Evaluation of Grafted and Nongrafted Hybrid and Heirloom Tomatoes in a Midwest High-tunnel Production System

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Introduction

High tunnels have emerged as a tool for Iowa vegetable growers to extend the growing season, increase crop production, and improve quality of the produce, but production in this system does not come without challenges. Continuous cropping of tomatoes in the same high tunnel gives rise to recurring soil-borne and foliar diseases, pest pressure, issues with soil fertility and salinity, and increased irrigation requirements. One tool to overcome these challenges may be the use of vegetable grafting. The process of grafting is accomplished by attaching a desired scion onto a rootstock that is typically bred for vigor and/or disease resistance.

Field research is being conducted over two years (2015 and 2016) to compare the effect of grafting on Cherokee Purple heirloom tomatoes (indeterminate) and Mountain Fresh hybrid tomatoes (determinate). The rootstock being utilized in this study is RST-04-106-T, which is resistant to Fusarium Wilt, Bacterial Wilt, and Tomato Mosaic Virus. This study utilizes a randomized complete block design to compare grafted and nongrafted plants for both tomato varieties.

Materials and Methods

Tomatoes were seeded in an ISU greenhouse on March 19, 2015. On April 8, 2015, half of the seedlings were grafted using the splice grafting method. This required cutting the rootstock stem at a 45^{o} angle below the cotyledon (seed leaf). The scion stem was cut at the same angle above the cotyledon. The two stems were joined together and held in place utilizing a silicon grafting clip. The transplants then were placed in a high humidity, light blocking "healing chamber" for three days before being re-acclimated to ambient greenhouse conditions.

On May 7, 2015, transplants were planted in a ClearSpan™ high tunnel with dimensions of 30 ft W × 12 ft H × 96 ft L covered with six millimeter polyethylene film. Automated roll-up sides on the high tunnel had a set-point of 80^{o}F. The tomatoes were planted 18 in. apart with 10 plants in each of the four treatment plots. Rows were replicated four times within the high tunnel at a spacing of 5 ft. Mountain Fresh tomatoes were grown using a stake and weave support system. Cherokee Purple tomatoes were grown as a single leader using the lower and lean trellis technique supported on the Rollerhook® system. A drip tape irrigation system was used to water at varied rates from 200 to 600 gallons/week. The entire high tunnel was mulched to a depth of 6 in. using switchgrass hay. During the week of July 27, 2015, a 50 percent shade cloth was added to the high tunnel to reduce light levels and moderate temperature.

Harvest took place 10 times throughout the season starting on July 22, 2015 and ending on October 12, 2015. Mountain Fresh tomatoes were harvested at the breaker stage of ripeness and were graded using the USDA size standards for diameter to determine grade one (greater than 2¾ in.), two (greater than 2½ in.), and three (greater than 2¼ in.). Non-

marketable Mountain Fresh tomatoes included fruit 2¼ in. and smaller as well as fruit with major surface defects and insect and disease damage. Cherokee Purple tomatoes were harvested at the "pink to red" stages classified according to the USDA maturity standards. The fruit was graded visually to determine marketability. Non-marketable Cherokee Purple fruit was sorted into categories based on fruit cracking, damage from sunscald, scab as a result of cat-facing, severely misshapen fruit, and insect damage. Fruit count and weight in kilograms was recorded for all categories of fruit for each harvest.

Plant vigor in response to grafting was evaluated using several parameters. During the peak of tomato production, five plants/treatment plot were sampled for chlorophyll content using an optimal spectrometer to determine an average SPAD reading. At the end of the season, October 19, 2015, five plants/plot were measured for stem diameter at a point 15 centimeters above the soil surface. On October 20, 2015, three plants from each plot were removed by collecting all shoot tissue and digging an 18-in. circumference hole to collect a uniform root sample. Roots and shoots from each plant were separated, dried, and weighed to compare biomass.

Post-harvest fruit quality was determined by collecting samples of marketable fruit for lab analysis. Using fruit harvested on September 18, 2015, density was calculated by weighing fruit samples and using water displacement to measure exact fruit volume. The same fruit samples were analyzed on September 22, 2015 to measure soluble solids (Brix°). One whole fruit from each plot was blended in a food processor and fruit juices were sampled in a refractometer.

