Celery

Wednesday afternoon 2:00 pm

Where: Grand Gallery (main level) Room D
MI Recertification credits: 1 (1B, COMM CORE, PRIV CORE)
OH Recertification credits: 1 (presentations as marked)
CCA Credits: PM(1.0) CM(1.0)
Moderator: Ben Werling, West Michigan Vegetable Educator, MSU Extension, Hart, MI

2:00 pm Celery Pathology Update (OH: 2B, 0.5 hr)
   • Blair Harlan, Plant, Soil and Microbial Sciences Dept., MSU
   • Mary Hausbeck, Plant, Soils and Microbial Sciences Dept., MSU

2:30 pm Celery Weed Control Update (OH: 2C or 3p, 0.5 hr)
   • Bernard Zandstra, Horticulture Dept., MSU

3:00 pm The Food Safety Modernization Act: Things for Celery Growers to Be Aware Of
   • Phil Tocco, Extension Educator, MSU Extension, Jackson, MI

3:30 pm Celery Industry Update from Ontario
   • Kevin Vander Kooi, Plant Agriculture Dept, Univ. Guelph, Ontario, Canada

4:00 pm Session Ends

Annual meeting of Michigan Celery Research Inc. will be held at the conclusion of the Celery session.
Michigan is ranked second in the country for celery production. In 2015, this crop was produced on 1,600 acres and valued at $18.9 million. Diseases that have been a problem in celery field production in Michigan include early blight, late blight, bacterial leaf spot, anthracnose and Fusarium yellows (Figures 1, 2).

Several diseases, including early blight (caused by *Cercospora apii*) and late blight (caused by *Septoria apicola*) can impact yield quality and quantity of celery in Michigan. The disease symptoms, including defoliation and stunting of the plants and petiole blighting, can result in severe yield losses for celery growers. *Cercospora* and *Septoria* may be seedborne fungi or overwinter in Michigan fields; therefore, resistant cultivars, fungicide programs, and disease-free seed are important for managing these diseases. Symptoms of *Cercospora* early blight include yellow to tan, circular-shaped lesions on the

![Figure 1. Diseases of celery in the field.](image-url)
upper and lower surface of leaves and elongated lesions on petioles (Figure 1A, B). Septoria late blight is the most common disease of celery in Michigan, and spreads quickly. Symptoms of Septoria late blight include yellow to brown, irregularly shaped lesions on the leaves and petioles (Figure 1C). The reproductive structures of the fungus, small black pycnidia, are embedded in these lesions. Pycnidia can also be observed on infected petioles (Figure 1D). When left uncontrolled, Septoria late blight can result in losses exceeding 70% especially, during wet conditions when disease incidence and severity are high.

Bacterial leaf spot of celery is caused by *Pseudomonas syringae* pv. *apii*. This pathogen can also be seedborne. The lesions only appear on leaves and are initially water-soaked around the margin (Figure 1E). Lesions of bacterial leaf spot may resemble those of late blight but can easily be distinguished by the presence or absence of pycnidia.

Anthracnose has been a problem on Michigan celery in recent years. Caused by the fungus, *Colletotrichum acutatum*, anthracnose causes curling and cupping of leaves and distortion of and lesions on petioles (Figure 2A). As the disease progresses, cracks along the petioles may develop adventitious roots (Figure 2B). High temperatures (>77°F) and long periods of wetness are conducive to leaf curling and lesion development on celery petioles.

Fusarium yellows disease (*Fusarium oxysporum* f.sp. *apii*, race 2) has historically been a limiting factor in celery production in Michigan but the use of resistant cultivars has been helpful. The pathogen is soilborne and causes yellowing and stunting of celery (Figure 2C, D). This disease cannot be controlled with fungicides or growing practices so it is essential to use *Fusarium*-resistant cultivars.

**Evaluating fungicides for control of foliar blights of celery.** Michigan State University established a trial with a grower cooperator in Oceana County in a muck field previously planted to celery. Celery ‘CR1’ seeds were planted the first week of May. The seedlings were transplanted into the field on 10 June with approximately 44,000 plants per acre. Spacing was 20 inches between rows and 8 inches between plants within a row. Fertilization, weed and insect control were managed by the grower cooperator and were to commercial standards. A completely randomized block design with four replicates was established. Each treatment replicate consisted of two rows that were 20 feet long with a 2-foot buffer zone between treatments within a row. Foliar treatments consisting of various fungicide programs (Table 1) were applied on 22 and 29 August; 6, 13 and 20 September using a CO₂ backpack sprayer and a broadcast boom equipped with three XR8003 flat-fan nozzles calibrated at 50 psi and...
delivering 50 gal/A. Leaves and petioles were evaluated for foliar blight and petiole lesions on 28 September following harvest. Plants were hand harvested from the center 5 feet of the two rows of treatment plots on 27 September, trimmed following market specifications and weighed on 28 September. Data were analyzed using an analysis of variance (ANOVA) with mean separation performed using Fisher's protected least significant difference (LSD).

