2021 Vegetable Trial Report

January 2022

MP-164

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 a majority of 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 2021.

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 Sources	
Dewitt Seeds P.O. Box 5556 Norman, OK 73070 www.dewittseed.com	Seedway/Bejo 99 Industrial Rd. Elizabethtown, PA 17022 www.seedway.com
Johnny's Selected Seeds 955 Benton Avenue https://www.johnnyseeds.com/	Syngenta Seeds, Inc. (Rogers) P.O. Box 4188 Boise, ID 83711-4188 www.syngenta.com
University of Florida Tomato breeding PO Box 110690 Gainesville, FL 32611 https://hos.ifas.ufl.edu/public/kleeweb/index.html	Territorial Seed Co. P.O. Box 158 Cottage Grove, OR 97424 www.territorialseed.com
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Rupp Seeds, Inc. 17919 County Road B Wauseon, OH 43567 800-700-1199 https://www.ruppseeds.com/vegetables/home	DeRuiter Seeds https://www.deruiterseeds.com/en-ca/tomato/beef.html

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Crop Culture

Bio-Intensive Cover Cropping for Soil Improvement
Cimarron Valley Research Station

Josh Massey[1], Lynn Brandenberger[1], Lynda Carrier[1], Hailin Zhang[1], João Antonangelo[1], and George Kuepper[2]

[1]Oklahoma State University, [2]Kerr Foundation/retired

Introduction and Objectives: Soil health is critical for sustainable soil productivity in the vegetable industry. One soil health parameter is the level of organic matter contained in field soils. In Oklahoma, soil organic matter is often well below 1% (generally at 0.5 to 0.7%). Organic matter in soils is critical because of its effects on nutrient stabilization, water availability, tilth, crop establishment, and soil physical structure in crop rooting and growth. Southern plains states have a longer warm season than in the northern plains, by several months. The longer growing season and warmer weather allows soil microbes to break down more organic matter than in the northern plains. In addition, clean-tillage systems used predominantly in vegetable production speed up microbial activity. This rapid microbial action and extended period in which it can occur adds to the reduction of soil organic matter. Organic matter can be added to soil a number of ways including compost, manure, organic fertilizers, etc. Some of the issues associated with these sources of organic matter include availability and cost, but also can include the potential for food-borne disease. As an alternative, cover crops can be seen as a “Grow in Place” source of organic matter with lower potential for contamination of fresh produce. Some added advantages of cover crops are the protection of the soil from erosion and reduction of weed pressure by shading out weed populations. The objective of this long-term study (5 year) is to compare three different cover crop regimens to a clean fallow system to determine each treatment’s effect on soil organic matter levels and crop responses to them.

Materials and Methods: The study area was divided into four different areas (each area is 90’ x 330’) within the fenced vegetable area at the Cimarron Valley Research Station, Perkins, OK (Figure 1). Three of the areas follow a specific cover crop regime and the fourth area is maintained as a fallow area when not planted to crops. The three cover crop and fallow areas are:

Treatment area # 1 cover crop combinations:

a. Cool season: Cereal rye + Crimson clover
b. Warm season: Sorghum-sudan + Cowpea

Treatment area # 2 cover crop combinations:

a. Cool season: Wheat + Crimson clover
b. Warm season: Forage cowpea

Treatment area # 3 cover crop combinations:

a. Cool season: Cereal rye + Austrian winter pea + Tillage radish
b. Warm season: Pearl millet + Forage cowpea

Treatment area #4 fallow treatment:

a. Both cool and warm seasons will consist of clean fallow using either tillage, mowing, with some postemergence herbicides to maintain the area when not planted to crops.

Each area is utilized for vegetable crop research plots and rotated between a summer and winter cover crop each year. This means that if a vegetable crop is not being grown in a given area there will be a cover crop growing on any open land within the three cover crop areas.

As in prior study years, for 2021, each treatment area was divided into five plots and soil samples taken from each. Sampling will continue each year for the duration of the study. Soil sample results include pH, N-P-K, and percent soil organic matter.

Results: For 2021, soil pH among cover crop treatments was significantly different in treatment 3, at 6.5, lower than other treatments. Soil pH of treatments 1, 2 and 4 ranged from 6.6 to 6.7 (Table 1).

Nitrogen ranged from approximately 5.4 to 6.2 lbs. per acre, and no treatments were determined to be significantly different from other treatments (Table 1). Differences in nitrogen between years requires further investigation (Tables 1 - 5, Fig. 2). Phosphorus ranged from 19.6 to 21.8 lbs. per acre and was not significantly different among treatments (Table 1). Potassium ranged from 248 to 363 lbs. per acre (Table 1). Treatment 4 displayed significantly lower potassium when compared to other treatments.

Soil organic matter ranged from 1.5 to 2.0% across all treatments. Treatments 1 and 2 were not significantly different, but treatments 3 and 4 were significantly different from 1 and 2 and differed from one another. Treatment 3 was significantly lower than treatments 1 and 2. The fallow treatment (#4) was significantly lower than all other treatments. Areas that received cover crop treatments had organic matter of 1.7, 1.9 and 2.0% (Table 1, Fig. 3). Figure 3 illustrates the decrease in soil organic matter in treatment 4 (fallow) over the years.

Acknowledgements: The authors would like to thank the staff at the Cimarron Valley Experiment station for assistance with this study.

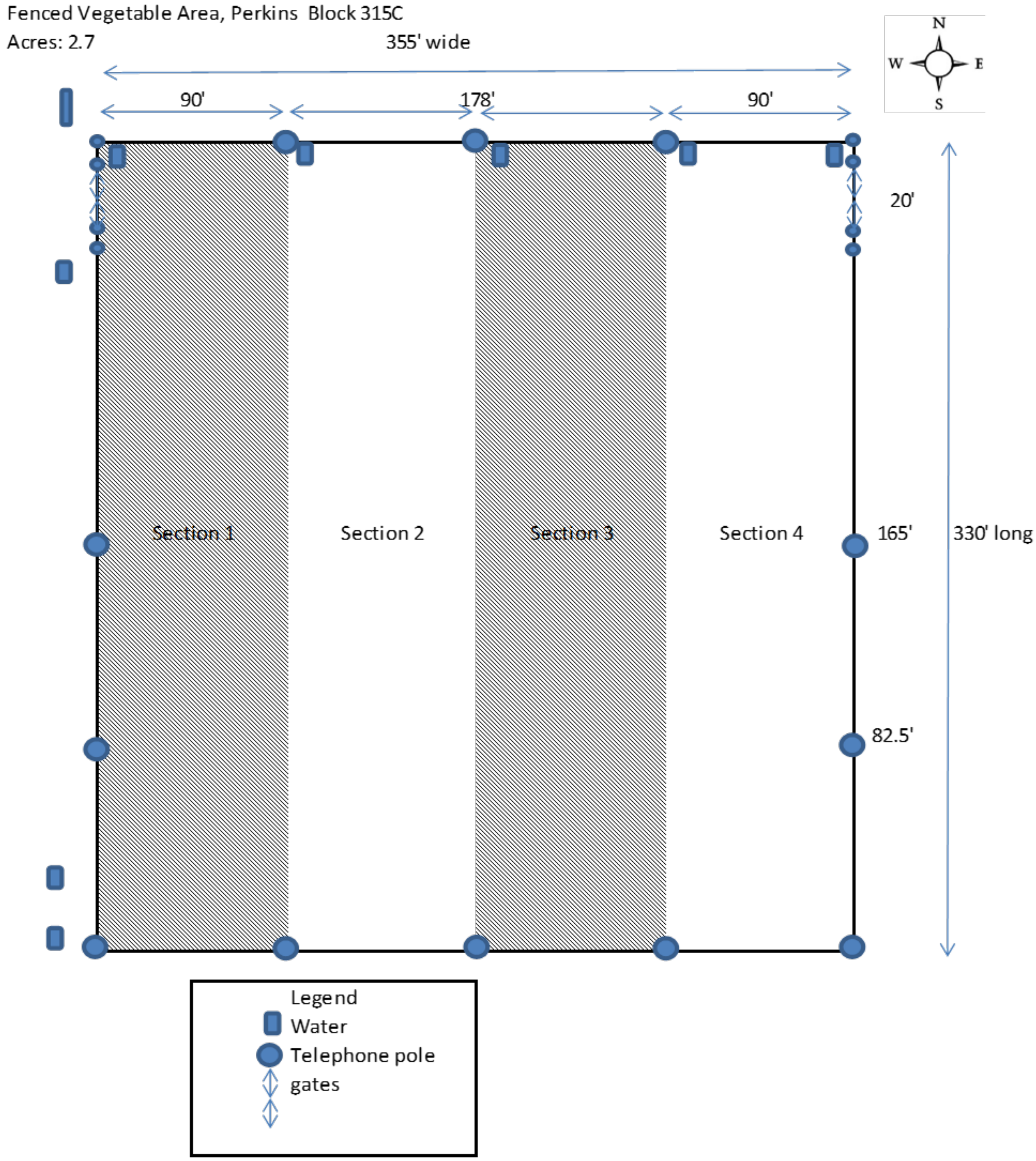
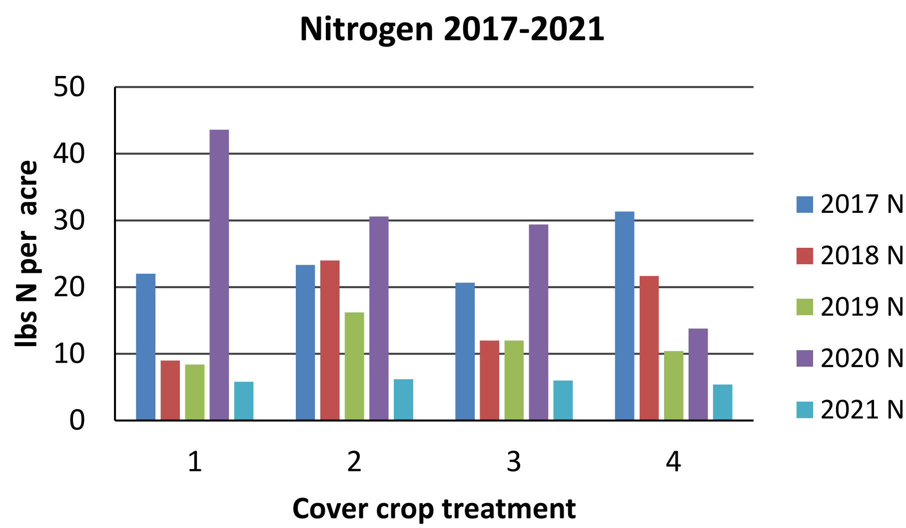
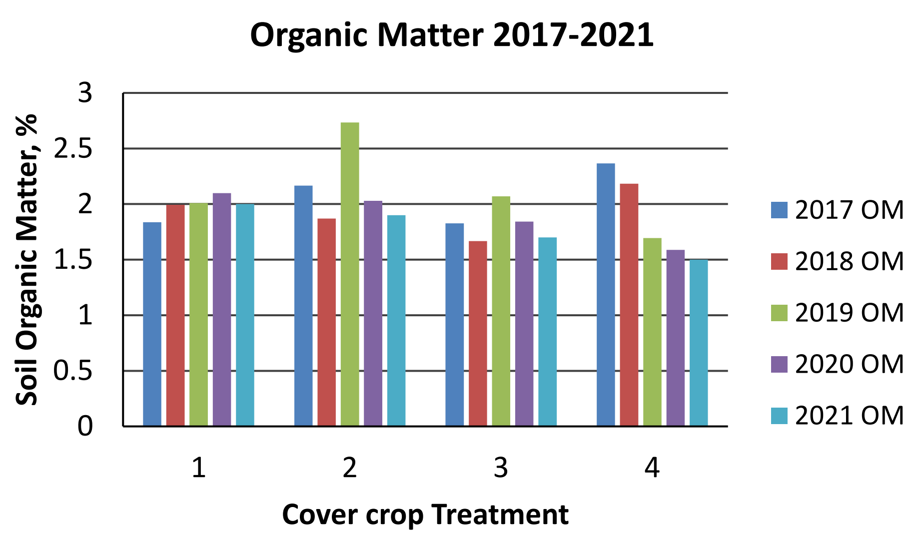


