2022 Vegetable Trial Report

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Department of Horticulture and Landscape Architecture
Division of Agricultural Sciences and Natural Resources
Oklahoma State University

The Department of Horticulture and Landscape Architecture, cooperating departments and experimental farms conducted a series of experiments on field vegetable production. Data were recorded on different aspects of each study, and can include crop culture, crop responses and yield data. This report presents those data, thus providing up-to-date information on field research completed in Oklahoma during 2022.

Small differences should not be overemphasized. Least significant differences (LSD) values are shown at the bottom of columns or are given as Duncan's letter groupings in most tables. Unless two values in a column differ by at least the LSD shown, or by the Duncan's grouping, little confidence can be placed in the superiority of one treatment over another.

When trade names are used, no endorsement of that product or criticism of similar products not named is intended.

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Seed and Plant Sources	
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Crop Culture

Spring Broccoli Variety Trial, Perkins, OK

Jessica Richmond, Niels Maness, & Lynn Brandenberger

Broccoli is a cool season crop that prefers temperatures between 60 and 68° Fahrenheit. This commodity came to the United States around 1925 and has risen in popularity to the sixth most consumed vegetable in the US. The majority of US broccoli is grown in California, but broccoli is produced in virtually every state in the US. On average broccoli takes 65 to 90 days to mature and is traditionally grown as a fall crop in OK. We are assessing alternative production seasons for broccoli, and this variety trial is the result of a spring planting.

Objectives: Objectives for this trial were to evaluate nine varieties for yield, earliness, and overall quality.

Materials and Methods: This study was conducted at the Cimarron Valley Research Station in Perkins, OK. Seeds were sown in the greenhouse into 1206 cell trays on January 20th and seedlings were transplanted into raised beds using 10 plants per plot with 1.5 feet in-row spacing on March 2nd. Plots were pre-plant fertilized with 19.62 lbs. of nitrogen and 50.14 lbs. of P_20_5. Varieties were replicated four times in a randomized block design. Weed control included the use of Prowl H_2O and hand hoeing. Insect control included the application of Asana XL on April 7th for cabbage loopers and cutworms. Plots received nitrogen twice per week for five weeks with urea to supply a total of 162 lbs./acre of nitrogen. Main heads from three plants from each plot were harvested upon maturity between May 6th and June 9th, and the initial side shoots after main head harvest were obtained approximately 7-12 days after main head harvest. Data recorded included days to first harvest, yield for main heads and initial side shoots, head and side shoot diameter and stalk diameter. A random sample of 10 beads per head were measured for bead size.

Results and Summary: There were three early season maturing cultivars including 'Castle Dome', 'Packman', and 'Lieutenant' in the trial. There were also three mid-season maturing cultivars including 'Monty', 'Green Magic', and 'Emerald Crown'. Late season maturing cultivars included 'Imperial', 'Millennium', and 'Marathon'. Days to first harvest per cultivar ranged from 65-88 days. On average, our earlier maturing cultivars produced smaller heads than the later maturing cultivars. We also observed a trend that none of our late season maturity cultivars were able to produce offshoots before the end of season.

Results for broccoli days to harvest, head weight, head diameter, stalk diameter and side shoot weight are shown in Table 1. The days to harvest for this planting date ranged from 65-88 days. This suggests that it might be beneficial for farmers to pair a 'Castle Dome' or 'Packman' (early season) with an 'Imperial' or 'Millennium' (late season) to take advantage of the full harvest season. For whole head weight, Imperial had higher head weight than all other cultivars. 'Millennium', 'Lieutenant', and 'Marathon' were the next highest in weight and were not different from each other. 'Lieutenant', 'Marathon', 'Monty' and 'Green Magic' were also not different in head weight from each other. For Average head diameter, the differences trended very similar to whole head weight with one single difference compared to weight in 'Castle Dome'. This Cultivar was statistically the same as 'Monty', 'Green Magic', and 'Emerald Crown' in terms of head diameter. In head diameter, 'Imperial' was larger than all other cultivars. In Stalk diameter the data indicates that 'Imperial' and 'Marathon' are not different from each other but are bigger in stalk diameter than all other cultivars. Stalk diameter for 'Millennium' was different from all other cultivars and was the median for stalk diameter sizes. 'Lieutenant', 'Monty', and 'Green Magic' showed no differences from each other. Side shoot data from this harvest indicates that

‘Green Magic’ side shoots were significantly smaller than ‘Castle Dome’ and ‘Packman’. Cultivars ‘Marathon’, ‘Imperial’, and ‘Millennium’ did not produce sideshoots. These cultivars, which are late maturing cultivars, may not be suitable for producing offshoots in the spring season.

Table 1. Broccoli Replicated Variety Trial- Perkins, OK 2022[x]

Cultivar	Seed Source	Days to first harvest	Weight[y] (ctns./Acre)	Average Head diameter (in.)	Stalk Diameter (in.)	Average Wt. per side shoot (g)[w]
Imperial	Rupp Seeds Inc.	88	619 a[z]	10.29a	2.38 a	-
Millennium	Seedway	88	490 b	8.98 b	1.98 b	-
Lieutenant	Seedway	65	400bc	8.77bc	1.73 c	73.14 ab
Marathon	Harris Seeds	85	401bc	8.75bc	2.90 a	-
Monty	Johnny's Selected	70	348cd	7.75cd	1.60 cd	60.8 ab
Green Magic	Rupp Seeds Inc.	75	340cd	7.79cd	1.67 cd	34.36 b
Emerald Crown	Rupp Seeds Inc.	70	248de	7.21de	1.60 cd	61.4 ab
Castle Dome	Park Seeds	65	201 e	6.44de	1.51 cd	102.16 a
Packman	Jung Seed	65	144 e	6.85e	1.44 d	101.92 a

[w] Side shoot data left blank did not grow enough offshoot for harvest or analysis
[x] Plot size 6 x 15 ft. 10 total plants per plot.
[y] One Carton (ctn.)= 22 lbs.
[z]Numbers in a column followed by the same letter exhibited no significant differences based on Duncan’s Multiple Range Test where P=0.05

Acknowledgements: We thank Jimmy Carroll, Preslee Pugh, Izzy Gonzales, Bryce Waugh, and Taylor Frentz for assistance with field plot maintenance.

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Spring Snap Bean Variety Trial, Perkins, OK

Jessica Richmond, Niels Maness, & Lynn Brandenberger

Originating in southern Mexico, Honduras and Costa Rica, snap beans are now grown throughout the United States. Wisconsin, New York, Oregon, Florida, and Michigan were leaders in snap bean production according to the 2019 USDA Vegetable summary. The optimal growing temperature for snap beans is between 65 and 85 degrees Fahrenheit and most varieties mature within 50 to 60 days after planting. Snap beans are a beneficial addition to our diet due to their high Vitamin C, Vitamin A, Fiber, Folate and Calcium content. The two main types of snap beans are pole beans and bush beans and pod colors include green, yellow, and purple. We limited evaluations to bush beans, for selected green and yellow podded varieties.

Objectives: The objective of this trial was to evaluate yield and pod characteristics during three successive hand picks for seven green- and two yellow-podded varieties of bush snap beans.

Materials and Methods: This study was conducted at the Cimarron Valley Research Station in Perkins, OK. Plots were preplant fertilized with 15.7 lbs. of nitrogen and 40 lbs. of P205 per acre. They were then direct seeded in double rows 10 feet long with 3 feet between rows on April 13th at a rate of ≈ 12 seeds/ft. Immediately after planting Prowl H_20 (2.5 pt/acre) and Dual Magnum (1.67 pt/acre) were applied as herbicides. Cultivars were replicated 4 times in a randomized block design. Thinning to 6 plants per foot was completed and plants were top-dressed with Urea to supply 62 lbs. N/acre on May 11th. Mature pods for five-foot sections of each double row plot were harvested by hand in three successive harvests on June 7th, 13th and 21st. Beans from each plot were weighed and representative samples of 10 beans per plot were used to evaluate pod length and sieve size.

Results and Summary: Results are shown for all three sequential harvests separately and as a total yield across harvests. Statistical significance was run through SAS with a Duncan's range test on the overall harvest for this planting date. 'BA-099' stood out as an early yielder during the first two harvests but declined by the last harvest. 'Carson' exhibited highest yield during the middle harvest with noticeably lower yield at the first and last harvest. All other varieties increased yield with each sequential harvest.

