

INTRODUCTION OF GRAFTING AS A NEW IPM TOOL IN ARIZONA MELON PRODUCTION

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Project Introduction

Western states in the U.S. have experienced a rapid population increase, while continuing to serve as major food production sites. To sustain agricultural food production, while maintaining steady economic growth, agricultural IPM is crucial. Since the 1970's a generation of U.S. vegetable growers including those in the Southwest has relied upon soil fumigants to control soil-borne pests in high value, fresh market vegetable production systems. Major challenges to identifying fumigation alternatives include the additional costs of alternatives, a limited spectrum of activity against soil-borne diseases/pests and issues relating to worker exposure. Therefore sustainable alternatives must integrate several effective techniques of disease/pest control.

Grafting has been used for many years worldwide, to achieve resistances to soil-borne diseases and nematodes, to increase yield and product quality, and to improve plant stress tolerance over chilling and salt stress. Yield increases usually outweigh the cost of introducing grafted seedlings and, therefore, this technology was quickly accepted by farmers in Asia, Europe, and Central America. However, access to the information on scientific evidence and locally-conducted feasibility analysis are limited in the U.S. and therefore vegetable grafting is still relatively unknown to U.S. open-field farmers, while many rootstocks are commercially available worldwide. The rootstocks used for melon production in Asia are known to be resistant to *Fusarium spp.* and melon necrotic spot virus (MNSV), but obtaining locally collected data regarding the performance of the rootstocks over different pests and pathogens locally problematic to Arizona and Southwestern states is crucial to adopt the technology. Melons are an important commodity in Western U.S. vegetable production. Currently in Arizona, there are more than 30,000 acres of melons including cantaloupes, honeydews, and watermelons (Arizona Ag Statistics, 2000). In the central and southern counties of California, melons rank #34 in crop value at \$157,986,000 annually.

Results of a preliminary experiment conducted in fall 2006 indicated that grafting can be an effective means to overcome vine decline caused by charcoal rot (*Macrophomina phaseolina*) and Pythium root rot (*Pythium aphanidermatum*). Charcoal rot has become a problematic soil-borne fungal disease widely spread in Arizona, particularly in drip-irrigated fields. However, fumigation is known to have only little control over the *M. phaseolina*, and there are, so far, no biological control means developed for this disease. Since charcoal rot is not a typical problem

in Asian melon production, where the most information on grafting and rootstocks is available, the rootstock performance over charcoal rot has not been documented in the seed/cultivar registrations. In our preliminary experiment, all cantaloupe plants grafted on interspecific squash rootstock (*Cucurbita maxima* x *Cucurbita moschata*) survived, while all non-grafted cantaloupe plants exhibited a late-season vine decline. Most of these plants were infected with either *M. phaseolina* or *Pythium aphanidermatum* (usually both), but preliminary results indicate that at least 80% of the affected plants probably died from crown decay caused by *M. phaseolina*. The study indicated that grafting can be the potential biological control means for soil borne diseases such as charcoal rot and more data need to be collected to confirm the effectiveness of using the technology.

Cucurbita moschata is known to have a tolerance over root-knot nematode (*Meloidogyne spp.*), which is also problematic to Arizona melon production. In this project, we conducted a spring trial using a small field infected with charcoal rot, *Pythium* and root-knot nematode. We also aim to evaluate the overall performance of the grafted cantaloupe plants.

Summary of the Outcome

1. Field Experiment

An experiment was conducted for the 2007 spring planting season at the University of Arizona Campus Agriculture Center. Seedlings were prepared in the following way using a commercial standard protocol. Scion variety ‘Olympic Gold’ (*Cucumis melo*) and rootstock variety ‘Tetsukabuto’ squash (*C. maxima* x *C. moschata*) were seeded on February 8th, 2007 and grafted on February 17th using two grafting methods widely adopted commercially. Non-grafted ‘Olympic Gold’ was seeded on February 12th. Field was prepared to have three 84 inch wide and 90 feet long beds. The soil type of the experimental plot was classified as silty clay. All seedlings (total of 54 seedlings) were grown inside a greenhouse and transplanted in a field plot on March 8th. No pre-planting fumigations were applied. Fertigation containing 1512 mg/L UN32 and 182 mg/L phosphorus and 545 mg/L potassium was applied using a drip line buried 9 inches under ground, so that the final fertilization rate was 100 lb per acre UN32, 20 lb per acre ‘Ortho Phosphate Plus’, and 60 lb per acre ‘Knockout’ potassium, following the recommendation from the industry collaborator.