Figure 1. Cover crop and fallow areas at Cimarron Valley Research Station, Perkins, OK.





Figures 2 and 3. Soil test results for Nitrogen and Organic Matter, respectively, as effected by cover crop treatment, 2017-2019.

Table 1. 2021 Soil sample results, Cimarron Valley Research Station, Perkins, OK.

Section	pH	lbs./acre Nitrogen	Phosphorus	Potassium	% Organic Matter
1	6.7 a[z]	5.8 a	21.8 a	363 a	2.0 a
2	6.6 a	6.2 a	19.6 a	330 a	1.9 a
3	6.5 b	6.0 a	16.6 a	344 a	1.7 b
4	6.7 a	5.4 a	20.4 a	248 b	1.5 c

[z]Numbers in a column followed by the same letter exhibited no significant differences based on Duncan's Multiple range Test, P=0.05.

Table 2. 2020 Soil sample results, Cimarron Valley Research Station, Perkins, OK

Section	pH	lbs./acre Nitrogen	Phosphorus	Potassium	% Organic matter
1	7.6 a[z]	43.6 a	38.0 a	519 a	2.1 a
2	6.6 b	30.6 b	17.8 b	450 ab	2.0 ab
3	6.4 b	29.4 b	16.0 b	418 ab	1.8 b
4	6.6 b	13.8 c	14.8 b	347 b	1.6 c

[z]Numbers in a column followed by the same letter exhibited no significant differences based on Duncan's Multiple range Test, P=0.05.

Table 3. 2019 Soil sample results, Cimarron Valley Research Station, Perkins, OK

Section	pH	lbs./acre Nitrogen	Phosphorus	Potassium	% Organic matter
1	7.0 a[z]	8.4 c	30.6 a	488 a	2.0 a
2	6.5 b	16.2 a	25.8 a	490 a	2.1 a
3	6.5 b	12.0 b	20.6 a	422 a	2.1 a
4	6.5 b	10.4 bc	30.8 a	448 a	1.7 a

[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.

Table 4. 2018 Soil sample results, Cimarron Valley Research Station, Perkins, OK

Section	pH	lbs./acre Nitrogen	Phosphorus	Potassium	% Organic matter
1	6.6 a[z]	9.0 c	27.7 a	473 ab	2.0 ab
2	6.4 b	24.0 a	21.3 b	494 ab	1.9 bc
3	6.2 c	12.0 b	20.3 b	429 b	1.7 c
4	6.1 c	21.7 a	31.7 a	534 a	2.2 a

[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.

Table 5. 2017 Soil sample results, Cimarron Valley Research Station, Perkins, OK

Section	pH	lbs./acre Nitrogen	Phosphorus	Potassium	% Organic matter
1	6.8 a[z]	22.0 b	21.3 b	374 c	1.8 b
2	6.5 b	23.3 b	30.7 a	433 b	2.2 a
3	6.4 b	20.7 b	21.7 b	394 bc	1.8 b
4	6.2 c	31.3 a	34.3 a	488 a	2.4 a

[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.

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Bio-Intensive Cover Cropping for Vegetables

Cimarron Valley Research Station
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[1]Oklahoma State University, [2]Kerr Foundation/retired

Introduction and Objectives: Many production areas in Oklahoma have very low soil organic matter, in the range of 0.5 to 0.7%. Cover cropping practices can add organic matter to the soil and potentially improve crop yield and quality. In addition, increases in soil organic matter could greatly improve soil health for the benefit of vegetable production. Organic matter in soils is critical because of its effects on soil chemical properties in nutrient stabilization and fertility; and soil physical properties such as water availability and tilth. These physical properties influence crop establishment, rooting and growth. Cover crops can be seen as a "Grow in Place" source of organic matter with lower potential for contamination of fresh produce. An objective of this long-term study (5 year) is to compare three different cover crop regimens to a clean fallow system to determine each treatment's effect on crop yield, marketability, and nutritive value.

Materials and Methods: The study area was divided into four different areas (each area is 90' x 330') within the fenced vegetable area at the Cimarron Valley Research Station, Perkins, OK (Fig. 1). Three of the areas follow a specific cover crop regime and the fourth area is maintained as a fallow area when not planted to crops (Table 1). The three cover crop areas and fallow area are:

Treatment area # 1 cover crop combinations:

c. Cool season: Cereal rye + Crimson clover
d. Warm season: Sorghum-sudan + Cowpea

Treatment area # 2 cover crop combinations:

c. Cool season: Wheat + Crimson clover
d. Warm season: Forage cowpea

Treatment area # 3 cover crop combinations:

c. Cool season: Cereal rye + Austrian winter pea + Tillage radish
d. Warm season: Pearl millet + Forage cowpea

Treatment area #4 fallow treatment:

b. Both cool and warm seasons will consist of clean fallow using either tillage, mowing, with some postemergence herbicides to maintain the area when not planted to crops.

Table 1: Cover Crop Treatments

Treatment #	1	2	3	4
Warm Season	sorghum Sudan and cowpeas	cowpea	pearl millet and cowpea	Fallow
Cool Season	cereal rye and crimson clover	winter wheat and crimson clover	cereal rye, Austrian winter pea, tillage radish	Fallow

Each area is utilized for vegetable crop research plots and rotated between a summer and winter cover crop each year. If a vegetable crop is not being grown in a given area, there will be a cover crop growing on any open land within the three cover crop areas.

In 2021, as in prior study years, each treatment area was divided into five plots, 4' x 50' (total plot area of 200 ft^2). Two vegetable crops were used to determine the effect of each cover crop on their yield and quality. Cowpea (*Vigna unguiculata*, var. Empire), and sweet potato (*Ipomoea batatas*, var. Covington) were planted and harvested.

Cowpeas were harvested after using glyphosate as a desiccant, using a research plot combine.

Sweet potatoes were planted June 21st and harvested October 22nd. Aboveground vines were moved using a flail mower and potatoes were dug with a 3-point potato harvester. Sweet potatoes were gathered per plot by hand and graded using USDA sweet potato standards. Grading was divided into more categories than used in prior years.

