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NEW JERSEY DEPARTMENT OF AGRICULTURE

RUTGERS New Jersey Agricultural Experiment Station

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Session Organizers

Tuesday, February 4

Morning Sessions

Organic Production – Joe Heckman, Extension Specialist in Soil Fertility

Wine Grapes – Hemant Gohil Agricultural Agent, Gloucester Co.

Hemp Agronomy – Steve Komar Agricultural Agent, Sussex Co.

Pepper – Andy Wyenandt Extension Specialist in Vegetable Pathology

Tuesday

Mid-Day

Mandatory Annual Training Documents for the FMNP Vendors with Q&A – Treemanisha Stewart and Jose Quann, both from NJDOH, and Bill Walker, NJDA

Tuesday, February 4

Afternoon Sessions

Integrated Pest Management – Kris Holmstrom/Joe Ingerson-Mahar Vegetable IPM Program Coordinators

High Tunnels – A.J. Both Extension Specialist in Ag Engineering

Regulatory Issues With Hemp – Bill Bamka Agricultural Agent, Burlington Co.

Tomato Tom Orton Specialist in Vegetable Crops

Wednesday, February 5

Morning Sessions

Blueberry – Gary Pavlis Agricultural Agent, Atlantic Co.

Small Fruit/Strawberry – Pete Nitzsche Agricultural Agent, Morris Co.

Creating Value Added Products and Services to Increase Profits – Bill Hlubik Agricultural Agent, Middlesex Co.

Specialty Crops – William Sciarappa Agricultural Agent

Wednesday, February 5

Mid-Day

Mandatory Annual Training Documents for the FMNP Vendors with Q&A – Treemanisha Stewart and Jose Quann, both from NJDOH, and Bill Walker, NJDA

VGANJ/NJDA Joint Session – Aggregator Panel for Sourcing NJ Produce

Wednesday, February 5

Afternoon Sessions

Food Safety – Meredith Melendez Agricultural Agent, Mercer Co.

Creative Marketing and Agritourism – Bill Hlubik Agricultural Agent, Middlesex Co.

Vine Crops – Michelle Infante-Casella Agricultural Agent, Gloucester Co.

New Technologies for NJ Agriculture – Rick VanVranken Agricultural Agent, Atlantic Co.

<u>Thursday, February 6</u>

<u>Full Day Session</u>

Produce Safety Alliance Training – Wes Kline & Meredith Melendez Agricultural Agents, Cumberland and Mercer Cos.

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Organic Production

ORGANIC SWEET CORN AT RODALE INSTITUTE

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Sweet corn is high in protein and a good source of carbohydrates and dietary fiber. It supplies potassium, phosphorus, manganese and vitamins including Vitamin B, and C (Sheng et al., 2018). It is also considered a great source of antioxidants and polyphenols (Dewanto, 2002; Song et al 2010). Americans consume approximately 25 pounds of corn per year but most of it is frozen or canned.

As of 2017, Pennsylvania was ranked 15th in the United States for fresh market sweet corn production. Forty percent (1,672 farms) of Pennsylvania growers produce sweet corn on 11,514 acres [US Dept of Ag (USDA, 2017]. Vegetable growers and industry representatives rated sweet corn second among vegetable crops warranting research (Sanchez et al., 2012).

A long-term Vegetable Systems Trial (VST), side by side comparison of organic (ORG) and conventional (CNV) vegetable cropping systems, was established at Rodale Institute, Kutztown, Pennsylvania in 2016. Sweet corn is one of the major four cash crops being evaluated in rotation with potato – winter squash-lettuce, in a randomized complete block design with four replications per system. The plot size is 20 ft by 80 ft.

Cover crop and bed preparation

In fall of each year, cover crops are seeded using a grain drill seeder. In the ORG plots, a cover crop mixture of cereal rye (90lb/acre) and hairy vetch (30lb/acre) is seeded, whereas, cereal rye at the rate of 100 lb/acre is seeded in the CNV plots. Cover crop biomass is sampled in spring and assessed for dry weight and nutrient content. Soil samples from each plot are collected and sent for nutrient analyses at the Pennsylvania Agricultural Analytical Services Laboratory (AASL), Early May the cover crop biomass is mowed and plowed under using moldboard plow. Based on soil nutrient results, soil is amended with fertilizer to supply about 150 lb N/acre. In the organic plots, blood meal fertilizer (12-0-0) is used, whereas, urea 46-0-0 is applied in the CNV plots using a frontier spreader. After disking, black plastic mulch with drip irrigation is laid using Rain-Flo mulch layer 2550, as soil temperatures approaches 50 F in late May. Three beds per plot are prepared few days before transplanting.

Seeding and transplanting

Organic and conventional sweet corn 'Coastal' cultivar seeds are seeded into 128- cell trays in the greenhouse. Using a water-wheel transplanter, seedlings are transplanted into two rows per bed, 3 beds per plot, spaced 12 inch in row and 18 inch between rows within 10-12 days from time of seeding (approximately on June 6). Liquid fish emulsion at 1% is watered in during transplanting of organic seedlings, whereas, Miller MIL12488 Sol-U-Gro® Starter 12-48-8 fertilizer at 5 lb per 100 gallons of water is used for CNV seedlings as a starter fertilizer. The sweet corn 'Coastal' cultivar matures in 77 days (mid-season maturing cultivar).

Weed control

In the CNV plots, a chemical herbicide Bullzeye[TM] (glyphosate) is applied at the rate of 58ml/5 gallons of water using a back pack sprayer between the plastic beds a month after planting. Cultivation and hand hoeing are practiced between plastic beds in organic plots.

Insect and disease management

During the growing season, sweet corn plants are monitored for a variety of pests including European corn borer, corn ear worm, and aphids. Five plants per each plot are checked on a weekly basis for a minimum of four weeks for the above mentioned pests and count number per pest is recorded. When pest threshold is warranted, pesticides are applied. In ORG plots, Javelin WG insecticide is applied at the rate of 1.25 lb/acre and Asana XL at 6 oz/acre on CNV plants. Plants are also monitored for leaf diseases and recorded.

Nutrient Assessment in leaf and kernel tissue

Eight leaves from plants in the middle beds per treatment are sampled at the base of sweet corn ear (initial silking), dried, ground and analyzed for mineral nutrients at the AASL. Samples of shaved kernels from freshly harvested ears are placed in plastic bags, sealed and stored at -4 F before they are freeze-dried, ground and subsampled for protein, minerals, and vitamins (C and B6).

Harvesting and grading

Sweet corn ears are hand-picked when silk tassel turn brown and the kernel is plumped and the juice appears milky when punctured. Ten ears from 10 plants per plot in the middle beds are harvested, weighed individually and in bulk. Data is collected on ear length, number of rows per ear, and number of kernels on the longest vertical row per sweet corn ear per treatment. Whole plants are also sampled from 10 plants per treatment and assessed for dry weight.

Results

In this document I am presenting results from 2018 and 2019 data related to mineral nutrients in leaves, crop yield, and nutrients (protein and vitamins) in sweet corn kernel.

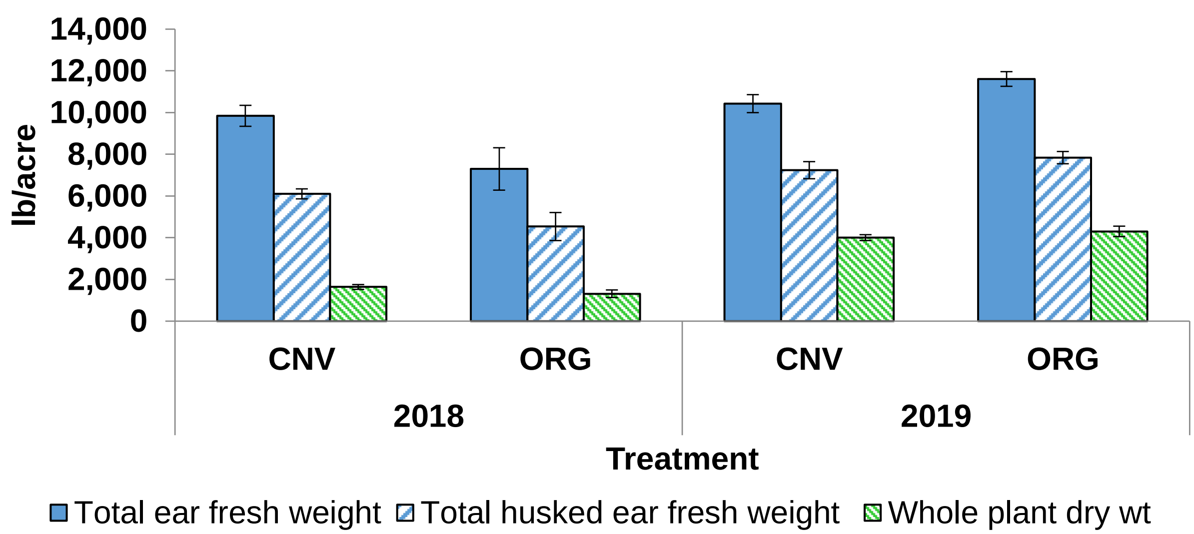
Mineral Nutrients in leaves: Mineral nutrients in leaves varied between cropping systems and year. When compared to sufficiency levels (see Table 1), mean nitrogen (N) level was lower in the ORG treatment in 2018 and was above in 2019. These N values were opposite for CNV treatment. Phosphorus (P), calcium (Ca), iron (Fe), boron (B), and copper (Cu) were above sufficiency levels in both years and systems (Table 1). Sulfur (S) levels were met in both years and systems. Potassium (K) levels were much below in 2018 in both systems but above sufficiency level in 2019. Magnesium (Mg) levels were lower than sufficiency levels in both systems and years.

Table 1. Nutrient sufficiency levels in sweet corn leaf taken at initiation of silking (ear-leaf) growth stage in 2018 and 2019.

	N	P	K	Ca	Mg	S	Fe	B	Cu	Zn	Mn
	(%)						(ppm)				
Nutrient sufficiency level	2.80	0.25	1.80	0.30	0.25	0.20	60	7	6	20	50
2018 CNV	3.17	0.35	1.33	0.49	0.20	0.20	71	21	9	19	42
2018 ORG	2.59	0.35	1.30	0.41	0.16	0.20	56	22	8	19	32
2019 CNV	2.63	0.38	2.86	0.53	0.20	0.19	86	14	34	47	40
2019 ORG	3.20	0.40	2.89	0.52	0.24	0.23	88	24	45	65	35

Sweet corn yield**:** In 2018, total ear and husked fresh weights were significantly greater in CNV treatment than in ORG (Figure 1). However, in 2019 total ear and husked fresh weights increased when compared to those in 2018 in both systems and were not significantly different between systems in 2019 (Figure 1). While there was no significant difference in whole plant dry biomass between cropping systems, yet whole-plant dry weight in 2019 has increased by 2.5 time in CNV and by 3.2 times in ORG system when compared to those in 2018.

Figure 1. Sweet corn yield and whole plant dry biomass in ORG and CNV cropping systems at Rodale Institute in 2018 and 2019.



***Sweet corn ear measurements*:** There was no significant difference in number of rows per sweet corn ear between cropping systems, averaging 17rows/ear. However, there was significant increase in rows/ear in 2019 (averaging 18) when compared to those in 2018 (averaging 16). Mean ear length was similar (averaging 7.5 inches) in ORG and CNV systems and both years as well as number of kernels on longest row (averaging 37 kernels).

***Protein and vitamins (C and B6)*:** In 2018, percent protein level averaged 16.1 in ORG and was not significantly different from those in CNV (averaged 15.7%) treatment. Vitamin C values varied with cropping system and time. Vitamin C level in ORG sweet corn kernel (averaging 27 mg/100g) was greater than the levels in CNV (averaging 18 mg/100 g) in 2018. However, vitamin C levels decreased in both systems in 2019 and they were lower in the ORG treatment averaging 9.4 mg/100 g when compared to CNV (averaging 12.2 mg/100g). Mean vitamin B6 values in sweet corn kernel did not vary by system but were significantly greater in 2019 (0.56mg/100g) than in 2018 (0.50 mg/100 g).

Literature Citation

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INSECT CONTROL FOR ORGANIC SWEET CORN PRODUCTION

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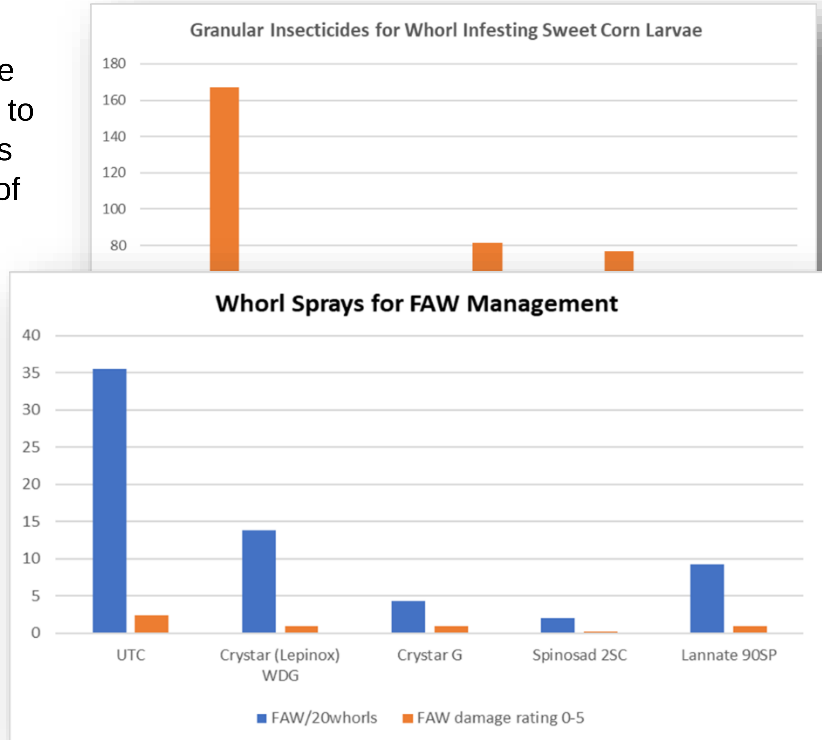
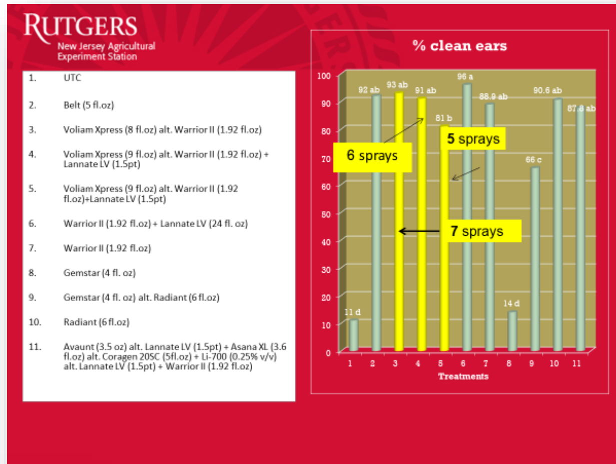
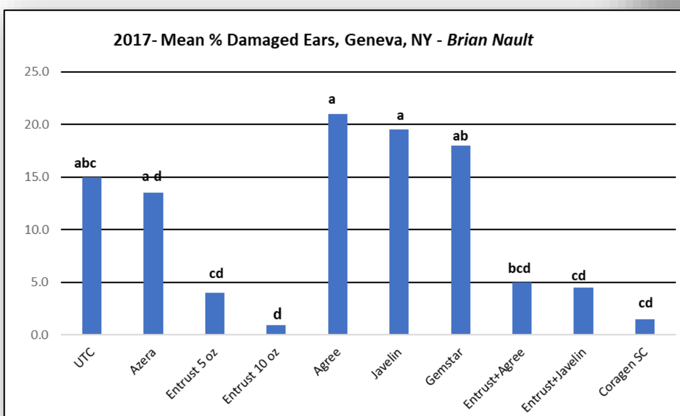
Insect control in sweet corn, regardless of whether the crop production scheme is organic or not, primarily involve management of the three primary caterpillar pests; European corn borer (ECB), fall armyworm (FAW), and corn earworm (CEW). Control tactics for these pests will be the focus of this presentation.

ECB in New Jersey typically has two complete generations, with the first moth flight occurring in May and early June and the second occurring in August. Egg masses are deposited on the underside of corn leaves, and whorl stage corn is the preferred host. After egg hatch, small larvae bore through the overlapping leaves of the whorl and into the developing tassel at the center of the plant. The injury to leaves that results from this behavior is what field scouts monitor for in the field. ECB larvae and their damage may be found as the plant proceeds from the whorl stage to tassel emergence (pre-tassel). This injury to emerging tassels is also monitored by field scouts. As tassels begin to open (full tassel), exposed ECB larvae leave this area and move down the stalks, boring back into the plant at leaf axils and where the developing ears form. Larval entry at this latter site results in infested or damaged ears. ECB control means that larval infestation rates must be reduced to acceptable levels while the larvae are feeding on vegetative portions of the plant, and before they enter developing ears. Field scouting for ECB injury should begin when plants are approximately 16" tall and involves regular sampling of five consecutive plants each in ten random locations throughout the planting for a total of 50 plants. Scouts multiply the number of plants exhibiting signs of ECB injury by two, to get the total percent plants infested. A 12% plants infested (by ECB alone, or in combination with FAW) action threshold is recommended in the Rutgers Vegetable Integrated Pest Management (IPM) Program. ECB populations have declined dramatically in the U.S., since the large-scale adoption of field corn genetically engineered to include toxins from the soil inhabiting bacterium *Bacillus thuringiensis* (*B.t.*) in 1996. Despite this, ECB can still be a significant economic pest of sweet corn, especially where small farms are situated in areas absent of field corn. OMRI approved insecticides for sweet corn insect control are limited, and while the spinosyn material "Entrust" is very effective at managing all caterpillar pests of corn, it is important to utilize alternative toxins where possible, to 1) avoid exceeding maximum permissible applications/rates of spinosyn, and 2) limit the opportunity for local pest populations to develop resistance to effective compounds. ECB populations have shown little ability to develop resistance to the crystalline (Cry1A) toxins found in the Kurstaki strain of OMRI approved *B.t.* insecticides like DiPel and Lepinox. For this reason, such insecticides are useful for reducing larval populations in whorl stage sweet corn. Dr. Gerald Ghidiu (ret.) of the Rutgers Agricultural Research and Extension Center in Bridgeton conducted tests in the 80's showing that *B.t.* formulations could be used effectively. The following study (at right) from 1987 demonstrates good control of both ECB and FAW larvae using a granular form of DiPel (now formulated as DiPel 10G) compared with the non-organic insecticides Lannate, Larvin and Diazinon. In this case, two applications were made at weekly intervals over the whorl at a rate of 11 lb. Dipel G/A. The whorl of the corn plant acts as a funnel, and holds the granules, allowing them to dissolve into a toxic solution where the larvae are feeding. *B.t.* toxins are then ingested (*B.t.* must be ingested; it is not a contact insecticide), and result in the formation of perforations in the caterpillar's gut membrane. Larvae cease to feed, and can die either from the injury alone, or through septicemia as bacterial spores pass through the gut perforations and cause infection. In order to make the best use of a granular *B.t.* formulation, it is helpful to configure a tool bar with hopper boxes over the rows so that granules can be dropped directly into the whorls. ECB larval infestations that continue into the pre-tassel and tassel stages should be managed with the contact toxin contained in Entrust, as there is reduced opportunity to consume *B.t.* toxins after the whorl stage. FAW, which generally appear in New Jersey from mid-July onward, also impact the vegetative stages of sweet corn. FAW moths lay eggs on corn leaves, and resulting larvae can cause extreme injury to plants as it feeds on foliage. This can even include seedling stage corn, under periods of heavy FAW population pressure. While FAW can infest corn ears, it is this foliar injury and subsequent stunting and yield reduction that are the primary issue. Ear infestations are typically limited by insecticide applications targeted at CEW. FAW larvae are also controlled effectively by the OMRI

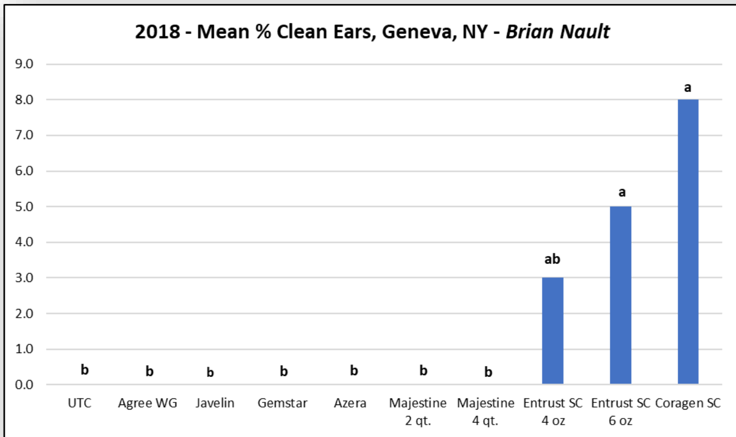


approved spinosyn “Entrust”. However, here too, it is useful to incorporate *B.t.* formulations when possible. Several *B.t.* based insecticides have been developed incorporating toxins from the Aizawai strain (*B.t.*a. – Xentari, Javelin, etc). These products include the Cry 1C toxin, among others, that targets armyworms. Although there is some baseline level of resistance in FAW to Cry 1A toxins, studies show that there is no cross resistance to the Cry 1C toxin found in these *B.t.*a. materials. Even *B.t.k*. materials like Lepinox have been shown to have positive effects on FAW populations in corn, as demonstrated in another study by Dr. Gerald Ghidiu. In this study, Crystar (now Lepinox) performed well relative to the non-OMRI approved material Lannate. The WDG formulation of Lepinox is dissolved in water and sprayed into the whorl. The G formulation is no longer manufactured. Note also, the effectiveness of Spinosad, which contains the same active ingredient as the OMRI approved Entrust. It is critical to understand that *B.t.* formulations are far more effective against smaller larvae. Therefore, when using *B.t.* insecticides, it is advisable to treat as soon as action thresholds are reached, and before larvae become large and numerous. When dealing with larger larvae, it may be necessary to use an effective contact toxin like Entrust. FAW are quite resistant to synthetic pyrethroid insecticides, which means that OMRI approved pyrethrin-based materials will be largely ineffective. CEW is easily the most economically important and difficult to manage pest of sweet corn. Not only is CEW highly resistant to Cry1 toxins found in *B.t.k*. (Dipel, Lepinox, etc.), and pyrethrin/pyrethroid-based insecticides (Pyganic, etc., and synthetic versions), but it’s life cycle and feeding preferences in corn effectively limit its’ exposure to insecticide applications. In New Jersey, a few CEW moths typically arrive from our south (or successfully overwinter in rare cases) in late May and early June. While limited in number, these individuals are capable of causing significant economic injury to sweet corn. Moths lay eggs singly on corn silks to avoid competition among their offspring. The newly hatched larvae do not feed on foliage but proceed directly into the silk throat of the ear while only lightly feeding on silks. This can take 3-10 days to occur, depending on temperature. Once inside the husk, no insecticide can reach the larvae. Therefore insecticide application frequency is based on numbers of moths caught (egg laying potential) in local insect survey traps. The main population begins building gradually from late July into August, and in most years we experience one or more large scale, weather-aided migratory influxes of moths. These events usually occur from mid-August through September, and put sweet corn under extreme pressure of infestation. Adequate protection of sweet corn at this time of the season often requires a 3-day spray schedule through the silking stage of each planting to eliminate small larvae between egg hatch and penetration into the silk throat of ears. Useful control strategies begin with acquiring information regarding CEW adult populations at all times during the silk period of sweet corn plantings. The RCE Plant and Pest Advisory – Vegetable IPM Update provides this information on a weekly basis during the growing season, with suggested spray schedules. Effective insecticide options for organic production are





limited. Positive results should not be expected from *B.t.* products or pyrethrin based products. However, as the following slide from Virginia in 2010 (**T. Kuhar, H. Doughty above at right**) shows, spinosyn (in this case Radiant) provided respectable control, used at a 3-day interval under heavy CEW pressure. We would expect fair to good control in NJ using the OMRI approved spinosyn Entrust. The **rotation** of spinosyn with the viral pathogen Gemstar, in this 2010 study did not improve control over the spinosyn alone. The 2017 study (**above**) shows the relative efficacy of OMRI listed materials and Coragen against ear infesting caterpillars, with CEW being the dominant species. This 2017 study from Geneva, NY took place under very low CEW pressure (note the untreated check only was 15% infested). The important message from this study is that *B.t.a* (Agree), *B.t.k* (Javelin) and the viral insecticide Gemstar did not differ from the untreated check. Also, the addition of either *B.t.* product to the low rate of Entrust did not improve the efficacy of the spray. In the 2018 study (**next page**) also at Geneva, NY, but under extreme CEW pressure, all OMRI listed materials except Entrust provided no adequate control. Note here that even the conventional product (Coragen) did not provide good control. While overall efficacy of biologically based insecticides have been largely unimpressive, results across years and regions are somewhat inconsistent. This fact, in conjunction with the need to find alternative materials for CEW control have spurred new interest in testing these products alone and in combination with other materials like spinosyns in the mid-Atlantic and Northeast regions. Additionally, because Entrust has limits on the number of applications and amount of active ingredient that can be applied to sweet corn plantings, it is advisable to use this most effective material early in the silk period of a planting. This should prevent the majority of any ear infesting larvae from being large individuals. Later in the silk period (possibly the last 2 sprays) biologicals may be used alone, or in combination with a reduced rate of Entrust to avoid exceeding the active ingredient limit on that product. Although efficacy with this strategy may be limited, larvae that infest ears late in the silk period will be small and perhaps less objectionable to the consumer. Every attempt should be made to concentrate spray material in the ear zone, rather than over the entire plant. This puts more active ingredient where it is needed and may improve efficacy of some of the biological insecticides. Consider the addition of drop nozzles to spray booms to achieve this effect. *Many thanks for data and input from: Drs. Gerry Ghidiu, Tom Kuhar, Dan Gilrein and Brian Nault.*



SOIL FERTILITY FOR ORGANIC SWEET CORN

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Approaches to building soil fertility and the nutrient sources are often quite different for organic versus conventional production systems. Soil fertility test and plant tissue analysis interpretations as developed from research conducted under conventional farming are generally assumed to be transferable for use in organic systems. After long term management under the contrasting systems, especially as a result of organic matter accumulation, the soils may become more biologically active and different enough that agronomic test results may need reconsideration. In the organic system there is strong focus on building up the N supplying capacity of the soil in advance of cropping a field to sweet corn. Because sweet corn is a heavy feeder on soil N, and because there are no cheap and readily available approved N sources for supplying supplemental N during the early growing season, it is important to design an organic farm plan that will minimize the need to apply side-dress N fertilizer for this organic crop. Rotations, legume cover crops, manures, and compost are methods and inputs to achieve this goal of soil N sufficiency. The pre-sidedress soil nitrate test (PSNT) can used to sample the soil at an early crop growth stage to hopefully confirm that the soil N available is sufficient (greater than 25 ppm nitrate-N) and no supplemental N fertilizer will be needed. Details on how to use the PSNT soil test are given in Rutgers NJAES fact sheet: Soil Nitrate Testing as a Guide to Nitrogen Management for Vegetable Crops.

If sweet corn growers happen to find when using the PSNT that they have too little available N in the soil to produce a good yield, they can apply some supplemental N fertilizer such as Chilean nitrate which contains 15%N. Pelleted poultry manure, which has about 4% N, might also be used.

N deficiency is generally easy to recognize on corn plants due poor color and reduced yield. Nitrogen deficiency symptoms appear first on lower leaves as yellowing and in severe cases as a dead tissue with a V shaped pattern from the leaf tip to midvein. When corn is provided with excessive amounts of N from soil or fertilizer the plants will have good green color just as may be expected for optimally fertilized corn. However, excessive N supply and N uptake are not so easy to diagnose from crop appearance alone. A good diagnostic test for excess N fertilization of sweet corn is the End-of-Season Stalk N Test. This plant tissue test is performed at harvest time. At this stage it is too late to take corrective action during the current growing season. However, a grower can learn from experience if year after year they are providing excessive N. With this “report card” information about their production practices, they can learn to adjust their fertility program in subsequent growing seasons. Details on how to use this tissue test are given in Rutgers NJAES fact sheet: Sweet Corn Crop Nitrogen Status Evaluation by Stalk Testing.

Besides N, sweet corn needs a proper balance of all essential plant nutrients. Fields intended for sweet corn should be sampled and tested to ensure that P and K fertility levels are at or near optimum levels. The target soil pH level for sweet corn is 6.5. Applications of limestone as recommended by soil test reports should supply any needed calcium (Ca) or magnesium (Mg). Sulfur (S) is an important nutrient for both yield and enhance corn flavor. Fields with very sandy soils are most likely to be S deficient. Organic growers who frequently apply manures or compost will generally have enough S fertility from the soil. The need for micronutrients can be assessed from soil tests. Boron (B) is an important nutrient for pollination and good kernel fill at the ear tip. Manganese (Mn) deficiency sometimes occurs on coastal plain soils. Foliar applications of manganese sulfate (1 lbs Mn/acre) is usually the best way to correct the Mn deficiency.

Amount of nutrient removal by crop harvest is a useful indicator for sustainable nutrient management. For sweet corn, we have data to show how much of macro and micronutrients are removed with every harvest of sweet corn (Table will be provided as a handout or on request by email: jheckman@njaes.rutgers.edu). Depending on whether sweet corn is grown for direct marketing, wholesale, or processing; growers may use different units to express yield. Thus, the nutrient removal values can be expressed both in units of ear number or weight. Also, the data set takes into consideration differences in nutrient uptake values for early, midseason, and late season sweet corn types. A crate typically consists of 50 ears as a market unit. Whether expressed as per 1000 ears, hundredweight (100 lbs = 1 cwt), or crate (50 ears), nutrient management planners can scale nutrient removal values up to a yield goal per unit land area by multiplication. As an example, for nutrient removal data we will assume a typical full season variety of sweet corn. And assume the yield level = 150 cwt/acre (or about 18,396 ears/acre or about 368 crates). (This example assumes weight of a typical fresh sweet corn ear of market size with green husk included = 0.815 pounds) This full-season variety of harvested fresh ears would be projected to remove in pounds per acre: N, 51, P, 9.1 (P_2O_5, 20.8), K, 34 (K_2O, 40.8), S, 3.7; Ca, 2.0; Mg, 3.9; B, 0.024; Cu, 0.014; Fe, 0.09; Mn, 0.044; and Zn, 0.072. Nutrient removal values would be less for short season sweet corn varieties.

Wine Grapes

NOTES

Hemp Agronomy

HISTORY AND BACKGROUND OF INDUSTRIAL HEMP PRODUCTION

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Industrial hemp is from the plant species Cannabis sativa and is used to produce a variety of industrial and consumer products. Hemp is a source of fiber and oilseed grown in countries worldwide. Many products, including fibers, textiles, paper, construction and insulation materials, cosmetic products, animal feed, food, and beverages can be produced from hemp. By definition, industrial hemp is low (less than 0.3%) in tetrahydrocannabinol (THC), the cannibis plant's primary psychoactive chemical.

There are over 25,000 reported uses for industrial hemp products globally according to a 2018 Congressional Research Service report. Industrial hemp is grown mainly for fiber production (fabrics, yarns, paper products, construction materials etc.) or seed production (food products, culinary oils, soaps, lotions, cosmetics). Some varieties are suitable for dual-use production. Hemp is also grown for the production of cannabidiol oil extracted from resins produced largely in its flowers. CBD is used as a health supplement with purported health benefits including pain relief, inflammation, and others.

Industrial hemp was once an important crop in the U.S. prior to being banned from US production under The Marihuana Tax Act of 1937. During the World War, industrial hemp was identified as a critical product needed by the US government, due to difficulty in sourcing fiber from Asia, for packaging, rope and other key products and as such was commercially grown domestically by American farmers. Today, one still finds the remnants of wild hemp growing in those former agricultural production regions. The 2014 Farm Bill paved the way for production of industrial hemp once again in the US. There is renewed interest and focus on industrial hemp now as a renewable and sustainable resource for a wide variety of consumer and industrial products.

This presentation will review the important historical role that hemp production has played nationally and will introduce how recent regulatory changes may provide opportunities for production in the northeast.

HEMP AGRONOMY: INTRODUCTION TO PEST MANAGEMENT, FERTILITY AND CULTURAL PRACTICES

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Industrial hemp is from the plant species Cannabis sativa and is used to produce a variety of industrial and consumer products. Hemp is a source of fiber and oilseed grown in countries worldwide. Many products, including fibers, textiles, paper, construction and insulation materials, cosmetic products, animal feed, food, and beverages can be produced from hemp. By definition, industrial hemp is low (less than 0.3%) in tetrahydrocannabinol (THC), the cannibis plant's primary psychoactive chemical.

Cannabis sativa is a summer annual plant. It is a very photoperiod sensitive crop. As a result, flowering is initiated according to day length (photoperiod) not physiological maturity. Most hemp varieties initiate flower development when day length is less than approximately 12 hours. It is mostly dioecious (male and female flowers occur on separate plants). Therefore, there are both male plants and female plants. Although some monoecious varieties exist, most cultivated hemp is currently dioecious. Different plant parts harvested for specific purposes will require different management strategies.

Types of Hemp

Grain: Grain varieties are selected for food and nutritional applications. Grain varieties have high protein, fatty acid, and seed fiber content and usually have lower CBD content. Grain varieties are often shorter in height, reducing the amount of biomass that passes through the combine and reducing wrapping in the combine. Grain hemp seed is thin-walled and can be fragile. The fragile seeds must be handled with care when harvested and transported to market.

Fiber: Fiber varieties of hemp produce long fibers and increased biomass. Fiber hemp varieties are generally taller and favor vegetative growth over seed production. These types of hemp have a wide range of uses, including textiles, building materials, pulp/paper, and more. Ideally, producers of hemp fiber will have access to processing facilities nearby due to the bulk of the product and cost of transport.

Dual Use (Hybrid): Dual Use varieties of hemp produce both fiber and seed, but not to the yield or quality of single purpose cultivars.

Cannabinoid (CBD): CBD varieties are currently the most lucrative for agricultural production and marketing. These varieties can present regulatory challenges when attempting to produce the highest yield of CBD, while keeping the THC within allowable levels. High CBD varieties are generally grown utilizing only female plants, as the combination of male and female plants leads to increased seed production and decreased cannabinoid yields.

If contemplating hemp production, it is important to keep in mind that there have been very few U.S.-based agronomic research studies on industrial hemp since the early 20th century. Information from previous research is important and useful but may not always be completely applicable for modern production systems. Industrial hemp is an untested crop in New Jersey. Research is needed to provide data on planting, management, fertility, harvesting, and processing specific to New Jersey. As a result, production information gaps may be encountered in the short term. It is important to note there are differences in production systems based on the end use of the hemp.

This presentation will provide information for producers investigating growing industrial hemp. Industrial hemp grown for grain or fiber production more closely matches existing grain and forage cropping systems than that of hemp grown for CBD. Because we currently have no New Jersey specific research results or production experience, the information provided will be based on information from surrounding states and the region that have participated in industrial hemp pilot programs.

CURRENT INDUSTRIAL HEMP RESEARCH IN THE NORTHEAST

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There are three distinct markets for industrial hemp crops: fiber, grain and cannabidiol (CBD oil). Crop production practices, equipment needs, and plant varieties are specific to the end use products. These differences necessitate that research be conducted regionally to provide producers the needed information regarding variety selection, production practices, fertility and many other parameters.

To help farmers succeed, agronomic research on hemp is critical, as much of the historical production knowledge for our region has been lost. The main objective of university trials is to evaluate the field performance (yield, costs and production) as well as industrial quality from NJ-grown hemp under a variety of environmental conditions.

This initiative will introduce industrial hemp varieties into three regions in New Jersey (northern, central and southern) reflecting some of the diversity of soils, climate and growing seasons, and carefully evaluate and monitor the levels of THC to ensure the hemp grown meets legal requirements and is of suitable quality for the industry. Results of this initiative will provide the foundation of information upon which state and Extension recommendations can be formed while minimizing production risks to the producer.

This presentation will review current hemp research conducted at land grant institutions in the northeast and will discuss the research that will be conducted at Rutgers, address specific questions from growers, and discuss concerns and potential for production in New Jersey.

CBD EXPLAINED FROM THE HEMP GROWER PERSPECTIVE

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Recently, the Federal Government reversed an 80-year-old law and made the cultivation of hemp legal once again in the United States where it had been grown since Colonial times for rope, clothing, shoes, sails and tents. Hemp and marijuana are varieties of the plant *Cannabis sativa*. One of the major differences between these two types of Cannabis is the content of the phytocannabinoid THC (delta-9-tetrahydrocannabinol), the compound responsible for the euphoric and intoxicating effect of marijuana. All types of hemp have THC content of less than 0.3% in all organs of the plant an amount too little to be intoxicating. Marijuana in contrast may have THC levels as high as 30% especially in the resins produced in and around the flower buds. Hemp varieties used for fiber or seed (grain) contain little, if any phytocannabinoids; however, some Cannabis plants may produce over 100 different types of phytocannabinoids in addition to THC, such as the non-intoxicating CBD (cannabidiol). Resin-producing hemp varieties can produce large amounts of CBD and the cultivation of CBD-hemp has proved more profitable in the US than hemp for fiber or seed oil. The flowers and flower buds containing the resinous glands are the part of plant harvested when grown for CBD, and when the dried flowers and buds are extracted, they produce an oil that may contain as much as 12% CBD with little or no THC. This type of hemp will likely be the major type grown in NJ.

