# 2019 Vegetable Trial Report

**January 2020**

**MP-164.10**

**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 2019.

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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# Crop Culture

## Bio-Intensive Cover Cropping for Soil Improvement

**Cimarron Valley Research Station**
**Josh Massey, Lynn Brandenberger, & Lynda Carrier**
**Oklahoma State University,**

**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 in 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 would mean 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.

In 2019, 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 organic matter.

**Results:** For 2019, soil pH tested at 6.5 in each treatment, except treatment area #1 at 7.0. (Table 1). Although treatment #1 was significantly different than other treatments, all sections had a soil pH that should not interfere with nutrient availability.

Nitrogen ranged from approximately 8.4 to 16.2 lbs. per acre, treatment #1 having the lowest and treatment #2 having the highest N availability (Table 1, Fig. 2). Phosphorus ranged from 20.6 to 30.8 lbs. per acre (Table 1). No differences were shown in soil P between treatments. No significant differences were shown in soil K between treatments, K ranged from 422 to 490 lbs. per acre (Table 1). Potassium in all treatment areas would be considered adequate for a majority of vegetable crops.

Organic matter ranged from 1.7 to 2.1% across all treatments with no significant differences detected between them. However, the fallow treatment did exhibit the lowest OM%. Areas that received cover crop treatments had organic matter of 2.0 and 2.1% (Table 1, Fig. 3). Treatments #2 and #3 both had 2.1% OM.

2019 is the first year where OM has been shown lowest in the fallow treatment. In 2017 and 2018, the fallow treatment showed the highest OM%, likely because if soil OM carryover from Bermudagrass cover that was in place prior to fencing the vegetable area and establishing the cover crop treatments (Tables 2 and 3, Fig. 3). If OM% continues to increase with cover crop additions in the remaining years of study, the authors expect to report differences in vegetable crop yields and soil health parameters between at least some of the treatments.

**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.

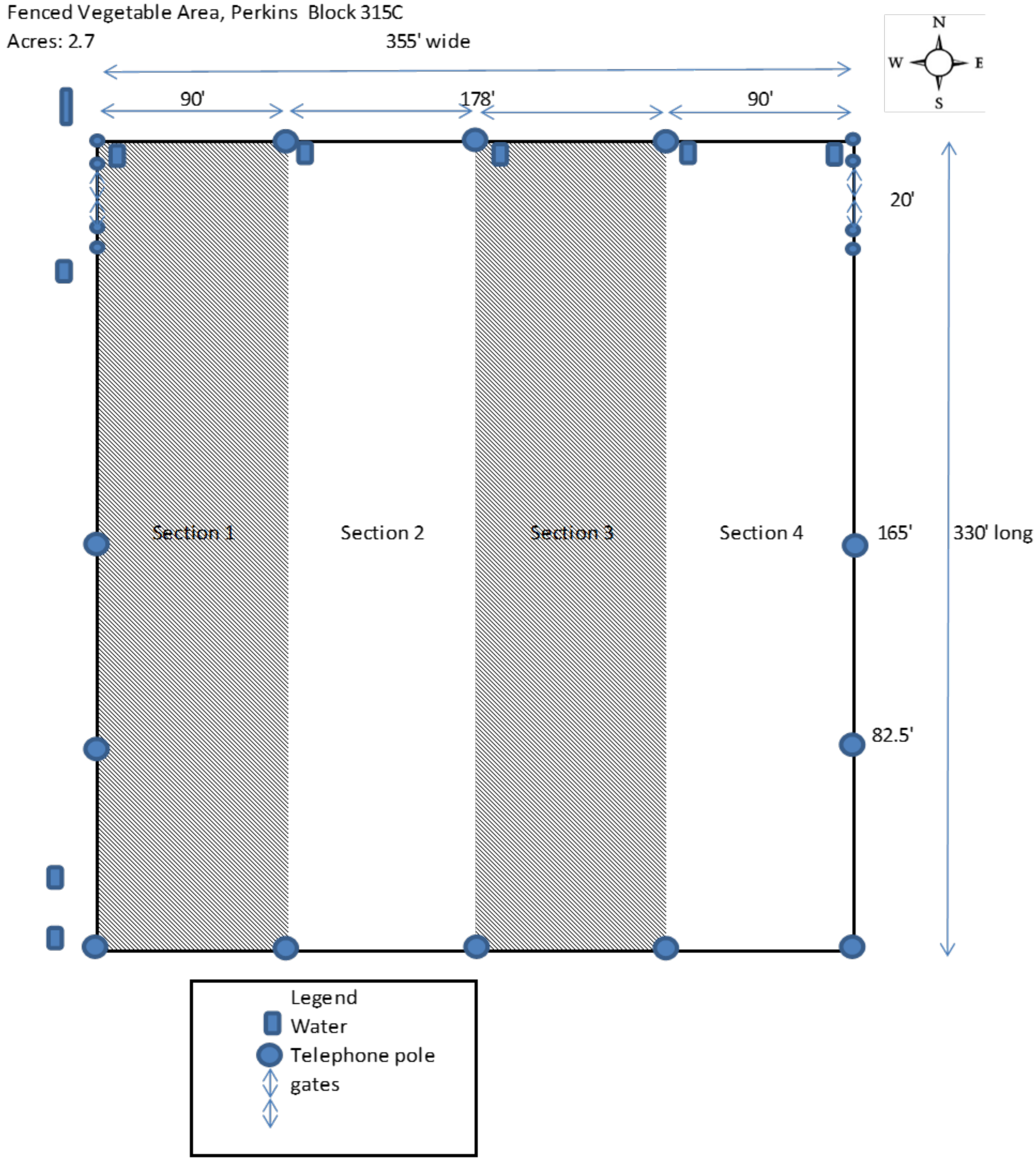


**Table 1.** 2019 Soil sample results, Cimarron Valley Research Station, Perkins, OK

| | | lbs./acre | | | % |
|---|---|---|---|---|---|
| **Section** | **pH** | **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 2.** 2018 Soil sample results, Cimarron Valley Research Station, Perkins, OK

| | | lbs./acre | | | % |
|---|---|---|---|---|---|
| **Section** | **pH** | **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 |

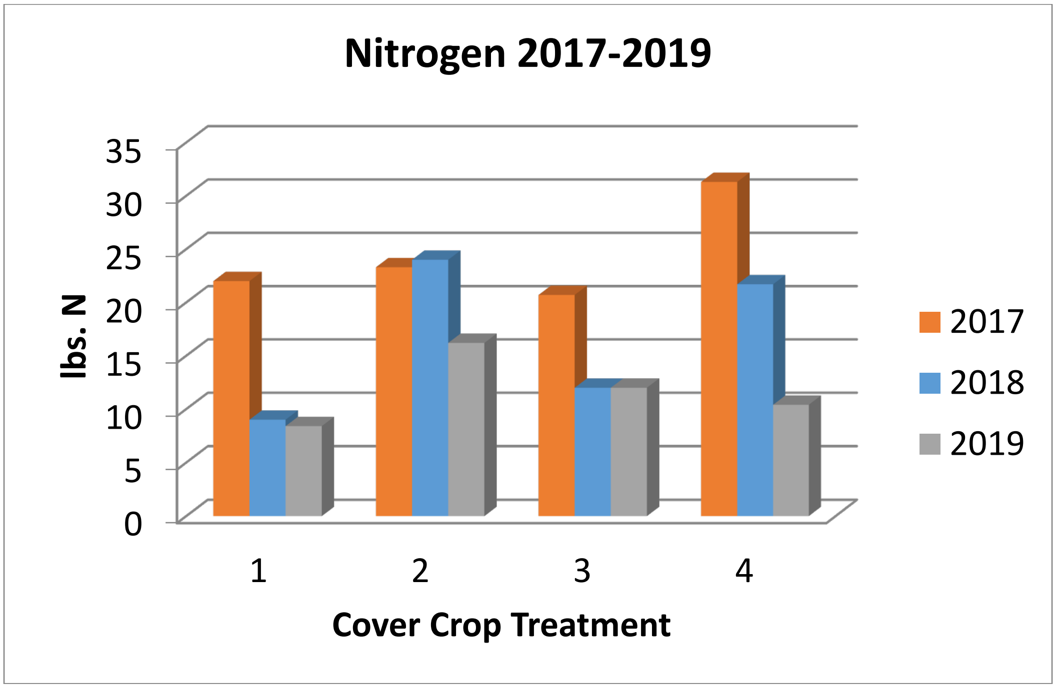
[z]Numbers in a column followed by the same letter exhibited no significant differences based on Duncan's Multiple Range Test where P=0.05.

**Table 3.** 2017 Soil sample results, Cimarron Valley Research Station, Perkins, OK

| | | lbs./acre | | | % |
|---|---|---|---|---|---|
| **Section** | **pH** | **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.