Results: Yields for cowpea were not shown to be significantly different from one another between treatments. Significant differences in moisture percentages were seen between treatments 3 and 4 from treatment 1, shown in Table 2.

Table 2. Summer 2021 Cowpea, Perkins, OK.

Cover Crop	Combined Shelled peas (lbs./acre) [z]	Moisture %
1	243.9 a[y]	28.2 a
2	449.1 a	21.2 ab
3	431.0 a	15.5 b
4	996.3 a	16.1 b

[z] **lbs./acre=** Plot size 50' long 2 row plots 3' spacing=300 (43560/300=145.2 sqft)
[y] Numbers in a column followed by the same letter exhibited no significant differences based on Duncan's Multiple Range Test where P=0.05.

Significant differences in marketable number and weight of sweet potatoes among cover crop treatments were not detected (Table 3). However, differences were shown in jumbo weights, canner weight and number, and cull weight. Jumbo weights of treatment 1 and 4 were significantly different, canner weights were significantly different between treatments 1, 2, and 3 and treatment 4 was significantly different from treatment 1. Cull weights of treatment 1 were significantly higher than all other treatments (Table 3). As cover crop treatments in this project have been planted over the last 4 years (2017-2021), trends in soil organic matter were detected and in 2020 significant differences in soil organic matter have been shown. Differences in yields and quality of crops grown due to soil quality enhancement have not been as evident.

Table 3. Summer 2021 Sweet Potato, Perkins, OK.

	lbs./1,000 sqft[a]						
Cover Crop	**Marketable[b] weight**	**Marketable[b] number**	**Jumbo[c] weight**	**Jumbo[c] number**	**Canner[d] weight**	**Canner[d] number**	**Cull[e] weight**
1	209.9 a[f]	321.0 a	119.3 a	58.3 a	22.6 c	163.0 c	83.9 a
2	192.5 a	337.8 a	84.7 ab	66.2 a	59.8 b	359.5 b	42.8 b
3	181.4 a	332.8 a	70.4 ab	44.4 a	87.6 a	508.6 a	29.8 b
4	129.1 a	258.8 a	33.7 b	22.7 a	73.9 ab	417.8 ab	25.4 b

[a] **lbs./1000 sqft =** Plot size 45' long raised bed, plants spaced 18 inches apart, average number plants was 33/plot

[b] **Marketable weight & number=** US #1 grade description can be found at ams.usda.gov/grades-standards/sweetpotatoes-grades-and-standards

[c] **Jumbo weight & number**= Grade descriptions can be found at ams.usda.gov/grades-standards/sweetpotatoes-grades-and-standards

[d] **Canner weight & number**= Grade descriptions can be found at ams.usda.gov/grades-standards/sweetpotatoes-grades-and-standards

[e] **Cull weight**= Roots must be 1: or larger in diameter and so misshapen or unattractive that they could not fit as marketable roots. Most culls were insect damage

[f] 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: The authors would like to thank the staff at the Cimarron Valley Experiment station for assistance with this study.

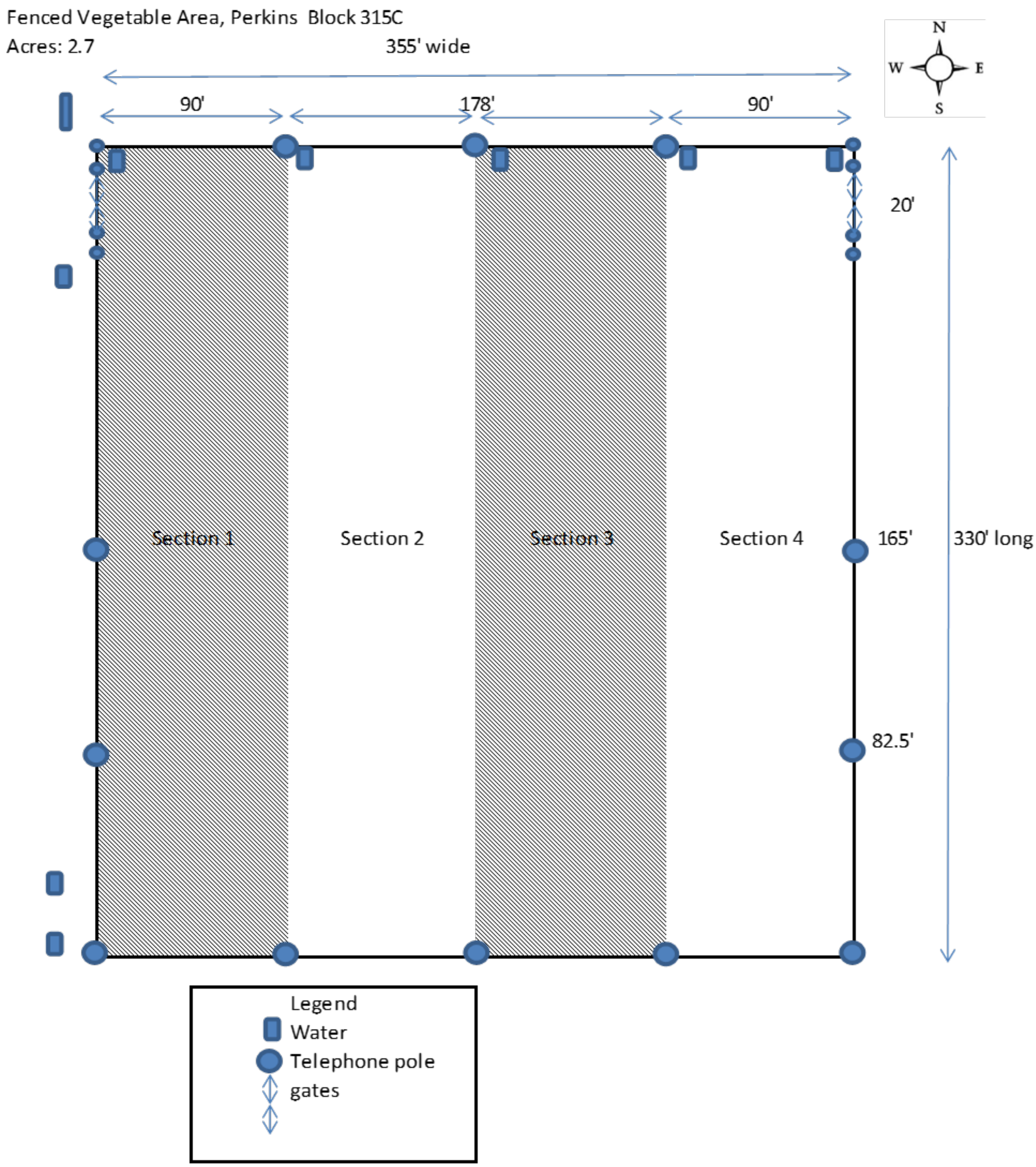

Figure 1. Cover crop and fallow areas at Cimarron Valley Research Station, Perkins, OK.

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Tomato Mulch Study – Stillwater

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Introduction and Objectives:
Polyethylene plastic mulch has been adopted in horticulture production for decades and is still the most widely used type of mulching material for agricultural application. Numerous benefits of plastic mulch have been well documented, including soil temperature modification, weed control, water retention, soil compaction and erosion prevention, insect pest and disease control. With all these benefits, plastic mulch has the potential to improve crop growth, enhance fruit quality, as well as increase the yield and income for vegetable growers. Its low cost, light weight, easiness to handle, durability, and simple application using machines also contribute to the continuous popularity and widespread use of plastic mulch for agricultural application.

Though very effective and efficient, plastic mulch has caused considerable environmental concerns. The disposal of plastic mulch required after the growing season not only costs fees and labor, but also becomes a significant source of environmental pollution. Besides, plastic mulch production systems lead to increased pesticide runoff, contaminating local waterways and threatening aquatic organisms. Therefore, researchers have investigated effective and affordable alternatives to plastic mulch to achieve comparable production benefits as plastic mulch with reduced environmental impacts.

Paper mulch is one such alternative to plastic mulch since it is effective and more environmentally friendly. Paper mulch was used for agricultural production even before plastic mulch. Many studies have concluded that paper mulch can achieve equal or even better weed control, and it can effectively control purple nutsedge (*Cyperus rotundus* L.), the weed capable of piercing polyethylene plastic mulch. Paper mulch can provide other benefits as plastic mulch including soil temperature regulation and soil moisture retention, and it has the potential to achieve comparable crop quality and yield as plastic mulch. It does not require removal after use and does not pose the environmental threat as does plastic mulch. However, some paper mulch materials may degrade too rapidly under field conditions, while thicker and more durable paper mulch materials can be too costly. Another challenge of using paper mulch is the difficulty in laying paper mulch by machines in large-scale production.

