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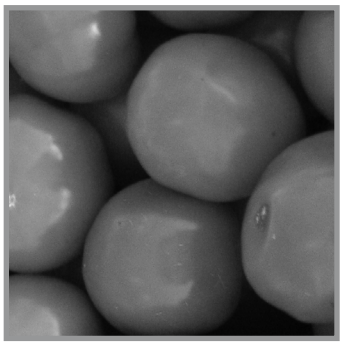

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GETTING YOUR CROP OFF TO THE BEST START: NUTRIENT PLACEMENT AND MANAGEMENT

Francesco Di Gioia[1]

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The availability of essential nutrients from the right source of fertilizer, at the right time, right place, and using the right amount of fertilizer (4R principle) is extremely important to get a good start in vegetable crops, especially at the early growth stages. Vegetable crops are in fact very sensitive to the amount of nutrients available in the root zone, and deficit or excess of nutrients can have negative effects on plant health, with consequent impact on yield and quality of the produce. Vegetable crops are in general characterized by shallow root systems, most of the roots are in fact concentrated in the top 8-inches of soil, and for this reason nutrient use efficiency in vegetable crops is rarely above 50% (Di Gioia et al. 2017). Plant nutrient uptake is determined by a complex interaction between genotype, environmental factors, and agronomic practices. Nutrient uptake is strictly linked to plant growth and availability of water and nutrients in the root zone, and plant growth is determined by the genotype in response to environmental conditions (solar radiation, temperature, availability of water and nutrients). Unpredictable environmental conditions make it difficult to predict plant growth and thus nutrient uptake over time. Nevertheless, the use of protected culture systems such as low-tunnel, high-tunnel, or greenhouses allow to mitigate the variation of environmental conditions and optimize plant growth thereby increasing nutrient use efficiency at the condition of adequate water and nutrient management. While a better control of the environment may assure higher plant growth and yield stability, microclimatic conditions have great influence on the soil-plant-atmosphere water and nutrient flux and dynamics, and nutrient management practices should be adapted to such conditions. Agronomic practices and efficient nutrient management play an important role in determining crop nutrient use efficiency and the long-term sustainability of protected culture systems. While total nutrient uptake may be estimated knowing the total crop biomass and measuring the pre-plant soil nutrient availability, the implementation of monitoring tools is necessary to determine the specific requirement of nutrients over-time. The application of starter fertilizer based on soil analysis and potential crop requirement is a common practice in vegetable production and is justified by the high-sensitivity of vegetable crops to nutrient deficiency and by the relatively low cost of fertilizer. However, several studies demonstrate that nutrient use efficiency during the early growth stage is much lower compared to subsequent growth stages. A strategy to increase crop nutrient use efficiency in the early growth stages is to reduce the rate of starter fertilizer while improving fertilizer placement. Fertilizer placement in proximity of the small root system in the early crop stage is key for a good start of the crop. To this regard a practice that is becoming popular for its potential advantages is the pre-plant application of starter fertilizer right in the planting hole using equipment that allow the precise application of very small amount of fertilizer. While further studies are necessary to assess the advantage of this practice, extreme attention should be placed in selecting the right fertilizer and application rate to avoid excess of nutrients and negative effects on the crop. Fertigation using drip irrigation systems is a common practice used for the fertilization of vegetable crops that if properly managed allows the timely placement of small doses of fertilizer within the root zone during the entire growing season, with consequent beneficial effects for the crop and the environment. Offering the possibility to apply small doses of fertilizer any time during the growing season, fertigation allows to reduce the amount of starter fertilizer used before planting, however, adequate monitoring strategies of the soil nutrient availability and of the crop nutrient status should be implemented to optimize the fer-

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tigation program and avoid or minimize nutrient leaching, accumulation of salt in the soil, or nutrient deficiencies. While new technology is being developed through intense research activity especially on agronomic crops, limited work has been done on effective solutions for monitoring the soil nutrient availability and the crop nutrient status in vegetable crops, especially for smallholder farms. Methods available to monitor the crop nutrient status after planting are classified in two main categories: plant monitoring methods and soil monitoring methods, respectively. Each of these methods has advantages and disadvantages and may be applied to large-scale or small-scale farms. In the case of vegetable crops, and especially under protected culture systems timely monitoring of potential nutrient deficiency or excess is extremely important to minimize negative impact on crop yield and quality, and often monitoring the availability of the nutrient in the soil may be more effective than monitoring the plant nutritional status, especially because a deficiency or excess of nutrient may be detected at the plant level when is too late to adjust the fertilization plant. Today, simple tools are available to monitor the nutrient availability of soil and prevent the accumulation of salts in protected culture systems. The use of suction lysimeters and of the Sonneveld soil water extracts (1:2 v:v) method are presented and discussed for their advantages and disadvantages, showing possible strategies to enhance the nutrient use efficiency and assure high yield and quality performances of vegetable crops, while minimizing risks for the environment.

MANAGING SOILBORNE DISEASES OF TOMATOES IN HIGH TUNNELS USING ANAEROBIC SOIL DISINFESTATION AND GRAFTING

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Growers who have produced tomatoes in a single location for several years may notice stunting, yellowing, and reduced yields. These symptoms may be caused by soilborne diseases. Soilborne disease complexes, composed of two or more soilborne pathogens, may reduce yield and quality of tomato crops, particularly in long-term protected culture production. Soilborne disease complexes consisting of Verticillium wilt, Fusarium wilt, corky root rot, black dot root rot, and root knot nematodes are present in tomato production operations in Ohio, and are likely to be widely distributed in high tunnel systems in the Midwest and Northeast where crop rotation is not practiced sufficiently. Other soilborne disease that may be present are Rhizoctonia root rot, Pythium root rot and Sclerotinia white mold. Symptoms of soilborne diseases include the following:

Verticillium wilt: Distinctive V-shaped lesions form on the edges of leaves, with V-shaped dead tissue surrounded by a yellow halo. Plants wilt and have yellowing and dieback. Plants may wilt during the day and recover overnight. The inside of the stem has brown discoloration.

Fusarium wilt: Plants have yellowing, dieback, and wilting. Sometimes only half a leaf or leaves on only one half of the plant turn yellow and die. The inside of the stem has brown discoloration near the soil line and discoloration may continue up the stem. Roots may look brown and rotten.

Corky root rot: Plants may appear slightly yellow and have weakened growth. Roots appear to be dry, brown, and cracked and have a similar appearance to tree bark. Cracked areas usually occur in distinctive bands and may be swollen. Dark brown cracking may occur on the crown and taproot of the plant.

Black dot root rot: Roots are discolored, usually a honey-brown to grayish-brown, and are speckled with black dots.

Root knot nematodes: Roots are misshapen with small to large galls. Galls may range in size from pin-head sized to finger-sized. Golden-brown dots (egg masses) may appear on the outside of galls. Plants may appear stunted and weak.

Rhizoctonia and Pythium root rots: Roots display a generalized rotting, including discoloration and deterioration of the roots and "rat-tail" symptoms.

Sclerotinia white mold: Tan to white lesions encircle stems or branches and girdle plants, killing tissues above the lesion, including entire plants. Large (1/8-1/2 inch) irregularly shaped black sclerotia of the pathogen are common on the inside or sometimes outside lesions.

Soilborne tomato disease complexes are best managed in tomato by integrating several practices including crop rotation, disease resistance, water management, soil quality improvement and sanitation. When pathogens build up to the point that they affect the health and yield of the tomato crop, measures need to be taken to reduce their numbers

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to a level low enough to minimize crop damage. Anaerobic soil disinfestation (ASD) is a relatively new method to reduce pathogen populations in soil. ASD is effective against a wide range of soilborne pathogens, including bacteria, fungi, and nematodes. In ASD, beneficial soil microbes break down the added carbon source, depleting oxygen in the soil and producing toxic byproducts that kill soilborne pathogens.

ASD is a three-step process

1. Soil amendment: Soil is amended with a carbon source, providing nutrients for beneficial soil microbes. These carbon sources are applied at high rates, from 4.5 to 9 tons per acre (9 tons per acres is equivalent to 0.413 pounds per square foot). Commonly used carbon sources such as wheat bran, wheat middlings, or molasses can be purchased at feed mills. Cover crops may be practical for on-farm production of carbon sources. Carbon sources should be easily broken down by soil microbes, so amendments such as straw or residues from older crops do not make effective ASD carbon sources. Carbon sources should be spread evenly over the area to be treated. If molasses is used as a carbon source, it must be diluted with water prior to application. Carbon sources should be incorporated to a depth of 6-8 inches using either a hand-pushed or tractor-drawn rototiller. For systems using raised beds, the carbon amendment is applied and worked into the soil prior to bed formation.

2. Soil irrigation: The second step of ASD is soil irrigation, during which soil pores are filled with water, reducing available oxygen in the soil. The soil needs to be saturated to the depth of carbon source incorporation (6-8 inches). The irrigation step takes at least 4 hours and usually takes longer depending on soil type. Soil should be irrigated until water ponds on the soil surface and soils should not be completely flooded during treatment.

3. Soil tarping: The third and final step of ASD is to tarp the treated area with plastic mulch to prevent air exchange. Plastic mulch, either black or clear, should be laid over the treated area as soon as possible after irrigation is complete. The edges of the mulch must be buried in the soil or covered to prevent air exchange. A heavier grade plastic mulch should be used, and an embossed mulch can help to prevent tearing. Older plastic sheeting, such as construction sheeting or high tunnel coverings, can be reused so long as any holes are sealed with additional plastic and duct tape. Biodegradable mulch is not suitable for use in ASD. Soils can be covered before irrigation if drip tape is placed under plastic sheeting and used for irrigation.

Once tarped, soils should remain covered for three to five weeks, depending on the soil temperature. A strong odor indicates that the soil has become anaerobic and is normal for the treatment. Plastic sheeting can be removed at the end of the treatment. After plastic removal, planting should be delayed five to seven days to allow time for the soil to dry and breathe. If ASD is applied to raised beds, holes can be cut into the plastic to allow the soil to breathe prior to transplanting.

Soil temperatures and tarping duration

As a general rule of thumb, ASD treatments are more effective with warmer soil temperatures and longer tarping periods. In Ohio, a four-week-long tarping period has been used successfully. A tarping period of three weeks should be effective for most pathogens if soil temperatures are consistently greater than 85° F.

Timing ASD treatments

Since ASD requires at least one month from treatment initiation to planting, some planning is needed to incorporate the treatment into production schedules. For protected culture production, a spring (March or April) or fall application (September or October) may be ideally incorporated into production schedules. For open field production it is most ideal to perform a late spring, summer, or early fall ASD application.

Combining ASD with other soilborne disease management strategies

ASD is effective in reducing soilborne disease populations but may not completely eradicate all soil pathogens. It is good practice to combine ASD with other soilborne disease management practices such as use of disease resistance, grafting, crop rotation, sanitation and other cultural practices. Rootstocks are available with resistance to numer-

ous soilborne plant pathogens, including corky root rot, Verticillium wilt, Fusarium wilt, and Tomato mosaic virus, among others; an up-to-date table of these rootstocks can be found here: http://www.vegetablegrafting.org/resources/rootstock-tables/tomato-rootstock-table/. The Vegetablegrafting.org information portal also provides information on how to graft plants, as well as a list of propagators (http://www.vegetablegrafting.org/resources/suppliers/) if purchasing already-grafted plants is preferred.

PUTTING TOGETHER A BIOCONTROL-BASED PEST MANAGEMENT PROGRAM FOR HIGH TUNNELS

Steve Bogash, Territory Business Manager, Marrone Bio Innovations

High tunnels can be an extra challenge in pest management due to the standard practice of cropping tomatoes continuously. We've seen a steady increase in the number and type of soil-related problems in tomato high tunnels along with the usual aphids, mites, whiteflies, tomato pinworms, Septoria leaf spot, Leaf mold, Early Blight, and occasional bacterial disease(s). Short of fumigation, conventional chemistries only partially meet these challenges. Biocontrols and biopesticides in particular offer alternative responses due to the many new modes of action these materials utilize.

Lesion and Root knot nematodes are the latest problem to infest tomato high tunnels. This problem was first recognized in high tunnels in the Midwest, but now seems to be spreading to tunnels in the NE and Mid-Atlantic. Symptoms vary from barely noticeable variations in plant health to severe stunting where populations of both nematodes have reaching high levels. Growers first get a notion that something is amiss when individual plants or clusters of plants show signs of stunting. When plants are dug up masses of galls are plainly visible along with numerous lesions on the roots. When some area growers first noticed stunting in late-May and June of 2018, we applied Majestene® nematicide at 1 gallon per acre through drip irrigation followed by Regalia at 1 gallon per acre also through the drip and got a positive response with renewed plant growth and no further stunting. This was repeated once every 4 weeks until the end of the season. Ideally, this treatment would begin at transplanting. High tunnel tomato growers should now include a nematode assay in their annual soil evaluation.

The use of soluble fertilizers in tunnels will typically result in salt levels / EC's increasing over time as unused nutrients buildup. As part of an annual soil evaluation include a soluble salt assay along with macro and micronutrient levels, nematode assay, and organic matter levels.

Growing a great crop in your tunnels requires looking at more than just the typical nutrient levels. Plan your season in advance with a proactive pest management program. After applying 50-80% of your expected nutrient requirements, adding organic matter (The author has often resulted to purchased well-made composts), and creating planting beds, begin your season by applying a pre-plant inoculant such as Actinovate® AG, RootShield® Plus, or Terra Grow® either while plants are still in their trays or at planting as a drench. These inoculants are designed to prevent many common soil-borne diseases and also enhance the uptake of nutrients. Then begin pest management from day one with a proactive insect, mite and disease preventative program.

For insects and mites: Rotate Grandevo® WDG with Venerate® XC applied foliarly weekly. Always add a spreader adjuvant such as yucca extract or a pinene-based material such as NuFilmP®. Final spray solution should have a pH between 6 & 8. Adding an azadirachtin-based product has often increased overall pest management. Do not include the azadirachtin product if also using beneficial insects. Grandevo and Venerate have been used successfully with many beneficial insects. If scouting determines that an infestation of mites or insects is occurring consider decreasing the number of days between sprays, using an insecticidal soap between regular applications, or including a B. bassiani mycoinsecticide in your program.

Steve retired as a Horticulture Educator and Researcher, PSU Cooperative Extension in June 2016. Since retiring, Steve joined Marrone Bio Innovations as their NE / Mid-Atlantic Product Development and Territory Business Manager. His territory runs from Raleigh, NC to Caribou, ME to the Western edge of OH. He now oversees several dozen university and private research company product trials as well as many on-farm demonstration trials using Marrone Bio Innovation products for pest management. Steve and his wife Roberta live in Harrisburg, PA and are renovating a home near the Susquehanna river built in 1933.

For diseases: Start with healthy plants at their prime for transplanting. Overgrown plants that have been held too long will never do the job we expect of them in a high tunnel. Once they start setting fruit, the plants focus on finishing that fruit vs. producing large plants with economically significant yields. Removing fruits and flowers does not reset these 'too old' plants. Then apply Regalia either as a pre-transplant drench or as a foliar spray at transplanting. Continue weekly applications as part of a maintenance program until disease pressure increases. This weekly program can contain any of all of the following materials: Regalia, Stargus, Double Nickel, LifeGard, various coppers, Actinovate AG, Cease, or Companion. In this session we will review specific rotations, tank mixes, and general rules of engagement for making product decisions.

Relying largely on biopesticides for high tunnel pest management has been demonstrated to work will in many situations. Understanding how to create effective tank mixes, when to tighten up applications, and proper adjuvant selection will all impact the success of your program. There is no 'one size fits all' program as conditions and pest pressure change constantly during every season. However, the number of pest management tools in our biocontrol toolbox has grown to the point that they can manage most every pest.

ANAEROBIC SOIL DISINFESTATION (ASD) IN WEED MANAGEMENT: AN ECO-FRIENDLY APPROACH

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Weeds are a major production constraint in both conventional and organic vegetable production systems, but especially in organic farming because of the relative lack of available management options. Weeds cause significant yield reduction in terms of quality and quantity due to competition for nutrients, light and moisture, inhibition of growth and reproduction through allelopathy, and harboring pathogens and pests of crops. Current weed management practices are labor intensive or rely heavily on herbicide applications. Anaerobic Soil Disinfestation (ASD) is a promising technique for weed, disease and pest management, with no known adverse health or environmental consequences. ASD is three step soil rehabilitation process that includes 1) incorporation of carbon sources into soil, 2) irrigation up to field capacity, and 3) covering the soil with plastic sheeting for 3-4 weeks. ASD treatment enhances the germination of weed propagules at the initial stage and abruptly creates hypoxic conditions in the soil, resulting in production of high concentrations of volatile and non-volatile organic acids to kill weed seedlings and propagules.

Several experiments were conducted to explore the efficacy of ASD with locally available carbon sources on inactivation of propagules of major weed species under growth chamber and field conditions. Germination and viability of seed/tubers of six weed species, including common lamb's quarters (*Chenopodium album*), black nightshade (*Solanum nigrum*), yellow nutsedge (*Cyperus esculentus*), American pokeweed (*Phytolacca decandra*), dandelion (*Taraxacum officinale*), and redroot pigweed (*Amaranthus retroflexus*) were tested with four carbon sources: molasses, wheat bran, mustard green leaves, and raw chicken manure in a factorial completely randomized design in a growth chamber. Furthermore, the effect of these carbon sources at 5, 10 and 20 g per kg soil (molasses, chicken manure and mustard green leaves) and 5, 10 and 15 g per kg soil (wheat bran) were evaluated on weed seed mortality to determine the appropriate amounts of carbon sources for weed management.

Overall, wheat bran was the most effective carbon source for inactivation of all weed propagules, followed by molasses. Dandelion and yellow nutsedge were very sensitive to ASD regardless of carbon source, with seed/tuber mortality above 95% in all treatments (Fig. 1). Pokeweed seed germination was inhibited most by mustard greens leaves, molasses and wheat bran amendments. Seed/tuber mortality for all three (dandelion, yellow nutsedge and pokeweed) was also high in the flooded, covered control. Lamb's quarters, pokeweed and nightshade germination was inhibited most by wheat bran and molasses amendments in ASD. Pigweed seed germination was inhibited more than 95% in ASD with wheat bran amendment, but less when mustard greens leaves, chicken manure or molasses were used as amendments.

Wheat bran and molasses rates >10 g per kg soil increased seed mortality significantly in lamb's quarters, nightshade and yellow nutsedge. However, pigweed was sensitive only with 15 g wheat bran and 20 g molasses per kg soil. Chicken manure was not as effective as molasses and wheat bran in increasing weed seed mortality (Fig. 2).

Ram Khadka is a Ph.D. student at The Ohio State University, Wooster, Ohio. His major focus is to explore eco-friendly weed and disease management techniques that are equally important for low-income countries. He completed his B.S. and M.S. degrees from Tribhuvan University, Nepal. Currently, he is on sabbatical leave from Nepal Agricultural Research Council (NARC) where he is a researcher in Plant Pathology. Before joining NARC, he worked as an agriculture development officer in food security projects with two different non-governmental organizations in the far-western development region of Nepal. He is a native of far-western Nepal. His wife Ranjana is also a Ph.D. student at OSU, and they have a 3-year-old daughter, Shrisma.

Only higher amounts (> 10 g dry matter per kg soil) of mustard green leaves inactivated all of the weed propagules (data not presented). Chicken manure only inactivated dandelion and nutsedge propagules.

Results of the study indicate the potential of ASD with wheat bran and molasses as carbon sources in weed management. This may be an effective weed management practice for organic farmers who have limited options, and in developing regions where herbicides are unavailable or prohibitively expensive.

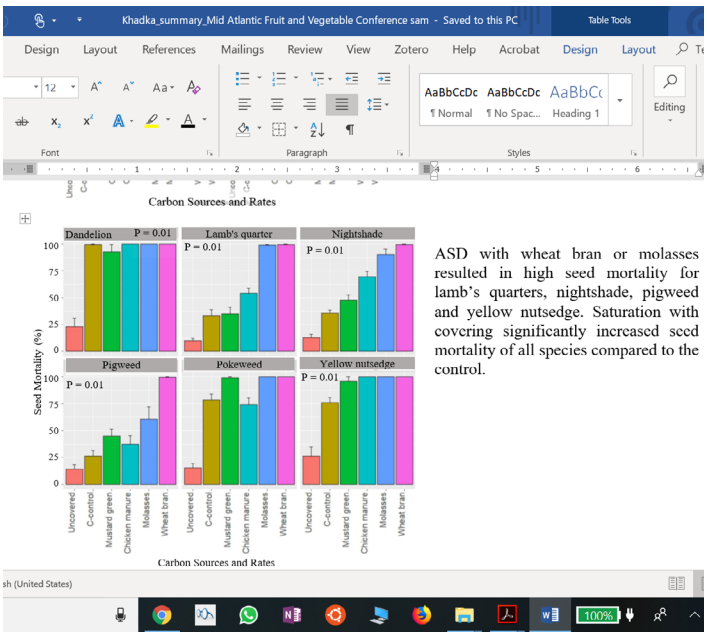

Fig. 1. Effect of carbon sources on weed seed/tuber mortality (%) in ASD. Untreated control was not amended, flooded or covered. C-control was flooded and covered but not amended.

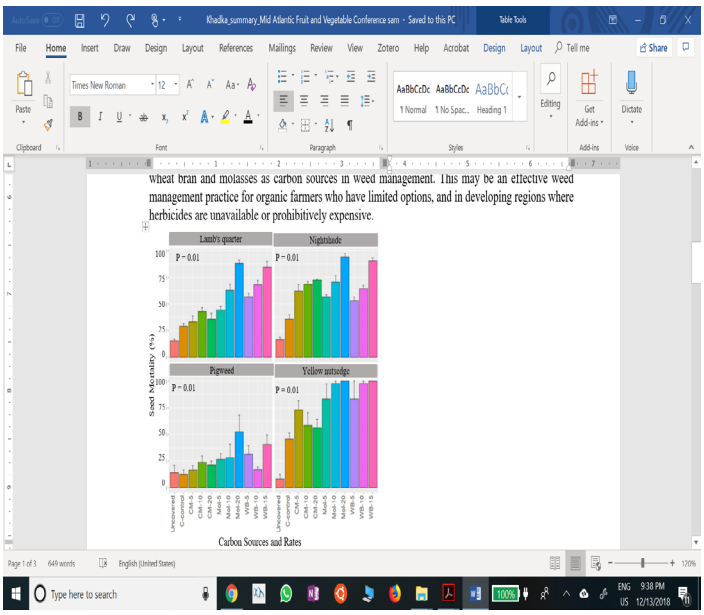

Fig. 2. Effect of different rates of carbon sources on weed seed mortality in ASD. Untreated control was not amended, flooded or covered. C-control was flooded and covered but not amended. CM- 5, CM-10, and CM-20 = 5, 10, 20 g chicken manure per kg soil; Mol-5, Mol-10, and Mol-20 = 5, 10 and 20 g molasses per kg soil; and WB-5, WB-10, WB-15 = 5, 10, 15 g wheat bran per kg soil.

THE CASE FOR SPIDER CONSERVANCY IN ORGANIC AGROECOSYSTEMS

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Introduction

Spiders are a diverse group of generalist predators and considered one of the most important groups of natural enemies of insects worldwide. They are important to agroecosystems (agricultural fields) because they contribute naturally to insect pest suppression. They represent more than half the predatory fauna in agroecosystems and are frequently the first natural enemies to colonize newly planted crop fields. Partially for these reasons, there is interest in the extent by which these often-overlooked predators, contribute to insect pest suppression. Some spider families (Lycosidae and Linyphiidae) are well studied and known to reduce important insect pests such as aphids and Lepidoptera larvae. Similar to other natural enemies, production and land management practices conducted within and in areas, neighboring crop fields affect spider diversity, numbers and efficacy as biological control agents. Consequently, practices that reduces or augment their numbers can affect their ability to influence insect pest densities. Agricultural intensification including increased use of inorganic pesticides and fertilizers, and removal of non-cropped flora in favor of extended acreage of monoculture crops, have been credited for reducing the biodiversity of beneficial invertebrates (e.g., pollinators, arthropod predators, parasitoids). Organic farms, which generally contain greater habitat heterogeneity (diversity of habitat types), offer opportunities for restoring the biodiversity of beneficial arthropods including spiders.