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



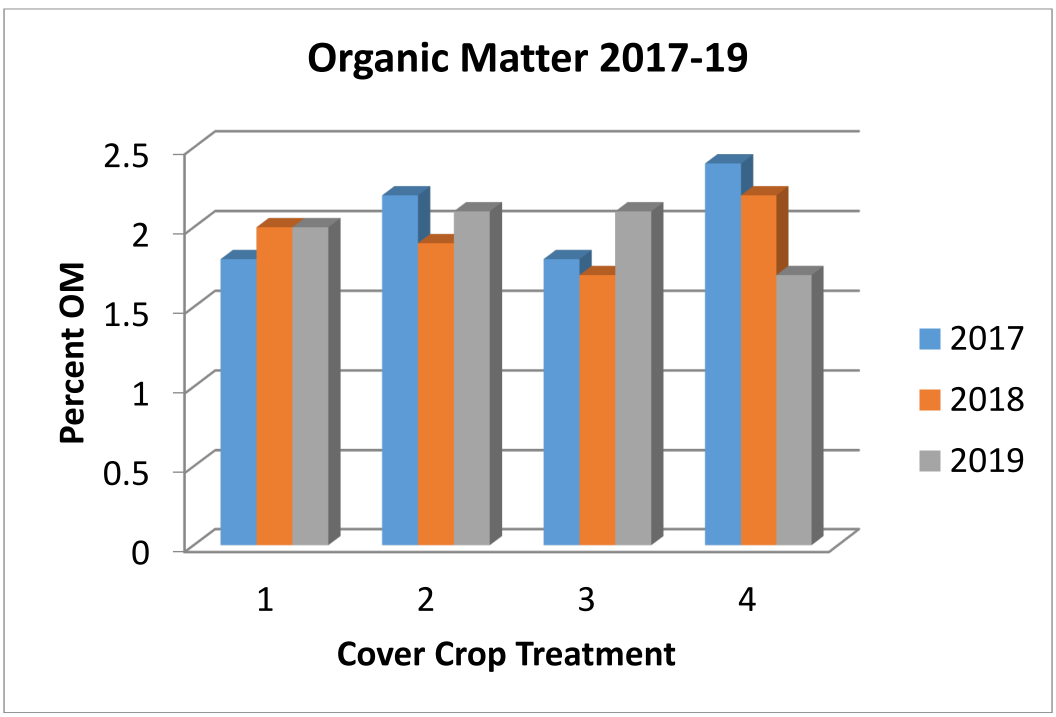



Figure 4.

Section 1 Warm Season
Sorgum Sudan + Forage cowpea

Section 2 Warm Season
Forage cowpea

Section 3 Warm Season
Pearl Millet +Forage cowpea

Section 4 Warm Season
Fallow

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## Bio-Intensive Cover Cropping for Vegetable Crop Production

**Cimarron Valley Research Station**
**Josh Massey, Lynda Carrier, & Lynn Brandenberger**

**Introduction and Objectives:** Cover cropping has potential to improve crop yield and quality by the addition of organic matter. Many areas of Oklahoma have soil organic matter levels of 0.5 to 0.7%. Increasing soil organic matter could greatly improve soil health for the benefit of vegetable production. Organic matter in soils is critical because of its Organic matter has effects on soil chemical properties affecting nutrient stabilization and fertility; and soil physical properties such as water availability and tilth, which effect 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 (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:

**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. This would mean 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.

In 2019, each treatment area was divided into five plots, 4' x 50' (200 ft$^2$). Three vegetable crops were used to determine the effect of each cover crop on their yield and quality. Spinach (*Spinacia oleracea*, var. Avon), cowpea (*Vigna unguiculata*, var. Empire), and sweet potato (*Ipomoea batatas*, var. Covington) were planted and harvested. Spinach was planted March 28$^{th}$ and harvested June 3$^{rd}$. Cowpeas were planted June 13$^{th}$ and harvested September 30$^{th}$. Sweet potatoes were planted June 6$^{th}$ and harvested October 11$^{th}$ and 14$^{th}$.

**Results:** For spinach data, stand counts were taken April 26$^{th}$, and no differences between cover crop treatments were determined, shown in Table 1. Most stands of spinach were poor, likely due to heavy rainfall the night spinach was planted. Differences in yield data are not significant with the exception of treatment 1, where spinach had died back to not be able to harvest (Table 2).

Yields for cowpea were not significantly different from one another between cover crop treatments, shown in Table 3. Differences between cover crop treatments were also not shown in sweet potato yield and quality (Table 4).

As this project continues, it is expected that differences will begin to be more indicated due to the addition of organic matter with cover crops incorporated into the soil. Organic matter is shown to decrease in the fallow treatment and generally increase in treatments with cover crops from 2017 to 2019.

**Table 2.** Summer 2019 Spinach, Perkins, OK.

| Cover Crop | Yield lbs $acre^{-1}$ *P* = 0.0481 | Stand Counts *P* = 0.0199 |
|---|---|---|
| 1 | ---- | 16.6 b |
| 2 | 107.3 b[x] | 30.2 ab |
| 3 | 74.1 b | 19.0 b |
| 4 | 424.9 a | 41.4 a |

[x] 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 3.** Summer 2019 Cowpea, Perkins, OK..

| Cover Crop | Combined Shelled peas (lbs./acre) [z] | Moisture % |
|---|---|---|
| 1 | 805 a | 16.1 a |
| 2 | 619 a | 17.4 a |
| 3 | 734 a | 16.7 a |
| 4 | 841 a | 13.6 a |

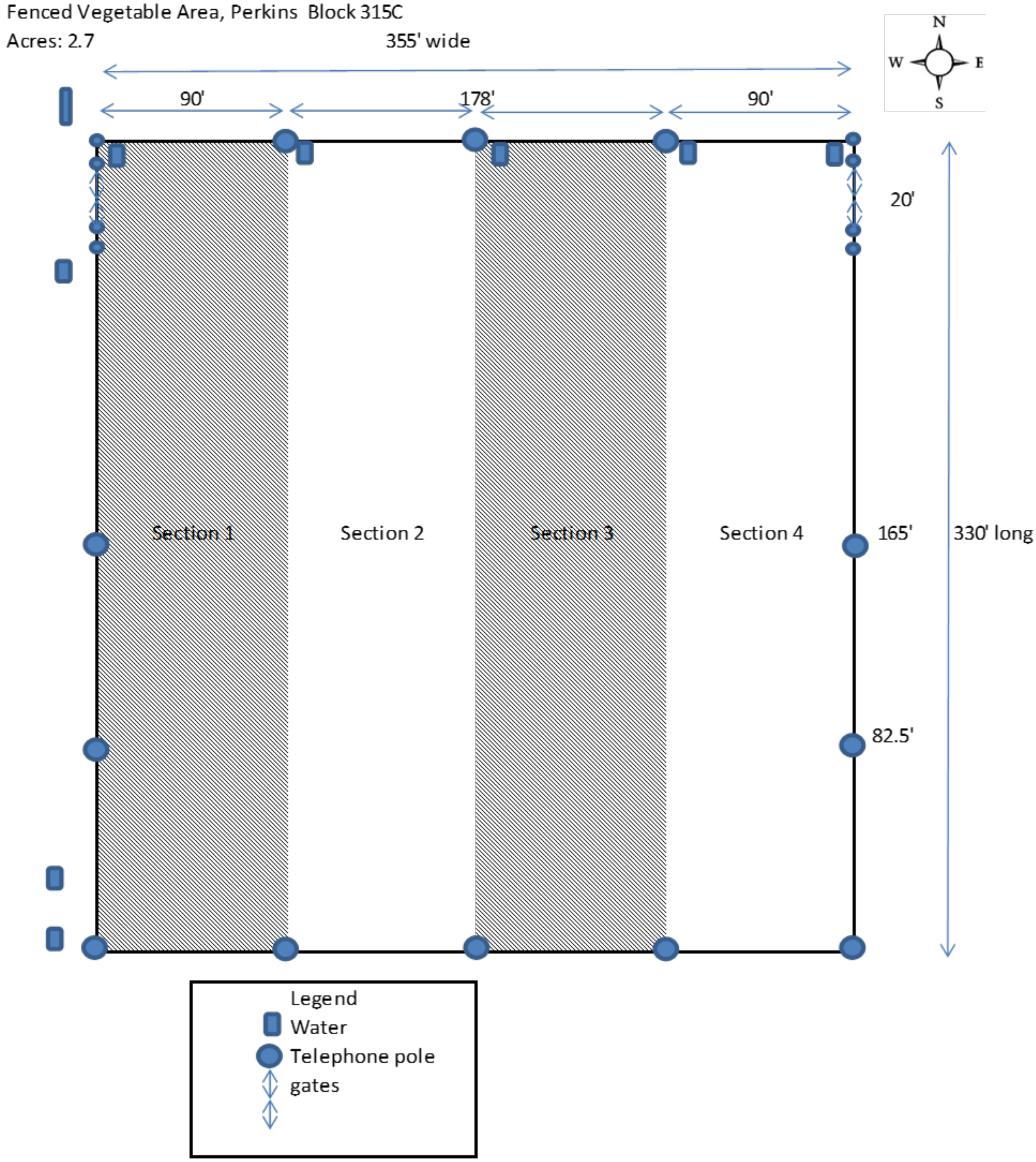
[z] **lbs./acre=** Plot size 50' long 2 row plots 3' spacing=300 (43560/300=145.2)
[y] Numbers in a column followed by the same letter exhibited no significant differences based on Duncan's Multiple Range Test where P=0.05.

**Table 4.** Summer 2019 Sweet Potato, Perkins, OK..

| | | lbs./Plot[z] | | | |
|---|---|---|---|---|---|
| **Cover Crop** | **Number marketable[y]** | **Marketable wt. [y]** | **Cull wt.[x]** | **Total marketable + culls** | **Average wt. (lbs)** |
| 1 | 209 a[w] | 181 a | 3.8 a | 185 a | 0.87 a |
| 2 | 177 a | 152 a | 2.0 a | 154 a | 0.86 a |
| 3 | 178 a | 161 a | 12.1 a | 174 a | 0.91 a |
| 4 | 190 a | 153 a | 5.7 a | 158 a | 0.80 a |

[z] **lbs./Plot=** Plot size 50' long raised bed, plants spaced 1 ½ feet apart, average number plants is 33/plot
[y] **Marketable wt. & number=**-US #1 + Canners + Jumbos.
[x] **Culls** – 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
[w] Numbers in a column followed by the same letter exhibited no significant differences based on Duncan's Multiple Range Test where P=0.05.