Results and Discussion

Cherokee Purple yield. Fruit yield from the Cherokee Purple tomatoes was significantly lower than the yield of the Mountain Fresh tomatoes (Table 1). However, there was not a significant difference in yield between the grafted and nongrafted plants. The percentage of marketable fruit by weight for the grafted tomatoes was 52.3 percent and 46.0 percent for the nongrafted plants. This low rate of marketability was due to many factors including early season sunscald damage and a high incidence of both concentric and radial cracking throughout the season. Yellow shoulder was also observed in the Cherokee Purple tomatoes.

Mountain Fresh yield. Although the Mountain Fresh tomatoes yielded much higher overall, there was still not a significant difference between grafted and non-grafted plants for the 2015 season. It is important to note that the percentage of marketable fruit for both grafted and nongrafted Mountain Fresh plants was much higher than the Cherokee Purple tomatoes.

Plant vigor. There were few significant differences between plant vigor measurements for the 2015 season (Table 2). This indicates that the RST-04-106-T rootstock did not significantly increase the growth response of either the Cherokee Purple or Mountain Fresh scions as compared with the nongrafted plants.

Fruit quality and density. The soluble solids (Brix°) measurements for fruit samples from each treatment were not significantly different (Table 3) with the exception of the Mountain Fresh grafted tomatoes, which had a lower value than other treatments. Fruit density was very similar for all four treatments.

Our early findings indicate that grafting Cherokee Purple and Mountain Fresh scions to the rootstock RST-04-106-T does not have

significant positive impact on fruit yield. Challenges presented by high temperatures and light levels within the high tunnel in the early season may have contributed to the low percentage of marketable fruit for Cherokee Purple. Another contributing factor may have been changes in irrigation practices mid-season as well as the need for better nutrient management. The 50 percent shade cloth will be used earlier in the 2016 season to prevent blossom abortion and sunscald damage on fruit. Further research is needed to test the feasibility of the RST-04-106-T rootstock for high tunnel production within the Midwest.

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Table 1. Average total yield and marketability of grafted and nongrafted tomato fruit harvest from Cherkokee Purple and Mountain Fresh during the 2015 season.

	Marketable fruit yield			Total fruit yield			Marketability (%)	
	Weight (kg)	Avg size (g)	Number	Weight (kg)	Avg size (g)	Number	Weight	Number
Cherokee Purple grafted	24.5 b	296 a	82.5 b	46.9 b	306 a	152.5 b	52.3 b	54.2 b
Cherokee Purple nongrafted	21.1 b	310 a	69.0 b	46.1 b	320 a	144.8 b	46.0 b	47.2 b
Mountain Fresh grafted	92.8 a	234 b	398.3 a	110.1 a	222 b	499.8 a	84.4 a	79.9 a
Mountain Fresh nongrafted	90.2 a	247 b	369.0 a	106.1 a	230 b	464.8 a	85.2 a	79.6 a

Mean separation in columns based on least significant differences at $P \leq 0.05$.
Values followed by the same letter within a column are not significant.
Weight (kg) and number is from ten plants/treatment per replication.

Table 2. Plant vigor indicators [SPAD readings (chlorophyll content), stem diameter, and end of season root and shoot biomass] during the 2015 season.

	SPAD	Steam diameter (mm)	Root biomass (g)	Shoot biomass (g)
Cherokee Purple grafted	44.3 ab	15.40 a	5.7 b	111.7 b
Cherokee Purple nongrafted	43.4 b	14.69 a	5.8 b	115.6 b
Mountain Fresh grafted	45.7 ab	15.19 a	14.9 a	339.8 a
Mountain Fresh nongrafted	47.0 a	14.25 a	12.9 a	346.2 a

Mean separation in columns based on least significant differences at $P \leq 0.05$.
Values followed by the same letter within a column are not significant.
Data is an average of 20 plants for SPAD and stem diameter and 12 plants for root and shoot biomass.

Table 3. Average total soluble solids (Brix°) and fruit density of marketable tomatoes in the 2015 season.

	Total soluble solids (Brix°)	Fruit density (g/ml)
Cherokee Purple grafted	5.1 a	1.02 a
Cherokee Purple nongrafted	5.4 a	1.08 a
Mountain Fresh grafted	4.5 b	1.01 a
Mountain Fresh nongrafted	5.3 a	1.10 a

Mean separation in columns based on least significant differences at $P \leq 0.05$.
Values followed by the same letter within a column are not significant.