Although several studies have shown that spiders can reduce insect pest populations and associated crop damages, their ability to contribute to pest suppression and productivity in organically managed fields has received minimum attention. However, organic farming systems partly because of their more complex crop rotation systems and enhanced non-crop plant flora are ideal environments for spiders. The lack of inorganic chemical inputs also creates conditions in which spiders can be of greater density, diversity and importance. Therefore, organic producers should be interested in knowing how spiders' presence affects pests on their farms and how to conserve and enhance their populations. However, most studies examining the impact of natural enemies on pests in organic fields have focused on parasitoids and insect predators. Spider contributions as biological control agents are often over-looked.

Conserving spiders in agricultural fields

Non-crop plants. Spiders respond positively to vegetation diversity and several studies have shown that diversification of agroecosystems with non-crop plants can increase their density and diversity. As such, the location of crop fields relevant to surrounding landscape and the makeup of neighboring landscape can influence the community of spiders within the crop. Spiders use field margins and non-crop lands as alternative habitats, refuges and overwintering quarters especially during periods when crop fields are not suited for their survival. As such, field margins and other neighboring vegetation in the landscape can serve as staging areas for spiders in the spring before they migrate into crop fields. For example, fields with a high proportion of perennial crops and degree of habitat heterogeneity in the surrounding landscape have been associated with enhanced spider populations. Forest environments also provide spiders with food resources and serve as alternative habitats; and the proximity of croplands to forest can influence spider abundance within crop fields. Higher proportion of forest in the surrounding landscape was

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associated with greater numbers of wolf spider species within crop fields. Agriculture ditches with a high degree of vegetation may also harbor spiders during the non-crop season. In general, crop fields neighboring landscapes with a high coverage of perennial crops, non-crop flora and forest, and are adjacent to vegetative diverse ditches should contain an augmented number of spiders.

Uncropped field margins are also particularly important for enhancing the abundance and composition of spiders in crop fields. Studies have shown that field margins can serve as a source of spiders who use vegetation in field margin for overwintering and searching for insect prey. For example, non-crop plants grown within and adjacent to chili pepper fields served as source habitat for spiders and improved their colonization in neighboring pepper fields. Shelterbelts (windbreaks, hedgerow) established along field margins can support communities of spiders also, and adding structural diversity in the form of fences to shelterbelts may further augment their numbers. For example, in New Zealand, fenced shelterbelts contained 67% higher spider densities than unfenced shelterbelts. Still not all spider species may benefit from non-crop habitats. While some studies have found that most spider species in crop fields benefited from having non-crop habitats in the surrounding landscape, some species declined in areas dominated by too much non-crop habitats. One reason spiders are found frequently in non-cropped areas such as field margins is partly due to these environments being less disturbed, especially compared to annual crop fields. Further, in temperate climates, natural enemies associated with annual crops, typically overwinter at the field edge, and diverse field edges increase the overwintering success of natural enemies. Still, the challenge of taking advantage of non-crop areas is when spiders fail to move out of these habitats into the crop field or the field's interior is large relative to the non-crop area so spiders only extend short distance within the crop field. Thus, the higher the ratio of non-cropped field margin to crop field, the more likely some spider species will move from their shelter habitat at the field's margin into the field interior.

*Beetle banks***.** Studies have shown that the activity of some natural enemies only extend 10s of meters into annual cropped fields. This inspired 'beetle banks', in which essential features of edge habitat were placed within crop fields in linear strips at a frequency great enough to allow natural enemy dispersal throughout the field. Beetle banks are permanent strips of natural vegetation intended to provide natural enemies long-term shelter and overwintering quarters. They typically consist of long, elevated earthen berms planted with perennial bunch grasses but may include wildflowers as a nectar source for parasitoids and pollinators. These dense vegetative strips provide undisturbed shelter for beneficial arthropods such as rove beetles, carabids and spiders and strengthen natural control of pests within agricultural fields. Beetle banks allow punctual movement of natural enemies back into crop fields when warm weather returns the following season. The beetle bank concept originated in Great Britain to provide habitat for beneficial arthropods that had declined due to the loss of hedgerows and other plant habitats neighboring cropland. Despite promising results, beetle banks remain largely unused in the United States.

Intercropping and interplanting. In addition to establishing strips of natural vegetation within crop fields, as with beetle banks, multiple crop species grown within the same field can influence spider numbers. This practice, referred to as intercropping or polyculture, increases vegetation and structural diversity within the field. A literature review conducted to determine the impact of vegetation diversification effects on spiders showed that plant diversification increased spider abundance by 63% (15/24) and in 80% of these studies the diversification mode was 'interspersed diversification' (e.g., undersowing, mulching) in which the additional vegetation was closely adjoining the main crop. In addition, interplanting main crops with cover crops can increase spider populations. Cover crops provide spiders a more sheltered microhabitat and alternate prey. A study conducted in Maryland showed that interplanting sunn hemp (*Crotolaria juncea*) with zucchini resulted in greater abundance of spiders on zucchini plants; and in earlier studies in Hawaii, it was found that interplanting broccoli into various living mulches (white clover, yellow sweet clover) resulted in enhanced spider numbers on broccoli plants compared to broccoli monoculture. However, this enhancement did not occur until later in the season as the clover encroached upon broccoli rows. These findings agree with an earlier study that suggested successful augmentation of spiders on crop plants is more likely to occur when companion plants are in close proximity to the main crop. Any practice that increases structural diversity within crop fields including intercropping, cover cropping and no-till farming that allows more plant species or dead

plant residue to remain on the soil surface helps create spider friendly environments. Some spiders may be more affected by habitat features within and or directly neighboring crop fields, and others the surrounding landscape. Thus, all three areas should be considered when devising a strategy for spider conservation and enhancement.

Effects of organic farming practices on spiders

Several studies have investigated the impact of organic versus conventional farming practices on spider communities. These investigations have shown that organic farming practices in general favor more spiders. Field studies suggest that organic farming positive impact on spider density is greater for spiders with lower dispersal abilities such as species that walk into crop fields as opposed to travel by ballooning. Some spider families are highly sensitive to pesticide sprays. As such, the lack of insecticide inputs may also help explain higher spider numbers in organically managed crops and is the essential cause in some instances. Further, spiders walking into crop fields are more likely to encounter insecticide sprays, which may partially explain "walking spiders" benefit more from organic practices. The absence of herbicide use, resulting in larger non-crop plant populations and more herbivorous prey, is another proposed explanation with respect to why more spiders colonize organic fields. Organic farms commonly have more ground cover or understory vegetation, which increases the number of surface-active spiders. In many instances, habitat complexity was greater on organic than conventional farms, which supports more decomposers that serve as prey for spiders. Although organic farming creates environments that are more congenial to spider colonization, enriching organic systems with more vegetation or structural diversity within crop fields and perennial vegetation in the surrounding landscapes may further augment their numbers within agricultural fields. A survey of Mediterranean vineyards concluded that organic farming alongside the maintenance of a high proportion of ground vegetation cover favored greater spider biodiversity. Coupling organic farming practices (e.g., organic fertilizer use, complex crop rotations) with ground vegetation coverage within and outside (e.g., field margin, landscape) the crop field and having a diverse mixture of plants should offer the best opportunity for attracting a range of spider species and enhancing their use and efficiency as biological control agents in organic systems.

ROOTS TO RIVER FARM - FARMING ORGANICALLY ON 15 ACRES

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Summary of the Farm

Roots to River Farm is a certified organic farm operating on two locations, one in New Hope Pennsylvania and one in Titusville NJ. We manage 28 acres of leased property and grow vegetables, fruits and flowers on 15 acres. We sell our produce through a 200 member year-round CSA program, 1 local farmer's market, our own on-farm farmer's market (open 3 days a week peak season, 1 day a week in the winter), directly to local restaurants and to a local wholesale company. In the peak season we have 6 full time and 2-3 part time employees, and in the winter we have 3 part time employees. This is our 7th season operating as Roots to River Farm and our 3rd season operating on 2 properties. We grow over 200 varieties of crops and pride ourselves in high quality produce and community engagement.

Fertilizing and Field Prep

We design our fields according to the organic standards of a 3-year rotation between botanical families. We never crop twice in the same bed for a season. Since we have enough land to keep some fallow or cover crop between cash crops we design a rotation that includes summer and winter hardy cover crops. This allows us to add organic matter and nitrogen using living crops rather than constantly having to add fertilizers. Fields that are not being used for the season will be seeded into clover or sudangrass in the spring. Fields that go into crop later in the season will stay in winter cover for as long as possible and then get plowed in with a moldboard plow or put into a short cover such as buckwheat before getting prepped for field crops. Spring cropped fields ideally will be put into a winter-killed cover in mid-September such as oats and peas. Late fields will put into rye or triticale and vetch through the end of October to gain rapid growth in the spring. This is of course the ideal scenario which we usually succeed in sections, but in a year like last year when it was hardly ever dry enough to till, we were unable to perform most of our cover cropping through the season.

Tillage is the organic systems greatest weakness. Since we can't use chemicals to kill plant matter – whether it be for weeds or prepping fields, we have to till. This practice destroys soil structure and can easily lead to compaction, drainage problems and prevent nutritional uptake. With that in mind we try to do a deep till with a spader or a plow if the plant matter is particularly thick (we do not use rototillers) once a season and the rest of the season use shallow tillage implements such as disc harrows and perfecta harrows to keep ground open, stale seed-bed and incorporate plant debris without disturbing the lower levels of soil.

For our heavy feeding crops such as solanacea and cucurbits we apply a thin layer of organic mushroom compost (22 tons per acre) and a standard 2-3-4 organic fertilizer at 400lb per acre. We also do seasonal applications of gypsum since our soils are deficient in calcium. For less heavy feeders such as greens and brassicas we generally only add the fertilizer and occasionally supplement based on our soil tests. It is amazing to see that our fields with the highest organic matter always yield significantly higher with much happier plants no matter the season.

Malaika Spencer, Owner/Operator of Roots to River Farm. Malaika owns and manages all aspects of production, distribution and sales of organic produce from her farm located in New Hope Pennsylvania and Titusville New Jersey. The farm produces 15 acres of organic vegetables for a year round CSA, wholesale, on farm and off farm farmer's markets. Malaika studied sustainable agriculture at Hampshire College and worked on farms in Costa Rica, Ecuador, Italy, Vermont, Massachusetts and New Jersey before founding Roots to River Farm in 2013. Malaika is originally from Bucks County PA and now lives with her husband in Point Pleasant PA with their 2 dogs.

Weed Control

Weed control is the biggest challenge in the organic system. It is what takes most of our time and energy and for me, is the most stressful part of organic farming at this scale. While we are not big enough to rely only on machine cultivation (and of course that relies on having working tractors which we don't always have) we are too small to rely only on hand weeding. So, like many farms conventional and organic we use plastic mulch for many of our transplanted crops and control pathway weeds by seeding the pathways with a cover crop such as Japanese millet or clover, using pathway cultivators for times when it is not too wet and the plants are not too big, or laying down landscape fabric. In non-mulched beds we use a combination of tractor cultivation with tines or a basketweeder, and hand weeding with stand-up hoes and hand hoes. Usually it is a combination of all 3 of these practices to control the weeds in every bed. According to our records we spent 1,000 hours weeding in 2018. The field prep, cover cropping and stale seed bedding with the perfecta cultivator are all very important in our weed control strategy and help immensely keeping down the weed seed bank.

Pests and Diseases

We have access to a few organically approved pesticides and fungicides and I find them sometimes to be extremely effective and sometimes not at all. We do not have any large spraying equipment so our spraying strategy is to use these chemicals as a last resort. We also think it is very important to minimally affect our farm's pollinators and natural insect predators so we don't like using pesticides on a regular basis. We use row cover for many crops in the spring especially for flea beetles, cabbage loopers and cucumber beetles. We usually do a spring and fall spraying of bT for cabbage loopers. If the flea beetles are really bad we will spray Entrust if we need to. We spray pyrethrum for leaf hoppers on potatoes and beans. We do lose some crops or varieties to pests every season but because of our diversity on the farm it is never too much of a problem. We also find that parasitic wasps are excellent control for leaf miners, onion maggot and Mexican bean beetles.

As for diseases, we don't have much of an option other than copper fungicides and since we do not have large spraying equipment we rarely spray for disease. We will delay or move up planting dates for crops if we think that will help their chances of maturing before a mildew arrives and we select intensively for disease resistant strains. Additionally, planting many successions will help continue the harvest even in the face of disease.

Season Extension

We have 6 high tunnels that we use for a variety of crops to help with disease control in the summer and extend our season in the winter and spring. Tunnels have been used for growing ginger, heirloom tomatoes, carrots and lots of winter greens. We think that tunnel growing is by far the best tool for the organic grower to achieve maximum yields and will become more and more important in the future.

Certification and Record keeping

We became certified organic because we thought it would be important for our customer base to know how we grow and since we were already putting in the work, why not get it certified. It also helped us reach a few more customers in our wholesale department. It means we have to take fairly extensive records during the season and adds a few more days of paperwork in the winter time. The cost is significant but not prohibitive and is income based. By implementing a collective record taking app for the crew and hiring someone a few hours a week to help with data entry we made the organic certification process extremely easy.

ORGANIC TOMATO PEST MANAGEMENT FOR THE WHOLE SEASON

Steve Bogash, Territory Business Manager, Marrone BioInnovations, Inc.

Tomatoes are tough! Lessons learned one season only partially translate to the next season. Weather, pest, and pest complex variations, new varieties and many other factors make growing tomatoes profitably a continuing challenge. However, the 'toolbox' of pest management options has made growing tomatoes a bit easier due to increased biopesticides. The single most important theme in making organic production viable is the need to be proactive; waiting until a disease, insect, or mite is a severe problem will never provide a good harvest.

Strong crop rotation program: Tomatoes can be hard on a soil. Root diseases such as Fusarium and Verticillium can quickly build in soils under continuous tomato production. Septoria leaf spot inoculum also increases rapidly in short rotation programs. Ideally, tomatoes (along with peppers, eggplants and potatoes) should not see the same patch of ground more often than once every 3 years with longer being better. Including a grass or buckwheat cover crop between tomato crops will greatly reduce carry-over pest challenges. While tomatoes are the single highest value high tunnel crop, it is worthwhile to allow a soil to rebuild every couple of years and try a cucumber crop in between.

Build a solid soil nutrition program: Tomatoes are heavy feeders and will remove substantial quantities of K, Mg, Ca, and P along with specific micronutrients. Since there are only limited options for soluble organic nutrients, be sure to apply sufficient nutrients prior to planting for 80 – 85% of your predicted crop requirements. Then follow-up by beginning a drip irrigated program from planting through harvest. Plan on high K usage from the onset of flowers.

Preplant inoculate your plants: One of the best tools we have going are preplant inoculants that contain Trichoderma fungi. While there are others on the market, RootShield Plus™, and TerraGrow™ can provide long-term management of many root and crown diseases. The Trichoderma spp. fungus in these materials forms a symbiotic relationship with the root system that not only provides a good measure of disease protection, but also assists in the uptake of nutrients. These materials are typically reapplied every 6-10 weeks during the season to maintain high levels of beneficial fungi.

Begin a proactive pest management program from day 1: Preplant inoculation is the beginning of a proactive disease management program. Apply Regalia™ every 2 weeks either foliarly or as a soil drench from the first true leaf. Alternate Regalia with Stargus™ on the opposite week. Regalia provides a strong ISR plant response which will assist in the management of many plant diseases and also acts as a biostimulant. Stargus brings Early blight, Timber Rot, Botrytis and Late blight management. Adding a Cu material to Regalia when applied foliarly provides a synergy for enhanced disease control. Beginning this program from the emergence of the first true leaf, through transplant production, transplanting and finishing will greatly reduce disease problems. Including Grandevo WDG alternated with Venerate XC tank mixed with your disease management materials will suppress aphids, whiteflies, many mites, and Western flower thrips.

Scout often and well to identify problems early: While a proactive program as described above will go a long way to reducing pest pressure throughout the season, only weekly or more often scouting will identify the inevitable

Steve retired as a Horticulture Educator and Researcher, PSU Cooperative Extension in June 2016. Since retiring, Steve joined Marrone Bio Innovations as their NE / Mid-Atlantic Product Development and Territory Business Manager. His territory runs from Raleigh, NC to Caribou, ME to the Western edge of OH. He now oversees several dozen university and private research company product trials as well as many on-farm demonstration trials using Marrone Bio Innovation products for pest management. Steve and his wife Roberta live in Harrisburg, PA and are renovating a home near the Susquehanna river built in 1933.

unusual problems that crop up during a typical tomato season. It is not unusual for aphid 'hotspots' to pop up that require additional treatment. The same holds true for other diseases, insects and mites.

Tissue test bi-weekly: The only way to know if your plants are at their nutritional best is through bi-weekly tissue testing. Test at the same time of day each time, compare results and adjust your nutritional program accordingly. Well-fed tomatoes will keep ripening fruit while making more flowers for future harvests. It is normal to have challenges maintaining sufficient K, Mg, P, and Ca when plants are carrying heavy loads of fruit.

Cull hard when necessary, scout often: Scout your fields and plantings often. Remove suspect plants and get any problems accurately identified. If you suspect a bacterial disease, contact your nearest Extension Educator, or send a sample directly to your nearest pathology laboratory. Leaf and stem symptoms of bacterial canker look very much like some fungal diseases.

Timing: it is best to wait until after the leaves are dry to work a field: bacteria ooze out to the edges of the leaves through hydathodes early in the day. As you work fields tying, spraying, harvesting and performing other maintenance chores, it is very easy to pick up and move bacteria to non-infected plants. By waiting until the plants are completely dry in the morning, you can reduce spreading bacteria.

By growing proactively and planning for insects, mites and diseases as they seem to be inevitable, it is getting to be a bit easier to grow great crops of great tasting tomatoes here in the Mid-Atlantic is spite of our challenging seasons.

INTEGRATING COVER CROPS IN ORGANIC HIGH TUNNELS

Kristine Lang[1] and Ajay Nair[2]
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Introduction

High tunnels are plastic-covered, passively ventilated and heated structures where crops are grown directly in soil. They have become important tools for Iowa specialty crop producers to increase production of quality crops, extend the season, and increase profitability. The environment without rainfall, limited space, and potential climate control in a high tunnel requires a unique set of crop management skills. With high tunnel production primarily dominated by tomatoes and interest among growers for year-round production in high tunnels, a cohesive and focused approach is needed to tackle issues that would arise due to continuous production under these structures. Few emerging issue include: lack of crop rotation, loss of organic matter, salt build up, resurgence of soil-borne and foliar diseases, poor soil structure, lack of microbial diversity, and reduced crop yields.

Approaches

One strategy to mitigate above mentioned issues would be to grow cover crops in high tunnels. The space under the high tunnel is of prime value so cover crops that are grown within high tunnels should be of short duration. Examples of such crops include buckwheat, cowpea, oats, sunn hemp, oilseed radish, yellow mustard, and sorghum-sudangrass. Cover crops provide multiple benefits such as soil and water conservation, organic matter input, nitrogen fixation, weed suppression, and bio-fumigation. Cover crops provide specific advantages based on their physiology, shape, size, and growth habit. Each individual cover crop might not provide every advantage, depending on their growth, morphology, and composition, certain cover crops have advantages over others. The same can be said for the disadvantages. For example, planting cowpea, a cover crop from the legume family, can fix atmospheric nitrogen but may not provide a high level of weed suppression compared to a cover crop like buckwheat. Buckwheat, on the other hand, can provide high levels of weed suppression but cannot fix nitrogen since it is not a legume.

Weed suppression is a common topic when evaluating cover crops. Suppression of weeds is accomplished by a cover crop in multiple ways: interception of sunlight, competition for soil nutrients, and allelopathy. Not all cover crops possess these characteristics and certain cover crops express these characteristics more than others. Figure 1 below displays the weed suppression capabilities of four cover crops tested in Iowa.

Dr. Ajay Nair is an Associate Professor working in the area of Sustainable Vegetable Production in the Department of Horticulture at Iowa State University. The focus of his research, extension, and education program is on cover cropping, conservation tillage, nutrient management, soil amendments and health, and season extension strategies in vegetable production. He also has an interest in local food production and works on production aspects and techniques needed to meet the rising demand of locally grown produce.
Kristine Lang is a PhD student in the Department of Horticulture at Iowa State University. Her research focuses on optimizing production practices for high tunnel vegetable crops. Key research area includes evaluating rootstocks for tomatoes, environment management using shade cloth, and season extension strategies for fall leafy greens production. Kristine has also conducted studies on winter hardy cover crops in conservation tillage systems.

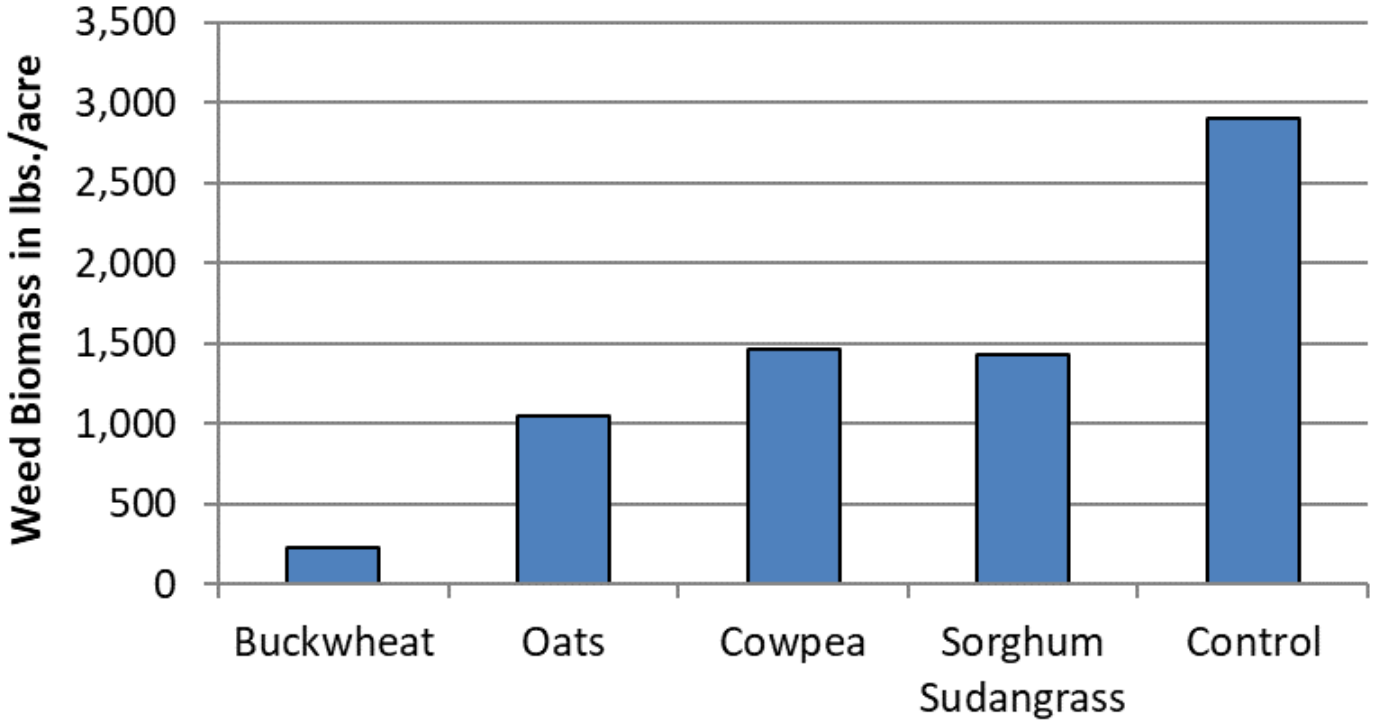

Figure 1. Amount of weed biomass collected in four cover crop plots 61 days after seeding as compared to plots with no cover crop (Control). Data collected August 2013 at the Horticulture Research Station, Iowa State University.