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

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**Sweet Potatoes at harvest**

| Cowpea’s at harvest | |
|---|---|
|  |  |

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## Eggplant Cultivar Trial 2019 – Durant, OK, Bryan County

**Freedom Acres Farm / Evan and Sarah Rowland**
**Jim Shrefler, SE District OCES**
**Robert Bourne and Brooke Hall, Bryan County OSU Extension**

Finding crops that will capture the attention of customers is one way to increase business activity at a Farmers' Market. There is typically an established demand for vegetables such as tomato and onion that are used frequently by many people and the grower can feel safe that it will be possible to sell what they produce for local market. For vegetables that are less commonplace, such as eggplant, it is more challenging to determine what customers will want to buy. Even more challenging is the need to determine which cultivars to produce since these vary widely in characteristics such as fruit size and color. In order to begin to assess the possibilities for growing eggplant for local market a cultivar trial was conducted in 2019 at the Freedom Acres Farm in Durant, which is in transition to become Organic.

The trial site was a newly established vegetable field and was planted without bedding. Rows were spaced on six foot centers. Eggplant plants were seeded on March 24 and grown on site in trays in a small greenhouse and transplanted on April1, 2019. Experimental plots consisted of a 12 foot section of row with six plants spaced 2 feet apart. There were three replications of each seven cultivars. Cultivar names, seed sources and descriptions are shown in Table 1.

Due to the relatively wet growing season soil moisture was excessive during the early portion of the crop cycle. As the plants developed there was some incidence of lodging that was attributed to decay or weak development of the lower portion of the root system due to extremely wet soil conditions in the lower region of the rooting zone. In spite of this, plant development and size appeared normal and plant heights are shown in Table 1.

Fruit were harvested 5 times over five weeks by collecting all fruit that appeared mature. For the initial harvest on July 3, fruits from the 3 replications of each cultivar were combined and then counted and weighed. Cultivar fruit numbers are shown in Table 2. For harvests made on July 12, 19 and 26 fruits were counted individually for each replication and shown in Table 2. The average weight per individual fruit of each cultivar was also determined using fruits harvested on July 12, 19 and 26. Fruit appearance is shown in Figure 1.

**Table 1.** Eggplant cultivars, seed sources, plant height, fruit weight and descriptions in the 2019 cultivar trial at Durant

| Cultivar | Seed source | Plant height[z] (inches) | | Fruit weight[x] (ounces) | Cultivar description |
|---|---|---|---|---|---|
| Listada de Gandia | Southern Exposure Seed Exchange | 27.6 | bc | 13.3 | Light purple with stripes |
| Annina | Harris seeds | 32.0 | a | 10.9 | Medium purple with stripes and oblong |
| Galine | Johnny's Seeds | 28.7 | ab | 12.3 | Dark solid purple and wide shape |
| Classic | Harris Seeds | 29.3 | ab | 13.6 | Dark purple |
| Traviata | Johnny's Seeds | 25.0 | c | 10.9 | Dark solid purple |
| Nubia | Johnny's Seeds | 30.3 | a | 13.8 | Dark purple with stripes |
| Dancer | Johnny's Seeds | 31.3 | a | 9.8 | Light solid purples |

[z]Plant heights measure on July 7. Means followed by the same letter are not different based on Duncan's Multiple Range Test.

[x]Average weight of individual fruits across harvests made on July 12, 19 and 26. Averages were determined from a sample size of at least 34 fruits and no statistical analysis was made.

**Table2.** Eggplant fruit yields in the 2019 cultivar trial at Durant

| | Harvest date | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *- - - number of fruit per acre - - -* | | | | | | | |
| Cultivar | July 3[y] | July 12 | | July 19 | July 26 | | total July 12-26 | |
| Listada de Gandia | 484 | 2420[z] | bc | 4598 | 2904 | bc | 9922 | bc |
| Annina | 4114 | 5566 | ab | 4114 | 6292 | ab | 15972 | ab |
| Galine | 3388 | 7502 | a | 2662 | 3146 | bc | 13310 | abc |
| Classic | 3146 | 4840 | abc | 6050 | 7502 | a | 18392 | a |
| Traviata | 5566 | 2904 | bc | 2420 | 4598 | abc | 9922 | bc |
| Nubia | 2178 | 4598 | abc | 4598 | 4840 | abc | 14036 | abc |
| Dancer | 2904 | 1936 | c | 4840 | 1542 | c | 8228 | c |

[y]No statistical analysis performed.

[z]Numbers in a column followed by common letters do not differ based on Duncan's Multiple Range Test

**Figure 1.** Eggplant fruit appearances as harvested.
Cultivars are as follows:
Column 1 (top to bottom) Classic, Traviata, Listada de Gandia
Column 2 (top to bottom) Galine, Annina, Dancer
Column 3 Nubia

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## Direct Seeding Establishment of Bell and Spice Pepper

**Cimarron Valley Research Station**
**Andi Nichols, Lynn Brandenberger, Lynda Carrier**
**Oklahoma State University**

**Introduction:** Pepper crops grown in Oklahoma include peppers for fresh markets such as farmer's markets, restaurants, etc. and pungent peppers grown for use in salsas, sauces, and the like. Pepper production accounts for 500-600 acres of production in Oklahoma, with an overall annual value of 2 million U.S. dollars. Our producers face multiple issues each year including pests, disease and greenhouse costs associated with transplant production. Research on direct seeding establishment was initiated in 2018 and will continue into 2020 with the goal of establishing productive and efficient direct seeding methods for peppers in Oklahoma to alleviate some of the input costs and issues that local producers face.

**Methods and Materials:** This year's study was conducted using Okala spice peppers and California Wonder bell peppers. Two planting dates were used based on soil temperatures. The first planting took place on April 11, 2019 with an average soil temperature of 63°F and the second planting was on June 11, 2019 with an average soil temperature of 72°F. Other treatments included seed priming and cover crops. Seed priming agents were selected from greenhouse trial results that took place in March 2018 and March 2019 at the OSU research greenhouses located in Stillwater, OK. The results showed significant increases in emergence for bell pepper from the potassium chloride (KCL) treatment and significant increases in emergence for spice pepper from the calcium chloride ($CaCl_2$) treatment. The same priming methods were used for field trial seeds and non-treated seeds were used as a control. Four cover crop treatments are located within the field and have been in cycle for two years before the trial began(Table 1). Seeds were planted at $^1/_2$ inch depth with our research planter at a seeding rate of 1-2 seeds/row foot. Plots were 13 feet long with 4 foot alleys and each row was placed within their corresponding cover crop treatment area and consisted of 16 plots with 4 treatment reps.

**Results and Discussion:** Data was collected on plant counts for emergence every 3-4 days for the first two weeks following the start of emergence of each planting date. Bell pepper emergence exhibited significant differences between controls and seed treatments, but this response varied between cover crop treatments. The data exhibited the highest difference between control and treated seeds in cover crop areas 1 and 2, but recorded no difference within treatments 3 and 4 (Figure 1). The data indicates that seed priming improved establishment for direct seeding. Producers would likely observe higher emergence rates through the use of strip tilling and cover crops and the use of a seed priming agent. The type of cover crop used may also affect seed priming efficacy. Results indicate that using KCl as a seed priming agent may improve emergence of direct seeded bell pepper depending on specific cover crops that will be used.

Spice pepper emergence also exhibited significant differences between controls and seed treatments, and this response again varied with cover crop treatments (Figure 2). In cover crop area 1, seed priming improved emergence, while in cover crop 2, seed priming reduced emergence, and seed priming again had no effect in cover crops 3 or 4. The inconsistency in response to seed priming suggest this method, or the specific priming agents, may not be a beneficial option for producers to implement when direct seeding spice pepper.

| 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 |

**Figure 1. 2018 and 2019 Bell Pepper Emergence by Cover Crop Treatment**

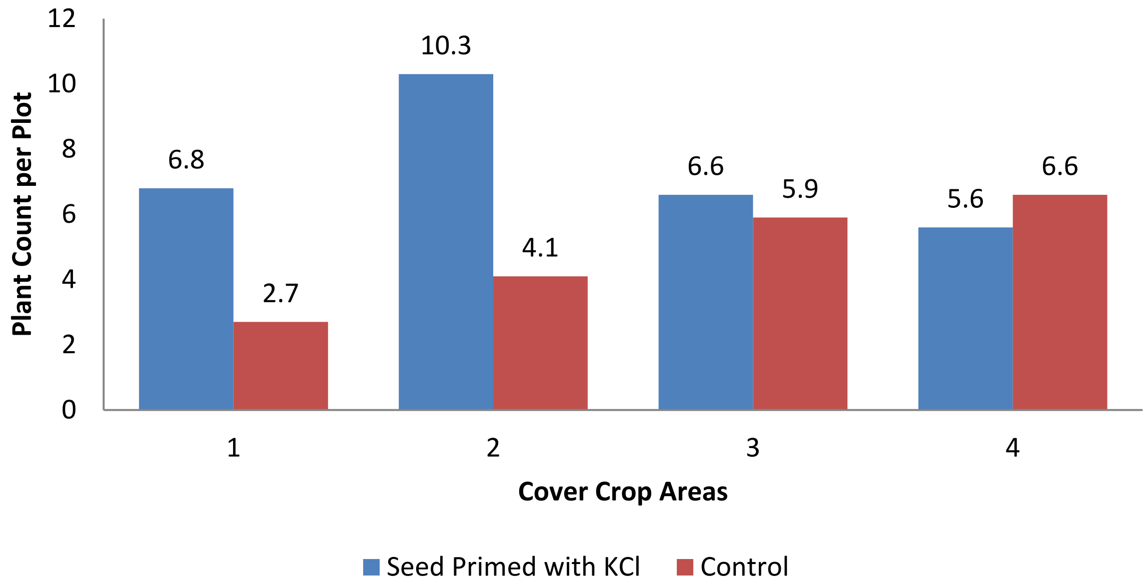
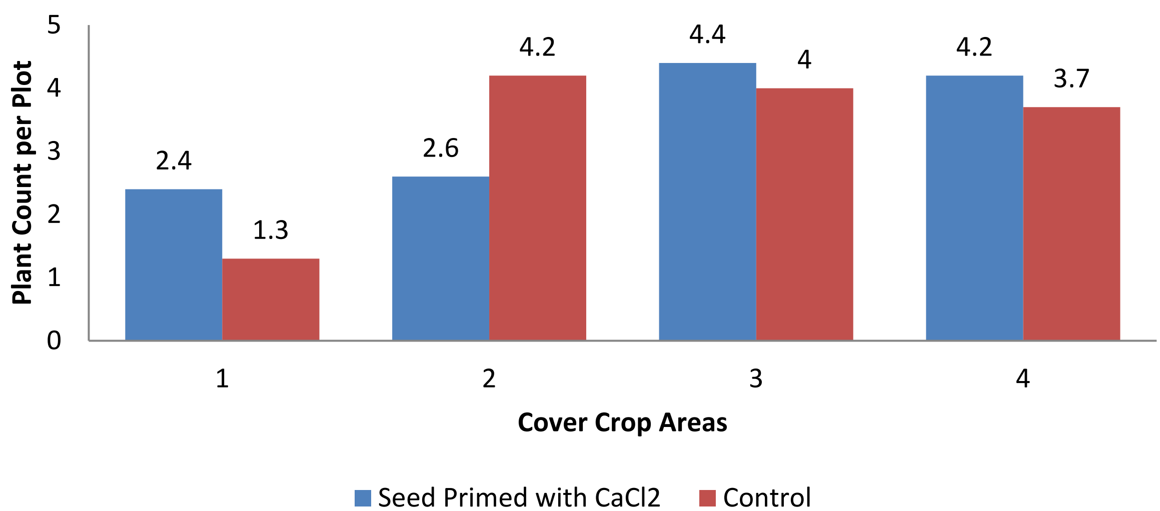