On March 26th and 30th, soil in the field plot was inoculated with root-knot nematode (*Meloidogyne incognita*). The experimental design was randomized block design (three blocks each with three experimental units (3 plants per unit)). Fully ripened fruits were harvested and the plants were collected for diagnosing infections of RKN and other pathogens.

Table 1 shows that the early growth (vine elongation) and development (branching) of grafted plants were significantly faster than non-grafted plants. The first and the last harvest of fruits were on June 4th and July 5th, respectively. Table 2 summarizes the yield and quality of fruits harvested over the experiment. The yield of harvestable fruits were 89% greater in grafted plants than in non-grafted plants. The greater yield in grafted plants was attributed to more fruit production per plant and a greater size of fruit in grafted plants than those in non-grafted plants. The soluble solid concentration, an index of fruit sweetness, was not significantly different between fruits produced by grafted and non-grafted plants. The duration of harvest was approximately four weeks, which was longer than the conventional commercial situation (~2

weeks). This was partly because we had insufficient natural pollinators and began manual pollination in the middle of plant maturation stage, and also because grafted seedlings were initially producing more male flowers than female flowers. The fertilization program needs to be optimized for grafted plants to promote a more reproductive state.

Table 3 summarizes the RKN egg counts per gram of root tissue and pathogen incidence. All plants were heavily infected by RKN. Grafted plants had more egg counts than non-grafted plants, although the grafted plants yielded significantly higher than non-grafted plants. This suggests that grafted plants are more tolerant to RKN than non-grafted plants.

Many plants declined and had to be removed from the field plot before harvest. Fig. 2 shows the cumulative percent incidence of vine decline over harvest dates. The incidence was greater in non-grafted plants than grafted plants at early harvest dates, but became almost the same at the end of season. Because of the heavy infection of RKN, other pathogen diagnosis was difficult. Among the 12 plants available for diagnostic incubation of sample root and stem tissue, 3 grafted plants and 3 non-grafted plants were infected with *Pythium aphanidermatum*, 2 non-grafted plants were infected with *Macrophomina phaseolina*, and one non-grafted plants was infected with *Rhizoctonia solani*. Unfortunately, due to the small number of samples, we could not conclude if grafted plants had tolerance over these pathogens. ‘Tetsukabuto’ squash rootstock is known to be sensitive to heat, and therefore the late vine decline observed in the grafted plants may have been partly due to the heat. Air and soil temperatures recorded in the Tucson AZMET weather station are summarized in Fig. 1. During the time grafted seedlings started declining, the daily maximum air temperature was at or exceeded 40°C.

Table 1. Summary of early vegetative growth of cantaloupe plants as affected by seedling type (grafted vs non-grafted seedling)

Seedling type	Main vine length (m)		Number of secondary vines (per plant)	
	34 DAT (April 11 th)	71 DAT (May 18 th)	34 DAT (April 11 th)	71 DAT (May 18 th)
Grafted seedling	0.42	1.43	4.7	N/A
Non-grafted seedling	0.15	0.87	1.9	N/A
Prob>F	0.0001	0.001	0.0001	--

DAT = days after transplanting

Table 2. Summary of fruit yield and quality as affected by seedling type (grafted vs non-grafted seedling)

Seedling type	Total harvestable fruit yield (kg m ⁻²)	Number of harvestable fruits per plant	Fruit diameter (cm)	Soluble solid concentration (Brix, %)
Grafted seedling	2.52 a	2.0 a	14.0 a	12.0
Non-grafted seedling	1.33 b	1.4 b	12.2 b	11.7
Prob>F	0.004	0.049	0.002	0.337

Table 3. Summary of root knot nematode egg counts.

Seedling type	RKN egg counts per gram of root tissue
Grafted seedling	36896 a
Non-grafted seedling	14952 b
Prob>F	0.01