There is considerable interest in the potential medical benefits from CBD treatment. CBD may reduce anxiety, pain, insomnia, seizures and involuntary muscle spasms without getting the user high. Since CBD has only recently been taken off the DEA list of drugs without medicinal benefit, there is only limited research into its effects and many of the claims may prove to be untrue. What we know is that THC and CBD do interact with the central nervous system and enter the brain from the bloodstream. These phytocannabinoids can mimic the activities of the natural occurring cannabinoids (endocannabinoids) that are made by humans and other animals. The endocannabinoid neurological system plays a role in controlling pain, mood, appetite, stress reaction and memory, and this may be why CBD can be an effective treatment for a variety of ailments. For the CBD-hemp grower and processor this creates an opportunity, but also a responsibility to provide a safe product free of microbial contamination with pathogens and chemical contamination with pesticides and heavy metals. The grower should consider microbial and chemical testing beyond that required for THC to obtain certifications to insure safety, and to get the best price for the hemp and/or CBD oil.

Pepper

PERFORMANCE OF EXOTIC PEPPERS IN CONVENTIONAL AND ORGANIC PRODUCTION SYSTEMS IN NEW JERSEY

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Abstract: In 2018 and 2019 we compared 5 and 6 groups of exotic peppers (*Capsicum* spp.) under conventional and organic production systems at Rutgers Horticulture Farm 3 (HF3), East Brunswick, Central New Jersey, and Rutgers Ag Research and Extension Center (RAREC), Bridgeton, Southern New Jersey, respectively. The pepper groups compared were: a) Habaneros, (*C. chinense*) b) Superhots, (*C. chinense*) c) Poblano types (*C. annuum*), d) Jalapenos (C. *annuum*), and e) African Birdeyes (*C. frutescens*) at HF3; plus f) Sweet Minibells (*C. annuum*) at RAREC. The conventional and organic plots were adjacent, and had relatively similar soil pH (5.8-6.8), texture (sandy loam) and optimum to high soil fertility. Cultivation was under black plastic mulch in the two systems. The conventional plots received minimum 20-20-20 NPK fertilizer (applied as fertigation) and herbicide application for weed control. The organic plots received no fertilizer application and weeding was done manually and mechanically between the plastic-mulched seedbeds. In both systems, weeds within the planting hole were removed manually as they emerged. The exotic peppers selected were the most promising in our collection based on yield and quality and consumer feedback regarding acceptability and desirability. Specific results are highlighted below:

Plant size: At both the HF3 and RAREC field sites, all pepper groups were larger in the conventional plot than in the organic plot at 14 weeks after planting. The difference in plant size was more pronounced at RAREC where organic matter (2.1-2.9%) and pH (5.8-5.9) were lower than at HF3 (OM 3-3.4%, pH 6.6-6.8). On a scale of 1-5 where 1= very small plant size, 5 = very large plant size, plants at HF3 were on average rated 4.5 and 4.3 in the conventional and organic plots, respectively; compared to 3.5 and 2 at RAREC in the two systems, respectively. Among the pepper groups in the two systems and at the two locations, the Habaneros, Superhots, and African Birdeyes, were the largest plants (30 -36 inches tall, 30-36 inches wide), followed by the Poblanos and the Sweet Minibells (28-33 inches tall; 24-30 inches wide) and the Jalapenos (12-24 inches tall; 10-18 inches wide).

Fruit yield, fruit number and fruit size: Considering total fruit fresh weight and number, the exotic peppers yielded more at HF3 than at RAREC, though individual fruit size did not differ significantly. At both locations, fruit yield and number were higher in the conventional plot than in the organic. Differences between the two systems were more at RAREC than at HF3. Fruit size again did not differ significantly between the conventional and organic systems at the two locations. Among the pepper groups, the Poblanos and Jalapenos produced the highest yields (5-7lb/plant) followed by the Sweet Minibells and Habaneros (4-6lb/plant), African Birdeyes (3-4lb/plant) and the Superhots (1-3lb/plant). Fruit number was in the order African Birdeyes

>>Habaneros=Sweet Minibells>Superhots>Poblanos>Jalapenos, while fruit size was in the order Poblanos>Jalapenos>Sweet Minibells>Habaneros>Superhots>African Birdeyes.

Fruit Heat Level (Scoville Heat Units -- SHU) (based only on data from HF3 records): As expected, significant variations occurred in heat level between peppers grown in the conventional and organic systems. Overall, the Superhots contained the highest heat level (500,000-900,000 SHU) followed by the Habaneros (25,000-180,000 SHU), Poblanos (0-180,000), African Birdeyes (28,000-65,000 SHU) and the Jalapenos (0-20,000 SHU). Among Superhots, fruit from the conventional system was slightly spicier than (or as spicy as) those from the organic plot (Carolina Reaper Seg 1 was an exception, much less heat but organic system seemed to produce spicier fruit). Among the Habaneros, Hab B1 and Hab C produced fruits in the organic system much spicier than the fruit from the conventional system. Others in the group produced fruit that were slightly more (or equally) spicy in the conventional system as in the organic system. The African Birdeye group produced spicier fruit in the organic system than in the conventional. In the Poblano group, the cultivation system impacted fruit heat level only in the Padron pepper where the heat level was higher under conventional than organic. The cultivation system had no significant impact on the other members of the group. Heat level in the Jalapeno fruit behaved erratically in response to the cultivation systems. It was not clear in this study how the members responded to conventional and organic systems. Upcoming studies could shed more light on this question.

Conclusions: Our work showed that plant size, fruit yield, and fruit number in exotic peppers responded more favorably to conventional production systems than organic systems at HF3 and RAREC. Fruit size seemed to respond less to the specific cultivation systems we used in these trials. Significant variations occurred in fruit heat level, and that appeared to be associated with specific pepper type among and within groups. We eliminated the impact of weed interference in this study by ensuring optimum manual and mechanical weed control in the organic plot and the use of herbicides in the conventional system. We did not apply any biofertilizers or manure to the organic system which might have improved crop performance. Future studies are planned to examine the efficacy of biofertilizers for exotic pepper production in New Jersey; and the economic ramifications.

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UPDATE AND RESEARCH ON X10R BELL PEPPER VARIETIES FOR USE IN NEW JERSEY

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Bacterial Leaf Spot

Bacterial leaf spot (BLS) caused by the pathogens *Xanthomonas euvesicatoria* and *Xanthomonas campestris pv. Vesicatoria* is the second most important disease on peppers in New Jersey.

BLS has become more of a concern over the last ten to fifteen years. The pathogen is favored by high humidity, hard driving rains, vigorous plant growth, infected stakes, and working in the field when plants are wet. There are eleven (0-10) races of BLS identified in the United States and in past research was shown that at least races 0-5 were present in New Jersey.

In 2016 we started screening varieties and advanced breeding lines for resistance to all races of bacterial leaf spot. The 2019 trials were carried out at the Rutgers Agricultural Research and Extension Center (RAREC) near Bridgeton, New Jersey and in a grower's field in Vineland, New Jersey. Plots were established on black plastic mulch with one drip line between double rows with distance between plants at 18 inches in double rows and 6 ft. between beds center to center and 5.3 ft in Vineland. The plots were transplanted June 5th at RAREC and May 30th in Vineland. All cultural practices such as staking/tying, fertilization and pest management were carried out by the grower in Vineland. The RAREC trial was not staked.

BLS was not observed at the Vineland locations except for the variety 'Paladin'. Plots at RAREC were rated twice, July 17 and September 9 (Tables 1). All entries showed some BLS, but 'Paladin' susceptible control consistently had the highest rating and most entries had less BLS for the second rating except 'Paladin'. There were no fruit symptoms for either date.

The entries were harvested 4 times starting 62 days after transplanting from July 31 to September 5 in Vineland and 5 times starting 75 days after transplanting from August 19 to October 11 at RAREC. Peppers were graded based on weight (extra-large >0.49 lbs., large 0.33 – 0.49 lbs., medium 0.25 – 0.32 lbs., culls >0.25 lbs.). Total season data is summarized in tables 2 and 3 for all harvests. Fruit quality for diameter and length, wall thickness and number of lobes are presented in Table 4.

Table 1. Bacterial Leaf Spot Ratings. RAREC. 2019.

		Mean	
Variety/Line	**Company**	**Jul 17, 2019**	**Sep 9, 2019**
9325	Seminis	1.5	1.25
Autry	Seminis	1.5	0.88
Placepack	Enza Zaden	1.5	1.33
Provider	Enza Zaden	1.5	1.5
Skyhawk	HM	1.5	1.38
3255	Seminis	2	0.75
7331	Seminis	2	0.75
Green Machine	Seminis	2	1
Labelle	Seedway	2	1.13
Outsider	Syngenta	2	1.13
Samurai S10	Sakata	2	2
Standout	Syngenta	2	2
Antebellum	Seminis	2.25	1.5
Aristotle X3R	Seminis	2.5	3
Green Flash	United Genetics	2.5	3
Mariner	United Genetics	2.5	1.75
Prowler	HM	2.5	1.38
Ninja S10	Sakata	2.75	2
7140	Seminis	3	2.25
Boca	Seedway	3	1.25
FPP2862	Sakata	3	1.38
Turnpike	Seminis	3	3.5
1819	Seminis	3.25	3.75
3963	Seminis	3.25	3
FPP2866	Sakata	3.25	2.25
Mercer	Sakata	3.25	3.13
Galleon	United Genetics	3.5	2.75
Playmaker	Seminis	3.5	1.38
SP2622	Sakata	3.5	1.13
SP2628	Sakata	3.75	0.88
Paladin	Syngenta	4	4

Rating Scale:

0=No symptoms

1=Few leaf spots, strong plant growth and canopy

2=Major leaf spotting and marginal necrosis, good growth

3=Heavy leaf spotting and leaf drop, regrowth good

4=Heavy defoliation, stunted, very little regrowth

Table 2. Extra-large, Large, Medium and Total Marketable Yield for Five Harvests Including Percent Marketable. RAREC. 2019.

Marketable Yield (28 lb. boxes) per Acre and Percent Marketable RAREC - 2019 - All Harvests - Bridgeton, NJ					
Variety/Line	**XL**	**L**	**M**	**% Marketable**	**Total Marketable**
Turnpike	85.25 ab[x]	674.20 a	254.26 b-f	92.80 a-e	1013.70 a
3964	103.12 a	593.20 abc	261.30 b-f	95.23 a-d	957.60 ab
Aristotle X3R	13.78 def	595.30 ab	269.12 b-e	91.10 a-e	878.20 abc
Mercer	13.83 def	525.50 a-d	332.73 ab	92.51 a-e	872.10 abc
Outsider	65.93 bc	487.70 a-e	272.75 a-e	94.51 a-d	826.40 a-d
1819	36.41 cde	486.20 a-e	287.20 a-d	94.70 a-d	809.80 a-e
3255	5.65 def	416.30 b-h	382.24 a	97.54 a	804.20 a-e
SP2622	16.73 def	456.90 a-f	304.24 a-d	97.33 a	777.90 a-f
Labelle	21.49 def	402.40 b-i	331.17 abc	91.55 a-e	755.10 a-f
FPP2862	39.00 cd	448.70 a-g	243.54 b-f	96.27 ab	731.20 a-f
SP2628	7.87 def	417.90 b-h	274.05 a-e	97.19 a	699.80 a-g
Green Machine	16.78 def	392.40 b-j	267.00 b-e	92.95 a-e	676.20 b-g
Playmaker	22.79 def	453.10 a-f	199.36 d-h	89.36 cde	675.20 b-g
Prowler	13.57 def	402.10 b-i	257.47 b-f	90.14 b-e	673.10 b-f
Antebellum	11.08 def	363.10 c-j	273.48 a-e	95.84 abc	647.60 b-g
Green Flash	32.11 c-f	335.60 d-j	248.20 b-f	87.25 ef	615.90 c-h
Boca	16.73 def	341.90 d-j	247.27 b-f	95.31 a-d	605.90 c-h
Autry	30.40 def	317.80 d-j	256.64 b-f	93.38 a-e	604.90 c-h
7140	23.00 def	283.00 e-k	276.74 a-d	86.83 ef	582.70 c-h
Samurai S10	15.80 def	290.70 e-k	274.72 a-d	95.17 a-d	581.20 c-h
Standout	34.08 c-f	324.70 d-j	221.84 c-g	94.83 a-d	580.60 c-h
FPP2866	8.08 def	306.10 d-k	199.31 d-h	95.62 abc	513.40 d-i
Skyhawk	5.18 def	241.80 f-l	241.83 b-f	88.43 d-f	488.80 e-i
9325	11.34 def	217.60 g-l	235.82 b-g	93.49 a-e	464.80 f-i
7331	8.34 def	198.50 h-l	254.47 b-f	93.63 a-e	461.30 f-i
Galleon	8.55 def	217.30 g-l	163.62 e-h	92.92 a-e	389.40 ghi
Provider	2.64 ef	166.00 jkl	209.46 d-h	93.40 a-e	378.10 g-j
Ninja S10	2.75 ef	164.80 j-l	154.66 fgh	82.06 f	322.20 hij
Mariner	8.44 def	181.20 i-l	107.84 hi	73.76 g	297.50 hij
Placepack	0.00 f	75.70 k-l	125.65 ghi	87.40 ef	201.40 i-j
Paladin	0.00 f	28.60 l	32.68 i	91.79 a-e	61.30 j
LSD	**34.99**	**231.73**	**110.72**	**6.90**	**322.22**

[x]Within columns, means followed by different letters are significantly different

Table 3. Extra-large, Large, Medium and Total Marketable Yield for Five Harvests Including Percent Marketable. Vineland. 2019.

Marketable Yield (28 lb. boxes) per Acre and Percent Marketable 2019 - All Harvests - Vineland, NJ					
Variety/Line	**XL**	**L**	**M**	**% Marketable**	**Total Marketable**
3964	224.93 a[x]	798.70 ab	98.52 gh	94.82 abc	1122.20 a
1819	120.49 bc	857.60 a	125.14 c-g	94.00 a-e	1103.20 a
Antebellum	115.16 bc	779.90 a-d	147.84 b-g	95.74 ab	1042.90 ab
Turnpike	131.01 b	794.40 abc	108.36 fgh	97.42 a	1033.80 ab
7140	45.84 ef	762.70 a-e	109.78 fgh	91.42 a-f	918.30 abc
Prowler	17.95 ef	692.00 a-f	190.20 abc	88.59 a-h	900.10 a-d
Aristotle X3R	107.53 bcd	677.90 a-g	112.71 efg	93.27 a-e	898.10 a-d
Skyhawk	31.26 ef	672.60 a-h	131.74 b-g	86.76 b-i	835.60 b-e
Provider	34.24 ef	609.90 b-i	179.54 a-d	88.30 a-h	823.70 b-e
Mercer	45.84 ef	609.30 b-i	147.44 b-g	88.33 a-h	802.60 b-e
Boca	107.13 bcd	560.60 d-j	132.18 b-g	85.98 c-i	799.90 b-e
Green Machine	18.25 ef	594.90 b-i	138.00 b-g	92.44 a-f	751.10 c-f
Standout	38.11 ef	562.70 c-j	142.80 b-g	88.83 a-h	743.60 c-f
FPP2862	34.98 ef	525.10 f-j	172.44 a-f	91.04 a-f	732.50 c-f
9325	15.41 f	519.10 f-j	148.28 b-g	91.97 a-f	682.80 c-g
SP2628	10.18 f	540.60 e-j	122.69 d-g	92.76 a-e	673.50 c-g
Outsider	72.79 cde	544.90 e-j	45.10 hi	89.31 a-h	662.80 c-g
ug_1730	48.04 ef	487.20 f-j	126.02 b-g	83.23 f-i	661.20 c-g
Autry	54.84 def	498.10 f-j	105.59 gh	94.67 abc	658.50 c-g
3255	14.28 f	444.90 g-k	190.20 abc	96.72 a	649.40 d-g
FPP2866	5.77 f	490.30 f-j	141.55 b-g	84.91 d-i	637.70 d-g
playmaker F	12.57 f	457.50 g-j	160.97 a-g	90.84 a-f	631.00 efg
SP2622	18.44 ef	449.10 g-k	163.34 a-g	81.32 ghi	630.90 efg
7331	7.92 f	441.30 h-l	178.36 a-e	94.24 a-d	627.60 efg
Ninja S10	0.00 f	393.00 i-m	223.91 a	89.98 a-g	616.90 e-h
Samurai S10	7.58 f	390.20 i-m	191.72 ab	91.84 a-f	589.50 e-i
Green Flash	2.74 f	358.60 j-m	163.24 a-g	80.18 hi	524.60 f-i
Playmaker	7.48 f	347.70 j-m	163.00 a-g	78.71 i	518.20 f-i
Placepack	5.28 f	353.40 j-m	101.70 gh	85.08 d-i	460.40 g-j
Galleon	5.43 f	211.00 lm	139.86 b-g	84.74 e-i	356.30 hij
Mariner	10.37 f	216.00 lm	113.86 d-g	51.16 j	340.20 ij
Paladin	13.65 f	168.70 m	32.14 i	95.10 abc	214.50 j
LSD	**56.85**	**233.42**	**66.36**	**3.66**	**262.91**

[x]Within columns, means followed by different letters are significantly different

Table 4. Fruit Size, Wall Thickness, and Number of Lobes. RAREC and Vineland 2019.

	RAREC			Vineland		
Variety	L/W	Wall Thickness (mm)	No. Lobes	L/W	Wall Thickness (mm)	No. Lobes
1819	0.89	5.65	4.00	1.15	5.88	3.60
3255	1.00	6.45	3.80	0.90	5.12	3.75
3963	1.06	6.06	3.60	1.29	6.15	3.30
7140	0.93	5.97	3.80	1.24	5.55	3.30
7331	1.00	6.17	3.80	1.09	5.70	3.80
9325	0.84	5.73	3.40	1.04	5.03	3.10
Antebellum	0.95	6.50	4.00	1.22	6.00	3.60
Aristotle X3R	1.12	5.66	3.50	1.31	6.14	3.20
Autry	0.78	5.93	3.83	1.08	5.55	4.00
Boca	0.88	6.23	4.20	1.03	6.48	3.50
FPP2862	0.96	5.77	4.00	0.96	5.48	3.50
FPP2866	0.81	5.95	4.10	0.87	5.01	4.10
Galleon	1.02	6.27	3.88	1.21	5.81	3.80
Green Flash	1.06	6.22	3.90	1.09	5.27	4.00
Green Machine	0.93	5.97	4.10	1.08	5.44	3.40
Labelle	0.87	5.83	4.00	1.14	5.20	3.40
Mariner	1.01	6.50	0.00	1.02	5.86	3.60
Mercer	0.92	5.69	3.60	1.18	5.87	3.20
Ninja S10	0.85	5.40	4.00	1.05	5.45	3.67
Outsider	0.98	6.39	3.70	1.19	5.85	4.00
Placepack	-	-	-	1.02	6.73	3.60
Playmaker	0.95	5.95	3.50	1.14	5.88	3.50
Provider	0.95	5.73	3.40	1.09	6.37	3.90
Prowler	0.97	5.93	3.40	1.03	6.41	3.70
Samurai S10	1.01	6.04	3.70	1.04	5.70	3.29
Skyhawk	0.74	5.72	3.50	0.92	6.14	3.50
SP2622	0.86	5.87	4.30	0.86	4.97	4.60
SP2628	0.86	5.92	4.20	1.22	4.82	3.20
Standout	0.83	6.23	3.80	0.95	4.99	3.70
Turnpike	1.04	6.26	3.70	1.38	6.30	3.30

UPDATE AND RESEARCH RESULTS ON DISEASE CONTROL IN PEPPER

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Controlling anthracnose fruit rot.

Anthracnose fruit rot has been an increasing problem in pepper production during the past few years. The pathogen, *Colletotrichum* spp., also causes a fruit rot in strawberries and tomatoes. The pathogen can infect pepper during all stages of fruit development resulting in serious losses if not controlled properly. Symptoms of anthracnose fruit rot include sunken (flat), circular lesions. In most cases, multiple lesions will develop on a single fruit. As lesions enlarge, diagnostic pinkish-orange spore masses develop in the center of lesions. During warm, wet weather spores are splashed onto healthy fruit through rainfall or overhead irrigation.

Managing anthracnose fruit rot begins with good cultural practices. The pathogen overwinters on infected plant debris and other susceptible hosts. The fungus does not survive for long periods without the presence of plant debris. Pepper fields should be thoroughly worked (i.e., disced, plowed under) after the season to help break down and bury old debris. Heavily infested fields should be rotated out of peppers for at least three years. Do not plant or rotate with strawberries, tomatoes, eggplant or other *solanaceous* crops. Once areas in fields become infested, management of the disease can be difficult. Prevention is critical to controlling anthracnose fruit rot.

Prevention is critical to controlling anthracnose fruit rot. Infected fruit left in the field during the production season will act as sources of inoculum for the remainder of the season, and therefore, should be removed accordingly. Thorough coverage (especially on fruit) is extremely important and high fertility programs may lead to thick, dense canopies reducing control. Growers have had success in reducing the spread of anthracnose by finding 'hot spots' early in the infection cycle and removing infected fruit and/or entire plants within and immediately around the hot spot.

Controlling Phytophthora crown and fruit rot.

Phytophthora blight (*Phytophthora capsici*) is one of the most destructive soil-borne diseases of pepper in the US. Without proper control measures, losses to Phytophthora blight can be extremely high. Heavy rains often lead to conditions which favor Phytophthora blight development in low, poorly drained areas of fields leading to the crown and stem rot phase of the disease. Infections often occur where water is slow to drain from the soil surface and/or where rainwater remains pooled for short periods of time after heavy rainfall. Always plant phytophthora-resistant/tolerant cultivars, such as Paladin, Aristotle, Turnpike, or Archimedes to help minimize losses to the crown rot phase of the disease. For an updated cultivar list please see the 2020/2021 Commercial Vegetable Recommendations Guide.

Managing bacterial leaf spot in pepper

Bacterial leaf spot (BLS) in pepper has increased in some areas of the mid-Atlantic region over the past few years. There are ~10 races of the pathogen and in the past few years races 1,2,3,4,5 and 6 have been detected in New Jersey. The pathogen can be seed-borne and can cause significant problems in the field if transplants are exposed to the pathogen during transplant production. Hot water seed treatment can be done to help mitigate potential problems due to BLS. Any seed suspected of carrying BLS should be hot water treated, this is especially important in heirloom varieties or organic seed where BLS problems have been suspected or an issue in the past. Some of the most commonly-grown commercial bell and non-bell pepper cultivars in the region carry resistance packages to different races of the pathogen. Many of the bell peppers grown in the region also have resistance/tolerance to phytophthora blight. Growers with past histories of BLS and/or phytophthora blight on their farm should only grow those cultivars that carry resistance/tolerance to both pathogens. For an updated cultivar list please see the 2020/2021 Commercial Vegetable Recommendations Guide.

Integrated Pest Management

CONTROL OF PLECTOSPORIUM BLIGHTAND OTHER DISEASES ON PUMPKIN

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Plectosporium blight, also known as White speck, can cause significant problems in cucurbit production. Plectosporium blight is favored by cool, humid or rainy weather. The fungus can overwinter on crop residue and can persist in the soil for several years. No pumpkin or summer squash varieties are known to be resistant to the disease. Spores are spread by rain-splash and wind. Lesions are small (<1/4 inch) and white. On vines, the lesions tend to be diamond shaped; and on fruit they are small, round and irregular. The lesions increase in number and coalesce until most of the vines and leaf petioles turn white and the foliage dies. Severely infected pumpkin vines become brittle. Early in the infection cycle, foliage tends to collapse in a circular pattern before damage becomes more universal throughout the field. These circular patterns can be easily detected when viewing an infected field from a distance. Fruit lesions produce a white russeting on the surface and stems that render the fruit unmarketable. The fruit lesions may allow for entry of soft rot pathogens that hasten the destruction of the crop (Boucher and Wick) (http://vegetablemdonline.ppath.cornell.edu).

In recent years downy mildew has become a significant problem in cucurbit crops throughout the US. Symptoms of downy mildew include irregular, chlorotic (yellow) spots which develop on the upper leaf surface of cucurbit crops. These lesions expand and cause leaves to turn from yellow to brown often resulting in a scorched appearance in a few days if left untreated. Diagnostic characteristics of downy mildew are the purplish-brown spores which develop on the bottom side of infected leaves. Spores can easily be seen with a 10x hand lens. Control of downy mildew begins with the early recognition of symptom development and preventative fungicide applications. Fungicide resistance to downy mildew has been reported and there is some evidence that new race(s) of the pathogen may be present in the US. Since fungicide resistance to other important cucurbit diseases, such as powdery mildew and gummy stem blight already exist in our area, proper preventative fungicide application programs must be followed.

Powdery mildew (*Podosphaera xanthii*) continues to be one of the most important foliar diseases of cucurbit crops in New Jersey. Symptoms of powdery mildew include white ‘fluffy’ colonies which develop on upper and lower leaf surfaces, vines and handles of fruit. Control of powdery mildew begins with planting powdery mildew resistant/tolerant cultivars and early detection of symptoms along preventative fungicide maintenance programs. Fungicide resistance to powdery mildew has been detected in NJ and growers need to follow fungicide labels and restrictions accordingly.

The diagnosis and control of these diseases and other important diseases of cucurbit crops will be discussed. An update on the newest fungicide chemistries available for controlling important diseases in cucurbit crops will also be presented.

UPDATE ON CORN EARWORM RESISTANCE TO B.T. TOXINS AND PYRETHROID INSECTICIDES

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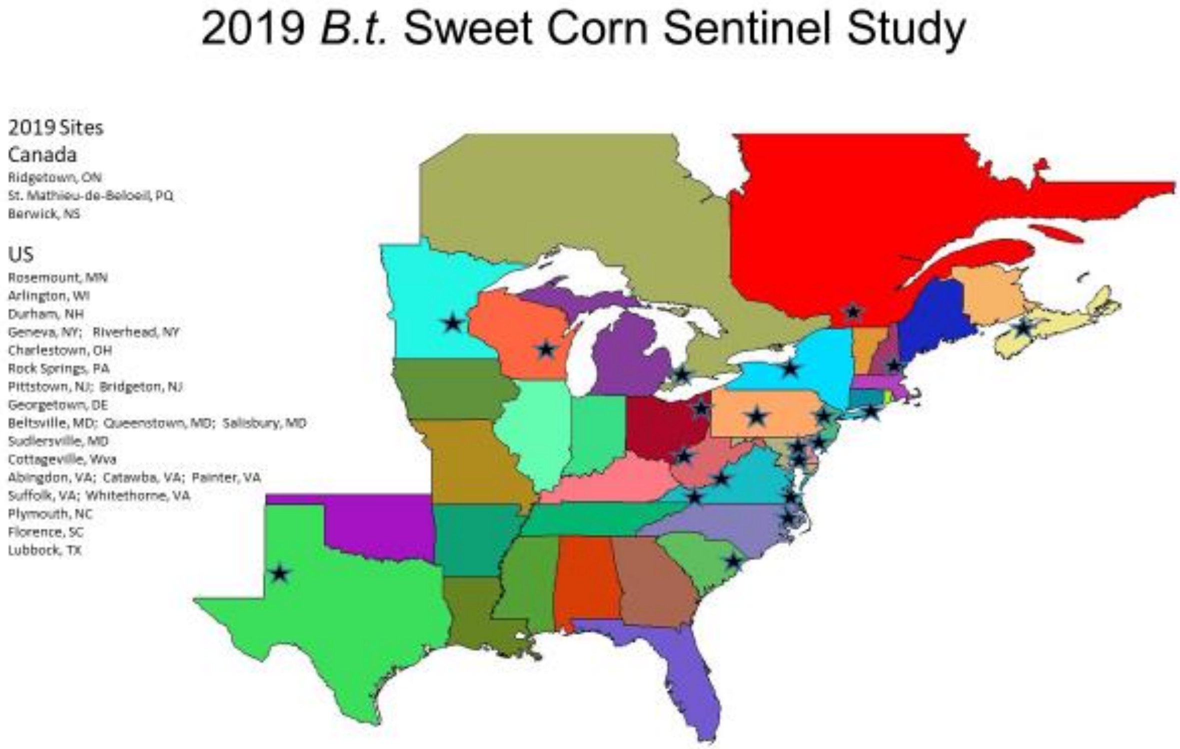
Corn earworm (CEW) is the primary ear-damaging insect in sweet corn production in the mid-Atlantic states, and is the principle driver of silk stage insecticide applications on this crop. In New Jersey, CEW moth populations are generally low, to very low from late May through mid-June. This is followed by a period through mid-July when CEW adults are nearly non-existent. This situation changes in August and September, with weather-aided migratory influxes of CEW moths from the lower Atlantic Coast states. IPM programs monitoring CEW moth numbers are able to provide critical information to growers so that they can adjust their silk stage insecticide applications in response to increasing pest pressure. In an effort to minimize insecticide applications during this later part of the season, many growers have opted to use sweet corn varieties that incorporate toxins from the soil inhabiting bacterium *Bacillus thuringiensis* (*B.t.*).

There are currently three types of *B.t.* sweet corn available commercially: Attribute® hybrids (expressing Cry1Ab toxin), Attribute® II hybrids (expressing Cry1Ab and Vip3A), both from Syngenta Seeds, and Performance Series™ hybrids (expressing the Cry1A.105 and Cry2Ab2 toxins) from Seminis Seeds. While all hybrid types provide excellent control of European corn borer (ECB), and fair (Attribute) to excellent (Performance, Attribute II) control of fall armyworm (FAW), the control of CEW has deteriorated rapidly and dramatically in *B.t.* hybrids as field resistance to Cry toxins has developed in that insect.

In response to increasing instances of poor CEW control in the mid-Atlantic region, and in order to better track regional changes in CEW field resistance to *B.t.* toxins in sweet corn, a multi-state sentinel plot study was begun in 2017 and continued through 2019 (see figure 1). *B.t.* sweet corn is an ideal crop with which to monitor resistance to these toxins because 1) the toxins are expressed at higher concentrations in sweet corn than in *B.t.* field corn, 2) we have years of data on CEW ear infestations in non-*B.t.* corn as a baseline for expected damage, 3) changes in infestation rates are easy to track because CEW is almost exclusively an ear infesting insect and 4) there are true isogenic hybrids among non-*B.t.* and *B.t.* varieties, meaning that the only difference between them is the inclusion/type of *B.t.* derived toxin.

Fig. 1. Cooperating sites

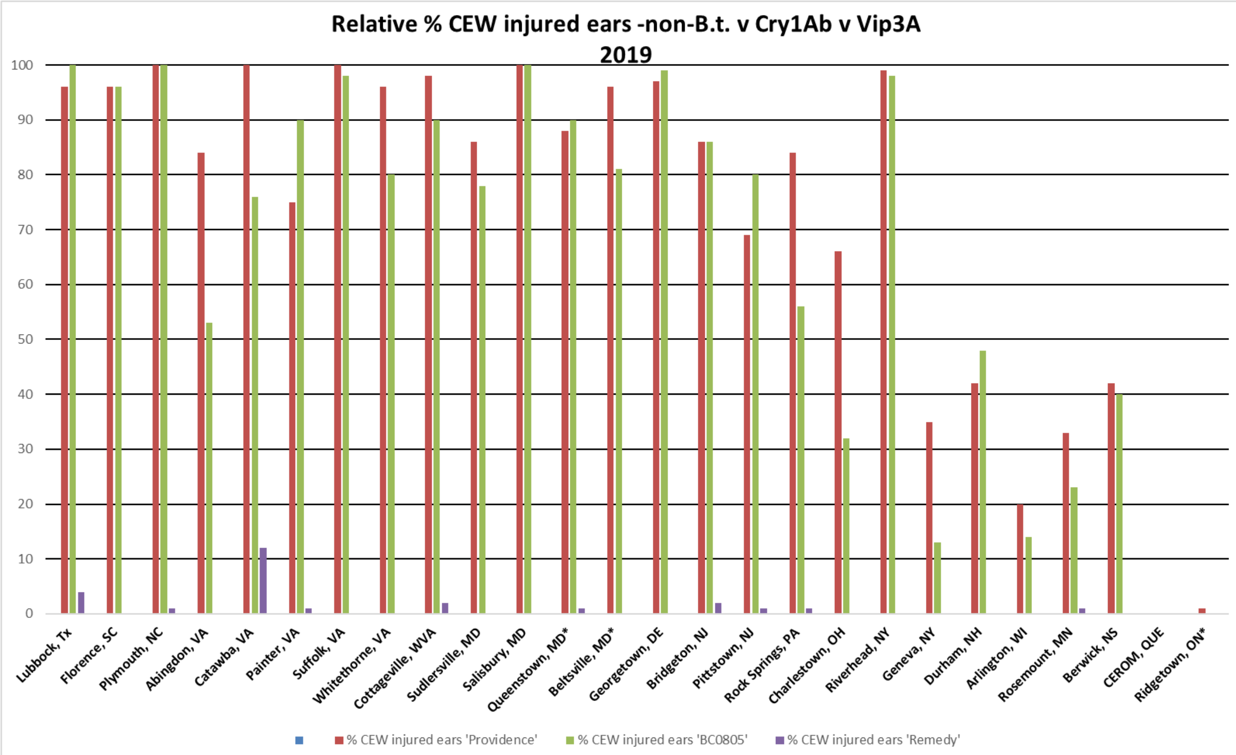


In 2019, all field plots contained the isogenic bicolor hybrids ‘Providence’ (non-*B.t.*), ‘BC0805’ (Attribute - Cry1Ab) and ‘Remedy’ (Attribute II – Cry 1Ab, Vip3A) and the isogenic hybrids ‘Obsession’ (non-*B.t.*) and ‘Obsession II’ (Performance Series – Cry1A.105 +Cry2Ab2). Plots were planted such that the silking periods would fall in the later summer when CEW moth numbers were at their highest. No insecticide applications were made. All evaluations of ear damage occurred at fresh market maturity. Data recorded included number of ears damaged by CEW, size of surviving CEW larvae, kernel area consumed and proportion of larvae reaching later instars. Of greatest concern to growers is the number of ears damaged by CEW, which is what is addressed here.

Non-B.t vs. Attribute I vs. Attribute II

Although the northernmost sites had lower *overall* infestation rates (sites in Ontario and Quebec, Canada had little or no infestation in any type), a trend was consistent throughout all sites. CEW field resistance to Cry1Ab toxin in sweet corn is widespread and significant enough that there is rarely a difference in CEW infestation between non-*B.t.* ‘Providence’ and Attribute I ‘BC0805’ (see Figure 2). Even at the lower infestation sites, ear damage by CEW would be considered unacceptable. At the same time, the Attribute II variety ‘Remedy’ shows at all sites that the Vip3A toxin is providing excellent control of CEW, with only limited (although slightly higher than in 2017) numbers surviving over all locations. Sites followed by an asterisk (*) indicate multiple harvests. Figures at these sites are averages of two or more evaluations.

Fig. 2 - CEW injury – non B.t., Attribute I and Attribute II

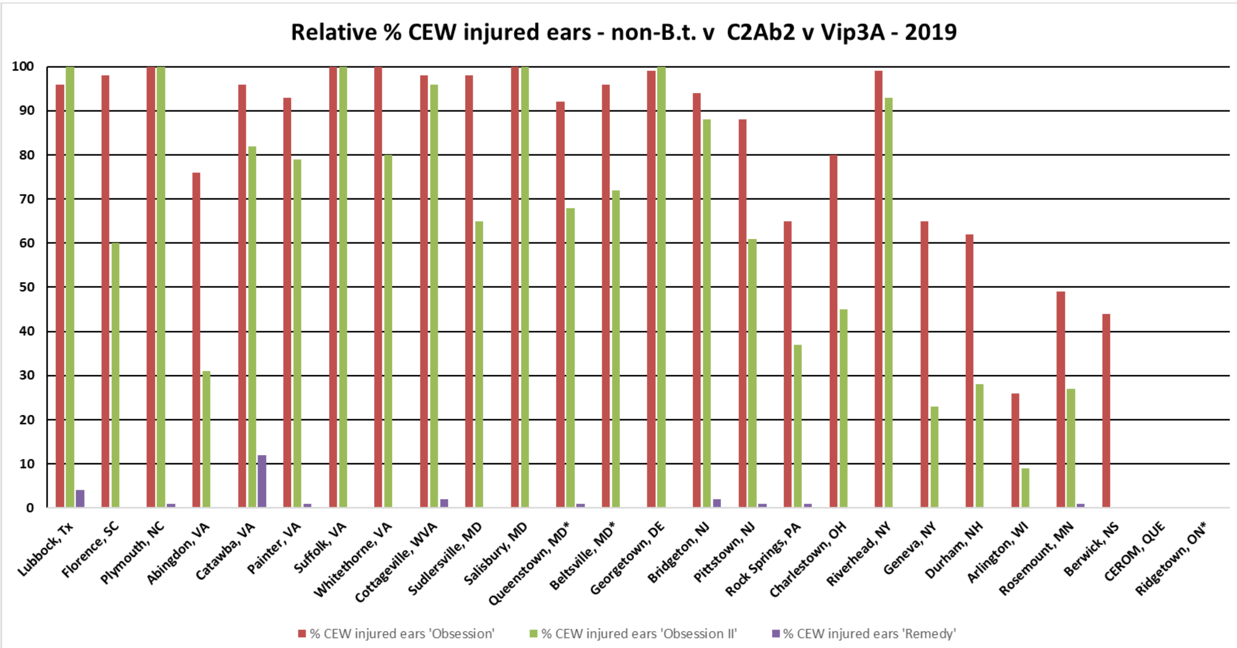


Non-*B.t.* vs. Performance Series vs. Attribute II

The sites in the study where 'Obsession II' (Performance Series – Cry1Ab, Cry 2Ab2) was paired with its' non-*B.t.* analog ('Obsession') showed that Cry 1Ab/Cry2Ab2 toxins no longer provide acceptable control of CEW (see Figure 3). Sites followed by an asterisk (*) indicate multiple harvests. Figures at these sites are averages of two or more evaluations.

