Tomato Grafting on a Small-Scale Farm

by Grow Ohio Valley

Table of Contents

ABSTRACT AND CONCLUSIONS

During the 2017 growing season, Grow Ohio Valley developed facilities and processes to graft tomato plants. Our intent was/is to benefit other small farms by documenting experimental designs, field notes and data.

Neither significant benefits nor detriments were observed *this year* as a result of this tomato grafting. Specifically, we experienced comparable results in yield and disease resistance between our grafted plants and ungrafted control group.

Benefits are likely to be seen over the long term, as unavoidable repetitive cropping increases soil-borne diseases on our farm. Our farm's layout and size is such that we will be unable to observe recommended crop rotations over the long term, enhancing our risk of soil-borne disease. The long term benefits experienced by farms worldwide, namely the ability to repetitively plant without significant crop damage from soil-borne disease, is worth continued observation and analysis.

Meanwhile, our grafting work in 2017, facilitated by OCIA, has set in place a low-cost, farm-scale system to continue incorporating grafting into our production system. As such, we will use the resources and skills garnered through this grant to pursue grafting as part of our production system into the future, continuing to note - and make public - the pros and cons of grafting on the small farm.

TERMS AND EXPLANATIONS

Healing Chamber: a controlled environment designed to regulate light, temperature, and humidity. In the early stages of "healing", the plants require near total darkness, consistent 80 degrees, and near 90% humidity. This keeps the scion from drying out and from pulling away from the rootstock towards any light until the scion and rootstock have connected. For a comprehensive review of the tomato grafting and healing process, we recommend information on Johnny's Seed Co. website[1], as well as videos recorded by Kansas State extension service[2]. If you are unfamiliar with grafting, we suggest you consult these two resources for general review.

Rootstocks: Tomato rootstocks fall generally into one of two categories: "vegetative" or "generative". Vegetative tend more toward production of leaf and stem tissue, while generative tend more toward fruit production. We used a generative variety called Estamino for our cherry varieties and a vegetative called Maxifort for all larger slicing variety scions.

Scions: The tomato cultivar that is grafted onto the rootstock, intended for marketing and consumption. We used over 25 cultivars in our experiment.

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[1] http://www.johnnyseeds.com/growers-library/vegetables/tomatoes-top-grafting-vigor-disease-

[2] https://www.youtube.com/watch?v=9Mxy0HfgpKY

Grafting style: Tomatoes can be grafted three ways: "top-graft", "side-graft", or "cleft graft". We chose top-grafting on our farm, as local instructors had the most familiarity with this process. Once again, we recommend consulting Johnny's Seed Co.'s technique on top grafting[3].

METHODS AND MATERIALS

Healing chamber construction: In January 2017, we built a mini-greenhouse inside of our larger greenhouse, to serve 2 functions:

1) To heat a smaller space for the small number of seedlings in January/February, as opposed to heating the entire greenhouse.

2) To create a controlled environment (temperature, humidity, and light) for the tomato plants' healing process.

The mini-greenhouse has a footprint of 4'x12'. It has its own thermostat activated heater (a small space heater) and a thermostat activated ventilation system (a small vent fan), both available from box stores or online. Both the heater and the fan are plugged into a direct plugin thermostat that allows for both cooling and heating control[4]. A portion of this mini-greenhouse was then cordoned off with scrap tarps, allowing for a space approximately 3'x3'x3' wherein specific healing chamber requirements could be maintained. We used a cheap, 1-gallon box-store humidifier. See the table below for a review of mini-greenhouse expenses.

We consider this mini-greenhouse excessive for the purposes of tomato grafting. A healing chamber can be set up for a fraction of the cost (see videos published by Kansas State[5]). For our farm, it has secondary value - a smaller space to heat when we want to start early transplants.

The mini-greenhouse was built mostly out of scrap building materials and leftover polycarbonate panels. Still, purchases (especially automatic climate control) totaled $330. The mini greenhouse took 40 hours of labor to build.

Tomato varieties

Scions: Since our farm sells tomatoes in "variety packs", we interplanted a wide variety of tomato cultivars: 14 cherry tomato varieties, and 11 full size tomato varieties. All full-size tomatoes were distinct heirlooms; there were no "red slicer"

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[3] http://www.johnnyseeds.com/growers-library/vegetables/tomatoes-top-grafting-vigor-disease-resistance-technique.html - Information sheet on top-grafting

[4] https://www.amazon.com/gp/product/B00V4TJR00/ref=oh_aui_search_detailpage?ie=UTF8&psc=1

[5] https://www.youtube.com/watch?v=9Mxy0HfgpKY

tomatoes grown for this experiment, nor on our farm in general. In total, 172 cherry tomato plants were planted: 138 ungrafted, 34 grafted. As such, 20% of all cherry tomatoes were grafted. In total, 111 full-size tomato plants were planted: 96 ungrafted, 15 grafted. As such, 14% of all full-size tomatoes were grafted. Analysis of harvest results takes into account this difference.