In terms of total yield, 'BA-099' was highest, followed by 'Contender' and the remainder of the varieties. In looking at the total of all three harvest for this spring planting date, 'Contender', 'BA099', and 'Sybaris' were not statistically different from each other in terms of yield (table 1). All cultivars except 'BA099' did not differ in terms of yield. Most bean pods were longest from the middle harvest, except for 'Momentum' which was longest at the first harvest. From harvest 1 to harvest 3, some cultivars will have higher yields each week and peak during the final harvest week and other cultivars will peak in yield during week two and begin their decline into the final week of harvest. Considering that some cultivars are going to have peak yields earlier and later in the harvest season than others, careful consideration can be made to plant certain cultivars together to help extend a farmer's harvest window of bush beans. For example, pairing production of 'BA099' with 'Contender' or another late yielding green snap bean variety could even out seasonal green snap bean harvests. Likewise, pairing 'SV1003GF' with 'Carson' could even out seasonal yellow wax bean harvests.

Table 1. Spring Snap Bean Replicated Variety Trial- Perkins, OK 2022[a]					
Harvest #	**Cultivar**	**Seed Source**	**Yield [e] (Bu/Acre)**	**Pod length (mm.)**	**Average Sieve Size[g]**
Harvest #1[b]	Bronco	Rupp Seeds	41.0	106.4	2.5
	Contender	Seedway	51.3	116.8	3.75
	Momentum	Rupp Seeds	36.6	143.3	2.75
	SV1003GF[f]	Rupp Seeds	20.1	112.6	3
	BA099	Rupp Seeds	119.8	102.3	3.25
	Strike	Rupp Seeds	17.8	108.8	3
	Sybaris	Rupp Seeds	5.5	102.0	2
	Valentino	Rupp Seeds	25.5	104.4	3
	Carson[f]	Seedway	41.1	109.0	3.5
Harvest #2[c]	Bronco	Rupp Seeds	83.5	123.0	3.75
	Contender	Seedway	94.8	133.7	3.5
	Momentum	Rupp Seeds	95.7	124.1	3.25
	SV1003GF[f]	Rupp Seeds	67.9	114.9	3.5
	BA099	Rupp Seeds	145.7	118.4	3.75
	Strike	Rupp Seeds	89.3	120.9	2.75
	Sybaris	Rupp Seeds	86.3	118.7	2.75
	Valentino	Rupp Seeds	76.1	121.0	2.75
	Carson[f]	Seedway	134.3	121.0	3.5
Harvest #3[d]	Bronco	Rupp Seeds	105.7	110.7	3.75
	Contender	Seedway	130.0	101.8	4
	Momentum	Rupp Seeds	87.2	107.4	3.5
	SV1003GF[f]	Rupp Seeds	122.3	110.6	3.75
	BA099	Rupp Seeds	74.9	96.4	4.25
	Strike	Rupp Seeds	123.5	104.4	3.75
	Sybaris	Rupp Seeds	135.5	101.6	3.75
	Valentino	Rupp Seeds	138.8	106.6	3.5
	Carson[f]	Seedway	68.2	91.7	4
Total over all 3 harvests	Bronco	Rupp Seeds	230.3 b[h]	113.4ab	3.33 ab
	Contender	Seedway	276.2 ab	117.4a	3.75 a
	Momentum	Rupp Seeds	219.7 b	124.9a	3.17 b
	SV1003GF[f]	Rupp Seeds	210.4 b	112.7abc	3.42 ab
	BA099	Rupp Seeds	340.5 a	105.7c	3.75 a
	Strike	Rupp Seeds	230.6 b	111.4abc	3.17 b
	Sybaris	Rupp Seeds	227.5 ab	108.5bc	3.00 b
	Valentino	Rupp Seeds	240.5 b	110.6abc	3.08 b
	Carson[f]	Seedway	243.6 b	107.2c	3.67 a

[a]Seeded-on April 13th. Plot Size: 6' X 10' double rows (4 Replications.)
[b]Harvested June 7th, [c] Harvested June 13th, [d] Harvested June 21st, [e]One bushel = 30 pounds.
[f]Carson and SV1003GF are yellow podded (Wax) beans.
[g]Sieve size is on a scale of 1-5. (**Sieve 1**< 5.8mm, 5.8mm< **Sieve 2**< 7.5mm, 7.5mm< **Sieve 3**< 8.5mm, 8.5mm < **Sieve 4** < 9.7mm, 9.7mm < **Sieve 5** < 10.9mm). This data is averaged.
[h]Numbers in a column followed by the same letter exhibited no significant differences based on Duncan's Multiple Range Test where P=0.05

Acknowledgements: We thank Jimmy Carroll, Preslee Pugh, Izzy Gonzales, Bryce Waugh, and Taylor Frentz for assistance with field plot maintenance.

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Grafted Tomato & Watermelon Production, Piedmont, OK

Micah Anderson, Preslee Pugh, & Bizhen Hu

Introduction and Objectives:

Grafting is an old practice commonly used for fruit tree and nut production for thousands of years. It is an emerging practice applied to vegetable production. The most commonly grafted vegetables include tomato, watermelon, and pepper on a global scale. The potential benefits of using grafted vegetables include improved disease and nematode resistance, reduced chemical inputs, increased plant vigor, higher yield, and enhanced fruit quality. The performance of grafted vegetables varies for different production systems and conditions. The goal of this study was to evaluate the performance of grafted tomato and watermelon in open-field production under Oklahoma conditions on a farm in Piedmont, OK.

Materials and Methods:

This experiment was carried out at the farm off Arrowhead Rd. NE & Morgan Rd. NE in Piedmont, OK from spring to early fall 2022. Grafted plants on two rootstocks and the un-grafted scion control were planted. Grafted plants were donated from Tri-Hishtil (Mills River, NC). The un-grafted scion control was propagated in the research greenhouse at Oklahoma State University.

Table 1. Scion and rootstock varieties included in the study.

Vegetable	Scion	Rootstocks
Tomato	Red Mountain	Rst-04-106-T; Maxifort
*Watermelon	Delta; Tri x 313	RS-841; Cobalt RZ F1

*Tri x 313 is a seedless variety (triploid), which needs a seeded variety, Delta (diploid), as the pollen source.

For tomato production, plots were laid out in a randomized complete block design with three replications. Two rows of free-standing raised beds with white-on-black plastic mulch and buried drip tape were installed. One row was 130 feet long and 26 inches wide, containing 6 plots. The other row was 70 feet long and 26 inches wide, containing 3 plots. Beds were spaced 8 feet on center. Dry granular diammonium phosphate fertilizer (18-46-0) was added during bed formation to supply all the needed phosphorus for the growing season and roughly half the nitrogen requirements. The remaining nitrogen required was added at a rate of 6 lb. N per week in the water-soluble form (20-20-20) through drip irrigation for 8 weeks. Plants were hand transplanted to the field on May 18th, 2022*.* Eight plants per plot were planted with 2.5 feet in-row spacing. Plants were supported using the stake and weave method. No pesticides were used.

For watermelon production, plots were laid out in a completely randomized design with three replications. Three rows of free-standing raised beds with black plastic mulch and buried drip tape were installed. Row 1 was 116 feet long, row 2 was 104 feet long and lastly, row 3 was 138 feet long. All rows were 30 inches wide. Beds were spaced 8 feet on center. Dry granular diammonium phosphate fertilizer (18-46-0) was added during bed formation to supply all the needed phosphorus for the growing season and roughly half the nitrogen requirements. The remaining nitrogen required was added at a rate of 8 lb. N per week in the water-soluble form (20-20-20) through drip irrigation for 8 weeks. Plants were hand transplanted to the field on May 18th, 2022*.* Five plants per plot were planted with 3 feet in-row spacing. No pesticides were used. Tomatoes were harvested on 7/27, 8/1, 8/4, 8/8, 8/9, 8/12, 8/16, 8/19, 8/23, 9/1, 9/7, and 10/4. Marketable tomato fruit was weighed. Watermelons were harvested on 7/27, 8/1, 8/4, 8/9, 8/16, and 8/19. Each harvested watermelon was weighed.

Results:

Table 2. Total yield of grafted and un-grafted tomatoes.