The performance of plastic and paper mulch materials on agricultural and horticultural production varies according to different climatic environments, production practices, and crops. Mulch degradation was dependent on the mulch type and geographic location. Oklahoma has hot summers with high wind and irregular rainfall. The high temperature may hasten the degradation of paper mulch and high winds may lift paper mulch off plots after the buried edges of paper degrades. On the other hand, paper mulch, especially with lighter colors, may lower the soil temperature compared to black plastic mulch and bare soil, which can be beneficial for crops such as tomato, which is known to reduce productivity when the temperature becomes too high (Zhang et al., 2008). Additionally, many vegetables grown in Oklahoma are on small acreages, which makes paper mulch a feasible practice even if manual application of paper mulch is needed. However, there is no research to evaluate the performance of paper mulch as an alternative to plastic mulch under specific production conditions in Oklahoma.

Tomato (*Solanum lycopersicum* L.) is one of the vegetables commonly grown on plastic mulch. Different mulch materials affected tomato yield by regulating soil temperature and soil moisture, but the effects varied among varieties, growing seasons, and production conditions such as disease pressure, weed pressure, temperature, and rainfall. The objective of this study was to investigate the performance of paper mulch compared with plastic mulch and bare soil for tomato field production under Oklahoma conditions. Based upon the results of these studies hopefully recommendations on mulching practices can be provided to Oklahoma growers to enhance tomato production in a cost-effective and environmentally-sustainable manner.

Materials and Methods:
The experiment was conducted on the student farm at the OSU Botanic Garden in Stillwater, OK. A randomized complete block design with five replications was used. Three treatments, paper mulch, black plastic mulch, and bare soil control were included. Treatment plots consisted of 25' long free-standing raised beds with 5' alleys and drip irrigation tape buried in the middle.

Tomatoes (variety Bella Rosa) were seeded into soilless media Sungro Professional Growing Mix in 4 x 9 (36 cell) six-packs (Landmark plastic) in a greenhouse on 3/15/21. Tomatoes were transplanted into all plots on 4/22/2021 with in-row spacing at two feet apart and six plants per plot. Tomatoes were supported using the stake and weave method with baling twine and metal pipes. Fertilization included Jacks Blossom Boost (10-30-20) applied through an injector on 4/16/21 and 4/27/21 at a rate of 3 lb and 2 lb each application, and then Jacks fertilizer (5-50-18) was added on 5/7/21, 5/14/21, 6/4/21, and 6/11/21 at a rate of 3 lb, 3 lb, 3 lb and 1 lb per application, respectively. A total of 1-2-2.8 lb N-P-K was applied through the growing season. Insect pests included tomato hornworms, aphids, tomato fruit worm, yellow striped armyworm, and whiteflies were treated with neem oil, Captain Jacks Dead bug Brew (Spinosad), and Thuricide BT Caterpillar Control.

Weed coverage was subjectively measured on 5/28/21 and 6/30/21 as a visual rating of the percentage of weed coverage in each plot. Then weeds were removed by hand in each plot and the time required to weed each plot was recorded. The weed biomass was also measured on 6/30/21. Soil temperature was measured using a soil temperature meter once a week from 5/27/21 to 7/9/21. Fruit was harvested from 7/1/21 to 8/12/21 with a total of 9 harvests. Fruit was determined as marketable or culls, and those in both categories were counted and weighed for each plot.

Results and Discussion:
On both days of weed assessment, both paper much and plastic mulch had very effective weed control compared to the bare soil control (Table 1). The weed coverage in plots

and the time for weeding were not significantly different between the paper mulch and plastic mulch treatments.

The effects of different mulching on the soil temperature varied during the growing season (Table 2). In the early season (May 27, June 4, and June 11), the soil temperature was lower in paper mulch and plastic mulch than that in bare soil. Later in the season (June 18 and after), there was no difference in soil temperature among the 3 treatments.

There was no difference in marketable fruit number and weight among the 3 treatments, even though the paper mulch had a numerically lower marketable yield than the plastic mulch and bare soil treatments (Table 3). Plastic mulch had a higher non-marketable fruit number, non-marketable fruit weight, total yield combining marketable and non-marketable fruit weight than paper mulch and bare soil treatments.

Table 1. Weed coverage percentage and weeding time for treatments.

Treatment	% Weed coverage		Weeding time in min	
	May 28	Jun 30	May 28	Jun 30
Bare soil	82.4 A[z]	88.8 A	46.1 A	28.1 A
Paper mulch	2.6 B	10.6 B	0.5 B	4.7 B
Plastic mulch	1.6 B	1.8 C	0.2 B	1.6 B

[z] Numbers in a column followed by same letter signifies there is no significant difference when α =.05

Table 2. Soil temperature in the three treatments

Treatment	**Days**										
	May 27	Jun 4	Jun 11	Jun 18	Jun 24	July 2	July 9	July 16	July 23	July 30	Aug 6
Bare soil	24 A[z]	32.2 A	34.8 A	40.4 A	39.8 A	28.0 A	34.8 A	34 A	34.8 A	33.6 A	33.2 A
Paper mulch	23.4 B	27.6 C	31.4 B	37.2 A	35.6 A	28.4 A	33.0 A	34.8 A	34.8 A	37.0 A	32.8 A
Plastic mulch	23.1 B	29.8 B	33.6 AB	37.8 A	36.8 A	27.2 A	32.0 A	32.8 A	32.4 A	33.4 A	33.4 A

[z] Numbers in a column followed by same letter signifies there is no significant difference when α =.05

Table 3. Tomato yield in the three treatments.

Treatment	Marketable fruit number per acre	Marketable fruit weight (lb/acre)	Non-marketable fruit number per acre	Non-marketable fruit weight (lb/acre)	Total fruit weight (lb/acre)
Bare soil	44257 A[z]	20958 A	35429 B	12207 B	33165 B
Paper mulch	33686 A	14806 A	38449 AB	14036 B	28841 B
Plastic mulch	46232 A	22982 A	50413 A	21816 A	44798 A

[z] Numbers in a column followed by same letter signifies there is no significant difference when α =.05

Acknowledgements: We would like to thank Omniafiltra LLC for donating the paper mulch.

Tomatoes growing in the paper mulch treatment.

Tomatoes growing in the black plastic mulch treatment.

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Mustard Greens Trial

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Introduction and Objectives:
Mustard Greens are in the Brassicaceae family and native to Central Asia and the Himalayas. Mustard greens have a very high nutritional value, high in Vitamins A, C, potassium, iron, and calcium. Its leaves are very strong flavored and pungent. Mustard greens are grown in many parts of the world. They are annual cool season crops, with the optimal growing temperature of 60 to 65 °F. Some greens have large leaves, and some have small, thin leaves. Mustard greens will tolerate a wide range of soils. Harvest is usually 50 to 55 days after planting. Mustard greens can be grown in Oklahoma in the open field for both spring and fall. They can also be grown in the greenhouse to extend the growing season. The objective of this trail was to compare the performance of 5 different mustard green varieties in the open field and greenhouse.

Materials and Methods:
The trial was conducted at the Pawnee Nation College open field and greenhouse in Pawnee, OK. The experiment was conducted as a randomized complete block design with 4 replications in the open field and 3 replications in the greenhouse. Seeds were ordered through Johnny's Selected Seeds. The five varieties included in this trial were Amara, Garnet Giant, Green Wave, Red Splendor, and Ruby Streaks. Five varieties of Mustard greens were planted in open field plots and in a raised bed in the greenhouse on August 24th, 2021. Seeds were planted ¼ to ½ inch deep. Plot size in the open field was 4-5 feet and 3-4 feet in the greenhouse. The open field was watered through drip irrigation and the greenhouse was watered by hand twice a day, in the morning and afternoon. 0.196 lbs. of BG Nitrogen 14-0-0 was applied to the field plots and the greenhouse plots every two weeks. This is a OMRI all-natural plant based Organic fertilizer. Crop was maintained organically, and no pesticides were used. Mustard greens were harvested on October 4th by hand cutting the leaves at the soil line using a knife. The fresh leaves were weighed and recorded for each plot.

Results:
The yield ranged from 59 to 86 lbs./100' row with no significant differences among the 5 varieties in the open field (Table 1). However, in the greenhouse, varieties Red Splendor and Garnet Giant had higher yield, followed by variety Green Wave, and varieties Ruby Streaks and Amara had the lowest yield.

Table 1. Yield of 5 mustard greens varieties grown in the open field and greenhouse.

Variety	lbs./100' row (12" wide)	
	Field	Greenhouse
Green Wave	86 a[z]	7.1 bc
Garnet Giant	77 a	9.3 ab
Ruby Streaks	69 a	3.5 c
Amara	63 a	4.0 c
Red Splendor	59 a	11.4 a

[z] The means in the same column with different letters represent significant differences at p=0.05.

Early plant growth in the greenhouse.

Plants ready for harvesting in the field.