**Figure 2. 2018 and 2019 Spice Pepper Emergence by Cover Crop Treatment**




Based on the results from this research, all treatments performed at a higher rate for both pepper types within cover crop area 2 (Figure 1 and 2). Cover crop treatment 2 area consists of cowpea for warm season cover crops and winter wheat mixed with crimson clover for the cool season. Planting date needs to be examined further, but the results from this research are encouraging.

The soil temperatures varied at each planting date as did emergence counts. This could be evidence of soil temperature having a greater effect on pepper emergence than originally thought as plant counts varied greatly when soil temperatures varied by a few degrees.

This provides further evidence that not just one aspect of the study can be implemented with the expectation of similar results. These fields trials will be conducted once more in 2020 and authors hope to clarify a few aspects of the protocols, including planting date in regards to soil temperature and cover crop effects on emergence.

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## Integrated Cucurbit Crop Scheduling
## Pest and Pollinator Management
### Preliminary Report

**Eric Rebek, Jim Shrefler, Lynda Carrier, Hollie Thorne,**
**Lynn Brandenberger, DeAnthony Price and Matt Beartrack**

**Introduction:** Summer squash is a popular vegetable crop both for commercial fresh market farms and home gardens. The primary insect pest of all squash is squash bug (*Anasa tristis*) which overwinters in the previous year's crop debris and can be devastating to squash crops. Control methods include crop rotation, cleaning up and destroying crop debris at the end of the growing season to remove overwintering sites for adult squash bug and consistent monitoring and the use of approved insecticides. All squash producers are challenged to manage this insect pest, but organic producers particularly struggle due to the limited number of effective insecticides. Therefore, the current challenge is to determine how to establish and produce squash with limited or no use of pesticides.

The objective in this study was to determine the effect of covering squash with insect excluding row covers to reduce the number of insects. Squash bugs are the primary pest for this crop which can destroy the crop quickly and spread to remaining plants. Two different types of studies were done with row covers, one focused on removal of one type of cover at different times. Covers were removed at 1, 2, 3, and 4 weeks after bloom to allow pollinator access. The study we will discuss involved 3 different types of row covers with daily removal for pollinator access. Due to multiple locations of the studies, only preliminary data are currently available and more insect data will be available in January 2020. This preliminary report focuses on the study at the Botanic Garden Student Garden where the daily removal program was used.

**Methods and Materials:** Treatment plots consisted of free standing raised beds with drip irrigation tape buried in the middle of the bed. These beds were installed on 5/16/19. The experimental design included a randomized block design with three replications. Yellow squash variety 'Lioness' was direct seeded on 5/28/19 by hand-planting 6 seeds per plot, with seed spaced 2 feet apart in the row. Plots were 15 feet long with 5' alleys between rows. Following direct seeding plots were sprayed with the pre-emergence herbicide 'Strategy' at a rate of 4 pts /acre on May 30th. Three lbs. of 10-30-20 blossom booster fertilizer was added through a fertilizer injector on 5/28/19. Additionally, on 6/25/19 and 7/2/19. 46-0-0 fertilizer was also added through an injector at a rate of three lbs. on 6/10/19. An equivalent of 66- 78- 52 lbs. per acre of N, $P_2O_5$, and $K_2O$ was applied during the trial period to meet crop fertility needs according to soil testing results. On June 3$^{rd}$ rebar and hoops were installed and row cover treatments were put over hoops. (Table 1 and Figure 1) July 9$^{th}$ treatment 1 (no cover) plots were harvested for the first time and uncovering of the covered treatments began. Covers were opened at 7:00 am each morning and closed by noon each day to allow pollinators to access flowers during peak activity. This continued daily until August 5, 2019. Harvest continued 2-3 times a week and final harvest was on September 3$^{rd}$. Yield data included weight, number of marketable fruit and cull fruit. Insect pest incidence (species and abundance counts) were done 2 times a week starting June 20 and continued until July 20$^{th}$.

**Results:** Yield data was recorded and analyzed (Table 2.) The number of Marketable fruit/plot did not vary significantly; although it was noted treatment 1 (no cover) had the earliest harvest, possibly due to pollinators being able to access flowers earlier. There were no differences in marketable yield (pounds/plot), but in non-marketable, treatment 2 (1 oz. cover) had significantly higher culls, with cull fruit being moldy (*Choanephora cucurbitarum)*. Stillwater had record rainfalls during the month of May and continued all summer. Humidity was high and the 1 oz. material appeared to keep an abundance of moisture under the cover. It was noted that when removing the covers each morning that treatment 2 had an excess of moisture under the cover. Temperature and humidity readings were recorded to see what differences there were between treatments on 8/6/19 Sunny and had recently rained.

Treatment 1 and 3 (no cover and woven mesh) air temp 97 Relative humidity 36%

Treatment 2 and 4 (1 oz. and 0.5 oz. material) air temp 109 Relative humidity 68%. We also took temps on a cloudy day and saw little or no difference in air temperature.

At the conclusion of the study on Sept 3, live plant counts were taken and recorded (Table 3.). Treatment 1 (no cover) had fewer live plants but was not significant. Preliminary insect data indicates treatment 1 (no cover) had a higher number of insects, squash bugs in particular. Further data will be published in an updated version of the study.

**Conclusions:** Treatments recorded few differences in overall yield, however more data will focus on squash bug counts in each of the treatments and may show differences for extending the plant life with covers. The possibility of using the covers to extend the harvest and growing season is a consideration; however the 1 oz. material had significant differences in non-marketable fruit, due to the moldy fruit. The temperature and relative humidity under the 0.5 oz. material and 1 oz. material was considerably higher than the woven mesh or no cover. The 0.5 oz. material was lighter and had fewer issues with retaining water under the cover, however in windy situations it would tear and needed to be repaired or replaced. In the no cover treatment most plants had died from squash bugs by the conclusion of the study where the covered treatments had several viable plants producing fruit. The woven mesh appeared to be a compromise of excluding pests, being sturdy and not retaining humidity.

**Table 1. 2019 Yellow Squash Insect pest exclusion, Botanic gardens, Stillwater, OK**

| Treatment # | Treatment |
|---|---|
| 1 | No Cover |
| 2 | DeWitt Row cover deluxe plus (1 oz. material) |
| 3 | Woven mesh |
| 4 | DeWitt Row cover 0.5 oz. material |

**Table 2. 2019 Yellow Squash Insect pest exclusion, Botanic gardens, Stillwater, OK**

| Treatment | Marketable number of fruit/plot | Marketable yield/plot | Non-marketable | Marketable + Non marketable | Average fruit weight |
|---|---|---|---|---|---|
| | | ----------------------------Pounds------------------------ | | | |
| No Cover | 59 a | 39 a | 1 b | 40 a | 0.23 a |
| DeWitt Row cover deluxe plus 1 oz. material | 85 a | 48 a | 19 a | 67 a | 0.33 a |
| Woven mesh | 86 a | 60 a | 5 b | 65 a | 0.34 a |
| DeWitt Row cover 0.5 oz. material | 96 a | 59 a | 5 b | 64 a | 0.21 a |

[z] plot size=6 plants per plot, spaced 2' apart on raised beds. To figure yield in lbs./acre multiply by 290

[y] Harvest 7/9/19 to 9/3/19

[x] 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 3. 2019 Yellow Squash Insect pest exclusion, Botanic gardens, Stillwater, OK**

| Treatment | Average Number plants at conclusion of harvest (9/9/19) |
|---|---|
| No Cover | 2.3 a |
| DeWitt Row cover deluxe plus 1 oz. material | 5.3 a |
| Woven mesh | 3.7 a |
| DeWitt Row cover 0.5 oz. material | 4.7 a |

Numbers in a column followed by the same letter exhibited no significant differences based on Duncan's Multiple Range Test where P=0.05.