Treatment	Marketable fruit weight (lb./plot)
Grafted Red Mountain on Rst-04-106-T	44.0 a
Grafted Red Mountain on Maxifort	26.4 a
Un-grafted Red Mountain	30.7 a

[z] Means in the same column followed by the same letter represent no differences using Tukey's HSD at alpha = 0.05.

Table 3. Total yield of grafted and un-grafted watermelons.

Treatment	Fruit number/15 plants	Average fruit weight (lb.)
Grafted Tri X 313 on RS-841	18	12.4
Grafted Tri X 313 on Cobalt	13	11.2
Un-grafted Tri X 313	19	11.2
Grafted Delta on RS-841	21	15.3
Grafted Delta on Cobalt	18	16.2
Un-grafted Delta	19	15.8

<table>
<tr><td></td><td></td></tr>
<tr><td>Newly transplanted tomatoes</td><td>Tomatoes growing</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Newly transplanted watermelons</td><td>Watermelons growing</td></tr>
</table>

Acknowledgements:
We thank Tri-Hishtil for donating the grafted tomato and watermelon transplants and the Anderson family farm for their cooperation.

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Grafted Tomato and Watermelon Production, Coyle, OK

Bizhen Hu, Bryce Waugh, Izzy Gonzales, & Preslee Pugh

Introduction:
Vegetable grafting is regarded as an emerging and must-test technology for the U.S. vegetable industry. The usage of grafted vegetables in Oklahoma is at its earliest stages due to the lack of research-extension-teaching programs on vegetable grafting. Grafting has the potential to benefit Oklahoma vegetable growers by better managing biotic and abiotic stresses, enhancing crop vigor, lengthening harvest window, increasing total seasonal yield, improving heirloom variety performance, and creating a potential source of income by preparing and supplying grafted plants. This study investigated the performance of grafted tomato and watermelon, which globally are the most grafted vegetable crops. Two grafting rootstock-scion combinations representing the locally preferred fruiting variety and production challenges were included for each crop as well as the non-grafted control.

Materials and Methods:
This experiment was carried out on a farm in Coyle, Oklahoma from spring to late summer 2022. Grafted plants on two rootstocks and the un-grafted scion control were planted. Grafted plants were donated from Tri-Hishtil (Mills River, NC). The un-grafted scion control was propagated in the research greenhouse at Oklahoma State University.

Table 1. Scion and rootstock varieties included in the study.

Vegetable	Scion	Rootstock
Tomato	Red Mountain	Rst-04-106-T, Maxifort
Watermelon	Tri X 313	RS-841, Cobalt RZ F1

For tomato production, plots were free-standing raised beds with black plastic mulch and buried drip tape. Potash and urea were applied based on soil test results to meet the crop nutrient requirements. Fungicides including Kocide and Bravo were applied as needed, the insecticide Asana was applied as needed, and insecticides Abba and Fan Fare were applied once during production. Tomato plants were hand transplanted to the field on April 26, 2022. Six plants per plot were planted. Each grafted combination included four replications with the un-grafted control next to each grafted plot. Plants were supported using the stake and weave method.

For watermelon production, plots were free-standing raised beds with black plastic mulch and buried drip tape. Watermelon plants were hand transplanted to the field on May 31, 2022. Four plants per plot were planted. Each grafted combination included seven replications with the un-grafted control next to each grafted plot.

Tomatoes were harvested on June 28, July 1, 7, 11, 14, and 18. Fruit was determined to be marketable or non-marketable, each was weighed and counted. Watermelons were harvested on August 5 and 26. Each watermelon fruit was weighed.

Results:

Table 2. Total yield of grafted and un-grafted tomatoes.

Treatment	Marketable fruit weight (lb/plant)	Marketable fruit number/plant	Non-marketable fruit weight (lb/plant)	Non-marketable fruit number/plant	Marketable + non-marketable fruit weight (lb/plant)	Marketable + non-marketable fruit number/plant
Grafted Red Mountain on Rst-04-106-T	3.6 a^{z}	12 b	1.5 b	7 a	5.1 b	19 a
Grafted Red Mountain on Maxifort	4.4 a	14 ab	2.0 a	8 a	6.5 a	22 a
Un-grafted Red Mountain	4.4 a	16 a	0.6 c	4 b	5.0 b	20 a

^{z} Means in the same column followed by the same letter represent no differences using Tukey's HSD at alpha = 0.05.

Table 3. Total yield of grafted and un-grafted watermelons.

Treatment	Fruit number/plot	Average fruit weight (lb)
Grafted Tri X 313 on RS-841	7.3 a^{z}	14.9 a
Grafted Tri X 313 on Cobalt	6.5 a	17.0 a
Un-grafted Tri X 313	6.5 a	16.8 a

^{z} Means in the same column followed by the same letter represent no differences using Tukey's HSD at alpha = 0.05.

Acknowledgements:
We thank Tri-Hishtil (Mills River, NC) for donating grafted tomato and watermelon transplants and Whitmore Farms for their cooperation.

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Grafted Pepper Field Production, Mulhall, OK

Bryce Waugh, Preslee Pugh, Izzy Gonzales, & Bizhen Hu

Introduction and Objectives:

Grafting is an old practice that has commonly been used for fruit tree and nut production for thousands of years. Vegetable grafting for commercial use is a relatively recent innovation. On the global scale tomato, watermelon, and pepper are the most grafted vegetables. The potential benefits of using grafted vegetables includes improved disease and nematode resistance, reduced chemical inputs, improved environmental stress tolerance, increased plant vigor, higher yield, drought tolerance, and enhanced fruit quality. The performance of grafted vegetables varies depending on the production systems and conditions. Vegetables in Oklahoma endure drought, flooding, extreme heat, and high wind conditions. The objective of this study was to evaluate the performance of grafted pepper in open-field production under Oklahoma conditions.

Materials and Methods:

This experiment was carried out at the Redeemed Soil Farms in Mulhall, Oklahoma from spring to early fall 2022. Grafted ‘King Arthur’ on two rootstocks ‘Dorado’ and ‘Bedrock’ and the un-grafted scion ‘King Arthur’ control were planted. Grafted plants were donated from Tri-Hishtil (Mills River, NC). The un-grafted scion control was propagated in the research greenhouse at Oklahoma State University.

Plots were laid out in a randomized complete block design with three replications. Three rows of hay bales were placed over topsoil, with drip tape laid over the mulch. The rows were 12 feet long and 6 inches wide. Plants were hand transplanted to the field on 6/3/2022*.* Six plants per plot were planted with one foot between row spacing. There are three plots per block, and three blocks in total. There were six replacement plants of each treatment planted on 6/17/2022. For block one, King Author/Dorado was replaced, for block 2 King Author/Bedrock was replaced, and for the final block, the un-grafted treatment was replaced. We replaced the original plants because they were affected by Pythium/Rhizoctonia root rot. While not all six plants of each treatment were tested, all of them shared traits (dwarfed and shriveled) of the tested plants. The replacement transplants were the same size as the original transplants. The peppers were watered for 45 minutes a day every day. No fertilizer was added to the plants.

Crops were harvested on August 12, 19, 26, September 2, 9, 16, 30, October 7, 11, and 14. Fruit was determined to be marketable or non-marketable, each was weighed and counted. Non-marketable fruit were determined by multiple factors not limited to Blossom End Rot, pest damage, or rot damage.

Results:

Table 1. Total yield of grafted and un-grafted peppers.

Treatment	Marketable fruit weight (lb/plant)	Marketable fruit number/plant	Non-marketable fruit weight (lb/plant)	Non-marketable fruit number/plant	Marketable + non-marketable fruit weight (lb/plant)	Marketable + non-marketable fruit number/plant
Grafted King Arthur on Bedrock	0.5 a[z]	3 a	0.3 a	4 a	0.8 a	8 a
Grafted King Arthur on Dorado	0.9 a	6 a	0.4 a	6 a	1.3 a	12 a
Un-grafted King Arthur	0.6 a	4 a	0.6 a	5 a	1.1 a	10 a

[z] Means in the same column followed by the same letter represent no differences using Tukey's HSD at alpha = 0.05.

Acknowledgements: We want to thank Tri-Hishtil for donating the grafted pepper transplants and Redeemed Soil Farms for their support of the trial.