Data from the 2019 study show that regionally, only varieties that incorporate the Vip trait (Attribute II) are providing excellent control of CEW without insecticide applications. Varieties that incorporate Cry toxins alone will require insecticidal intervention by growers at levels approaching that required on non-*B.t.* sweet corn. It bears repeating that all *B.t.* types to date are highly effective at preventing ECB injury at any growth stage, and Performance Series and Attribute II varieties provide excellent control of FAW as well. *B.t.* technology does not control sap beetles or corn leaf aphids. Because CEW populations in the southern U.S. are exposed to lower doses of *B.t.* toxins in field corn and cotton, they have developed strong resistance to them at the higher doses found in sweet corn varieties. This resistance is encountered in the Northeast U.S. later in the season because most of our CEW moths are migratory from points south. This may be due to susceptible individuals migrating from areas where resistance has yet to develop to the degree is has in the southeast. Resistance trends will be monitored further, as refugia requirements in field corn have been relaxed. This may intensify resistance to *B.t.* toxins in CEW, and puts the Vip trait at risk for resistance development.

Fig. 3 - CEW Injury – Performance Series



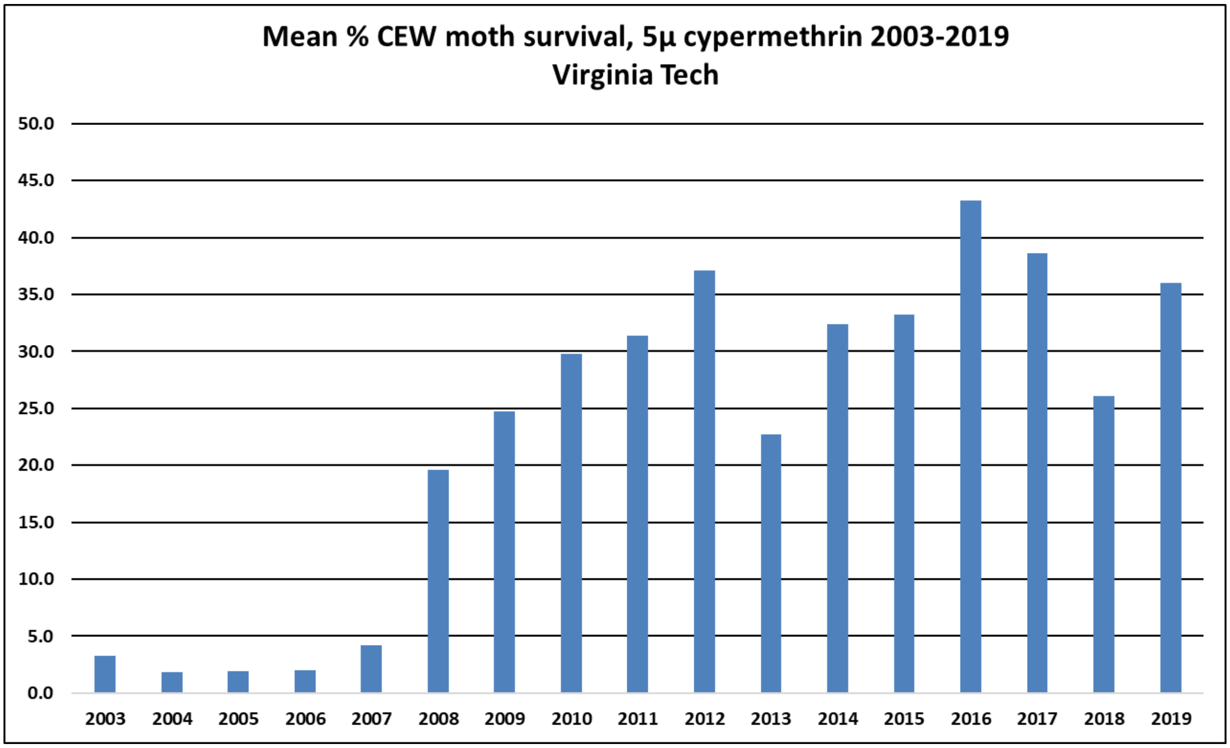
Potential changes in CEW response to Vip 3A toxin

While Vip 3A expressing Attribute II sweet corn varieties still demonstrate excellent control of CEW, FAW and ECB, several disturbing findings emerged from the 2018 study. In 2019, Catawba, VA experienced 12% survival on Vip3A expressing corn, while Lubbock, TX had 4% survival. The few sites having CEW infested ears in the 2019 Attribute II (Remedy) plots in this study indicate a similar presence of low-level resistance to that found in 2018. Additionally, in CEW infested ears, CEW larvae survived longer in 2018-19 and consumed more kernel area than in previous years. Although control efficacy remains very high in Attribute II types, these findings indicate the possibility that CEW populations are beginning to develop resistance to the Vip 3A toxin, as has occurred with previous *B.t.* derived toxins. Sentinel studies in the mid-Atlantic region are essential in monitoring changes in CEW population susceptibility to *Bt* derived toxins in commercial sweet corn varieties. The cooperators in these studies plan to continue this work in order to inform the grower community regarding the status of CEW resistance, as well as provide data to assist regulatory agencies in developing management plans to help preserve this trait as an effective management tool.

CEW resistance to pyrethroid insecticides

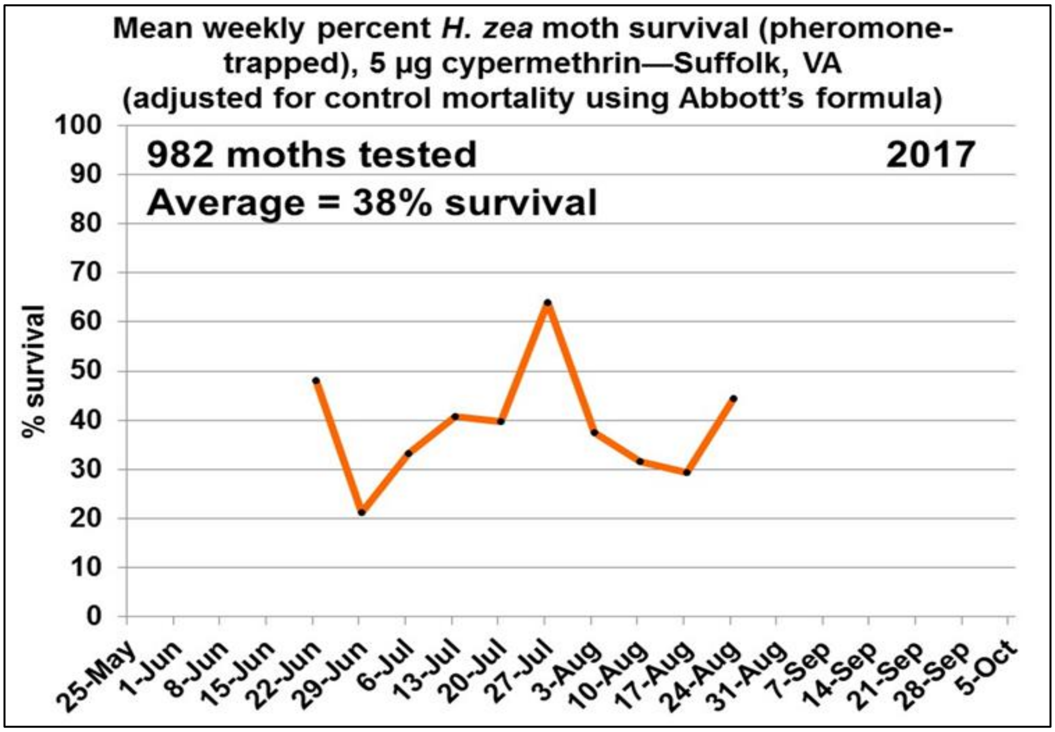
For the past ten years, sweet corn growers in New Jersey have experienced periodic, but devastating breakdowns in earworm control when using synthetic pyrethroid insecticides as the main silk spray product. In our area, this appears to be a late summer event, either because early CEW adults are more susceptible to the toxins or due to sheer numbers of moths later in our growing season, ie. more resistant individuals are represented in the larger population. For the past 17 years, Extension faculty and staff at Virginia Tech have captured CEW moths live from pheromone traps and placed them in vials coated with 5 micrograms of cypermethrin (Ammo), a synthetic pyrethroid. Initially resistance was low, but this changed in 2008 (see Fig. 4, below). As of 2019, mean survival of moths was 36%. This change manifested itself in resistance to other pyrethroids as well, as in NJ, growers began to have trouble managing CEW with cyfluthrin and lambda-cyhalothrin.

Fig. 4 – CEW moth survival when exposed to cypermethrin



Pyrethroid resistance is inconsistent through the growing season, as shown in Fig. 5. This leaves growers in a position to assume that any given population will not respond favorably to applications of this class of insecticide.

Fig. 5 – Seasonal survival of CEW moths exposed to cypermethrin



Reliable control of CEW on silk stage sweet corn must include insecticides in the following classes: IRAC* Grp 5 (Spinosyns – Radiant, Entrust, Blackhawk), IRAC Grp 28 (diamides – Coragen, Exirel, Besiege (chlorantraniliprole+lambda-cyhalothrin)) IRAC Grp 1A (carbamates – Lannate). The use of synthetic pyrethroid insecticides for CEW protection on silk stage sweet corn is likely to be unsatisfactory, and growers are encouraged monitor the RCE Vegetable IPM Update weekly, for information as to CEW population and spray schedules, and to rotate materials to help avoid further resistance development.

* IRAC = Insecticide Resistance Action Committee

The author wishes to acknowledge:

Dr. Galen Dively (Uinv. Of MD) for organizing the 2017-19 sweet corn sentinel plot projects, as well as conducting efficacy work on genetically engineered sweet corn since its inception. Virginia Tech for providing updated CEW/pyrethroid resistance data.

NON-INDIGENOUS WEED SPECIES AND THEIR MANAGEMENT IN NEW JERSEY SPECIALTY CROPS

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Weeds are a problem in fruit and vegetable crops because they compete with crops for light, water, and nutrients; harbor pests and diseases; and can restrict the movement of workers and equipment in the field. Invasive weeds are non-indigenous plants that have been introduced into an environment outside of their native range. In their new environment, they have few or no natural enemies to limit their reproduction and spread. Invasive weeds affect us all - farmers, homeowners, taxpayers, consumers, and tourists. In this presentation, we will focus on identification, biology and control strategies of 9 invasive weed species that affect field and vegetable crops in New Jersey: Palmer amaranth, jimsonweed, Canada thistle, mile-a-minute, Japanese knotweed, and mugwort.

Palmer amaranth (*Amaranthus palmeri* S. Watson) is a summer annual aggressive and invasive weed native to the desert regions of the southwest United States and northern Mexico. It slowly colonized the southeast United States and has become one of the most troublesome weeds of cotton and soybean crops. Palmer amaranth is present in south New Jersey and has been reported from asparagus, pepper and tomato fields. Palmer amaranth aggressiveness and adaptability is the consequence of several biological features: dioecious reproduction, prolific production (> 100,000 seeds per plant) of small easily dispersible seeds, very fast growth (2-3" a day), and good shade tolerance. Palmer amaranth population in the mid-Atlantic region have been confirmed to have resistance to ALS-inhibiting herbicides (group 2) and to glyphosate (group 9). Resistance to other herbicide families is known from the Southeast and Midwest regions. Controlling plants before they produce seeds is critical for successful management of this species. The ideal stage for mechanical or chemical control of this weed is when the seedlings are 3" or less. Preemergence herbicide providing long residual control are critical for managing this species and need to be applied as close to the planting date as possible.

Jimsonweed (*Datura stramonium* L.) is widespread in warm temperate regions around the earth, so its origins are uncertain. Jimsonweed grows throughout New Jersey. Jimsonweed is listed as a noxious weed in New Jersey due to its poisonous alkaloids present in all parts of the plant. Jimsonweed seedlings emerge intermittently during the growing season, so monitoring and repeated pulling may be required. Once an area is infested, new seedlings will spring up for several years because seeds can remain viable in the soil for numerous years. Jimsonweed is not known to have evolved resistance to herbicide and can be efficiently controlled with preemergence herbicide belonging to groups 8, 13 or 14. Once jimsonweed has emerged, effective chemical options are limited to shielded application of paraquat when the seedlings are still at the cotyledon stage.

Canada thistle [*Cirsium arvense* (L.) Scop.] is an invasive weed species that was probably introduced from Europe into the United States by accident in 17th century. It is widespread across the US and throughout New Jersey where it is considered a noxious weed species. Canada thistle is an erect perennial that is commonly found in patches due to an extensive underground stem system that extents up to 3.5 feet into the soil and from which new plants can emerge (asexual reproduction).Plant can also reproduce by producing wing-dispersed seeds that can remain dormant but viable for up to 20 years. Plants can also regenerate from root fragments as small as 1” long. Thus, cultivation is not an effective option for controlling Canada thistle as it will contribute to spreading of the weed. Effective control can be achieved by depleting the carbohydrates pool. Successive mowing every 3 weeks can help starving underground stems. No preemergence herbicide will provide effective season-long control of Canada thistle. Control of established patches will require frequent mowing or multiple postemergence herbicide (glyphosate, clopyralid) applications within a single year over the course of several seasons.

Mile-a-minute [*Persicaria perfoliata* (L.) H. Gross] is an annual wine native to eastern Asia and introduced into the U.S. from the Philippines several times between the late 1800s and the 1930s. It is now common in several states of the Mid-Atlantic region, including New Jersey. Mile-a-minute fast growth helps it to quickly outcompete other plants. Seeds eaten by birds and released in their droppings assure its dispersal. While not a problem in regularly tilled crops, mile-a- minute can be a troublesome weed in perennial crops where it can use bushes or trellis as a climbing support. Removal should be done prior to fruit formation. Repeated mowing will prevent the plant from flowering and thus reduce or eliminate fruit and seed production. A systemic herbicide like glyphosate will work on mile-a-minute, especially when used with a surfactant that will help to penetrate the leaves’ waxy coating. The herbicide should be applied on young seedlings, before mile-a-minute starts covering non-target vegetation.

Japanese knotweed (*Reynoutria japonica* Houtt.) is a perennial weed that grows in dense patches to heights of 10 feet. It is native to Asia, and was originally introduced to the U.S. as an ornamental in the late 1800's. It propagates through rhizomes that will spread vigorously, expanding the size of the knotweed stand. Similar to Canada thistle, new knotweed plants can sprout from individual small fragments of rhizomes. Strategies for controlling knotweed should focus on the rhizome system to deplete the plant from the nutritional reserves stored in the underground structures. Mowing around June 1st will help exhausting the energy reserves in the rhizomes and stimulate the development of shorter new shoots. However, mowing by itself is not a sufficient strategy and needs to be complemented by using a systemic herbicide. A late summer application of glyphosate (Rodeo) on a spray-to-wet basis is the key to maximizing injury to the root system, especially if knotweed has been mowed around June 1st. If you’re not planning to mow the knotweed, then plan on spraying twice. First Rodeo application should occur between mid-July and early-August, and must be followed by a second application by mid-September. Knotweed is frost-sensitive, so it is important to make the second application prior to frost. Re-sprouting from the rhizome will likely occur the following season. Wait until at least July 1, then spot-treat. After the second season plan on at least one annual application to any knotweed sprouts.

MANAGING PEPPER WEEVIL IN 2020

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Pepper weevil (PW) remains as one of the most destructive crop pests affecting all varieties of peppers, wherever they are grown. Prior to 2004, PW infestations in New Jersey were sporadic with sometimes large gaps of years between significant infestations. Since 2004, there has been a nearly annual infestation somewhere in southern NJ. Serious infestations have occurred in 2004, 2012, 2013 (the worst year) and now again in 2019. At least thirteen farms were infested with varying levels of loss. Three farms experienced severe infestations and two of the thirteen farms experienced PW for the first time, including a farm with greenhouse peppers.

How did this happen?

Pepper weevils (Anthonomus eugenii) are subtropical insects of the Americas that probably have co-evolved with Capsicum (pepper) species. They exist year-round in the southern climes of Mexico, the Caribbean and across the southern tier of states of the US. They cannot persist where frosts kill solanaceous weeds and crops, as they require a constant food source.

The life cycle is short, 2 ½ to 3 ½ weeks, from egg hatch to the adult stage. Each female lays 200-300 eggs, individually inserted into the cuticle of flowers and developing fruit. As the larva begins to feed on the interior of the fruit, the plant perceives a biochemical signal to abort the small, infested fruit. The larva continues to feed and develop in the fallen fruit, finally emerging as an adult. As the smaller fruit are aborted the weevils are forced to lay their eggs in larger, non-aborting fruit. These infested peppers remain on the plant and if no external blemishes appear, they are harvested and shipped to other locations.


Three pepper weevils feeding on flower buds.

New Jersey is one of those destinations for peppers grown in weevil infested areas. The PW found in NJ are primarily from the peppers that come to local processers and repackers. As the peppers are cut and processed, or culled, the waste material ends up in a dumpster, in most cases, from where the adult weevils escape into the local area, seeking out food and oviposition sites. Other sources of invasive PW are terminal markets, auctions, and possibly migrant workers. Once the weevils are here in NJ they are easily spread about by their own dispersal, flying from field to field, and transported by vehicles. There is evidence, though not proven, that weevils travel in small swarms.

PW is extremely difficult to manage. The adults are susceptible to most foliar insecticides, but, because of their biology, the larvae are very difficult to kill. This allows non-synchronous emergence of adults so that even with weekly insecticidal applications the infestation continues to expand, suppressed but not managed.

Avoidance and aggressive management

Perhaps the best management is to avoid allowing an infestation to develop. How can this be done?

1) Avoid planting a solanaceous crop within one mile of a processing plant/repacker and landfills, if possible
2) Apply a foliar insecticide at first flower
3) Do not allow the dumping of raw vegetable waste on your farm and be aware if your neighbor does
4) Strategically place pheromone traps to intercept invading PW
5) Sanitize produce bins brought onto the farm from a processing plant/repacker before using them

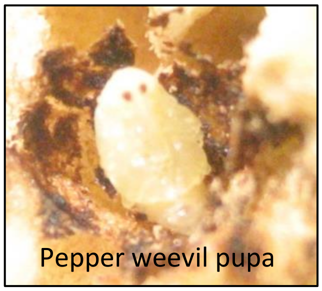
Pepper waste dumped in a field.

Once an infestation becomes established what can be done about it?

1) Determine the extent of the infestation
2) Deploy non-lured yellow sticky cards to help trap out the adults
3) Remove aborted fruit
4) Rotate weekly applications of insecticide. In Florida where PW is endemic, a rotation of Actara and Vydate with another insecticide (Torac, Exirel, or pyrethroid) seems to offer the best control

The most aggressive management has to come with early season infestations occurring in May and June to avoid near total crop loss. Infestations occurring later in the season may still cause significant crop loss though infestations originating in September may cause little loss.

One very important thing to remember is how rapidly PW populations can build up. Even with 50% mortality, one female weevil can lay up to 300 eggs and in 3 generations (7 to 11 weeks depending upon temperatures) producing 843,750 progeny. Since frequently there are multiple larvae per aborted fruit, the number of aborted fruit would be approximately 562,500!



Pepper weevil pupa

Under this scenario, a field is transplanted the 2nd week of May. First flower occurs about two weeks later with one female weevil present. By August 1st, about a half million pepper fruit will be lost. This is an intolerable loss. Farmers must remain vigilant for this pest.

High Tunnels

RASPBERRY PRODUCTION IN HIGH TUNNELS

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What is a high tunnel? It is a greenhouse type structures, large enough to walk in, covered with a single layer of poly, using roll up sides for passive ventilation and generally not heated. There are many types of high tunnels with varying widths and lengths. In my estimation, there is nothing magical about the size. The best tunnel is whatever works for your operation, for the site that you have and the crops that you intend to grow. The most important considerations are the orientation of the tunnel, the height of the side openings and the height of the tunnel. The side openings must be a minimum of five feet for adequate ventilation. Six feet openings are even better. If you are growing raspberries for production during the summer, you want the high tunnel to run in a north-south orientation. Most locations have a predominantly westerly wind which will help with ventilation of the tunnel. The other reason why the north-south orientation is best is because you do not want the hot summer sun to burn berries not covered by leaves. As far as the height of the tunnel is concerned, the higher the tunnel the better. Temperature management and ventilation are more easily achieved in a higher tunnel.

The high tunnels are covered with plastic (poly) with a UV inhibitor. We have used one tunnel with light diffusing poly covering that helps to maintain a lower temperature while breaking up the light (diffusing the light) so that more areas of the plant receive light. It has a slight green appearance from the outside. One tunnel has been covered with poly with an infrared blocker that is supposed to help reduce re-radiation of heat out of the tunnel at night. If you use this type of poly, install it so you can read the printing on the poly from **inside** the tunnel. Researchers continue to investigate different types of plastic for berry yield and quality improvements.

The floor area of our high tunnels is covered with landscape fabric which controls weed growth and allows a nice surface to walk on. We have an opening that is about two feet wide where the canes grow. Once a planting is established, there is not a great deal of weed pressure. We use compost mulch to cover the soil in the area of the canes. Care needs to be taken that the mulch is not too deep to inhibit new cane emergence in the spring.

All the raspberries are drip irrigated with a row of tape down each side of the row. We have an injector mounted on a hand cart so that we can move the injector from house to house as we feed the raspberries through the drip system. We use pasteurized mushroom compost and inject fertilizer again at flowering. We check the pH of the soil each year and add lime as required.

All the raspberries in high tunnels are primocane varieties. We have looked at several varieties, but have settled on ‘Heritage’, ‘Crimson Giant’ and ‘Joan J’. We fruit our primocane varieties twice - once in the late summer and fall of the year and then the second crop on those canes comes off in May, June and early July. With the different maturities of the varieties we have and the way we manage our canes, we have raspberries continuously from May through November.

All the raspberries are trellised. Raspberries can grow very tall in high tunnels; much taller than outdoor berries. I do not exaggerate when I say the canes can be 8 to 10 feet tall. These canes will fall over into the walkway if a sufficient trellis system is not present. The high tunnel can turn into a jungle without trellises. There are different types of posts that can be used from wood to steel. Whatever type of post make sure it is strong. We use wooden fence posts with cross braces to run wire on either side of the cane. We have a minimum of three wire heights, i.e. ~24 inches above the soil surface, ~ 42 inches above the soil surface and ~60 inches above the soil surface. We use wire tighteners to maintain tension on the trellis system.

At the beginning of the growing season and at the end of the growing season, daily raising and lowering of the sides of the high tunnel will be necessary. To keep the plastic sides from blowing when lowered, we installed screw in eyes at the top and the bottom of the opening at each hoop at the beginning and end of the tunnel and at every other hoop toward the center of the tunnel. We use baler twine or nylon rope in an "V" or “X” pattern to hold the plastic in place when down. The twine does not interfere with raising the sides when ventilation is needed. This system is also useful for protecting the berries should a severe storm pass through the area. We have problems with nor'easters that bring wind driven rain off the ocean. A word of caution - never leave one side up. This allows an area for wind to get trapped in the tunnel and can cause severe damage to the structure.

There are manual roll-up systems for high tunnels as well as automated roll-up systems. Since heat can build up very quickly in a high tunnel, you must be around to roll up the sides on a sunny day. When rolling up the poly, try to roll it under so that rain is not trapped in the poly. It isn't a perfect world, so when rain does get trapped, empty it as soon as possible. Water weighs a lot!

Our biggest pest problem in the high tunnels is with two spotted spider mite (TSSM). Since no rain falls on the canes, the natural control agent for TSSM has been removed. Introducing the predatory mite, *Neoseiulus fallacis* in May has worked very well for season long control. This predatory mite feeds on pollen as well as several species of mites and it has given better control than *Phytoseiulus persimilis*.

We pick raspberries every day. Berries are picked into half pint green pulp containers with the containers placed in a master that will hold twelve half pints. After the master is filled, the berries are placed in a cold room that is maintained at 40ºF. When the berries are chilled, they are graded. A plastic lid with a Jersey Fresh seal goes on the half pint container after grading. Our berries are marketed at farmers' markets, farm markets, and restaurants.

To cool our berries, we built a 12 by 12-foot cold room in one corner of our barn. We insulated it very well <u>including the floor</u>. Four inches of styrofoam insulation are recommended for a cold room. I purchased a room air conditioner and a temperature override system (called a CoolBot) for the air conditioner so that the temperature can be lowered from the minimum 60 degrees of the air conditioner to as low as 35º F. The CoolBot also has a regulator for the defrost cycle to keep the air conditioning unit from freezing up. If you plan on purchasing a CoolBot visit the website: https://www.storeitcold.com/. It is important that you purchase the correct size and model of air conditioner. Check with the company since even the same brand or model of air conditioner change from year to year. We also put a vinyl strip door covering outside the insulated steel door into the cold room to reduce cold loss as we go in and out of the cold room.

What I like best about growing the raspberries in high tunnels is the quality of the berry produced. We never spray our raspberries. That is important to our customers even though we are not certified organic producers. We do not have problems with *Botrytis* gray mold because the environment under the tunnel does not favor the disease-causing organism. The berries never are rained on nor does dew settle on the berries. Almost all disease is favored by the presence of rain and dew.

Obviously, the high tunnels help us get into the market earlier than producers who grow raspberries outdoors. In Southern New Jersey, we typically have raspberries two to three weeks before strawberries are available outdoors. Outdoor raspberries aren't available until the end of June to the first week of July. In the fall of the year we typically have raspberries for 4 to 6 weeks after outdoor producers have stopped harvesting due to frost and/or inclement weather. The tunnels protect the berry crop down to 28ºF.

The other advantage of the high tunnels is that we can harvest regardless of the weather. That makes us reliable producers. When outdoor producers are out of the market because of a wet summer or fall, we still have excellent quality berries.

USING CFD TO IMPROVE HIGH TUNNEL VENTILATION

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High tunnels are cost effective, plastic film-covered growing structures that use very little to no modern environmental control technology. Natural ventilation is used to control temperature and, to a certain extent, humidity in these structures. Typically, ventilation openings are created along the sides and sometimes the roofs by manually rolling up a section of the plastic film cover. Operators have to account for seasonal changes to control the indoor environment. In this paper, we focus on summer ventilation. During the summer, it is important to maximize the air exchange rate within high tunnels in order to maintain inside temperatures as close to the outside temperature as possible. Computational fluid dynamics (CFD) simulations were used to evaluate summer ventilation in high tunnels. The CFD models were developed and validated using environmental data (wind speed and direction, air temperature and relative humidity, soil temperature and heat flux, leaf temperature, net incident radiation) collected from high tunnels located at a research site maintained by the Pennsylvania State University High Tunnel Research and Education Facility (Rock Springs, PA). Several ventilation designs (side vents, roof vents, or combinations of the two) were evaluated and results are reported in this paper. Recommendations were developed that growers can use to assist them with decisions about the best ventilation strategies.

HIGH TUNNEL DESIGN AND CONTROL

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A recent trip to visit high tunnel operations in the province of Québec, Canada provided insights into the design of growing structures used for the production of raspberries, strawberries and blueberries. This abstracts contains several images showing growing structures that could be of interest to New Jersey growers who either already grow these crops or are considering growing these crops. Additional details will be provided during the presentation.

Figure 1. Raspberry production under rain shelters.

Figure 2. Raspberry production under gutter-less shelters.

Figure 3. Raspberry production in gutter-connected high tunnels.

Figure 4. End wall design for raspberry production in gutter-connected high tunnels.

Figure 5. Raspberry production under rain shelters with insect netting.

Figure 6. Strawberry production (table-top system) under rain shelters.

Figure 7. Greenhouse strawberry production using movable trays.

Figure 8. Blueberry production under insect netting.

For additional information, please visit: https://www.tunnelberries.org/

Useful reference:

Both, A.J., K. Demchak, E. Hanson, C. Heidenreich, G. Loeb, L. McDermott, M. Pritts, and C. Weber. 2019. High tunnel production guide for raspberries and blackberries. Available for download at the above mentioned website.

Regulatory Issues with Hemp

SOME CONSIDERATIONS ON THE INTENSIVE HORTICULTURAL PRODUCTION OF INDUSTRIAL HEMP

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Industrial hemp is by legal definition a grouping of non-psychoactive cultivars and selections of *Cannabis sativa* L., with a delta-9 tetrahydrocannabinol (THC) concentration of not more than 0.3 percent on a dry weight basis (Johnson, 2019; Small, 2016). The industrial hemp cultivars are grown to produce three major types of farm products – fiber, grain for oilseed and flowers (for cannabidiol = CBD oil) (Table 1), ultimately yielding a large variety of end-products through various processing methods (Cherney and Small, 2016). While the Farms Bills of 2014 (Agricultural Act of 2014, P.L. 113-79) and 2018 (Agriculture Improvement Act of 2018, P.L. 115-334) have relaxed restrictions on U.S. hemp, distinguishing from the federally controlled marijuana cultivars and selections, industrial hemp production and marketing are still subjected to regulatory oversight, requiring licensing and supervision by state departments of agriculture, with systematic reporting to USDA and DEA (Johnson, 2019). In brief, growers and processors of industrial hemp need permits and monitoring from their state department of agriculture, which in turn needs previous authorization from USDA to run and administer these hemp program. The NJ Department of Agriculture (NJDA) submitted its proposed Hemp Program to USDA, and on December 27, 2019 it received approval to launch the industrial hemp program starting the 2020 season. The Plant Industry Division of NJDA has posted the hemp program regulations on its website along with the guidelines, requirements and forms to apply for grower and processor licenses (https://www.nj.gov/agriculture/divisions/pi/prog/nj_hemp.html).

Considering various logistical, crop management and inputs/expenditures, industrial hemp crops could be separated as to which ones are agronomic (extensive) and horticultural in nature (intensive). Cultivars used for fiber and grain production are within the realm of agronomic crops, whereas those grown for manually harvested flower tissues can be defined as an intensive, specialty, horticulture crop (Table 1). While the planting densities of hemp cultivars grown for flowers (for CBD/cannabinoid extraction) are significantly lower than those used for fiber and seed, the cost of the required feminized seeds ($1-2 per seed; $3,000 to $4,000 per acre) or clonally propagated (rooted-cutting) transplants ($5-7 per female transplant; up to $15,000 per acre) quickly separate them, even before adding the need for the minimally-required drip irrigation and plastic mulching. Even if the use of plastic tunnels or greenhouses is not considered as an option, the cost of manual labor for harvest of flower tissues, further distance the gap from fiber and grain cultivation, and steeply rise the production costs of hemp for CBD.

Table 1. Characteristics of industrial hemp crops. [z]

Feature	Hemp Crop Type		
	FIBER (*Agronomic*)	**GRAIN (*Agronomic*)**	**FLOWERS (*Horticulture*)**
Desired Plant Material	Stalks (bast & hurd/core fibers)	Dried seeds	Cut & dried flower buds and tissues
Common Uses	Bast fibers for paper, insulation, composites, textiles Hurd/core fibers for animal bedding, concrete, fiberboard, oil absorbents	Foods and body products Shelled seed and fines Oil and seed cake	Extractions of plant resin (CBD, other cannabinoids) Nutraceuticals and wellness products
Planting Density	Best with <12" rows 200,000-300,000 plants/acre (15-30 plants/ft2); sowing with grain drill at 35-55 lbs./acre	Optimized grain production with <150,000 plants/acre, sowing seed at 20-30 lbs./acre	Well-spaced, 3-5' feet between rows & plants, totaling 1,500 to 4,000 plants per acre.
Physical characteristics	Tall plants with small stalks and sparse leaves	Short to medium plants with small stalks and sparse leaves	Bushy/stocky plant with profuse branching to promote flowers/buds
Harvest Height	10-15 feet	6-9 feet	4-8 feet
Harvesting Considerations	Typically using hay equipment	Needs harvesting within a short window to minimize seed scattering	Highly labor intensive (manual) harvesting; requires drying down to 10% moisture
Yields	1.0-5.5 tons per acre of dry matter (whole dry stems)	Avg: 800-1,000 lbs./acre (up to 1,600 lbs./acre)	Variable; one plant could yield an average of one pound (0.8 to 1.4 lbs.) of dried material
Post-Production Process	Separating the soft fibrous exterior bast fibers from the tough woody interior hurd fibers (process called decortication)	Dehulling and pressing of dried hemp seeds (grain)	Requires extraction using a variety of methods and solvents
Price (2017)	$70-$135 per ton	$0.65-$0.75 per pound	$25-$200 per pound
Forward Contracting	About 8¢/lb. ($160/ton).	NA	NA
Return per Acre	Up to $700 per acre	Up to $1,200 per acre	NA

[z] Adapted from R. Johnson (2019), with updated data and information from Bennett (2019), Rhizosciences (2019), Wortmann and Dweikat (2019).

While *Cannabis* is generally considered a short-day plant, wild and cultivated hemp selections are adjusted photoperiodically to the latitude of their origin (Small, 2016), meaning that their growth, flowering and seed maturation will be out-of-phase if grown in significantly different latitudes. For instance, cultivars bred/selected from latitudes farther south than New Jersey will likely flower and mature seeds too late when grown here. Therefore, it is recommended to preferably seek out cultivars that were selected/bred from latitudes comparable to New Jersey (i.e. Toronto and southern Canada, middle Europe and central Asia). Furthermore, in as much as possible, attention should be paid to the newest industrial hemp cultivars that incorporate lineage/parentage of high-THC (i.e. marijuana) cultivars from southern latitudes. These newer-type of cultivars are likely to yield flowers with THC levels pegged to the maximum legal limit 0.3%, and the slightest or minimal changes in environmental conditions or cultural practices could cause THC spikes that lead to crop destruction, and even reporting to/prosecution from the DEA if they exceed the 1% THC threshold. Those cultivars that have been proven to be stable with respect to their THC levels, even under stressful conditions, will likely be accompanied by a certificate from hemp seed and clone purveyors. Be wary of cultivars requiring signature of waivers on THC concentrations. Some states, like Kentucky maintain and update listings of recommended, prohibited and "variety of concern" industrial hemp cultivars (KY Dept. Agric., 2018), and they should be consulted or cross-referenced when considering new cultivars.

Regarding the need for drip irrigation for CBD-hemp cultivars, the use of overhead sprinkler irrigation is discouraged as the chemical and biological quality of the irrigation water can negatively affect the chemical and biological quality of the extracted products (heavy metals, pesticide & agrichemical residues, biological toxins, *E.coli*, coliform bacteria counts, etc.), rendering the crop (i.e. flower tissues) unsalable. In addition, minimizing wetting of the valuable flower structures will reduce the potential incidence of diseases. The use of drip irrigation in field-grown hemp for CBD, coupled with a proper irrigation management program, preferably one that tracks both soil moisture and evapotranspiration to guide when and how much water to supply, should help to minimize crop water stress (both drought and waterlogging). While hemp is reported to grow, mature and reproduce under a wide range of moisture conditions (Clarke and Merlin, 2013), flooding, and drought in particular, significantly and negatively affect flower formation and resin secretions, and could trigger unwanted THC spikes (Small, 2016).

As with other horticultural species growing in soilless systems (substrates and hydroponics), growing CBD-hemp cultivars in these production systems do run a higher risk of rootzone water and air (oxygen) stresses which can negatively affect flower yields, CBD and THC contents over very short time scales (minutes to hours). While it can be argued that there is cultural information on soilless *Cannabis* production to be drawn from recreational marijuana circles, be warned that most of it is not based on formal, science-based studies, and in fact, a good deal of the irrigation and fertilization practices used there are to enhance the THC concentrations in flower tissues (Rosenthal, 2010). There are some initial formal university studies reports surfacing on the pH and fertigation management of substrate-grown hemp (Whipker et al., 2019a, 2019b).

Being a new crop, there are not yet any officially labelled pesticides and herbicides for legal use in industrial hemp crops (Kaiser et al. 2015; Roth et al., 2018). The ecogeographic (ecological) origins and evolution of hemp and marijuana (*Cannabis sativa, C. indica* and relatives; Clarke and Merlin, 2013; Small, 2016) define them as a highly competitive ruderal genus, more weed-like in nature (Lambers et al., 2008). As such, when they are found in high densities in non-managed (natural) or managed (agriculture) ecosystems, they out-compete other plant species. Thus, timely sown industrial hemp cultivars for fiber and seed, at very high densities, will likely overcome potentially competing weeds. This, however is not the case of the sparsely planted CBD-hemp cultivars, and thus they require at a minimum the use of plastic (or straw) mulches, otherwise they will succumb to weed competition.

During the 2020 season a team of Rutgers research/extension personnel will be setting-up research studies/trials and demonstration plots across the state to evaluate industrial hemp cultivars, best management production practices and harvesting/processing techniques, to identify those that are more suitable for the state. These activities will be closely coordinated with NJDA, and shared with new licensed hemp growers and processors through extension/educational programs and venues (including newsletters, websites and field days).