Integration of cover crops in high tunnels could be challenging given the expectation of putting high tunnels to work all year round. A possible solution could be planting of a short duration cover crop to occupy a short-fallow period between two vegetable crops, for example, between a vegetable crop that is harvested in early summer and a fall planted vegetable crop. Short duration cover crops can also be planted after a fall harvested vegetable crop. There could also be repeated plantings of cover crops, usually two to three, within a given year, if the intent is to rotate the high tunnel out of vegetable production for a year, although that is unlikely, but not impossible. Care has to be taken when leaving a short duration cover crop to grow for an extended amount of time. These cover crops can reseed themselves and become a weed in the following vegetable crop. For information and examples of integrating cover crops into vegetable crop production systems please refer to Iowa State University Extension and Outreach publication *Cover Crops in Vegetable Production Systems (HORT 3026)* (Nair et al., 2015).

Another option would be to seed cool season short duration cover crops such as oilseed radish and yellow mustard in high tunnels (Fig. 2) before planting of the main cash crop, for example tomatoes, late April. Oilseed radish and yellow mustard belong to the brassicaceae family, are short duration (mature 35-45 days after seeding), and also known to produce a compound called Isothiocyanate (ITC) which acts as a biofumigant. In an experiment at Iowa State University these cover crops were seeded early March before a tomato crop. Cover crop biomass ranged from 3,000 to 4,000 lbs. per acre. Cover crop plots had lower weed biomass than the control, although there were no statistically significant difference for marketable yield.

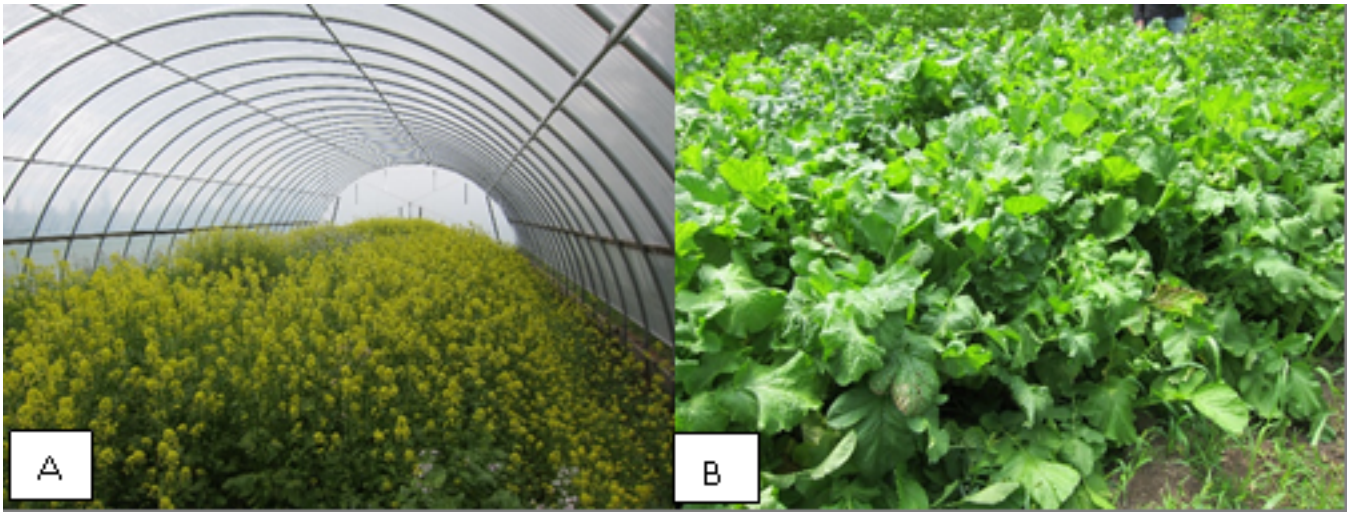

Figure 2. Cool season cover crops in high tunnel; Yellow mustard (A) and Oilseed radish (B)

Seeding of cover crops after the main crop in the fall is also a relevant practice. Crops such as tomatoes, peppers, and cucumbers come to close around mid-October. This does not leave much time for summer cover crops such buckwheat, sorghum sudangrass, oats, etc., however, winter hardy cover crops such as Austrian winter peas, cereal rye, hairy vetch, and winter wheat are excellent choices. An important thing to consider while using legumes is to inoculate them with compatible strains of *Rhizobium* rhizobia for efficient N fixation. In addition, termination of hairy vetch in spring could be a challenge due to high biomass and viney nature of growth, which leaves a tangled mature vetch biomass that can overwhelm many small mowers or disks. Flail mowing before tillage helps, but that is a time and horsepower intensive process. Sickle-bar mowers could be used but only when the vetch is well supported by a cereal rye companion crop and the material is dry.

Cover crop mixtures are often more effective than planting a single species. Combining benefits of grasses, broad-leaves, legumes, and brassica can help achieve winter survival, biomass and N production, and weed control. Seeding rate of species within mixtures must be adjusted to ensure adequate growth of the companion species. Example mixtures for fall seeded cover crops could include cereal rye and hairy vetch; cereal rye, hairy vetch, and oilseed radish/brassica; cereal rye and Austrian winter peas; oats and hairy vetch; or oats and oilseed radish/brassica. Example mixtures for summer-seeded cover crops could include sorghum-sudangrass and sunn hemp, buckwheat and sunn hemp, or sorghum-sudangrass and cowpea.

Summary

Managing soil fertility and productivity in high tunnels requires an integrated approach that combines multiple tactics. Cover crops are one of the tactics in addition to the use of compost, reduced tillage, irrigation management, and crop rotation. High tunnels are intensively managed systems so the long-term sustainability of soil is critical. Cover crops provide multiple benefits such as the addition of organic matter, weed suppression, nutrient cycling, bio-fumigation, soil aeration, and an enhancement of soil biology. They are not, however, do-it-all "wonder crops." To find a suitable cover crop or cover crop mixture for high tunnels, growers should have a clear understanding of cover crop species, growth habits, and the positive and negative aspects of cover crops. In addition, growers should identify the best time for a cover crop in their crop rotation system. Testing cover crop species before integration in crop rotation is highly recommended as it reduces risks and management challenges.

ALLIUM LEAFMINER : WHAT WE NOW KNOW, AND HOW TO MANAGE IT

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The allium leafminer (ALM) (*Phytomyza gymnostoma*) reached the Western Hemisphere by December 2015 and is now confirmed in 5 states (Fig. 1). It is a small fly (a species in the family Agromyzidae) that is a specialist on plants in the Allium plant family. We suspect it will utilize all *Allium* species, and we have confirmed it in onion (*A. cepa*), leek (*A. porrum*), garlic (*A. sativum*), chives (*A. schoenoprasum*), garlic chives (*A. tuberosum*), an ornamental (*A. christophii x A. macleanii*), ramps (*A. tricoccum*) as well as weedy wild garlic (*A. vinaela*). Farms with a continuous supply of allium hosts, such as chives, onions, leeks, garlic, as well as weedy alliums, provide a host for both the spring and fall generation, and these farms may be most at risk.

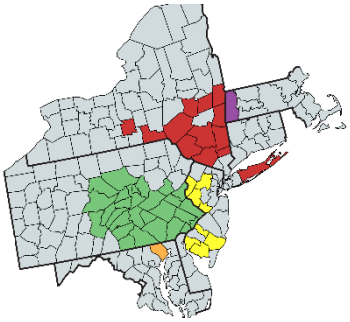
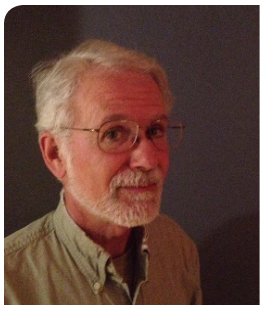


Fig. 1: Distribution of ALM as of 2018.
Map: R. Harding

ALM overwinter as pupae either within or in close association with leaf or bulb tissue. Adults emerge early in the spring. We've detected spring emergence starting in April and continuing well into May. During that time, the adults are finding and laying eggs. These oviposition marks (Fig. 2) have been our best method so far for monitoring and are predictive of the number of larvae/pupae that we recover from plants. The eggs develop into larvae (maggots) that mine the leaf tissue, moving downward into the swollen leaf base that makes up the bulb, or into the stem of leeks. Mines can be difficult to find. The larvae develop into pupae, which stop or dramatically slow development. Thus, these summer pupae undergo a summer aestivation until fall. The pupae eventually restart their development, and hatch out as adults, in the fall. We've seen this 2nd adult flight begin in late September in some years, and as late as mid-October in 2018. Fall adult flight continued into November in 2016 and 2018, but it 2017 it seemed to end earlier, by about the 2nd or 3rd week of October. These fall adults lay eggs into allium leaf tissue, which hatch into larvae and develop into the pupae that will overwinter.

Fig. 2: ALM oviposition marks.
Photo: C. McGrady

Adults are making choices among the alliums. We've seen higher rates of oviposition marks on scallions compared to leeks, but we recover similar numbers of ALM when we dissect these plants later in the season. In a field setting, when given a choice among different ages of scallions in the fall, the youngest scallions resulted in the highest ALM infestation. However, in transplanted 'Candy' onions, grown in the same method as in the Simply Sweet® program, the opposite occurred: in onions present during the spring flight, the oldest onions, with the most leaf tissue, resulted in the most infestation.



Dr. Fleischer is on the faculty of the Department of Entomology at The Pennsylvania State University where he specializes in population dynamics of insects. He has been worked in vegetable agroecosystems for 28 years. He previously was a Research Scientist at Virgina Tech and Research Associate at Auburn University. He received his B.S. in Biology from St. Mary's College of Maryland, his M.S. in Entomology from Virgina Tech and his Ph.D. in Entomology from Auburn. A native of Washington, D.C., he and his wife Barbara have two daughters and three grandchildren.

We've also seen strong differences in how ALM develop within different allium hosts. Within leeks, we pull out larvae deep within the harvestable stalk that is used for sale. Our top record, so far, has been 30 ALM within a single leek (this one came from a leek at the Arboreteum at Penn State). In contrast, almost all the ALM we have dissected out of 'Candy' onions were in one of the scale leaves: the outermost leaves that dehise as the plant moves into a 'bulbing' growth stage and form the papery coating on the outside of the plant.

We've conducted efficacy trials with both conventional and organic insecticides and have been coordinating our trials with colleagues in New York to enable more rapid results, relevant to a wider range of production systems. Among conventional options, not surprisingly, we are getting highest efficacy with systemics, both neonicotinoids (IRAC 4A options) and diamides (IRAC 28 options) (Fig. 4), but we are also seeing differences among the types of these materials and the application methods. We are testing both foliar sprays and delivery via drip irrigation. So far, the foliar sprays have worked the best, but as we better time the chemigation options, we may see them perform well. Among the organic options, several are showing promise – we have not yet obtained statistically significant results, but we certainly have seen promising results with at least 2 organic options. Utilization patterns (rates, surfactant, timing) are affecting results of both conventional and organic options, and studies are underway to optimize these factors.

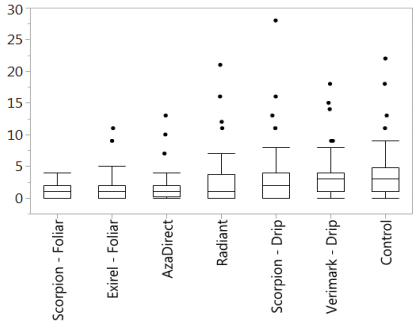


Fig. 4: ALM per leek, comparing conventional and organic insecticides.

And, in some very good news, we've been able to recover parasitoids (Fig 5)! Although parasitoid recovery has been slow, we hope to see this increase, and we are working to determine the species and perhaps source of the parasitoids.


Fig. 5: Parasitoid recovered from ALM. Photo: D. Roberts.

MANAGEMENT: All this information can be used for developing integrated management plans. The fact that ALM is a strong specialist –it requires allium leaf tissue – suggests that managing your farmscape so that allium leaf tissue is not available for either the spring or summer flight should help keep populations low. Of course, you need to consider wild alliums (wild onion, wild garlic) as hosts. Delayed planting in the spring, until after the spring flight occurs, should accomplish a similar result of 'escaping' damage, if you can obtain the yield you need with that practice. Row covers during adult fight should prevent egg-laying. We are documenting the host-choice behaviors – between different allium species, and between different ages of plants – to develop trap crop options. Scouting for oviposition marks can help determine if ALM is present and help time insecticide sprays, but you need to look carefully to find these marks. Insecticide trials are showing promise, for both conventional and organic insecticides, and in coordination with colleagues in New York, we are working with rates, choice-of-materials, and timing studies to provide insecticide recommendations useful for different allium crop species, and different production systems. Finally, a longer-term solution is biocontrol. In its native range in Europe, ALM is parasitized by multiple species of wasps, and we've initiated the work to enable biocontrol to become part of the IPM plan for this invasive species as well.

Along with ALM – we need to watch for yet another invasive: the leek moth (Acrolepiopsis assectella). This species is now known to be present in eastern Canada and New York. Young larvae mine the leaves, older larvae make

2018 ONION VARIETY TRIAL

T. Butzler and Mike Orzolek
Horticulture Research Farm
Rock Springs, PA

Date seeded: February 12, 2018

Date transplanted in field: May 7, 2018

Population: 40 plants per plot (unless noted)

Production system: raised beds covered with black plastic mulch with 2 drip irrigation tapes placed 1.5 inches deep in bed. Four row/bed 5.0 feet long with 6x6 inch spacing, 40 plants/rep
Design: Randomized Complete Block with 3 replications

Herbicide Application: Medal at 1.5 pts/acre broadcast prior to transplanting onions.

Fertility: April 26, 2018, broadcast and incorporated 500 lbs/A of 19-19-19 and incorporated in the soil prior to laying beds and transplanting the onions.

Harvested:
September 8, 2018 (Scout, Candy, Cabernet)
September 15, 2018 (Rhino, Rossi Di Milano)
September 20, 2018 (Red Hawk, Red Mt., Yukon, Yosemite, Monastrell)
September 24, 2018 (Aruba, Great Western, Dulce Reina, Saffron, Sedona, Mondella, Cherry Mountain, Red Carpet, Diamond Swan, Lyrica, White Opera, LA50)

Drying: Bulbs from individual plots were placed in 100 lb. potato Burlap bags and placed on benches, after harvest, in a 30' x 96' high tunnel covered with 2 layers of row cover.

Approximately 40 bulbs of each variety were placed in a wooden slatted box in 55 F storage

Graded: October 26, 2018 on a TEW Grader. Approximately 40 bulbs of each variety were placed in a wooden slatted box in 55 F storage before shipping for testing of soluble solids and pungency.

Samples processed for pungency and sugars: November 1, 2018

Tom Butzler has been the Horticulture Educator for Penn State Cooperative Extension in Clinton County, Pennsylvania since 2000. Tom earned his Master of Science degree in Plant Pathology at North Carolina State University and a Bachelor of Science degree in Horticulture from The Pennsylvania State University. Prior to his appointment with Penn State, he was an extension educator in commercial horticulture with North Carolina Cooperative Extension
Michael D. Orzolek is Professor Emeritus of Vegetable Crops, Department of Plant Science, The Pennsylvania State University. He came to Penn State in 1981 with a three-way appointment – 60% Extension, 22% Research and 18% Teaching. Since his retirement in July, 2012, he has kept active conducting applied field research and moving his office to the Horticulture Research Farm, Rock Springs, PA. He has done extensive research on stand establishment, plastic mulches, high tunnels, weed management and tillage systems. Mike is still the current Director of the Penn State Center for Plasticulture and the CP High Tunnel Research and Education Facility at Rock Springs, PA..
Dr. Orzolek formerly was Extension Vegetable Specialist at the University of Delaware (1974-81). He received his B.S. in Biology from Alliance College, his M.S. in Horticulture from West Virginia University, and his Ph.D. in Horticulture/Botany from the University of Maryland.

Table 1. Onion Varieties evaluated in 2018.

Variety	Source	Bulb Color
Aruba	Sakata	Yellow
Yosemite	Sakata	Yellow
Saffron	DePalmer Seeds	Yellow
Rhino	Hazera Seed	Yellow
Mondella	Seedway	Yellow
Scout	Johnny's	Yellow
Candy	Field grown transplants	Yellow
Yukon	Sakata	Yellow
Cherry Mountain	DePalmer Seeds	Red
Cabernet	Johnny's	Red
Monastrell	Johnny's	Red
Rossa di Milano	Johnny's	Red
Red Hawk	Bejo	Red
Red Mountain	Bejo	Red
Red Carpet	Johnny's	Red
Diamond Swan	DePalmer Seeds	white
Lyrica	Tozer	white
White Opera	Tozer	white

Results

Eighteen onion varieties (Table 1) were seeded on 12 February in 200 plug seed trays with soilless media. Transplants were cut and maintained on 14 March and 23 April at a 4-inch height in the greenhouse prior to transplanting in the field. Five hundred pounds of 19-19-19 per acre was incorporated into the soil prior to laying beds and transplanting the onions. Medal was applied at 1.5 pts/acre on May 3, 2018 for early weed control. Hand-pulling/hoeing of weeds was used the rest of the growing season. Growing conditions in 2018 were not ideal. While temperatures were average for the growing season, the area around the Horticulture Research Farm, Rock Springs set a summer rainfall record (previous record set in 2003). These weather conditions may have adversely affected yield and bulb size when compared to previous years.

The Pennsylvania standard yellow onion variety, Candy, yielded 15.38 tons per acre (Table 2) which was the highest not only among the yellows but throughout the whole trial. Scout, Aruba, and Yukon were the next highest yielding yellows at 13.43T/A, 12.4T/A, and 12.30 T/A respectively. Average bulb size for yellow varieties was highest with Yukon at 13.8 ounces (oz), followed by Mondella (13.1 oz.) and Aruba (13.0 oz.). Yukon's average bulb size was the highest for all varieties in the trial. For large bulbs, Mondella was the highest with 68 percent of bulbs greater than 3 inches in diameter.

Seven reds were trialed and the highest marketable yielding red was Red Hawk at 13.4 T/A followed by Red Mountain and Cherry Mountain at 11.5 T/A and 11.3 T/A respectively. Red Hawk also had the highest average bulb size at 11.4 oz with Red Mountain (10.1 oz.) and Red Carpet (10.7 oz.) the next highest. For large bulbs, Red Hawk was the highest with 55 percent of bulbs greater than 3 inches in diameter.

Three whites were evaluated and Lyrica was the highest yielding white variety at 13.0 T/A followed by White Opera at 11.5 T/A. Lyrica also produced the highest average bulb size at 12.3 oz. For large bulbs, Lyrica was the highest with 51 percent of bulbs greater than 3 inches in diameter.

Culls were very low with Red Mountain, Diamond Swan, and White Opera having the highest amount (Table 3). The pungency ratings for all the onion varieties fell into the very mild sweet onion level (1-4 micromoles of pyretic acid (Table 3). Five of the seven red varieties had the highest soluble solid levels in the trial (Red Carpet, Red Mountain, Rossi do Milano, Cherry Mountain, and Red Hawk). The highest soluble solids for the yellow and white varieties were Mondella and White Opera respectively. Sweet onions should be high in soluble solids and low in pyruvic acid.

Table 2. The marketable yield of eighteen Spanish onion varieties evaluated at the Horticulture Research Farm, Rock Springs, PA – 2018

Variety	Total MKT		
(Yield T/A)X	Avg. bulb		
(wt. – oz)Y	% LargeZ		
Aruba	12.5	13.0	64
Yosemite	10.0	12.2	54
Saffron	10.6	10.7	37
Rhino	8.9	10.9	32
Mondella	10.6	13.1	68
Scout	13.4	12.6	53
Candy	15.4	12.2	59
Yukon	12.3	13.7	61
Cherry Mountain	11.3	9.9	33
Cabernet	6.3	6.4	1
Monastrell	8.5	9.6	26
Rossa di Milano	9.0	9.0	23
Red Hawk	13.4	11.4	55
Red Mountain	11.5	10.1	37
Red Carpet	10.6	10.7	49
Diamond Swan	8.5	11.3	43
Lyrica	13.0	12.2	51
White Opera	11.6	11.6	49

X - The total marketable yield included all bulbs greater than 2.5 inches in diameter and is based on an onion population of 50,000 plants/A

Y - The average bulb weight in ounces included all bulbs greater than 2.5 inches in diameter

Z - The percent large bulbs included all onion bulbs greater than 3.0 inches in diameter.

Table 3. The cull numbers, soluble solids, and pungency rating of eighteen Spanish onion varieties evaluated at the Horticulture Research Farm, Rock Springs, PA – 2018

Variety	Total # of cull bulbs	% soluble solidsY	pungencyZ
Aruba	0	8.2	2.7
Yosemite	1	7.8	2.0
Saffron	3	8.6	1.3
Rhino	2	7.1	1.7
Mondella	1	8.8	2.6
Scout	2	6.7	1.7
Candy	3	8.1	2.6
Yukon	0	6.8	2.1
Cherry Mountain	0	9.3	2.0
Cabernet	0	8.8	3.1
Monastrell	0	8.4	2.4
Rossa di Milano	2	9.6	3.2
Red Hawk	0	9.0	3.4
Red Mountain	5	9.8	4.o
Red Carpet	3	9.9	3.1
Diamond Swan	5	7.4	2.1
Lyrica	5	6.7	2.2
White Opera	2	8.1	2.5

Y - The percent soluble solids (sugars) as measured by Waters Agricultural Laboratories, Camilla, GA

Z - Pungency was measured by determining the pyruvic acid content of the bulb by Waters Agricultural Laboratories, Camilla, GA. Onions may be classified as to pungency according to the following scheme:

- very mild sweet onion..... 1- 4 mmoles pyruvic acid/kg weight of bulbs
- mild sweet onion..... 5- 7 mmoles
- intermediate pungency..... 8-10 mmoles
- pungent.. .....11-15 mmoles
- very pungent.. ..... >15 mmoles

30 YEARS OF SNAP BEAN VARIETY TRIALS… WHAT LOOKS GOOD FOR 2019

James Ballerstein - Cornell Agritech - Cornell University Research Support Specialist - Horticulture

Brief History of Snap Bean Cultivar Progression over the years. Some other snap bean research (virus)
Procedure for the NY Snap Bean Variety Trials
Summary of 2018 Trial
Yield Tables for 2018 Below

Table 1. Yield Characteristics (3-4 sieve)

Cultivar	Days to harv.	Heat Units to Harv.	% 2 Sieve	% 3 Sieve	% 4 Sieve	% 5 sieve	2-4 % Sieve	3 sieve seed length (mm)	4 sieve seed length (mm)	Plants per foot	T/A Harvest
Camaro	64	1267	6	24	44	26	74	81	99	7.3	5.2
SVGG2053	64	1267	20	37	36	8	92	85	96	7.5	4.4
SV1136GF	64	1267	8	41	42	9	91	89	94	7.0	7.4
Jaguar	64	1267	14	28	55	4	96	94	106	7.1	4.9
BSC897	64	1267	20	32	46	3	97	83	105	7.2	6.0
Echo	62	1221	30	41	27	3	97	86	103	7.5	5.4
Colter	62	1221	10	16	57	17	83	94	111	7.1	6.4
Annihilator	62	1221	7	14	60	19	81	80	97	7.3	6.4
Dominator	64	1267	10	15	45	30	70	79	103	6.3	5.3
SB4738	64	1267	7	17	58	18	82	82	96	7.1	7.8
SB4748	62	1221	6	10	55	29	71	81	99	7.2	6.9
Cabot	65	1290	15	22	56	7	93	84	99	8.7	6.0
Cassidy	65	1290	33	42	23	2	98	95	102	7.9	4.6
Sybaris	65	1290	11	16	62	11	89	83	100	7.8	7.2
Baltimore	65	1290	22	23	51	4	96	81	106	8.1	4.4
BSC934	65	1290	75	21	3	1	99	88	109	8.4	3.6
BEX034	65	1290	58	28	14	0	100	104	112	7.6	3.5
Paloma	65	1290	18	30	43	8	92	94	108	7.0	6.3
587	65	1290	40	29	29	2	98	98	108	7.7	3.9
Affirmed	67	1325	18	30	45	7	93	74	99	7.4	6.2
Messi	67	1325	33	29	34	5	95	71	98	8.3	3.8
BEX057	67	1325	27	36	34	2	98	78	91	7.6	5.3
SB4754	67	1325	24	16	33	26	74	80	103	7.8	7.2
Wax											
SV1003GF	67	1325	14	14	55	17	83	82	109	6.0	6.0
Goldmine	65	1290	16	16	50	18	82	77	97	6.7	4.5