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Grafted Heirloom Tomato in Aquaponics & Hydroponics

Che Deer, Bizhen Hu, Bruce Dunn, & Carla Goad

Introduction: Vegetable grafting and soilless systems are unique solutions to solving some of the world's challenges of agricultural food production. Sustainability is a component that many experts face when addressing the need for food; hence soilless systems and grafting are introduced as separate solutions. However, the literature discusses little regarding the combination of the two techniques. Research into grafted vegetables grown in aquaponics is limited, especially within Oklahoma's climate. This study has the potential to illuminate whether benefits from aquaponics can be implemented in a southcentral greenhouse location to cultivate grafted tomatoes.

The tomato heirloom variety 'Cherokee purple' is highly sought-after due to its preferred flavor. However, the plant lacks resistance to soil-borne pathogens and lacks vigor, which often leads to lower yields. Production practices such as grafting and soilless systems can potentially improve the crop performance of 'Cherokee Purple' in a sustainable manner. The objective of this study aims to assess how grafted tomato 'Cherokee Purple' performs in soilless systems, including hydroponics and aquaponics. Results from this study can provide information on the combination of vegetable grafting and soilless systems to improve sustainability as it pertains to agriculture.

Materials and Methods: The research occurred at Oklahoma State University Research Greenhouses in Stillwater, OK (Latitude: 36.1260 Longitude: -97.0752). The greenhouse's average relative humidity (RH) during the study period was 67%. The average solar radiation for the seedling growth period (March-May) was 17 mJ/m^2, and the production period (May-November) was 19 mJ/m^2. Daily light integral (DLI) monitored by a Lightscout DLI meter (DLI 100; Spectrum Technologies INC., Thayer Court, Aurora, IL) was 10-14 Mols during the seedling growth period (March-May) and 20-24 Mols for the production period (May-November). Temperatures during the seedling growth period ranged from 21.1 to 26.6℃ in the daytime and 5 to 21℃ at night. During the production period, temperatures in the daytime ranged from 26.7 to 32.2℃, and nighttime temperatures ranged from 15.5 to 21.1℃.

Construction of hydroponics and aquaponics systems: Three hydroponics and three aquaponics systems were used. The hydroponics systems were constructed with 1.85 m^2 media grow beds (Symbiotic Aquaponics, Talihina, OK) filled with expanded shale (Symbiotic Aquaponics, Talihina, OK). The hydroponic grow beds were placed on two non-treated wooden pallets to a height of 1.37 m through the support of concrete cinder blocks. Three 378.54 L stock tanks (Rubbermaid Commercial Products, Atlanta, GA) were used for nutrient reservoirs. These reservoirs were covered, painted black and placed underneath the grow beds to prevent algal growth.

Furthermore, a 30.48 cm tall bell siphon (Smokey Mountain Aquaponics, Shady Valley, TN) was placed at the center of the hydroponic grow beds with a 10.16 cm diameter polyvinyl chloride (PVC) media guard. Foam boards were utilized to separate the grafting treatments in each grow bed and to help with root biomass collection. A 2700 gallons per hour (GPH) underwater pump (Vivosun, Ontario, CA) with 100.58 cm of aquaculture pump tubing made from plastic delivered the nutrient solution from the reservoir to the grow bed. The waterspout was constructed from 76.2 cm of 6.35 cm diameter PVC with two 5.0 cm American ball valves to adjust flow rates.

Three aquaponics systems with 1.85 m^2 media grow beds (Symbiotic Aquaponics, Talihina, OK) were used in the study. The fish tank, filtration components, and grow beds combined held

575.38 L of water. The fish tank was composed of food-grade molded plastic, with dimensions of 1.52 m x 1.22 m x 33.02 cm and was placed directly underneath the grow beds. The grow beds were placed onto a durable steel rack to support the total weight of the media and water. The aquaponics systems utilized the same expanded shale media in the grow beds as the hydroponic systems. A 30.48 cm tall snorkel bell siphon was placed in the center of aquaponic grow beds with a 20.32 cm diameter PVC as an added media guard. Each system utilized a mechanical bead filtration unit (AquaDyne, Ocala, FL) complete with filtration media (AquaDyne, Ocala, FL) to filter water and solid fish waste while allowing for biofilter establishment. The systems pump was a 3200 GPH pool pump attached to a mechanical filter on the pipe portion of the system. The filter screen and mechanical filter helped to prevent excess solids from clogging the pump or accumulating in the filtration unit. Aquaponics systems were highly dependent on optimal water levels, so when water levels were too low, systems could not fill and drain properly.

Nutrient management for aquaponics: Nutrient cycling in aquaponics systems began with adding 575 L of untreated greenhouse tap water with an initial pH of 7.4 to each system on 8 April 2021. De-chlorination took approximately 4 days after adding water to each system with constant air pump aeration at 6-7 ppm dissolved oxygen. Nitrifying bacterial inoculation of each grow bed took place on 12 April 2021 by adding one cup of media from a pre-established aquaponics system. The media was spread out to span multiple points in the grow beds to ensure even colonization. Following the inoculation, each aquaponics system was fed 3 g of fish feed (Optimal Fish Feed, Omaha, NE) twice daily for 24 days.

Water quality was monitored daily with measured parameters ammonia (NH_3), nitrite (NO_2^-), DO, pH, water temperature, EC, and nitrate (NO_3^-). The NH_3 and NO_2^- levels were never allowed to reach over 4 ppm as this could potentially cause widespread mortality of the bacterial colonies. The amount of feed added to each system and frequent water quality tests aided this procedure. Dissolved oxygen was maintained at 6-7 ppm using air stones and two 227.12 L aeration pumps, allowing optimal cycling. The pH was maintained from 7.9-8.4 to allow for bacterial population establishment (Antoniou et al., 1990). Cycling in the aquaponics systems occurred with the first presence of NO_3^- in the system; this happened 10 days after inoculation. Next, the pH gradually dropped to 6.8-7.0 using reverse osmosis water over the next 20 days. The water temperature ranged from 24-29℃ in the daytime and 18-21℃ at night. The EC was measured to provide a total soluble salt range, ranging from 0.77-0.83 mS/cm after the systems were supplemented with fish feed. Finally, NO_3^- in each system was allowed to reach 40-50 ppm to provide adequate nutrition for tomato crop production. Backwashing was not necessary for the establishment phase of each system as there were little to no solids to purge from each system. Solid waste is needed to accumulate for the systems to establish the biofilter further. However, backwashing was necessary 2-3 times every week during production.

After the initial establishment phase of the biofilter and nutrient cycling, nutrient management was the next task concerning maintenance. Fish were fed twice daily at 10:30 am and 5:30 pm. Fish were fed 'ad libitum' (i.e., apparent satiation) with a mix of 2 mm floating pellet and 1.5 mm fingerling feed (Optimal fish feed, Omaha, NE). Feed was increased depending on the NO_3^- level accumulation; each system was allowed to reach 40-50 ppm as a baseline reading. The pH management was done using a homogenized buffer blend of calcium carbonate ($CaCO_3$) and magnesium carbonate ($MgCO_3$). Potassium carbonate (K_2CO_3) (Symbiotic Aquaponics, Talihina, OK) was added at a rate of 2.4 – 2.6 g 2-3 times every 2 days, and these chemicals were added to raise the pH, with the added benefit of these nutrients being uptaken by the plants once in aqueous form. Additionally, 11% DTPA chelated iron (Symbiotic Aquaponics, Talihina, OK) was added to the systems to address nitrogen deficiencies bi-weekly at a rate of 1.5-2.0 g per application per system. Each chemical means of supplementation was directly mixed with 18.93

L of system water and added directly to the grow beds of each system in between backwash events. The average water temperature was 26.9℃ through production.