Variety Garnet Giants

Variety Amara

	
Variety Ruby Streaks	Variety Red Splendor
	
Variety Green Wave	

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Langston University Horticulture Cantaloupe Trial

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Department of Agriculture and Natural Resources
Langston University

Due to the lack of availability of the popular variety ‘Super 45’, there was a need to evaluate other varieties of cantaloupe suitable for small or market gardens. In this trial, 4 cantaloupe varieties (‘Atlantis’, ‘Sarah’s Choice’, ‘Sugar Cube’, and ‘Sugar Rush’) were evaluated for yield, circumference, weight, and number of culled fruits. Seeds of each variety were spaced 1 m apart and planted into 2 plasticulture rows on June 22 in Langston, Oklahoma. Each plot consisted of 4 plants and each variety repeated 4 times (Fig.1). Fallow buffer spacing of 1.25 m between each variety was included in each row, with a surrounding plant buffer 2 rows of ‘Super 45’ plants. All rows received the same amount of irrigation and fertilizer. Fruits were harvested once or twice weekly as needed August 24-September 8, 2021.

Results:

Variety	**No. Marketable Fruit**	**Mean Weight (lbs.)**	**Mean Diameter (in.)**	**No. Cull Fruit**	**Total Cull Weight (lbs.)**
Atlantis	63	6.02	20.65	2	11.4
Sarah's Choice	41	7.14	22.65	7	28.5
Sugar Cube	120	2.58	16.36	5	12.5
Sugar Rush	57	3.94	18.60	20	70.4

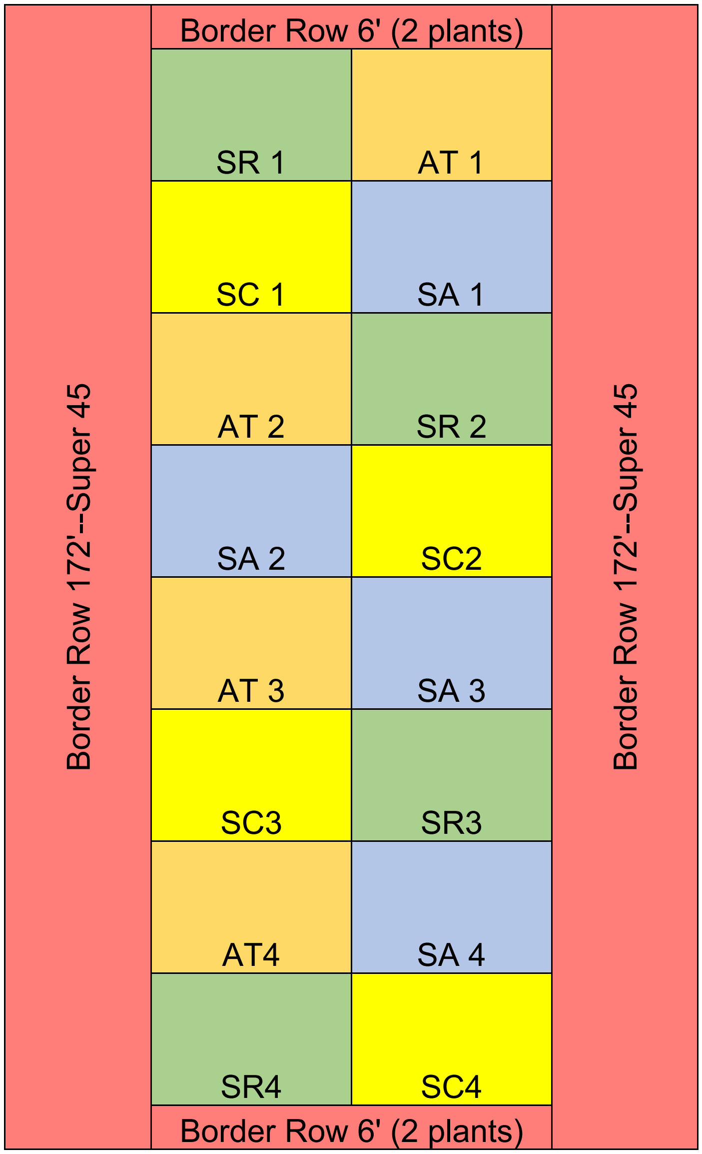
Sugar Rush

Sugar Cube

Sarah's Choice

Atlantis

Figure 1: Langston University Cantaloupe Variety Trial 2021 Plot Plan. Abbreviations: AT=Atlantis, SA=Sarah's Choice, SC=Sugar Cube, SR=Sugar Rush



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Assessing Heat Tolerance of Field Produced Lettuce

John Unterschuetz, Niels Maness, Bizhen Hu, Mason McLemure, Matt Beartrack, and Lynda Carrier

Introduction and Objectives:

Lettuce (*Lactuca sativa*) is an emerging cash crop in the United States, with demand for fresh leafy salad continuing to rise (Cook 2011). Fresh lettuce contains many antioxidants that support human health (Yang et al., 2018). In Oklahoma, lettuce is typically grown in the spring and fall seasons by small farmers (USDA 2017). Lettuce is a cool season crop traditionally; it does not respond well to heat stress, producing unmarketable growth (early bolting onset) and bitter flavor (caused in part by the accumulation of sesquiterpene lactones) in the summer growing season. Unsurprisingly, the price of lettuce grown in Oklahoma varies dramatically, with higher prices in the winter and very low prices over the summer months (USDA 2017). One possible reason why lettuce prices fall so dramatically in Oklahoma during the summer is that heat stress is causing a loss in average quality.

If the lettuce production season could be extended to the warmer time of the year, that would increase the prosperity of small farmers across the state. To investigate this possibility, we used micro sprinkler technology to evaluate the possibility of extending the lettuce growing season into the Oklahoma summer by lowering temperature for lettuce in the field through evaporative cooling. We compared the yields of our selected cultivars in each growing season within this article, to provide a more tangible measure of the crop's success. 18 cultivars of lettuce were grown. Through our efforts, we aim to recommend cultivars for small farmers in Oklahoma across each growing season to maximize their investment returns with higher quality lettuce on average.

Materials and Methods:

In this study we utilized 18 commonly grown commercial cultivars of lettuce, from 5 different groups of cultivars. Our cultivar selections are in the table 1 below.

Table 1. Lettuce cultivars included in the study.

Cultivar	Type
Black Seeded Simpson'	Loose Leaf
Waldman's Dark Green'	Loose Leaf
Panisse'	Loose Leaf
Nevada'	Batavian
Cherokee'	Batavian
Sierra'	Batavian
Jericho'	Romaine
Paris Island'	Romaine
Coastal Star'	Romaine
Butter Crisp'	Butterhead
Nancy'	Butterhead
Optima'	Butterhead
Summer Crisp Green	Salanova©
Summer Crisp Red	Salanova©
Oakleaf Green	Salanova©
Oakleaf Red	Salanova©
Butter Green	Salanova©
Butter Red	Salanova©

We included these cultivars to capture the genetic diversity of lettuce commonly grown in our geographic area, as well as more effectively evaluate the effects of the different genetics on performance in the three seasons and under micro sprinkler treatment.

Fifty Seeds of each cultivar were sown onto Sungro Horticulture's Propagation Mix and then allowed to chill in a cooler for 3 days at 40 F. After this short stratification, plants were grown in the Greenhouse Learning Center at Oklahoma State University campus. Plants were fertilized every other day starting from the first true leaves development using Jacks 20-10-20 constant liquid feed at a rate of 100 ppm N, and hardened outdoors prior to transplanting. Plants were transplanted to the field at the Cimarron Valley Research Station in Perkins, OK when they had fully developed root systems, to prevent as much transplant loss as possible. We grew plants during the spring, summer, and fall of 2020 and 2021, with the following timelines in table 2.

Table 2. Transplant production date sown and transplanted.

Season	Year	Sowing Date	Transplant Date
Spring	2020	3/2/2020	4/2/2020
Summer	2020	6/1/2020	7/16/2020
Fall	2020	8/27/2021	9/24/2020
Spring	2021	3/4/2021	4/9/2021
Summer	2021	5/30/2021	7/9/2021
Fall	2021	8/20/2021	9/28/2021

Plots were arranged using a randomized complete block design with 4 replications to account for the variables of soil inconsistency among other variables that could not be controlled, and which were outside the scope of the study. The lettuce for evaluating the 18 varieties was grown in two rows of free-standing raised beds that were 6 feet wide (including tire treads for accessibility) and 254 feet long, with drip tape at the center. Plants were transplanted using a water wheel transplanter with 12 inch in-row spacing and 7 plants per cultivar per replication. A third row for evaluating the effects of micro sprinklers consisted of free standing raised beds that were 6 feet wide and 168 feet long. The selected varieties for micro sprinkler treatment were Salanova© 'Summer Crisp Green', Salanova© 'Summer Crisp Red', Batavian 'Nevada', Butterhead 'Buttercrunch', Loose Leaf 'Black Seeded Simpson', and Romaine 'Jericho'. The micro sprinkler plots were grown in every season except spring 2020. All plots with or without micro sprinklers were irrigated twice a day for 30 minutes, except during wet, rainy periods. The duration of micro sprinkler treatment was 30 mins per hour for 5 hours from 10 AM to 3PM, for a total of 2.5 hours of sprinkling per day in summer 2020. Because that was too much water, in summer 2021, we used an interval of 5 mins per hour for 5 hours from 10AM to 3PM, for a total of 25 minutes of sprinkling per day. Plants were fertigated to reach commercially acceptable levels of macronutrients, as determined by soil tests prior to planting. Our target nitrogen level was 120 lb/acre, Phosphorous was 150 lb/acre, and Potassium was 150 lb/acre. Weed control was achieved through hand hoeing mostly, although Poast herbicide was applied in the summer 2021 growing season at a rate of 1.5 pint per acre along with ammonium sulfate at 2 lb/acre. Pest control was necessary in summer and fall 2020. In summer the crop was sprayed with 3 oz/acre rate of Mustang

Maxx on 7/31/2020, and in the fall it was sprayed with Permethrin on 10/8/2020 to control damage caused by army worms. Plants were harvested by cutting off whole plants at their base. Fresh weight of each lettuce was recorded.