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REGULATORY COMPLIANCE FOR HEMP PRODUCTION

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P.L. 2019, c.238. The new statute, known as the "New Jersey Hemp Farming Act" was enacted in August 2019. The New Jersey Hemp Farming Act repealed and replaced the New Jersey Industrial Hemp Pilot Program. This new legislation complies with the 2018 Farm Bill, which authorized hemp producers to grow and sell hemp for commercial purposes. On October 31, 2019, the USDA published its interim final rules for domestic hemp production in the Federal Register at 7 CFR 990 et seq. The new rules became effective immediately upon publication. Any state seeking primary regulatory authority over hemp production must inform the USDA that it is developing a hemp production plan. The USDA will not begin issuing licenses for New Jersey applicants in December because they are aware that New Jersey is developing a hemp plan. The USDA's regulations implement the 2018 Farm Bill and specify provisions that are required in state hemp production plans, including procedures for sampling and testing, disposal of noncompliant hemp, enforcement, and various reports and information sharing with authorities. Accordingly, the Department will establish a USDA approved hemp licensing program in order to promote the cultivation and processing of hemp, develop new commercial markets for farmers and businesses through the sale of hemp products; and promote the expansion of the State's hemp industry to the maximum extent permitted under federal law.

These rules establish the New Jersey Hemp Program ("Program"), which will be administered by the Plants Division within the Department. The objective of the Program is to provide licenses for growing, processing, and handling hemp pursuant to the New Jersey Hemp Farming Act, and the 2018 Farm Bill and its implementing regulations at 7 CFR 990 et seq.

The Program establishes a schedule of fees to be paid based upon whether the hemp producer will be growing, processing, or handling hemp. Growers will pay an annual $300 plus $15 per acre fee, handlers will pay a $450 annual fee, and processors will pay an annual fee for each type of hemp component they process. For example, a hemp producer who processes grain ($450) and CBD extract ($1,000) will pay a $1,450 annual fee. Growers are permitted to process and handle their own hemp without paying additional fees. However, once a grower processes or handles hemp from at least one (1) separate hemp producer, the grower must pay applicable processor and handler fees.

The primary federal requirement is to ensure that all hemp grown and processed maintains the appropriate delta-9 THC concentration limit of 0.3 percent on a dry weight basis. Additional requirements include, but are not limited to, reporting certain information to the USDA and ensuring compliance with the enforcement provisions of the 2018 Farm Bill. For example, hemp farmers cannot be subjected to adverse criminal law enforcement actions for mere negligent violations but will instead be subject to a Corrective Action Plan tailored to prevent future violations. However, three (3) negligent violations committed within a period of five (5) years will render a hemp producer ineligible to work in the Program for a period of five (5) years beginning on the date of the third violation. All hemp with a delta-9 THC concentration of more than 0.3% must be destroyed, but it will only be considered a negligent violation pursuant to these rules if the hemp has a delta-9 THC concentration of more than 0.5% on a dry weight basis. A hemp producer who violates these rules with a culpable mental state greater than negligence may be subject to criminal law enforcement actions.

The Federal interim rule states that hemp with a THC concentration in excess of 0.3% on a dry weight basis will be considered marijuana, and subject to the Controlled Substances Act and DEA regulations. Noncompliant hemp must be destroyed in accordance with reverse distributor regulations at 21 CFR 1317.15. The Department is currently seeking to obtain a reverse distributor license from the DEA in order to provide this service when necessary.

The Program establishes reporting requirements throughout the growing season, including pre-planting reports, planting reports, pre-harvest reports, and one annual production report. Hemp producers are required to report hemp crop acreage and other relevant information to the USDA Farm Service Agency. The Department is required to provide two reports to the USDA each month. One report will update the status of any hemp producer's license, and the other will provide information to the USDA regarding noncompliant hemp violations. The Department will also submit an annual report to USDA regarding total hemp acreage grown and disposed. The reports will ensure that accurate legal descriptions of land and quantities of hemp are maintained, that the Department's inspectors can work efficiently when they go to licensed areas, and that all hemp is produced with a THC concentration of less than 0.3 percent on a dry weight basis. Production reports will provide useful information regarding whether certain varieties tend to violate the federally defined THC level for hemp or produce low yields.

The Program also establishes procedures for sampling and testing hemp. Fifteen (15) days prior to the anticipated harvest date, an inspector from the Department or a DEA-registered third-party lab will collect samples to test for compliance with the federally defined THC level for hemp. All results are subject to review by the Department, which is authorized to re-test and collect samples as necessary to ensure compliance. THC testing procedures must use postdecarboxylation or other similarly reliable methods and must measure total THC. Test results must show the measurement of uncertainty being utilized and state if a given sample meets the 0.3 percent threshold based on the distribution range established by the measurement of uncertainty. Furthermore, hemp producers must agree to grant entry to the Department onto premises where hemp is grown, processed, or handled for inspection purposes. In addition to individual sampling and testing requirements, the Department will also conduct an annual inspection of, at a minimum, a random sample of hemp producers.

Any person with a criminal conviction relating to controlled substances may not participate in the hemp program for a period of ten years following the date of the conviction, unless they were already participating in an industrial hemp pilot program prior to the passage of the 2018 Farm Bill. To comply with this federal requirement, all key participants involved in a hemp production operation, including owners, CEO’s, and CFO’s, must undergo and pass a criminal background check by the New Jersey State Police.

SAMPLING SERVICES & PROCEDURES FOR THE HEMP INDUSTRY

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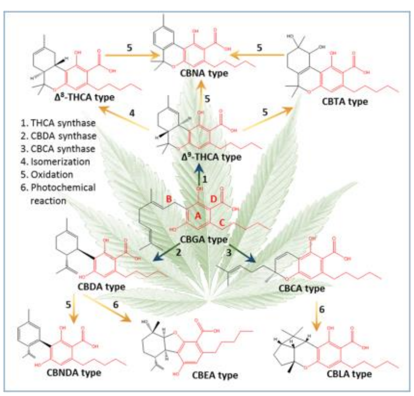
In December 2019, the USDA approved New Jersey's hemp plan. At the time of the printing of this proceedings the specific New Jersey regulations that must comply with federal standards relative to sampling of the hemp, i.e. the allowable content level of delta-9 THC; the anticipated requisite chain of custody, procedures and required documentation for the hemp growers and processors, which were not available to the public. BY the time of this February 04, 2020 workshop, the specifics will be known and the regulatory compliance issues for NJ hemp production will be reviewed by the Division of Plant Industry, New Jersey Department of Agriculture. As such, the following description will provide highlights as to some of the sampling services that Rutgers will be conducting in support of the NJDA and the NJ hemp industry and for which we invite your participation. During this presentation, we will cover in detail the sampling services and procedures required for growers.

The NUANPP Lab at Rutgers is preparing to conduct quality control for hemp including quantitative analyses of CBDs, delta-9 and delta-8 THC and to conduct these tests according to New Jersey Department of Agriculture protocols. Specifically, this would involve the receiving of hemp samples, testing the sample's actual moisture content to derive at a normalized % dry weight content, and then proceeding to quantitate the THC concentration. Most critically, growers and others involved in the hemp industry first need to ensure that their crop meets the state and federal regulations. The most important question is whether their hemp and/or hemp product is too "hot" (e.g. exceeding the maximum allowable THC concentration). Given the THC levels as well as the CBD levels are recognized to be impacted by the genetics of the hemp (your specific germplasm or cultivar used), the actual environmental conditions during its growth (heat, stress and more), time of harvest, method of harvest and postharvest handling, and proper testing for THC are critical.



Source: Natural Products Rept., 2016(33): 1357.

Therefore, Rutgers is poised to conduct the following analytical testing for THC and CBDs:

Analytical Testing for THC and CBDs: We have state of the art analytical instrumentation to accurately quantitate THC and CBD concentrations and their respective ratios from any part of the hemp plant (e.g. seeds, leaves to buds including inflorescences); or from partial or semi-processed products to finished products (e.g. from powder to seed oil or CBD oil). We would be using our Agilent 1290 Infinity II UHPLC with DAD and 6546 Q-TOF analytical instrumentation for such quantification and focus on THC and CBDs. In addition, and as back-up, we also have an Agilent 1290 Infinity II UHPLC interfaced with an 6470 Triple Quadrupole MS with ESI and also an Agilent 1100 series HPLC interfaced with a MSD Ion Trap Mass Spectrometer with an ESI source.

During this presentation we will also be sharing a list of other private certified labs that could also be used by growers for such THC testing. Growers can then make an informed choice as to where they prefer to go relative to costs, turn around time and more.

In addition to the mandatory tests required, growers and processors may be interested in focusing on other tests that address issues of quality. Rutgers is already geared and poised to conduct these other optional sampling services to consider:

Analytical Testing for Short Chain Fatty Acids (SCFA) and Volatile Aromatic Terpenes (VATs): In hemp and CDB oil, the fatty acids and aromatic terpenes are of interest as they are associated with quality of the plant products, the seeds, the oil and raw and processed and finished product. To quantitate the SCFA and VATs, we would be using our Shimadzu GCMS-TQ8040 Triple Quadrupole MS interfaced with a Shimadzu AOC6000 autosampler allowing us to us to detect very low concentrations of minor compounds.

Growers and processors should be aware that significant changes of cannabinoids including THC and CBD could occur during hemp post-harvest handling & storage.

Pesticide Residue Quantification Tests: During this presentation, we will also provide a list of certified labs that conduct such analyses, along with their prices (if available).

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MARKETING HEMP

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Industrial hemp was once an important crop in the United States. During the World War, industrial hemp was identified as a critical product needed by the US government, due to difficulty in sourcing fiber from Asia, for packaging, rope and other key products and as such was commercially grown domestically by American farmers. The 2014 Farm Bill paved the way for production of industrial hemp once again in the US. There is renewed interest and focus on industrial hemp now as a renewable and sustainable resource for a wide variety of consumer and industrial products.

Although industrial hemp production may provide an opportunity for New Jersey, it is crucial that producers carefully examine the market and accessibility of market channels as part of their overall operation. As is the case with any emerging agricultural product, limited data exists to quantify the economic feasibility of industrial hemp production in New Jersey.

It is extremely important to know how to market hemp and where to sell it. One of the most common reasons for not succeeding with an alternative or niche crop is from lack of research as to where to sell the crop and its potential value. It is recommended to first determine if there are processors or buyers in close proximity. Producers growing industrial hemp should also determine if there is any requirement to contract with a buyer in order to sell the crop. Keep in mind that certain contracts specify varieties to be grown and may also require the crop to be grown using specific production practices.

This presentation will focus on potential marketing opportunities for New Jersey hemp production and the economic feasibility of production and processing of hemp products.

Tomato

UPDATE ON WEED MANAGEMENT STRATEGIES & RESEARCH FOR NEW JERSEY TOMATO GROWERS

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Proper management of the many weed species that compete with tomato plants is essential for obtaining good yield and fruit quality, and prevent the onset of disease or pest problems. Efficient control will rely on various integrated weed management (IWM) strategies that need to be tailored to weeds specific to your tomato field.

Prevention: The first step of any weed management program is to prevent introduction, establishment, and/or spread of a specified weed species into an area not currently infested with that species. Control of weeds already emerged with burndown herbicide programs prior to planting, meticulous cleaning of agricultural equipment before moving from infested to non-infested fields, use of weed-free irrigation water, control of weeds on field borders and ditches, and prevention of weed seed production are some of the key elements of an effective weed control prevention program.

Weed Scouting: Weeds should be targeted at the seedling stag as much as possible. Control of fully developed weeds cab be inconsistent because their size prevent homogenous distribution/absorption of herbicides, or because of their ability to regrow following mechanical or chemical control. Scouting for detection of weed seedlings shortly after their emergence is a critical component of a successful weed management program. The goal of weed scouting is to get a representative idea throughout the whole field of the diversity and density of weed species as well as weed growth stage. An efficient scouting program should also provide information on crop phenology as some herbicides cannot be applied beyond a given crop growth stage.

Identification: Accurate weed ID is important for effective management because herbicide efficacy vary according to species, as do some mechanical, cultural, and biological strategies. Some species can look similar to other species from afar, but may have drastically different management requirements. They should be examined closely to determine herbicide programs. Guides such as Weeds of the Northeast (http://www.cornellpress.cornell.edu/book/) or weed identification websites can be helpful to accurately determine weed species and become familiar with their biology and ecology.

Cultural Weed Control: Growers should keep clean soil prior to planting by ridding the soil of weeds through a burndown herbicide application, a thick, suppressive cover crop mulch, or mechanical weed control such as tillage and cultivation. Preventing seed production of weeds growing in the field prior to planting through frequent soil cultivation will help reducing the soil weed seedbank. A late summer or fall application of glyphosate mixed with dicamba or 2,4-D to healthy weed help suppressing broadleaf perennial weeds, such as bindweed, Canada thistle, or horsenettle.

Chemical Weed Control Before or At Planting: Various herbicides are labeled on tomatoes for soil applications prior to weed emergence and crop planting. Choose herbicides that control the weeds in the field (prior knowledge of weed history in the field is importance), apply the proper rate for soil texture and organic matter of the field, spray and incorporate herbicides (mechanically or through irrigation/rainfall) to minimize the risk of crop injury and maximize weed control.

- Treflan HFP (trifluralin; WSSA group 3) and controls annual grasses, pigweeds, common lambsquarters, and a few other small seeded broadleaf weeds. Mechanical incorporation two to three inches deep within eight hours of application is necessary to prevent loss by breakdown by sunlight. Crop injury is a concern when cool and wet conditions prevail after transplanting.
- Prowl H2O (pendimethalin; WSSA group 3) is only labeled as a banded directed shielded spray between the rows of plastic mulch. Apply 1 to 3 pints of Prowl H2O per acre and activate with 1/2" of rainfall or irrigation to control most annual grasses and certain annual broadleaf weeds. Prowl H2O is chemically related to and similar to Treflan, but is not sensitive to sunlight so applications can be made to the soil surface and activated with moisture. Do NOT apply under plastic mulch or "over the top" of tomatoes as this will result in crop injury.
- Metribuzin 75 DF (metribuzin; WSSA group 5) is an effective annual broadleaf weed herbicide that can be applied before transplanting tank-mixed with a preplant incorporated annual grass herbicide, postemergence after the crop reached 2 full-sized true leaves and weeds nor more than 1" tall, or both. Under plastic mulch applications are labelled for transplanted tomatoes only. Repeated postemergence applications will suppress annual nutsedge. The addition of nonionic surfactant to postemergence applications increases the risk of crop injury slightly, and the use of oil concentrate increases the risk further, so tank-mixes with other herbicides requires caution.
- Devrinol 2-XT (napropamide; WSSA group 15) has similar weed control spectrum than Treflan, but crop injury is less of a concern when weather conditions are not favorable after planting. Incorporation is necessary, but can be accomplished with irrigation/rainfall (1") within two days of application. Devrinol can be used under plastic before laying mulch. Yellow nutsedge and many large seeded broadleaf weeds are not controlled by Devrinol.
- Dual Magnum (*s*-metolachlor, WSSA group 15) can be used as a pre-transplant surface treatment, or post-transplant as a shielded directed spray between rows. Dual Magnum provides control of annual grasses, nightshade species, galinsoga, and pigweed species, and suppresses yellow nutsedge. Irrigation is needed to "activate" the herbicide. Application under mulch is possible but not usually recommended as this may result in temporary crop stunting and delayed maturity. PHI is 30 days if 1.33 pt/A per season or less was used, and 90 days if more than 1.33 pt/A was used during the season.
- Sandea 75DF (halosulfuron; WSSA group 2) may be applied to suppress or control certain broadleaf weeds and yellow nutsedge pre-transplant under plastic mulch, postemergence over-the-top (not recommended for plasticulture), or post directed between rows of plastic mulch. Sandea will not control grasses, and may not control or only suppress common lambsquarters. Tank-mix Sandea with other herbicides to broaden the spectrum of weeds controlled. The number of broadleaf weeds controlled

by Sandea applied postemergence is less than the number controlled by preemergence applications, but yellow nutsedge control is more consistent when treated postemergence. Apply Sandea postemergence when the crop has been transplanted at least 14 days and the broadleaf weeds are less than 2 inches in height. Delay the application when yellow nutsedge is the target to allow the perennial sedge more time to develop a leaf canopy to intercept the spray. Sandea is a group 2 herbicide. Herbicides in this class of chemistry have a single site of action in susceptible plants. Always use sequentially or in tank-mixed with other herbicides with a different site of action to prevent or delay the development of resistant weed populations.

Chemical Weed Control After Planting: In addition to Sandea, Metribuzin and Dual Magnum that can also be used postemergence (see previous paragraph), other herbicides are specifically labeled for postemergence applications in tomatoes.

- Matrix or Solida (rimsulfuron; WSSA group 2) controls many weeds in tomatoes, including foxtail and pigweed species, and suppresses common lambsquarters, common ragweed, jimsonweed, and morningglory species. A key to using Matrix successfully is the addition of nonionic surfactant, and application when the target weeds are small, less than 1" tall. Tank-mixing with Metribuzin will increase the spectrum of weeds controlled and assist in controlling weeds that have evolved resistance to group 2 herbicides.
- Poast (sethoxydim; WSSA group 1) and Select (clethodim, WSSA group 1) will exclusively control emerged grasses. Successful control can be achieved with these herbicides when grasses are actively growing and before they start tillering. The addition of nonionic surfactant at 0.25% v/v will help improving weed control. Never tank-mix these herbicides with other pesticides unless labeled, or crop injury or poor weed control may result. Poast or Select will not control yellow nutsedge, which is a sedge, not a grass.
- Gramoxone 2SL (paraquat; WSSA group 22) and Reglone 2SL (diquat: WSSA group 22) are registered for postemergence applications to control weeds between rows on plasticulture. Reglone received a 24c Special Local Need label for New Jersey in 2019. This 24c SLN will expire on December 21, 2021. These herbicides must be applied after weed emergence as a directed shielded spray. Drift on to the crop will cause injury and must be avoided. Always add a nonionic surfactant and a drift control agent. Spray relatively high water volumes at low pressure.

Since November 14, 2019, all pesticide certified applicators must successfully complete an EPA-approved training program before mixing, loading, and/or applying paraquat.
Application of paraquat "under the direct supervision" of a certified applicator are no longer allowed. Only certified applicators, who successfully completed the paraquat-specific training, can mix, load or apply paraquat. Applicators who successfully completed the online EPA-approved training program receive a certificate by the end of the training and must repeat the training every three years. https://www.epa.gov/pesticide-worker-safety/paraquat-dichloride-training-certified-applicators

EVALUATING TOMATO VARIETIES FOR HEAT STRESS TOLERANCE AND STRESS MITIGATION IN TOMATOES

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Climate change has the potential to affect tomato yield and quality as temperatures increase. Climate data from the region has shown a steady increase in average temperatures over the last 100 years with average night temperatures in summer months increasing the most. The summer of 2019 was one of the hottest on record in the Northeast with many days in the 90's and nights in the 70's. Tomatoes had losses due to the heat. Providing adequate moisture through irrigation is critical in high heat periods. However, water cannot completely compensate for extreme heat.

Photosynthesis rapidly decreases above 94°F, so high temperatures will limit yields in tomatoes. Plant stomates will close earlier in the day thus limiting gas exchange. Respiration increases with temperature. While daytime temperatures can cause major heat related problems in plants, high night temperatures can have great effects on vegetables, especially fruiting vegetables such as tomatoes. Hot night temperatures (nights above 75) will lead to greater cell respiration. This limits the amount of sugars and other storage products that can go into fruits and developing seeds. Because of this increased respiration the plant uses up photosynthates that do not go into yield components.

In flowering and fruiting crops such as tomatoes, high heat will affect pollen production, often reducing viable pollen numbers. Reproductive parts in plants (anthers, stigmas) may not form properly or function properly. If pollen is transferred to stigmas, pollen germination may be reduced or halted due to heat and desiccation. Reduced pollination can result in smaller fruit.

If pollination is successful, early fruit abortion may occur due to lack of photosynthates or heat damage. In heat stressed plants, the hormone balance is affected and there is an increase in abscisic acid that is involved in these abortions.

High soil temperatures can damage surface roots, limiting water and nutrient uptake. This is particularly an issue in crops grown on black plastic mulch.

On black plastic mulch, surface temperatures can exceed 150°F. This heat can be radiated and reflected onto vegetables causing tremendous heat loading. This is particularly a problem in young plants that have limited shading of the plastic. High bed temperatures under plastic mulch can also lead to reduced root function limiting nutrient uptake. This can lead to increased fruit disorders such as white tissue, yellow shoulders, and blotchy ripening in tomato fruits.

As growers face the challenges of climate change, there are several tools or strategies that can be used to mitigate the effect of higher temperatures.

Managing mulch is one such tool. This includes changing plastic film to white, silver or metalized colors for summer production and the use of natural mulches such as rolled small grain cover crops to reduce soil temperatures. In tomatoes, high soil temperatures have been shown to reduce potassium uptake and increase fruit quality defects (white tissue and yellow shoulder). Use of white plastic has been shown to reduce these defects.

Radiation blocks or reflective materials can reduce heat effects by reflecting away some solar radiation. Commonly, particle films are used as radiation blocks including kaolin (white clay) based or calcium carbonate (lime) based materials. These are sprayed on plants during high temperature periods. Research at the University of Delaware and University of Maryland has shown that tomato quality and yield is improved with the use particle films

Shading is another strategy. Commonly, shade cloth or netting is used for this purpose. This netting comes in black, green, white, and reflective aluminum colors and is commonly used at the 20-30% shade levels. Shading is applied during the hottest periods or periods when the plant is most sensitive to heat (such as tomato fruit development). Research at the University of Maryland showed that shading tomatoes during fruiting can improve fruit quality and reduce culls.

Some biological root inoculants have also been shown to reduce plant stress. Mycorrhizal fungi can act as root system enhancers, increasing the effective area for absorbing water from the soil. The University of Delaware has released a Bacillus subtilis bacteria for root inoculation that has been shown to improve plant stress tolerance.

While stress mitigation tools may be more commonly used in fruits and vegetables as the climate warms, adaptive changes should be considered for more long-term stress management.

One adaptive strategy is to breed more heat tolerant cultivars. 2019 Delaware tomato trials that included heat tolerant varieties identified those with limited white tissue development under high heat (see table that follows).

2019 Staked Tomato Heat Stress Variety Trial, Georgetown, Delaware. (Transplanted May 30, black plastic mulch, drip irrigation, loamy sand soil, 1.5 ft. between plants in the row, 6 ft. between beds)

Variety	Marketable lbs/plant	Cull Percent	White Tissue Percent	White Tissue Rating 1-10 (L-H)
Bella Rosa	13.8	12	39	3.0
BHN 589	17.4	13	23	2.0
BHN 602	10.7	8	31	4.3
Biltmore	14.3	24	35	3.3
Camaro	8.4	29	46	8.3
Dixie Red	12.4	12	36	4.7
FTM 5187	12.9	10	40	4.7
FTM 6163	11.8	13	44	4.0
FTM 6281	13.7	8	31	3.0
FTM 6298	13.1	5	25	2.2
FTM 8011	10.0	17	28	1.3
Grand Marshall	17.6	4	41	3.0
Jamestown	9.7	3	25	2.3
Mountain Fresh	11.1	3	53	4.3
Mountain Majesty	12.6	22	29	2.0
Mountain Merit	11.3	16	49	4.3
Myrtle	9.4	8	39	3.0
Primo Red	15.3	12	19	2.7
Red Bounty	13.6	13	18	2.8
Red Deuce	14.8	26	25	4.0
Red Mountain	21.6	12	33	3.0
Red Snapper	11.7	10	38	5.7
Roadster	14.7	27	33	1.7
Saybrook	8.8	10	39	4.3
Scarlet Red	13.6	8	28	3.7
STM 2255	18.3	9	33	1.7
SV 7101	13.7	9	29	2.7
XTM 2256	16.2	11	21	3.0

UNRAVELING DISEASE RESISTANCE AND GENE STACKING STRATEGIES IN THE DEVELOPMENT OF NEW TOMATO CULTIVARS

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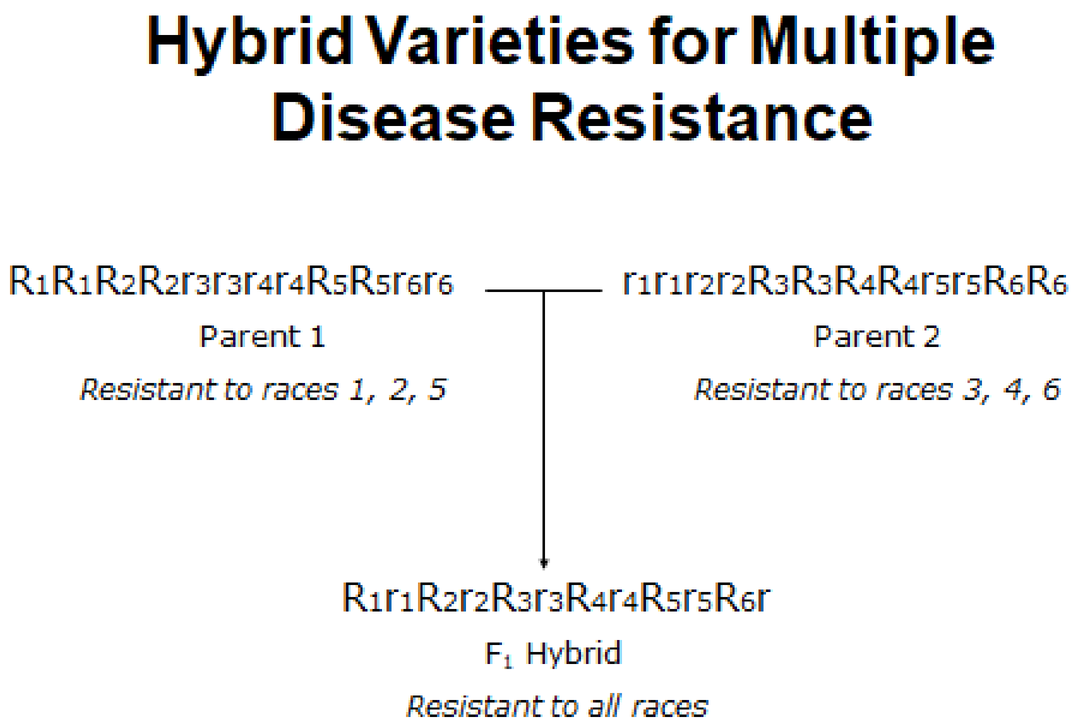
Tomato breeders have been disease resistant and tolerant cultivars since the early 20th century. Over time, a system of abbreviations was adopted to denote the presence of specific disease resistance genes within the genome of the cultivar. Terminology has evolved to denote cultivars that possess many resistant genes: “stacking” or “pyramiding”. A large number of cultivars are offered to growers as possessing resistance to multiple diseases. Many of these diseases are problematic in different regions of North America, and not necessarily in the Mid-Atlantic. Which diseases are prevalent on the U.S. east coast, and how many of these have been the focus of breeding efforts for resistance genes?

Why are all diseases not equally prevalent in different regions of the continent (or world)? Disease is a consequence of a host (the crop) interacting with another organism (the pathogen) that “steals” energy resources from the host, usually with collateral damage or adverse effects (the disease). There is a third factor involved with the ability of the pathogen to invade the host: the environment. The combination of different hosts, different pathogens with different soil, moisture, humidity, sunlight, etc. create regional differences in the incidences and severity of diseases. For example, soil diseases such as Fusarium and Verticillium wilts and root knot nematodes are common in west coast growing locations, but less common in the southern and eastern U.S. Foliar and fruit diseases such as early and late blights, anthracnose, and bacterial spot and speck are more prevalent in the southern and eastern U.S. than in the west.

By the mid-20th century, the existence of two broad categories of host resistance was well established. “Qualitative” or “vertical” disease resistance refers to single genes that exert strong, dominant effects over other genes that cause disease susceptibility. Crossing resistant and susceptible plants gives rise to F_1 hybrids that are resistant. When the F_1 plants are self-pollinated, the F_2 progeny are ¾ resistant and ¼ susceptible with no plants being intermediate in resistance.

“Quantitative” or “horizontal” resistance pertains to a situation where resistance is conferred by the joint action of many independent genes that have additive effects. Crossing resistant and susceptible plants usually generates F_1 plants that are intermediate in resistance. Resistance in the F_2 is often seen as a continuum from resistant to susceptible, with most of the population being intermediate. Since horizontal resistance is a consequence of the collective effects of many genes, this class of resistance is inherently more “durable” than is vertical resistance. More on that later.

Breeders prefer to work with vertical resistance because it is easier and also produces new cultivars with strong, or absolute, resistance to the responsible pathogen. Since vertical resistance genes are dominant, it is possible to produce F_1 hybrids that are resistant to a large number of diseases and disease races:



Over the past 20 years, breeders have found inert “marker” genes that are tightly linked to vertical resistance genes, and now use the markers to select for resistance to avert the need to select based on the presence or absence of disease. Using disease to select for resistance can be time-consuming, expensive, and inaccurate.

In tomato, dozens of vertical resistance genes to races of 12 different pathogens have been found and incorporated into cultivars by breeders. A list of the tomato diseases in which vertical resistance has been found (Scott 2005):

Disease	Pathogen	Vertical Resistance gene symbol	Approx # races
Fusarium wilt	*Fusarium oxysporum* f. sp. *lycopersici*	*I*	3
Verticillium wilt	*Verticillium dahliae*	*Ve*	2
Alternaria stem canker	*Alternaria alternata* f. sp. *lycopersici*	*Asc*	1
Early blight	*Alternaria solani*	*Ebt*	1
Late blight	*Phytophthora infestans*	*Ph*	3
Septoria leaf spot	*Septoria lycopersici*	*Sls*	1
Cladisporium leaf mold	*Cladisporium fulvum*	*Cf*	25
Tobacco mosaic virus	Tobacco mosaic virus	*Tm*	1
Tomato mosaic virus	Tomato mosaic virus	*Tom*	1
Tomato leaf curl virus	Tomato leaf curl virus	*Tylc*	1
Bacterial speck	*Pseudomonas syringae* pv. *tomato*	*Pto*	2
Root knot nematode	*Meloidogyne incognita*	*Mi*	1

Most pathogens are microbes that exist as populations of billions of organisms in the soil, water, or aerosol. Since pathogens exist in a changeable world of environments and hosts, they have become programmed for frequent change to adapt to host and environmental fluxes. When a new, resistant cultivar is deployed, pathogens do not give up. New genetic variability is generated within populations, and variants ultimately emerge that can overcome the new resistance gene (Anderson et al., 2010). Since there is only one gene to contend with, mutation by the pathogen to overcome resistance is common (Boyd et al., 2013). This new mutation is referred to as a new “race” and can quickly come to predominate within a region within the host crop is grown.

The breeders respond with new genes for resistance to the new race. The pathogen responds to the new resistance gene with another new race. The number of different “R” (resistance) host and “a” (avirulence) pathogen genes proliferates as breeders develop and deploy new “R” genes (Jimenez-Gasco et al., 2004). Many pathologists now term this host-pathogen tit-for-tat as a disease “arms race” (Bergelson et al., 2001; Boller and He, 2009). The consequences are that the effectiveness of any given new cultivar becomes relatively short, as the pathogen mutates to overcome “R” genes. Also, the number of pathogen races that are potential threats to the crop increases to the point that it is difficult to account for all of them (Brunner et al., 2010). For example, in wheat stripe rust, over 170 races have been documented based on “R” genes for all the different combinations of pathogen “a” genes (Liu et al., 2009). For downy mildew of spinach, the number of documented races has increased from 8 in 2008 to 16 in 2019.

Breeders have not worked with horizontal resistance very much for the converse of the reasons that they prefer vertical resistance (Oldroyd and Staskawicz, 1998). Another associated reason is that it is very difficult to find linked marker genes due to the incrementally small effects of horizontal resistance genes. Markers have been identified for a few horizontal resistance genes, for example resistance to late blight in potato, but this is a daunting task. Moreover, horizontal resistance is usually associated with more crop damage than is vertical resistance, although damage is often below the economic threshold.

Due to the high cost and time commitment necessary, the private sector seed companies are not able to embark on a new strategy to develop and deploy cultivars with horizontal resistance. It will be incumbent on the universities to conduct basic research to reach a better understanding of the identity and functions of horizontal resistance genes. An understanding of the genes involved will enable markers to be developed, and for seed companies to move into horizontal resistance breeding to complement existing strong efforts in vertical disease resistance breeding.

So what do those symbols on the seed packets mean? If a packet has “VFFNT” printed on it, the seeds of the cultivar inside contain vertical resistance genes for Verticillium wilt (*Ve-1*), Fusarium wilt races 2 and 3 (*I-2*, *I-3*), root knot nematode (*Mi*), and tobacco mosaic virus (*Tm*). None of these pathogens is a serious problem on the east coast U.S.

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Blueberry

LATEST RESEARCH ON SPOTTED WING DROSOPHILA

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Spotted wing drosophila (SWD), *Drosophila suzukii* Matsumura (Fig. 1), is a pest native to Southeast Asia that has rapidly expanded its geographic range to include many countries in North and South America and Europe. Since its arrival in the United States in 2008, it has become an important agricultural pest of several small fruit crops including blueberries. SWD is a challenging pest in agroecosystems because of its wide host range, which includes many wild hosts (e.g. wild cherry, dogwood, buckthorn and honeysuckle). These wild hosts can provide alternative food and overwintering sites. In New Jersey, highbush blueberry is commonly cultivated near non-crop, forest habitats, where wild blueberry bushes are abundantly found in the understory.

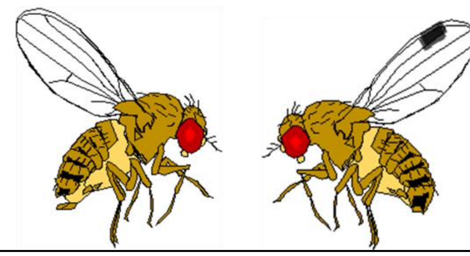

Fig. 1. Female (left) and male (right) SWD. Males have a distinctive black spot on each wing near the tip. Females are slightly larger than males and possess a large serrated ovipositor.

In 2015-2017, studies were conducted to understand the influence of non-crop habitats, and the wild hosts therein, on SWD populations in adjacent blueberry fields. In addition, a large-scale trapping network was implemented for SWD in blueberry farms in New Jersey to: a) determine the effectiveness of traps at predicting fruit infestation, b) evaluate management program efficacy based on trap counts, and c) investigate the effects of landscape features on SWD.

Non-crop Habitats

The seasonal (June through August) activity of SWD was monitored for two years (2015-2016) using traps baited with a commercial SWD lure (Fig. 2) placed in blueberry field interiors and in neighboring non-crop, forest habitat. Additionally, seasonal differences in oviposition and adult SWD emergence between wild and cultivated blueberry were assessed. We found that SWD is active in non-crop habitats throughout the harvest and post-harvest blueberry seasons (Fig. 3). Moreover, wild blueberries served as suitable alternative hosts for SWD oviposition and development during the ripening period of cultivated fruits. These findings indicate that SWD utilitizes non-crop habitats and wild hosts therein, and thus can serve as potential sources of adults to neighboring blueberry fields. The study highlights the

Fig. 2. SWD trap in a blueberry field.

importance of developing cultural, behavioural, and biological management strategies not only in blueberry fields but also in neighboring non-crop habitats to control this pest.

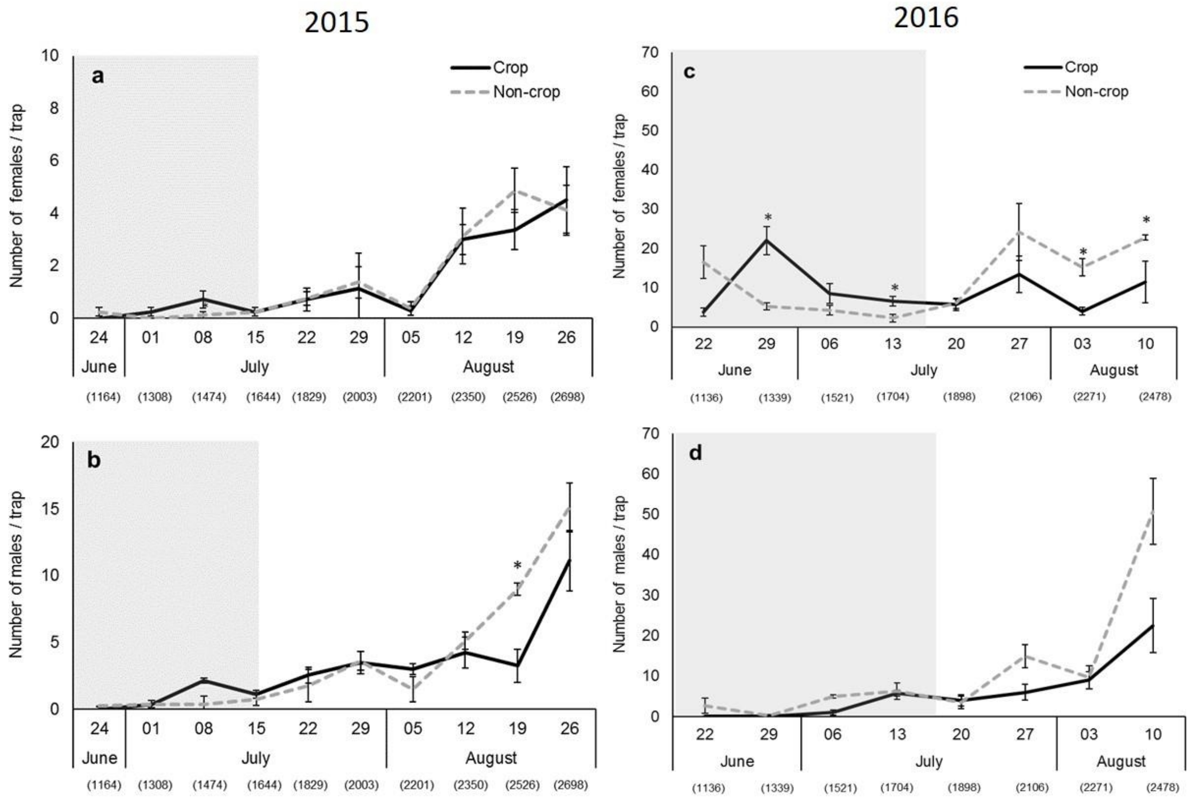

Fig. 3. Numbers (mean ± SE) of SWD females (a and c) and males (b and d) captured per trap in non-crop (forest) and crop (blueberries) habitats in 2015 and 2016. The period in grey represents the time of harvest. On the x-axis, degree-days for each sample are shown in brackets. An asterisk indicates significant differences between non-crop and crop habitats on the number of flies captured in traps.