**Figure 1.**

| Trt 1 No cover | at Conclusion 9/9/19 |
|---|---|

Trt 2 1 oz. material

at Conclusion 9/9/19

Trt 3 Woven mesh


at Conclusion 9/9/19

Trt 4 0.5 oz. material


at Conclusion 9/9/19

Covered

Moldy fruit (trt. 2)


All treatments

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# High Tunnel Spinach Trial

**Lynn Brandenberger, Lynda Carrier**
**Oklahoma State University**

**In cooperation with Don Blehm, Eva Bierig, and Debby Taylor**
**Hitchcock, Oklahoma**

**Introduction and Objectives:** High tunnel vegetable crop production is used in the U.S. and worldwide. A key aspect of fresh market growing is producing and selling crops year round. Results from high tunnel trials in 2012 (Brandenberger et al. 2012) indicated that fresh spinach was very popular in the market and had the potential to be one of the more profitable leafy greens that could be produced in a high tunnel. Spinach ranks high in its nutritive value and compares well with other leafy greens. Previous efforts by Blehm Farms resulted in the need for purchasing spinach plants for transplanting into production beds in the high tunnel. Due to the cost, inconvenience of ordering, and shipping the grower desired to determine if spinach transplants could be grown on-site. The objectives of this trial were two-fold: First to determine if spinach transplants could be grown on-site and second to trial several spinach cultivars to determine which ones would perform well under the operations conditions.

**Methods:** Spinach seed were pre-germinated four days prior to seeding into Oasis blocks for seedling germination and growing. Pre-germination consisted of a 24 hour soak of seeds at approximately 40$^{o}$F, followed by a triple rinsing of soaked seed, draining and then placement of soaked seeds in a wetted paper towel after it had been wetted and wrung out. After placement between two layers of the prepared paper towel the seeds and towel were then placed into a large zippered plastic bag with the end left slightly open to allow air exchange into the bag. Seed and paper towel were checked once or twice per day (2-3 days) and once seed radicles began to emerge the seed were ready to be placed into ¾ x ¾ inch “Oasis” cubes to complete germination and seedling growth.
Spinach plants were transplanted into a soilless planting mix (BM-7) on May 10, 2019. Planting mix was held in a large open container created from multiple new leaching chambers lined with landscaping fabric to stabilize the planting mix while allowing for drainage of excess water from the containers. Plot size was approximately 2.3 square feet with approximately 21 plants per plot. Crop fertility was managed through the addition of 20-20-20 water soluble fertilizer through the irrigation water.

**Results:** Yields did not vary significantly between cultivars in the trial for any of the three harvests or for the total yield (Table 1). Yield ranged from 0.5 to 1.1 lbs. per square foot for the first harvest (May 10) with Avon having the highest yield (1.1 lbs.) Yields on May 17 were the highest of the three harvest dates with yield ranging from 2.5 to 3.5 lbs. per square foot. Avon, Banjo, Emperor, and Persius had yields of 3.5, 3.3, 3.1, and 2.5 lbs., respectively. On May 24 yield ranged from 1.8 for Avon and Banjo to 2.7 and 2.1 lbs. per square foot for Emperor and Persius, respectively. Overall yield was 6.5, 5.7, 6.4, and 5.2 lbs. per square foot for Avon, Banjo, Emperor, and Persius, respectively.

Observations were made at the end of the trial regarding the condition of the crops. Bolting (flowering) was noted although no ratings were taken for bolting. Spinach in general will flower at day lengths longer than 11.5-12 hours so it was not unexpected to observe bolting in cultivars included in the trial.

**Conclusions:** The trial allowed the growers to gain experience with new cultivars that they had not previously grown and to gain knowledge on how to germinate and produce spinach transplants from seed. Although there were no differences observed for yield Avon and Emperor did record higher yields overall.

**Acknowledgements:** The author would like to thank Don Blehm, Eva Bierig, and Debby Taylor for conducting the trial at Blehm Farms.

**Citations:** Lynn Brandenberger, Charles Rohla, Steve Upson, Jim Shrefler, Warren Roberts, Merritt Taylor, Tony Goodson, Wyatt O'Hern, Julia Laughlin, Brian Kahn, Rex Koelsch, Marie Koelsch, Sue Gray, and Lynda Carrier. 2012. Final Report for Extended Season Leafy Greens Research, E-1031, Oklahoma Cooperative Extension Service. Pp. 22. http://www.hortla.okstate.edu/outreach/pdfs/high-tunnel-leafy-greens.

**Table 1. 2019 High Tunnel Spinach Variety trial, Don Blehm, Omega, OK**

| | | Yield (lbs./ft$^2$)$^z$ | | | |
|---|---|---|---|---|---|
| **Variety** | **Seed Source** | **May 10** | **May 17** | **May 24** | **Total** |
| Avon | Sakata | 1.1 a | 3.5 a | 1.8 a | 6.5 a |
| Banjo | Seedway | 0.5 a | 3.3 a | 1.8 a | 5.7 a |
| Emperor | Sakata | 0.6 a | 3.1 a | 2.7 a | 6.4 a |
| Persius | Sakata | 0.7 a | 2.5 a | 2.1 a | 5.2 a |

[z] Yields reported on a pounds per square foot basis.
[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.

**Figure 1.** Blehm Farm high tunnel spinach trial 2019.

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## Quality Evaluations of Fresh Market Tomatoes– Stillwater

**Lynda Carrier, Ty Bowman, Matt Beartrack, & Lynn Brandenberger**
**Oklahoma State University**
**Stillwater, OK**

**Introduction and Objectives:** Tomato [*Lycopersicon lycopersicum* (L.) Karsten] originated in South America in Bolivia or Peru. It is a warm weather crop and a member of the Solanaceae family—also known as the nightshade family. Tomatoes did not become popular in the United States until later in the 1800s but were introduced in 1710. The objectives for this trial were to examine varieties used primarily for greenhouse production and compare yield differences in tomatoes from three different treatments; greenhouse, high tunnel and field grown. Research at Oklahoma State University and Langston University will evaluate tomato production in three different growing systems to compare yield and quality to support local market production. Field production of tomatoes still dominates the market, however use of season extending production systems like greenhouses and high tunnels is increasing to meet market demands of readily available tasteful tomatoes. Both greenhouse and high tunnel production are thought to improve yields and nutritional quality with fewer inputs compared to field production by allowing growers to avoid Oklahoma's unpredictable weather. This research will evaluate cultivars of two different types of tomato (slicing and cherry) using similar cultivars adapted to each system. Objective testing procedures will determine quality characteristics not only yield to better market crops. The results of the field study are one part of the three part study, this part is focusing on field production only. The outcomes include a taste panel, lycopene results and field harvest data.

**Methods:** Tomatoes were direct seeded into soilless media [Sungro Professional Growing Mix] in the finish containers [Landmark plastic; 4 x 9 (36 cell) six-packs] on 3/15/19. Plants were unable to be transplanted due to extremely wet conditions and remained in the greenhouse until 5/7/19 when transplants were moved to an outdoor hardening facility. Raised beds and drip tape were installed on 5/16/19. Tomatoes were transplanted into all plots on 5/16/19 with in-row spacing at two feet apart with a total of six plants per treatment plot. Beds were spaced 10' apart from center of each bed, plots were 12' long. After transplanting Stillwater received additional heavy rains, which caused erosion and some plants had to be replaced the following week. During the month of May the test site received over 17 inches of rainfall. Tomatoes were supported using the stake and weave method with baling twine and metal pipes. Three lbs. of 10-30-20 blossom booster fertilizer was added through a fertilizer injector on 5/28/19. Additionally, on 6/25/19 and 7/2/19. 46-0-0 fertilizer was also added through an injector at a rate of three lbs. on 6/10/19. An equivalent of 66 - 78 - 52 lbs. per acre of N, $P_2O_5$, and $K_2O$ was applied during the trial period to meet crop fertility needs according to soil testing results. Insect pests included tobacco horn worm and yellow-striped armyworms which were treated with Permethrin one time on 6/21/19 applied at a rate of 0.10 lbs. ai/acre. The experimental design included a randomized block design with three replications. Treatment plots consisted of free-standing raised soil beds with drip irrigation tape buried in the middle. Harvest started on 7/12/19 and continued until 9/4/19 a total of 13 harvests were recorded. Fruit were determined as marketable or culls, and those in both categories were counted, then weighed for each plot. Tomatoes were divided into 2 groups; Cherry and slicer for statistical purposes (Table 1). There were 3 cherry tomato varieties and 6 slicer varieties.

**Results:** On July 22, 2019 we conducted a taste panel with 15 participants. Tomatoes were cut into small bite sized pieces and placed on a plate with a corresponding number. The varieties were not separated by type. Participants were asked to rate them on a 0-10 scale. Most desirable taste=10 and a 0 would be undesirable flavor. Due to lack of ripe fruit with BHN 964, it was not included in the sampling. Garden Treasure, a slicer, had the highest flavor ratings with a 6.1, followed by BHN 268 a cherry tomato. The least liked tomato was Geronimo at 3.8. (Table 2).

The lycopene concentration in ug/gm is a measure of lycopene “strength” in the fruit tissue. ug/fruit brings in mass of the fruit. Lycopene results for the cherry tomatoes had very little significance; (Table 3) overall ug/g recorded no significance. ug/fruit, BHN 268 had the highest at 650 ug/fruit, Favorita had the lowest at 250 ug/fruit as it is the smallest fruit also. Lycopene results for the slicers (Table 4) Overall ug/g all three University of Florida varieties were much higher than the other varieties, Garden Gem, Garden Treasure, and W had 76, 77, and 76 respectively. BHN 964, Geronimo and Trust were 45, 40, and 41 respectively. Garden Treasure had the highest concentration of lycopene with 11,706 ug/fruit. Overall Garden Treasure topped the taste panel and lycopene results.

Marketable yield for Cherry tomatoes (Table 5.) did not have significance; however cull weight had significance, BHN 268 had the most cull fruit, this is believed to be from the excessive rainfall that caused splitting in this variety, while Favorita and Sakura had minimal culls and splits. Overall weight including culls, BHN 268 had the highest yield and was also the largest cherry fruit at 0.04 lbs. All the Cherry varieties produced fruit in the early market, which was the first 4 weeks.