Nutrient management for hydroponics: The nutrient management procedure for hydroponics started with filling each 100-gallon reservoir with 378.54 L of tap water on 24 May 2021. Nutrients used in the starting nutrient solution were 0.63 g of 4–18–38 water-soluble fertilizer (Masterblend Tomato Formula, Morris, IL) per liter of water. Additionally, 0.63 g of calcium nitrate (15.5-0-0 PowerGrow, Vineyard, UT) and 0.32 g of magnesium sulfate (PowerGrow, Vineyard, UT) were supplemented per liter of water. The nutrient levels were maintained at an EC level of 0.8 mS/cm for the seedling stage, 1.0-1.5 mS/cm for early vegetative stages, and 2.0-2.3 mS/cm for later production. The target pH was 6.3 and adjusted with pH Up (potassium hydroxide) and pH Down (phosphoric acid) (General Hydroponics, Santa Rosa, CA), which were monitored daily and recorded weekly. Water temperature, pH, and EC were monitored daily with a HANNA meter (HANNA Instruments, Smithfield, RI). The average water temperature throughout the production was 27.3℃. Two 227.12 L aeration pumps were used to maintain DO levels at 6-7 ppm. Top-off rates were monitored to prevent micro-nutrient toxicities through nutrient solution exchange, followed by added tri-weekly top-off at 19-38 L of water to each hydroponic unit. Once the amount of water added totaled half the reservoir volume, the entire nutrient solution was replenished. However, from 13 August 2021 to 16 August 2021, the fish feed was mistakenly added to the hydroponics systems, resulting in a pH spike and severe wilting of multiple plants. The hydroponics nutrient solution was replaced entirely utilizing 240 g of Jack's 20-10-20 water-soluble fertilizer (JR Peters INC., Allentown, PA) per 378.54 L of water and maintained at a pH of 7.0 and EC of 2.3 mS/cm. This practice was selected as a quick solution due to the lack of the 4-18-38 fertilizer (Masterblend Tomato Formula, Morris, IL) at the time. The addition of 4-18-38 water-soluble fertilizer (Masterblend Tomato Formula, Morris, IL) was added back to the original rate after the plants recovered from the incident.

Plant materials: Nongrafted ‘Cherokee Purple’ tomato plants were seeded on 22 March 2021. The tomato seedlings were sown in a soilless horticulture media (SunGro, Agawam, MA) in plastic inserts (1206; Landmark Plastic, Akron, OH) under a controlled greenhouse environment. Seedling fertilization occurred with 3 g of 20-10-20 Jack's (JR Peters INC., Allentown, PA) water-soluble fertilizer for every 5 L of water at an EC rate of 0.80 mS/cm and a pH of 7.1 during the early seedling stage. The rate for the later vegetative stage was 4.5 g fertilizer for every 5 L of water achieving a 1.00 mS/cm EC. The grafted 'Cherokee purple' on the rootstalk 'Maxifort' was provided by Tri-Hishtil (Tri-Hishtil Seed Company, Mills River, NC) and delivered on 28 April 2021. These plants were fed the same fertilizer at a 1.00 mS/cm EC and 7.1 pH before transplanting. The tomatoes were transplanted to each soilless system on 24 May 2021 in the late evening to reduce the stress from transplant shock. Trellising tomatoes occurred monthly, followed by weekly pruning of fruits and vegetative material. Tomatoes were double stemmed or grown with two heads to account for limited overhead space in the greenhouse environment while not compromising yield.

Moreover, the environment resulted in edema, which saw correction with increased airflow using commercial-grade fans. The disease *Alternaria solani* posed another problem for the harvest analysis of control plants. Plants in aquaponics systems were the only ones affected; however, the disease resolved itself within the system, likely due to its diverse micro-community. Interestingly, the grafted plants were unaffected by disease within the systems, as the literature reports disease resistance as a primary attribute of grafted plants. Additionally, occurrences of mold posed a problem, which resulted in quality issues for some fruits. The need for more airflow and pruning presents itself for future work.

Remediation of whitefly (*Trialeurodes vaporariorum*) presence and fall armyworm (*Spodoptera frugiperda*) larvae saw remediation with the beneficial insects. Parasitic wasps (*Encarsia formosa*) and green lacewing (*Chrysoperla rufilabris*) were applied every month for control, and armyworms were also hand removed. Greenhouse age might affect yield in this study. The greenhouse material used was fiberglass materials past the point of degradation, resulting in the yellowing of the material and reduced light penetration, which could reduce tomato yield.

Fish acquisition and acclimation: Coppernose bluegill were purchased from Dunn's Fish farm (Fitzhugh, OK). Then the total population of 120 fish were stocked into the aquaponic tanks (15 May 2021), 40 per tank (0.45 kg of fish harvest weight/30.28-37.85 L of water). Gradual acclimation of each fish was done to prevent stress among the fingerlings. The transport bags holding the fish were mixed with system water for 10-15 minutes until 9.46 L of system water filled the 18.93 L bag. The acclimation process took 30-45 minutes until the aquaponic system's water temperature and pH were similar to the transport bag, monitored with a pH/EC/temperature meter (HANNA Instruments, Smithfield, RI). Fish were then released into the tanks and monitored for the next 3 weeks. During the initial stocking phase, the systems accumulated a 9.6% mortality rate for the entire fish population. Expected mortality rates of 15% were standard when acclimating new fish to each system.

Experimental design: This study was conducted as a split-plot design. There were four treatments, the soilless systems as the main factor and grafting as the subfactor. Three aquaponics and three hydroponic systems were used for the three replications, with five grafted and five nongrafted plants in each system.

Harvest data collection: Harvest data collection included both marketable and unmarketable fruit numbers and weight and deformity occurrence from each plant. Fruits were harvested at the first occurrence of the light red to red maturity stage from 2 August 2021 to 21 November 2021, with 17 harvests totaled in 2021. The appearance of fruit defects such as catfacing, splitting, and blossom end rot was noted for each occurrence.

Statistical methods: The data for this experiment were obtained on each of the five plants in each replication of the system/graft combinations. All data were averaged for the five plants in the same replication. A linear mixed models analysis was performed for each response variable. Random effects were the replication or block effect at the whole plot level and the whole plot error (replication by system). Means comparisons of significant effects were made using unadjusted t-tests (Fisher). All tests were conducted at the nominal 0.05 level. The data analysis for this experiment was performed using SAS/STAT® software, Version 9.4 for Windows. Copyright © 2014 SAS Institute Inc. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute, Cary, NC, USA.

Results:

Table 1. Observed main effects of System[1] (S), Graft[2] (G) for the marketable, unmarketable, and total fruit weights and fruit numbers for 2021.

	Marketable		Unmarketable		Total	
Main effect	Weight (lbs)	Number	Weight (lbs)	Number	Weight (lbs)	Number
System						
Aquaponics	3.34^{a}	17^{a}	5.35^{b}	44^{a}	8.69^{a}	61^{a}
Hydroponics	4.19^{a}	19^{a}	8.15^{a}	27^{b}	12.34^{a}	46^{b}
Graft						
Grafted	4.34^{a}	19^{a}	7.55^{a}	37^{a}	11.89^{a}	56^{a}
Non-grafted	3.19^{a}	17^{a}	5.95^{a}	34^{a}	9.14^{b}	51^{a}

[1]System: aquaponics, hydroponics

[2]Graft: grafted, ungrafted

Means within a column followed by the same letters are not significantly different at P $\leq$ 0.05.

Tomatoes growing in hydroponics and aquaponics.

A grafted tomato.

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Survival of 3 Grafted Vegetable Species in Different Conditions

Che Deer, Bizhen Hu, Bruce Dunn, & Carla Goad

Introduction and Objectives: Vegetable grafting is a technique that can improve crop production. To propagate grafted vegetable transplants, careful management is required to ensure complete reunion of the scion and rootstock immediately after grafting. The healing process stems from environmental parameters, specifically relative humidity (RH), temperature, and light. Consequently, the mismanagement of these parameters results in severe wilting and, eventually, poor callous union establishment or graft failure. The requirements for healing are different for each plant species. Solanaceous crops such as pepper and tomato can have a 90% survival when RH is at a constant saturated range of 90-100% and total darkness during the first 3-4 days. Subsequently, RH should be decreased and not allowed to fall below 40-50% for more than an hour during the next 4-7 days. It takes approximately 7 days to heal tomatoes. Watermelon survival rates range from 51% to 80%. Moreover, watermelon grafting success rates are lower than tomato and pepper; this is due to the demand for cooler temperatures (21.1-22.7℃) compared to the higher temperature ranges (21.1-26.6℃) for tomato and pepper. Watermelon has a longer recovery interval of approximately 9 days. Shading can increase survivorship. For many vegetable grafters, black mulch cloth is a simpler alternative to shade cloth. Shade reduces the temperature and helps maintain RH by reducing light or heat energy. Therefore, a lack of shade promotes wilting, leading to higher transpiration rates and graft union failure.