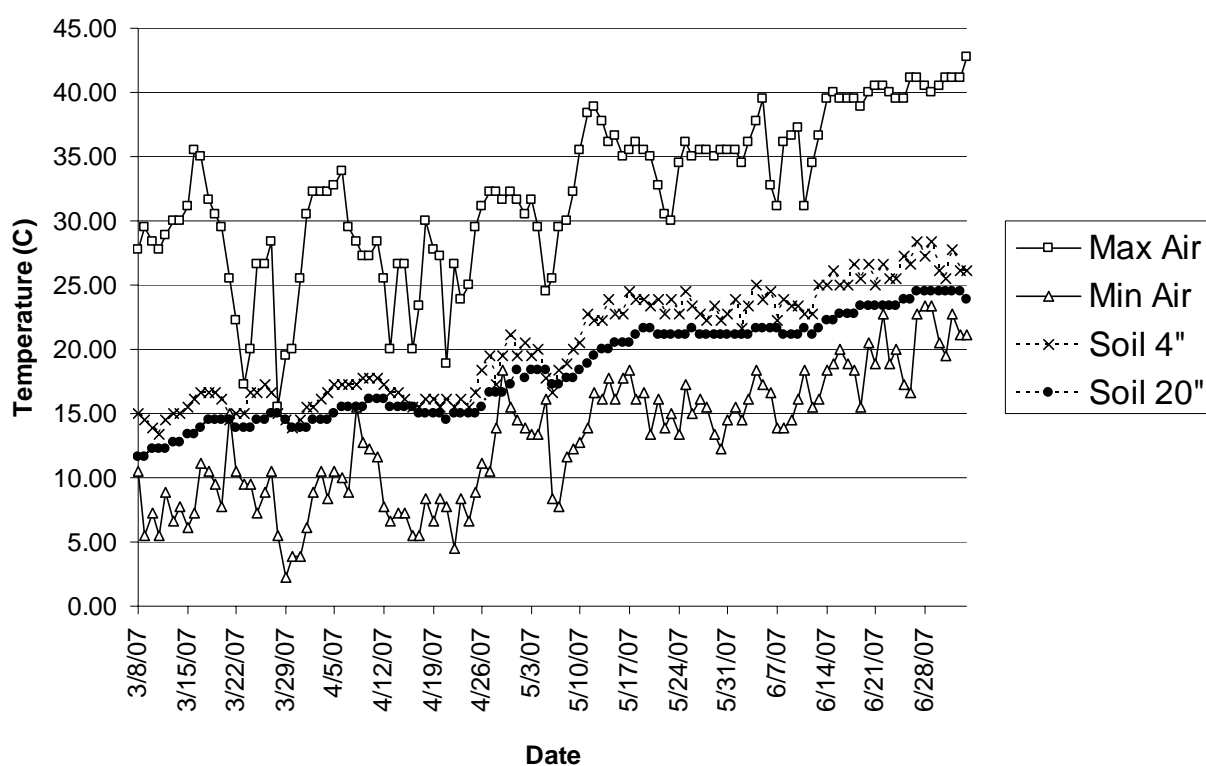


Fig. 1. Air temperature and soil temperature (at 4 and 20 inch depth) during the experiment (March 8th, 2007 – July 4, 2007) recorded in Tucson AZmet Weather Station (AZMET, 2007).

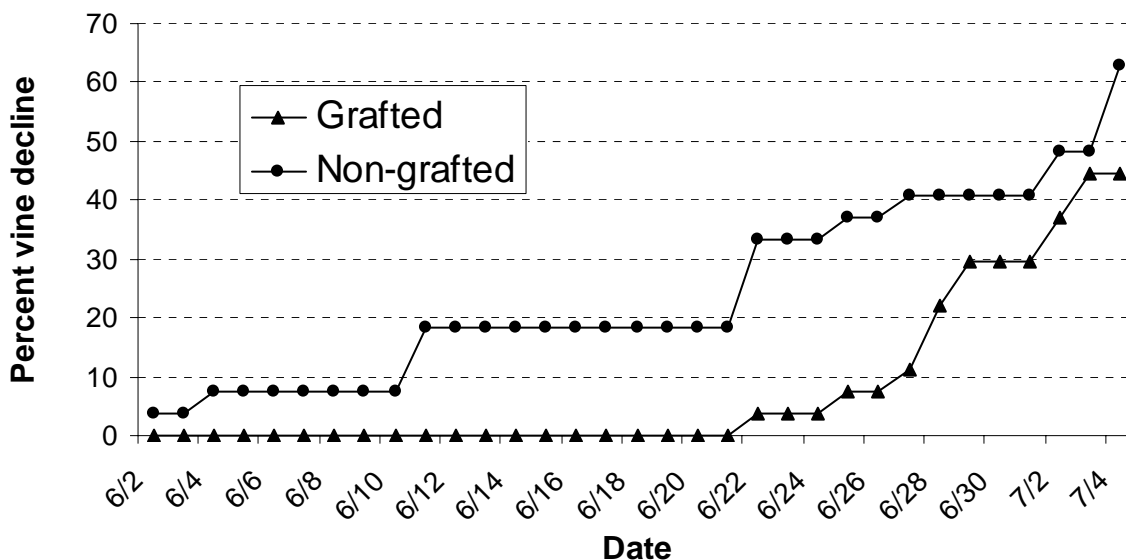


Fig. 2. Percent incidence of vine declining over harvest time.