Table 2. Yield Characteristics (large bean planting date 5/24)

cultivar	Days to Harv.	Heat Units to Harv.	% 2 Sieve	% 3 Sieve	% 4 Sieve	% 5 Sieve	% 6 Sieve	% 2-4 sieve	4 sieve seed length (mm)	5 sieve seed length (mm)	Plants per foot	T/A Harvest
Venture (std	60	1100	2	3	7	32	56	12	114	124	6.8	4.4
CR1218	60	1100	2	3	25	54	16	30	115	125	6.1	4.8
CR1218	62	1146	2	4	17	54	22	24	115	130	8.4	6.4
CR1218	64	1189	2	3	12	54	28	17	116	130	8.4	5.9
Bridger	61	1121	2	4	10	36	47	16	105	119	6.9	4.9
Bridger	63	1169	2	6	7	14	71	15	116	120	7.5	4.8
Bridger	65	1213	2	6	8	19	65	15	113	139	8.4	5.2
BBL156	63	1169	3	3	12	32	52	17	92	110	7.6	7.0
BBL156	65	1213	3	4	12	34	48	19	100	115	7.7	6.9
BA1001	61	1121	2	4	14	53	27	20	89	96	7.4	4.8
BA1001	63	1169	1	3	5	34	57	9	93	102	7.2	4.4
BA1001	65	1213	2	2	10	35	50	15	108	117	7.4	4.9
Silverado	61	1121	2	7	22	40	30	30	80	85	7.0	3.4
Silverado	63	1169	3	3	10	29	55	16	87	94	7.0	4.0
Silverado	65	1213	5	5	10	33	47	20	100	113	7.6	5.0
524	61	1121	2	4	43	44	7	49	99	107	6.4	5.6
524	63	1169	1	4	30	47	18	35	100	105	7.5	5.8
524	65	1213	1	2	18	52	26	22	111	121	7.3	6.3
4624-3	61	1121	1	2	14	45	37	18	94	101	7.1	4.7
4624-3	63	1169	2	6	12	27	53	20	98	104	7.2	5.3
4624-3	65	1213	6	6	10	21	57	22	99	114	7.9	5.8
Huntington	62	1146	2	5	18	50	24	26	81	96	6.7	5.3
Huntington	64	1189	1	2	12	43	42	15	94	102	7.8	5.2
Huntington	67	1254	1	4	8	26	61	13	109	112	8.1	5.6
Pismo	62	1146	1	3	16	50	31	20	86	97	7.2	4.4
Pismo	64	1189	2	5	14	40	39	21	96	105	8.9	4.7
Pismo	67	1254	2	4	8	26	61	14	103	113	8.3	4.8
GVS17	62	1146	4	7	21	36	33	31	94	109	6.8	5.7
GVS17	64	1189	2	5	22	40	31	30	87	115	7.5	4.9
GVS17	67	1254	1	7	16	26	50	24	102	109	8.0	4.8
UW#4	62	1146	2	5	22	41	30	29	79	110	6.6	6.1
UW#4	64	1189	3	6	20	45	27	28	115	121	8.0	5.8
UW#4	67	1254	2	4	16	41	36	23	111	130	7.3	5.8
PV857	62	1146	2	3	20	48	27	25	101	110	6.6	6.2
PV857	64	1189	2	2	21	50	26	25	109	122	8.6	6.1
PV857	67	1254	2	3	17	50	29	21	114	130	7.8	6.0
Chisolm	63	1169	2	5	6	22	65	13	79	84	6.6	4.2
Chisolm	65	1213	1	3	5	19	71	10	91	98	7.7	5.1
Chisolm	67	1254	1	4	5	12	77	10	88	108	7.4	6.1
SB4754	63	1169	3	6	11	46	34	20	84	93	6.8	4.8
SB4754	65	1213	2	4	12	38	44	18	93	114	8.8	5.3
SB4754	67	1254	2	9	11	34	45	22	115	117	8.0	6.2
HMX0164494	65	1213	10	9	17	24	40	36	78	87	7.1	2.7
HMX0164494	67	1254	5	8	21	26	39	34	63	96	7.4	4.1

Table 3. Yield Characteristics Whole and Extra Fine

Cultivar	Days to Harv.	Heat Units to Harv.	% 2 sieve	% 3 sieve	% 4 sieve	2 Sieve Seed Length (mm)	3 sieve seed length (mm)	Plants per Foot	T/A Harvest
Whole Beans									
Flavor Sweet	63	1303	33	38	29	67	83	7.7	5.1
SV1286GW	63	1303	64	30	6	67		8.1	4.0
Blevet	63	1303	99	1	0	66		8.7	5.1
Weston	63	1303	50	35	15	72	97	7.7	4.0
Oakley	63	1303	73	24	3	89	97	8.5	4.2
Greenfield	64	1322	81	19		98		6.6	3.3
Elegance	64	1322	100			83		6.6	3.9

Cultivar	Days toHarv.	Heat Units	% 1sieve	1 Sieve Seed Length (mm)	Plants per Foot	T/A Harvest
Extra Fine						
DX170	63	1303	100	78	7.7	4.4
Denver	65	1336	100	64	7.4	4.0
Compass	65	1336	100	74	6.9	4.3
Astute	65	1336	100	74	6.5	4.3
Crosser	63	1303	100	74	6.6	4.2
Surfer	65	1336	100	74	7.7	4.1
Zanibar	65	1336	100	76	8.0	3.2

Full report available upon request.

WHITE MOLD MANAGEMENT IN A DIGITAL ERA

Sarah Pethybridge[a], Julie Kikkert[b], Beth Gugino[c], Ethan Hughes[d], Jan van Aardt[d], and Denis Shah[e]

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White mold, caused by the fungus, *Sclerotinia sclerotiorum* continues to be one of the highest priority diseases for snap bean growers in the Northeastern United States. Infection of snap bean flowers leads to direct losses from diseased pods (Fig. 1), canopy collapse making harvest problematic, and additional sorting may be required to discard moldy pods after harvest. The disease also leads to substantial production of sclerotia (hard, compact resting bodies of the fungus) that fall back into the soil and survive for many years. Sclerotia pose a risk for additive loss in future crops that are susceptible to white mold grown in the same field. Sclerotia remain in the soil during winter and upon exposure to cold temperatures for several months, become 'conditioned' and can germinate to produce 'apothecia' (i.e. small mushroom-type structures; Fig. 1) upon which ascospores are produced. Ascospores are liberated into the wind and infect senescing flowers to initiate the disease.

White mold is a challenge to manage due to the long-lived sclerotia of the fungus in the soil, the broad host range

Fig. 1. White mold caused by the fungus Sclerotinia sclerotiorum in snap bean cv. Huntington (left). A key part of the lifecycle of S. sclerotiorum is the germination of sclerotia to produce apothecia (right) upon which ascospores are liberated to infect snap bean flowers.

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of the pathogen, including many field and vegetable crops in typical rotations, and the absence of appreciable host resistance. Management strategies to reduce inoculum (i.e. sclerotia) in the soil need to be highly effective to reduce the level below approximately 1 sclerotia/ft of beans. Recommendations for the management of sclerotia using tillage are mixed. Burying sclerotia reduces viability if done for at least three years. However, regular tillage will move new populations of sclerotia to the upper profile where they can germinate and cause disease. Rotation to non-host crops (e.g. cereals) may also achieve reductions in sclerotial inoculum but are complicated by common weeds (e.g. velvet leaf) in these crops also being hosts. Narrow rows and high plant populations typical of modern farming practices also exacerbate white mold.

An additional major challenge in managing white mold is the uncertainty in knowing in which fields outbreaks will occur. Due to this uncertainty, white mold control often relies upon preventative application of fungicides because of the potential for high crop loss and absence of fungicides with substantial eradicant activity. Until the early 2000s, the fungicide Ronilan® (vinclozolin) was the most commonly used for the management of white mold in snap bean. Ronilan® was highly efficacious and only applied when white mold was initially observed. Registration of Ronilan® was revoked because of human health and environmental concerns and replaced by fungicides with predominantly protectant and contact activity, such as Topsin®. However, despite the intensive use of fungicides, poor or suboptimal control of white mold persists and annual epidemics result in substantial crop loss.

The objective of our white mold research and extension program has been to i) identify factors that may contribute to the poor control of white mold in snap bean and ii) the site-specific risk factors contributing to white mold outbreaks. A complementary objective was to iii) evaluate new and innovative methods to use digital agriculture tools for white mold control.

Factors contributing to poor white mold control

One explanation for poor white mold control despite fungicide application is the development of resistance to the commonly used modes of action. A survey was conducted and over 150 *S. sclerotiorum* isolates were collected from snap bean fields exhibiting poor disease control to test for sensitivity to the fungicides Topsin® 4.5FL (thiophanate-methyl), Omega® 500F (fluazinam), and Endura® (boscalid). All isolates were highly sensitive to fluazinam and boscalid. Approximately 30% of isolates were less sensitive to thiophanate-methyl than isolates that had not been exposed, but this was not attributed to true resistance. The potential for fungicide resistance within *S. sclerotiorum* populations to have an impact upon white mold control has therefore been discounted.

Small-plot replicated trials conducted at Cornell AgriTech at The New York State Agricultural Experiment Station in Geneva, NY since 2015 have also evaluated the efficacy and optimal timing of Topsin® 4.5FL, Omega® 500F, and Endura®. Trials used cvs. Huntington and Denver with a 30-inch row spacing, an in-row plant density of ~9 seeds/ft, and inoculated with *S. sclerotiorum* ascospores using a backpack sprayer. Trials demonstrated that two applications of either Topsin® 4.5 FL, Omega® 500F or Endura® were highly and equally efficacious for white mold control. In timing trials, fungicides were applied at either early (10%) and/or late (100%) flowering. Application of Topsin® 4.5 FL at early flowering was optimal for disease control and a second application at late flowering did not generally improve control. In contrast, if Topsin® 4.5 FL was delayed until late flowering, the control of white mold was poor and, in some cases, did not significantly differ from nontreated plots. Timing of Endura® and Omega® 500F was more flexible and not significantly different between a single application at early or late flowering. A second application of either of those products did not significantly improve white mold control. Delaying the application of Topsin® 4.5 FL to later in flowering may therefore be one contributing factor in the poor control of the disease in snap bean. Optimal timing of Endura® or Omega® 500F appears less critical and may offer growers flexibility when conditions are not optimal for application early in flowering and allow for rotation to different modes of action but with trade-offs in cost.

Similarly, timing of OMRI-approved products for white mold control in snap bean are also critical. In complementary trials conducted at Geneva, the most efficacious OMRI-approved treatments were the biopesticides Double Nickel™ LC (1 qt/A; Certis USA) and Stargus™ (1 qt/A; Marrone Bio Innovations). These products both contain *Bacillus amyloliquefaciens* (but different proprietary strains). Two applications were required beginning at early flowering (10% of plants with at least one open flower).

Site-specific risk factors for white mold in snap bean

To identify the site-specific risk factors associated with white mold in snap bean, a historical dataset from surveys conducted in 2006, 2007 and 2008 by Helene Dillard and Denis Shah (Cornell University) was analyzed. In this survey, white mold was present in 20% of fields. Factors evaluated for their association with white mold presence included cultivar and sieve size, planting month, soil type, canopy openness at bloom and pod development, and elevation. The most influential predictors (in decreasing order) were: canopy openness during pod development, the number of days after planting, hydrological soil group, canopy openness during bloom, and elevation. There was a sharp increase in the risk of white mold when the canopy was more than approximately 73% closed at bloom or more than approximately 60% closed at the pod development stage.

Precision agriculture tools and white mold

The increasing popularity of precision agriculture tools has offered broadacre vegetable and field crop growers improvements in productivity and management efficiency. For example, plant health can be evaluated using sensors to optimize yield with in-season nitrogen application or to predict yield based on spectral metrics throughout the season and counts of the number of harvestable units. Since timing of Topsin® 4.5 FL is a critical issue in achieving optimal white mold control, our research has evaluated canopy spectral signatures to assist in fungicide scheduling to protect snap bean flowers from infection by *S. sclerotiorum* ascospores. A DJI Matrice-600 unmanned aerial system (UAS) was used to acquire imagery with a high-resolution color camera, Headwall Photonics Nano imaging spectrometer (272 color bands between 400 and 1,000 nm), and a Velodyne VLP-16 light detection and ranging (LiDAR) system, before and at flowering, and during pod development. Over a broad range of planting dates in cv. Huntington, wavelengths with the highest accuracy in predicting the presence of flowers were 521 nm, 543 nm, 672 nm, 761 nm and 785 nm at accuracies >90%. The algorithm rapidly detects snap bean plants, and then assesses flowering using only these silicon-range (affordable, operational range) wavelengths. Next steps involve calculation of canopy structural metrics from LiDAR and structure-from-motion (3D imaging) to assess critical openness variables and white mold risk. The long term goal therefore is to evaluate such an innovative remote assessment using a UAS system in the near infrared (silicon) range, or with standard vegetation spectral indices, alongside structural assessments of crops, to identify spatially-explicit white mold risk and therefore when/where it is cost effective to apply fungicides.

Acknowledgments. We are grateful for funding and cooperation from the Pennsylvania Vegetable Marketing and Research Program and Pennsylvania Vegetable Growers Association, the New York Vegetable Research Association and Council, USDA-NIFA Critical Agriculture Research and Extension Award Number 2017- 68008-26207.

EDIBLE FLOWERS AN INDUSTRY OVERVIEW

Thomas G. Ford
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Edible flowers are a staple in a variety of Asian, New American, and Mediterranean cuisines and have become a profitable crop for growers in this era of social media and self-documentation. Edible flowers are utilized by chefs to stimulate the visual appeal of a plated meal and to impart subtle flavors to a variety of fresh salads and culinary creations. Edible flowers are also used to infuse teas and fruit flavored drinks and to add a floral garnish to adult beverages like martinis and cocktails.

There are over 72 common flowers that are considered to be edible by most experts. While this may seem like a rather small list, consumers and growers need to recognize that many flowers contain compounds which can be toxic to humans in very small amounts. Never guess or experiment with flowers that have not been documented by the industry to be edible. One small mistake can put you and your farm in legal jeopardy if a plant poisoning occurs because of the ingestion of a flower sourced from your operation.

When considering growing edible flowers for market make sure that the flower to be grown is first deemed edible. Second, never purchase transplants and/or plugs for edible flower production if they were not specifically grown for that purpose. Many edible flower cultivars are rendered inedible due to the application of crop protectant chemistries and/or plant growth regulators in the production phase in the greenhouse. Many of the plant growth regulators and crop protectant chemistries labeled on floral crops do not have legal tolerances established for plant parts that are to be consumed by humans. As a result, most edible flowers are produced utilizing organic production methodologies and biocontrol.

Edible flowers are best produced under protective culture to ensure floral quality and to maximize production. Edible flowers are frequently harvested directly into clamshells and sent to market. Typically, most edible flowers have a 7-10-day shelf life if placed in refrigerated storage.

Pricing for edible flowers is dependent upon the specific flower marketed, the quantity sold, and the local market. Edible flowers can fetch a premium price at white table cloth restaurants in urban areas. Prices for edible flowers can range in price from $0.50 to $1.25 a flower in a 24 to 48 count clamshell container.

Edible flowers are a niche crop for many producers. While edible flowers can fetch a lucrative price, the market can be volatile at times which may leave growers with excess inventory on their hands which can lead to deeply discounted products and limited profitability. Growers/entrepreneurs interested in edible flowers should contact area chefs first to gauge their interest before embracing this micro-enterprise.

Edible Flowers for Mid-Atlantic Growers

Common Name	Flavor Profile	Potential Uses
Anise hyssop	Anise or Licorice	Used as a seasoning, in teas, and in potpourris
Basil	Spicy	Seasoning
Bee Balm	Citrus-like, mint-like	Infuse drinks or use in teas

Thomas Ford has worked for over 35 years with Cooperative Extension in Maryland, North Carolina, and Pennsylvania. During his career he has worked intensively with vegetable and fruit growers, greenhouse and nursery operators, landscape and turf professionals and area farmers with their production and pest management issues. Tom is a native of Central Maryland and resides with his wife, Laura and their four sons in Duncansville, PA. Tom has a B.S. degree in Ornamental Horticulture from the University of Maryland and a MBA from Frostburg State University in Frostburg, MD. Tom currently serves as a Commercial Horticulture Educator with Penn State Extension and is housed in the Cambria County Extension Office in Ebensburg, PA.

Common Name	Flavor Profile	Potential Uses
Begonia	Citrus	Eaten raw or used in sauces
Borage	Cucumber-like flavor	Eaten fresh or used as a garnish
Broccoli flowers	Spicy	Eaten fresh
Calendula	Peppery or tangy	Used as a garnish
Chervil	Licorice-like	Seasoning
Chicory	Bitter	Eaten raw
Chives	Strong onion flavor	Use as a garnish
Chrysanthemum	Mild flavor	Used raw or to make beverages
Daylily	Asparagus flavor	Used fresh or dried
Dianthus	Clove flavor	Garnish
Elderberry	Sweet	Used to make syrups
Hollyhock	Bitter	Edible garnish
Lavender	Sweet	Flowers can be candied
Marigold	Spicy	Use in teas
Marjoram	Sweet/spicy	Seasoning
Mint	Sweet/minty	Use in teas and beverages
Nasturtium	Peppery	Salads and garnishes
Oregano	Spicy	Seasoning
Pansy	Wintergreen	Use fresh as a garnish or candied
Garden Pea	Pea-like	Use in salads or as a garnish
Radish	Spicy	Use in salads
Squash	Mild	Batter and deep fry, use in soups
Thyme	Milder than the leaf	Seasoning
Violet	Sweet	Eaten raw or candied

Source: Lauderdale, Cyndi, Bradley, Lucy. 2014. “Choosing and Using Edible Flowers”. NC State Extension

CARING OF FIG TREES

Bill's Fig Trees, William Muzychko
329 Old York Road
Flemington, NJ 08822
wmuzy@comcast.net (908) 806-4887 (732) 407-6980

Mr. Muzychko is the founder and owner of Bill's Figs located in Hunterdon County, New Jersey. At Bill's Figs he manages every stage in the life of a fig tree including the planting, growing, picking, pruning and winterization of every tree he grows. He now has over 200 varieties of fig trees with even more in development.

Fig trees are warm weather plants that need special care in cooler climates such as New Jersey. Fig trees cannot survive outdoors in the northeast without being sheltered or covered. Remember helping your grandfather use tarp, burlap, insulation and whatever else was available to wrap his fig tree like a mummy for the winter? Or did your father dig a trench and try to get all the branches of the tree bent over and covered in the trench for the winter?

This explains the cumbersome and unsightly contraptions that folks have developed to protect their fig trees from killer frosts that are so common in our area during the winter.

Mr. Muzychko has developed a system that not only eliminates the need to "bury" fig trees during the winter months but also dramatically increases crop output. Each of his trees comes with a unique, built-in irrigation system that will allow you to bring your tree into your garage or barn for the winter, if purchased. His system guarantees that your fig tree will be given the correct amount of water and fertilizer that it will need at any given time during the year.

Come springtime, instead of being faced with the unpleasant task of having to remove all of the tar-paper, old carpets and cardboard boxes that you used to swaddle your fig tree during the winter, all you have to do is bring the fig tree that you purchased from Bill's Figs outdoors for the growing season.

Bill's watering and potting system eliminates all worries with over wintering your tree. Just move your tree into an unheated garage or shed and let it rest, dormant for the winter. Then remove it in the spring. No winter care at all! Below are your simple to follow care instructions.

1. Placement of your tree. Place your tree in a sunny outdoor place, once all

chance of frost is over or cover the tree when frost is predicted. Bring it out in mid-April. It can remain outdoors until the end of November. If the weather remains warm a few of the fruit currently on your tree may ripen yet this year.

2. Watering. Water your tree using the patented watering system. There is a watering spout at top of the pot, near the base of the tree. In the cooler weather of the fall your tree can probably be watered every 3 or 4 days. In the summer your tree will need to be watered every day. With the EZ-Care watering system there is no worry or guesswork. You cannot over water your tree. On the side of the pot there is an overflow weep hole. When your tree has enough water it will overflow out of the hole. If you wonder whether your tree needs water, try watering it and your question will be answered virtually immediately. Do not permanently remove the black plastic on the top of the pot. It insures that water is not lost to the air (and also helps keep the roots warm in early spring and prevents weeds from growing).

3. Over-wintering. Your tree will survive the first frost – so do not worry. It will not survive a heavy period of freezing. Given normal weather conditions, your tree can stay out doors until Thanksgiving, by which time it should drop its leaves and go dormant for the winter. Bring your tree into an unheated garage or shed and place it in a darker area

William Muzychko is the founder and owner of Bill's Figs located in Hunterdon County, New Jersey. At Bill's Figs he manages every stage in the life of a fig tree including the planting, growing, picking, pruning and winterization of every tree he grows. He now has over 200 varieties of fig trees with even more in development.

for the winter and forget it until spring. The shed or storage place should not freeze and the temperature should be kept just above freezing. It should be watered periodically, ie. once a month, no other care is needed for the winter. Bring your tree out doors when all danger of frost has passed. Place it in sunny area and water! You are set.

4. Trimming. You should trim the tallest branches of your tree back by up to one third of their length before you bring it indoors. Do not worry. You can not make a mistake. Fig trees love being cut back and 3 or 4 new branches will appear the next year where you cut the branch back. And figs develop on the near year's growth so your trimming will bring you a larger crop. If you want to keep the tree its present size for over wintering storage or to make it easy to move, trim it to your needs in the fall. Your tree can be moved with a standard hand truck initially and then with a fig mover (see Bill).

5. Fertilizing. Your tree is already potted with fertilizer. However you should reinvigorate the fertilizer once a year in the spring. "This takes around 5 minutes". Remove the black plastic cover. Take about (7 oz) of Osmocote fertilizer for the garden (14 – 14 – 14) and work it into the top of the soil. **FOLLOW THE LABEL DIRECTIONS ON THE FERTILIZER**. Do not over fertilize. Your tree will be unhappy. Once in the spring is enough. When first potting the tree, stir in 10 cups of granular limestone to adjust the soil PH. Figs thrive at a soil PH of 7.75 – 8.00.

6. Picking the fruit. Fig trees do not flower. You will see the small figs develop late in the spring. Your crop will begin to come in, in late summer (late August or September). The fruit are ready when they start to feel soft. Some year's particular varieties may develop ripe fruit in the early spring and then again in the late summer.

CHOOSING AND USING PRODUCT CONTACT SURFACE SANITIZERS

Meredith Melendez , Rutgers NJAES Cooperative Extension of Mercer County
Wesley Kline, Rutgers NJAES Cooperative Extension of Cumberland County

There are many ways that product contact surfaces can come to harbor human pathogens. Normal production of fresh produce involves the potential for contact with soil, farm workers, harvest and packing equipment, irrigation water and postharvest water to name a few. Once contaminated these items, considered food contact surfaces, can spread the pathogen onto the produce that it touches. Contact surfaces vary from farm to farm, the easiest way to identify them is to trace produce from the field to the sales location identifying each surface along the way. Direct marketers need to consider the potential risk with pick-your-own containers, product displays, and shopping containers and bags. Product contact surfaces must be washed, rinsed and sanitized regularly to reduce the likelihood of human pathogen contamination. Surfaces that come in contact with produce must be easy to assess for cleanliness, easy to clean and easy to sanitize. This may require you to take apart the equipment, particularly if conveyers, rollers or brushes are components.

Human pathogens, such as *E. coli*, Salmonella and Listeria, can grow on surfaces when the environmental conditions are appropriate. These pathogens thrive, and reproduce, in moist conditions. Smooth surfaces are much easier to clean than rough surfaces, and wood cannot be sanitized. Keep in mind that even stainless steel surfaces can harbor pathogens if not cleaned and sanitized properly. A regular cleaning schedule must be developed utilizing appropriate cleaners and sanitizers. Standard operating procedures (SOPs), or detailed instructions, must be written and posted describing how and when the cleaning and sanitizing produces will take place.