Table 1. Products tested for foliar diseases on celery in 2016 field studies.

<table>
<thead>
<tr>
<th>Product</th>
<th>Active ingredient</th>
<th>FRAC code</th>
<th>Labeled for celery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bravo WeatherStik SC</td>
<td>chlorothalonil</td>
<td>M5</td>
<td>yes</td>
</tr>
<tr>
<td>Kocide 3000</td>
<td>copper hydroxide</td>
<td>M1</td>
<td>yes</td>
</tr>
<tr>
<td>Merivon SC</td>
<td>fluxapyroxad/pyraclostrobin</td>
<td>7/11</td>
<td>yes</td>
</tr>
<tr>
<td>Quadris SC</td>
<td>azoxystrobin</td>
<td>11</td>
<td>yes</td>
</tr>
<tr>
<td>Tilt EC</td>
<td>propiconazole</td>
<td>3</td>
<td>yes</td>
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</table>

In the field study, foliar blight occurred and was caused by *Septoria apicola* and *Cercospora apii*. *Alternaria* spp. was also observed. All treatments significantly reduced foliar disease in comparison to the untreated control (Table 2). Petiole lesions were observed and were caused by *Cercospora* infection. No significant differences in petiole disease incidence were detected; however, all treatments had fewer plants with one or more petiole lesions than the untreated plants. The untreated control had the highest amount of diseased plants by weight and the lowest yield of marketable celery although all treatments were statistically similar to the untreated control. The treatment of Bravo WeatherStik SC alternated with Quadris SC had the highest marketable yield and the lowest petiole lesion incidence.

Most foliar leaf blights can be controlled with registered fungicides. Fungicides should be used in rotation with one another and all can be tank-mixed with copper-based products for dual control of both fungal and bacterial diseases. Good fungicide coverage of the celery foliage and petioles is a challenge and may be why the treatments that we tested still resulted in a significant amount of blighted petioles. Once the plants are large enough to form a thick canopy, coverage to the lower portions of the plants is limited.

Table 2. Evaluation of fungicide treatments for controlling foliar blights of celery.

| Treatment and rate/A, application schedule, applied at 7-day intervals | Foliar disease severity* | Petiole lesion incidence† | Yield (lb/5 ft row) |  |
|------------------------------------------------------------------------|--------------------------|----------------------------|----------------------|
| Untreated control                                                     | 4.8 a                      | 74.6                        | 5.6                  | 19.2 | 24.8 |
| Tilt EC 4 fl oz, apps A,C,E -alt- Kocide 3000 24 fl oz, apps B,D      | 3.8 b                    | 61.6                        | 8.4                  | 18.4 | 26.8 |
| Merivon SC 11 fl oz, apps A,C,E -alt- Kocide 3000 24 fl oz, apps B,D  | 3.8 b                    | 69.7                        | 8.8                  | 14.3 | 23.1 |
| Bravo WeatherStik SC 32 fl oz, apps A,C,E -alt- Quadris SC 15.5 fl oz, apps B,D | 3.8 b | 50.6 | 9.8 | 14.8 | 24.6 |

*Rated on the Horsfall-Barratt scale of 1 to 12, where 1=0% plant area diseased, 2=>0 to 3%, 3=>3 to 6%, 4=>6 to 12%, 5=>12 to 25%, 6=>25 to 50%, 7=>50 to 75%, 8=>75 to 87%, 9=>87 to 94%, 10=>94 to 97%, 11=>97 to <100%, 12=100% plant area diseased.

†Petiole lesion incidence = plants with ≥1 lesion/total, %.

*Column means with a letter in common or no letter are not significantly different (LSD t Test; P=0.05).
Acknowledgments. This research was partially supported by funding from Celery Research Inc. and by Syngenta Crop Protection.