The slicer tomatoes (Table 6) had several differences in the number of marketable fruit ranging from a low with BHN 964 having 89 marketable fruit per plot and at the high end with Garden Gem at 425 marketable fruit. The size of the tomatoes also reflects the number of fruit where BHN 964 had the largest fruit size at 0.43 lbs. per fruit and Garden Gem with the smallest fruit at 0.11 lbs. per fruit. The variety W had the earliest fruit where Trust had the fewest in the early market. In overall marketable weight Geronimo topped the numbers with 48 lbs. per plot, followed by Garden Gem, Garden Treasure and W. Trust had the lowest marketable weight with 19 lbs. per plot. Geronimo also had the highest total weight at 58 lbs. per plot and Trust had the lowest total weight at 34 lbs. per plot.

**Acknowledgements:** The author would like to thank Niels Maness and Donna Chrz for sampling lycopene content.

**Table 1. 2019 Tomato Variety trial, Botanic gardens, Stillwater,OK**

| Variety | Seed Source | Type |
|---|---|---|
| ***Cherry*** | | |
| BHN 268 | Rupp | Determinate Cherry |
| Favorita | Paramount | Indeterminate Cherry |
| Sakura | Johnny’s | Indeterminate large Cherry |
| ***Slicer*** | | |
| BHN 964 | Rupp | Determinate 10 oz. fruit |
| Geronimo | Johnny’s | Indeterminate large fruit |
| Trust | DeRuiter | Indeterminate Beefsteak |
| Garden Gem | U of Florida | Semi-determinate 2 oz. fruit |
| Garden Treasure | U of Florida | Indeterminate 8 oz. fruit |
| W | U of Florida | Determinate 6 oz. fruit |

**Table 2. 2019 Tomato Tasting, July 22, 2019**

| Variety | Rating (0-10)10 being best flavor |
|---|---|
| BHN 268 | 6.0 a |
| Favorita | 5.1 ab |
| Sakura | 5.5 ab |
| BHN 964 | N/A |
| Geronimo | 3.8 b |
| Trust | 4.7 ab |
| Garden Gem | 5.8 ab |
| Garden Treasure | 6.1 a |
| W | 5.7 ab |

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 3. 2019 Tomato lycopene results, cherry varieties, Botanic garden, Stillwater, OK**

| | Lycopene ug[z] | | |
|---|---|---|---|
| **Variety (cherry)** | **ug/g** | **ug/fruit** | **Average Fruit wt. (g)** |
| BHN 268 | 38 a[y] | 650 a | 17.3 a |
| Favorita | 37 a | 250 b | 6.7 c |
| Sakura | 46 a | 554 a | 12.1 b |

[z] Lycopene ug=micrograms/gram, micrograms/fruit, ug/fruit=micrograms/g x avg. fruit weight.
[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.

**Table 4. 2019 Tomato lycopene results, slicer varieties, Botanic garden, Stillwater, OK**

| | Lycopene ug[z] | | |
|---|---|---|---|
| **Variety (Slicer)** | **ug/g** | **ug/fruit** | **Average Fruit wt. (g)** |
| BHN 964 | 45 b[y] | 7,575 b | 168 a |
| Geronimo | 40 b | 5,703 c | 137 ab |
| Trust | 41 b | 4,761 cd | 118 b |
| Garden Gem | 76 a | 3,596 d | 47 c |
| Garden Treasure | 77 a | 11,706 a | 151 ab |
| W | 76 a | 8,346 b | 109 b |

[z] Lycopene ug=micrograms/gram, micrograms/fruit, ug/fruit=micrograms/g x avg. fruit weight.
[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.

**Table 5. 2019 Tomato harvest data on field grown, Botanic garden, Stillwater, OK**

| Variety (Cherry) | Number marketable fruit | Yield (lbs./plot)[z] Early Mkt[y] (First 4 weeks) | Weight marketable | Weight Culls | Total weight | Average size (lbs.) |
|---|---|---|---|---|---|---|
| BHN 268 | 1165 b[x] | 18 a[x] | 43 a | 15 a | 58 a | 0.04 a |
| Favorita | 2290 a | 9 a | 30 a | 2 b | 32 b | 0.01 c |
| Sakura | 1633 ab | 10 a | 35 a | 2 b | 37 ab | 0.03 b |

[z] Plots=12' long on raised beds, 6 plants/plot, spaced 2' apart. To figure yield in lbs./acre multiply by 363

[y] Early Mkt=Early Harvest began on 7/12/19 to 8/5/19 (4 weeks). Harvest data continued to 9/4/19 (total of 9 weeks)

[x] 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 6. 2019 Tomato harvest data on field grown, Botanic garden, Stillwater, OK**

| Variety (Slicer) | Number marketable fruit | Yield (lbs./plot)[z] Early Mkt[y] (First 4 weeks) | Weight marketable | Weight Culls | Total weight | Average size (lbs.) |
|---|---|---|---|---|---|---|
| BHN 964 | 89 b[x] | 4 b[x] | 36 ab | 12 a | 48 ab | 0.43 a |
| Geronimo | 184 b | 4 b | 48 a | 10 ab | 58 a | 0.27 c |
| Trust | 91 b | 2 b | 19 b | 15 a | 34 b | 0.22 d |
| Garden Gem | 425 a | 12 ab | 41 a | 5 b | 46 ab | 0.11 e |
| Garden Treasure | 111 b | 13 ab | 38 a | 13 a | 51 ab | 0.34 b |
| W | 153 b | 17 a | 41 a | 10 ab | 51 ab | 0.27 c |

[z] Plots=12' long on raised beds, 6 plants/plot, spaced 2' apart.. To figure yield in lbs./acre multiply by 363

[y] Early Mkt=Early Harvest began on 7/12/19 to 8/5/19 (4 weeks). Harvest data continued to 9/4/19 (total of 9 weeks)

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

**Figure 1.**


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# Tomato Cultivar Trial 2017

## Boswell, OK, Choctaw County

**Marty Montague, Patti Testerman, Macy Jo Maxwell and Jim Shrefler, SE District OCES**
**Lynn Brandenberger and Lynda Carrier, OSU Department of Horticulture**
**Cooperating Growers – Rod and Christine Hammond**

In southeast Oklahoma there is interest on the part of retailers to source locally grown produce and tomatoes are a primary concern. Whether for commercial scale sales or market gardeners, successful production of vegetables requires using cultivars that are adapted to the production location and that will provide adequate yields of marketable quality fruits. Trials reported recently for other areas of Oklahoma identified several cultivars that performed well for mid-summer production. This trial was conducted on a local farm to further evaluate some of these previously identified cultivars and included Solar Fire, Celebrity, Bella Rosa, Valley Girl and Red Morning. The trial site was an established vegetable garden and was planted without bedding. Fertilizer was applied based on the grower's usual practice (which resulted in tomato plants with good vigor and color). Rows were spaced on six foot centers. Tomato plants were grown in the OSU Horticulture greenhouses in Stillwater and transplanted on May 1, 2017. Experimental plots consisted of a 12 foot section of row with six plants spaced 2 feet apart. There were three replications of each cultivar. Plants were supported using a stake and weave system. Drip irrigation was installed along the plant rows.

Fruit were harvested 8 times over four weeks by collecting all fruit that were near full pink stage. Harvested fruit were classified as either marketable (fruits with little or no blemishes) or cull (severely cracked, decayed, insect damage, sunburned). Marketable fruit were weighed and counted and culls were weighed.

Initial crop development was normal and an initial harvest was made at 8 weeks after transplanting. Over the next week there was a total of 10 inches of rain at the trial location. Substantial fruit set had already occurred and the support system stakes began to lean substantially and could not be straightened due to the weight of the vines and fruit. Exposed fruit began to show signs of sunscald. In order to protect fruit from direct exposure to sunlight, metal hoop were used to support a polyester crop blanket material above the rows. Some incidence of possible leaf spot disease became evident and an application of Azoxystrobin and liquid copper fungicides was made on July 13.

Yield data are shown in the table. For marketable yield, differences were found for each of the total number of fruit, weight of fruit harvested during the first two weeks of the harvest period and for the total harvest. Red Morning produced the greatest number of fruit while Celebrity had the lowest and the remaining cultivars fell in between these. For the early harvest period Red Morning had the highest yield while the others did not differ significantly. Over the entire harvest period, Celebrity yielded less than the other cultivars. However, there were no differences detected among that group. The weight of individual fruits that were considered marketable ranged from 0.24 to 0.36 lbs. The weights of individual Red Morning fruits were less than those of the remaining cultivars.

There were no differences among the weights of the non-marketable fruit. Based on casual observation, the main causes of loss of marketability included sunburn, cracking, chewing insect feeding damage, stink bug damage, and green shoulders. In summary, all varieties in the trial produced appreciable yields of marketable quality fruit, indicating that selection of these varieties based on the previous trialing within the state was advantageous.

Tomato cultivars, yields and fruit weights in the 2017 tomato cultivar trial at Boswell, OK.

| Cultivar | Marketable fruit / acre: Total Number | | Marketable fruit / acre: Early harvest weight (lbs)[z] | | Marketable fruit / acre: Total harvest weight (lbs) | | Non-marketable fruit weight / acre (lbs) | Marketable Individual fruit weight (lbs) | |
|---|---|---|---|---|---|---|---|---|---|
| Solar Fire | 68800 | b[y] | 2628 | b | 19340 | a | 6144 | 0.28 | ab |
| Celebrity | 35200 | c | 2668 | b | 11569 | b | 7792 | 0.32 | a |
| Bella Rosa | 61800 | b | 2228 | b | 22000 | a | 4996 | 0.36 | a |
| Valley Girl | 64400 | b | 1824 | b | 19008 | a | 6664 | 0.3 | ab |
| Red Morning | 99400 | a | 5160 | a | 23690 | a | 6328 | 0.24 | b |

[z]Early harvest is for fruit harvested during the initial two weeks.
[y]Numbers within a column followed by the same letter do not differ based in Duncan's Multiple Range Test where P=0.05.