This study aims to provide growers with data showing grafted tomato, watermelon, and pepper survivorship under different healing conditions. Ultimately, the study will focus on the propagation of grafted vegetables, hoping to provide information that commercial growers, small-scale home growers, and all growers alike can use to produce grafted vegetable plants in Oklahoma. Ideally, the research will lay the foundational knowledge to mitigate soil-borne disease pressure and other environmental stressors for vegetable production.

Materials and Methods:

Description of research site: Research in greenhouses took place at Oklahoma State University (OSU) research greenhouses in Stillwater, OK, latitude: 36.1260 longitude: -97.0752. The east side of the greenhouse was the location for the outdoor treatment. The headhouse was the residential treatment simulation. Each treatment was comprised of three chambers and occupied 2.16 m^2.

Experimental design: This experiment was designed as a factorial split-plot study. The main factor was the location of the healing chambers, including residential indoor, greenhouse, and outdoor. There were three healing chambers for each location for three replications. The subfactor was the three crops, tomato, watermelon, and pepper; each chamber held ten plants of each crop.

Scion and rootstalk cultivation: The scions used were 'King Arthur' (Tomato Growers Supply Company, Fort Myer, FL) for pepper, 'Cherokee Purple' (Seed Kingdom, Miami, FL) for tomato, and 'Delta' (Seedway Vegetable Company, Hall, NY) for watermelon. The rootstalks used were 'Dorado' (Tri-Hishtil Seed Company, Mills River, NC) for pepper, 'RST-04-106-T' (Dependable Proven Seeds, Yume, AZ) for tomato, and 'Cobalt' (Tri-Hishtil Seed Company, Mills River, NC) for watermelon. Scions and rootstalks were scatter-sowed on Monday, Wednesday, and Friday during each cultivar's sowing phase; sowing and grafting dates are shown in Table 1. Scatter sowing matched each scion and rootstalk's growth and stem diameter size. The growth media used was 'SunGro' horticultural soil mix (Southern Mill, Agawam, MA). Peppers and tomatoes were sowed in 1206 6-pack inserts, while watermelons and the respective rootstalk were sowed in 1204 4-pack inserts. Each plant received tap water at a pH of 7.1 during germination. After every plant had 2-3 true leaves, a fertigation schedule was established 1-2 times daily every 3 days, depending on nutrient needs. The 20-10-20 Jack's (JR Peters INC., Allentown, PA) water-soluble fertilizer was used and fed at a rate of 0.3 g per liter of water and a pH of 7.1. The EC was maintained at 0.80 mS/cm for young seedlings using a pH, EC, and temperature meter (HANNA Instruments, Smithfield, RI) to prevent nutrient damage while allowing for growth (Cuartero and Fernández-Muñoz, 1998). Seedlings were housed in the greenhouse until grafting. The daily light interval in the greenhouse was recorded by a Light scout 100-meter (Spectrum Technologies INC., Thayer Court, Aurora, IL) and ranged from 10-14 Mols during early spring and 20-24 Mols for mid and late summer, interceding into early fall. One day before each plant's grafting procedure, water was withheld to aid the grafted seedlings' healing process by reducing water at the fusion union.

Table 1. Seasonal sowing and grafting dates for tomato, watermelon, and pepper.

Season	Crop	Sowing Date	Grafting Date
Spring 2021	Tomato	17 March 2021	5 May 2021
Spring 2021	Pepper	15 March 2021	21 May 2021
Spring 2021	Watermelon	7 April 2021	12 May 2021
Fall 2021	Tomato	4 May 2021	7 July 2021
Fall 2021	Pepper	9 June 2021	15 July 2021
Fall 2021	Watermelon	3 July 2021	30 July 2021

Grafting procedure: Before grafting, all tools, including razors, clips, and grafting areas, underwent sanitization with a 10% bleach solution. Hand washing was mandatory after every ten plants to ensure that diseases were not transmitted. Razors were replaced after every ten plants. After grafting every five plants, they were immediately placed in the first chamber of every treatment, followed by the second and third chambers of each treatment. This procedure helps to prevent variation of survivorship from outside environmental exposure. The splice grafting procedure was implemented for the peppers and tomatoes. The tomato and pepper rootstalks were cut diagonally at a 45-degree angle below the cotyledons to prevent rootstalk regrowth and fitted with 2 mm silicone tube clips to affix to the scions for healing. The tomato and pepper scions were all cut diagonally at a 45-degree angle above the cotyledons. Watermelon 'Delta' scions underwent grafting using the single cotyledon procedure onto 'Cobalt' rootstalks. Scions were cut below the cotyledons, and the rootstalk was removed, leaving a single cotyledon shoot. The cut rootstock and scion were secured with spring-loaded clips.

Healing of grafted plants: The healing chamber design heavily influences grafted plants' success or failure and optimal environmental maintenance of RH and temperature. The volume inside each healing chamber totaled 0.38 m^3, and the treatment area was 1.86 m^2. Chambers were covered with 6-mm polyethylene film plastic (ULINE, Pleasant Prairie, WI), and chamber frames were constructed by a 1.91 cm diameter polyvinyl chloride (PVC) pipe. Inside each healing chamber resided a capillary mat (Phytotronics, INC, Earth City, MO) pre-soaked with clean tap water to fit the total size of the base.

Peppers stayed in the healing chambers for 15 days. During the first 7 days, the grafted peppers were left covered by four layers of black mulch cloth (Sta-Green, Rowlett, TX) to provide 80% shade and a maintained RH of 90%-100%. The mulch cloth was lifted only to rest on the top of each chamber on day 7. The chambers were opened for 30 minutes starting on day 5. The venting time increased by 30 minutes daily for the remaining 10 days. This practice gradually reduced RH to 50-60% RH. Tomato healing in the chambers occurred for 7 days; during the first 4 days, an RH of 90%-100% and shade at 80% were maintained using the same protocol as that for pepper. The mulch cloth was lifted only to rest on the top of each chamber on day 4. Tomatoes were vented for 30-minutes starting on day 5, 1 hour on day 6, and 3 hours on day 7 to gradually reduce RH to 50-60%. Grafted watermelons were kept in the chambers for 9 days. The RH was maintained at 90%-100% for the first 4 days while remaining 80% shade. On day 5, the plants were vented for 30 minutes to attain roughly 80-90% RH. Following this practice, gradual light acclimation occurred by lifting the mulch cloth to expose the sides of each chamber in correspondence to venting times. On day 6, watermelon venting happened for 1 hour to achieve 70-80% RH, 3 hours on day 7 with 60-70% RH, and 6 hours on day 8 with 50-60% RH.

Four 5.08 cm holes were cut on both ends of the healing chambers to reduce humidity to aid the venting process for each stage of the plants. Spray misting occurred for each chamber with a hand sprayer four times a day throughout the week before venting to achieve 90-100% RH. After the healing period in the chambers, grafted plants were moved to a bench in the greenhouse for 1 week to acclimate with a 0.8 mS/cm fertigation using Jack's 20-10-20 (JR Peters INC., Allentown, PA) at a rate of 0.3 g per liter of water.

Data collection: Survivorship data was taken on the same day when each crop was removed from the healing chambers. Graft survival was determined as plants having turgidity of both scion leaves and stem, with failure expressed as plants showing severe wilting on both the leaves and stems of the scion. However, wilting does not translate to crop death, as wilted grafted plants can recover through gradual acclimation to light and nutrients. Therefore, the second assessment of survivorship and physiological stress was recorded 1 week after being removed from chambers. The survival of the ten plants of every crop in each chamber was calculated as a percentage. Compactness measurements were collected as follows. The plant stem heights were measured with a ruler from the soil level to the apical tip of the plant. After measuring stem height, the grafted plants were cut at the soil line and dried in ovens at 53℃ for 7 days to attain the dry shoot weight. Compactness was calculated by dividing the dry shoot weight by the stem height (An et al., 2020).

Statistical methods: Compactness was analyzed using linear mixed model methods. The survival proportion was analyzed using a generalized linear model for a binomial proportion. All tests were performed at the nominal 0.05 level. Post-hoc comparisons were unadjusted (Fisher) t-tests. The data analysis for this experiment was performed using SAS/STAT® software, Version 9.4 for Windows. Copyright © 2014 SAS Institute Inc. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute, Cary, NC, USA.