Results:
Based on results from table 3, we conclude that lettuce tends to prefer Oklahoma's spring weather pattern, across the board. Interestingly, many cultivars had higher yields in summer 2021 than Fall 2020. This may have been caused by a relatively mild summer in 2021, or the stress endured by the plants in the drastic changes in day and night temperature in the fall 2020.

The highest yields are associated with 'Romaine Jericho' and 'Romaine Paris Island'. In the spring 2021 season. The Romaine cultivars are associated with relatively higher yield, regardless of season.

When comparing green and red Salanova© cultivars that are closely related, the green types yielded more on average. 'Salanova Butter Red' tended to have the lowest yields among the cultivars throughout the experiment.

While the Loose leaf varieties appear to have competitive yields in this table, more than half of the 'Black Seeded Simpson' plants in any given growing season were bolting prior to harvest. We expect lab analyses to show these plants to contain more bitter compounds as a result. Many of the 'Waldman's Dark Green' plants in every season were also exhibiting bolting signs by the time of harvest. However, In Fall 2020 'Waldman's Dark Green' had higher yield values than most cultivars. This generality did not extend to the 'Panisse' however. While 'Panisse' in general did not yield as much as the other loose leaf types, it had a more marketable growth habit, regardless of season.

Looking more closely at all the "heat tolerant" groups, a few cultivars stood out for their performance in very hot conditions. 'Batavian Sierra'*,* had a higher yield than most other cultivars in summer 2020, which was the hotter of the two summers that we grew plants in and that difference was statistically significant. In general, the Butterhead group did not perform statistically different from the more traditional cultivars. However, there is a large observable change in the yield of 'Butterhead Optima'. This cultivar failed to germinate well in Summer 2020, but had decent yields in summer and fall 2021, where it had a higher yield than most other cultivars. The poor yields likely had more to do with poor seed storage than the actual performance of the cultivar.

When considering our micro sprinkler treatments, one thing is for certain (table 4). Our first interval of micro sprinkler treatment caused more harm than good for the plants, with lots of death and tip burn due to overwatering and a lack of transpiration. However, our micro sprinkler treatment in summer 2021 yielded healthy plants, but not more generally than the main study plots in the same time interval. This may indicate that the benefits of micro sprinkler irrigation is not feasible in our climate or that we simply did not choose the correct interval. We also did not solely water the micro sprinkler plots with the sprinklers, they were connected to the drip irrigation and received both types of watering simultaneously. More research should be conducted to evaluate the proper interval of micro sprinkler use with lettuce and the use of micro sprinklers both in conjunction with and separate from drip irrigation.

Table 3. Yield of 18 lettuce varieties in spring, summer, and fall of 2020 and 2021.

Cultivar	Type	lb/acre[z]					
		Spring 2020	Spring 2021	Summer 2020	Summer 2021	Fall 2020	Fall 2021
Cherokee	Batavian	1612cd[y]	2765efg	840bcde	1199efgh	1001bc	1628cdefgh
Nevada	Batavian	2195bc	2471efg	407de	1616def	1175ab	1387defghi
Sierra	Batavian	1940bcd	2453efgh	1641a	1439efg	1171ab	2171bc
Butter Crunch	butterhead	2220bc	2214fgh	1260abc	1261efgh	967bc	1274efghi
Nancy	butterhead	2618ab	2760efg	306*	1787cde	857bc	1604defghi
Optima	butterhead	2498ab	2585efg	95*	2992ab	992bc	3182a
Black Seeded Simpson	loose leaf	2630ab	3878cd	894bcde	1606def	1014bc	1846cdef
Panisse	loose leaf	1908bcd	2945def	230*	1239efgh	859bc	1577cdefghi
Waldman's Dark Green	loose leaf	2427ab	3433cde	658de	NA	1518a	1772cdefg
Coastal Star	romaine	3111a	NA	1084abcd	2261cd	996bc	2803ab
Jericho	romaine	3141a	6836a	1281ab	3297a	1066abc	2040cde
Paris Island	romaine	2616ab	5665b	735cde	2356bc	1077abc	2031cd
Butter Green	Salanova©	NA	2035fgh	1315ab	1150efgh	958bc	1115fghi
Butter Red	Salanova©	1287d	1866gh	293e	667h	690c	790h
Oakleaf Green	Salanova©	1557cd	1924fgh	450de	1008fgh	840bc	1138ghi
Oakleaf Red	Salanova©	1224d	2130fgh	766bcde	799gh	755bc	891h
Summer Crisp Green	Salanova©	2490ab	4183c	536de	1217efgh	817bc	1063gh
Summer Crisp Red	Salanova©	1283d	1380h	208*	495*	758bc	842h

[z]Average yield lb/acre was calculated using a 6 ft between rows and 1 ft in row spacing.
[y] Means in the same column followed by the same letter represent no differences using Tukey's HSD at alpha = 0.05
*Excessive plant death made statistical analyses impossible because of disparate sample group sizes.

Table 4. Yield of 6 lettuce varieties grown with micro sprinkler treatments in summer 2020 and 2021.

		lb/acre	
Cultivar	**Type**	**Summer 2020**	**Summer 2021**
Nevada	Batavian	970a	1554b
Butter Crunch	Butterhead	849ab	1408b
Black Seeded Simpson	Loose Leaf	NA*	1320b
Jericho	Romaine	832*	3132a
Summer Crisp Green	Salanova©	335b	1144b
Summer Crisp Red	Salanova©	NA*	519c

[z]Average yield lb./acre was calculated using a 6 ft between rows and 1 ft in row spacing.
[y] Means in the same column followed by the same letter represent no differences using Tukey's HSD at alpha = 0.05
*Excessive plant death made statistical analyses impossible because of disparate sample group sizes.

Plots with micro sprinklers

Plots without micro sprinklers

Sources:

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Grafted Tomato, Pepper, and Watermelon Field Production

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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, pepper, and watermelon in open field production under Oklahoma conditions.

Materials and Methods:

This experiment was carried out at the Oklahoma State Cimarron Valley Research Station in Perkins, Oklahoma from spring to late summer/early fall 2021. Three vegetables, tomato, pepper, and watermelon were chosen for grafting. Two rootstocks per scion for each vegetable and the un-grafted scion control were planted. Scions and rootstocks for each vegetable can be found in table 1. Grafted plants were donated from Tri-Hishtil (Mills River, NC). The un-grafted scion control was propagated in the research greenhouse at the Oklahoma State University.

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

Vegetable	Scion	Rootstock
Tomato	Red Mountain	Rst-04-106-T, Maxifort
Pepper	King Arthur	Dorado, Bedrock
*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.

Tomato and pepper plots were laid out in a randomized complete block design with three replications. Watermelon plots were laid out in a completely randomized design with three replications. Winter cover crops were mown with a flail-mower, and strip tilled both were tractor powered. Four rows of free-standing raised beds with white-on-black plastic mulch and buried drip tape were installed on April 22 using a Rain-Flo bed shaper (model 2550, East Earl, PA). The rows were 280 feet long and 30 inches wide. Soil test results indicated that 140 lb of nitrogen and 109 lb of P_2O_5 per acre were needed and no additional potassium was needed to meet the target 150-150-150 lb/Acre N-P-K for watermelons and 100-150-200 lb/Acre N-P-K for tomatoes and peppers. Dry granular diammonium phosphate fertilizer (18-46-0) was added during bed formation to supply all the needed phosphorus for the growing season for all three crops and roughly half the nitrogen requirements. The remaining nitrogen required for tomatoes and peppers was added at a rate of 0.673 lb. N per week in the form of water-soluble urea (46-0-0) through drip irrigation for about 12 weeks. Remaining nitrogen requirements for watermelons were added at a rate of 1.39 lb. N per week from urea (46-0-0) through drip irrigation for about 12 weeks. Tomatoes and peppers were hand transplanted to the field on April 30th, 2021. Watermelons were hand transplanted on May 28th, 2021. For tomatoes and peppers 8 plants per plot were planted with 3 feet in row spacing for tomatoes and 2 feet in row spacing for peppers. Beds were spaced 8 feet on center. For watermelons 5 plants per plot were planted with 5 feet in-row spacing and 10-feet bed spacing on center. Tomato and pepper were supported using the stake and weave method using metal T-posts and tomato twine. One application of Lambda-cyhalothrin (Warrior) was applied over the watermelons at a rate of 3oz per acre to control striped blister beetles. No other pesticides were used for the study.