SWD Trapping Network

Eight farms were chosen based on their locations within the state, their surrounding habitats, and the management strategies they employ. A total of 147 baited SWD traps were deployed across those 8 farms. The number of traps employed at each farm was based on the acreage and traps were positioned along the exterior as well as the interior of the farms. Traps were equipped with commercial (Scentry) lures (Fig. 2), and were deployed throughout the fruit harvest seasons (June-August) of 2016 and 2017 and monitored weekly for 12 weeks. Total of SWD adults in traps were counted under a microscope. If needed, sub-sampling was employed in processing trap samples; 1/4th of the samples were processed by volume and SWD adult numbers estimated.

In agreement with our previous results (above), our monitoring data showed that SWD trap near forest edges (within 200 m from the field’s edge) captured more SWD flies than traps placed in field interiors (Fig. 4). These results re-enforce the fact that non-crop, forest habitats serve as an important source of SWD to nearby blueberries.

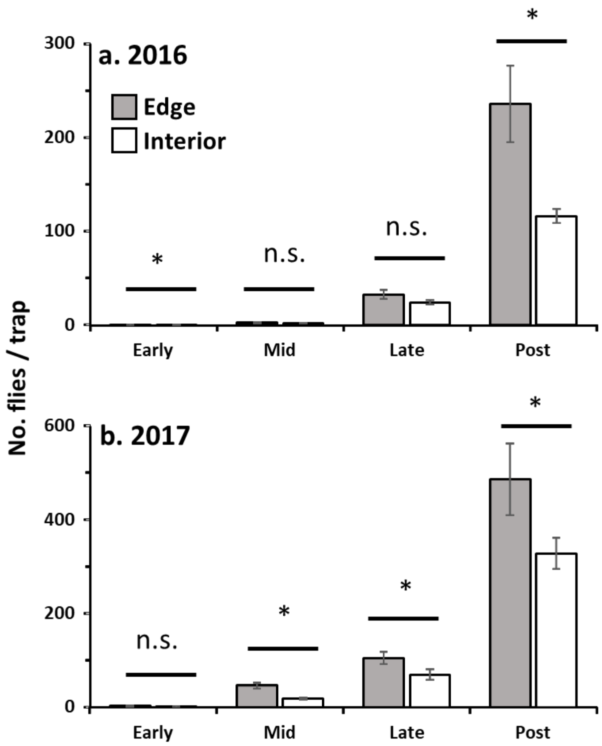

Fig. 4. Numbers (mean ± SE) of SWD flies captured per trap placed in blueberry fields near non-crop (forest) habitat and in the field's interior during the early ('Duke'), mid ('Bluecrop'), late ('Elliott'), and post-harvest seasons of 2016 (a) and 2017 (b). An asterisk indicates significant differences between edge and interior trap counts. n.s. = not significant.

To determine if trap counts correlate with levels of fruit infestation, fruit samples were taken from both 'Duke' and 'Bluecrop' varieties during a six week harvest period (June-July with 'Duke' samples beginning 2 weeks earlier than 'Bluecrop') of 2017. Fruit samples were taken from the same fields where the SWD traps were placed (total of 2 samples were taken from 40 fields of each variety across all farms; for a total of 960 samples), and SWD larval infestation was assessed using a salt test. Each sample was 8-oz by volume and taken from multiple bushes surrounding the trap area from all areas of the bush (top, middle, bottom). Two samples were taken from each field, an interior and an edge sample. Edge samples were taken from the exterior row of bushes bordering a wooded area. Interior samples were taken at least 10 bushes in from the edge. Fruit samples were placed in plastic bags and incubated at room temperature for 10 days to insure any eggs present in the fruit would develop into larvae that could easily be counted using the salt float method. Fruit samples were submerged in salt water (1 cup salt per gallon of warm water) for 24 hrs to extract any larvae present and then collected by filtering through a fine mesh screen and assessed under a stereomicroscope.

Our data showed that SWD trap counts accurately predict fruit infestation >85% of the time during the early and mid-season harvest periods, i.e., when 'Duke' and 'Bluecrop' is fruiting. Moreover, SWD fly captures were significantly higher in fields that had infested fruits than in flies with non-infested fruits (Fig. 5), indicating that SWD trap counts provide information about the risks of larval infestation in blueberry fruits.

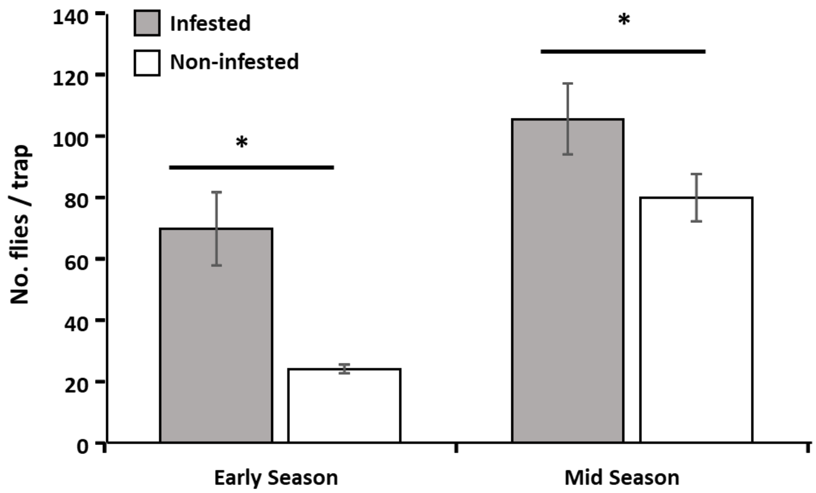

Fig. 5. Numbers (mean ± SE) of SWD flies captured per trap in blueberry field with infested and non-infested fruits during the early ('Duke') and mid ('Bluecrop') harvest seasons. An asterisk indicates significant differences between trap counts.

Acknowledgments

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Update on Weed Management Strategies & Research for New Jersey Blueberry Growers

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Weeds remain a major challenge in highbush blueberry (*Vaccinium corymbosum* L.) production. Like for any other agronomic system, annual grasses and broadleaves account for most of the weed species. However, the lack of annual crop rotation and soil cultivation make blueberry plantations more prone to the development of hard-to-control perennial weeds. Efficient weed management strategies will rely on various control measures that need to be tailored to weeds specific to your blueberry plantation.

Prevention: The first step of any weed management program is to consider the steps that need to be taken to prevent introduction, establishment, and/or spread of a specified weed species into an area not currently infested with that species. The purchase of weed-free seeds when sodding the row middles, the necessity of cleaning equipment before moving from infested to non-infested fields, the use of weed-free irrigation water, the control of weeds on field borders and ditches, and prohibiting weeds already present from going to seeds are some of the key elements of an effective weed prevention program.

Weed Scouting: Prevention is a necessary step but is not enough by itself. Weeds have generally to be targeted at the seedling stage since controlling fully developed weeds can be extremely difficult because of their size that prevent effective herbicide distribution on the plant, or because of their ability to regrow following mechanical or chemical control. Scouting for detecting weed seedlings shortly after their emergence is a critical component of any successful weed management program. The goal of weed scouting is to get a representative idea of the weed populations throughout the whole field. An efficient scouting program should also provide information on crop phenology as this may extremely important with regards to chemical weed control.

Identification: Accurate weed ID is important for effective management because herbicide recommendations vary according to species, as do some mechanical, cultural, and biological strategies. Some species can look similar to other species from afar, but may have drastically different management requirements. They should be examined closely to determine herbicide programs. Guides such as Weeds of the Northeast (http://www.cornellpress.cornell.edu/book/) or weed identification websites can be helpful to accurately determine weed species and become familiar with their biology and ecology.

Cultural Weed Control: Growers should keep clean soil prior to planting by ridding the soil of weeds through a burndown herbicide application, a thick, suppressive cover crop mulch, or mechanical weed control such as tillage and cultivation. Preventing seed production of weeds already growing in the field through frequent soil cultivation will help reducing the soil weed seedbank.

Complete weed control is critical the first two years following blueberry planting to ensure high survival rates and quick establishment as weed competition can dramatically slow growth of young plants. Frequent hand hoeing or hand pulling of weeds is recommended as mechanical cultivation may damage the root system and slow the growth of newly planted blueberries.

The use of mechanical cultivation equipment in the row of established plantings is seldom recommended due to risk of damaging the shallow roots of the blueberries. Weeds control on the row can be achieved with mulch such as sawdust, wood chips or coarse leaf mulch applied three to four inches thick when the rows are weed free. All organic mulches break down over time and tie up important nutrients, especially nitrogen, so the use of mulch may require additional fertilizer. Mulch should be reapplied as needed to maintain weed suppression.

Weed management of the row middles can be done through the seeding of a dense sod that will compete with weeds but will require fifteen to twenty months to establish. During this period, it is critical to control broadleaf weeds growing in the sod. The flowers of dandelion, clover, mustard species and other weeds may coincide with bloom and are preferred by pollinating insects. The same weeds, and others, may also bloom before or after the crop blooms and attract bees into the field when insecticides must be sprayed.

Chemical Weed Control: Chemical weed control has many advantages, including control and cost efficiency, safety when correctly used, and the elimination of crop and root injury caused by cultivation. However, in order to minimize potential problems with herbicides, some specific considerations should be addressed before using them.

Factors Affecting the Efficiency of Weed Control

- ⇨ **Target** – Is herbicide labelled for the targeted weed species?
- ⇨ **Soil properties** – Is the selected rate appropriate to soil texture and organic matter content?
- ⇨ **Timing** - Is herbicide used at the right time in relation with crop and weed phenology?
- ⇨ **Activation** - Has preemergence herbicide been activated with sufficient rainfall?
- ⇨ **Persistence** - How is irrigation affecting the persistence of active ingredients?
- ⇨ **Herbicide Resistance** – Has the targeted weed developed resistance to the active ingredient?

Small Fruit and Strawberry

EXTEND AND MAXIMIZE POSTHARVEST QUALITY OF STRAWBERRY

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NEW RESULTS in 2019: Compared Oregano Oil to Thyme Oil, and evaluated effect of new CO_2 emitters and O_2 scavengers on growth of *Botrytis cinerea*

Strawberry harvest in the Northeast is limited to an average of three weeks. One way to extend the season and increase profits is to contain postharvest losses. Currently, there is no postharvest treatment to maintain freshness and control disease for strawberry. Postharvest losses of strawberries and other specialty crops is estimated to be as high as 25% due to disease, dehydration, and over ripeness, resulting in economic losses to farmers and consumer dissatisfaction.

To solve this problem, we use sachets containing anti-microbial essential oils encapsulated into cyclodextrin to control disease and sachets containing compounds that absorb oxygen and release carbon dioxide. These sachets are combined with modified atmosphere packaging (MAP) to prevent water loss of fruit. The goal is to bring sustainable advanced packaging technology to the strawberry grower to increased fruit freshness and storage life. The treatments are evaluated for disease, fresh weight, soluble solids and fruit firmness and compared to conventional storage.

Essential Oils –History and Use

- Essential oils are aromatic and volatile liquids obtained from plants
- Leaves, flowers, fruits, bark and wood may all be sources of essential oils
- Essential oils have been used in medicine, cooking, cosmetics, perfumes, and pest control
- Ancient Egyptians used the herb thyme (*Thymus vulgaris*) as part of the embalming procedures for mummies
- Thymol, a component of thyme oil, was used as an antiseptic in late 19th surgeries because it is less irritating to wounds and more germicidal than carbolic acid (phenol)
- Evidence for anti-bacterial and anti-fungal activity

Factors Limiting Postharvest Storage Life

- Fungal diseases are a major factor limiting storage life of fruits and vegetables
- Most important diseases are Grey Mold (*Botrytis cinerea),* Anthracnose (*Colletotrichum sp.*), Blue Mold (*Penicilium sp.*)
- Infections generally occur during flowering and remain latent until the fruit ripen

Antifungal Activity of Thyme Oil is Easily Demonstrated

- On petri plates against pathogen cultures
- But thyme oil can be phytotoxic when directly applied to plant tissue

- Exposure to thyme oil vapors is much less toxic and can be more effective
- However volatile compounds are more difficult to work with and less persistent

Encapsulation Can Stabilize Thyme Oil

- Cyclodextrin (CD) has a cage-like structure that can trap small molecules
- Encapsulated thyme oil (TO) is stabile to at least 55°C

Flowers and Fruit Continue to Transpire after Harvest

- When the flowers or fruit transpire, the water vapor displaces the thyme oil volatiles from the capsules into the package
- The TO/CD capsules can be placed in a sachet or formulated into a coating and added to the packaging
- Clamshell packs or flower sleeves are enclosed in MAP films before storage or shipping at 0-4 °C

Wrapping the Packaging in MAP Increases Disease Control and Reduces Water Loss

- Modified Atmosphere Packaging (MAP) plastic films have micropores that stabilize the gas composition of the package
- MAP maintains a low O_2 (5%) , high CO_2 (2%) atmosphere in the package and prevents H_2O condensation

Table 1. 2019 Strawberry post-harvest disease control with Thyme Oil (TO) cyclodextrin sachets placed in 16 oz clamshells after 7 days at 4°C

Treatment	% initial wt	Mean % disease	Mean Firmness (N/cm2)	Mean Brix
(1) No TO No MAP	96.1b	17.7a	7.5b	5.6a
(2) No TO + MAP	99.7a	18.9a	11.8a	5.6a
(3) +TO+MAP	99.7a	5.9b	12.5a	5.8a
Initial			8.2	6.5
MAP vs No MAP	***	NS	*	NS
TO: vs No TO	NS	**	NS	NS

Table 2. 2019 Strawberry post-harvest disease control with Oregano Oil (OO) cyclodextrin sachets placed in 16 oz clamshells after 7 days at 4°C

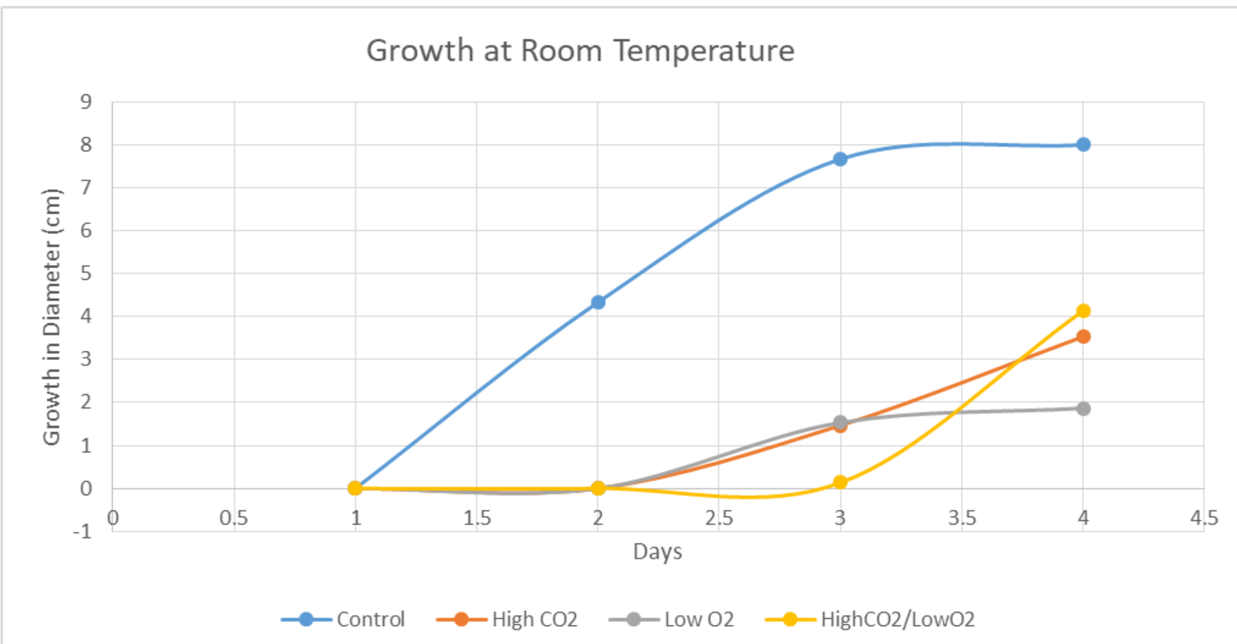
Treatment	% initial wt	Mean % disease	Mean Firmness (N/cm2)	Mean Brix
(1) No OO No MAP	96.2b	17.1a	10.7a	5.6a
(2) No OO+ MAP	99.7a	21.5a	11.7a	5.9a
(3) +OO+MAP	99.6a	9.0a	11.8a	5.8a
Initial			8.2	6.5
MAP vs No MAP	***	NS	NS	NS
OO vs No OO	NS	**	NS	NS

Controlling the Atmosphere in the MAP Bags

Carbon Dioxide Emitters work by producing CO_2 from citric acid and sodium bicarbonate when the fruit transpire. Oxygen Scavengers work by reacting iron powder with the O_2 in the air causing the iron powder to rust

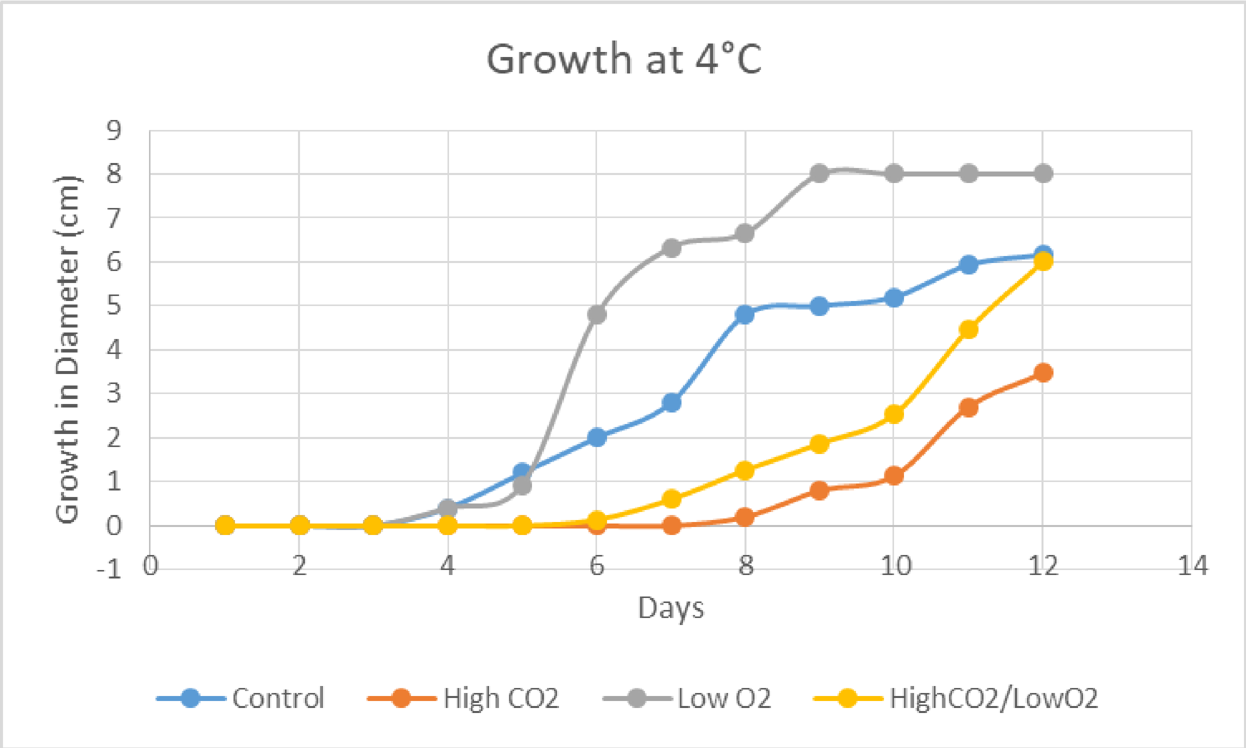
Experimental Design

- Two 1-cm diameter plugs of grey mold (*Botrytis cinerea*) culture were placed on a 8-cm PDA plate (three plates/treatment) with paper towel wick
- Experiment was conducted at room temperature (25C) and in the cold room (4C)
- Treatments:
    - TRT1: Control; no CO_2 Emitter or O_2 Scavenger
    - TRT2: High CO_2; one CO_2 Emitter
    - TRT3: Low O_2; one O_2 Scavenger
    - TRT4: High CO, Low O_2; one CO_2 Emitter and one O_2 Scavenger
    - All treatments were placed in a 22-cm x 30-cm MAP bag and heat sealed
    - CO_2 and O_2 were measured daily along with *B. cinerea* radial growth (cm)



Room Temperature Results

- All treatments significantly inhibited fungal growth compared to control
- However, fungal growth increased in all treatments as the atmosphere composition started to reach normal conditions
- When *B. cinerea* plates were removed from bag after experiment was complete they resumed growth, but lagged in maturation compared to the control (not shown)



Cold Room Results

- High CO_2 was the most effective treatment for inhibiting *Botrytis cinerea* growth
- Low O_2 treatments reduced the effectiveness of high CO_2 for inhibiting *Botrytis cinerea* growth when the O_2 content increased after 4 days
- Low temperature application decreased growth rates significantly compared to room temperature

ENHANCING FALL "ALBION" STRAWBERRY PRODUCTION

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Fall Strawberries

In the late 1990's I developed a greenhouse based, off-season strawberry production system using photoperiod and temperature conditioned plants of the short-day cultivar 'Sweet Charlie'. Plugs were given short days followed by chilling in a walk-in cooler, then planted in a hydroponic greenhouse system for mid-winter production. The system was never commercially adopted due to the cost constraints associated with the conditioning protocol.

A much more feasible approach uses the long-day cultivar 'Albion', planted in the spring or early summer for fall production the same season. Numerous reports in the literature describe efforts to develop off-season strawberry production systems for temperate North America using long day cultivars in field or protected culture. Conditioning of plant material before planting may or may not improve off-season fruiting, depending on planting date.

The current recommendation for off-season LD cultivar production is to use dormant, cold-stored crowns planted directly in the field as early in the spring as possible (before May 1). Field conditions (wet and cold) often preclude early planting dates in the eastern US. In these situations, plugs can be produced in the greenhouse from dormant, cold-stored crowns then planted in the field when conditions allow however, later planting leads to a reduction in yield.

Photoperiod and nitrogen conditioning may enhance flowering and off-season, fall field production in long-day cultivars depending on field planting date and plug size. Elevated nitrogen during floral initiation enhances and accelerates flowering of long day cultivars. The response to conditioning is rapid (4 weeks after treatment) and cultivars respond with increased rate (enhanced precocity) and intensity (enhanced inflorescence/flower number) of flowering with elevated N. The reduced yield often observed with later planting (22 July) is alleviated with photoperiod and nitrogen conditioning, however, earlier plantings (2 and 22 June) do not benefit from conditioning. While larger plugs are often more productive than smaller ones, fewer larger plugs are produced per unit area, thus smaller plugs are often utilized. Smaller plugs of LD cultivars are often less precocious and productive due to a SD response imposed by higher plant density during propagation. When smaller plugs are used, their precocity and early fall production is enhanced with conditioning.

This past season, supplemental field lighting with inexpensive holiday light strings was evaluated as an alternative to greenhouse conditioning. This approach eliminates greenhouse ‘plug’ (actually potted dormant crowns) production with concomitant conditioning with photoperiod and nitrogen.

Plants were lit with supplemental lighting daily, for 15 minutes every hour from 7 pm to 7 am for 28 days in July or 28 days in August. Flowering and fruiting were evaluated to determine if either or both treatments enhanced long-day flowering in ‘Albion’. Flowering and fruiting were both enhanced with the supplemental lighting.

If you are interested in trying such an approach, e-mail me at durner@sebs.rutgers.edu and I can provide you with more details on how to do it.

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SMALL FRUIT WEED MANAGEMENT

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Weed management can be a significant challenge for small fruit growers as weeds compete directly with the crops for water, nutrients and light; direct interference can impact crop growth and, ultimately, yield quantity and quality. Weeds can also impact crops, indirectly by interfering with the deposition of crop protection chemicals, harboring pests and pathogens, and impeding harvest operations. Crops stressed because of competition may be more susceptible to insect infestations and high densities of weeds can alter microclimates to facilitate disease development and spread.

Weed management must begin before small fruits are planted and extend beyond harvest to ensure that unwanted vegetation is not allowed to achieve reproductive maturity and replenish the seedbank, which will facilitate problems in following years. Ideally, weed management considerations must begin in the years preceding the establishment of small fruit plots. Difficult-to-control, perennial weeds (e.g. quackgrass, nutsedges, Johnsongrass, and bindweeds) will need intensive and frequent management to suppress their growth and development. This includes applications of systemic herbicides when chemicals are readily translocated to root systems. This may also include repeated cultivation to exhaust nutrient reserves, although care must be taken to ensure that soil disturbance events do not enable the spread of vegetative tissues withing and among fields. Stale seedbed techniques can be used before planting to induce weed seed germination; emerged seedlings can be removed using non-selective physical or chemical control strategies. Not all weeds will respond to this technique; species with dormant seeds may not germinate readily/evenly and growers should be aware of the weed infestation history prior to investing in a procedure.

In plasticulture production, fumigation is often needed for weed management. Till soils and pack beds making sure to eliminate dirt clods that can affect fumigant distribution. Repair holes and tears in tarps that will allow for volatilized chemicals to escape. Weeds that grow through planting holes or between mulched rows will need to be managed via herbicides or through hand-weeding. Chemical control in matted row production can be influenced by the status of crop (e.g. new planting, bearing, renovation, dormant) and are also affected by the timing of their application relative to weed emergence (PRE, POST). Ultimately, herbicide options are limited to a few chemical classes (Groups 1, 3, 4, 5, 14, 15, 22) as determined by the Weed Science Society of America (WSSA). See the following website for more information: http://wssa.net/wssa/weed/herbicides/.

Members of WSSA Group 1 (clethodim, fluazifop, sethoxydim), the ACC-ase inhibiting herbicides, are selective POST herbicides for the control of grasses and are susceptible to the development of herbicide resistance (www.weedscience.org). Currently, 48 different grass species worldwide have developed resistance to the Group 1 herbicides. Although some perennial grasses can be controlled by the Group 1 herbicides, grass-like weeds (e.g. yellow nutsedge, wild onion, wild garlic) are not affected. DCPA (WSSA group 3) is a residual microtuble assembly-inhibiting herbicide that will not control emerged plants and must be applied to weed-free soils in spring or fall. It is, primarily, a herbicide for controlling annual grass species although some broadleaves, including common purslane, are also susceptible. 2,4-D, which is a POST group 4 herbicide (synthetic auxin), can be applied to established stands during dormancy (late winter or early spring); applications made prior to dormancy can affect flower bud and fruit formation. Group 4 herbicides are selective against broadleaf species and should only be used when possible injury to the crop is acceptable. 41 species, worldwide, have developed resistance to the synthetic auxins. Terbacil (Group 5, photosystem II inhibiting herbicides) is used for the control of many annual broadleaf weeds, although it can be weak on pigweeds. Herbicide resistance is also a concern with the photosystem II inhibitors (Group 5, and Groups 6 and 7). Terbacil may stunt strawberry on light, sandy soil. Although multiple protoporphyrinogen oxidase herbicides (WSSA 14) are registered for use in strawberries, many may cause unwanted levels of crop injury. Flumioxazin, which controls many broadleaf weed species, should be applied to established matted row strawberries that are dormant. It can also be used as a hooded or shielded spray between rows on plastic mulch before fruit set. Napropamide (WSSA 15) is a very long chain fatty acid inhibitor that provides residual control of grasses and some broadleaf weeds. It should be applied in late fall through early winter or in early spring, but not on frozen ground. Irrigation or rainfall is needed to incorporate the herbicide and prevent photodegradation. Paraquat (WSSA 22, photosystem I electron diverter) is used as a non-selective shielded spray to emerged weeds between crop rows after establishment. Paraquat drift will injure crop plants. Currently, 42 weed species, worldwide, have developed resistance to the Group 22 herbicides.

Information included in this abstract was derived from the 2019 Mid-Atlantic Commercial Vegetable Production Recommendations. Herbicide labels are the law and must be followed; all applicators should familiarize themselves with the most current legal guidelines regarding application protocols.

Creating Value Added Products and Services to Increase Profits

THE PUBLIC AND THEIR ANIMALS: REGULATIONS AND RISKS TO YOUR DIRECT MARKET FARM

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An increasing number of customers are bringing animals when visiting farm markets, pick your own farms, or agritainment activities. Animals can pose a food safety risk to produce, introduce disease to farm animals, and frighten or upset farm animals. Outside animals can also pose a potential risk to employees, market customers and farm visitors. Farmers need to consider these risks while maintaining food safety regulatory compliance and buyer requirements. Also important is maintaining biosecurity for protection of farm animals. The Americans with Disabilities Act (ADA) governs what actions are legally allowed regarding customers visiting your market or on your farm with service animals. This fact sheet covers specifics of the ADA, animals not protected by the ADA regulations, and how to reduce potential risks from outside animals. States may have regulations that exceed the federal ADA regulation, information presented is specific to New Jersey. If you farm in another state please consult the state by state guide linked at the end of this article.

What do the ADA regulations cover?

While many types of animals can provide comfort and emotional support, only service animals are protected by the ADA, specifically within Title II and III. The ADA regulations define “service animal” as dogs, and less commonly miniature ponies, that are individually trained to do work or perform tasks for people with disabilities such as guiding a blind person, alerting people who are deaf, assisting a person in a wheelchair, alerting and protecting a person who is having a seizure, reminding a person with mental illness to take prescribed medications, calming a person with Post Traumatic Stress Disorder (PTSD) during an anxiety attack, or other duties. The work or task a service animal has been trained to perform must be directly related to the person’s disability. Some disabilities are obvious, others are not.

What questions can you legally ask?

When it is not obvious that an animal is a service animal only two questions may be asked to determine if the animal is a service animal.

1) Is the service animal required because of a disability?
2) What work or task has the service animal been trained to perform?

The service animal must have been trained to perform a specific task or work for a person with a disability in order to qualify for protection under the ADA regulations. Note that service animals do not always wear vests or harnesses, and there is no paperwork or identification card carried by anyone with a service animal.

What questions are you legally prevented from asking?
1) You may not ask about the person's disability.
2) You may not ask for proof of the person's disability.
3) You may not ask for documentation or proof that the service animal is trained.
4) You may not ask for an animal health certificate.

What should you do once you are satisfied the animal is a service animal?
1) Inform the handler which areas of the farm are open to the service animal and handler.
2) Inform the handler where handwashing areas are located, and they should wash their hands before handling and consuming produce.
3) Inform the handler of the proper area for the service animal to relieve themselves.
4) Inform the handler of where plastic bags and trash cans are available to dispose of fecal material.
5) Inform the handler of any farm policies specific to service animals.

Are comfort or emotional support animals protected by regulations?
Neither comfort nor emotional support animals are covered by the ADA regulations. Without the ADA regulatory protection these animals can be refused entry to your farm without fear of legal ramifications based on risk to your crops, farm animals, employees or customers.

What risks do outside animals pose for farm livestock and other farm animals?
When outside animals are present on your farm there are diseases that can be spread to and by your farm animals and livestock. Zoonotic diseases are diseases spread between humans and animals and include *E. coli* O157:H7, salmonella, and others. The most common way for diseases to spread is through direct contact, indirect contact, vectors, and contaminated food. It is estimated that six out of ten known infectious diseases impacting humans are spread also by animals. For more information on zoonotic disease risks and preventive controls visit the CDC Zoonotic Diseases webpage: https://www.cdc.gov/onehealth/basics/zoonotic-diseases.html

Can you deny entry to animals on the farm?
In general, the ADA regulations state that service animals may be present where the public is normally permitted. You may restrict service animals from specific areas such as produce handling areas used for washing, packing, and storage (risk of food contamination), or livestock areas (natural predator/prey relationships that can upset farm animals or potentially be a source of disease transmission).

What is appropriate behavior for a service animal and their handler?
Service animals should always be under the control of their handler. Service animals must be harnessed, leashed, or tethered, unless these devices interfere with the service animal's work or the individual's disability prevents using these devices. Service animals have been trained on how to perform a service for their handler and should be focused on that task.

Can you ask someone with a service animal to leave the farm?
If the service animal is behaving in a way that indicates they are not under the control of their handler, or if the handler is unable to control the animal, you may ask them to leave. Examples of this type of behavior would be: consumption of produce, urination, marking, or defecation in the production areas, excessive barking, or aggressive behavior.

Can service animals go into you-pick areas?
You should consider your production practices and the risk involved with an animal in your fields when determining what parts of the farm service animals can access. Crops typically consumed raw are considered higher risk since there is no process to kill potentially pathogenic organisms found on the surface. Crops grown near the ground, such as strawberries, leafy greens and lettuces, are inherently higher risk crops for contamination when compared to crops growing farther from the ground such as tree fruit. In many pick-your-own settings the customers are eating produce in the fields as they pick. Contact with animals can increase the risk of contamination of that produce as it is harvested and consumed. Handwashing stations should be provided to give customers an opportunity to clean their hands after touching the service animal.

Can service animals go into farm stores?
Service animals may be given access to store areas that are generally open to the public. Service animals would be prohibited from food processing areas, such as a store kitchen, due to contamination risk.

What should you provide to help reduce risk when service animals are on the farm?
While the presence of service animals on your farm is likely to be a rare event, be prepared by having a designated area for service animals to relieve themselves, complete with pick-up bags and a trash can to dispose of fecal material. Handwashing facilities should be available for the handler.

What if I let my customers bring animals onto my farm, without restrictions?
Should you allow animals other than service animals onto your farm be prepared to deal with customers with animals frequently? At minimum you should consider the following:

- Where will animals urinate and defecate?
- What supplies will you provide to allow proper clean up of defecation? (i.e. plastic bags and a trash can)

- Who will be trained to properly monitor this area to ensure that it does not become a contamination risk or an eyesore for your farm?
- Where will the customer handwashing station be located so that hands can be washed after handling their animal and after managing a defecation event?
- What signage will you need to instruct customers on your expectation for animal behavior and handling at the farm?
- How will you handle a situation when the animal and/or the handler is behaving inappropriately?

What are the steps to enforce your policies when someone wants to bring an animal on the farm?

Your own policies regarding service animals on your farm will dictate the conversation with a member of the public who wishes to bring an animal onto your property. Below are two examples of a farm policy:

Service Animals Covered by the ADA Regulations Permitted Only
1. Animals other than service animals will be asked to leave the farm.
2. If the disability is not known or obvious the handler will be asked the following questions to confirm the animal is a service animal: a. "Is the animal a service animal required for a disability?" b. "What task has the service animal been trained to do?"
3. If the animal is confirmed as a service animal you will be informed of the following: a. Areas that are open to the handler and service animal b. Location of hand washing areas c. Areas that the service animal can eliminate waste d. Policies at the farm specific to service animals
4. If the animal is not a service animal, you will be asked to remove the animal from the property. If you refuse to leave the property, the police may be called.

Customers are Permitted to bring Outside Animals onto the Farm Property
1. Animals are permitted on the farm property without restriction.
2. Customers are made aware of the farm policies regarding outside animals on the farm by prominent signage at: a. The farm entrance b. The designated animal relief area/s at the farm.
3. Signage will inform the customer the following: a. Areas that are open to the animal b. Location of hand washing areas c. Situations that would warrant when it is appropriate to wash their hands d. Area/s that the service animal can eliminate waste e. Instructions for what the customer should do if their animal accidentally relieves themselves in inappropriate areas

4. Animal behavior that is considered unacceptable in the farm environment a. Consumption of produce b. Urination, marking, or defecation in areas outside of the designated relief area c. Excessive barking d. Aggressive behaviors towards other customers, employees, or farm animals
5. Customers who are not handling their animals in accordance with the farm policies may be asked to leave.

What do you need to do to comply with the Food Safety Modernization Act Produce Safety Rule or a buyer required third party audit?

Produce safety inspectors and auditors will focus on the potential risk of contamination with animals on your farm. You can expect questioning to focus on the production areas where the animals are permitted access, the areas that the animals are allowed to relieve themselves, how those areas are maintained, availability of handwashing facilities for the handler, and relevance and prominence of appropriate signage for the handler. Signage should indicate your expectations for the animal handler, locations of areas to support proper handwashing and trash disposal, and appropriate areas for the animal to urinate and defecate.