Results:

Table 2. Observed means of main effects of Season[1] (S), treatment[2] (T) for the compactness of tomato, and watermelon for 2021.

Main effect	Tomato	Watermelon
Season (S)		
Spring	21.51b	64.49a
Fall	29.99a	53.73b
Treatment (T)		
Greenhouse	25.74ab	67.66a
Indoor	22.85b	46.92b
Outdoor	28.66a	62.74a

[1]Season: spring, fall
[2]Treatment: greenhouse, indoor, outdoor
Means within a column followed by the same letters are not significantly different at $P < 0.05$.

Table 3. Observed Season[1] and Treatment[2] (S x T) interaction for the compactness of pepper and survival of pepper, tomato, and watermelon for 2021.

	Compactness	Survival		
Source	Pepper	Pepper	Tomato	Watermelon
S x T				
Spring				
Greenhouse	21.15ab	100.0a	100.0a	100.0a
Indoor	21.62a	100.0a	96.6a	100.0a
Outdoor	15.76c	86.6a	100.0a	100.0a
Fall				
Greenhouse	17.74bc	100.0a	90.0a	90.0a
Indoor	16.93c	93.3a	80.0a	73.3a
Outdoor	20.12abc	100.0a	56.6b	90.0a

[1]Season: spring, fall
[2]Treatment: greenhouse, indoor, outdoor
Means within a column followed by the same letters are not significantly different at $P < 0.05$.

	
A grafted tomato.	A grafted pepper.
	
A grafted watermelon	The healing chamber.

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Heirloom Sweet Potato Trial, Perkins, OK

Lynn Brandenberger, Niels Maness, Jess Richmond, Micah Anderson
Lynda Carrier, & Mathew Beartrack

Introduction: Sweet potato (*Ipomoea batatas*) belongs to the morning glory family and although it is grown as an annual root crop, it is a perennial. This crop is thought to have originated in Central and South America and does well in hot climates. Sweet potato provides high levels of Beta carotene and vitamin C especially in orange cultivars and has lots of complex carbohydrates and fiber (Peirce, 1987). Performance of different cultivars varies by location, therefore the need for trialing cultivars for their adaptation to local and state conditions. Although we have completed sweet potato trials in the past, we have never trialed heirloom cultivars. The objectives of this trial were to determine the performance and quality of different heirloom sweet potato cultivars in the central Oklahoma region.

Methods: The trial was organized in a randomized block design with three replications. Plots were spaced on 8 feet row centers, were 10 feet long with slips (sweet potato plants) spaced one foot apart in the row. Plots were prepared by clean cultivating the area to be planted then each row was bedded (into a free-standing raised bed), installing drip irrigation in the process. Weed control included a pre-plant application of Valor (flumioxazin) at 1.8 oz. per acre over the top of the free-standing raised beds and hand hoeing and cultivation during the first six weeks following planting. The trial was established on 6/21/22 using commercially grown slips (George McLaughlin-source) transplanted with a tractor-drawn water-wheel transplanter.
Trial fertility was based upon pre-plant soil analysis fertility recommendations. Sixty pounds per acre of actual phosphorus (P_2O_5) was applied pre-plant using diammonium phosphate (18-46-0) as the source of phosphorus which also provided 23.5 lbs. of actual nitrogen per acre. Additional applications of nitrogen utilized urea (46-0-0) applied through the drip irrigation system in four applications on 6/29/22, 7/5/22, 7/20/22, and 8/3/22. Total actual nitrogen applied to the study pre-plant and during the growing season was approximately 70 lbs. per acre.
Plots were harvested and graded using standards for sweet potato grading on 10/20/22.

Variety Descriptions from George McLaughlin:

1. Red Wine Velvet - Red skin, deep orange flesh, heart shaped leaves, good yields, good keeper, very moist flesh. heirloom, running vines, mid-season.
2. Oklahoma Red - red skin, orange flesh, heart shaped leaves, mid-season, running vines, good yields, noted for producing well in clay soil. Oklahoma Red is a good all-around variety, deserves more attention than it gets.
3. Ginseng Orange - Early, orange skin and flesh, semi bush grow, ivy leaf, good yield, and flavor. Excellent keeper and produces slips very easily. Some of our customers consider this one to be nearly ideal. Fits with traditional American expectations of sweet potato color, texture, and flavor.
4. Grand Asia - Reddish skin, white flesh, large vines, heart shaped leaves. Can produce early/quickly. Very high production, often of very large roots. Roots cook up mealy, somewhat dry, and sweet, with a delicate sweetness which is hard to describe. Grand Asia is one of several similar varieties from the Pacific Rim area. Very unlike American store-bought varieties, yet quite good. Excellent keeper.
5. Japanese White - Dark purple/red skin, dense white flesh, relatively sweet and moist. Heavy production of generally blocky roots, all centered right under the plants' main stem.
6. Okinawa (limited amount) - Also known as Hawaiian Purple, white skin, light purple flesh which turns darker purple when cooked. Very sweet and moist, though generally

reported as a poor producer on mainland USA. I only obtained to slips in 2021 and they gave me 6 decent sized roots. Maybe our Oklahoma heat agrees with this one. Time will tell.

7. Brinkley White - Tan skin, white/light yellow flesh, heart shaped leaves, running vines, good yields, excellent sweet flavor, good keeper, mid-season.
8. Ozark County - Orange skin & flesh, mid-season, vining, heart shaped leaves, excellent keeper, maintained over 50 years by a couple in Missouri. Mid-season, heirloom. Fits in well with traditional American varieties.
9. Becca's Purple - light purple flesh and purplish skin. Heart shaped leaves and large vines. This one flowers quite a bit. Flavor is sweeter than Molokai, but still has that distinct “purple sweet potato flavor.”
10. Molokai - Dark purple skin and flesh, very high in antioxidants, rampant vines, heart shaped leaves. Originally from Hawaii. Roots can be used for natural purple dye. Excellent keeper. Huge production of long, crooked roots which look almost black. Flavor is “purple.” Dry flesh. Some adore these, some don’t like them.
11. Gunlock - Grown and esteemed for generations around Gunlock, KY. whitish tan skin and white flesh. Apparently, a good keeper. This one has been a champion for getting early slips.
12. Hopi - light tan skin, yellowish flesh, delicate sweet flavor. Excellent keeper. Fits the mold of a traditional American sweet potato.
13. Barberman - orange skin and flesh, vining growth, heart shaped leaf, good yields, early, concentrated root set for easier digging. Early. Excellent keeper. If you want a “normal,” traditional flavor and texture, this one’s a good one.
14. Covington- orange skin and flesh, developed by N.C. State, used as a comparison standard.

Results: ‘Red Wine Velvet’, ‘Oklahoma Red’, and ‘Ginseng Orange’ had higher yields of number 1’s than four other varieties and ranged in yield from a high of 2,240 to 1,697 pounds of 1’s per acre (Table 1). There were no differences observed for canner yield between varieties in the trial with canner yield ranging from 224 to 1,136 lbs. per acre. Yields of Jumbos ranged from zero for ‘Becca’s Purple’ to highs of 2,191 and 2,080 lbs. per acre for ‘Red Wine Velvet’ and ‘Japanese White’, respectively. Combined yields of 1’s, canners, and Jumbos varied significantly and ranged from a low of 229 lbs. per acre (‘Becca’s Purple’) to a high of 4,973 lbs. per acre for ‘Red Wine Velvet’. In general cull yields were highest for the higher yielding varieties ‘Red Wine Velvet’ and ‘Oklahoma Red’.

Based upon the data the authors would recommend on-farm trialing of ‘Red Wine Velvet’, ‘Oklahoma Red’, ‘Japanese White’, ‘Old Yellow’, and ‘Barberman’ for production of heirloom sweet potato varieties.

Acknowledgements: The authors wish to thank the student helpers that assisted in harvest operations and Mr. George McLaughlin for producing slips of each of the heirloom varieties included in the trial. We want to thank Mr. Micah Anderson for providing the ‘Covington’ slips for the trial.

Table 1. Summer 2022 Sweet Potato, Perkins, OK.