Tomatoes were harvested on July 9, 20, 26 and August 3, 2021. Peppers were harvested on July 12 and 21, August 3 and 29, 2021. Fruit was determined to be marketable or non-marketable, each was weighed and counted. Watermelons were harvested on August 6 and 11, 2021. Fruit was determined to be marketable or non-marketable, each was weighed and counted. Watermelon fruit was assessed for hollow heart by cutting in half, no incidence of hollow heart was found.

Results and Discussion:

The marketable fruit weight of grafted tomato 'Red Mountain' on rootstock 'Rst-04-106-T' was higher than that of the un-grafted control (Table 2). There was no different between the two grafted tomato combinations on 'Rst-04-106-T' vs. 'Maxifort'. The yield of the two grafted pepper combinations and the un-grafted control was not significantly different (Table 3). Grafted Tri x 313 on both rootstocks had a numerically higher marketable fruit number and larger average fruit weight than the un-grafted control (Table 4).

Due to a smaller size of the flats used for the un-grafted control propagation, the un-grafted transplants were smaller in size than the grafted transplants at the time of transplanting. The tomato plants were infested with Septoria leaf spot. No fungicides were applied through the growing season. The un-grafted plants were more severely affected by the disease and most un-grafted plants were dead by the last harvest while the grafted counterparts were still alive.

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

Treatment	Marketable fruit weight (lb/acre)	Non-marketable fruit weight (lb/acre)	Marketable + non-marketable fruit weight (lb/acre)
Grafted Red Mountain on Rst-04-106-T	27,424 a[z]	8,838 a	36,262 a
Grafted Red Mountain on Maxifort	24,679 ab	10,011 a	34,689 a
Un-grafted Red Mountain	16,257 b	8,062 a	24,319 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 season yield of grafted and un-grafted peppers.

Treatment	Marketable fruit weight (lb/acre)	Non-marketable fruit weight (lb/acre)	Marketable + non-marketable fruit weight (lb/acre)
Grafted King Arthur on Bedrock	7,884 a[z]	2,820 a	10,704 a
Grafted King Arthur on Dorado	7,883 a	3,685 a	11,568 a
Un-grafted King Arthur	6,720 a	2,787 a	9,507 a

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

Table4. Total season yield of grafted and un-grafted watermelons.

Treatment	marketable fruit number/acre	average fruit weight (lb)
Grafted Tri x313 on RS-841	2,807	12
Grafted Tri x313 on Cobalt	2,904	13
Un-grafted Trix313	1,936	10
Grafted Delta on RS-841	1,936	13
Grafted Delta on Cobalt	1,452	15
Un-grafted Delta	1,646	16

Acknowledgement

We want to thank Tri-Hishtil for donating the grafted tomato, pepper, and watermelon transplants.

Free standing raised bed with white-on-black plastic mulch, newly transplanted grafted tomatoes, cover crop strips

Tomato plots with grafted tomato plants and the un-grafted control

Pepper plots with grafted pepper plants and the un-grafted control

Watermelon plots with grafted plants and the un-grafted control

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Spring Brussels Sprout Variety Trial

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Introduction and Objectives:
Brussels sprouts (*Brassica oleracea, group gemmifera*) originated in Belgium in the sixteenth century and are currently grown around the world. They are a cool season crop that has reasonably high levels of calcium and vitamin C (Pierce, 1987). The objectives for this trial include examining cultivars for use in Oklahoma and determining if spring Brussels sprouts are a viable crop for fresh market production in the state.

Materials and Methods:
Fifteen cultivars of Brussels sprouts (Table 1) were seeded into BM7 Berger 25% pine bark, 10% perlite soilless mix in 606 inserts of 6 cells with cell dimension at 2.25" deep and1.5" square on January 12, 2021. Hestia cultivar was reseeded on January 19, 2021, due to low germination rates. On January 27, 2021 seedlings began receiving a weekly low dose of Miracle-Gro water soluble tomato and vegetable fertilizer (18-18-21) at ½ teaspoon per gallon of water for approximately three weeks. Watering was done by hand with a 2-gallon watering can. Fertilizer applications ceased and watering frequency was lessened around February 17, 2021, to begin the hardening off process.

On January 19, 2021, plots were established on the student farm in the Botanical Garden at OSU in Stillwater, Oklahoma. Winter cover crops of crimson clover and winter wheat were mowed down, and strip tilled with a tractor powered roto tiller. Free standing raised beds with buried drip tape were created using a Rain-Flo (model 2550) single row bed shaper. Beds were spaced 10 feet on center. On February 24, 2021, based on soil test results, a pre-plant fertilizer application of dry granular diammonium phosphate (18-46-0) was broadcast by hand over each bed at a rate of 107 lb. P_2O_5/acre to reach a target of 125 lbs./acre to supply all phosphorus requirements for the season. No additional potassium was needed. Remaining nitrogen requirements of 125 lb. N/acre were needed to reach a target of 175 lbs. N/acre. Water soluble Urea (46-0-0) was added through a drip irrigation system on a weekly basis to supply the remaining nitrogen. First urea application began on March 7, 2021, and again on March 11, 16, and 19, with 0.325 lb. of granules per application. On March 26, 2021, the amount of urea was increased to 0.975 lb. and applied weekly based on watering needs until a total of 8.77 lbs. of urea was applied.

Seedlings were transplanted to the plots on February 25, 2021. Plants were spaced 18 inch apart in double staggered rows with a total of 10 plants per treatment plot. Plastic row cover was then installed over the seedlings which remained until April 1, 2021. All plots were weeded by hand and straw mulch was applied on April 3 at about 6-8 inches in thickness. All plants had tops and yellowing lower leaves removed on May 13, 2021, to encourage sprout development along the stem. A total of three harvests were taken. Five plants with the best sprout development were harvested from each plot. Entire plants were cut at the ground level with all leaves removed. Stems with sprouts attached were then weighed and sprouts were removed and sorted into marketable or non-marketable. Sprouts were marketable if they were larger than ¾ inch, but under 2 inches in diameter. Both marketable and non-marketable sprouts were counted and weighed. Cultivars Capitola, Dagan, Groninger, Gustus, Hestia, and Marte were harvested on June 4, 2021. Confidant, Diablo, and Divino were harvested on June 8, 2021. Churchill, Nautic, Redarling, and Roodnerf were harvested on June 15, 2021.

Results and Discussion:
Among the 15 cultivars selected for the trial, 12 produced sprouts of marketable size and quality. The remaining three cultivars either produced sprouts of poor quality or failed to produce sprouts at all. Local climate conditions may account for the lack of production of the three cultivars. The top performers were cultivars Marte, Dagan, and Confidant. Considerable experience was gained during the 2021 season for growing Brussels sprouts in Oklahoma. Starting seeds mid-January to allow for February transplanting allowed sufficient time for an early summer harvest. Also, using clear plastic low tunnel row covers allowed for protection from cold temperatures and high winds which otherwise would have slowed growth considerably. With the early transplanting and row covers, the yield was higher in 2021 than that in 2020 (Table 2).

Table 1. The 15 Brussels sprout cultivars included in the trial.

Cultivar	Source	Type	RDH[z]
Churchill	Johnny's	Green F1	123
Dagan	Johnny's Bejo	Green F1	134
Diablo	Johnny's	Green F1	110
Divino	Bejo	Green F1	123
Groninger	Rareseeds	Green F1	NA
Hestia	Johnny's	Green F1	127
Long Island Improved	Rareseeds	Green OP	100
Marte	Bejo	Green F1	123
Nautic	Territorial	Green F1	120
Red Rubine	Territorial	Red OP	85
Roodnerf	Territorial	Green OP	100
Capitola	Syngenta	Green F1	135
Confidant	Syngenta	Green F1	130
Gustus	Syngenta	Green F1	110
Redarling	Syngenta	Purple F1	140

[z]RDH Reported Days to Harvest

Table 2. Yield of the top three Brussels sprout cultivars.

Cultivar	Yield (oz. sprouts/plant)	
	2020	2021
Marte	7.6	18
Dagan	8.5	15
Confidant	Not included	15

Brussels sprouts transplants protected by row covers in the early spring.

Brussels sprouts ready for harvest.

Cultivar Marte

Cultivar Dagan

Cultivar Confidant

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Okra Mulch Study - Stillwater

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Introduction:

Okra (*Abelmoschus esculentus*) 'Heavy Hitter' was the cultivar developed from selections from 'Clemson Spineless'. Okra is believed to have originated in Ethiopia, found itself on American soil during the Atlantic Slave Trade, and is one of the oldest cultivated crops in the world. Grown in hot arid conditions, it is naturally drought and heat tolerant (Anderson, 2021).

Mulch is used to increase fruit quality by reducing soil and fungal pathogens and by increasing moisture retention in the soil (Ni, 2016). It is also used to suppress weeds and regulate soil temperature. Therefore, mulch has the potential to increase crop performance and yield. Plastic mulch is convenient and affordable for growers, but it requires disposal after the season, and it releases microplastics into the environment and decreases soil health (Qi, 2020). An alternative to plastic mulch is paper mulch. When tested against the performance of plastic mulch, this environmentally friendly alternative proved itself as a viable alternative by repressing weeds and regulating soil temperature at the same levels as plastic mulch. Paper mulch, although more expensive, is biodegradable and because its benefits for warm season crop production is comparable to plastic, it is a viable alternative to plastic mulch (Brault 2002).