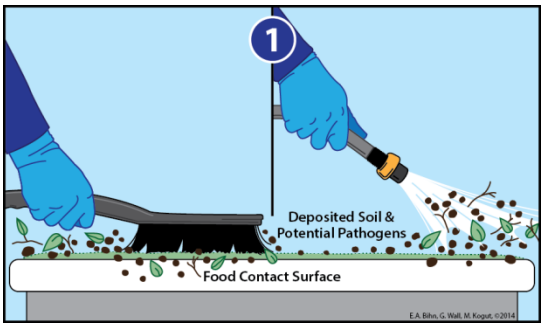
Picking a sanitizer

There are many sanitizers available on the market for use, including approved for organic use sanitizers. Options include chlorine, peroxyacetic acid, quaternary ammonium, hydrogen peroxide and others. Using too little of a sanitizer is ineffective, and too much of a sanitizer can cause damage to the surface you are cleaning. Consideration should be given to compatibility of the surface to be sanitized with the sanitizer. Incompatibility can reduce the effectiveness of the sanitizer and degrade the surface. This is also true for the detergent used to clean the surface. Label instructions should give guidance on what detergents are acceptable for the sanitizer. Be sure to read labels of the sanitizers, often available online, prior to purchase. Each sanitizer will have its own instructions for use, which can vary considerably.

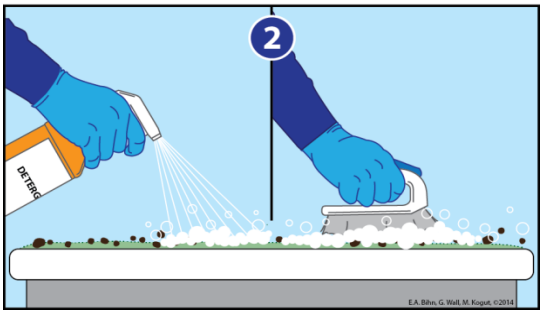
What is proper cleaning and sanitization of product contact surfaces?

Cleaning is the removal of dirt from surfaces which uses clean water and detergent. Sanitizing is the treatment of a cleaned surface to reduce or eliminate microorganisms. Dirty surfaces cannot be sanitized, the soil can render the sanitizer ineffective. Cleaning must take place before sanitization. Always use clean water that is free from generic *E. coli* for all cleaning and sanitizing steps.

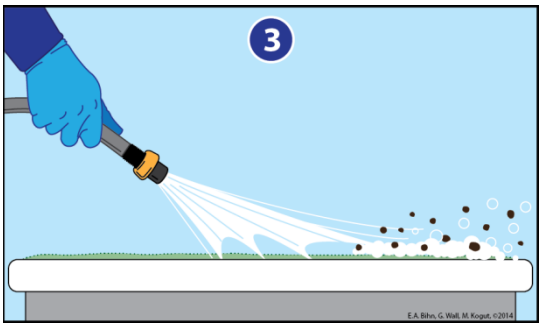
Meredith Melendez is the Agricultural Agent for Rutgers Cooperative Extension of Mercer County. She has worked for Rutgers Cooperative Extension since 2006, working with Mercer County agricultural producers since 2010. Meredith is responsible for agricultural educational outreach and research in including beginning farmer outreach, organic production systems and on-farm food safety. Meredith is a member of the Rutgers On-Farm Food Safety Team, the New Jersey Food Safety Task Force, the Rutgers Vegetable Working Group, the NJAES Agritourism Working Group and Annie's Project NJ. She has a Bachelors Degree in Plant Science from Ferrum College and a Masters in Environmental Conservation Education from New York University.



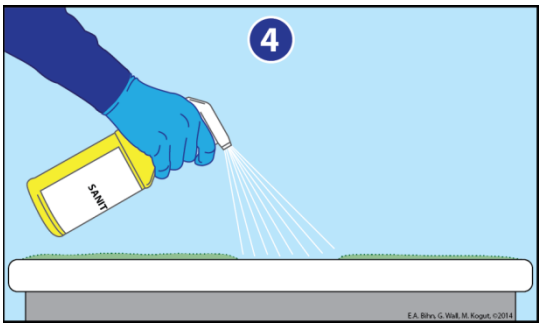
Step 1: Remove any obvious dirt and debris from the food contact surface.



Step 2: Apply an appropriate detergent and scrub the surface.



Step 3: Rinse the surface with clean water, making sure to remove all of the detergent and soil.



Step 4: Apply a sanitizer approved for use on food contact surfaces. Rinsing may be necessary
Let the surface air dry.

Critical points to consider:

- Only use sanitizers that are approved for food contact surfaces, and follow the label directions exactly.
- Develop a regular cleaning schedule with a written SOP detailing the products used, how they are used, and the steps involved in cleaning and sanitizing the surfaces. Daily sanitizing is best!
- Utilize smooth surfaces that cannot absorb water as your product contact surfaces, wood can be covered with linoleum or painted with food grade paint.
- Avoid cracks and crevices in your packing areas, these are difficult to clean and sanitize.
- Train workers annually on Worker Health and Hygiene, including proper handwashing.
- Train workers annually on the importance of sanitation and the farms developed SOPs.
- Workers must wear clean clothing daily.
- When gloves are used workers must be trained on how to use them so they do not become a contamination source.
- Remove surface moisture in the packinghouse/area whenever possible using squeegees and fans.
- Remove culls from the packing area daily so they do not become an attractant for wildlife.
- Utilize a pest control program in the packing and storage areas, focusing on rodents and other wildlife intrusions.
- Remove as much soil as possible from produce in the field, not in the packing area.
- Use new containers or containers that can be cleaned and/or sanitized to pack and display produce.
- Storage areas and coolers should be monitored for cleanliness, and be included in the rodent control program.

Resources:

Sanitation and Postharvest Handling. National Good Agricultural Practices Program, Cornell University. 2016. https://gaps.cornell.edu/educational-materials/decision-trees/sanitation-and-postharvest-handling

Small Scale Postharvest Handling Practices. University of California, Davis. 2003. http://ucce.ucdavis.edu/files/datastore/234-1450.pdf

*Photos curtesy of the Produce Safety Alliance

SOIL HEALTH AND YOUR FARM:

Denny Wildman
Advanced Agriculture & Assoc East

Soil Health is becoming a very popular topic, and there's considerable hype about soil health all around us. But what does this mean for practical fruit and vegetable production in 2019 and beyond? Have you ever wondered why your favorite fertility programs aren't working like they used to? Why are we being challenged with additional plant issues?

We'll take a detailed look at vegetable crop research conducted at Penn State as well as other locations where vegetable growers have experienced positive results by simply improving their soil structure. Better soil tilth brings improved utilization of fertilizer and better drought resistance through improved water management. We know that the benefits of improved nutrient exchange reduces plant stress which improves pollination, fruit set, and overall farm profitability.

Denny Wildman

- Raised on the family dairy farm, where he still farms with his son and family.
- Studied Soil Science, Plant Biology, and Ag Engineering at State University of NY, Cobleskill College of Agriculture and Technology
- Founded Advanced Ag East LLC --- where for 40 years has assisted growers understand the language of the plant, and the science of preserving yield.
- Founding member of the International AG Associates Conference – now in their 25th year
- Crop Consultant and Field Researcher for several leading edge Agri-Business companies
- Married to wife, Beth, (3 children, and 5 grandchildren)

NEXT GENERATION CEA PRODUCTIVITY SYSTEM

Tim Ransford, Principal
Anglesea LLC, Chicago IL.

This is a technology story with a range of benefits for the Controlled Environment Agriculture space. For the past several years, we have been reducing grower risks and improving productivity at a net energy savings. The modular, portable or permanent system is suitable for high tunnels and indoor growing facilities in scale.

Please join us to learn how to improve your productivity.

Discussion Items:

Heating solutions…the good, the bad and the ugly

How to reduce the delay, damage or total destruction of your crops

How to improve quality, yield and time to maturity

High value crops and high market pricing

Schedule certainty

Scale, a portion of a row, to microgreens, to whole tunnel heating

Profit expectations

Tim Ransford, Principal, Anglesea LLC, Chicago IL.
2013 to Present, An independent business/product development consultancy. Current focus on agriculture and addressing multiple heating needs in the CEA space. These range from primary heating for new construction, in concrete or retrofit, both buildings and greenhouses…to modular, portable and tactical heating of the growing environment in high tunnels. With unmatched efficiency, safety and flexibility, this technology will become standard.
Other applications under the umbrella of the technology include industrial ground thaw, rapid deployment shelter heating for the military and primary heating for commercial and residential applications.
Prior to 2013, I spent my career in the financial sector from futures trading to financial services.

RESEARCH UPDATES ON SENSOR-BASED IRRIGATION SCHEDULING STRATEGIES

Long He, Daeun Choi, James Schupp, Tara Baugher
Penn State Fruit Research and Extension Center, 290 University Drive, Biglerville, PA 17307

Irrigation is the application of controlled amounts of water to plants at needed intervals. Irrigation helps grow agricultural crops, maintain landscapes, and revegetate disturbed soils in dry areas and during periods of inadequate rainfall. Currently, most irrigation is applied based on grower experience or simple observations. This may lead to the waste of over-irrigation or the ineffectiveness of under-irrigation. When correctly employed, appropriate irrigation scheduling methods may reduce water usage and increase profitability and sustainability. In this study, different sensor systems and technologies have been investigated and tested for precision irrigation, including drip irrigation, weather-based, soil-based and plant-based sensor systems.

Drip Irrigation System

Drip irrigation is a type of micro-irrigation system that has the potential to save water and nutrients by allowing water to drip slowly to the roots of the plants, either above the soil surface or buried below the surface. Drip irrigation has been widely used in the Mid-Atlantic region. Beside the high water use efficiency (90%-95%), drip irrigation also could reduce the risk of plant diseases that thrive in wet conditions.

Experimental Setup

A sensor-based irrigation test was conducted at Fruit Research and Extension Center research orchard at Biglerville, PA. This is a 0.9-acre Fuji block, located at a location with relative high elevation. Figure 2 shows the research Fuji block with drip irrigation system. There are total nine row of apple trees. The emitter space along the tube is 24 inches, the size of the tube is 0.5 inch. Figure 1 shows the layout of the experimental design. Four irrigation treatments were designed, and two rows of trees were used for each treatment. The treatments include conventional method which is determined by the experience of the operator; ET based irrigation, which was based on the calculation of the daily based ET and rainfall; crop water stress based irrigation, and soil moisture sensor based irrigation.

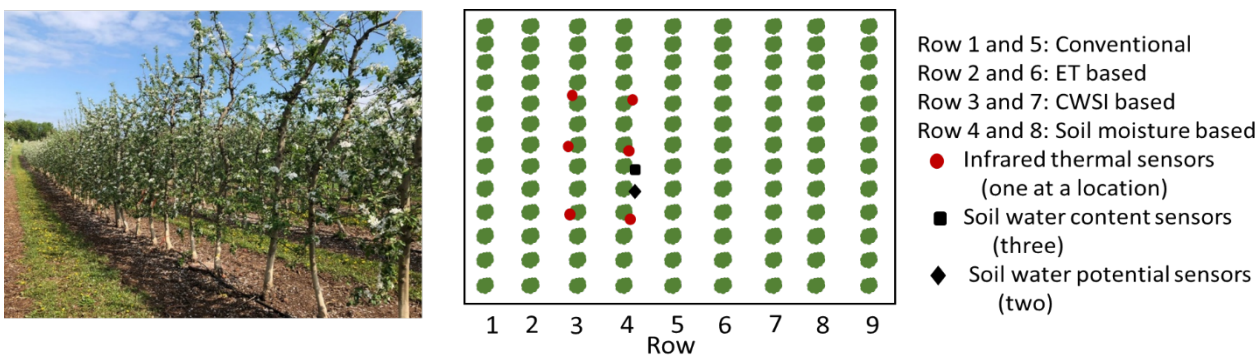
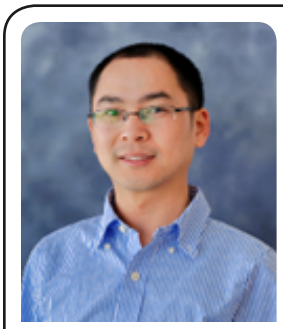


Figure 1. The experiment site and the treatments setup for sensor-based irrigation test



Long He is an Assistant Professor and Extension Specialist in specialty crop production at Penn State Fruit Research and Extension Center. His research and extension interests are mainly on mechanization and automation for specialty crop production, and precision agriculture. He has Ph.D degree in Mechanical Engineering. Before started at Penn State, he was a postdoc research associate and research engineering at Washington State University and University of California at Davis. He and his wife Ying have three daughters, Taryn, Elaine, and Grace.

Crop Water Stress Based Irrigation

Canopy temperature has been shown to be an indicator of plant water stress. Infrared thermal sensors are a good way to measure the canopy temperature to assess crop water stress. Figure 2 shows the thermal sensor, data logger, the installation of sensors in the field, and the data acquisition system. The sensor was mounted on the top of the canopy within about 1ft distance with facing down to the tree leaves. Six sensors were installed in two neighboring rows, and the data was recorded at 5 minutes interval into the data logger.

Figure 2. Infrared thermal sensor system setup, a) Infrared thermal sensor and datalogger; b) the installation of the thermal sensor on the top of tree canopy; c) data acquisition system

To identify the crop water status, the crop water stress index (CWSI) can be calculated using the canopy temperature and weather data, such as air temperature, relative humidity, day of the year, wind speed, and solar radiation. The CWSI could be calculated using the equation in Figure 3a. The CWSI is a value between 0 and 1, with larger number indicating more on water stress. A threshold value of CWSI was selected for the decision of irrigation event, based on the previous studies, 0.4 was selected in our study.

a)

$$\text{CWSI} = \frac{\Delta T_m - \Delta T_l}{\Delta T_u - \Delta T_l}$$

- ΔT_m: Measured difference of canopy and air temperature
- ΔT_u: Difference of canopy and air temperature for non-transpiring canopy
- ΔT_l: Difference of canopy and air temperature for well-watered canopy

b)

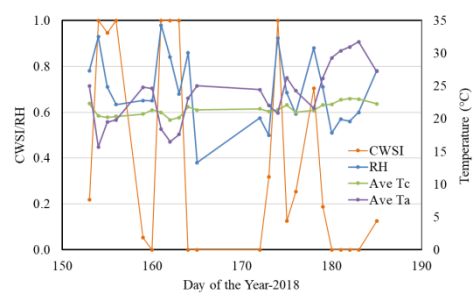


Figure 3. Crop water stress index and other specifications of the monitored tree rows

Figure 3b shows the preliminary results of the CWSI over the days in 2018. CWSI was calculated on daily base to indicate the stress status of the crops directly. From the results, we can find that in most of days, the CWSI values were less than 0.4, while there were a few of them close to 1. Look into these days with large CWSI, either it was a very humid day with relative humidity greater than 85%, or the average air temperature was below 65 F. Typically, if the plant is water stressed, then it will close the stomata and restrict water loss and therefore the plant leaves will be relatively warmer than a non-stressed plant. While, when the weather is too humid (RH is large) or the air is too cool, then the difference of the temperature between leaves and atmosphere, which could result in large CWSI but the crop may not be necessary under stress. Therefore, the current model for calculating the CWSI is more feasible for clear days with high temperature. We will investigate more to develop a better model for robust representation of crop water stress status.

Soil Moisture Sensors

Soil moisture measurements acquired in the field adjacent to the crops being irrigated are one of the best and simplest ways to support water management decisions. Soil water content and soil water potential are two indicators of plant-available water used by soil-based irrigation systems. In this study, we used these types of soil moisture sensors, one is soil water content sensor, and the other one is soil water potential sensor. Figure 6 shows the two types of sensors, the installation and the data acquisition. In this study, three soil water content sensors were installed at

different depth under ground, e.g. 1, 2, and 3 ft under the ground. Two soil water potential sensors were installed at the depth of 1.25 ft and 2.5 ft. A data logger was used to record all the sensor data at 10 minutes rate.

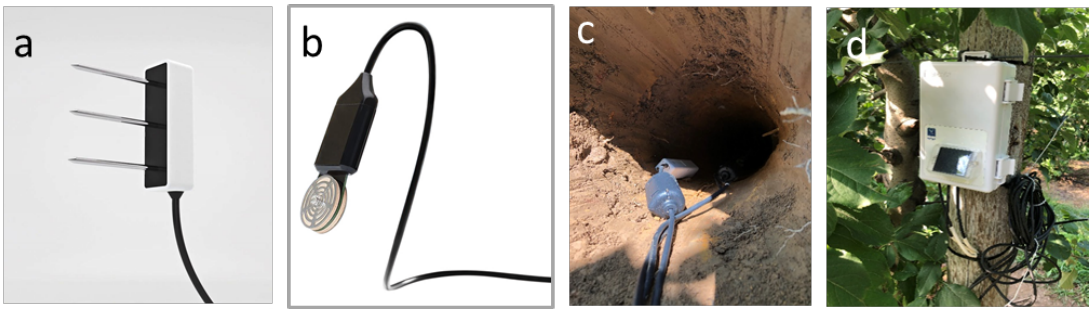


Figure 4. Soil moisture sensor systems. a) soil water content sensor; b) soil water potential sensor; c) installation of sensors; and d) sensor data acquisition

Figure 5a shows the daily average soil water content through days. There was an irrigation event conducted on the 180th day. In the Figure, WC #1 to WC #3 represent three water content sensors from top to botton in the ground. Average of the water content, rainfall, and irrigation are also illustrated. Figure 5b shows the hourly change of soil water content during an irrigation event. A threshold was set for the irrigation, in this study, 0.30 was used for the thrshold. As shown in Figure, the water contents were slightly different at the three depths. The water content values from three sensors increased after a few hours of irrigation, and reached the field capacity at the end of the irrigation event. The results indicated that it is feasible to use the water content sensor for future irrigation sheduling.

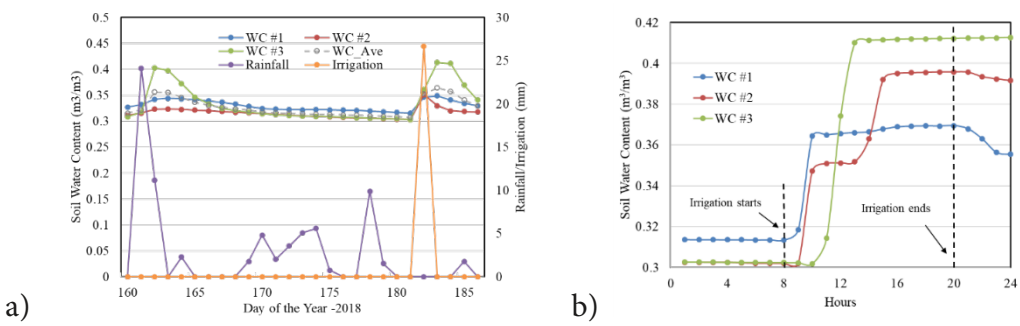


Figure 5. a) Soil water content through days; and b) soil water content in an irrigation event

Figure 6a shows the daily average soil water potential through days. And also there was an irrigation event conducted on the 180th day. In the Figure, WP #1, and WC #2 represent two water potential sensors from top to botton in the ground. Average of the water potential, rainfall, and irrigation are also illustrated. Figure 6b shows the hourly change of soil water content during an irrigation event. A threshold was set for the irrigation, in this study, -30 kPa was used for the thrshold (different soil type has different threshold). After the irrigaiton event, there is an obvious change of the soil water potential, which went close to -10 kPa. The water content reached the field capacity at the end of the irrigation event. The results indicated that it is also feasible to use the water potential sensor for future irrigation sheduling. The combination of using both water content and water potential sensors will be investigated in our future study.

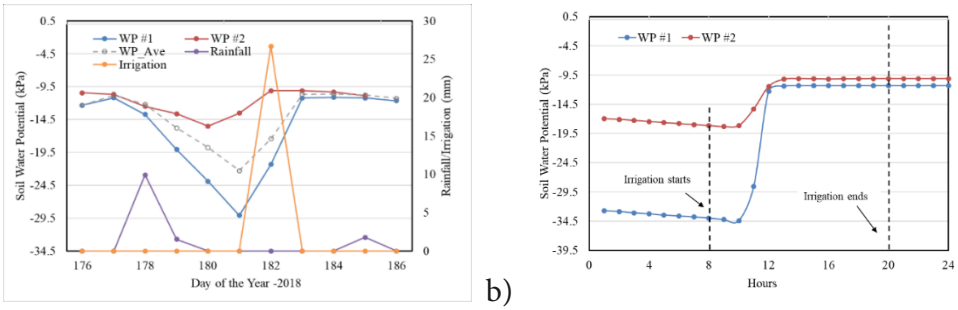


Figure 6. a) Soil water content through days; and b) soil water content in an irrigation event

ET-Based Irrigation

Weather-based irrigation is also called evapotranspiration (ET)-based irrigation. ET-based irrigation requires a complete set of weather parameters from a nearby weather station to calculate ET rate. The ET rate can be calculated using the Penman-Monteith equation. The Penman-Monteith model must be modified to suit different growing conditions and the disparate plant architectures of tall discontinuous crops like fruit trees. In our study, weather parameters were recorded, and then the P-T model was used to calculate the daily based ET. Based on the rainfall, ET and irrigation, then the estimated deficit could be calculated. When the water deficit reaches certain value, then the irrigation will need to be scheduled. As shown in Figure 7b, we obtained plenty of rainfall during these days, therefore, the water deficit was always staying at low level. On the 180th day of the year, the water deficit reached 18.5 mm, and the irrigation was applied. In our calculation, there was no negative deficit, which means the minimal water deficit is zero, and if the rainfall/irrigation was larger than the current water deficit, the value of water deficit was set to zero at the end of the day.

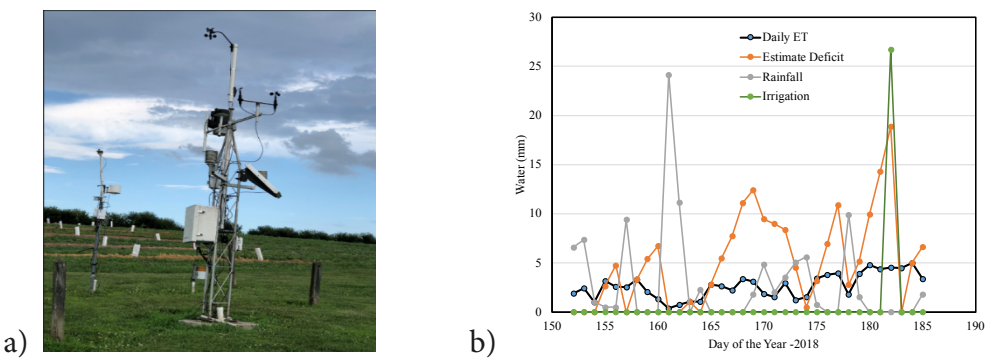


Figure 7. a) A weather station near test field; b) daily based ET, rainfall, irrigation, and water deficit

The year of 2018 is a wet year, we had much more rainfall during the growing season comparing to regular years, resulting in no much need for the irrigation. While the sensors we tested in the season, as well as the data we connected and analyzed provided very useful information for the irrigation scheduling and will be very helpful for our future studies.

TRENDS AND CONSUMER DEMAND FOR SPECIALTY CUT FLOWERS

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According to a research study conducted in 2016 and funded by the Society of American Florists (SAF) in partnership with the American Floral Endowment (AFE), 75% of survey participants purchased flowers from their local florists, 70% from supermarkets, and 42% from nursery or garden centers (Russel Research, 2016). As might be expected, Internet sales were on the rise, as well as purchases from farmer's markets. The research also focused on identifying differences in consumer attitudes and behaviors based on their generation. While Baby Boomers (born between 1946 and 1964; U.S. Census data) associated giving flowers as a gift with emotions (e.g., caring, personal, thoughtful), longevity and price were identified as "barriers to purchase" (Russel Research, 2016).

A key factor for Generation X (born between 1965 and 1979; U.S. Census data) when selecting a florist was "interesting designs/styles that make an impact," while Generation Y (born between 1980 and 1995; U.S. Census data) sought out florists who had an "availability of unusual, exotic, or hard-to-find flowers" (Russel Research, 2016).

While the SAF/AFE study did not involve Generation Z consumers (born between 1996 and 2014), 24.3% of consumers are members of this generation (2016 U.S. Census data), and they greatly depend on social media to both learn from and share with others. A brief search online reveals many sources that warn businesses, including florists and related, that ignoring social media's influence or not regularly updating Instagram, Pinterest, etc. will result in their demise (Floranext, June 27, 2018).