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# Pest Management

## Control of Bacterial Spot on ‘Red Mountain’ Tomato, 2019

**Brett Johnson, John Damicone, T. K. Wallace, and Madi Musick**
**Department of Entomology and Plant Pathology**

**Introduction:** Bacterial spot, caused by the bacterium *Xanthomonas* spp., is a destructive foliar disease of tomato. In a 2019 survey, this disease was identified in field-grown tomatoes throughout central and eastern Oklahoma. Control of bacterial spot has historically relied on copper containing bactericides. The objective of this trial was to evaluate several commercially available bactericide and biological control products for efficacy in controlling bacterial spot of tomato in Oklahoma. Treatments included Kocide 3000, a copper hydroxide formulation, and Cueva, a copper octanoate formulation. The fungicide Dithane contains mancozeb, which is combined with copper- based bactericides to control bacterial plant pathogens. The biological control product, Agriphage, contains a viral pathogen (phage) of the bacterial spot pathogen. The biological control product, Double Nickel, contains the bacteria *Bacillus amyloliquefaciens* strain D747, which has been demonstrated to suppress the growth of bacterial plant pathogens. Actigard is a plant defense activator that induces systemic resistance to a wide range of plant pathogens.

**Material and Methods:** The trial was conducted at the Entomology and Plant Pathology Research Farm in Stillwater in a field of Norge loam soil that was previously fallowed. Granular fertilizer (77-138-0 lb/A N-P-K) was incorporated into the soil just prior to transplanting on 17 May. The herbicide Treflan was applied at 1.5 pt/A and incorporated before transplants were set in the field. Tomato plants were grown in formed beds covered with black plastic mulch, trellised by the stake and weave method, and drip irrigated when necessary. Plots consisted of 12-ft-long rows containing 6 plants spaced 2-ft apart. The row spacing was 8-ft. Treatments were arranged in a randomized complete block design with four replications separated by a 4-ft-wide buffer zone containing a tomato plant. Two border rows of tomato plants along each side of the trial were inoculated with a pathogenic isolate of *Xanthomonas* spp. on 11 July. Plants within each buffer zones were also inoculated on 22 July. Treatments were directed to plants with 8005vs flat-fan nozzles using a CO2-pressurized wheelbarrow sprayer. The sprayer was calibrated to deliver 28 gal/A at 40 psi using two nozzles per row and 54 gal/A at 40 psi using four nozzles per row. All treatments except Agriphage were applied alone or in rotation on 7-day intervals beginning 19 June. Agriphage was applied twice within a 7-day period alone or in rotation. Monthly rainfall totals were 17.30 in. for May, 4.21 in. for June, 0.76 in. for July, 8.26 in. for Aug., and 6.51 in. for Sept. Disease incidence, the percentage of leaves showing symptoms of bacterial spot including defoliated leaves, and defoliation alone, were visually assessed on three plants per plot on 10 Aug. and 9 Sept. Plots were harvested ten times between 12 July and 16 Sept. Data were analyzed by analysis of variance using the GLM procedure of SAS 9.4 and means were separated using Fisher’s least significant difference test at P=0.05

**Results and Discussion:** Total rainfall during the cropping period of May through September was 16.93 in. above normal when compared with the 30-yr average. However, rainfall was below normal in June and July. Average daily temperatures were below normal in May and June, near normal in July and Aug., and above normal in Sept. Disease symptoms were slow to appear after inoculation, which was likely caused by the dry conditions that persisted through July. Bacterial spot incidence was reduced in August by all treatments except Double Nickel LC, while the treatments giving the best reduction in disease incidence were Actigard 50WG / Kocide 3000DF, Kocide 3000DF, and Kocide 3000DF + Dithane 75DF. Bacterial spot incidence was reduced on 9 Sept. by Actigard 50WG / Kocide 3000DF, Agriphage, Kocide 3000DF, and Kocide 3000DF + Dithane 75DF, while the greatest reduction was achieved by Kocide 3000DF +

Dithane 75DF. Defoliation on 10 Aug. was low (<10%) and was not reduced by any treatment and was significantly worse on the Double Nickel LC-treated plots when compared to the non-treated check. Defoliation was reduced on 9 September by Actigard 50WG / Kocide 3000DF, Agriphage, Kocide 3000DF, and Kocide 3000DF + Dithane 75DF, while the most significant reduction was achieved by Kocide 3000DF + Dithane 75DF. Although the majority of treatments provided a statistically significant reduction in disease symptoms compared to the non-treated check, Kocide 3000DF + Dithane 75DF and Kocide 3000DF alone, provided the best control of bacterial spot. Marketable yield did not differ significantly among treatments. The lack of a yield response to treatments was probably the result of bacterial spot developing late in the cropping season.

**Table 1.** Evaluation of bactericides and bio-controls for control of bacterial spot on 'Red Mountain' tomato, 2019.

| Treatment and rate/A (timing)[z] | Bacterial spot (%) | | Defoliation (%) | | Yield (cwt/A) | |
|---|---|---|---|---|---|---|
| | 10 Aug. | 9 Sept. | 10 Aug | 9 Sept. | Marketable | Diseased |
| Non-treated check | 24.2 a[y] | 81.3 a | 6.7 b | 44.2 bc | 111.1 a | 31.9 a |
| Actigard 50WG 0.75 oz (1,5,9,13,17) Agriphage 2.3 pt (3,4,7, 8,11,12,15,16,19,20) | 16.3 b | 75.4 ab | 7.5 ab | 49.2 ab | 97.8 a | 19.6 a |
| Actigard 50WG 0.75 oz (1,5,9,13,17) Kocide 3000DF 1.25 lb (3,7,11,15,19) | 8.8 c | 55.8 c | 5.0 b | 19.6 ef | 117.2 a | 26.4 a |
| Double Nickel LC 3 qt (1,3,5,7,9,11,13,15, 17,19) | 25.8 a | 82.1 a | 10.0 a | 59.6 a | 94.2 a | 26.2 a |
| Cueva FL 2 qt (1,5,9,13,17) Agriphage 2.3 pt (3,4,7, 8,11,12,15,16,19,20) | 12.1 bc | 78.8 ab | 5.4 b | 36.3 cd | 104.2 a | 24.5 a |
| Agriphage 2.3 pt (1-20) | 12.5 bc | 68.8 b | 6.3 b | 25.4 de | 83.1 a | 25.9 a |
| Kocide 3000DF 1.75 lb (1,3,5,7,9,11,13,15,17,19) | 5.8 c | 39.2 d | 5.0 b | 10.8 fg | 99.3 a | 12.7 a |
| Kocide 3000DF 1.75 lb + Dithane 75DF 2 lb (1,3,5,7,9,11,13,15,17,19) | 5.8 c | 27.1 e | 5.4 b | 7.5 g | 104.1 a | 11.7 a |
| P>F[x] | <0.01 | <0.01 | <0.01 | <0.01 | 0.93 | 0.34 |
| LSD (P=0.05) | 7.2 | 11.8 | 2.5 | 11.6 | NS[w] | NS |

[z] Timings 1 to 20 correspond to the spray dates of 1=19 June, 2=21 June, 3=26 June, 4=28 June, 5=2 July, 6=5 July, 7=10 July, 8=12 July, 9=17 July, 10=19 July, 11=24 July, 12=26 July, 13=31 July, 14=2 Aug., 15=7 Aug., 16=9 Aug., 17=14 Aug., 18=16 Aug., 19=21 Aug., 20=23 Aug.

[y] Means followed by the same letter are not statistically different according to Fisher's least significant difference test at P=0.05

[x] Probability of a significant treatment effect.

[w] NS=Treatment effect not significant at P=0.05.

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## Control of Bacterial Spot on 'Red Mountain' Tomato, 2018

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**Department of Entomology and Plant Pathology**

**Introduction:** Bacterial spot, caused by the bacterium *Xanthomonas* spp., is a destructive foliar disease of tomato. In a 2018 survey, this disease was identified in field-grown tomatoes throughout central and eastern Oklahoma. Control of bacterial spot has historically relied on spray programs with copper containing bactericides. The objective of this trial was to evaluate several commercially available bactericide and biological control products for efficacy in controlling bacterial spot of tomato in Oklahoma. The bactericidal products that were evaluated included Cueva, a formulation of copper octanoate, and Kocide 3000, a commonly used copper hydroxide formulation. The biological control product, Agriphage, contains a viral pathogen (phage) of the bacteria causing bacterial spot. The biological control product, Double Nickel, is a formulation of the *Bacillus amyloliquefaciens* strain D747, which has been shown to suppress the growth of bacterial plant pathogens. Actigard is a plant defense activator that induces systemic resistance to a wide range of plant pathogens.

**Material and Methods:** The trial was conducted at the Entomology and Plant Pathology Research Farm in Stillwater in a field of Easpur loam soil that was previously fallowed. Granular fertilizer (46-0-0 lb/A N-P-K) was incorporated into the soil just prior to transplanting on 11 May. The herbicides Treflan at 1.5 pt/A and Dual II Magnum at 1.5pt/A were applied between rows and incorporated before transplants were set in the field. Tomato plants were grown in formed beds covered with black plastic mulch, trellised by the stake and weave method, and drip irrigated when necessary. Plots consisted of 12-ft-long rows of 6 plants spaced 2 ft. apart. The row spacing was 8 ft. Treatments were arranged in a randomized complete block design with four replications. Replications were separated by 4-ft-wide buffer zones containing a single border plant. Treatments were directed to plants with 8005vs flat-fan nozzles using a CO2-pressurized wheelbarrow sprayer. The sprayer was calibrated to deliver 30 gal/A at 40 psi using two nozzles per row. All treatments except Agriphage were applied alone or in rotation on 7-d intervals beginning on 12 June. Agriphage was applied twice within a 7-d period alone or in rotation. Two border rows of tomato plants situated along each side of the trial were inoculated with *Xanthomonas* spp. on 27 June. Monthly rainfall totals were 3.88 in. for May, 5.97 in. for June, 3.12 in. for July, and 5.59 in. for Aug. Disease incidence, the percentage of leaves showing symptoms of bacterial spot including defoliated leaves, and defoliation alone, were visually assessed on three plants per plot on 10 Aug. and 9 Sept. Plots were harvested eight times between 7 July and 17 Aug. Data were analyzed by analysis of variance using the GLM procedure of SAS 9.4 and means were separated using Fisher's least significant difference test at P=0.05.