Where can I learn more about the ADA regulations on service animals?

ADA 2010 Revised Requirements – Service Animals
https://www.ada.gov/service_animals_2010.htm
Frequently Asked Questions about Service Animals and the ADA
https://www.ada.gov/regs2010/service_animal_qa.html
State Specific Regulatory Table
https://www.animallaw.info/topic/table-state-assistance-animal-laws

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The Potential for Value Added Products with Hazelnuts

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Hazelnuts are garnering significant interest as a crop in the United States due to increasing cultivation in the Pacific Northwest, breeding efforts in the East and Midwest, and world-wide demand for kernels. Over the past 20 years, Rutgers University's hazelnut research and breeding program has been studying hazelnuts and developing new cultivars that are well adapted to New Jersey and the Mid-Atlantic region of the United States. These new cultivars are resistant to the disease Eastern Filbert Blight (EFB), a fungal pathogen which has historically been the major limiting factor to hazelnut cultivation in the eastern United States. The first cultivars released from the breeding program (Raritan, Monmouth, Hunterdon, and Somerset) are currently being produced in tissue culture and trees will start to become available from commercial nurseries in 2021. While wholesale in-shell hazelnut prices have ranged from $1 to more than $2 a pound in recent years, local growers have the potential for much greater earnings by creating value-added products for sale in local markets. With over 20 million consumers in the New York City/Philadelphia area alone, the market potential for value-added products appears very high. Hazelnuts are currently in high demand, with a wide variety of product options that include candies, cookies, nut butters and spreads, oils, ice cream, and many other items. Interestingly, most hazelnuts currently sourced for these products are imported (largely from Turkey), leaving a lot of room to utilize domestic sources. In addition to more complex value-added products, on farm shelling of nuts for kernel sale is another avenue for higher-priced sales, as they could be sold directly to consumers, restaurants, confectionary shops, and/or bakeries. Given the phenology of this crop, it could also lend itself for pick your own operations since nut maturity coincides with other orchard harvests in the early fall. Additionally, in-shell hazelnuts can be stored for over a year after harvest, allowing farmers to sell retail products throughout the year or when wholesale prices are highest.

Specialty Crops

FROM MANAGEMENT TO GENETIC RESISTANCE: NEW DISCOVERIES IN CONTROLLING BASIL DOWNY MILDEW & FUSARIUM WILT

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Sweet basil is the most important annual culinary herb commercially grown in the US. Basil downy mildew (BDM), caused by *Peronospora belbahrii* is the most economically important disease of basil in the US. Infected plants are characterized by yellowing of the foliage and by sporangia developing on the lower leaf surfaces, leading to leaf necrosis and significant economic loss (Wyenandt et al., 2015). After nearly a decade's worth of research and breeding efforts, At Rutgers University, and with assistance from colleagues at Cornell, UMass and UF, introduced four new sweet basil varieties with Downy Mildew Resistance (DMR): Rutgers Obsession DMR, Rutgers Devotion DMR, Rutgers Passion DMR and Rutgers Thunderstruck DMR. The four new sweet basil varieties being commercialized by Van Drunen Specialty Seeds (VDF Specialty Seeds) and can be purchased directly through VDF Specialty Seeds or through a number of seed outlets across the US including those that service NJ and regional growers as well as Master Gardeners and others (e.g. Johnny's Seeds, Harris Seeds, High Mowing Organic Seeds, Stokes and VDF Specialty Seeds).

Rutgers worked diligently to identify and breed DMR lines (Pyne et al. 2015) into commercially-acceptable chemotype standards through volatile analysis of their aroma profiles. We conducted taste tests and pilot marketing studies and all four were found to be acceptable to consumers and to the marketplace. We also have been field-testing our four new lines in addition to a wide range of commercially available sweet basils annually including examining any other commercial varieties purported to have DMR. The presentation will focus on these new varieties and highlights from our 2019 field studies.

In 2019, one of our new lines, Sweet Basil Newton was commercialized and seeds can be obtained through Johnny's Seeds. Newton is a classic large leaf Italian sweet basil with excellent taste, high yields, but no resistance at all to downy mildew. In parallel, to our downy mildew studies, we have conducted extensive studies to develop even newer Fusarium resistant (FOB) sweet basils. These newer sources of FOB resistance have been identified and now will be used for crossing into our DMR sweet basils.

<u>Highlights from 2019 Field studies:</u>

Table 1. Area under the Disease Progression Curve for Downy Mildew Disease on field-grown Sweet Basils, Rutgers Agriculture and Extension Center, NJ,

Sweet Basil Variety	R/S*	AUDPC
Newton	S	7503 a
Prospera	R	5134 b
Rutgers Thunderstruck DMR	R	4360 c
Rutgers Devotion DMR	R	4269 c
Rutgers Obsession DMR	R	4225 c
Rutgers Passion DMR	R	2025 d

*R-Downy Mildew Resistant; S-Downy Mildew Susceptible

Results from direct seeding and transplanted basil showed that the Rutgers DMR lines performed well despite high innoculum pressure from DM. These lines and all DMR sweet basil lines will exhibit some degree of sporulation and disease symptoms, but the timing as to when they will appear and the extent will depend upon variety and season itself. None are immune and as such growers are urged to use these DMR sweet basils in combination with a preventative control program. New field studies using our DMR sweet basils suggest that the number of sprays can be significantly reduced without compromising quality of product.

Controlling basil downy mildew when growing resistant varieties (Simon et al 2020)

The DM pathogen has the potential to evolve relatively quickly with the emergence of the sexual stage (i.e., oospore production) which has been reported in infected basil leaves in Italy and Israel. Oospores increase the durability of the pathogen, allowing it to overwinter and potentially overcome chemical and genetic control. Work from Israel has provided initial evidence for mefenoxam resistant BDM races. To mitigate this threat, organic and conventional growers should always use an integrated management program by applying fungicides in combination with resistant varieties and follow fungicide resistance management guidelines.

Several fungicides have been registered for managing BDM through the Rutgers University Interregional Research Project #4 (IR-4 Project), which has been facilitating the registration of sustainable pest management technology including conventional, biopesticide and organic products on specialty food crops (fruits, vegetables, nuts, herbs) for 56 years. To date, conventional product registrations obtained with the help of the IR-4 Project include oxathiapiprolin (greenhouse and field use; FRAC Group 49), mandipropamid (field use, FRAC Group 40), fluopicolide (field use, FRAC Group 43), fenamidone (field and greenhouse use, FRAC Group 11) and cyazofamid (field and greenhouse use, FRAC Group 21). In the 2019 field season, the IR-4 Project in cooperation with Agriculture & Agri-Food Canada will conduct residue and efficacy/crop safety studies with the new active ingredient picarbutrazox (FRAC Code U17) on basil for field and greenhouse use.

Growers and individuals who are interested in following our BDM research program can follow us on Instagram at #Rutgersbasil.

Grower and Master Gardener Observations:

Our Rutgers Obsession DMR is the Master Gardeners 2020 Plant of the Year Selection https://web.uri.edu/mastergardener/?wysija-page=1&controller=email&action=view&email_id=705&user_id=0&wysijap=subscriptions
*From Produce Grower- See:
http://magazine.producegrower.com/article/august-2019/top-stories-from-produce-growers-website.aspx

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NUTRIENT DENSE MICROGREENS: PRODUCTION AND COMPARATIVE ANALYSIS

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Introduction: Microgreens, also called "vegetable confetti" (Treadwell et al., 2013), belong to the group of plant foods classified as "functional foods" because they possess particular health promoting or disease preventing properties that are additional to their normal nutritional value (Samuolienė et al., 2012). Morphologically microgreens are plant seedlings that are between the cotyledonary and the first fully formed primary (true) leaf stages of growth (Treadwell et al. 2013). Commercially and in culinary terms, they fall between the "sprout" and "baby green" vegetable packaging (Bliss, 2014). For plants with tiny seedlings such as tropical spinach (*Amaranth* spp), the microgreen growth stage may be stretched a little longer than the first true leaf stage. While sprouts need water, air and food reserves in the seed cotyledons (for dicot plants) or endosperm (for monocots) to germinate, emerge from the seed (or grain), and grow, microgreens, in addition to these elements, need light for photosynthesis and nutrients from the growth media. Sprouts may be cultured exclusively in moist soilless media with or without light. However, microgreens rely on the food reserves in the sprout as well as nutrients in the growth media to support the initial stages of metabolism needed to provide energy for subsequent vigorous growth of the microgreen, baby green and the mature plant. The microgreen reflects quite closely the nutrient density of the sprout from which it derives.

Microgreens are gradually gaining commercial attention globally as nutrient dense seedlings capable of supplying high nutritional and health values at relatively small consumption quantities compared to mature vegetables (Bliss, 2014; Ebert et. al. 2015; Lenzi et. al. 2019; Senevirathne et. al.2019, Stoleru et. al. 2016; Goora and Srividya, 2018; Verlinden 2019, Bunning 2019). In the United States, interest in microgreens has increased 100% since 2004 (https://trends.google.com/trends/explore?date=all&geo=US&q=microgreens accessed 12/21/19) with Montana (#1 – 100%), Hawaii (#2 – 92%) and Vermont (#3 –75%) topping the list of states with high interest in microgreens. On the same scale New Jersey ranks #45 (of 50) with rather slow rate of growth of interest (32%) in microgreen production and/or consumption since 2004. It is desirable to add these nutrient dense plant sources to our food basket in NJ to promote the vitality of our workforce and enhance our agricultural economy.

In our Ethnic Crop Research Program at Rutgers University, we are interested in documenting the nutritional value of top ethnic crops in our collection starting with tropical spinach (*Amaranthus* spp.) and roselle (*Hibiscus sabdariffa*) as microgreens and mature field grown crops. Such data will enable us compare more effectively the dynamics of nutritional qualities as we promote these ethnic crops for adoption by our diverse population. In this paper, we compare partial nutritional content of these crops including the digestible carb, digestible protein, total fat, dietary fiber, and macro- and micro-nutrients, as greenhouse cultured microgreen and mature field grown vegetables.

Materials and Methods:

Microgreens: Between 2017 and 2019, multiple 10- to 20-day cycles of tropical spinach and roselle microgreens were raised in the greenhouse at the New Jersey Ag Experiment Station (NJAES) greenhouses on Cook Campus, Rutgers University, New Brunswick, NJ. The computer regulated growth conditions were 75-85^{o}F temperature, 14-hr high-pressure sodium (HPS) light/day, and 75-85% relative humidity. Tropical spinach (Caribbean Red selection) seeds were obtained from previously processed seeds harvested from ongoing ethnic crop research plots at Rutgers' Horticulture Farm 3, East Brunswick, NJ. Seeds for raising roselle microgreens were purchased from Seeds of India (Marlboro, NJ). For tropical spinach, microgreens were raised in black 1020 trays (Greenhouse Megastore, Danville, IL) half-filled with Pro-Mix (Premier Tech Horticulture, Quakertown, PA) potting mix. In each of nine trays, approximately 3g of seed was carefully spread by hand evenly across the surface of the potting mix and worked lightly into the mix. For roselle, nine 48-cell insert trays (Greenhouse Megastore, Danville, IL) were used to raise microgreens. Trays were filled with potting mix, then two roselle seed were placed about 1.5cm deep in each cell using the blunt end of a ballpoint pen and covered. For both tropical spinach and roselle, trays were watered gently with a sprinkler until water started to drip at the bottom of the flat. Seeded trays were set on greenhouse bench and watered once in two days for the first 10 days after seeding (DAS), then increased to once a day until study was terminated 20 DAS. After emergence trays were watered once (about 6-7 DAS) with 3g/L (0.4oz/gal) 20-20-20 NPK solution. For each type of microgreen, three trays were sampled each at 10, 15, and 20 DAS for nutrient analysis using a pair of scissors to clip seedlings at ground level.

Mature Vegetables: In the 2018 and 2019 growing seasons, tropical spinach (Caribbean Red selection) and roselle (Indian Red-Red or IRR cultivar) were seeded first week in June and managed conventionally (fertilized with 10-10-10 NPK) under black plastic mulch at Rutgers Hort Farm 3, East Brunswick, NJ and Rutgers Ag Research and Extension Center (RAREC), Bridgeton, NJ, respectively. In 2.2-meter (6-foot) plots, tropical spinach seed was sprinkled about 1 cm deep along a slit cut into the plastic mulch at the center of the seedbed. In 3.6- meter (10-foot) plots, roselle was seeded about 2cm deep using 3-4 seed/hole spaced 30 cm (24-inches) apart along the center of the seedbed. Seedlings were thinned to two/hole about 10 days after sowing. Marketable foliage of tropical spinach was sampled twice at 5 and 7 weeks after sowing (WAS) while marketable foliage from roselle was sampled at 7 and 9 WAS. For tropical spinach, samples were taken from plants within 30 cm at the center of the plot and for roselle, samples were taken from the three plants at the center of the plot.

Plant and Data Analyses: Microgreen and mature vegetable samples were dried in an oven (Wisconsin Oven, Memmert Model, East Troy, WI) set at 122^{o}F (50^{o}C) for 72-96 hours at College Farm Road on Cook Campus, New Brunswick, NJ. Composite samples of the same treatment taken from three replications were ground using the Thomas Scientific (Swedesboro, NJ) plant sample grinder and mixed. We took two subsamples from each treatment, packaged them carefully and mailed to Brookside Laboratories in New Bremen, Ohio, for proximate analysis. The data were analyzed using the two subsamples as two replications for each treatment. Means were separated using Fisher's least significant difference test at 5% probability level (LSD_{05}). The average values of the data obtained for the microgreens at 10, 15 and 20 DAS and the averages obtained from the two sampling dates for the field grown crops (5 & 7 WAS for tropical spinach and 7 & 9 WAS for roselle) were used to compare the partial nutritional status of tropical spinach and roselle microgreens and mature plants.

Results

Figures 1 and 2 show the stages of growth at which the tropical spinach and roselle microgreens were sampled for analysis, while Figure 3 shows the growth status of the field grown tropical spinach and roselle at the times of sampling.

Tropical Spinach Microgreen and Mature Plant:

Carb, protein, fat and fiber: In tropical spinach, the microgreen contained higher digestible protein (32.5%) than the marketable foliage from the field-grown crop (25%). Fat was also higher in the microgreen (2%) than in mature vegetable (<0.5%). However, the digestible carb was higher in the mature crop (27%) than in the microgreen (17.5%). The dietary fiber content (13%) was the same in the microgreen and mature plant (Figure 4).

Macronutrients: Among the macronutrients, the microgreen contained higher level of potassium (K) (6.7%) than the marketable foliage of mature tropical spinach (4.1%), but calcium (Ca) was higher in the mature plant (2.9%) than in the microgreen (0.9%). The levels of phosphorus (P) (about 1%) and magnesium (Mg) (about 1.5%) were not affected by the growth stage of tropical spinach (Figure 4).

Micronutrients: Tropical spinach microgreen contained much higher levels of manganese (Mn) (> 260 ppm) and zinc (Zn) (170ppm) than the mature marketable foliage which contained <50 ppm Mn and <40 ppm Zn. Iron (Fe) was reasonably high (about 120ppm) in the microgreen and mature tropical spinach but no statistical difference was observed between the two. Copper was very low (0.5-1ppm) both in the microgreen and mature tropical spinach (Figure 4)

Roselle Microgreen and Mature Plant

Carb, Protein, Fat and Fiber: As observed in tropical spinach, digestible protein was higher in roselle microgreen (30%) than in the mature plant (22%). In addition, similar to tropical spinach, digestible carb was higher in the mature roselle (36%) than in the microgreen (24%). The fiber content of roselle microgreen and the mature foliage was close to 15% and we observed no difference in the two. The total fat content was low (1-2%) and no difference was observed between the microgreen and the mature plant (Figure 5).

Macronutrients: Except Ca, all macronutrients were present at higher levels in the microgreen than in mature roselle foliage. The most significant were P and K where the elements were twice higher (or more) in the microgreen than in the mature foliage. As observed in tropical spinach, Ca was significantly higher in the mature roselle (1.7%) than in the microgreen (0.9%) (Figure 5).

Micronutrients: Manganese, Fe and Zn were present in high amounts in roselle microgreen and mature plant, but much higher in the microgreen. Copper was low in both the microgreen and mature plant (1-4ppm) (Figure 5).

Discussion and Conclusions: In our studies, we found that tropical spinach and roselle microgreens do contain high amounts of digestible protein, macronutrients especially K in tropical spinach and P, K and Mg in roselle. Micronutrients especially Mn and Zn are high in both tropical spinach and roselle microgreens; and roselle is a good source of Fe, one of the most deficient elements in human body globally. However, the mature plants contain higher digestible carb and Ca. The Ca level in the mature plants is of particular interest where bone development and/or health is a challenge. Both tropical spinach and roselle contain substantial amount of dietary fiber (>10%), but this component did not seem to vary with the plant's growth stage. Tropical spinach microgreen showed higher affinity for total fat than the mature plant. These results showed that microgreens have the capacity to enhance human nutrition especially where protein, essential macro and micronutrients may be deficient in traditional diets. They confirm the findings of several researchers that microgreens are a powerhouse of high nutrition for human use (Xiao at 2012, Ebert et. al. 2015). Nursing mothers, children and people in less privileged communities where access to good quality food is limited, should benefit from these nutrient sources.

Producing microgreens is not complicated and may be adopted under relatively unsophisticated circumstances, provided there is adequate light, water, nutrient supply, dependable seed and good sources for high quality growth media. Microgreens are not as susceptible to food safety issues as sprouts (Bunning 2019), making them more adoptable by the general population. Depending on the plant under consideration, the growth cycle may be as short as 10 days, or less (for wheatgrass as found in our studies) or a little longer (for roselle). We project an increase in demand for microgreens in New Jersey and the Mid-Atlantic as the community becomes more aware of the nutritional and health values hidden in this powerful repository of essential nutrients and health principles. Work is in progress around the country and globally, to determine the impact of light on nutritional quality of microgreens (Samuoliene et al. 2012; Xiao et al 2012). One expects that in the near future it should be possible to customize microgreens to manufacture unique foods and medicines to address some human nutrition and health issues as we move forward in the 21st Century. We plan to include other aspects of nutrition not included in this project in our future studies on microgreens, including antioxidant activity, vitamins, etc.

Acknowledgements: I am grateful to Rutgers SEBS/NJAES Administration for supporting my work and the Rutgers Dining Services for collaborating with me on the integration of our microgreens into the University menu. I am also indebted to several interns and student workers who have assisted me to accomplish the microgreen studies.

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Figure 1. Greenhouse cultured tropical spinach (Caribbean Red) microgreen at 10, 15 and 20 days after seeding (DAS), Photos by Albert Ayeni

Figure 2. Greenhouse cultured roselle (Indian Red) microgreen at 10, 15, and 20 days after seeding (DAS), Photos by Albert Ayeni

Figure 3. Field grown tropical spinach (Caribbean red) (top) and roselle (Indian Red) (bottom) at sampling for nutrient status determination, Photos by Albert Ayeni

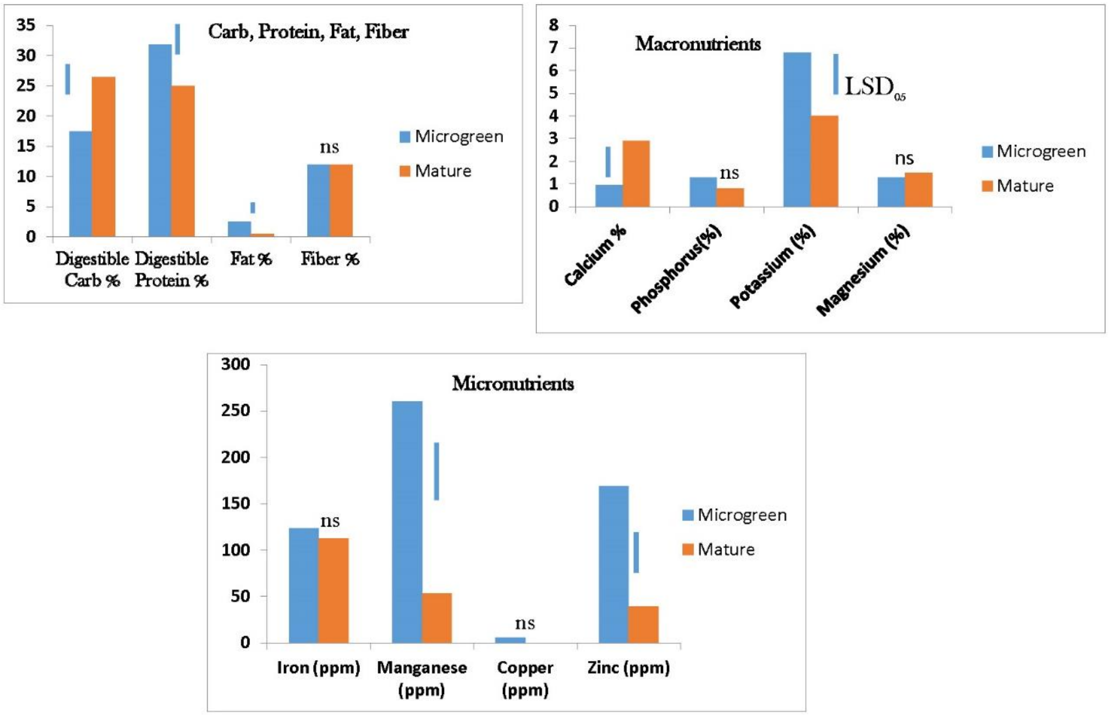

Figure 4. Partial nutrient status compared between tropical spinach (Caribbean Red) microgreen and mature plant (ns = no significant difference)

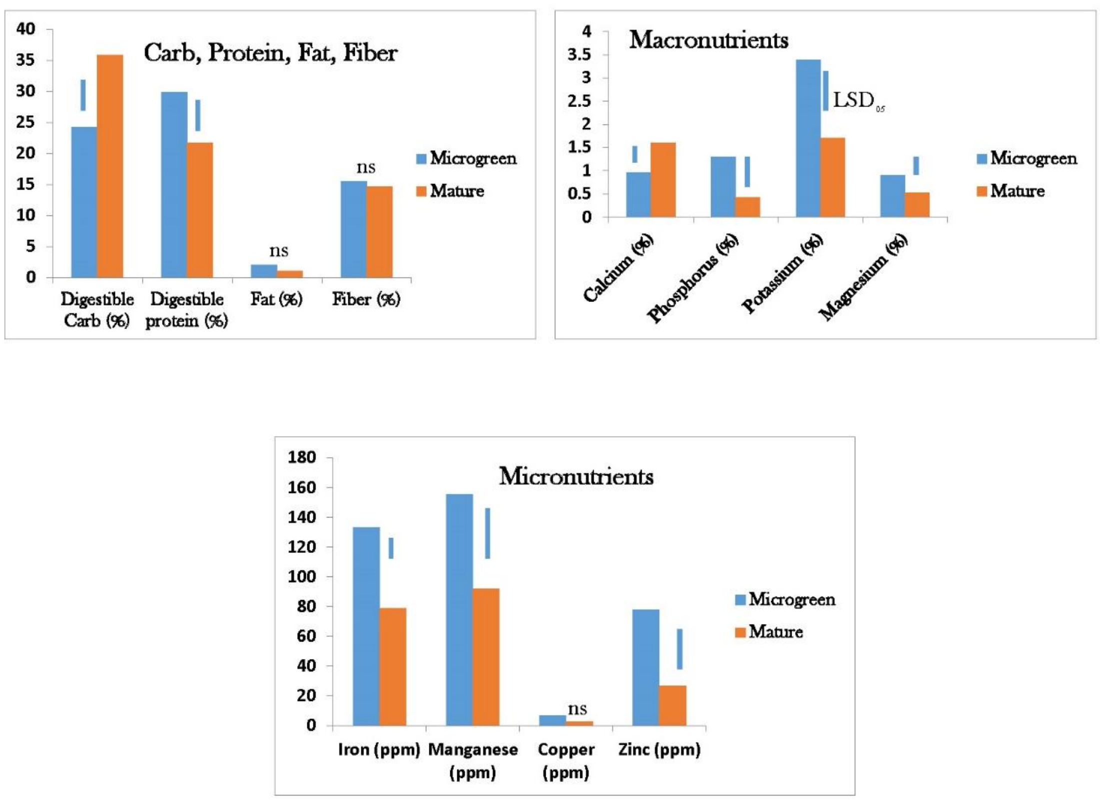

Figure 5. Partial nutrient status compared between roselle (Indian Red) microgreen and mature plant (ns = no significant difference)

GOLDENBERRY PRODUCTION

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Goldenberries (*Physalis peruviana*) are a South American, *Solanaceous* fruit quickly gaining attention in North America. It has many different common names, including: Cape gooseberry, Poha berry, Incaberry, and Pichuberry and is closely related to the tomatillo (*P. ixocarpa*) and ground cherries (*P. pruinosa*). Even though they are native to tropical South America and plants are injured at a temperature of about 30^{o}F, goldenberries can be grown as an annual in temperate regions. They have a very long growing season and are started in the greenhouse and transplanted outdoors much like tomatoes, peppers or eggplants as soon as the threat for frost is over.

A two-year Northeast Region SARE project 'LNE18-362- Goldenberries (*Physalis peruviana*): A New Fruit for CSA Farms and Farmers Markets' is underway trying to identify germplasm suitable for growing in the Northeast region. Some of you may have participated in this study in 2018 and will hopefully return in 2019. If you weren't involved in 2018 but would like to join our efforts, please send me an e-mail at durner@sebs.rutgers.edu and I'll be sure to include you in 2019.

Their long growing season is a problem for more northerly growers. Researchers at Rutgers, Cornell, Cold Spring Harbor Labs and the University of Florida are investigating the possibility of developing a goldenberry with a much shorter growing season requirement. The work is in it's infancy (a Specialty Crops Research Initiative pre-proposal has been submitted to the USDA), but you'll be sure to hear of our progress as work progresses.

Goldenberry has been cultivated for years in the Andes Mountains of South America. The fruit has spread worldwide however; it has not become a significant crop in most regions. Localized industries have developed in South America, South Africa, Australia, New Zealand and India but large-scale commercial production is not common.

There are over 100 species of *Physalis* and many are considered weeds. However, four are grown for their fruit (tomatillos (*P. ixocarpa*), ground cherries (*P. pruinosa*, *P. pubescens*), and goldenberries (*P. peruviana*)). Goldenberries are often confused with ground cherries (*Physalis pruinosa*, *Physalis pubescens*) however, they are easy to distinguish. Goldenberry foliage is extremely pubescent (hairy) while ground cherries are glabrous (smooth). In addition, the calyx (husk) of goldenberry has 10 ribs while husks of ground cherries have 5. Mature goldenberry plants are much larger (up to 5 or 6 feet) than ground cherries (at most 3 feet).

One of the distinguishing features of *Physalis* species is their husk. Goldenberry flowers are yellow, up to ¾ inch wide, pendulous and bell-shaped with purplish spots in the throat. They appear in the leaf axils. Flowers are cupped by a purplish-green, hairy, 5-pointed calyx which expands after the flower falls following pollination and fertilization to form the husk. The fruit, which is a berry, is encased in the husk which starts out soft and green when young but becomes tough, brown and paper-like when the fruit is mature. The husk is much larger than the fruit it encloses and it is inedible.

Unlike ground cherries, goldenberries do not abscise (fall off the plant) when ripe and are harvested directly from the plant. Fruit are ½ to 1-inch-wide globe-like berries with smooth, glossy orange skin with a juicy pulp containing many very small edible seeds when fully ripe. Fruit has a pleasant tropical flavor, tasting like a mixture of pineapple, strawberry, sour cherry and citrus.

Seeds must be obtained from a reliable source. Goldenberries are often mislabeled by seed companies, often being *P*. *pruinosa* or *P*. *pubescens* (both ground cherries) or *P*. *ixocarpa* (tomatillo). Seeds are sown in flats of a sterile seeding mix of your choice, barely covering the seeds, and are kept moist. Seeds germinate in 14 to 21 days in a moderately warm greenhouse and seedlings transplanted when they are about 1-inch-tall into 24 to 50 cell plug trays. They are grown in the greenhouse for at least 6 weeks before they are transplanted to the production field. Plants are large enough to transplant outdoors when they are 6 to 8 inches tall and there is no chance for frost.

Goldenberries produce best on well-drained ‘poor’ soils but they need adequate moisture as they tend to ‘go dormant’ during a drought. We recommend planting goldenberries on standard raised beds covered with black plastic mulch with trickle irrigation, much like you would use for tomato production. Do not supply any pre-plant fertilizer or any at the time of transplanting as fertilization greatly reduces fruit production. Beds can be spaced according to your equipment measurements but should be at least 4 feet on center. Plants should be spaced 4 to 5 feet apart within the row. Plants tend to have a sprawling habit and are sensitive to high winds thus they should be supported with a simple 1 wire (at 3 to 4 feet) trellis with main stems clipped or tied to the wire. We use T stakes with heavy duty twine and standard tomato clips.

Goldenberry plants grow as a single stem for 9 to 15 nodes when they then bifurcate (branch as a Y). This branching habit continues during subsequent stem growth. All axillary shoots and suckers should be removed up until the first bifurcation of the main stem. A trip through the field once every week or two should suffice. Pruning normally lasts for 3 to 4 weeks, thus labor requirements for pruning are not excessive. Once the plant has branched, minimal sucker removal is required.

The first flower appears at the node of bifurcation (approximately a month or so after transplanting) and flowering will continue until frost in the fall. Flowers are wind and insect pollinated and are self-pollinating. Cross pollination within goldenberry is rare and pollination between species (i.e. goldenberry with ground cherries or tomatillos) is even rarer. Genetic lines stay true to type when seeds are collected and saved from year to year. Goldenberries typically produce 150 to 300 fruit per plant, beginning in late August or early September and continuing until the first fall frost.

We have seen two significant insect pests during our trials: the three lined potato beetle (*Lema daturaphila*) (particularly the larvae on young plants) and tobacco and tomato hornworms (*Manduca sexta* and *Manduca quinquemaculata*, respectively) particularly later in the season on mature plants. The tobacco hornworm is more common than the tomato hornworm and can be distinguished from the tomato hornworm by its seven diagonal white stripes and its usually red 'horn' while the tomato hornworm horn is bluish-black.

Fruit are ripe when they turn a golden color which is often easily seen through the husk, which by the time of fruit ripening has faded and turned yellowish brown and translucent. Green fruit are not ripe and will not ripen once removed from the plant. Ripe fruit do not abscise like ground cherries and are harvested by hand. Fruit should be harvested when they are dry; if they are moist from dew or rain they are likely to mold. Fruit is normally left in the husk for sale in pint containers, but sometimes the husk is removed and the golden berries displayed in half-pint containers for sale. Many chefs prefer fruit with the husk as it is often used for decoration. Additionally, fruit will keep at room temperature for up to 3 months if they are left in the husk.

Fruit is eaten fresh or cooked. Fresh goldenberries fit well in in mixed green or fruit salads, make a wonderful addition to salsas and make an elegant dessert when partially dipped in chocolate. The fruit makes excellent pies, jams and jellies and is naturally high in pectin. A serving of fresh goldenberries (100 g) provides approximately 75 calories, 0.3g protein, 0.2g fat, 19.6g carbohydrate and 4.9g fiber. The medicinal qualities of goldenberry are too numerous to list. We will provide a well-researched chapter complete with references and citations on the medicinal properties of goldenberry in our forthcoming production manual.

Numerous internet reports suggest that goldenberry plant tissues and green fruit are poisonous. Green tissues including unripe fruit contain solanine which can cause gastroenteritis and diarrhea, thus consumption of unripe fruit should be avoided.

This material on Goldenberries is based upon work supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, through the Northeast Sustainable Agriculture Research and Education program under sub-award number LNE18-362.

Food Safety

HOW DO INSIDIOUS MICROBES ENTER THE FOOD SUPPLY?

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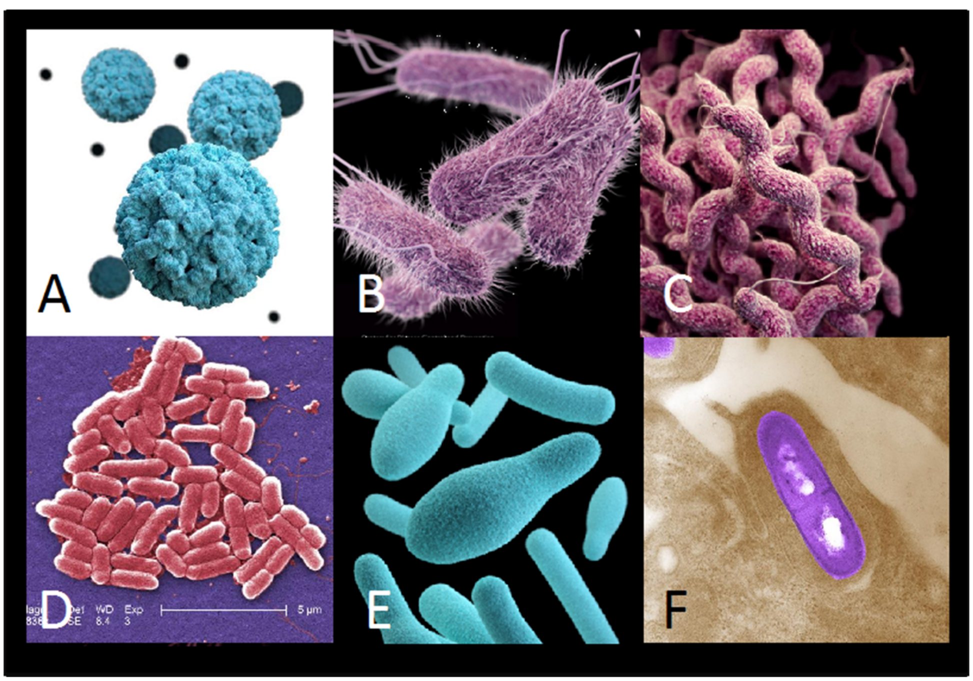
The CDC (Centers for Disease Control and Prevention) estimates that over the course of a year 48 million people become ill from some form of a foodborne illness, with 128,000 hospitalizations, and roughly 3,000 deaths. Transmission of these illnesses, which are caused by a variety of microbes, often follows the fecal-oral route. The first symptoms of foodborne illness include vomiting, and/or diarrhea with abdominal cramps/distress, nausea, fever, joint/back aches, and fatigue also attributed. Raw foods from animal origins (chicken, dairy, shellfish) are common sources of contamination, however serious and often-deadly outbreaks are routinely linked to inappropriately handled fruits and vegetables. Additionally, many fruits and vegetables (especially leafy greens, sprouts) are consumed raw (without heating to germicidal levels) in many everyday dishes, thus compounding the potential for food-related illness.

Some insidious microbes causing foodborne illness.
(royalty-free images sourced: Public Health Image Library (PHIL), CDC.gov)



A: Norovirus **B**: *Salmonella typhi* **C**: Campylobacter
D: *E. coli,* strain O157:H7 **E**: *Clostridium botulinum (Botulism)* **F**: Listeria

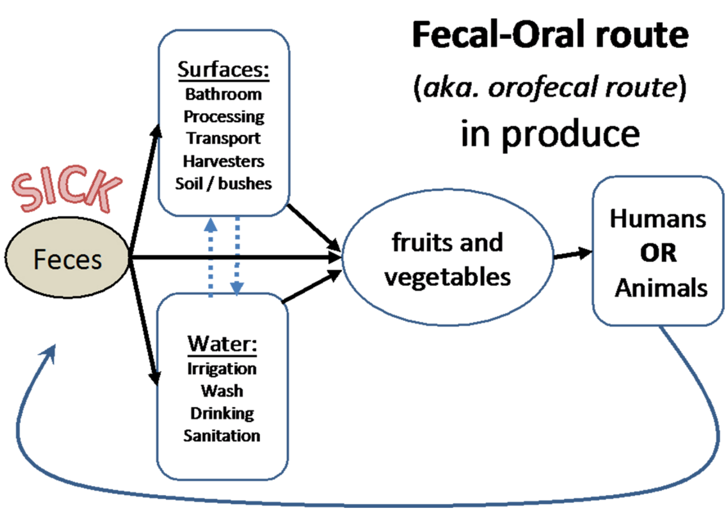
A FEW examples of recent foodborne illness outbreaks in fruits and vegetables.

Current - Outbreak of **Salmonella** Infections Linked to Cut Fruit (7 sick and counting)
Current - **E. coli** (E. coli O157:H7) Linked to Romaine Lettuce (138 sick and counting)
2019 - " of Salmonella Infections Linked to Pre-Cut Melons (137 sick)
2016 - Multistate outbreak of **hepatitis A** linked to frozen strawberries (56 sick)
2016 - " " of **Listeriosis** Linked to Frozen Vegetables (9 sick, 3 dead)
2016 - " " of Listeriosis Linked to Packaged Salads (19 sick, 1 dead)
2014 - " " of Listeriosis Linked to Commercially Prod. Caramel Apples (34 sick, 7 dead)
2011 - " " of Listeriosis Linked to Whole Cantaloupes (143 sick, 43 deaths)

Although some foodborne illness can be life threatening, almost half of the "food-poisoning" cases are attributed to Norovirus and seldom require hospitalization. However, in cases of individuals with compromised immunity, pregnancy, and young/old age the effects of any foodborne illness can be greatly exacerbated.

So where are these microbes coming from in an agricultural setting?