With prom season not too far away, searching for relevant hashtags on Instagram (e.g., #prom, #prom2019, #promposal, #promfloral) will inspire florists and help them identify the trendsetters and sought-after styles. In addition, by posting images of prom flowers with appropriate hashtags, prom-goers will be able to see examples of local florists' creations. Engagement will continue to be a factor when trying to connect with this audience. In 2018, SAF designed a "Which Prom Personality Are You?" video "to get teen girls excited about prom flowers" (aboutflowers.com/promquiz). After the user responds to a short list of questions about likes and interests, their "prom flower personality" is identified. Social media usefulness, along with influencers such a Martha Stewart, spans across all generations. Internet searches for "top Instagram florists" or "best Instagram florists," for example, will build lists of designers who are cutting edge. Florists should also seek out industry resources (e.g., Florists' Review) other authorities (e.g., catering, venues, event planning industries) to get their take on what colors, styles, and factors are trending.

Floral trends, as well as fashion and interior design, change seasonally. Thus, identifying sources that discuss what to expect customers to ask for during consultations is key. Wedding Ideas Magazine, for example, published a list of floral trends that they expect to be of great importance in 2019 (Read-Dominguez, 2018). These include:

- Nude and pastel wedding flowers
- Peonies
- Floral installments that are a "wow" factor (e.g., wedding arches, chandeliers, hanging floral hoops)
- Floral crowns

This article, as well as other sources, also focused on the importance that the Pantone Color of the Year 2019 – Living Coral, will have on all aspects of fashion, home decorating, floral, etc. (https://www.pantone.com). Merely search for "coral floral arrangements" online and a range of centerpieces, altarpieces, bouquets, etc. will be created.

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Providing floral designs for multi-cultural or multi-faith weddings, as well as assisting families in need of flowers for events that celebrate their culture are excellent opportunities for florists. Learn about the length of the event and rituals, what flowers are exchanged during a ceremony, and what flowers should be incorporated (and avoided). Indian weddings, for example, can last for a number of days (Forrest, January 26, 2017). Thus, multiple arrangements may be needed for different spaces and uses. While white flowers are commonly used in traditional American weddings, they should be avoided in Chinese weddings as they symbolize death (Weddingandpartynetwork.com, 2008). Instead, red flowers, for examples roses which represent "joyfulness and power," should be used. Consult resources such as theknow.com and weddingwire.com to learn more.

Resources

Floranext. June 27, 2018. Florists, Are You Ready for Generation Z? Available at: https://floranext.com/florists-are-you-marketing-for-generation-z/

Forest, K. January 26, 2017. Attending an Indian Wedding? Here's What to Expect. Available at: https://www.theknot.com/content/hindu-wedding-guest-qa

Read-Dominguez, J. 2018. Wedding Flowers: The Floral Trends You Need to Know About for Your Summer Wedding 2019. Available at; https://www.weddingideasmag.com/wedding-flowers-floral-trends-2019/

Russell Research. 2016. 2016 Generations of Flowers Study, Final Report. Available at: https://endowment.org/wp-content/uploads/2016/03/SAF-2016-Generation-of-Flowers-Study-_ExecutiveSummary.pdf

KEY DISEASES IN SPECIALTY CUT FLOWERS

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Disease prevention and management is critical to the success of specialty cut flower operations throughout our Mid-Atlantic region. High humidity coupled with frequent rainfall often creates ideal conditions for the dissemination and infection of cut flowers by fungal and bacterial pathogens. Prevention of plant diseases in most growing systems starts with cultivar selection and crop rotation practices. Growers should select cultivars (when available) that exhibit tolerance or resistance to the most common diseases observed in the production area. Crop rotation should always be practiced to minimize plant exposure to pathogens and pests that may have been detected in the field during the previous growing season.

Many growers purchase plugs, cuttings, bulbs, rhizomes, or corms from specialty propagators. Pathogens and pests can hitchhike on these vegetative materials and can be easily introduced into your operation. Growers should carefully inspect all shipments of plugs, cuttings, bulbs, rhizomes, and corms for evidence of pests or pathogens. If something is detected upon receipt of the shipment, contact your supplier immediately and either isolate the materials in a quarantine area temporarily or reject the shipment completely. If you elect to receive and plant-out a contaminated shipment you may end up dealing with these pest and disease issues on your farm for the next several years.

Disease prevention in cut flowers can be aided by adopting a variety of best management practices. The employment of trickle irrigation by growers will minimize the wetting of floral parts and should reduce the incidences of infection by a variety of pathogens. The utilization of mulches both organic and inorganic in the field will reduce the splashing of fungal spores and bacteria onto unprotected floral parts which should reduce the incidence of infection. Best management practices like wide row spacings can also be employed to facilitate the rapid drying of flowers and foliage after rain or dew events to minimize infection.

Prophylactic applications of protectant fungicides can also be employed to prevent infection in specialty cut flowers. Contact fungicides like chlorothalonil can be quite effective in preventing fungal diseases, but in overly wet years like 2018 they will yield less than satisfactory results because our frequent rains will wash away the protective fungicidal residue from the flowers and foliage of the treated plants.

Translaminar and true systemic fungicides will offer a greater degree of protection from fungal pathogens than contact fungicides, but systemic fungicides are often considered to be a greater risk for disease resistance than many broad-spectrum contact fungicides. To lessen the likelihood of fungicide resistance most plant pathologists recommend rotating FRAC codes (modes of action) or tank-mixing contact, protectant fungicides with translaminar and systemic fungicides.

There are several diseases that are frequently observed in specialty cut flowers most seasons. Botrytis or gray mold is the most common and perhaps injurious disease observed on farms. Botrytis can cause a blighting or spotting of floral parts resulting in a drop in floral quality. Botrytis infection is frequently observed when humidity levels increase and when wet weather is observed.

Rust is largely a foliar pathogen than will infect the foliage of several major cut flowers including snapdragons. Once infection occurs it cannot be easily eradicated so growers are frequently resigned to rogueing out and destroying the infected plants.

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Powdery mildew thrives under conditions of high relative humidity. While the fungal spores won't germinate on wet tissue, most growers experienced high humidity in their fields and high tunnels in 2018. Powdery mildew mycelial growth coats the leaves of infected plants resulting in the foliage taking on a gray or whitish appearance.

Root and stem rots are the least forgiving of the many fungal pathogens that are observed in cut flower fields. Phytophthora root rot, a common water mold thrives under moist wet conditions. As a water mold its oospores are motile and will move with free water in the soil to infect susceptible crops. Phytophthora can be frequently detected in surface water sources like streams, rivers, and ponds. The utilization of surface water for irrigation can increase the risk of crop infection from water molds like Phytophthora.

Bacterial diseases are frequently observed in specialty cut flowers under moist, rainy conditions. Zinnias are one of the most popular annual flowers grown by specialty cut flower growers. Bacterial leaf spot which can be seed transmitted is the most commonly observed bacterial disease observed on cut flower farms. Dark brown spots with yellow halos or borders on the zinnia foliage are the most frequently observed signs of infection. Human activities in the field during wet conditions can facilitate the spread of the bacteria throughout the field resulting in reduced vigor in the zinnias and poor floral performance (yield).

Disease Resistant Perennials Selections for Cut Flower Growers

Plant	Pathogen or Disease	Resistant Cultivars
Bee Balm (*Monarda spp.*)	Powdery Mildew & Rust	Blaukranz, Colrain Red, Jacob Cline, Marshall's Delight, Petite Delight, Gardenview Scarlet
Delphinium	Powdery Mildew	Blue Bird, Blue Lace, Cameliard, Galahad, King Arthur, New Zealand series
Hollyhock	Hollyhock rust	Happy Lights
Peony (*P. lactiflora*)	Botrytis	America, Buckeye Belle, Krinkled White, Old Faithful, Pink Hawaiian Coral, Roselette, Scarlet O'Hara, White Cap
Garden Phlox (*Phlox paniculata*)	Powdery Mildew	Alpha, David, Pastel Dream, Frosted Elegance, Laura, Miss Lingard, Norah Leigh, Robert Poore, Shortwood, David's Lavender

Source: Beckerman, Janna and Lerner, B. Rosie. 2009. "Disease-resistant Annuals and Perennials in the Landscape". Purdue University. ID414W

MANAGING BACTERIAL SPOT IN TOMATOES

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In recent years the occurrence of frequent, intense summer thunderstorms in many growing areas in the Midwest, Northeast and Mid-Atlantic regions have contributed to a high incidence of bacterial spot in processing and fresh market tomatoes. Bacterial spot is one of the most common and important bacterial diseases in these regions, and is also seedborne, so management has to start before seeds are planted in the greenhouse. Once bacterial spot becomes established in the field, it is not possible to control it under conditions that are favorable for the disease, the most critical of which is an overabundance of moisture. Bacterial spot is also favored by higher temperatures. It can cause defoliation and deep fruit spotting on tomatoes. Fruit lesions vary in size but are generally large, deep and rough to the touch (Fig. 1). The particularly large, deep, star-shaped lesions (Figure 1D) cause serious problems on processing tomatoes as they are not removed during the normal peeling process. On tomatoes the disease is caused by up to four species of *Xanthomonas*, including *X. gardneri*, *X. perforans, X. euvesicatoria and X. vesicatoria*.

A B C D

Figure 1. Tomato seedlings with leaf spots (A), field tomato plant with bacterial spot lesions on peduncles, calyces and leaves (B) and fruit with bacterial spot lesions (C, D).

Populations of *Xanthomonas* species have been known to shift over time. In Florida, bacterial spot populations shifted from *X. euvesicatoria* to *X. perforans* in the late 1990s. In Ohio, the majority of bacterial spot strains in the 1990s were *X. vesicatoria*, but by 2010 the majority had shifted to *X. gardneri*. In surveys in the Midwest (mainly Ohio), the proportion of *X. gardneri* strains isolated from tomatoes steadily declined, while the proportion of *X. perforans* strains steadily increased between 2010 and 2018 (Table 1). *Xanthomonas vesicatoria* and *X. euvesicatoria* have essentially disappeared from these areas.

Copper-based bactericides have been used for decades to manage bacterial spot. However, resistance to copper is now common in *Xanthomonas* species, reducing its efficacy for bacterial spot control. All of the Midwestern *Xanthomonas* strains isolated between 2010 and 2018 were resistant to a low concentration of copper sulfate (30 ug/ml), and most strains were also resistant to 100 ug/ml copper sulfate, depending on the year. In 2010 and 2011, most strains isolated were sensitive to 200 ug/ml copper sulfate, but in 2017 and 2018, approximately 50-80% of the *Xanthomonas* strains isolated were resistant to this high concentration of copper sulfate.

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Table 1. Distribution of *Xanthomonas* spp. isolated from processing and fresh market tomatoes in surveys conducted in Ohio and other Midwestern states from 2010 – 2018.

Species	2010	2011	2012	2013	2017	2018
X. gardneri	83%	75%	66%	50%	53%	23%
X. perforans	5%	25%	34%	50%	19%	63%
X. perforans-like	-	-	-	-	28%	14%
X. euvesicatoria	12%	0	0	0	<1%	0
X. vesicatoria	0	0	0	0	0	0
Total # strains	58	52	21	8	252	355

Managing Bacterial Spot

Use Clean Seed. The first step in prevention of bacterial spot and other seedborne bacterial diseases is to exclude pathogens from the crop. Obtaining clean seeds should be a first priority. If seeds are purchased, they should be obtained from a reputable producer with a good track record for selling high quality seed. Ideally, the producer will have tested a sample of the seeds for the presence or absence of bacterial pathogens. If they have been tested and the results are negative, there is a relatively low risk that the pathogen may be present. If they have not been tested, seeds should be treated with dilute Clorox to kill any bacteria on the surface. If seeds are saved by the farmer from the previous year's crop or obtained from a source with an unknown track record, they should *always* be treated. Seed sanitizing protocols can be found here: http://go.osu.edu/ChGb.

Use Pathogen-Free Transplants. The greenhouse environment in which seedlings are produced, if not managed properly, is highly conducive to bacterial diseases. Bacteria present on only a very small number of seeds (e.g. 1 in 10,000) can become a significant threat in some greenhouses. The following practices will reduce the threat of bacterial spot and other diseases: 1) use of new or sanitized plug trays or flats and pathogen-free mixes, 2) sanitizing equipment, installing solid flooring and raising trays from the floor, 3) limiting movement of personnel and equipment between greenhouses, 4) cleaning benches and greenhouse structures thoroughly after the crop; and 5) prohibiting exotic or experimental pepper or tomato varieties, or plants from saved seed, in the same greenhouse with commercial seedlings unless all seeds are sanitized. Since bacterial disease development and spread is promoted by wet conditions, relative humidity should be low, air circulation should be high and plants should be watered only enough to ensure growth and minimize the risk of drought stress. Surface water (from ponds, lakes, rivers, etc.) or re-circulated water should never be used to irrigate seedlings unless it has been treated (e.g. ozone, chlorine) and is tested regularly to assure that bacteria are killed. Seedlings should be sprayed with streptomycin and/or a copper bactericide on a 7-day schedule prior to planting. Farmers who purchase transplants from others should ask about their management practices, and visit them during transplant production.

Choose the Best Site and Rotate. Crop rotation is an important strategy that not only reduces disease problems but also affects weed, insect and nutrient management. Crop rotation should be done between crop families; peppers, tomatoes, eggplants, and potatoes are solanaceous plants. Plants in the same crop family often share the same or related pathogens, and thus should never be used as rotational crops with each other. For bacterial leaf spot management, a relatively short rotation of two years out of solanaceous crops is adequate. However, longer rotations for tomatoes are recommended to minimize other diseases.

Use Appropriate Cultural Practices. Our research has shown that increasing the organic matter content of soil not only improves crop growth and yield, but may also reduce some diseases. Organic amendments such as high quality compost and manures should be considered if available within a practical distance from the farm. Organic amendments are best applied in the fall or early spring to allow leaching of excess salts and destruction of pathogens. Care should be taken with any fertilizer program to avoid excessive nitrogen, which can increase plant susceptibility to disease. Irrigation should be carefully controlled to minimize the time that plants are wet.

Use Crop Protectants as Needed. Bactericides are usually ineffective in stopping established bacterial diseases under favorable environmental conditions. Copper bactericides alone or mixed with mancozeb or other EBDC fungicides can be applied on a 5-14 day schedule after transplants are placed in the field. However resistance to copper bactericides limits the effectiveness of this approach. The plant activator Actigard is effective in reducing bacterial diseases and should be part of the disease management program. If the other steps in the integrated disease management program have been followed, however, the need for bactericides is significantly reduced.

UNDERSTANDING INDUCED RESISTANCE AND HOW TO USE IT

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For more than 100 years researchers have recognized that a plant can be preconditioned to respond more quickly to disease if it has already been exposed to a pathogen. It was later discovered that avirulent microbes and some chemicals could induce a similar preconditioned response. This reaction has been termed Induced Resistance (IR).

Induced Resistance is made up of two similar but physiologically different pathways, Systemic Acquired Resistance (SAR) and Induced Systemic Resistance (ISR).

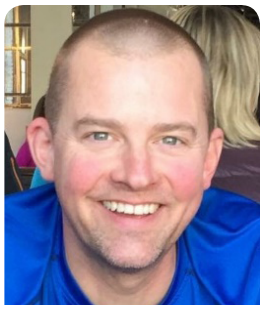
Induced Systemic Resistance	*Systemic Acquired Resistance*
- Root induction	- Foliar induction
- Jasmonic Acid and Ethylene Mediated	- Salacylic Acid Mediated
- Can activate NPR1	- Activates NPR1
- Production of PR Proteins	- Production of PR Proteins
- Up-Regulation of other functions	- Up-Regulation of other functions

Numerous fungicide products on the market today claim Induced Resistance as either their primary or secondary mode of action. This mode of action relies on the ability of the product to trigger an immune response in the plant even in the absence of a pathogen. There is a measurable physiological response inside the plant when these products are used and if they are used properly they can greatly add to a disease control program.

Successfully using IR compounds - whether the product contains conventional or biologically derived active ingredients – requires a different approach to disease control.

- Apply before disease presence is suspected
  - Allow for Induction time
  - Many product labels call for application 3-5 days before expected disease
- Use in a program with other effective modes of action
- Can be used in addition to or to replace other modes of action
  - As part of a resistance management plan
  - To boost overall control of hard to manage diseases

Greg Rogers is the Field Development Manager for the Northeast and Midwest at Certis USA Columbia, MD. Greg is responsible for the Certis field research program as well as for supporting the sales organization in his territory. He received his B.S. in Horticulture and his M.S. in Plant Improvement from the University of Delaware. He formerly worked as a Field Development Representative and Global Data Manager for DuPont Crop Protection. A native of Kittery Point, ME, he and his wife Ashly have a daughter Lauren and a son Cameron.



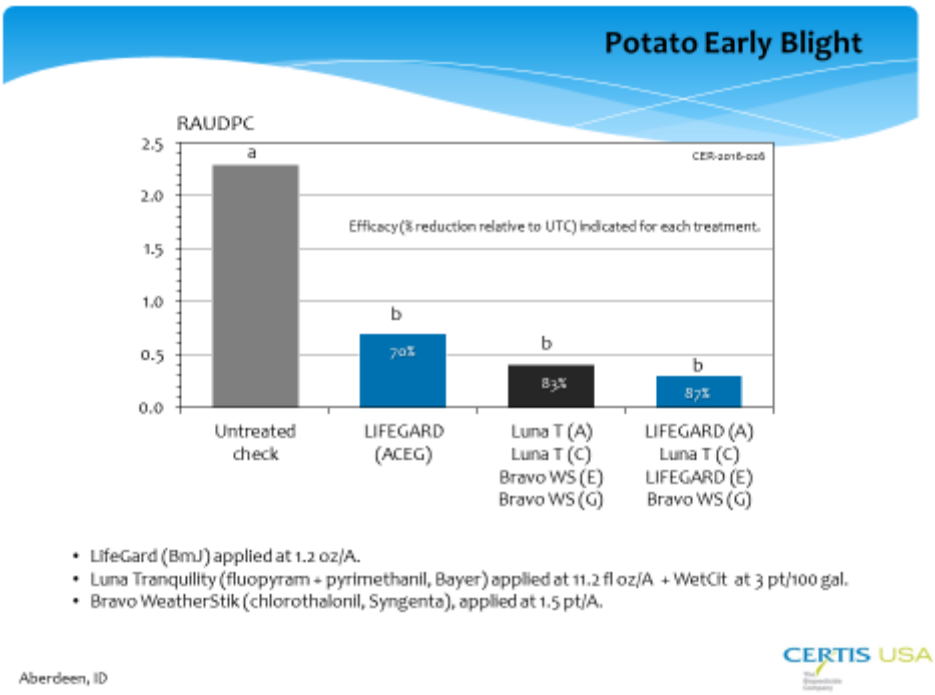


Diagram 1: Although IR compounds (LifeGard) may not be a standalone option, using it in a program can offer good disease control. Here the IR compound replaces 2 conventional product and retains control

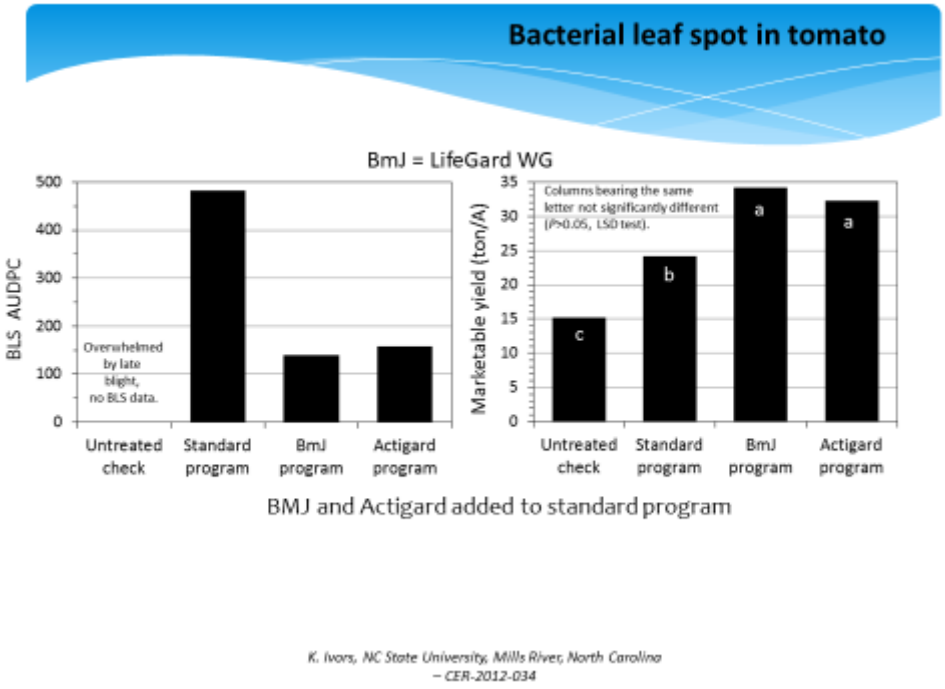


Diagram 2: SAR compounds demonstrate efficacy on bacterial diseases both alone and in programs. Here two IR compounds are added to a grower standard to boost disease control and yield.

Other effects of the IR reactions can include increased nutrient uptake and plant growth and thickened cell walls. These factors can often result in yield enhancement in addition to disease control.

If used properly, IR compounds offer another effective tool to help growers successfully manage disease in many of their crops.

PACKING HIGHER QUALITY TOMATOES

Steve Bogash, Territory Business Manager, Marrone Bio innovations

General Principles

There are five requirements to creating high quality tomatoes: variety selection, field rotation, crop nutrition, pest management and post-harvest handling. Assuming that a grower is meeting basic crop needs, nutrition and pest management offer the broadest avenue and the most variability in creating great produce.

-Variety selection: Crop genetics play a major role in the final quality and brix levels of fruits and vegetables. This is not a discussion of heirloom vs. hybrid or even a GE / GMO argument. Based on years of tomato, bell pepper and melon variety trials, there are simply varieties that consistently work better under local and regional growing conditions and have the inherent genetics to achieve higher brix levels and production numbers. Since this meeting is taking place in the Mid-Atlantic, we will keep the discussion(s) to our climate and weather. The highly variable conditions under which we grow the crops in question greatly limits the varieties that produce sustainable harvests of marketable fruit. High tunnels and greenhouses open the door to some additional varieties, but controlling humidity in the middle of our typical summers is largely outside of high tunnel managers' control.

-Field rotation: Rotating between vegetable families is one of the easiest ways to reduce diseases, avoid(some) soil dwelling or overwintering insect pests, and improve nutrient availability. This works especially well when incorporating cover crop strategies into your rotation scheme.

-Crop nutrition: Managing crop nutrition through preplant, fertigated and foliarly applied nutrients is the most direct path to improving the flavor and brix levels in fruit. High N levels can create soft fruit and will compete with K in plant tissue incorporation. The relative balance between the plant cations K, Ca, and Mg has a major impact on fruit firmness, flavor and brix levels.

-Pest management: Insect and disease management directly impacts fruit quality as many insects feed on tomato fruit skin and flesh, while many diseases will impact fruit packout and storage quality. Other insects and diseases will damage plant leaves and stems reducing nutrient and photosynthate movement, thus reducing fruit quality. Creat a proactive pest management program with sufficient flexibility to allow for seasonal challenges. Know your transplant producer, work with them to get the highest quality plants at their optimum transplant stage and begin pest management from Day 1.

-Post Harvest handling: How fruit are handled during and after harvest has another major impact on fruit quality. Tomatoes can be very tender when fully ripe, so require great care during harvest and packing. Tomatoes lose substantial flavor after storage below 50F.