2. Communication with Stakeholders

Informal surveys among seed companies were conducted during two growers conferences held in Tucson, AZ and Leon, Mexico in 2007. Also, we have communicated with the seed companies on their interest in terms of introducing grafting. Almost all seed companies that participated in both conferences were aware of grafting vegetable seedlings (tomato and cucurbits). We identified 19 cucurbit rootstock varieties from six seed companies (American Takii, d.palmer, Nunhems, Sakata, Syngenta, and Zeraim Gedera) currently available in the U.S. market and two other seed companies (Seminis and Abott&Cobb) are planning to introduce new rootstock varieties for grafting cucurbits. Although there are only limited amounts of trial data available out of U.S. open fields, most of the seed companies are willing to cooperate with academic researchers and producers to test their rootstock varieties. Syngenta Seeds is such an industry who is conducting trials in multiple locations for grafted watermelon, and held a conference in Florida in March 2007. Although we could not participate in the Syngenta conference, during the annual conference of American Society for Horticultural Science (Scottsdale, AZ), Dr. Kubota met six academic researchers who conduct grafting trials with Syngenta Seeds. The conference contents are available on line from the American Society for Horticultural Sciences website (www.ashs.org). Overall, as expected, we recognized a rapidly increasing interest in use of grafted seedlings in vegetable and fruit production in U.S. open fields, yet only limited amount of U.S. trial data and scientific information is available.

Dr. Kubota also helped a relatively large Texas-based propagator who produces vegetable seedlings to establish a sizable capability of grafted seedling production of both cucurbits and tomato. They successfully produced 20,000 grafted cantaloupe seedlings in Fall 2007.

3. Presentations

Kubota, C. 2007. Transplants and grafting: The first significant step for your success and a business opportunity. Greenhouse Crop Production and Engineering Design Short Course, January 2007.

Kubota, C. 2007. Current use and technology status of grafted tomato seedlings in North America. International Tomato Congress, Leon, Mexico, July 2007.

Kubota, C. 2007. Vegetable grafting: history, use, and current technology status in North America. ASHS Workshop 'Grafting Vegetables for Enhanced Production and Quality' during the American Society for Horticultural Science Annual Conference, Scottsdale, AZ, July 2007.

4. Publications

Kubota, C., M.A. McClure, N. Kokalis-Burelle, M.G. Bausher, and E.N. Roskopf. 2007. Vegetable grafting: History, use, and current technology status in North America. HortScience (submitted)

5. Extramural grant application

Kubota, C., M.A. McClure, N.K. Burelle, M.G. Bausher, E.N. Roskopf, and D.O. Cellemi. Use of grafted seedlings for methyl bromide transition in U.S. open-field fresh vegetable production. Effort 10%, PI, USDA/CSREES (Integrated Research, Education, and Extension Competitive Grant Program – Methyl Bromide Transition), 2007-2010, \$884,330. (Dr. Mary Olsen participates as a collaborator)

Impact

This collaborative research afforded a unique opportunity to study an IPM tool relatively unknown in Arizona for controlling multiple pests/diseases without negative impact to the environment or human health, consistent with APMC Goals and Priority Issues under Agricultural IPM. A local melon producer, who grows melons on 10,000 acres of open-fields, started a formal collaboration funded by USDA/CSREES (PIs: Kubota et al.) in the fall 2007. We will continue the trials of using grafted seedlings in Arizona melon production for two years using organic fields and conventional fumigated fields.

The medium and long-term outcomes and impacts will include other producers, propagators and seed companies who exist in Arizona and beyond. Because the source of grafted seedlings is limited in the U.S. while the demand can be huge (5,000 plants needed for every acre of planting field), the long term impact will include business opportunities to start specialized propagation operations using the unique grafting techniques. A new independent propagator in Texas is prepared for supplying grafted seedlings to Arizona starting in Spring 2008. Another Arizona-based propagator will start their test production of grafted seedlings in 2008/2009.

Project Pictures



Photograph 1. Grafted seedlings after acclimatization. Seedlings were grafted using a hole-insert and rootless grafting method (left) and a splice grafting method (right). Pictures were taken on Feb. 28.



Photograph 2. Grafted (orange tag) and non-grafted (white tag) cantaloupe plants on the planting date (March 8). They were approximately at the same developmental stage with two-three large true leaves.



Photograph 3. Grafted cantaloupe plants on June 14.



Photograph 4. Squash plant roots heavily infected by RKN.