	Marketable Yield					
	Number 1's[z]	Canner's[y]	Jumbo's[x]	Total Mkt.[w]	Culls.[v]	Total Mkt. + culls
Cultivar	Pounds per Acre					
Red Wine Velvet	2,240 a	543 a	2,191 a	4,973 a	6,164 ab	11,137 a
Oklahoma Red	1,957 ab	1,136 a	532 c	3,625 abc	6,396 a	10,021 ab
Ginseng Orange	1,697 ab	744 a	363 c	2,804 abcd	2,519 c	5,323 bc
Grand Asia	1,133 abcd	367 a	468 c	1,967 bcd	2,882 bc	4,850 bc
Japanese White	1,387 abcd	200 a	2,080 ab	3,666 abc	2,472 c	6,138 abc
Old Yellow	1,365 abcd	975 a	962 c	3,302 abc	1,510 c	4,812 bc
Brinkley White	762 abcd	588 a	0 c	1,350 bcd	1,933 c	3,283 c
Ozark County	417 bcd	421 a	94 c	933 cd	1,993 c	2,926 c
Becca's Purple	0 d	229 a	0 c	229 d	232 c	461 c
Molokai	319 cd	432 a	182 c	933 cd	1,163 c	2,096 c
Gunlock	548 bcd	367 a	330 c	1,245 bcd	2,084 c	3,329 c
Hopi	911 abcd	780 a	1,016 c	2,708 abcd	2,922 bc	5,630 bc
Barberman	1,569 abcd	617 a	1,136 bc	3,321 abc	2,643 c	5,964 abc
Covington	1,517 abcd	1,260 a	1,027 bc	3,804 ab	1,514 c	5,318 bc

[z] **Number 1's:** 3-9" in length, 2 to 3 ½" in diameter few if any blemishes.
[y] **Canner's:** 2-7" in length, 1 to 2" in diameter.
[x] **Jumbo's:** >9" in length, >3.5" in diameter.
[w] **Total Mkt:** Total yield of number 1's, Canners, and Jumbos.
[v] **Culls** Roots must be 1 inch or larger in diameter and so misshapen or unattractive that they could not fit as marketable roots.
[u] **Numbers** in a column followed by the same letter exhibited no significant differences based on Duncan's Multiple Range Test where P=0.05.


2022 Heirloom Sweet Potato Trial on 8/16/22

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SI (METRIC) CONVERSION FACTORS

Symbol	When you know	Multiply by	To Find	Symbol	Symbol	When you know	Multiply by	To Find	Symbol
	Approximate Conversions to SI Units					*Approximate Conversions from SI Units*			
		LENGTH					**LENGTH**		
in	inches	25.40	millimeters	mm	mm	millimeters	0.0394	inches	in
ft	feet	0.3048	meters	m	m	meters	3.281	feet	ft
yd	yards	0.9144	meters	m	m	meters	1.094	yards	yds
mi	miles	1.609	kilometers	km	km	kilometers	0.6214	miles	mi
		AREA					**AREA**		
in^2	square inches	645.2	square millimeters	mm^2	mm^2	square millimeters	0.00155	square inches	in^2
ft^2	square feet	0.0929	square meters	m^2	m^2	square meters	10.764	square feet	ft^2
yd^2	square yards	0.8361	square meters	m^2	m^2	square meters	1.196	square yards	yd^2
ac	acres	0.4047	hectacres	ha	ha	hectacres	2.471	acres	ac
mi^2	square miles	2.590	square kilometers	km^2	km^2	square kilometers	0.3861	square miles	mi^2
		VOLUME					**VOLUME**		
fl oz	fluid ounces	29.57	milliliters	mL	mL	milliliters	0.0338	fluid ounces	fl oz
gal	gallon	3.785	liters	L	L	liters	0.2642	gallon	gal
ft^3	cubic feet	0.0283	cubic meters	m^3	m^3	cubic meters	35.315	cubic feet	ft^3
yd^3	cubic yards	0.7645	cubic meters	m^3	m^3	cubic meters	1.308	cubic yards	yd^3
		MASS					**MASS**		
oz	ounces	28.35	grams	g	g	grams	0.0353	ounces	oz
lb	pounds	0.4536	kilograms	kg	kg	kilograms	2.205	pounds	lb
T	short tons (2000 lb)	0.907	megagrams	Mg	Mg	megagrams	1.1023	short tons (2000 lb)	T
		TEMPERATURE (exact)					**TEMPERATURE (exact)**		
°F	degrees Fahrenheit	(°F-32) /1.8	degrees Celsius	°C	°C	degrees Fahrenheit	9/5(°C)+32	degrees Celsius	°F
		FORCE and PRESSURE or STRESS					**FORCE and PRESSURE or STRESS**		
lbf	poundforce	4.448	Newtons	N	N	Newtons	0.2248	poundforce	lbf
lbf/in^2	poundforce per square inch	6.895	kilopascals	kPa	kPa	kilopascals	0.1450	poundforce per square inch	lbf/in^2

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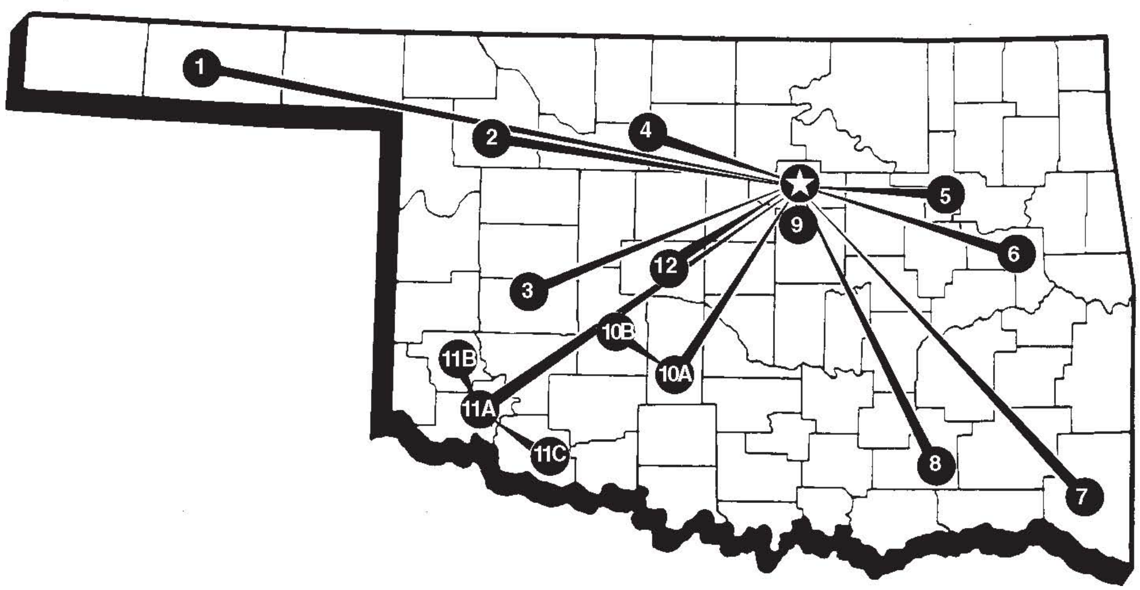
Location of Oklahoma Agricultural Experiment Stations

THE OKLAHOMA AGRICULTURAL EXPERIMENT STATION
SYSTEM COVERS THE STATE



✪ **MAIN STATION—*Stillwater and adjoining areas***

1. **Oklahoma Panhandle Research and Extension Center—*Goodwell***
2. **Southern Plains Range Research Station—*Woodward***
3. **Marvin Klemme Range Research Station—*Bessie***
4. **North Central Research Station—*Lahoma***
5. **Oklahoma Vegetable Research Station—*Bixby***
6. **Eastern Research Station—*Haskell***
7. **Kiamichi Forestry Research Station—*Idabel***
8. **Wes Watkins Agricultural Research and Extension Center—*Lane***
9. **Cimarron Valley Research Station—*Perkins***
10. **A. South Central Research Station—*Chickasha***
    B. Caddo Research Station—*Ft. Cobb*
11. **A. Southwest Research and Extension Center—*Altus***
    B. Sandyland Research Station—*Mangum*
    C. Southwest Agronomy Research Station—*Tipton*
12. **Grazingland Research Laboratory—*El Reno***

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