 1)	5	4	3	4
Sclerotium rolfsii	4	3	0	4
Verticillium dahliae race 1	0	1	4	5
Verticillium dahliae race 2	0	1	5	2

0 = not important or grafting has no value; 5 = very important disease or grafting has high value as an IPM tool; ? = role of grafting is not known.

Table 2: Examples of rootstock names or codes and level of disease control observed through on-farm and research station experiments in North Carolina.

		Fusarium (commonly called race 1, 2 & 3; new codes are 0, 1 & 2)			Verticillium (Vd[c])		Root Knot Nematode [b]		
Rootstocks	**ToMV[cd]**	**FOL 0**	**FOL 1**	**FOL 2**	**race 1**	**race 2**	**Mi (race1)**	**Rs[f]**	**SB**
Solanum lycopersicum x *Solanum sp.* (interspecific hybrids)[g]									
Beaufort	5[h]	5	5	0	5	---	4	1	4
Big Power	5	5	5	0	5	---	5	1	4
Maxifort	5	5	5	0	5	2	4	1	4
Robusta	5	3	---	0	5	---	---	1	---
TMZQ702[i]	5	5	5	0	5	0	---	1	---
S. lycopersicum									
CRA 66	0	0	---	0	0	---	---	5	---
Dai Honmei[i]	5	5	---	0	5	---	---	4	---
Hawaii 7996	0	5	---	0	0	---	---	5	---
Hawaii 7998	0	0	---	0	0	---	---	4	---
RST-04-105[i]	Tm/+	5	---	0	5	---	---	4	---

[a] Compatibility and ratings are primarily based on field experiments in NC and/or commercial marketing publications and each rootstock has not been systematically evaluated across multiple sites against multiple pathogens. Therefore growers need to verify site-specific uses.

[b] Although the same *Mi* gene may be in each rootstock, the level of resistance varies.

[c] ToMV, Tomato mosaic virus; Fol: 0ï 2, *Fusarium oxysporum* f.sp. *lycopersici* races 0, 1 and 2 (Fusarium wilt); Vd, *Verticullium dahliae*; Mi, *Meloidogyne incognita* (root knot nematode); Rs, *Ralstonia solanacearum* (southern bacterial wilt); SB, *Sclerotium rolfsii* (Southern blight).

[d] ToMV resistance may not be effective for all strains.

[e] selections are highly resistant (5) to Vd race 1 and possibly tolerant to race 2 populations.

[f] Some selections are highly resistant in only certain regions of North Carolina due to strain diversity.

[g] Interspecific hybrid rootstocks are available from many companies and generally have similar genetic profiles; these selections were evaluated in NC and are listed in published papers but are not meant to be exclusive options or recommendations for growers. For example, some recent rootstock releases also have Fusarium race 3 (FOL 2) resistance.

[h] Resistance scores: 5 = highly resistant; 3 = moderately resistant or tolerant; 0 = susceptible; --- = data not published in references or not tested in NC.

[i] Tomato species background uncertain.

Table 3 showing core issues the project will address, objectives of the core issues and working group teams that will address the core issue		
Core Issue	**Objective**	**Working Groups**
1. Propagation and Distribution	Optimize grafting technologies to reduce costs of producing and distributing grafted seedlings and to make the technology readily available to US open-field producers	•Grafting Technologies
2. Effective Use and Management	Integrate discovery-based, applied and on-farm research to optimize field production outcomes.	•Cucurbit Evaluation and Growing Systems •Tomato Evaluation and Growing Systems •Postharvest Quality
3. Economic and Social Metrics	Evaluate economic and social metrics to guide the direction of emerging grafting technology advancements	•Economic and Social Analysis
4. Adoption, Education and Evaluation	Translate outcomes and facilitate the application of grafted plants as a significant tool in vegetable crop production	•Extension, Outreach and Education •Evaluation

Table 4: Executive Team Members and Institutional Leaders (alphabetical order)

Dr. Nancy Burelle, Research Ecologist, USDA-ARS, Fort Pierce, FL.
Dr. Josh Freeman, Assistant Professor, Dept. of Horticulture, Virginia Polytechnic Institute and State University, Eastern Shore Agricultural Research and Extension Center, Painter, VA.
Dr. Richard Hassell, Associate Professor, CREC, Clemson University.
Dr. Matthew Kleinhenz, Associate Professor, Dept. of Horticulture and Crop Science, The Ohio State University.
Dr. Chieri Kubota, Professor, School of Plant Sciences (jointly appointed with Dept. of Agricultural Biosystems Engineering), The University of Arizona.
Dr. Frank Louws, Director of the NSF Center for Integrated Pest Management (CIPM) and Professor, Dept. of Plant Pathology, North Carolina State University.
Dr. Xin Zhao, Assistant Professor, Dept. of Horticultural Sciences, University of Florida.