One of the greatest challenges in growing tomatoes (and bell peppers) in an intensive production system is keeping up with the plants high consumption of potassium during fruit production. Past recommendations have been based around beginning to increase potassium application along with the first tissue test at the onset of flowering. This often results in our chasing potassium levels over 2-4 weeks in order to get them above 3% by dry matter. Very often some of the first fruit are yellow shouldered. The heavy consumption of potassium actually starts about 2 weeks prior to when the first flowers are visible. The concept of 'banking' potassium or applying extra a bit earlier seems

Steve retired as a Horticulture Educator and Researcher, PSU Cooperative Extension in June 2016. Since retiring, Steve joined Marrone Bio Innovations as their NE / Mid-Atlantic Product Development and Territory Business Manager. His territory runs from Raleigh, NC to Caribou, ME to the Western edge of OH. He now oversees several dozen university and private research company product trials as well as many on-farm demonstration trials using Marrone Bio Innovation products for pest management. Steve and his wife Roberta live in Harrisburg, PA and are renovating a home near the Susquehanna river built in 1933.

indicated in order to reduce packing house losses and maximize flavor.

Before you start applying extra potassium, your irrigation / fertigation solution needs to be at the correct pH. Tomatoes and peppers optimally extract nutrients at a pH of 6.2-6.5. For growers pulling irrigation water from limestone aquifers, this will probably mean the addition of acid on a constant basis. Get your water tested at a laboratory for pH and alkalinity expressed as ppm bicarbonate. Since the pH scale is logarithmic, each 1 point on the scale is a 10X difference in pH. A two point difference is 10 x 10 or 100X. This means that small variances from the ideal pH of 6.2-6.5 can result in major nutrient deficiencies. Most growers use either sulfuric acid or citric acid. Organic growers can use citric acid. Use the online alkalinity calculator to get your sulfuric, phosphoric, and nitric acid concentrations: http://extension.unh.edu/Agric/AGGHFL/alk_calc.cfm. Be sure to follow all directions on the calculator and pay careful attention to the pull down menus on the input side to get the correct recommendations. There is no calculator for using citric acid. However, Tom McCarty, PSU Water Quality Educator Retired, and I did extensive experiments on water samples collected throughout Central and SE PA and found that 9 oz. of powdered citric acid consistently reduced the pH of 100 gallons of irrigation water by 1 full point. Growers using acids to modify irrigation water must regularly use a calibrated digital pH meter to adjust their water pH as injected nutrients, weather events, and for surface sources time of day all impact the pH in the irrigation flow.

Since we need to start the application of higher levels of potassium earlier than flowering in order to bank some and have high enough levels for the first fruit, tissue analysis should start as soon as your plants are large enough to collect full sized mature leaves from and not cripple your plants. Make the change to a higher potassium ratio fertilizer about 2 weeks prior to what you've been doing along with starting a weekly application of a foliar potassium at that same time. Be sure your fertilizer is compatible with foliar application. Organic growers will use potassium sulfate for this purpose. Good quality, highly soluble potassium sulfate at 1-2T / gallon applied foliarly just to the point of wetness works well for this application

Growing great tomatoes that are full flavored and have low losses in the packing house requires keeping tissue potassium levels above 3%. From before the first blossoms to the last harvest, tomato plants (and peppers as well) require huge amounts of potassium to produce the most flavor and prevent yellow shoulders / gray wall. Although I look at every nutrient level, those most important to packout are:

1) Tissue N levels should be at about 4% as fruit are developing. Higher levels can create soft fruit, more foliage, and fewer fruit. Higher N levels will also create more yellow shouldered fruit.

2) Tissue K levels need to be above 3% for tomatoes and peppers to produce the highest quality fruit and to keep creating new blossoms.

3) Ideally Ca should be at about 3% and Mg at 0.8-1%. This prevents cracking and produces fruit that are tough enough for packing and shipping. In retrospect, although I've always recommended bi-weekly tissue testing to growers due to the cost of the tests, I now recommend weekly sampling that starts as early as the plants can handle the cut.

If you plowed down 80% of your soil test recommended potassium, calcium and magnesium when getting your soil ready and work to keep these levels at their optimum values, you should be able to increase yields and reduce packing house losses.

Begin your pest management at or before transplanting. Preplant inoculants containing Trichoderma spp. fungus applied as a drench will greatly reduce soil-borne diseases. Drenching with Regalia™ every 2 weeks alternated with Stargus™ in between will boost the plants ISR and SAR responses making them much better at defending themselves from diseases. Including a biopesticide such as Grandevo WDG alternated with Venerate XC will suppress insect and mite populations helping to keep them from getting out of control.

ENHANCING AUTHORITY MTZ SAFETY FOR PROCESSING TOMATOES

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Overall summary:

- Significant early-season injury was observed with most treatments except:
  - Authority MTZ at 6 oz/A PPI at UD-REC
  - Authority MTZ at 6 and 8 oz/A applied PPI at PSU-RS.
- At 6 WAP, tomato biomass reduction at UD-REC was observed with Authority MTZ, 12 and 16 oz/A PPI, Authority MTZ, 12 oz/A PRE, and both PRE rates of metribuzin plus Spartan Charge, and Authority Elite.
- At 6 WAP, tomato biomass reduction at PSU-RS was at least 25% with Authority MTZ at 16 oz/A PPI, Authority MTZ, 12 oz/A PRE, and both treatments including Authority Elite.
- Mid-season at UD-REC, tomatoes recovered with no treatment resulting in more than 15% biomass reduction; at PSU-RS the levels of biomass reduction observed at 3 WAP remained throughout the growing season.
- Total yield at UD-REC did not differ between treatments.
  - Authority MTZ at 16 oz/A PPI, and metribuzin at 4.3 oz/A plus Spartan Charge at 5.5 fl oz/A resulted in delayed fruit maturity.
- Weed control was acceptable in all treatments, except Authority MTZ at 6 oz/A applied PPI.

Introduction:

Authority MTZ is a pre-packaged herbicide of sulfentrazone and metribuzin, labeled for transplanted tomatoes. The Authority MTZ label mentions control of eastern black nightshade, ivyleaf morningglory, common lambsquarters, and pigweed species; all weeds that are difficult to control with current herbicide programs. The sulfentrazone portion of the product can also help manage herbicide-resistant weed biotypes. There has been little research with this product in the Mid-Atlantic States to help provide guidance to tomato farmers and crop advisors about the appropriate rates. Furthermore, the Authority MTZ label requires a pre-plant incorporated application. Results from the 2017 Pennsylvania Vegetable Marketing and Research Program showed at least 17% stunting with the 6 oz rate, however the tomatoes did recover from that injury. Additional research is needed to determine if application method (i.e., soil surface application vs. mechanical incorporation) can improve tomato safety. Spartan (a product from FMC with only sulfentrazone) is labeled for surface applications before transplanting, without incorporation. Applying sulfentrazone to the soil surface, rather than incorporating it into the root zone, may improve crop safety.

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Dr. VanGessel is a professor at the University of Delaware. His extension program focuses on developing and disseminating weed control recommendations and other technical information appropriate to agronomic and commercial vegetable crops. Technical information emphasizes weed biology and ecology. Extension responsibilities include assisting with weed management for agronomic crops in New Jersey.

Improved crop safety of metribuzin and sulfentrazone may allow for higher applications rates and improve weed control. Research is needed to determine optimum rate range for Mid-Atlantic growing conditions as well as our weed spectrum. In addition, it is important to evaluate this approach as part of a weed control program, with a postemergence treatment.

Objectives:
Evaluate metribuzin and sulfentrazone for safety with processing tomatoes under different application strategies; and Determine level of early-season weed control from metribuzin and sulfentrazone.

Procedures:

The experiments were conducted in 2018 at the University of Delaware's Research and Education Center (UD-REC) and Penn State's Russell E. Larson Agricultural Research Farm (PSU-RS). UD-REC plots were established in sandy loam soil (79:13:8 sand:silt:clay), 1.1% o.m. and 6.7 pH and PSU-RS site was a silt loam (20:60:20 sand:silt:-clay), 1.8% o.m. and 6.7 pH. The field at UD-REC was conventionally tilled with chisel plow and disk. Plots consisted of 2 twin rows of plants on 5 feet centers, each 24 feet long. On May 29, preplant incorporated (PPI) treatments were applied, field-cultivated, and immediately followed by applications of preemergence (PRE) treatments. Processing tomatoes ('Heinz 3402') were hand-transplanted at UD-REC on May 31 with twin rows of plants staggered 9 inches across row and 18 inches apart in the row. At PSU-RS, the field was conventionally tilled and PPI treatments were incorporated with heavy rakes. PPI and PRE applications and transplanting all occurred on June 12. Tomatoes at PSU-RS ('Heinz 3406') were hand transplanted in single row 20 feet long, with plants spaced 15 inches apart. Herbicide rates and timings for UD-REC are listed in Table 1 and for PSU-RS are listed in Table 2. A weed-free and an untreated check were also included. The experiment was conducted as a randomized complete block design; both sites had three replications. A postemergence (POST) herbicide application of Matrix (rimsulfuron) at 2 oz wt/A, metribuzin at 3 oz wt/A plus a nonionic surfactant was made to all plots 3 and 4 weeks after planting at PSU-RS and UD-REC, respectively.

Applications were made with a 6-nozzle boom delivering 20 gal/A at UD-REC and 15 gal/A at PSU-RS. Visual crop response and weed control ratings were made based on appropriate check plot on a scale of 0 to 100. Crop response was evaluated seven times at UD-REC and three times at PSU-RS. A single destructive yield was taken at UD-REC on August 28 when fruit maturity (red/orange tomatoes) was greater than 60%. Eight plants were pulled (4 consecutive plants in two rows) and all fruit was picked and sorted. Weight of the three groups was taken separately; (red/orange), ripening (yellow) and unripened (green) fruit.

Results:
UD-REC. Tomato response was observed with all treatments. At 4 weeks after planting (WAP) >40% biomass reduction was observed with Authority Elite, Spartan Charge at 5.5 fl oz, and Authority MTZ at 12 and 16 oz/A (see Table 1). Spartan Charge at 3.7 fl oz/A and Authority MTZ, 12 oz/A PPI resulted in 33 and 32% biomass reduction, respectively. Authority MTZ at 6 oz/A PPI was the only treatment that did not differ from either the untreated or weed-free check. At 6 WAP plant biomass was significantly reduced in all treatments except the 6 oz/A PPI and the 8 oz/A PRE of Authority MTZ as compared to the untreated check. At 8 WAP Authority MTZ at 12 and 16 oz/A PPI and Authority Elite resulted in 10, 15, and 12% biomass reduction, respectively. At harvest tomato injury was observed with Authority MTZ at 12 and 16 oz/A PPI, Spartan Charge at 5.5 PRE, and Authority Elite treatments (data not presented). Application method, PPI versus PRE, was not significant, although there was a trend for less injury with PPI applications compared to PRE.

Carpetweed was the only species present where differences in control existed (data not presented). The weed-free treatment of Devrinol showed 75% control, and the lower rates (6, 8 oz) of Authority MTZ PPI treatments provided 82-90% control of carpetweed. All other treatments had greater than 90% control of carpetweed. No significant differences were observed with Palmer amaranth control throughout the entire season. At 4 WAP Palmer amaranth control ranged from 85 to 99% and after the POST application control was ≥96% for all treatments. Annual grasses were rated late in the season with all treatments having greater than 93% control. [Weed densities were low in the

early season and the broadcast POST application controlled most weeds through mid-season. Late season Palmer amaranth was hand-weeded from plots to prevent seed dispersal.]

Table 1. Tomato injury at 4, 6, 8 weeks after planting (WAP) at UD-REC.

Herbicide[1]	Rate/A	Applic. method[2]	% Stunting (4 WAP)[x]	% Biomass Reduction (6 WAP)	% Biomass Reduction (8 WAP)	Cumulative Injury[3]
Untreated check			0	0	0	0
Authority MTZ	6 oz wt	PPI	12 de	6 c	0 a	276 d
Authority MTZ	8 oz wt	PPI	21 cde	16 bc	6 a	679 bcd
Authority MTZ	10 oz wt	PPI	25 cd	16 bc	0 a	705 bcd
Authority MTZ	12 oz wt	PPI	32 bc	25 ab	10 a	1236 abc
Authority MTZ	16 oz wt	PPI	43 ab	36 a	15 a	1720 a
Authority MTZ	8 oz wt	PRE	22 cd	15 bc	2 a	593 cd
Authority MTZ	12 oz wt	PRE	45 ab	32 a	6 a	1366 ab
Metribuzin fb Spartan Charge	2.9 oz wt 3.7 fl oz	PPI fb PRE	33 abc	26 ab	7 a	1151 abc
Metribuzin fb Spartan Charge	4.3 oz wt 5.5 fl oz	PPI fb PRE	45 ab	30 ab	3 a	1413 a
Authority Elite	24 fl oz	PRE	47 a	34 a	12 a	1738 a
Weed-free[4]			6 e	3 c	3 a	220 d
$P^x > F^y$			0.0001	0.0023	0.0624	0.0008

[1]Authority MTZ = sulfentrazone + metribuzin; Authority Elite = sulfentrazone + s-metolachlor; Spartan Charge = sulfentrazone + carfentrazone; Devrinol = napropamide. All plots received a POST treatment of Matrix (rimsulfuron) at 2 oz wt plus metribuzin at 3 oz wt/A plus nonionic surfactant

[2]PPI (preplant incorporated) and PRE (preemergence) applications were made the same day.

[3]Cumulative injury is total injury over the season (total of average injury per day).

[4]PPI treatment of Devrinol at 2 qts/A + metribuzin at 3.5 oz wt/A. This treatment was also hand-weeded

[x]Means within a column followed by the same letter are not significantly different (p=0.05) according to Fisher's protected LSD test.

[y]P values ≤0.05 indicate significant differences exist among treatments.

PSU-RS. Tomato injury at 2 weeks after planting was most severe with metribuzin applied PPI followed by Authority Elite PRE. Injury was significantly higher than Authority MTZ at 10 oz/A applied PPI. This was the same rates as Authority Elite, but Authority Elite also contains s-metolachlor (Dual Magnum) which confounds the interpretation of the results. As a trend, PPI applications of Authority MTZ resulted in less injury than PRE applications. Injury continued throughout the season, with similar injury ratings at 6 weeks after planting and at end of season.

Large crabgrass control was excellent (≥96%) for most treatments except Authority MTZ at 6 and 8 oz/A applied PPI. Redroot pigweed and common lambsquarters control was at last 95% for all treatments at 3 WAP and remained consistent throughout the season due to the POST application of Matrix plus metribuzin. Eastern black nightshade is a late emerging species and was not rated at 3 WAP, but at 6 WAP all treatments except the lowest rate of Authority MTZ provided ≥92% control.

Table 2. Tomato injury and weed control at PSU-RS.

Herbicide[1]	Rate/A	Applic. method[2]	% Biomass Reduction (3 WAP)[x]	% Biomass Reduction (6 WAP)	Lg. crabgrass (3 WAP)	Redroot pigweed (3 WAP)	Eastern black nightshade (6 WAP)
Untreated check			0	0	0	0	0
Authority MTZ	6 oz wt	PPI	4 e	5 e	65 c	95 b	71 b
Authority MTZ	8 oz wt	PPI	9 de	8 de	89 b	99 a	92 a
Authority MTZ	10 oz wt	PPI	13 cde	17 cde	96 ab	99 a	94 a
Authority MTZ	12 oz wt	PPI	20 bcd	19 b-e	98 a	99 a	97 a
Authority MTZ	16 oz wt	PPI	33 ab	35 ab	97 ab	99 a	99 a
Authority MTZ	8 oz wt	PRE	23 abc	22 b-e	97 ab	99 a	99 a
Authority MTZ	12 oz wt	PRE	27 abc	28 abc	96 ab	99 a	99 a
Metribuzin fb Authority Elite	4.3 oz wt 25 fl oz	PPI fb PRE	37 a	42 a	99 a	99 a	99 a
Authority Elite	25 fl oz	PRE	23 abc	25 a-d	99 a	99 a	99 a
$P^x>F^y$			0.0018	0.0068	0.0016	1.000	0.0001

[1]Authority MTZ = sulfentrazone + metribuzin; Authority Elite = sulfentrazone + s-metolachlor; Devrinol = napropamide. All plots received a POST treatment of Matrix (rimsulfuron) at 2 oz wt plus metribuzin at 3 oz wt/A plus nonionic surfactant

[2]PPI (preplant incorporated) and PRE (preemergence) applications were made the same day.

[x]Means within a column followed by the same letter are not significantly different (p=0.05) according to Fisher's protected LSD test.

[y]P values ≤0.05 indicate significant differences exist among treatments.

Yield. Tomatoes were harvested at UD-REC when approximately 60% ripeness was observed in the weed-free check. Yield of ripe (red/orange) tomatoes and immature (green) tomatoes showed significant differences between treatments (see Table 3). A significant reduction (34%) of ripe tomatoes occurred with the Spartan Charge, 5.5 fl oz/A and Authority MTZ at 16 oz/A applied PPI. Although not significantly different from the untreated check, fewer ripe tomatoes were recorded with Authority MTZ 12 oz/A PRE treatment as compared to the weed-free check. Authority Elite, Spartan Charge at 5.5 fl oz, Authority 8 oz/A PRE and Authority MTZ 16 oz/A PPI resulted in greater than 55% increase in weight of green tomatoes as compared to the untreated. No significant difference was observed with total yield (ripe + yellow + green tomatoes) or with yellow tomatoes (data not presented).

Table 3. Tomato yield and distribution of fruit maturity at UD-REC.

Herbicide[1]	Rate/A	Applic. method[2]	Yield Ripe lbs/plot[x]	% Ripe Fruit	Yield Green lbs/plot	% Green Fruit
Untreated check			28.3 ab	73 a	3.8 e	10 f
Authority MTZ	6 oz wt	PPI	25.8 abc	69 abc	7.0 cde	17 cde
Authority MTZ	8 oz wt	PPI	28.7 a	72 ab	5.8 de	12 ef
Authority MTZ	10 oz wt	PPI	24.1 abc	63 a-d	6.1 de	14 def
Authority MTZ	12 oz wt	PPI	28.1 ab	62 bcd	8.5 a-d	17 cde
Authority MTZ	16 oz wt	PPI	19.3 c	53 de	9.5 abc	24 ab
Authority MTZ	8 oz wt	PRE	24.1 abc	58 cde	10.3 ab	23 abc
Authority MTZ	12 oz wt	PRE	21.3 bc	60 cd	8.5 a-d	23 abc
Metribuzin fb Spartan Charge	2.9 oz wt 3.7 fl oz	PPI fb PRE	22. abc	62 bcd	7.1 bcd	20 bcd
Metribuzin fb Spartan Charge	4.3 oz wt 5.5 fl oz	PPI fb PRE	19.3 c	49 e	11.7 a	28 a
Authority Elite	24 fl oz	PRE	22.8 abc	59 cde	9.9 abc	24 ab
Weed-free[3]			29.5 a	65 abc	6.1 de	13 ef
$P^x>F^y$			0.0480	0.0036	0.002	0.001

[1]Authority MTZ = sulfentrazone + metribuzin; Authority Elite = sulfentrazone + s-metolachlor; Spartan Charge = sulfentrazone + carfentrazone; Devrinol = napropamide. All plots received a POST treatment of Matrix (rimsulfuron) at 2 oz wt plus metribuzin at 3 oz wt/A plus nonionic surfactant

[2]PPI treatments and PRE applications were made the same day.

[3]PPI treatment of Devrinol at 2 qts/A + metribuzin at 3.5 oz wt/A. This treatment was also hand-weeded.

[x]Means within a column followed by the same letter are not significantly different (p=0.05) according to Fisher's protected LSD test.

[y]P values ≤0.05 indicate significant differences exist among treatments.

IMPROVING PRODUCTION OF GRAFTED TOMATOES IN A FIELD SETTING

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The use of grafted vegetables to manage soilborne diseases is growing in the southeastern United States, but the application of grafted tomatoes to increase yields in fields with low soilborne disease pressure is not as well documented. In theory, more vigorous rootstocks may have the potential to increase yields in the absence of soilborne disease pressure. Furthermore, there has been interest from the industry to assess cultural practices such as plant spacing, plant pruning, and pinching (clipping the lead shoot before transplant to allow two side shoots to emerge) to increase yields and optimize the performance of rootstock-scion combinations. The objectives of this research were to evaluate the effect on yields of: (1) grafted Mountain Fresh Plus (MFP) and Tasti-Lee (TL) scions compared to non-grafted (Grower standard); (2) spacing grafted plants at 22" and 24" compared to grower standard of 18"; (3) pruned and non-pruned grafted plants (Beaufort rootstock only); and (4) pinched and non-pinched plants. In total, there were 34 (2017) or 36 (2018) treatment combinations in 30-foot plots replicated 4 times in a field at the Mountain Horticultural Crops Research Station in Mills River, NC in 2017 and 2018. Scions were grafted onto Beaufort, Arnold, and Shield. In 2018, both scion varieties also were grafted onto Fortamino; these treatments were pruned, spaced at 24", and not pinched.

Overall, grafting MFP and TL on Beaufort, Arnold, and Fortamino (2018 only) significantly improved yield (marketable lb/A) compared to grafting onto Shield and the non-grafted Grower standard. When comparing performance of the two scions on grafted tomatoes, yields from TL was significantly greater than MFP. Pinching the grafted tomatoes significantly improved yield over Non-pinched in 2018; in 2017, yields from pinched and non-pinched were statistically similar. Pruning the grafted plants (Beaufort only) decreased yields compared to Pruned plants. Yields from grafted plants spaced at 22" were statistically similar to plants spaced at 24". Overall, the use of more vigorous rootstocks can increase yield from grafted tomatoes in fields where soilborne disease pressure is low.

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INTEGRATED FOLIAR FUNGAL DISEASE MANAGEMENT OF TOMATO

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Foliar fungal diseases such as early blight and Septoria leaf blight continue to be a challenge to manage especially in a wet year and minimal available host resistance available to provide a backbone for a disease management program. Much of what we rely on are cultural practices that aim at reducing leaf wetness by improving air circulation within and around the plants. As the frequency of wet weather increases so will the interest in shifting to protected culture production to reduce the impact of direct rainfall on disease development. However, even without the direct impact of rain, foliar diseases can still be problematic.

Depending on the season and the field, early blight and/or Septoria leaf spot can be challenging to manage. Symptoms of early blight caused by *Alternaria solani* are initially small, brown to black circular lesions that may or may not develop a yellow chlorotic halo. As the disease develops the lesions enlarge and develop concentric rings that are characteristic of this disease and common for Alternaria diseases on other crops (e.g. Alternaria leaf spot on broccoli and cabbage caused by *Alternaria brassicicola*). Symptoms often develop first on the lower leaves and then move upward on the plant. Lesions can coalesce together and lead to defoliation. The disease is favored by wet and warm temperatures (75 to 84°F).

Fruit rots which are more commonly observed later in the season can be caused not only by the early blight pathogen but also another species of Alternaria (*Alternaria alternate*) in additional to several species of Colletotrichum which cause anthracnose. Neither *A. alternata* or the Colletotrichum spp. cause foliar symptoms, only fruit symptoms. Fruit lesions caused by Alternaria are usually near the petal end and develop concentric rings while those characteristic of anthracnose are circular, depressed, develop salmon-colored spore masses in the center and can be anywhere on the fruit. Infection occurs early when the fruit are immature, but symptoms are not visible until red mature.

Septoria leaf blight (caused by *Septoria lycopersici*) on the other hand, does not cause fruit symptoms, only foliar symptoms. Similar to early blight, small dark circular leaves start on the lower leaves and as the lesions expand they are tan to gray in the center with a dark margin and sometimes a yellow halo. In the center of the lesions small black dots called pycnidia develop and produce spores which are rain splashed onto adjacent plants and leaves further up the plant. Although the lesions do not get very large in size, many of them will coalesce together and can cause the entire leaf to blight down and drop off the plant. This disease is favored by wet and temperatures ranging from 66 to 77°F (cooler that those favored by early blight).

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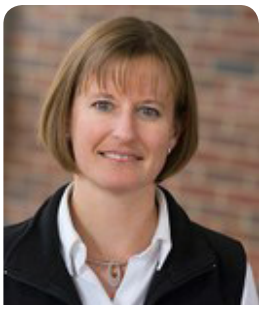

General integrated management strategies for these diseases include:

- Select cultivars that are well adapted for our region to reduce overall plant stress. Host resistance for early blight and Septoria leaf spot is limited.
- Implementing a 3- to 4-year crop rotation to enable the crop residue to thoroughly decompose. Neither pathogen can survive in the soil long in the absence of host plant tissue. Both are limited to members of the Solanaceous plant family as hosts including weeds like horsenettle so they are not a problem on crops like cucumbers, broccoli, etc.
- Maximize plant spacing as much as economically possible and orient the rows to maximize air flow. Stake, tie and sucker plants up to the first flower cluster.
- Use of mulches to reduce soil splash up onto the plants.
- Minimize leaf wetness by using drip irrigation.
- Work in youngest plantings first before moving to older plantings to reduce risk of spreading disease between plantings. Avoid working plants when they are wet early in the morning.
- Scout regularly especially with the onset of fruiting when early blight and Septoria leaf spot are most likely to develop as the plant allocates more resources to fruit production rather than maintaining the lower leaves.
- Use an in-season fungicide program to reduce potential secondary spread by spores that are produced in the lesions.