Figure 3. The treatment of Bravo WeatherStik SC alternated with Quadris SC (top) produced the highest yield of marketable plants, although statistically the differences were not significant from the untreated control (bottom).
Celery Weed Control Update

Bernard Zandstra
Michigan State University
EXPO, Grand Rapids, MI
December 7, 2016

Current Herbicide Labels for Celery

Dual Magnum 7.62 EC
When: Before or after transplanting
Rate: 2 pt (1.9 lb ai)
PHI: 62 days
Weeds: Annual grasses, nutsedge, pigweeds, nightshades
Label: 24c indemnified
(www.farmassist.com)

Caparol 4L
When: After transplant, 4-6 weeks later
Rate: 1-2 qt (1-2 lb ai); 2 qt max per year
Weeds: Broadleaves and grasses
Label: Section 3; 1 or 2 applications

Lorox 50 DF
When: After transplant
Rate: 1.5-2 lb (0.75 - 1 lb ai)
Weeds: Broadleaves and grasses
Label: Section 3

Chateau 51 WDG
When: Before transplant or 3-7 days after transplant
Rate: 3 oz (0.096 lb ai)

Poast 1.5 E and Select Max 0.97 E
Post grass control
**New Herbicides Coming**

**Zidua 85 WDG (pyroxasulfone)**

When: Pre or Post transplant  
Rate: 2.5 – 5.0 oz (0.133 – 0.267 lb ai)  
Weeds: Annual grasses, common ragweed, marsh yellowcress, Virginia pepperweed  
Label: IR4 project: 2-3 years

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**2016 Research Results**

**Two Experiments**

Cnossen Farms  
Schreur Farms

Develop data to support registration of Zidua (pyroxasulfone) and bicyclopyrone on celery.  
Study PSII resistance in common purslane.

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**Zidua PRE Transplant on Celery 5/11**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate lb ai/A</th>
<th>Celery 6/9</th>
<th>Celery 6/23</th>
<th>kg/plot 7/28</th>
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<tbody>
<tr>
<td>1. Zidua</td>
<td>0.133</td>
<td>1</td>
<td>1</td>
<td>42</td>
</tr>
<tr>
<td>2. Zidua</td>
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<td>1.3</td>
<td>1</td>
<td>43</td>
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<tr>
<td>3. Dual Magnum Chateau</td>
<td>1.9 0.096</td>
<td>1</td>
<td>1.3</td>
<td>42</td>
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**Weed Control PRE Transplant**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate lb ai/A</th>
<th>COPU 6/9</th>
<th>LATH 6/9</th>
<th>RRPW 6/9</th>
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<tr>
<td>1. Zidua</td>
<td>0.133</td>
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<td>6.7</td>
<td>9.3</td>
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<td>2. Zidua</td>
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<td>4.7</td>
<td>8.3</td>
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<tr>
<td>3. Dual Magnum Chateau</td>
<td>1.9 0.096</td>
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<td>5.3</td>
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**Zidua POT on Celery 5/12**

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<th>Treatment</th>
<th>Rate lb ai/A</th>
<th>Celery 6/9</th>
<th>Celery 6/23</th>
<th>kg/plot 7/28</th>
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<td>1. Handweeded</td>
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<td>2. Zidua</td>
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**Zidua POT Weed Control 6/9**

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<th>COPU 6/9</th>
<th>LATH 6/9</th>
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Zidua POT Weed Control 6/23

<table>
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<th>LATH 6/23</th>
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<tr>
<td>4. Zidua Caparol</td>
<td>0.133 2 POST</td>
<td>10</td>
<td>3</td>
<td>10</td>
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Celery Post Transplant Cnossen (1)

<table>
<thead>
<tr>
<th>Treatment (7/5)</th>
<th>Rate lb ai/A</th>
<th>Celery 7/26</th>
<th>Celery 8/17</th>
<th>kg/plot 10/5</th>
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<tbody>
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<td>25</td>
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<td>1.9</td>
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<td>25</td>
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<tr>
<td>3. Dual Magnum Chateau</td>
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</tr>
<tr>
<td>4. Zidua</td>
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<td>2</td>
<td>26</td>
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Celery Post Transplant Cnossen (2)

<table>
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<th>Treatment (7/5)</th>
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<th>Celery 7/26</th>
<th>Celery 8/17</th>
<th>kg/plot 10/5</th>
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</thead>
<tbody>
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<td>2</td>
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<td>21</td>
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<tr>
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Post Transplant Weed Control (1)