Even though paper mulch is a viable alternative to plastic, it is a different mulching media giving it the potential to affect plants differently than plastic. These differences might present in ways that may or may not be favorable to growers. This experiment tested how okra production, weed control, and soil temperature are affected by the three treatments: plastic mulch, paper mulch, and bare soil.

Methods and Materials:

The experiment was conducted on the student farm at the OSU Botanic Garden in Stillwater, OK. A randomized complete block design with five replications was used. Three treatments, paper mulch, black plastic mulch, and bare soil control were included. Treatment plots consisted of 25' long free-standing raised beds with 5' alleys and drip irrigation tape buried in the middle.

Okra seeds (variety 'Heavy Hitter') were direct-seeded into soilless media Sungro Professional Growing Mix in 4 x 9 (36 cell) six-packs (Landmark plastic) in the greenhouse on 5/2/21. Okra was transplanted into all plots on 5/28/2021 with in-row spacing at two feet apart and six plants per plot. Fertilizer Jacks Blossom Boost (10-30-20) was applied through an injector on April 16 and April 27 at a rate of 3 lb and 2 lb each application, and then Jacks fertilizer 5-50-18 was added on May 7, May 14, June 4, and June 11 at a rate of 3 lb, 3 lb, 3 lb and 1 lb per application, respectively. Insect pests included tomato hornworms, aphids, tomato fruit worm, yellow striped armyworm, and whiteflies were treated with neem oil, Spinosad, and Thuricide BT Caterpillar Control.

Weed coverage was subjectively measured on 5/28/21 and 6/30/21 as a visual rating of the percentage of weed covered in each plot. Then weeds were removed by hand in each plot and the time required to weed each plot was recorded. The weed biomass was also measured on 6/30/21. Okra harvesting began on 7/2/21 and continued to 10/2/21 for a total of 20 harvests. Fruit was removed from plants using hand clippers, then determined as marketable or culls, and those in both categories were counted and weighed for each plot.

Results and Discussion:
The percent weed coverage for paper mulch and plastic mulch were consistently lower when compared to the control on May 28th with bare soil having 82.4% weed coverage, paper mulch having 2.6% weed coverage, and plastic mulch 1.6% (Table 1). On June 30, the bare soil had 88.8% weed coverage, paper mulch had 10.6%, and plastic mulch had the lowest weed coverage at 1.8%. Due to the paper mulch degrading during the time between the two weeding dates, a significant number of weeds were able to grow increasing the percent of weed coverage.

Time for weeding the bare soil plots were significantly longer than the other two treatments on both 05/28/2021 and 06/30/2021. On both days paper mulch and plastic mulch showed no significant difference (Table 1). The paper mulch weeding time increased from 05/28/2021 to 06/30/2021. This increase is most likely due to the paper mulch degrading and exposing more soil for weeds to grow. On both days of data collection for the weed coverage and weeding time, paper mulch and plastic mulch, had significantly less weeds and took significantly less time to weed compared to the bare soil control. This means both treatments successfully deterred the number of weeds and are viable options for weed suppression.

As for regulating soil temperature, after June 11 the weather reached high temperatures that resulted in neither mulch treatment being able to regulate temperatures resulting in no differences among all three treatments (Table 2). On May 27 both the paper and plastic lowered the soil temperature compared to the bare soil treatment. On June 4 the paper mulch had a significantly lower soil temperature compared to the plastic and bare soil. On June 11, paper mulch had a lower soil temperature than bare soil.

Overall yields were highest for plastic mulch at 652 bushels per acre (Table 3). Marketable and unmarketable harvest data were not separated because unmarketability was due primarily to an inadequate number of harvests resulting in oversized fruit. There were no differences for individual fruit weights among the treatments.

Conclusions: In terms of weed suppression, both the plastic mulch and paper mulch are viable options. Under high summer temperatures, neither plastic mulch nor paper mulch has a significant effect on soil temperature regulation, while paper mulch can potentially lower soil temperature in more temperate climates. Okra performed better in terms of total fruit weight when plastic mulch was used.

Table 1. 2021 Okra mulch study, weed coverage, weeding time, The Botanic Garden, Stillwater, OK.

	% Weed coverage		Weeding time in min	
Treatment	**28-May**	**30-Jun**	**28-May**	**30-Jun**
Paper mulch	2.6 B[z]	10.6 B	0.5 B	4.7 B
Plastic mulch	1.6 B	1.8 C	0.2 B	1.6 B
Bare soil	82.4 A	88.8 A	46.1 A	28.1 A

[z] Numbers in a column followed by the same letter exhibited no significant differences based upon Tukey's multiple comparison where P=0.05.

Table 2. 2021 Okra mulch study, soil temperature data, The Botanic Garden, Stillwater, OK

	Date										
Treatment	**27-May**	**4-Jun**	**11-Jun**	**18-Jun**	**24-Jun**	**2-Jul**	**9-Jul**	**16-Jul**	**23-Jul**	**30-Jul**	**6-Aug**
Paper mulch	23.4 B[z]	27.6 C	31.4 B	37.2 A	35.6 A	28.4 A	33 A	34.8 A	34.8 A	37 A	32.8 A
Plastic mulch	23.1 B	29.8 B	33.6 AB	37.8 A	36.8 A	27.2 A	32 A	32.8 A	32.8 A	33.4 A	33.4 A
Bare soil	24 A	32.2 A	34.8 A	40.4 A	39.8 A	28 A	34.8 A	34 A	34.8 A	33.6 A	33.2 A

[z] Numbers in a column followed by the same letter exhibited no significant differences based upon Tukey's multiple comparison where P=0.05.

Table 3. 2021 Okra mulch study harvest results, The Botanic Garden, Stillwater OK.

	----Bushels of fruit/acre[z]----	Individual fruit weight
Treatment	**Total non-marketable + marketable**	**(lbs.)**
Paper mulch	364 B[y]	0.058 A
Plastic mulch	652 A	0.055 A
Bare soil	284 B	0.053 A

All Okra plots were harvested 7/02/2021 to 10/02/2021 (20 harvests)

[z] Bushels of fruit per acre based upon 30 pounds per bushel

[y] Numbers in a column followed by the same letter exhibited no significant differences based upon Tukey's multiple comparison where P=0.05.

Acknowledgements: We would like to thank Mr. Ron Cook for supplying 'Heavy Hitter' okra seeds and Omniafiltra LLC for providing the paper mulch.

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Okra harvest

Okra plot without mulch before weeding

Okra plot without mulch post weeding

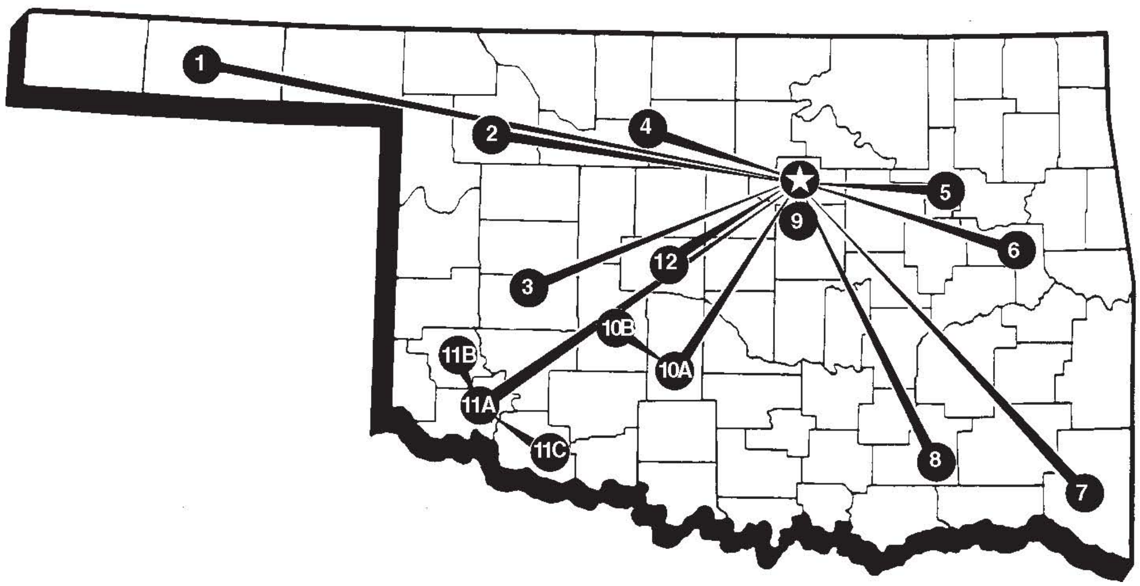
Table of Contents

SI (METRIC) CONVERSION FACTORS

Approximate Conversions to SI Units					*Approximate Conversions from SI Units*				
Symbol	**When you know**	**Multiply by**	**To Find**	**Symbol**	**Symbol**	**When you know**	**Multiply by**	**To Find**	**Symbol**
		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

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***