**Results:** Total rainfall during the cropping period of May through August was 2.68 in. above normal when compared with the 30-yr average. Temperatures were above normal in May and June, near normal in July, and below normal in August. There were no symptoms of bacterial spot prior to inoculation of border rows. Disease increased rapidly in all plots after inoculation (Table 1). The treatments of Actigard 50WG + Agriphage and Actigard 50WG + Kocide 3000 reduced bacterial spot incidence in July compared to the non-treated check. The Actigard 50WG + Agriphage treatment also reduced defoliation in July compared with the non-treated check. However, no treatment effects were evident for disease incidence or defoliation in August. Yield did not differ among treatments. However, marketable yield was numerically lowest in the Actigard 50WG + Agriphage treatment, which is consistent with reports of reduced yield resulting from Actigard 50WG. Some treatments reduced levels of bacterial spot. However, none provided adequate disease control. This poor disease control may be due to conditions being persistently conducive for disease development.

**Table 1.** Evaluation of bactericides and biocontrols for control of bacterial spot on 'Red Mountain' tomato, 2018.

| Treatment and rate/A (timing)[z] | Bacterial spot (%) | | Defoliation (%) | | Yield (cwt/A) | |
|---|---|---|---|---|---|---|
| | 23 July | 24 Aug. | 23 July | 24 Aug. | Marketable | Diseased |
| Non-treated check | 87.5 ab[y] | 96.7 a | 41.7 a | 75.9 a | 49.3 a | 9.1 a |
| Actigard 50WG 0.75 oz (1,4,7,10,13) Agriphage 2.3 pt (2,3,5,6,8,9,11,12,14,15) | 71.2 c | 91.7 a | 23.3 b | 68.3 a | 39.2 a | 7.3 a |
| Actigard 50WG 0.75 oz (1,4,7,10,13) Kocide 3000DF 1.25 lb (2,5,8,11,14) | 72.9 c | 93.3 a | 30.9 ab | 74.5 a | 44.4 a | 7.4 a |
| Double Nickel LC 3 qt (1,2,4,5,7,8,10,11,13,14) | 89.2 a | 89.2 a | 45.0 a | 70.8 a | 44.4 a | 8.8 a |
| Cueva FL 2 qt (1,4,7,10,13) Agriphage 2.3 pt (2,3,5,6,8,9,11,12,14,15) | 79.2 bc | 91.7 a | 30.4 ab | 72.5 a | 48.4 a | 8.1 a |
| P>F[x] | <0.01 | 0.23 | 0.05 | 0.60 | 0.90 | 0.92 |
| LSD (P=0.05) | 9.0 | NS[w] | 15.3 | NS | NS | NS |

[z] Timings 1 to 15 correspond to the spray dates of 1=12 June ,2=19 June, 3=25 June, 4=26 June, 5=3 July, 6=6 July, 7=10 July, 8=17 July, 9=20 July, 10=24 July, 11=31 July, 12=3 Aug., 13=7 Aug., 14=14 Aug., and 15=17 Aug.

[y] Means followed by the same letter are not statistically different according to Fischer's least significant difference (LSD) test at P=0.05

[x] Probability of a significant treatment effect.

[w] NS = Treatment effect not significant at P=0.05.

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## Evaluation of Fungicides for Powdery Mildew Control on Pumpkin

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**Introduction:** Powdery mildew, caused by the fungus *Podosphaera xanthii*, is a widespread problem on cucurbit vegetable crops in Oklahoma. The disease is managed with resistant varieties and/or fungicide spray programs. The objective of this trial was to evaluate a new fungicide (Miravis Prime) in comparison with older registered fungicides. Sulfur is an economical organic treatment and Inspire Super and Quintec are standard fungicide treatments that have provided good control of powdery mildew in previous trials.

**Materials and Methods:** The experiment was conducted at the Entomology/Plant Pathology Research Farm in Stillwater, OK in a field of Teller loam previously cropped to peppers. A powdery mildew-susceptible cultivar ('Gold Rush') was seeded on 27 June. The herbicides Sonalan 3E at 3.5 pt/A, Permit 75DF at 0.75 oz/A, and Round-Up 4L at 1.5 pt/A were broadcast after planting to control weeds. Plots were top-dressed with granular fertilizer (50-0-0 lb/A N-P-K) on 26 July. Plots consisted of single, 25-ft-long rows spaced 15 ft apart. Plots were thinned to a 2-ft within row spacing. Insects were controlled with Warrior 1F at 3.84 fl oz/A on 24 Aug and 29 Aug. The experimental design was a randomized complete block design with four replications and a 10-ft fallow buffer separating replications. Fungicides were broadcast through flat-fan nozzles (8002vk) spaced 18-inches apart using a $CO_2$-pressurized wheelbarrow sprayer. The sprayer was calibrated to deliver 27 gal/A at 40 psi. Applications were made on approximately 7-d intervals beginning when the vines began to run on 1 August. Rainfall during the cropping period totaled 0.76 in. for July, 8.26 in. for August, and 6.51 in. for Sept. Plots received eight applications of 0.5 in water by sprinkler irrigation during July. Disease incidence was assessed by visually estimating disease incidence (percentage of leaves with symptoms of powdery mildew that included defoliation) and defoliation alone (percentage of leaves defoliated) in three areas of each plot on 30 Sept. Yield of marketable pumpkins was taken on 8 Oct. Data were analyzed using the GLIMMIX procedure of SAS 9.4 and means were separated by t-type tests produced with the LINES option at $P \leq 0.05$.

**Results and Discussion:** Rainfall was 2 inches below normal (30-yr avg.) in July and nearly 8 in. above normal during August and Sept. Average daily temperature was below normal in July and August and was over 6°F above normal during Sept. Powdery mildew appeared in Sept. and reached moderate levels in non-treated check plots by harvest compared to previous trials (Table 1). All treatments reduced powdery mildew and defoliation compared to the non-treated check. Inspire Super, Quintec, and Miravis Prime at the 9.2 fl oz rate provided the best control. Yields were variable and did not differ among treatments, likely because the disease developed late in crop development. None of the treatments caused phytotoxicity symptoms.

**Table 1.** Evaluation of fungicides for control of powdery mildew on pumpkin, 2019.

| Treatment and rate/A (timing)[z] | Powdery mildew (%) | Defoliation (%) | Yield (cwt/A) |
|---|---|---|---|
| Non-treated check | 87.5 a[y] | 61.7 a | 173.5 a |
| Microthiol 80DF 6 lb (1-5) | 64.3 b | 25.7 bc | 161.0 a |
| Miravis Prime 3.3F 9.2 fl oz (1-5) | 45.8 c | 14.3 c | 229.8 a |
| Miravis Prime 3.3F 11.4 fl oz (1-5) | 62.3 b | 41.0 b | 267.4 a |
| Inspire Super 2.8F 1 pt (1-5) | 57.5 bc | 17.5 c | 168.5 a |
| Quintec 2.08F 5 fl oz (1-5) | 53.5 bc | 17.5 c | 278.4 a |
| P>F[x] | <0.01 | <0.01 | 0.52 |

[z] Numbers (1 to 5) correspond to the spray dates of 1=1 Aug., 2=10 Aug., 3=15 Aug., 4=24 Aug., and 5=29 Aug.

[y] Values in a column followed by the same letter are not significantly different at P=0.05 according to the lines option of SAS Proc GLIMMIX.

[x] Probability of a significant treatment effect.

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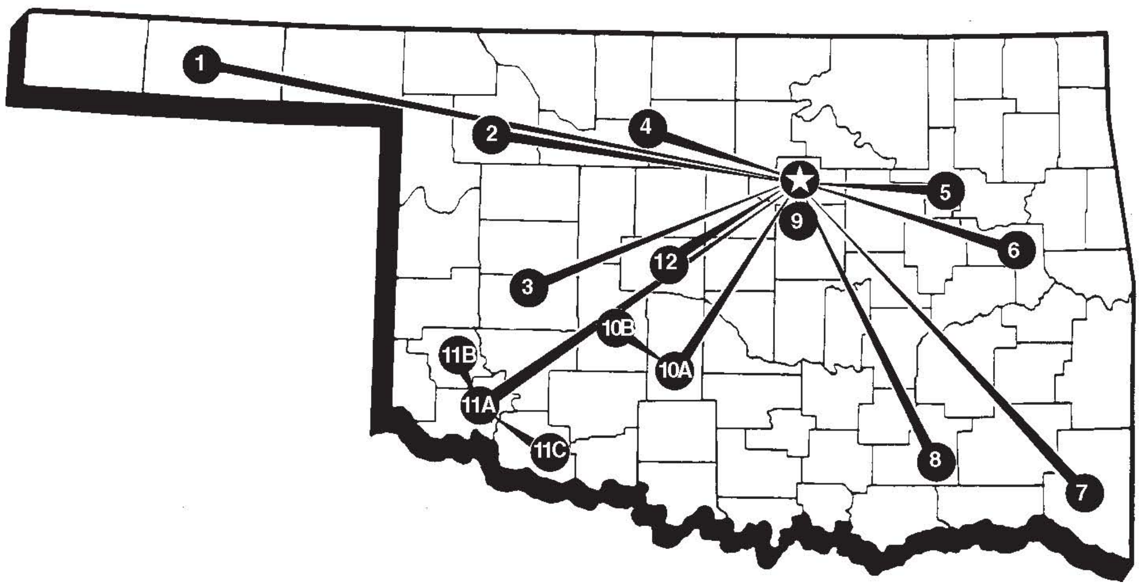
## SI (METRIC) CONVERSION FACTORS

| *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 | $lbf/in^2$ |

**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***
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