Rootstocks: Per general recommendations, we grafted our cherry tomatoes onto generative rootstocks ("Estamino" cultivar), and our full-size tomatoes onto vegetative rootstocks ("Maxifort" cultivar).

Grafting process: Graft unions were made approximately 1/2 inch from the soil line, using the "top-graft" method. All grafted plants were immediately put in the healing chamber at 100% humidity. Humidity was gradually decreased over 7 days to 25%. All plants were removed from the healing chamber after 7 days at 72% survival-rate. We closely followed grafting recommendations laid out in Johnny's guide to top-grafting[6].

The predominant challenge with grafting, for us, was matching diameters of rootstock and scions to each other. In the future, we will reduce light a few days before grafting to encourage the plants to become "leggy". As it stood, ours grafts were often performed close to the base of the plant. This created difficulties with transplanting and trellising, as we attempted to keep the scions from making ground contact and forming adventitious roots.

High Tunnel Production: **Planting**

Layout: Grafted tomato plants were planted in a 4ft bed, single row, 24" apart, and trained to a double leader. This method was used to maximize fruit yield per plant based on best practices regarding relationship of light penetration and potential for air circulation. Ungrafted plants were treated the same.

Timing: All tomatoes were planted into the high tunnels on April 15-16. Our planting date was determined by ambient temperature: steady temperatures in the 60's. It was waxing to full moon on those two nights.

Soil: We submitted soil samples to Logan Labs and amended soil minerals according to the recommendations from the online software system "Organicalc".

No mulch: Grafted plants were planted into bare soil. We chose not to use organic material (such as hay) as mulch on the grafted plants, because we worried it would encourage scion rooting. Scion rooting partially negates the effects of grafting.

High Tunnel Production: Ongoing Care

Disease control: All tomatoes received biweekly application of Serenade[7], a biofungicide that establishes beneficial bacteria on the plant tissues. We had

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[6] http://www.johnnyseeds.com/growers-library/vegetables/tomatoes-top-grafting-vigor-disease-resistance-technique.html

[7] https://www.bayeradvanced.com/serenadegarden

incidences of both brown and gray molds in the first month after planting, aggravated by cool temperatures. During that time period, liquid copper fungicide was used on a weekly alternating pattern with Serenade.

Fertility: During the first month of growth, all tomatoes received bi-weekly foliar spray of fish emulsion (tank mixed with Serenade). We noticed a decline in overall tomato production in mid-August. At that time, we injected 3-3-3 fish emulsion into our drip tape as a soil drench, at a rate of 2.5 gallons of fish emulsion for the entire high tunnel (3,000 ft2). This was repeated biweekly for a total of 3 soil drench applications.

Pruning: Tomato plants were pruned to either a single or a double leader system, with all suckers removed. The plants were lowered using the "lower and lean" method[8]. The grafted plants presented an extra challenge during the lower-and-lean process, in that the scion portion of the plant would be touching the ground, risking development of adventitious roots. To mitigate that risk, we placed sheets of cardboard under the stem of each grafted plant. To our surprise, the lowering and leaning did not cause the tomato plants to break at the graft union. The unions were pliable and strong.

OUTCOMES

Precocity: Grafted plants were 2-3 weeks **delayed** in maturation, presumably due to the trauma and healing process of grafting.

Plant survival rates: The grafted plants performed comparably to ungrafted plants as relates to general health and survival rates, with one exception. All of the ungrafted tomato plants of the variety "Yellow Pear" were completely dead by end of August due to fusarium wilt. Our repeated experience, on our farm, has been that Yellow Pears die of fusarium long before the end of the season. However, as of October 11, the grafted Yellow Pear plant is still alive, showing no signs of fusarium wilt.

General health: We noticed no significant difference in general health and vigor of grafted plants vs ungrafted. Both had equal presentation of brown and gray molds.

Yield: Yields were slightly lower for grafted plants (see Table 1). While 20% of cherry tomato plants were grafted, those grafted plants only produced 15% of total yield. Meanwhile, 14% of full-size plants were grafted, but only produced 11% of total yield. This discrepancy can be explained by the slower start of the grafted plants, after the first month of production, grafted and ungrafted plants produced an equal per-plant volume. This discrepancy most likely would be mitigated by starting the grafted plants several weeks sooner, to account for the healing process.

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[8] https://www.youtube.com/watch?v=J8L_x42RieA&t=76s

CONCLUSION AND DISCUSSIONS

We saw neither significant detriment nor advantage to planting grafted tomatoes *this year*. Specifically, we experienced no enhanced yields, and minimal advantage in disease resistance. Thus, we are unable to draw firm conclusions about the benefits of grafting. Any conclusions would be premature; however, we think it worthy to continue the practice on our farm, for the following reasons.