<table>
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<tr>
<td>2. Prowl H₂O</td>
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<td>8.3</td>
<td>9</td>
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<tr>
<td>3. Dual Magnum Chateau</td>
<td>1.9   9.7</td>
<td>10</td>
<td>9.7</td>
<td></td>
</tr>
<tr>
<td>4. Zidua</td>
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<td>9.3</td>
<td>8.3</td>
<td>9.7</td>
</tr>
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</table>

Post Transplant Weed Control (2)

<table>
<thead>
<tr>
<th>Treatment (7/5)</th>
<th>Rate lb ai/A</th>
<th>COPU 7/26</th>
<th>LATH 7/26</th>
<th>RRPW 7/26</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Zidua</td>
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<td>9.3</td>
<td>10</td>
</tr>
<tr>
<td>6. Dual Magnum Zidua</td>
<td>1.9 0.267 PO1</td>
<td>6.7</td>
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<td>9.3</td>
</tr>
<tr>
<td>7. BIR</td>
<td>0.033</td>
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<td>7.7</td>
<td>8.3</td>
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</tbody>
</table>

Conclusions

1. Zidua was safe PRT and POT on celery at all rates
2. Caparol did not provide good COPU control
3. Prowl H₂O, Chateau, and Zidua controlled COPU
4. BIR stunted celery moderately; it probably is not safe enough for celery
New Labels Coming for Celery

Prowl H₂O – Complete at IR-4 (2 yr)
Zidua – Field studies complete (2-3 yr)

Acknowledgements

- Michigan AgBioResearch
- MSU Extension
- USDA-NIFA
- Celery Research inc.
- Cnossen Farms
- Schreur Farms
- K-I Chemical USA
- Syngenta Crop Protection

http://www.hrt.msu.edu/people/dr_bernard_zandstra

Thank You.
Questions?

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517-353-6637
FSMA Final Rule: Ready or not, it’s here.

Phil Tocco
MSU Extension

Objectives

- Understand the context of the new Produce Rule.
- Determine whether you are exempt or not.
- Begin to look at things that MUST be done to comply, whether you are exempt or not.
A Change in Federal Focus

Before FSMA
- Focus was on response
- Intervention happened after outbreak occurred.

A Change in Federal Focus

After FSMA
- Focus is on prevention
- Intervention happens BEFORE outbreak occurs.

Covered farms...
- Grow food typically eaten raw

Exempt farms...
- Grow food NOT typically eaten raw.
- Send their produce to be processed.
- Consume their food on-farm
- Have less than $25,000 in annual food sales
- Have less than $500 K in food sales with 50% local (in-state or within 275 miles)
Exempt Under FSMA

- Asparagus
- Dry Beans (Black, Northern, Pinto, Navy, Kidney and Lima)
- Beets, roots and tops
- Cashews
- Sour Cherries
- Chickpeas
- Collard Greens
- Dill
- Eggplant
- Figs
- Lentils
- Okra
- Ginger
- Hazelnuts, Pecans, & Peanuts
- Horseradish
- Cranberries
- Dates
- Coffee Beans
- Peppermint
- Potatoes
- Water Chestnuts
- Sugarbeet
- Sweet Corn
- Sweet Potatoes
- Pumpkins and Winter Squash

Food Safety Modernization Act (FSMA)

Produce Rule includes:
- Manure Source, Use, and Handling
- Irrigation and Wash Water Sources
- Employee Training and Hygiene
- Wild and Domesticated Animals
- Farm and Equipment Sanitation

FSMA Compliance Dates

Final Rule: October 2015
- Large Businesses: 2018
- Small Businesses: 2019
- Very Small Businesses: 2020

All farms above $25,000 are subject to the rule. Farms below $500,000 are qualified exempt IF more than half of gross sales are sold to the end user or within 275 miles from where it’s grown.
Biological Soil Amendments

Treated:
- Physically or chemically processed.
- Composted

Untreated:
- Not fully processed
- Treated and untreated.
- Contains a compost tea additive

Approved Composting Process

- Static Compost: minimum of 131 F for 3 consecutive days then "adequate curing"
- Turned Compost: minimum of 131 F for 15 days non-continuous, with five turns then "adequate curing"

Irrigation Water

- Agricultural Water
- Indirect Water

- [Image 77x544 to 277x547]
- [Image 66x682 to 287x699]
- [Image 71x558 to 209x656]
- [Image 77x325 to 277x327]
- [Image 66x462 to 287x479]
- [Image 72x336 to 272x441]
- [Image 77x106 to 277x108]
- [Image 66x243 to 287x260]
- [Image 195x110 to 277x201]
- [Image 73x140 to 188x228]
Irrigation Water

Indirect Water

- Indirect water is not regulated.
- No need to test indirect water.
- Can apply over threshold water indirectly.