The typical bacterial or viral pathogens (microbes) causing foodborne illnesses can rapidly spread from an infected individual to other people (workers) and/or animals (wild, pets, cattle/poultry) that are in close physical contact due to cramped housing/transportation conditions (often viruses, particularly hepatitis-A) or through the transfer of bodily fluids. This could be shared drinks/food, intimacy/kissing, or the use of unsanitary restrooms. Given that many of these pathogens induce vomiting or diarrhea (rather messy events), there is a high potential for transmission through the fecal-oral route (aka. orofecal route). In this type of transmission a sick/compromised individual can transmit these pathogens directly to other humans and foods or, as is more often the case, indirectly to restroom surfaces, break-rooms, food packing lines, bins, machinery, and hot/damp transportation surfaces further infecting workers and foods. Alternatively, irrigation or "rinse-water" could also be contaminated (from humans or animals), directly transmitting microbes to foods or indirectly through other people or surfaces that come into contact with the food. However, this cycle can be easily broken. Enforced worker hygiene, temperature management ("Danger Zone" = 40° - 140 ° F), removal of any unnecessary handling events, and routine sanitization of food-handling surfaces can dramatically reduce the probability of foodborne illness.



KEY THINGS TO KNOW ABOUT SERVICE ANIMALS

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There is a lot of confusion about service animals today and there are a number of factors contributing to this confusion. To begin with, many people are not entirely clear about what is and is not a service animal. Public entities covered by the Americans with Disabilities Act often do not know their rights and responsibilities when it comes to service animals. This is compounded by the difficulty of finding accurate and consistent information about these issues. We are in an environment where more and more people with disabilities are relying on task-trained service animals while some are purchasing vests and ID's for animals that are not trained to perform tasks. The goal of this presentation is to provide you with some information that is straightforward and easy to remember when a person with a service animal comes to visit your farm.

The best place to start is by explaining who is covered by the Americans with Disabilities act (ADA) and how that is relevant to you. The ADA is the law that protects people with disabilities from discrimination and grants them equal access to public places. This means that pick-your-own farms and roadside produce stands that are open to the public are covered by the ADA. The ADA does not cover farms or portions of farms that are not open to the public.

The next important step is to define what a service animal is and is not. Under The ADA, a service animal is a dog that is trained to perform a task for the benefit of a person with a disability. In very rare circumstances, service animals can also be miniature horses. If you follow the news and spend any time on the internet, you may be hearing a lot about emotional support animals. Emotional support animals alleviate the effects of a disability, but there are two things about them you should know. They are not trained to perform tasks and they are not covered by the ADA.

It may sometimes be a challenge to determine if a dog brought to your farm is in fact a service animal, but the law gives you tools to make this assessment. It is important not to act on assumptions about whether the dog is a service animal and whether the person really has a disability. You can ask two questions if you do not know whether a dog is a service animal: 1) Do you need the animal because of a disability? And 2) what work or task is the animal trained to perform? You should not ask these questions if the person's disability and the need for the animal are obvious, e.g. a blind person working with a guide dog. It is illegal to ask the person to give you specific information about the nature of their disability.

We can now turn our attention to what is in fact a task. Service animals perform tasks for people with disabilities, such as guiding a blind person, providing balance support for a person with a mobility disability, fetching objects, alerting a person with diabetes that their blood sugar is low, etc. The dog is trained to recognize when a certain condition is present and respond by performing a specific task. The service animal handler should be able to tell you in simple terms what task the dog is trained to perform for them. However, if a person says the dog keeps them calm by simply being there, that is not a task. Remember, the dog must be trained to recognize that something needs to happen and then perform a specific task in response.

If someone tells you their dog is an emotional support animal, then you do not have to allow them access to your goods and services with the dog. You can do so if you choose to, but you are not required to do so. You have the right to tell the person they are welcome to be on your farm but they have to remove the dog and may come back after that.

You are not required to allow any animal on your farm that is misbehaving if the handler cannot take effective steps to get it under control. If a dog is misbehaving or posing a threat, i.e. growling or barking repeatedly; jumping, snapping, or lunging at people; relieving itself in inappropriate places e.g. on your crops, it does not matter whether the dog is a service animal because you do not have to allow it on your farm under those circumstances.

If you make it a practice to charge visitors for damage they cause to your property or goods, you have the right to apply this rule to service animal handlers. You may want to establish rules that will protect your produce without depriving service animal handlers of equal use and enjoyment of your goods and services, such as requiring a handler to make sure their service animal walks between the rows so that crops do not get trampled. It would be in your best interest to designate relieving areas far enough away from the produce to keep it from being contaminated. It is the handler’s responsibility to supervise and care for their service animal at all times. It is not unreasonable to require that the handler notify you if their service animal relieves itself in an inappropriate place so that any contaminants that might jeopardize the produce can be removed.

We understand this is a lot of information to digest. If you have any more questions, please feel free to call us at 973-539-4425 or send an email to advocacy@seeingeye.org. You may also want to visit us on the web at seeingeye.org/access.

FSMA PSR INSPECTION UPDATE

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The NJDA is actively promoting the safety of produce grown in New Jersey.

There is an MOU with Rutgers Cooperative Extension to provide Produce Safety Alliance (PSA) Grower Training. The 21CFR112 Produce Safety Rule states that a representative from each farm must complete this training or an equivalent as acceptable to the FDA.

NJDA and Rutgers and perform voluntary On Farm Readiness Reviews (OFRRs) to assess readiness for the Produce Safety Rule. In New Jersey, there were 78 OFRRs in 2018 and 10 OFRRs in 2019.

The NJDA has 6 Inspectors who have pursued rigorous training and who have been commissioned and credentialed by the FDA to conduct Produce Safety Rule (PSR) Inspections.

Many growers that participate in Third Party Audits are not in compliance with the PSR. The PSR is aligned with Audits, but not identical. Audits are voluntary, commodity-specific and buyer-driven. The PSR is a federal code of regulations, applies to all covered commodities and FDA Inspections are mandatory.

Our inspectors have kept detailed observations from each inspection, and we have identified several common issues that occur frequently on farms in NJ. This presentation will identify and discuss the most common recurring themes.

The PSR requires each farm to have at least one individual attend PSA Grower Training or the equivalent as acceptable to the FDA. FDA Inspectors will ask to see your Certificate of Completion. There must be an assigned Food Safety Supervisor who oversees all food safety operations and implements the principles of the PSR.

All employees, including family members, must receive adequate training in farm food safety. Employees must be trained upon hiring, and periodically retrained as needed, at least annually. Training videos in English and Spanish are available from Rutgers (onfarmfoodsafety.rutgers.edu) and are also on YouTube. Worker training records are required.

The FDA has not released the final rule on water testing. NJDA recommends continuing your current practices. You will need to perform an annual agricultural water distribution system risk assessment. Keep records of risk assessment and all major repairs. Also obtain and retain certificates of compliance from municipal water sources and for ice.

Cleaning and sanitizing is a two-step process and applies to all equipment, tools, vehicles and buildings. Keep complete vehicle logs, including rental trucks. Maintain control of tools and harvest bins, use approved sanitizing materials and monitor dosage rates. Properly store tools, equipment, hoses and packing materials. Records of cleaning and sanitizing are required.

The number of toilet facilities needs to be adequate. Refer to the NJ Migrant Labor Law for specifics. Porta Johns need to be reasonably close to workers in the field. You must have a plan for an unintended spill.

Handwashing stations are essential in the field and must be supplied with soap, potable water, single-use towels, trash can and disposal for waste water. Hand sanitizer is not an acceptable substitute.

Contamination can occur from animal intrusion in the fields, storage and production areas. Recommended practices include preharvest field assessments, rodent and bird control, and safe storage of harvest and packing materials.

The records required by the PSR, at this time, include certificate of PSA Grower Training, Worker Training, Biological Soil Amendments of Animal Origin, Water Distribution System Risk Assessment and Major Repairs, Cleaning and Sanitizing. Water Testing records will be required upon finalization of FDA requirements. Be sure to include your farm Name and Address on all required records.

Farms that claim Qualified Exempt status must have verified income of less than $500,000 in annual produce sales and more than 50% of produce sold to qualified end users. You are required to keep records and receipts. FDA Inspectors will inspect your records.

The FDA is requiring the NJDA to compile an inventory of all farms in New Jersey. A representative from the NJDA will contact you for information. Questions will include # of acres, # of employees, crops grown, and participation in Third-Party Audits. You will also be asked your Income Range to determine when your inspection will be scheduled. Please be cooperative.

Overall, we have a very strong program and are making progress in New Jersey in terms of Food Safety. In 2019, NJDA Inspectors completed 100 PSR inspections, 10 OFRRs and 135 USDA Audits for a total of 245 Farm Food Safety Assessments in NJ.

We have received a lot of positive feedback from farmers for the educational approach we are using for the PSR Inspections as well as our availability for consultation and support.

Hygienic Design for Produce Farms

Introduction

The purpose of hygienic design is to intentionally create or improve spaces and equipment so that they can be cleaned and sanitized as appropriate. The motivation for this is the reality that microorganisms such as human pathogens are small and can persist in even the tiniest of spaces in the right conditions. The role of hygienic design is to prevent this by incorporating, often passive, design features into equipment and buildings to minimize or eliminate harborage of human pathogens.

The inside of this produce brush washer has areas that are hard to reach and see which makes cleaning challenging.

The **5 key principles of hygienic design**[*] related to produce farms include:

1. **Visible and Reachable Surfaces -** If you can't see it and can't reach it... you can't clean or sanitize it.
2. **Smooth and Cleanable Surfaces -** Surfaces should be smooth and cleanable to enable efficient and complete cleaning.
3. **No Collection Points -** Niches, sandwich joints, lap joints, and flat or concave horizontal surfaces should be avoided to prevent the collection of water and material.
4. **Compatible Materials -** Materials should be compatible with the product being handled and the cleaning and sanitization processes used.
5. **Preventing Contamination -** Handling systems and buildings should protect the product from contamination.

Visible and Reachable Surfaces

A surface must be visible and reachable in order to be adequately maintained, including cleaning. This does not mean the surface must *always* be accessible. For example, often drive components of a machine have protective covers to prevent worker injury. However, these covers should be able to be removed to allow for cleaning of equipment on a regular basis.

If tools are required to partially disassemble a machine prior to appropriate cleaning, the tools should be clearly marked for that purpose, a **standard operating procedure (SOP)** should be developed for the steps involved, and employees responsible for the process should be trained accordingly.

It may be helpful to purchase a mirror for inspection and a flashlight to improve your ability to see some of the far

This produce rinse conveyor is normally run in a horizontal position, but opens up with a hinge and pneumatic cylinders to allow access, visibility, and cleaning of the conveyor belt and tanks underneath.

[*] This is a summarized list of hygienic design principles intended for produce growers limited to on-farm washing and packing operations. There are complete courses that address the topic, more detailed publications, and also lengthy industry checklists that can be consulted for more in-depth coverage. For more information, please see the references noted in each section and at the end of this document.

corners inside and under equipment.

Cleaning procedures may require partial disassembly of equipment for adequate cleaning of food contact surfaces. It may be possible to replace nuts and bolts on guards and shields with other "tool free" fasteners (e.g., weldnuts, weldstuds, wingnuts, camlocks, or twist locks) that are easier to remove or operate and don't require tools. Some fasteners allow for disassembly without resulting in loose parts, which can reduce mechanical contamination risk. Consult with the manufacturer and the equipment manual before making changes. Always disconnect power, shut off equipment water supply, and de-energize all other relevant utilities before cleaning. Let others in the work area know that you will be cleaning the machine and that the utilities are off for a good reason and should not be turned back on until the cleaning is complete. Consider implementing a lock-out, tag-out (LOTO) procedure and training employees in it.

▲ *There are fasteners beyond nuts and bolts that can make disassembly and reassembly easier and reduce the risk of losing parts. The fasteners above are available from most hardware stores.*

▲ *The use of clamping handles can allow for tool-less disassembly and reassembly with fasteners that stay connected to the equipment.*

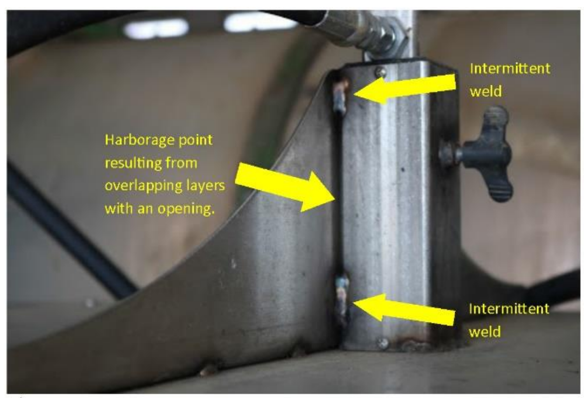
What is an SOP?

A Standard Operating Procedure (SOP) is a document that captures the standard set of steps and actions required to perform a routine task. An SOP is intended to ensure that multiple people can perform the same job, at the same level of quality with a predictable outcome. This document can take many forms include photographic, written, video, wall poster, or permanent labeling on a machine. An SOP is usually accompanied by an activity log to document the activity that was completed with date, time, person responsible and any significant challenges or findings.

It may be helpful to purchase a mirror for inspection and a flashlight to improve your ability to see some of the far corners inside and under equipment.

Smooth and Cleanable Surfaces

Often the best hygienic design elements are passive. Smooth, filleted or rounded welds at the corner of tanks lead to more effective cleaning. Favor continuous welds over intermittent welds. Grind and sand the welds smooth to improve cleaning. Avoid hollow member construction and areas with sandwiched or lapped layers of material such as the space



▲ *This joint illustrates how intermittent welds lead to a gap, or sandwich joint that can lead to harborage. A continuous weld that is then ground smooth would lead to a seal and be easier to clean, sanitize, and dry completely.*

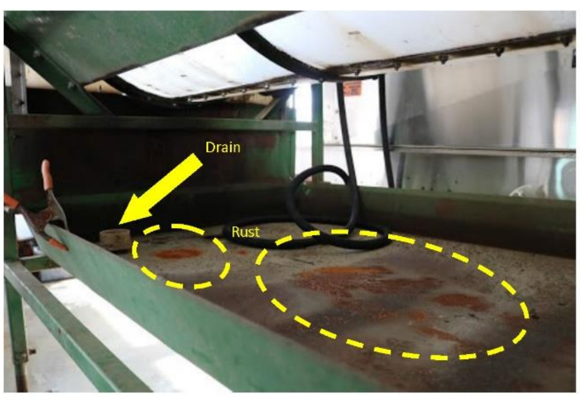
inside the top edge of tank formed by rolled or crimped sheet metal. Another common practice is to avoid flat horizontal surfaces in structural members of a machine opting for circular tube construction or rotated square stock instead. Rotating square stock to a 45° angle reduces areas where water and soil can collect.

No Collection Points

Another key principle of hygienic design is avoiding spaces where water and other material can collect. This includes niches and sandwich joints. Sandwich joints are common where two surfaces are brought together in an assembly and are not completely sealed with a continuous weld that is then ground smooth. A narrow harborage site results between two surfaces. These harborage sites allow water and solids to accumulate. This provides conditions that support the growth of microorganisms including human pathogens.

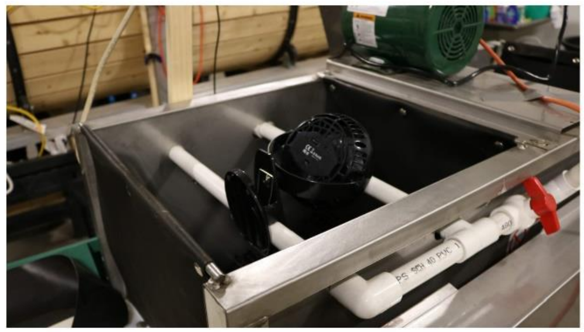
> **What is harborage point?**
>
> Harborage sites are places where water and pathogens can enter and be protected from cleaning, and sanitizing, and drying. This can lead to cross-contamination between batches and can also lead to premature corrosion and rot of equipment materials.

Hollow spaces, such as the interior of tube or square stock structural members, can also become harborage locations if they are not completely sealed. A little bit of seepage of water and organic matter with each day of produce washing can accumulate in a hollow space over time. These spaces hold moisture and also promote rusting of steel equipment.



▲ *This collection pan is an intentional collection point that should allow for collected water to easily drain. The rust spots are evidence that it doesn't drain completely and therefore doesn't dry easily. An increased pitch in the pan or a "break" in the sheet could create more aggressive draining and better cleaning, sanitizing and drying as a result. The rust also suggests the material isn't compatible with the use.*

Collection points are, unfortunately, very common on produce equipment. They result from assembly practices that are favored because they are relatively inexpensive and easy. Some ways to address existing collection points may include adjusting the legs on equipment to achieve a slight pitch to encourage flow to a drain, re-breaking (bending with cross diagonals) or replacing sheet metal collection pans with more aggressive drain pitch, adding bottom drain ports to



▲ *A small clip-on fan is attached to this brush washer following a cleaning and sanitizing procedure to push air into the enclosed portion of the machine to promote drying.*

▲ *A variety of cleaning tools may be needed to easily reach and completely clean produce wash equipment. From left to right: extension sticks with scrubbers on the end, stiff short brush, toilet brushes, large bottle brush, paint scraper, scrub pads, assorted bottle brushes large to small, long scrub brush, inspection mirror, small bottle brushes, assorted test strips.*

equipment with difficulty draining from existing side ports, and including a squeegee and towel dry step to a cleaning SOP for particularly challenging areas.

Fans and blowers can be very helpful in promoting drying of equipment after cleaning and sanitizing. This drying step is very important as a means to remove the availability of water that can promote pathogen survival and growth. The wash/pack area can be warmed slightly with a space heater to reduce the relative humidity of the air and increase the air's capacity to carry water away as vapor which speeds and deepens the drying. Floor fans or blowers designed for drying floors and carpets are portable and inexpensive tools for supplying large amounts of air flow to the inside of equipment that may otherwise be difficult to dry. It is also important to provide some ventilation of the wash/pack area to encourage air exchange. The air that is made humid from drying equipment needs to be exhausted outside and fresh, relatively dry air needs to be drawn in from outside. The relative humidity of the air can be reduced by heating to improve rate and efficacy of drying.

Special cleaning tools may be helpful in reaching far corners that are not easily accessible or for fitting into small areas that are otherwise hard to clean. It may take some experimentation and ingenuity to find the right tool. Ladders may also be helpful for getting above the equipment to inspect for cleanliness and to complete the cleaning process. Finally, it may be helpful to turn certain machines on their side or upside down to access certain hard to reach areas. Some of this work may require a second or third partner to be completed safely.

Compatible Materials

The materials used in the construction of equipment must be compatible with both the product the machine is handling and also the cleaning and sanitizing procedures used. Appropriate materials are generally smooth, durable, corrosion resistant, and impermeable to water. This includes being compatible with cleaners and sanitizers and generally favors stainless steels and food grade plastics since these materials have been developed specifically for this type of use.

Incompatible materials will degrade more quickly due to nicks, cracks, corrosion and other wear. Painted carbon steel may not hold up well to water and eventually the paint will flake and the steel will rust. Both of these could become mechanical and/or chemical contaminants and will result in the surfaces not being cleanable.

Consider the chemicals in the cleaners and sanitizers you use relative to the materials in your equipment. Think beyond the obvious food contact surfaces and consider rubber seals, bearings, drive components, electrical housings, etc.

Preventing Contamination

The layout, construction, and materials used in handling equipment and buildings should prevent the contamination of product from the environment, the building, the equipment and by cross-contamination among the product itself.

This includes excluding animals that may introduce fecal or other contaminants. Passive measures can be very effective at excluding birds (rafter netting) and rodents (wire mesh or hardware cloth in framing). Maintaining a clean area around the building helps to reduce attraction and cover for wildlife pests. Keeping cull piles to a minimum and locating away from the wash/pack area, trimming grass, and keeping items in storage at least 6" from the walls can all help to reduce attraction and cover for pests. Exterior baiting and exterminating can be used as a final option.

Evaluating Equipment and Buildings for Hygienic Design

The principles of hygienic design can be readily applied to any piece of equipment or building. The accompanying checklist has been developed tailored to farm-based produce handling equipment and buildings. It is based on other, more extensive guides from the processing industry. This checklist provides for a focused evaluation against the principles outlined above. The checklist is available as a spreadsheet that will sum the ratings based on the reviewer's assessment. It is also attached as the last pages of this guide as a hand-written sheet.

Conclusion… It is Never Done.

Hygienic design is a process of continual improvement. The checklists available are meant to aid in evaluating equipment and buildings as a "snapshot" of one point in time. The act of reviewing the equipment or building should motivate a plan for improving certain areas of design. Once those changes are made and put into practice, the team can review the equipment again. These checklists can also be helpful in identifying either preventive or reactive maintenance of equipment and buildings that may not be obvious during normal operation. A team approach to review is encouraged to provide multiple perspectives from multiple users with different skills and ideas.

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Agricultural ENGINEERING

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An online version of this publication is available at go.uvm.edu/hygienicdesign

Creative Marketing and Agritourism

CUT FLOWERS AS A LOW-COST VALUE-ADDED OPTION

Presenter: Brendon Pearsall

For farmers who are interested in converting a portion of their crop into value-added products one of the major barriers is the expense associated with developing the kitchen facilities necessary for processing. In New Jersey in particular there are many regulations that can discourage a grower from pursuing value-added production. Kitchens must be built in accordance with local codes, zoning issues can present a problem, and regular health inspection and certification requirements can add up to a lot of extra cost before you've even canned your first tomato.

As an Agriculture student at Rutgers University I had the opportunity to intern on a local family farm, Giamarese Farm and Orchards, in East Brunswick, New Jersey. Last February, the farm's owner, Jim Giamarese, lent me the use of a small piece of land to attempt my own farm operation. I only had about a third of an acre to work with, so I wanted to choose a crop that would maximize my profitability on small acreage. My mind turned to value-added products as a way to get the most out of my piece of land. I thought that I could make salsas or tomato sauces out of my produce. After a little research I discovered that New Jersey's stance on "cottage industries" was not favorable for what I wanted to do. The more I researched, the more I realized that if I wanted to get the most out of my small parcel, and incorporate a value-added element, then I only had one real option, cut flowers.

The term "specialty cut flowers" refers to any of the wide variety of seasonal summer flowers that do not ship well and so must be sourced relatively locally. These include sunflowers, zinnias, lisianthus, dahlias, ageratum, celosia, cosmos and more. There is an increasing level of awareness among consumers regarding how far products travel to reach them. Building off the popularity of local food movements, the #grownnotflown campaign has become prominent among flower growers. This campaign brings attention to the fact that the vast majority of our commercial cut flowers are flown in from the Netherlands, Columbia, Kenya and Israel and helps to inform customers and encourage them to buy locally grown flowers.

Growing any of these varieties of flowers on their own can be a profitable use of small to medium acre fields. For additional profits value-added elements such as bouquets and arrangements can greatly boost sales. **You do not have to be any kind of artist to make saleable bouquets!** There are simple mechanical techniques that can be used to create attractive flower arrangements. It is the same as following a recipe, but it doesn't require an expensive certified kitchen space. You need the right balance of focal flowers, fillers, spikes, airy elements and greenery. These techniques are difficult to describe in text but there are plenty of online resources to get you started.

Floret Farms in Mount Vernon, Washington has developed a website (floretflowers.com) with EXTENSIVE resources for the production and sale of cut flowers and bouquets. There are plenty of other online resources, including instructional videos on YouTube.

Production

It's important to note that when I first began planning out my cut-flower operation I had next to zero flower growing experience, helping my mother in her garden as a kid was the extent of my contact with flowers. I had only made one flower arrangement in my life, in a horticulture class at Rutgers. I was not "passionate" about flowers, I was passionate about farming. So, I approached cut flowers like any other crop. I learned about intensive production systems, researched varieties, planned out successions, and bought seed. I largely followed established guidelines and seed packet instructions, and incorporated advice from other local flower farmers. Most cut flower varieties can be grown very intensively, with spacings of only 6-9 inches and the ability to get multiple harvests out of the same bed with proper succession planting. This small space intensity combined with the high demand for locally produced flowers is why you will see per acre cut flower sales figures of $30,000-$40,000. My sales from my third of an acre fell comfortably within this range, in spite of the MANY mistakes that I made having never done anything like this before.

I grew all of my flowers on black plastic mulch with drip irrigation that was put down with 10-10-10 fertilizer. Additional liquid fertilizer was supplied via drip irrigation throughout the rest of the growing season. If you are using liquid fertigation for your vegetable crops already, you can use the same liquid fertilizer on your flowers so you don't have to split lines, this is what every grower I talked to did. Most of my varieties were planted with staggered 9-inch spacings. My beds were 36" wide so they could comfortable support 3 rows. I only had a single drip line down the middle, though I did not notice any water related issues with the outer plants I would use two lines in the future.

Planting is one of the more time-consuming aspects of flower production due to the large amount that you can fit in a small space. Most of my flowers were direct seeded, a few were planted from plugs. I did not have significant up-front capital to afford many plugs, and so opted for seeds. The down side of this was significant slug damage to seedlings early on which delayed some of my first harvest times. In order to mark out and make holes for planting I used a three-foot wide piece of sheet metal with 2-inch holes drilled in for the correct staggered spacing. I made two of these templates, one for 6-inch spacing and one for 9-inch spacing. These would be laid on top of the black plastic and a propane torch was used to burn the holes. This allowed me to lay out my planting holes very rapidly and with a consistent pattern.

Pests and Diseases

Insect pests other than the slugs were not a huge problem for me and so I opted not to spray. This became a positive marketing point for many of my customers who were glad to hear that no insecticides were used. I did get some minor Japanese Beetle damage to my zinnias and dahlias but the zinnias grew out of it and my dahlias had bigger problems. I did see a few sunflower moths around later in the season, but since I was cutting sunflowers as they opened there was no chance for them to cause damage. I used organic slug baits early on to deal with the slug problem.

Disease was a bigger issue, I lost quite a few zinnias and celosia to Alternaria Leaf Spot, and my many of my dahlias were killed by bacterial stem rot due to my poor timing for pinching them back. Powdery mildew is what eventually put an end to my zinnias, I sprayed alternating treatments of Daconil and Quadris to slow down the disease progression.

Harvest and Post-Harvest

I would generally harvest every 2-3 days. I sold at two farmers markets and would harvest a day or two before the market so that I would have the time to process the flowers and make bouquets. Harvesting was done with a sharp pair of pruning shears and I would keep rubber bands on hand to bunch as I went. Bunches of 5 were standard for sunflowers and cockscomb celosia, and bunches of ten were standard for most other flowers. Stems were cut at a 45-degree angle, excess leaves were stripped off, and finished bunches were placed in a bucket of clean water with one packet of FloraLife Express 300 added in. Refrigeration was not required since the time from harvest to market was so short.

Markets

I took advantage of multiple marketing channels in order to sell my flowers and arrangements. Direct sales through a pair of local farmers markets made up the bulk of my sales, but I also sold a small amount to a local wholesaler, a florist, through a farm store, and made several special-order deliveries to office buildings, parties, and even one wedding. I also sold 8 weekly CSA shares, 6 that were weekly bouquet deliveries, and 2 bucket share deliveries, which consisted of buckets of assorted bunches. Those customers who participated in the CSA model loved the weekly flower deliveries, and are eager to participate again.

I found that community farmers markets were far and away the best outlet for cut flowers and bouquets. Many customers were drawn to my section of the market by the abundance of flowers on display. If you’re a fruit and vegetable grower, adding a robust display of cut flowers to your market stall creates a visual draw that can bring in customers to see what else you have, it’s like having a billboard that sells itself! I had many customers who would return week after week to buy my flowers, and I would regularly sell out of everything I could transport.

My best-selling items were invariably my mason jar arrangements, one-quart mason jars with burlap collars tied around the rim. I would make small bouquets, around 10-12 stems, and place them sticking up out of the jar with some FloreLife treated water in the bottom. These would often sell faster than I could make them, and I had regular orders to deliver them by the dozens to one local office building. These easy, low-cost value-added arrangements made up the largest portion of my total flower sales, next to sunflowers.

For one last piece of advice, **SUNFLOWERS SELL,** people love them and they will pay well for big beautiful sunflowers. If you have a bouquet on your table that’s not selling, stick a sunflower in it and it will sell. If you’re not interested in value-added cut flowers at all, just take away this one piece of advice, grow a few rows of sunflowers, sell them through farmers markets, do pick-your-own, let people come take pictures in front of them. Flowers in general and sunflowers in particular are a great addition to any farm's portfolio.

CURRENT TRENDS IN DIRECT MARKETING IN NEW JERSEY ATTRACTING THE NEXT GENERATION OF CONSUMERS

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Direct marketing and Agritourism (AT) have become extremely important income sources for many farmers in New Jersey. Although some may question how long these trends will continue, local informal surveys and discussion groups conducted over the past 4 years indicate that there is a growing number of young educated consumers that want to purchase products from local farmers that are within 10 to 30 miles of where they live. Information gathered from younger consumer's ages 18 to 24 were very supportive of locally produced food and enjoy participating in Pick Your Own and AT events. The majority of these young consumers report preparing their own meals three to five times per week and would rather purchase local fruits and vegetables produced close to home for food preparation. We know that Agritourism has been very successful for many farmers and as a result many more people have been exposed to on-farm activities. This exposure has helped to provide a foundation for the next generation of consumers. Despite these positive trends, it was revealed that better use of social media is needed to enhance on-farm AT participation and sales to younger consumers. These young educated consumers are interested in purchasing products from farmers where they believe in the mission of the farm. Students are attracted to interesting stories about the farm on social media sites as well as hands-on activities they can participate in with friends and family. The next generation of consumers have genuine concerns about the protection of the environment and how businesses such as local farms are responding to those concerns. Farms that practice of on-farm composting, enhancing pollinator habitat, and regenerative farming techniques may be more likely to capture the interest and spending dollars of the next generation consumer.

WINTER MARKETS: SELLING IN THE "OFF-SEASON"

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The frost-free growing season in New Jersey generally spans early May through October, depending where in the state a farm is located. Direct marketing of produce through farmers markets and community supported agriculture programs (CSAs) typically occurs from June through October for most farms. This means that during the other seven months of the year, very little if any New Jersey-grown produce is being sold directly to these customers. The demand for locally produced food is increasing, and there is a need to meet that demand in all 12 months of the year. Currently, local produce is lacking throughout New Jersey during the winter months, representing an untapped market that accounts for more than half of the calendar year. This provides an opportunity for beginning farmers to enter the market, established farms to expand their markets, and farms that want to remain at their current scale to spread their work-load and cash-flow throughout the year instead of maintaining intensive operations in the summer months.

There is a diverse variety of crops that can be provided to customers in the winter months. Some of these crops can be grown during the summer and stored throughout the winter, while others can be harvested fresh in the winter with proper planning and minimal infrastructure.

Crops for the Winter Market

Alliums, such as onions, shallots, and garlic are excellent crops that can be grown during the summer then harvested, cured, and stored for distribution throughout the winter months. Alliums are best stored at 35 to 55 degrees Fahrenheit with a relative humidity between 50 and 60 percent. Storage varieties of onions should be selected; maximizing the diversity of offerings by including red, yellow, and white varieties will help to satisfy the customer base. Higher value specialty onions, such as Cippolinis, as well as French and Dutch shallots, and several varieties of garlic can easily expand the number of winter alliums to a dozen or more unique products available to customers.

Winter squash is another crop that can be produced in the summer and stored and sold throughout the winter. There are many varieties of winter squash that each have their own unique characteristics. When properly cured, acorn and spaghetti squash can last for two and a half months after maturity, while delicata and sweet dumpling can last for 3 months. Buttercups, butternuts, kabochas, and hubbards can last up to four months with their eating quality improving as time progresses. Optimum storage conditions for winter squash are 50-55 degrees Fahrenheit and 50 to 60% relative humidity.

Root crops, including carrots, beets, and turnips can be harvested and stored for several months or harvested fresh throughout the winter when grown in a high tunnel. Including rainbow carrots as well pink, purple, and golden beets will add color and interest in a winter market display or CSA box.

Potatoes of all colors and sizes, including russets, yellow flesh, purple flesh, red-skinned, and fingerlings can add further diversity to a winter market. Understanding the eating quality and characteristics of each type of potato is important to communicate to customers to hep them choose the right potatoes for mashing, roasting, or boiling.

Cabbages and Brussel sprouts can also be stored and distributed to winter customers. Recipes for cabbage salads and sauerkraut can help to provide ideas for fresh and fermented local food options throughout the winter.

Winter greens such as lettuce, kale, collards, spinach, and mustards can be grown in a high tunnel and harvested throughout the winter to provide freshly harvested produce in the winter. Proper variety selection and timing are important because growth will slow considerably during the months of December and January when daylength is at its shortest for the year. These cold-hardy crops can be continuously harvested through the winter, provided there is enough early growth in the fall. In February and March, growth will resume and harvest will shortly follow. Row covers inside the high tunnel can also provide an extra layer of protection. These are high value crops that will be in high demand during the winter months.

Apples can be sold throughout the winter, with several excellent storage varieties improving in quality as time progresses. Ashmead’s Kernel, Black Oxford, Baldwin, Cox’s Orange Pippin, and Golden Russet are just a few of the many apple varieties that are best enjoyed during the winter months. Providing unique winter apples that are not typically available in a supermarket can encourage customers to return to the winter farmers market on a regular basis.

Direct Marketing in the Winter Months

Winter farmers markets allow growers to maintain a consistent relationship with their customer base throughout the entire year. These markets generally have a more relaxed pace compared to the bustle of summer farmers markets and therefore allow for more personal attention to individual customers. Discussions about farming practices, the best varieties, and new plans for the following season will help to build relationships with customers who will continue to support the farm throughout the year. Many winter markets will also include bakery items, prepared foods, crafts, educational workshops, live music, and/or children’s activities to create a winter destination for families to attend and spend quality time together. Winter farmers markets may occur weekly, bi-weekly, or once per month. Specialty holiday markets focused on providing food and gifts for the

Thanksgiving and Christmas seasons can also provide opportunities to market winter produce to a target audience.

Winter CSAs are another way that produce can be marketed directly to customers during the off-season. Pickups are generally less frequent in the winter (bi-weekly or monthly, as opposed to weekly) and the boxes are generally larger because many of the storage crops have a longer shelf-life. Bi-weekly distribution is inherently more efficient than weekly distribution, requiring less time packing boxes and coordinating pickups. Multi-farm winter CSAs can collaborate to provide vegetables, fruit, herbs, mushrooms, meat, eggs, dairy products, and baked goods to customers at a centralized pick-up location.

Providing local full-diet options to customers throughout the winter months can be achieved in New Jersey. Proper timing, variety selection and diversity, combined with creative marketing and positive cooperation amongst producers are essential components to success in winter markets. Increased revenues, new markets, and customer continuity are all benefits that can be realized by marketing produce in the "off-season."

Vine Crops

SOIL FERTILITY FOR PUMPKIN

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Well drained soils are best for growing pumpkin. Although it is tempting to plant pumpkin year after year in the same field in pick your own operations, doing so greatly increases pest pressure and disease. Rotation to new fields is very important for ensuring crop health. Alternating pumpkin with other crops also provides opportunities to build soil fertility and break up pest cycles. Good rotation crops should be from an unrelated crop family such as sweet corn, small grains, cruciferous vegetables, etc. Legume cover crops are also good choices and an opportunity to build up soil organic content and soil N fertility.

Nitrogen fertilizer rates for pumpkin typically range from 50 to 100 lbs. N/acre but could potentially be near zero following a good stand of a legume cover crop. Recent applications of compost or manures can also decrease the need for N fertilizer. Avoiding excessive N fertilization of vine crops is critical to yield because high rates of N fertilization tends to promote vegetative growth and suppress flowering. Based on research conducted in Connecticut the presidedress soil nitrate test (PSNT) has been shown to be a useful to for preventing excess N fertilizer application to pumpkin. The PSNT soil sample should be taken at the early vine growth stage. When the PSNT finds 25 ppm nitrate-N or higher, no supplemental N fertilizer would be recommended. Details on how to use the PSNT soil test are given in Rutgers NJAES fact sheet: Soil Nitrate Testing as a Guide to Nitrogen Management for Vegetable Crops.

The application of phosphorus (P) or potassium (K) fertilizer should be based a recent soil test. When fertility test levels are at optimum levels, typical maintenance application rates of P and K fertilizers are 50 lbs. P2O5 and 100 lbs. K2O per acre. Soil tests might also reveal a need for micronutrients. Boron and manganese are frequently found deficient on some New Jersey soils. The target soil pH level for pumpkin is 6.5. Where liming is needed to raise soil pH, careful consideration should be given to type of liming material. One should use a high calcium source on soils in need of calcium and a high magnesium source for soils in need of magnesium. The need for liming is also an opportunity to apply a silicon based liming material such as wollastonite. The enhanced silicon uptake by pumpkin plants from soluble silicon amendments has been shown to effectively suppress powdery mildew disease. For more information: Rutgers NJAES.

HERBICIDE STUDY RESULTS IN PUMPKINS

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Ferebee, J., Cahoon, C., Besançon, T., Flessner, M., Langston, D., Hines, T, .,Blake, H., and Askew, M. (2019). Fluridone and acetochlor cause unacceptable injury to pumpkin. Weed Technology, 33(5), 748-756. doi:10.1017/wet.2019.42

Residual herbicides are routinely applied to control troublesome weeds in pumpkin production. Fluridone and acetochlor, Groups 12 and 15 herbicides, respectively, provide broad-spectrum preemergence weed control. Pumpkin tolerance to fluridone and acetochlor is unknown. Residual effectiveness of fluridone and acetochlor against many troublesome weeds coupled with improved crop safety of acetochlor ME make these herbicides candidates for pumpkin production. The primary objective of this research was to evaluate weed control and pumpkin tolerance to fluridone, acetochlor EC, and acetochlor ME applied PRE compared to commercial standard residual herbicides.