> **Replant tolerance**: One of the touted benefits of grafting tomato plants is "replant tolerance", or the ability for tomato plants to be grown repetitively in the same ground without succumbing to soil-borne disease buildup[9]. This is particularly relevant to our farm, where we have only 2 high tunnel greenhouses. Our customer demand indicates that one high tunnel per year be planted in tomatoes. As such, we do not have the infrastructure to accomplish the 3-4 year rotation recommended for tomatoes. This replant tolerance could have significant implications for our farm projecting years into the future. As of now, that benefit is not quantifiable.
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> **Research and knowledge-sharing**: With an expectation that benefits will be confirmed - or not - over the next 5 years, we plan to continue grafting and share our observations with other small farms.

We plan to continue planting grafted tomato plants as ~20% of our total tomato planting, for at least the next 5 years. That timeframe will allow us to document the impact of grafting on a repetitive tomato cropping system. We plan to continue to make that information available - through local and national distribution channels - to other small farms weighing the benefits of grafting.

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[9] "The main reason to graft tomatoes is to avoid soilborne diseases. The rootstock should have resistance to the common diseases on your farm that would normally shorten the life of tomato plants or reduce their vigor and yield. Soilborne diseases tend to become a problem in hoophouses when tomatoes or other Solanaceae crops are grown year after year." - from https://www.growingformarket.com/articles/Grafted-Tomatoes

Three weeks after transplant. The row on the left is grafted (not mulched, drip tape is visible), while other rows are mulched heavily with hay.

Grafted “Cherokee Purples” as of September 26, immediately before harvest.

Tomato Yields, 2017			
Date	**Grafted**	**Ungrafted**	**Type**
7/4	2	55	Cherry Tomatoes (pints)
7/4	0	0.4	Full-size Tomatoes (10# flats)
7/10	0	1.6	Full-size Tomatoes (10# flats)
7/10	17	82	Cherry Tomatoes (pints)
7/12	0.13	1	Full-size Tomatoes (10# flats)
7/24	0	24	Cherry Tomatoes (pints)
7/18	16	210	Cherry Tomatoes (pints)
7/25	42	138	Cherry Tomatoes (pints)
7/28	14	79	Cherry Tomatoes (pints)
7/29	1.5	5.5	Full-size Tomatoes (10# flats)
8/1	10	116	Cherry Tomatoes (pints)
8/4	21	79	Cherry Tomatoes (pints)
8/5	1	8	Full-size Tomatoes (10# flats)
8/8	2	12	Full-size Tomatoes (10# flats)
8/8	17	77	Cherry Tomatoes (pints)
8/10	10	23	Cherry Tomatoes (pints)
8/12	0	4	Full-size Tomatoes (10# flats)
8/12	0	10	Cherry Tomatoes (pints)
8/15	1	15	Full-size Tomatoes (10# flats)
8/15	15	57	Cherry Tomatoes (pints)
8/17	0	7	Full-size Tomatoes (10# flats)
8/18	12	52	Cherry Tomatoes (pints)
8/19	0	3	Full-size Tomatoes (10# flats)
8/22	0	1	Full-size Tomatoes (10# flats)
8/22	20	130	Cherry Tomatoes (pints)
8/26	1	4	Full-size Tomatoes (10# flats)
8/26	13	70	Cherry Tomatoes (pints)
8/29	12	36	Cherry Tomatoes (pints)
9/3	1	5	Full-size Tomatoes (10# flats)
9/3	7	36	Cherry Tomatoes (pints)
9/5	12	96	Cherry Tomatoes (pints)
9/5	1	3	Full-size Tomatoes (10# flats)
9/6	8	15	Cherry Tomatoes (pints)
9/8	7	16	Cherry Tomatoes (pints)
9/8	1	3	Cherry Tomatoes (pints)

9/12	12	75	Cherry Tomatoes (pints)
9/15	9	81	Cherry Tomatoes (pints)
9/19	2	14	Full-size Tomatoes (10# flats)
9/22	14	90	Cherry Tomatoes (pints)
9/26	2	16	Full-size Tomatoes (10# flats)
9/29	11	67	Cherry Tomatoes (pints)
10/3	1	6	Full-size Tomatoes (10# flats)
Totals	**Grafted**	**Ungrafted**	**Grafted yield as a percentage of total yield**
Cherries (pints)	302	1717	14.96%
Full-size (10# flats)	13.63	106.5	11.35%
Average Per-plant Production (whole season)			
	Grafted	**Ungrafted**	
Cherries (pints)	8.88	12.44	

Grafting Expenses		
Expense	**Amount**	**Notes**
Recurring Expenses		
Labor (grafting and healing)	$185	Hourly farmer wage
Grafting clips	$18	From Johnny's Seed Co.
Grafting knives	$3	Blade from a straight-razor (used for shaving)
Rootstock Seed	$42	From Johnny's Seed Co.
One-time expenses		
Mini-greenhouse construction	$330	Materials
	$400	Labor
Total Expenses	$1,124	includes 15% overhead allocation
Total Recurring Expenses	$285	"