Irrigation Water

General Requirements

- Inspect Water Source(s)
- Test for generic E. coli.
  - Different standards pre and postharvest
- Respond to unacceptable results.

Irrigation Water

Agricultural Water from a Surface Source

- Growers must establish a water profile of 20 samples by full implementation of the rule (Compliance + 2 yrs)
- Profile must have no more than:
  - Geometric Mean (GM) of 126 CFU/100 ml
  - Standard Threshold Value (STV) of 410 CFU/100 ml
Irrigation Water
Agricultural Water from Wells

• Growers must establish a water profile of 4 samples by full implementation of the rule (Compliance + 2 yrs)

• Profile must have no more than:
  – Geometric Mean (GM) of 126 CFU/100 ml
  – Standard Threshold Value (STV) of 410 CFU/100 ml

Irrigation Water
Establishing a Profile

5 samples (2018)  5 samples (2019)
5 samples (2020)  5 samples (2021)

Irrigation Water
Handling an Exceedance

• Growers have options if their water tests exceed the thresholds. These can include:
  – Water Sanitizers (UV, Chlorine, Hydrogen Peroxide, and others)
  – Waiting a number of days to bring it into compliance (0.5 log/day up to 4 days)
  – Washing or produce storage
  – Alternative water supplies (Municipal water, well water, etc.)
  – Changing method of irrigation to make it indirect water
Irrigation Water
Annual Water System Inspection

• For Ag Water
• The inspection should include:
  – Nature of the water (Ground or surface)?
  – How much control you have over it
  – How protected it is.
  – What nearby land uses are
  – How likely it will be for it to be contaminated.
• Must be repeated if an exceedance occurs.

Employee Training

• Employees must be trained by a supervisor.
• A record of training must exist for the employees.
• At least one supervisor must attend the standardized FDA approved training (PSA Training).

Employee Training

• Training must include:
  – Basic food safety principles.
  – Proper hygiene.
  – Signs and symptoms of illness (If you’re sick, don’t handle it)
  – When not to harvest produce.
    (Scout for wildlife damage)
  – Inspecting containers
  – Handling contaminated produce.
  – Report issues to the supervisor.
**Employee Hygiene**

- Toilets and handwash stations are required for workers.
- A FSMA compliant handwash station consists of:
  - A Basin
  - Container or outlet with potable water
  - Soap
  - Drying device (single use towels, etc.)

**Employee Hygiene**

- Handwashing is expected:
  - Before starting work
  - Before putting on gloves
  - After using the toilet
  - After breaks
  - After handling animals

No food contact = No handwashing

**Wild and Domesticated Animals**

- Restriction of domestic animals in production areas.
- Wild animals should be monitored.
- Restriction of domestic and wild animals in packing areas.
- Employees that handle animals then produce must wash hands before handling produce.

Farm and Equipment Sanitation

- Food contact surfaces should be clean and sanitized or new.
  - Wagons
  - Knives
  - Conveyors on packing lines
  - Knives on toppers

- Equipment that does NOT come into DIRECT contact with produce should be clean.

Record Keeping Requirements

**Record Required**
- Employee Training.
- Water Tests or Public Water System Cert of Compliance.
- Water System Inspection.
- Water Corrective Action Docs.
- Compost Supplier Cert if it’s animal derived.
- Cleaning and sanitizing record of tools and machines.

**No Record Required**
- Wildlife Monitoring
- Visitor logs
- Nonconformances
- Illnesses and injuries
- Full Food Safety Plan

Record Retention

- Records must be stored so as to be accessible on-site within 24 hours.
- Records must be retained for 2 years.
- Can be maintained via hard copy or digitally*.

*Not all digital platforms are acceptable
Packhouses

- Who owns the packhouse?
  - Farm = Produce Rule
  - On it’s own = Preventive Controls.
- Who owns the product?
  - >50% on-farm = Produce Rule
  - <50% on-farm = Preventive Controls.

The Future of FSMA

- Determine if you’re Exempt.
- IF you’re exempt, fill out an Annual Review of FSMA Exemption by 2018 at the earliest.
- If you’re NOT exempt, begin complying and be aware of your full compliance date.

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