Field research was conducted in Virginia and New Jersey in 2017 and 2018 to evaluate pumpkin (“Kratos”) tolerance and weed control to various preemergence herbicides. Pumpkins were direct-seeded into fields prepared with one pass by a moldboard plow followed by a disc harrow then a field cultivator. Treatments consisted of fomesafen at two rates, ethalfluralin, clomazone, halosulfuron, fluridone, *S*-metolachlor, acetochlor emulsifiable concentrate (EC), acetochlor microencapsulated (ME), and no herbicide.

Weed control

Ivyleaf morningglory, spurred anoda, and yellow nutsedge were present in four, three, and two sites, respectively (Table 1). Fluridone controlled ivyleaf morningglory 73% 42 DAP. No other treatment controlled ivyleaf morningglory more than 33% 42 DAP. Morningglory species are particularly troublesome in cucurbit crops, and no viable chemical options currently exist. Likewise, fluridone controlled spurred anoda 93% 42 DAP, whereas clomazone provided 92% 96% control 42 DAP. Comparatively, spurred anoda control by fomesafen, ethalfluralin, halosulfuron, *S*-metolachlor, and acetochlor was less than 40%. Similar yellow nutsedge control was noted with halosulfuron, fomesafen HR, *S*-metolachlor, and acetochlor EC, ranging from 56% to 69% 42 DAP.

Table 1. Ivyleaf morningglory, spurred anoda, and yellow nutsedge control by herbicides applied PRE for herbicide comparison experiment, 2017 and 2018.[a–c]

	Ivyleaf morningglory				Spurred anoda				Yellow nutsedge			
Herbicides	28 DAP		42 DAP		28 DAP		42 DAP		14 DAP		28 DAP	
	%											
Fomesafen LR[d]	37	bc	6	d	37	b	15	b	21	cd	20	c
Fomesafen HR[d]	47	bc	29	bc	21	b	6	b	62	ab	56	ab
Ethalfluralin	38	bc	22	bcd	31	b	18	b	21	cd	19	c
Clomazone	16	d	11	cd	92	a	96	a	29	cd	13	c
Halosulfuron	52	b	25	bcd	36	b	14	b	79	a	63	a
Fluridone	91	a	73	a	93	a	93	a	4	d	0	c
S-metolachlor	30	cd	33	b	29	b	6	b	68	ab	66	a
Acetochlor EC[d]	41	bc	23	bcd	31	b	20	b	70	ab	69	a
Acetochlor ME[d]	28	cd	18	bcd	34	b	20	b	44	bc	29	bc

[a]Means within a column followed by the same letter are not different according to Fisher's protected LSD test at P = 0.05.

[c]Data pooled across experiment sites where weeds were present. Ivyleaf morningglory control pooled across all experiment sites in NJ and Painter. Spurred anoda
control pooled across Painter, 2017 and Painter field 2, 2018. Yellow nutsedge control pooled across experiment sites in New Jersey and Painter field 1, 2018.

[d]Abbreviations: EC, emulsifiable concentrate; HR, high rate; LR, low rate; ME, microencapsulated.

Common ragweed, redroot pigweed, and common lambsquarters infested only the New Jersey location. At this location, fluridone completely controlled common ragweed at 28 DAP and provided 83% control at 42 DAP (Table 2). At 28 DAP, fomesafen, halosulfuron, and acetochlor EC controlled common ragweed similarly to fluridone (64% to 100%), whereas all other treatments resulted in 0 to 15% control. Similar trends for common ragweed control 42 DAP were observed with the exception of halosulfuron, which resulted in less control (38%) compared to fluridone. In contrast to common ragweed control, redroot pigweed was controlled well by *S*-metolachlor, acetochlor, halosulfuron, and fomesafen; at 28 DAP, 80% to 100% control was observed, whereas at 42 DAP control was 75% to 100%. Fluridone was only marginally effective against redroot pigweed, controlling the weed 63% at 28 DAP and 58% at 42 DAP.

Table 2. Weed control 14 and 28 d after planting (DAP) by herbicides applied PRE in New Jersey for herbicide comparison experiment in 2018.[ab]

	Common ragweed				Redroot pigweed				Common lambsquarters			
Herbicides	28 DAP		42 DAP		28 DAP		42 DAP		28 DAP		42 DAP	
	%											
Fomesafen	64	a	45	ab	80	ab	75	a	23	cd	13	d
Fomesafen	65	a	56	ab	95	ab	95	a	31	cd	60	abc
Ethalfluralin	5	b	4	d	55	b	50	ab	38	cd	23	cd
Clomazone	15	b	10	cd	8	c	0	b	90	ab	69	ab
Halosulfuron	75	a	38	bcd	98	a	95	a	98	a	69	ab
Fluridone	100	a	83	a	63	ab	58	a	99	a	100	a
S-metolachlor	0	b	0	d	100	a	75	a	10	d	5	d
Acetochlor EC[c]	80	a	55	ab	100	a	100	a	51	bc	43	bcd
Acetochlor ME[c]	8	b	0	d	85	ab	75	a	38	cd	24	bcd

[a]Means within a column followed by the same letter are not different according to Fisher's protected LSD test at P = 0.05.

[c]Abbreviations: EC, emulsifiable concentrate; ME, microencapsulated.

Pumpkin tolerance

Pumpkin injury at New Jersey was statistically similar across all treatments at 14 and 28 DAP, and injury ranged from 8% to 40% at 14 DAP and 11% to 27% at 28 DAP. However, because of poor emergence caused by soil crusting after seeding followed by lack of rainfall for 10 days, no yield data were collected for the New Jersey location. At other locations in Virginia, fluridone completely eliminated fruit production in 2018. Highest yield was noted with *S*-metolachlor (68,300 kg ha^{-1}), while all other plots, including those treated with acetochlor EC, produced lower yield (30,900 to 50,200 kg ha^{-1}) than plots treated with *S*- metolachlor.

We concluded that fluridone and acetochlor formulations are unacceptable preemergence herbicide candidates for pumpkin production.

Reflex 2SL new 24c Special Local Need label (expires 12/31/2022)

A special Local Need label has been approved on October 1st, 2019, for use of Reflex 2SL to control weeds in pumpkins, squash (straight neck yellow, crooked neck yellow, and zucchini types ONLY), and watermelon in New Jersey. Reflex is a preemergence herbicide not intended to be used as a stand-alone weed control program at rates below 16 fl oz/A. Reflex should be used with other herbicides and/or other methods of weed control that support weed resistance management. Reflex provides both residual and postemergence control of susceptible weed species (pigweed species, common purslane, ragweed, galinsoga, carpetweed nightshade), and suppressed yellow nutsedge. Foliar application of Reflex will severely damage or kill cucurbits, thus always avoid contact with emerged plants.

Bare ground seeded: Apply Reflex within 24 hours after planting at 8 fl oz/A (squash), 8 to 10 fl oz/A (pumpkin), or 10 to 12 fl oz/A (watermelon). Application should be followed with ½" irrigation or rainfall at least 36 hours prior to crop cracking the ground.

Bare ground transplanted: Following field preparation, apply Reflex at 8 fl oz/A (squash), 8 to 10 fl oz/A (pumpkin), or 10 to 12 fl oz/A (watermelon), and irrigate ½" to activate the herbicide. Do not punch holes for transplanting until after Reflex application and activation have occurred.

Plastic mulch pre-seeded or pre-transplanted (squash and watermelon ONLY):

- Under plastic mulch: Reflex can be applied at 8 fl oz/A (squash) or 10 to 12 fl oz/A (watermelon) on the row after laying drip or running bed pan, but immediately prior to laying plastic mulch without disturbing the soil.
- Over plastic mulch: Reflex can be applied at 8 fl oz/A (squash) or 10 to 12 fl oz/A (watermelon) over top of plastic mulch. Reflex must be washed off of plastic mulch with ½" rainfall/irrigation in a single event prior to seeding or transplanting.

Row middle application post-transplant (watermelon ONLY): Apply Reflex at 16 to 24 fl oz/A to row middles with shielded/hooded sprayer before the vines run out of plastic mulch.

A maximum of 24 fl oz/A of Reflex may be applied in ALTERNATE years

ZUCHINNI AND YELLOW SQUASH VARIETY TRIAL RESULTS

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Field research was conducted with 4 green zucchini and 4 yellow summer squash varieties to evaluate yield and quality under field conditions in 2019 at a commercial vegetable farm in Mullica Hill, New Jersey. The trial was planted in the same field as the farmer's zucchini squash field. Varieties were chosen based on popular varieties that were recently available to growers that needed university evaluation to be listed in the Mid-Atlantic Commercial Vegetable Production Recommendations guide. The varieties 'Spineless Beauty' and 'XPT 1832 III' were used as standards to compare the new varieties to for yield and quality. The field was hand-seeded into raised beds with black plastic mulch and drip irrigation on Apr 22, 2019. Spacing was 5' centers between rows and 30" between plants in a row. The trial consisted of 3, 8-plant replications per variety. Fertility and pest control practices were done as per the farm's standard practices for squash production; consistent with cooperative extension recommendations. Harvests began on Jun 10 and were conducted 3 times weekly for 3 weeks. Harvests were discontinued earlier than expected due to heavy rains that promoted excessive levels Phytophthora fruit rot and crown rot. Varieties included in the trial for green zucchini were: 'Spineless Beauty', 'Spineless Perfection', 'Spineless Supreme' and 'SV0914YG'. Straightneck yellow squash varieties included: 'XPT 1832 III', 'Enterprise', 'Grand Prize', and Smooth Criminal'. All varieties performed well in the trial and had similar marketable yields and high quality. Statistics showed no significant differences in yields between squash types. All varieties in the trial were added to the 2020 Mid-Atlantic Commercial Vegetable Production Recommendations guide.

New Technologies for NJ Agriculture

BIOLOGICALS IN SUSTAINABLE FOOD PRODUCTION: WHY AND HOW?

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The term biologicals in agriculture refers to biological organisms or materials of biological origin that are used for agronomic or plant protection purposes. Biological control agents, entomopathogens, botanical or microbial biostimulants, biopesticides, non-pesticidal beneficial microorganisms, and soil amendments of biological nature are considered as biologicals. In an undisturbed ecosystem, there is a continuous interaction among many of the living organisms and non-living factors to maintain a natural balance plants, pests, diseases, natural enemies, and other organisms. Such a natural balance is disrupted in agricultural systems especially when agricultural inputs are used for improving farm production without an emphasis on the ecological balance. There has been a major shift in agriculture in the last 10-15 years towards sustainable food production and exploring the potential of biologicals. Several scientific studies described various strategies for successfully using biologicals for improving crop health and yields.

Each kind of biologicals has a different mode of action. While arthropod natural enemies kill the target pests by predation or parasitism, various entomopathogens cause infections when ingested or when they come in contact with pests. Other beneficial microbes antagonize plant pathogens, induce systemic resistance in plants, improve nutrient and water absorption, or the plant's ability to withstand abiotic stressors. Biostimulants also induce systemic resistance in plants to biotic and abiotic stressors. Some entomopathogens and other beneficial microbes also have biostimulant properties and play multiple roles in crop production. Biostimulants induce two kinds of systemic resistance in plants to phytopathogens, arthropod pests, and abiotic stressors such as salinity and drought (Fig. 1). Systemic acquired resistance is exhibited when plants are exposed to chemicals, virulent and avirulent pathogens, and non-pathogenic organisms. Certain genes are activated in response to these stressors resulting in the production of salicylic acid and pathogenesis-related proteins preparing the plants to handle the stress. For example, if plants are inoculated with non-pathogenic Fusarium spp., something like vaccination in humans and animals, plant defense mechanism is turned on preparing it to fight infection from pathogenic Fusarium spp. Induced systemic resistance is triggered when plants are exposed to beneficial microbes activating pathways of two plant hormones, jasmonic acid and ethylene, and production of pathogenesis-related proteins. Using beneficial microbes in agriculture is like taking probiotics to improve human health. Inoculate the transplants with biostimulants to induce systemic resistance and periodically apply, especially after fumigation, to improve the beneficial microbial activity in the soil.

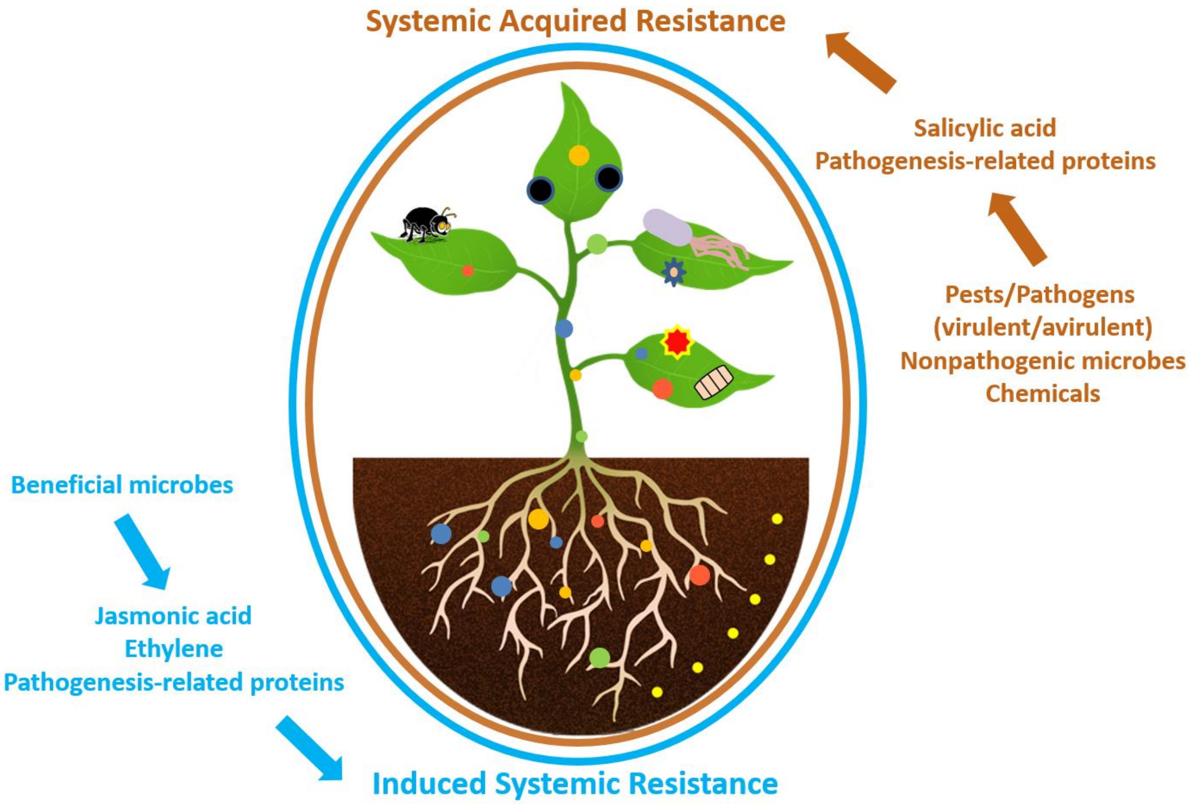


Fig. 1. Two mechanisms of systemic resistance in plants to biotic and abiotic stress factors

Induced systemic resistance mechanisms in plants to biotic and abiotic stress factors

These biostimulants can be used inoculate seeds or transplants prior to planting and/or can be applied to the soil or sprayed on the plants during the crop cycle as necessary. While biopesticides are applied for curative purposes, biostimulants or beneficial microbes with biostimulant properties can be applied as preventive treatments to build plant's immune system.

A few examples of using biologicals for improving yields or controlling pests will be discussed here.

Strawberry: A study conducted in a commercial strawberry field in Santa Maria, CA during the 2017-2018 growing season evaluated 11 treatment programs with an untreated control and the grower standard program (Dara and Peck, 2018). These treatments included products containing plant extracts, worm extract, various beneficial bacteria and fungi, and a fertilizer additive, which were added on top of the grower standard fertility program. Plant growth, health, yield, fruit quality, and shelf life were monitored. There were significant differences in the marketable fruit yields among various treatments with 2.5 to 16.3% increase compared to the grower standard alone (Fig. 2A). A similar field study conducted at a research station in Shafter, CA during the 2018-2019 season compared five treatment programs added on top of the grower standard program (Dara, 2019a). Treatment materials included neem extract, beneficial fungi and a bacterium, organic acids, and nutrient materials. Although not statistically significant, marketable fruit yields were 10 to 36% higher in various treatments compared the grower standard alone (Fig. 2B).

Grape: The western grapeleaf skeletonizer (*Harrisina metallica*) is re-emerging in parts

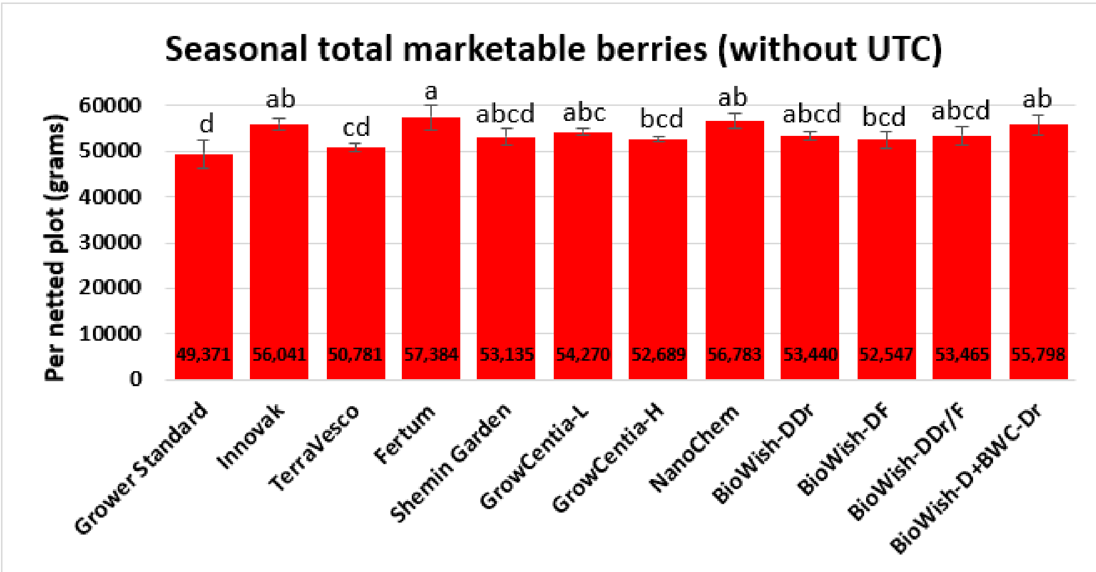
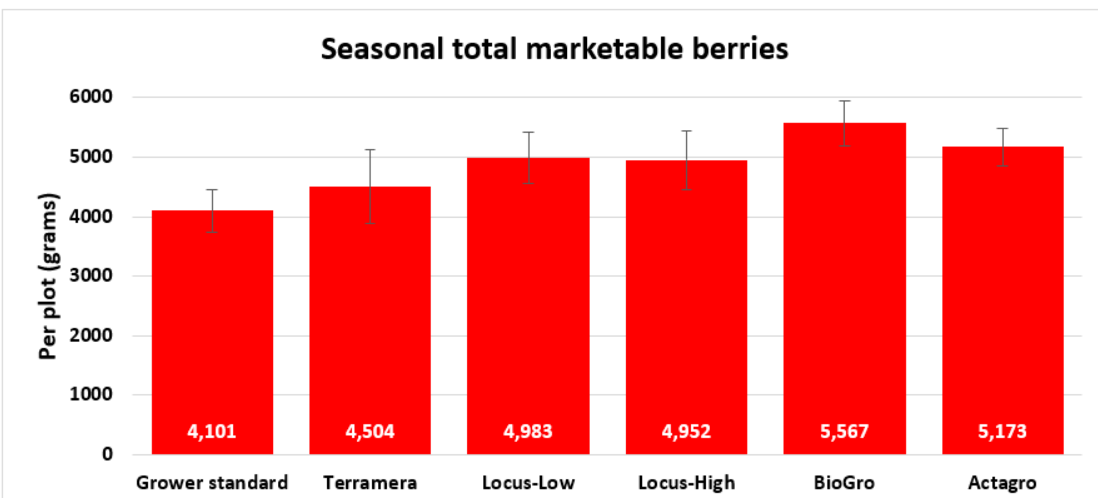


Fig. 2. Marketable strawberry yields from the grower standard and supplemental treatment programs from the 2017-2018 (above) and the 2018-2019 (below) studies.



of California threatening organic vineyards and backyard vines. A bioassay evaluated biopesticides based on spinosad, *Bacillus thuringiensis*, and azadirachtin, along with unformulated entomopathogenic fungi, *Beauveria bassiana* and *Metarhizium anisopliae* s.l. (Dara et al., 2019). Spinosad (Entrust®) and *M. anisopliae* provided 100% control followed by *B. bassiana,* azadirachtin (Neemix® 4.5), *B. thuringiensis* subsp. *aizawai* (Agree® WG) offering some non-chemical control options (Fig. 3).

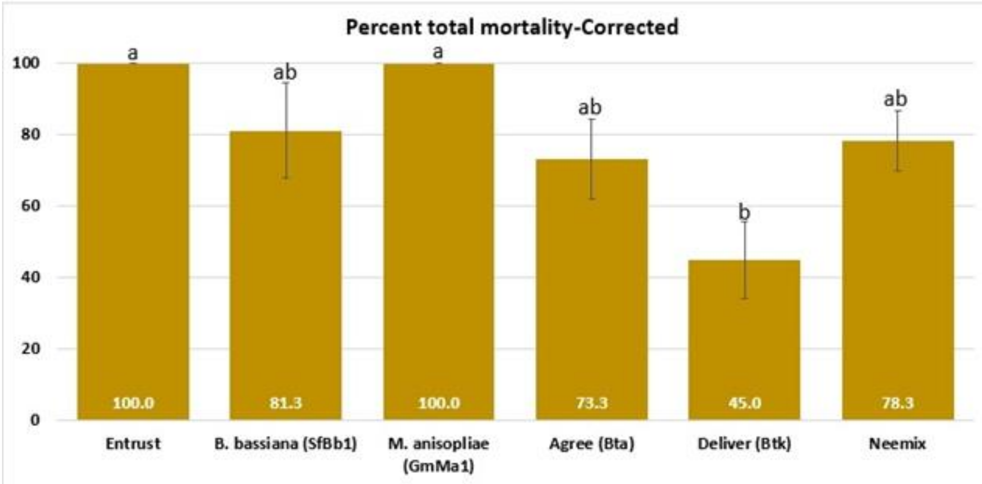


Fig. 2. Efficacy of various formulated and unformulated biorational options against the western grapeleaf skeletonizer

Tomato: Two field studies were conducted at a research station in Shafer, CA in 2017 (Dara and Lewis, 2018) and 2018 (Dara, 2019b) using various mineral, botanical, and microbial biostimulants with nutrient supplements. Although statistically not significant, some treatments resulted in 27 to 32% higher yields in the 2017 compared to the grower standard. In the 2018 study, a product containing botanical extracts and soluble potash significantly improved the tomato yields by 27%.

These studies demonstrate the potential of various biostimulants and biopesticides in improving crop yields and providing pest management. Data from various other studies can be found at https://ucanr.edu/JEB. **References**

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FORGET THE DRONES! BEES CAN DELIVER PEST CONTROLS DIRECTLY WHERE NEEDED

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About BVT

Bee Vectoring Technology (BVT) is a Canadian ag-tech company dedicated to sustainable agriculture. Founded in 2012, they have developed technology that uses bees to deliver crop protection products to flowering crops. Their flagship product is Vectorite with CR-7, which received EPA registration Sept 2019. Vectorite with CR-7 uses a safe strain of *Clonostachys rosea* to protect crops from disease and increase yield.

Clonostachys rosea is a beneficial endophytic fungus that is found in soils throughout the world in many different climates. BVT's strain of *C. rosea,* CR-7, was selected from over 1400 isolates for its crop protection qualities.

How BVT Works

Blooms often the primary entry point for diseases. BVT uses the natural pollination behaviors of bees to deliver crop protection products directly to these vulnerable tissues. The BVT system provides more efficient and targeted delivery compared to traditional fungicide programs and is compatible with commercial bumble or honey bee hives.

Vectorite™ powder containing BVT CR-7 spores adheres to the legs and bodies of the bees as they walk through the Vectorpak™ when exiting the hive. The bees deliver the beneficial spores directly to the flowers while foraging for nectar and pollen. Within a few hours, the *C. rosea* spores germinate and form microscopic colonies among cells of the flower tissues (Figure 1). BVT CR-7 prevents infection by blocking potential infection sites (Figure 1) and once established inside plant tissue, helps prevent the growth and development of pathogens without any phytotoxicity.

Clonostachys protects plants from infections in several ways:

Rapid Growth and pre-emptive exclusion

Attempted infection of flowers by pathogens triggers the endophytic colonies of BVT CR-7 to grow rapidly and densely occupy tissues proximal to the sites of attempted invasion. Further growth of the pathogen and progress of the disease are thereby blocked. Natural tissue senescence similarly triggers tissue occupation by BVT CR-7 and reduces pathogen development.

Resistance

Local and systemic signals from the tiny endophytic colonies of BVT CR-7 enhance natural resistance of the plant to disease organisms.

Plant Vigour
BVT CR-7 also increases plant resistance to abiotic stresses (e.g. water stress) and enhances the overall plant vigor. The functional lifespan of green tissues (e.g. Leaves and calyces) may be prolonged, thereby extending periods of photosynthesis and the productive lifetime of the plant.

Performance
<u>Low bush blueberry, Nova Scotia, Canada</u>
Dalhousie University

- Low disease pressure, but BVT system still produced 75% increase in yield compared to the untreated control and standard fungicide program.

<u>Strawberry, Florida</u>
Grower Demonstrations

- Growers saw 6-24 % increase in yield over standard fungicide program

University of Florida

- The BVT system worked just as well as the standard fungicide program and BVT+fungicide reduced Botrytis fruit rot (BFR) more than either BVT or fungicide applications alone
- The BVT system worked just as well as the standard fungicide program to reduce postharvest losses and BVT+fungicide reduced postharvest BFR more than either BVT or fungicide applications alone

<u>Sunflower, North Dakota and Serbia</u>
North Dakota State University

- Trial were done at two NDSU extension sites, found that using the BVT system reduced disease by up to 50 % compared to the control.

Institute of Field and Vegetable Crops Novi Sad

- Using the BVT system reduced disease by 25-40 % compared to the control

Benefits of Using BVT

- Water-less application
- No heavy machinery
- Low toxicity
- Efficient and targeted delivery
- Higher yields
- Better quality produce
- Longer produce shelf life
- Another tool for organic growers or those concerned about pesticide residues

For more information please visit beevt.com or email info@beevt.com

Images

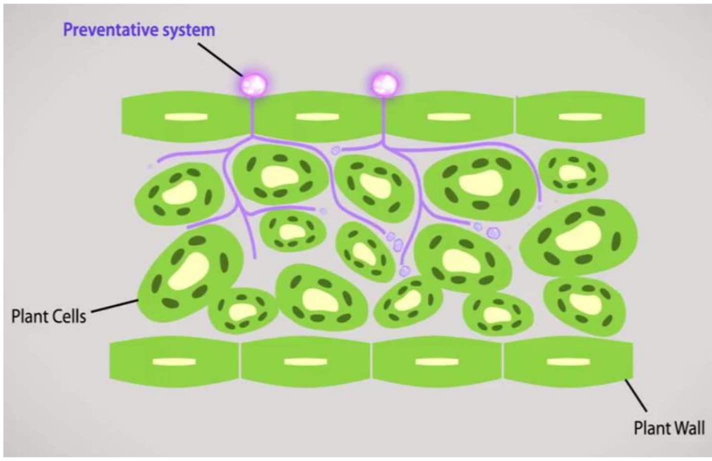

Figure 1. BVT's C.rosea (purple in the diagram) occupies intercellular space and potential infection sites, making them unavailable to pathogens. This is called competitive exclusion.

TECHNOLOGY AND WEED CONTROL: WHERE WE CURRENTLY STAND AND WHERE WE MIGHT BE GOING

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Weed control is crucial for producing agronomic and horticultural commodities as interspecific competition for nutrients, water and light can directly impact crop growth and yield. Interference from weeds can also affect the deposition of crop protection chemicals, alter in-crop microclimates, harbor unwanted pests and pathogens and interfere with the movement of men and machinery in the field. Technology has been, and always will be, crucial for eliminating unwanted vegetation. Our earliest known tools (plows, hoes and cutting implements) for managing weeds are still used today, although advances in engineering and manufacturing have influenced both design and durability. Tools to improve the crop spacing and alignment (such as precision planters) facilitate the use of mechanical implements and have contributed, significantly, towards improving weed management. The invention and adoption of transplanters allows growers to start fields with crops that are taller and more robust that emerging weed seedlings, which can support a competitive/suppressive environment. Synthetic herbicides (and genetically modified crops) have been and will continue to be significant tools for managing weeds even though herbicide resistance (160 species x site of action occurrences in the US, alone) and a decrease in the number of companies involved in discovery, production and registration could limit the utility of these chemicals in many systems. The development of improved electrical discharge systems or UV light-based weeders could add novel non-chemical strategies to the weed control toolbox. The future of weed management is being driven by satellites (e.g. GPS guided tractor systems and autonomous robots) and sensing (e.g. aerial image collection and high-throughput data analysis); it's 'smart' technology, like vision-guided see-and-spray systems. The future of weed control also sits in the palms of everyone's hands via smartphone apps to calibrate sprayers, manage vehicle fleets, map invasive pests, and leverage visual recognition software to identify unknown plants. This presentation will discuss the history of weed control; the current status of chemical registration, resistance development and herbicide-tolerant crop technologies; artificial intelligence/robotic weed control systems in use/under evaluation; and innovative, non-chemical weed control strategies currently in development, This talk will also focus on changes in farming demographics and labor markets that could influence the adoption of novel technology, the economic costs of adoption, and the educational needs for the future of weed science.

Produce Safety Alliance Training

PRODUCE SAFETY ALLIANCE TRAINING

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The Food Safety Modernization Act (FSMA) was signed into law January 2011. The final rule was published November 2015 after comment periods and public meetings. This is the biggest change to food safety that directly impacts fresh fruit and vegetable growers in over 70 years. The Act went into effect January 2018 and will be implemented over the next several years with compliance for growers with annual produce sales (previous three-year period) over $500,000 starting in January 2018, small operations ($250,000 – $500,000) in January 2019 and the very small operations ($25,000 – $250,000) in January 2020. All operations will have four additional years (2022 for operations over $500,000; 2023 for operations between $250,000 and $500,000; and 2024 for operations between $25,000 and $250,000) for the water component, which is still under review. Growers with produce sales less than $25,000 are not covered under this rule. If the operation produces fresh fruits and vegetables, this Act applies except if the produce is commercially processed, consumed on the farm or meets the qualified exemption.

If all food, including animal feed and farm stand products, sold from the farm is less than $500,000 averaged over the last three years (adjusted for inflation based on the most recent baseline values found at https://www.fda.gov/food/guidanceregulation/fsma/ucm554484.htm), goes directly to an end user (restaurant, roadside stand, supermarket, etc.) and it is sold within 275 miles or within the same state where it is grown then the operation meets the requirement for the qualified exemption. The operation must have receipts or other documents to show they meet this criterion, but there is no specific record which means it could be receipts, sale figures for CSA members, IRS schedule F, etc.

Growers should be aware that a buyer may still ask the operation to meet all the requirements for FSMA or to have a third-party food safety audit. The difference between FSMA and an audit is that FSMA is government regulation and inspection based while a third-party audit is voluntary that may be required by buyers.

Produce Safety Training:
The Produce Safety Alliance Grower Training Course is one way to satisfy the FSMA Produce Safety Rule requirement outlined in § 112.22(c) that requires '*At least one supervisor or responsible party for your farm must have successfully completed food safety training at least equivalent to that received under the standardized curriculum recognized as adequate by the Food and Drug Administration'.* This is the only training recognized by the FDA at this time!
Fruit and vegetables growers and others interested in learning about produce safety, the Food Safety Modernization Act (FSMA) Produce Safety Rule, Good Agricultural Practices (GAPs) and co-management of natural resources and food safety should also attend this training.

What to Expect at the PSA Grower Training Course?
This is approximately a seven-hour course to cover these seven modules:

- Introduction to Produce Safety
- Worker Health, Hygiene, and Training
- Soil Amendments
- Wildlife, Domesticated Animals, and Land Use
- Agricultural Water (Part I: Production Water; Part II: Postharvest Water)
- Postharvest Handling and Sanitation
- How to Develop a Farm Food Safety Plan

In addition to learning about produce safety best practices, parts of the FSMA Produce Safety Rule requirements are outlined within each module and are included in the grower manual provided. There is time for questions and discussion, so participants are encouraged to share their experiences and produce safety questions.

Benefits of Attending the Course
The course provides a foundation of Good Agricultural Practices (GAPs) and co-management information, FSMA Produce Safety Rule requirements, and details on how to develop a farm food safety plan. Individuals who participate in this course are expected to gain a basic understanding of:

- Microorganisms relevant to produce safety and where they may be found on the farm
- How to identify microbial risks, practices that reduce risks, and how to begin implementing produce safety practices on the farm
- Parts of a farm food safety plan and how to begin writing one
- Requirements in the FSMA Produce Safety Rule and how to meet them.

After attending the entire course, participants will be eligible to receive a certificate from the Association of Food and Drug Officials (AFDO) that verifies they have completed the training course. To receive an AFDO certificate, a participant must be present for the entire training and submit the appropriate paperwork to the trainers at the end of the course.

On-Farm Readiness Review:
As a follow-up to the produce safety training course, farm walkthroughs are available to review farming operations. The Food and Drug Administration is interested in helping growers with tools that they can use for a self-assessment prior to any inspections from NJDA. They want to educate before and while they regulate and work in a partnership with growers and the individual states. The Rutgers On-Farm Food Safety Team has been working with the National Association of State Departments of Agriculture (NASDA) and four state departments of agriculture (Oregon, North Carolina, Florida and Vermont) the Food and Drug Administration (Produce Safety Office of Regulatory Affairs, Inspectors), United States Department of Agriculture (FDA liaison and GAP auditors), Cooperative Extension Organizations in Michigan, Florida, North Carolina and the Produce Safety Alliance at Cornell University to develop materials for growers to help them prepare for an inspection.

An On-Farm Readiness Review manual has been developed to help simplify the Produce Rule for growers. This On-Farm Readiness Review (OFRR) is intended to be used by produce growers to help them prepare for farm inspections conducted under the Food Safety Modernization Act (FSMA) Produce Safety Rule (PSR) and for OFRR reviewers to conduct on-farm assessments. The manual is intended to be adaptable to farms producing a wide range of covered commodities, using diverse production practices, and adaptable to a wide range of geographical production regions using unique growing and harvesting practices. Part of the OFRR is a farm visit where someone from Cooperative Extension and NJDA will team up to help growers assess their operations.

The purposes of the OFRR process and the farm visits are to:

- Prepare farmers for implementation of the FSMA PSR
- Help OFRR reviewers better understand how the PSR gets translated on the farm
- Provide a conversational approach to help farmers assess their readiness for implementation of the FSMA PSR
- Provide the tools to help assess how prepared an individual farm is to implement the rule

There are numerous reasons why a grower might want to undertake an OFRR:

- It is voluntary, free and confidential
- It will help them align what they are doing with what is required in the rule
- It will help them determine what they are missing
- It provides a personalized discussion about their farm's food safety activities
- Notes taken by the farmer remain the property of the farmer
- It will improve the farmer's readiness for a PSR inspection

The authors worked under the guiding principle that any farm inspection process should include "education before regulation." The hope, therefore, is that growers and extension and regulatory staff will use the manual to build their knowledge about the PSR and learn the most effective and consistent ways to apply that knowledge on the farm during production and inspection. For produce farmers, the manual provides a

practical guide for assessing their on-farm food safety practices against the regulatory provisions of the PSR. Farmers are required to also complete PSA Grower Training or equivalent prior to having an OFRR, to maximize the value of that review. Exempt farms may choose to receive a full readiness review as an educational opportunity.
For extension and regulatory staff, the manual provides another resource to help understand the diversity and complexity of farming practices, equipment, and procedures used in the production of fruits and vegetables. The manual helps to identify critical food safety practices that need immediate attention and those that may be addressed in the future. It is meant to be a functional tool that can be used over time to assess practices and compliance, as farming operations or commodities change.

The manual is intended to be a useful and workable tool for growers, extension and inspection staff to improve food safety practices at the farm level. Every person stepping onto a farm, regardless of their role, bears responsibility to help ensure that the best food safety practices are understood and used when growing produce. Growers who go through the OFRR will receive a manual during the farm visit.

Inspections:
The New Jersey Department of Agriculture (NJDA) began inspections for the U.S. Food and Drug Administration (FDA) for operations over $500,000. The other size operations will also be delayed by one year i.e. 2020 for small operations and 2021 for very small operations. The first inspections will be educational with the NJDA evaluating the farming operation. This will give the grower an opportunity to see what the NJDA considers area where improvement may be needed. After the inspection NJDA may do another inspection with possible enforcement in the future.

NOTES