There are several conventional fungicides that are effective for managing both early blight and Septoria leaf spot on tomato. Check the 2019 Mid-Atlantic Fruit and Vegetable Recommendations for the most up-to-date list of recommended fungicides. Although early blight resistance to the strobilurin fungicides (Fungicide Resistance Action Committee code 11; FRAC 11; e.g. Quadris) has not been documented in our region it has been problematic in the southeastern U.S. It is important to rotate between different FRAC codes with each application and tank mix with a protectant fungicide such as chlorothalonil especially if the product is not already a premix (e.g. Quadris Top contains both azoxystrobin and difenoconazole; FRAC 11 + 3). Also keep in mind that tank mixing with late blight specific product such as Ranman (cyazofamid FRAC 21) or Previcur Flex (propamocarb FRAC 28) will not help manage early blight resistance since the active ingredients in these products do not have any activity against Alternaria spp. or any other true fungal pathogen.

In 2018 a trial funded by the Pennsylvania Vegetable Growers Association and Pennsylvania Vegetable Marketing and Research Program was conducted to evaluate the coupling of host resistance with the incorporation of biofungicides and/or OMRI-approved products into conventional fungicide programs for the management of early blight on tomato (as well as several other diseases not discussed here). Although early blight host resistance is limited, there are some cultivars considered less susceptible so cv. Mountain Fresh Plus (susceptible) was compared to cv. BHN 964 (less susceptible). Five fungicide treatments were overlaid on these two cultivars in a split-plot randomized complete block design with four replicates. Four augmented treatments were compared to the conventional commercial standard program of Bravo Weather Stik (2 pt/A) alternated with Quadris (5 fl oz/A) plus Bravo Weather Stik (2 pt/A) (Fig 1). Fungicide applications were made using a tractor mounted, R & D CO_2-powered offset-boom sprayer traveling at 3 mph and calibrated to deliver 28 gal/A at 32 psi through three TX-18 hollow-cone nozzles on 27 Jul, 7, 16, 24, 30 Aug, and 6, 13 and 20 Sep for a total of eight fungicide applications. Plots were artificially inoculated with a mix of three Pennsylvania *Alternaria solani* isolates. Supplemental water was applied using overhead misters to extend the dew period and create more favorable conditions for disease. Foliar early blight severity was evaluated on 3, 8, 16, and 23 Sep by estimating the percent of leaves with early blight across the whole plot. Area under the disease progress curve was calculated and converted to the percent control relative to the untreated controls (Fig 1). Rainfall totals (in.) were 2.71, 10.20, 7.22, and 6.22 for 26 to 30 Jun, Jul, Aug and 1 to 23 Sep, respectively.

In the trial, disease severity developed slowly but did reach near 100% in the untreated control plots of both tomato cultivars by the end of the trial. All treatments significantly reduced early blight disease severity compared to the untreated controls for both cultivars. Replacing Bravo Weather Stik with the biofungicides LifeGard (a.i. *Bacillus mycoides* isolate J from Certis USA), Double Nickel (a.i. *Bacillus amyloliquefaciens* strain D747) or the OMRI-approved

copper Champ (a.i. copper hydroxide from Nufarm Agricultural Products) reduced half of the number of chlorothalonil applications but did not reduce tomato early blight control on either cv. Mountain Fresh Plus or BHN 964. It in not know why rotating Fontelis and Regalia (a.i. *Reynoutria sachalinensis* extract from Marrone Bio Innovations) each tank mixed with Kocide 3000 was equally effective on cv. Mountain Fresh Plus but not on cv. BHN 964. In general disease severity was higher on cv. BHN 964 compared to Mountain Fresh Plus but this was due in part due to the difference in plant growth habit since the plants were not staked and tied.

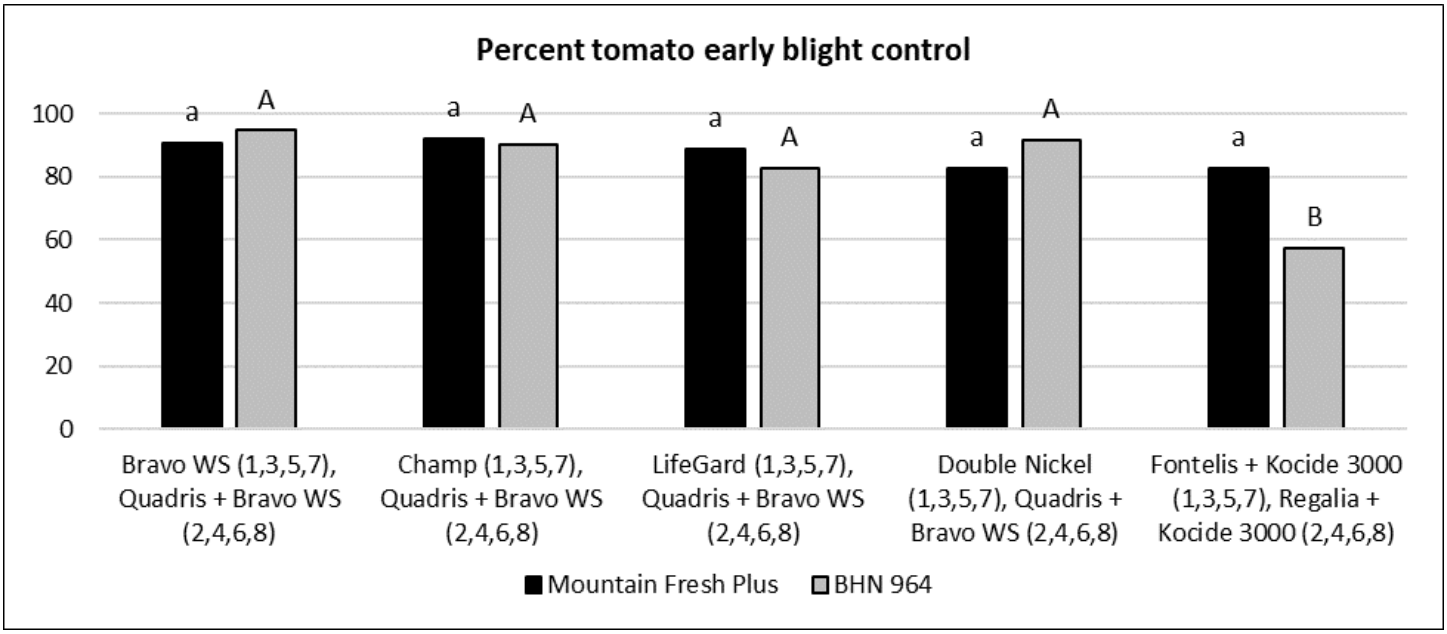

Fig 1. The fungicide rates are as follows: Bravo Weather Stik (Bravo WS 2 pt/A), Quadris (5 fl oz/A), Champ (3.2 lb/A), LifeGard (4.5 oz/100 gal), Double Nickel (3 lb/A), Fontelis (1 pt/A), Kocide 3000 (1 lb/A) and Regalia (4 qt/A). The numbers in parentheses reflect the following fungicide application dates: 1 = 29 Jul; 2 = 7 Aug; 3 = 16 Aug; 4 = 24 Aug; 5 = 30 Aug; 6 = 6 Sep; 7 = 13 Sep and 8 = 20 Sep. Data was analyzed using PROC GLM which indicated a significant cultivar by fungicide treatment interaction ($P = 0.0006$) in additional to significant main effects (cultivar $P = 0.0366$; treatment $P < 0.0001$), so fungicide treatments were analyzed separately within cultivar using an analysis of variance and treatment means separated using Fisher's Least Significant Difference test (SAS v. 9.4, SAS Institute, Cary, NC). As indicated by the letters at the top of the bars, there was no significant differences in the level of disease control obtained on cv. Mountain Fresh plus regardless of treatment (lower case letters and black bars; $P = 0.4106$). The Fontelis/Regalia plus Kocide treatment was not as effective on cv. BHN 964 (upper case letters and gray bars; $P = 0.0021$).

Although this trial only reflects the results from one year, it is clear depending on the crop and disease, augmenting conventional fungicide programs with select biofungicides or OMRI-approved products can still provide the same or similar level of disease control as the conventional program. Although the additive effect of coupling with host resistance was less clear this season when disease pressure was high and the wet conditions favorable for disease development, selection of resistant cultivars is still an important part of an integrated disease management program. Evaluating programs such as these over multiple field seasons is important to account for these types of differences. When evaluating the incorporation of new products into your own fungicide programs, it is important to not only review the research-based results available to help select the most promising biofungicides and OMRI-approved products but also consider conducting your own on-farm comparisons. The efficacy of fungicide programs can also be dependent on farm-specific factors so conducting a side-by-side comparison in conjunction with regular scouting to monitor disease development are important for successful disease management.

ON-FARM SOIL HEALTH ASSESSMENT WITH 4R TWEAKS

H. Grant Troop, AgXplore

North America Soil Health Assessment Worksheet

	Productivity Enhanced	Productivity Limited	Productivity Restricted	Numerical Rating			Comments
Indicators/ Resource Concerns	**Excellent (8 - 10)**	**Fair to Moderate (4 - 7)**	**Poor (1 - 3)**	**Year 1**	**Year 2**	**Year 3**	
Soil Structure	Stable, strong soil aggregates; good weight- bearing ability by soil super structure; excellent tilth; low potential for compaction, crusting and/or puddling	Weak to moderate soil aggregates from some soil disturbance; fair to good tilth; medium to high potential for compaction, crusting and/or puddling	Structure-less to weak soil aggregates; usually pulverized by tillage; poor to fair tilth; high to very high potential for compaction, crusting and/or puddling				Structure varies by soil type
Surface Cover	Soil surface cover year-round with growing crop, crop residue and/or cover crop; 50-100% soil cover	Some soil surface cover; perhaps short periods with reduced soil cover; 30-50% soil cover	Little or no soil surface cover; 0-<30% soil surface cover				Is the residue lignified (durable)?
Water Infiltration and Drainage	Soil drains well after rain; brief or no ponding visible; surface pores; low runoff	Water drains moderately well to slow; some ponding; limited surface pores; increased runoff	Water drains slow to poor; ponding evident; sealed soil surface; high runoff rates				
Organic Matter	Organic matter content stable at or increasing toward high levels for given soil type; active carbon sequestration practices	Organic matter content stable or slowly decreasing below median levels for given soil type	Organic matter content well below median level for given soil type with continued oxidative carbon practices				Monitor with soil test
Soil pH	Soil pH within the optimum range for grown plants	Soil pH marginally within the acceptable range for grown plants	Soil pH outside the acceptable range for grown plants				Monitor with soil test
Fertility	Sufficient levels of all essential plant nutrients; proper nutrient balance ratios	Insufficient levels of essential plant nutrient(s) and/or minor imbalanced nutrient ratios	Plant nutrient deficiencies and/or major imbalances in nutrient ratio(s)				Soil test
Soil Movement	No visual evidence of soil movement; surface runoff generally clear	Some visual evidence of sheet and rill erosion; cloudy runoff	Obvious signs of soil movement; sheet and rill erosion; down slope gully formation and/or sediment deposition; muddy runoff				Is surface water control needed?
Soil Biodiversity	Numerous signs of earthworms including night crawlers; active strong bio- diverse soil life community present	Some signs of earthworms; few or no night crawlers; some bio-diverse soil life community present	Few signs of earthworms; no night crawlers; very limited bio-diverse soil life community present				
Plant Growth	Healthy uniform growth; consistently high yields; robust root system; plants resist stress	Somewhat uniform growth; fair to good yield; some root vigor reduction; crops moderately resistant to stress	Uneven or spotty good growth; root growth restricted; plants susceptible to stress				

North America Soil Health Assessment

"Soil quality is the capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support Human health and habitation."

Soil Science of America

Field ID _____ *Acres*_____ *Soil Type* _____

	Year 1	Year 2	Year 3
Current Crop			
Crop Rotation			
Cover Crop			
Soil Disturbance			
Lime Applied			
Fertilizer Applied			
Manure Applied			
Pesticides Applied			
Yield			

Instructions: Fill out the field information below. Draw a map of the field so that you can mark special areas for further attention. Use the worksheet on the other side to guide your assessment of the soil quality in this field. Note the best time for making each assessment. A shovel will be useful in making some of the assessments. Check the appropriate rating or insert a score and note any observations that might help interpret the results. If you have other indicators be sure to include them. Evaluate the ratings for each indicator based on the properties of the soil from the soil survey and the management information below. Determine where changes can be made to improve your soil management. A recommended use of this worksheet is to periodically assess soil quality in your fields to determine if it is getting better or worse and to adjust management accordingly.

Field Map (Mark areas for special attention)

hgt – June 27, 2008
revised Penn State Coop Ext, Form #10Mps35729

PHYSICAL AND CHEMICAL COMPONENTS OF HEALTHY SOILS

Michelle Infante-Casella, Agricultural Agent and Associate Professor
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Creating a healthy soil environment is the most effective way to maximize nutrient availability, water uptake and ultimately, healthy, productive plants. There are many reasons that plants can or cannot absorb nutrients contained in the soil they are growing in and the process can be complicated. It is important to understand the physical and chemical components of soil and how they interact. Managing soils through tillage, cropping systems, and amendment applications can help improve soil health. The physical and chemical components of soil are explained below.

PHYSICAL COMPONENTS OF SOIL:

1. **Horizonation**

Soil "horizons" are individual layers that make up a soil profile. Typically, these layers are parallel with the ground surface. Listed below are some of the layers or horizons that make up some soils.

O horizons are dominated by organic material. Some are saturated with water for long periods or were once saturated but are now artificially drained; others have never been saturated.

A horizons are mineral layers that formed at the surface or below an O horizon, that exhibit obliteration of all or much of the original rock structure, and that show one or both of the following:

- an accumulation of humified organic matter intimately mixed with the mineral fraction and not dominated by properties characteristic of E or B horizons
- modification as a result of the actions of cultivation, pasturing, or similar kinds of disturbance

E horizons are mineral layers that exhibit the loss of silicate clay, iron, aluminum, humus, or some combination of these, leaving a concentration of sand and silt particles. These horizons exhibit obliteration of all or much of the original rock structure.

B horizons are mineral layers that typically form below an A, E, or O horizon and are dominated by obliteration of all or much of the original rock structure and show one or more of the following:

- Illuvial concentration of silicate clay, iron, aluminum, humus, carbonate, gypsum, or silica, alone or in combination
- Evidence of removal of carbonates
- Residual concentration of sesquioxides
- Coatings of sesquioxides that make the horizon conspicuously lower in value, higher in chroma, or redder in hue than overlying horizons without apparent illuviation of iron
- Alteration that forms silicate clay or liberates oxides or both and that forms granular, blocky, or prismatic structure if volume changes accompany changes in moisture content; or brittleness

Michelle Infante-Casella has been an Agricultural Agent and Associate Professor, since 1996, with Rutgers NJ Agricultural Experiment Station, Cooperative Extension, in Gloucester County, NJ. She is responsible for vegetable production and marketing as well as field crops in Gloucester County. Michelle is also the County Extension Department head for Rutgers Cooperative Extension of Gloucester County. She is the chairperson of the Rutgers NJAES Agritourism Working Group. This group conducts education and research programs for farmers with on-farm direct marketing operations. Michelle is the NJ State Professional Development Program Coordinator for the U.S.D.A. Sustainable Agriculture Research and Education Program. She is also the Rutgers Chairperson for the Farm Safety and Health Team. Michelle has a Bachelors Degree in Horticulture from Delaware Valley University and a Masters in Plant Science from Virginia Tech. Originally from Monmouth County, NJ, Michelle and her husband Ben reside in Gloucester County, NJ and have two sons

C horizons are mineral layers which are not bedrock and are little affected by pedogenic processes and lack properties of O, A, E or B horizons. The material of C layers may be either like or unlike that from which the overlying soil horizons presumably formed. The C horizon may have been modified even if there is no evidence of pedogenesis.

R horizons are layers of hard bedrock.

Transitional horizons are dominated by properties of one master horizon, but have subordinate properties of another. AB and B/C are examples of transitional horizon designations.

2. **Soil Color**

In well aerated soils, oxidized or ferric (Fe+3) iron compounds are responsible for the brown, yellow, and red colors you see in the soil. When iron is reduced to the ferrous (Fe+2) form, it becomes mobile, and can be removed from certain areas of the soil. When the iron is removed, a gray color remains, or the reduced iron color persists in shades of green or blue.

3. **Soil Texture**

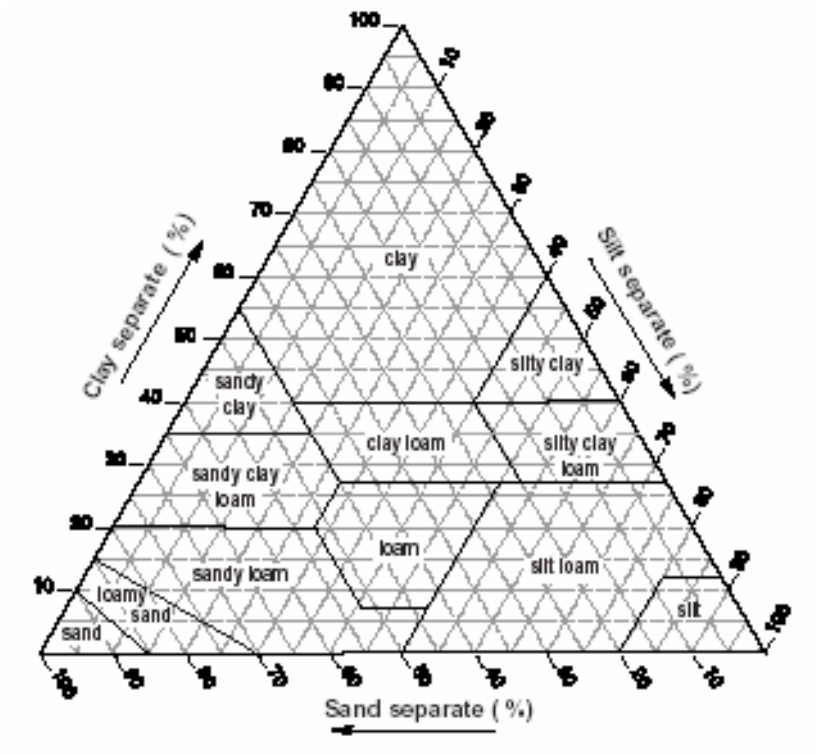
Soil texture refers to the proportion of the soil "separates" that make up the mineral component of soil. These separates are called sand, silt, and clay. These soil separates have the following size ranges:

- Sand = <2 to 0.05 mm
- Silt = 0.05 to 0.002 mm
- Clay = <0.002 mm

Sand and silt are the "inactive" part of the soil matrix, because they do not contribute to a soil's ability to retain soil water or nutrients. These separates are commonly comprised of quartz or some other inactive mineral.

Because of its small size and sheet-like structure, clay has a large amount of surface area per unit mass, and its surface charge attracts ions and water. Because of this, clay is the "active" portion of the soil matrix.

For all mineral soils, the proportion of sand, silt, and clay always adds up to 100 percent. These percentages are grouped into soil texture "classes", which have been organized into a "textural triangle".



Soil texture can affect the amount of pore space within a soil. Sand-sized soil particles fit together in a way that creates large pores; however, overall there is a relatively small amount of total pore space. Clay-sized soil particles fit together in a way that creates small pores; however, overall there are more pores present. Therefore, a soil made of clay-sized particles will have more total pore space than a will a soil made of sand-sized particles. Consequently, clayey soils will generally have lower bulk densities than sandy soils.

Collectively, the soil separates of sand, silt, and clay are called the "fine-earth fraction", and represent inorganic soil particles less than 2mm in diameter. Inorganic soil particles 2mm and larger are called "rock fragments".

When the organic matter content of a soil exceeds 20 to 35% (on a dry weight basis) it is considered organic soil material, and the soil is called an organic soil. As this material is mostly devoid of mineral soil material, they cannot be described in terms of soil texture. However, the following "in lieu of" texture terms can be used to describe organic soils:

- "peat"; organic material in which the plant parts are still recognizable
- "muck"; highly decomposed organic material in which no plant parts are recognizable
- "mucky peat"; decomposition is intermediate between muck and peat

4. **Soil Structure**

The soil separates can become aggregated together into discrete structural units called "peds". These peds are organized into a repeating pattern that is referred to as soil structure. Between the peds are cracks called "pores" through which soil air and water are conducted. Soil structure is most commonly described in terms of the shape of the individual peds that occur within a soil horizon.

Types of Soil Structure

Graphic Example	Description of Structure Shape
	**Granular** – roughly spherical, like grape nuts. Usually 1-10 mm in diameter. Most common in A horizons, where plant roots, microorganisms, and sticky products of organic matter decomposition bind soil grains into granular aggregates
	**Platy** – flat peds that lie horizontally in the soil. Platy structure can be found in A, B and C horizons. It commonly occurs in an A horizon as the result of compaction.
	**Blocky** – roughly cube-shaped, with more or less flat surfaces. If edges and corners remain sharp, we call it angular blocky. If they are rounded, we call it subangular blocky. Sizes commonly range from 5-50 mm across. Blocky structures are typical of B horizons, especially those with a high clay content. They form by repeated expansion and contraction of clay minerals.
	**Prismatic** – larger, vertically elongated blocks, often with five sides. Sizes are commonly 10-100mm across. Prismatic structures commonly occur in fragipans.
	**Columnar** – the units are similar to prisms and are bounded by flat or slightly rounded vertical faces. The tops of columns, in contrast to those of prisms, are very distinct and normally rounded.

5. **Soil Consistence**

Soil consistence refers to the ease with which an individual ped can be crushed by the fingers. Soil consistence, and its description, depends on soil moisture content. Terms commonly used to describe consistence are:

Moist soil:

- loose – noncoherent when dry or moist; does not hold together in a mass
- friable – when moist, crushed easily under gentle pressure between thumb and forefinger and can be pressed together into a lump
- firm – when moist crushed under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable

Wet soil:

- plastic – when wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger
- sticky – when wet, adheres to other material and tends to stretch somewhat and pull apart rather than to pull free from other material

Dry Soil:

- soft – when dry, breaks into powder or individual grains under very slight pressure
- hard – when dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger

6. **Bulk Density**

Bulk density is the proportion of the weight of a soil relative to its volume. It is expressed as a unit of weight per volume, and is commonly measured in units of grams per cubic centimeters (g/cc). Bulk density is an indicator of the amount of pore space available within individual soil horizons, as it is inversely proportional to pore space: Pore space = 1 – bulk density/particle density. For example, at a bulk density of 1.60 g/cc, pore space equals 0.40 or 40%. At a bulk density of 1.06 g/cc, pore space equals 0.60 or 60%. The addition of even a small percentage of organic soil material to a mineral soil can affect the bulk density of that soil. Compare the two soil samples below:

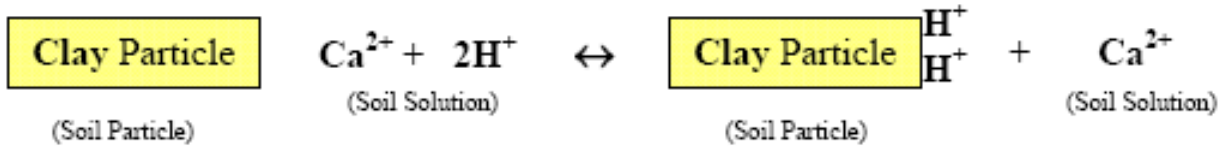
Soil "A": 100% mineral soil material; bulk density = 1.33 g/cc
Soil "B": 95% mineral soil material and 5% organic soil material; bulk density = 1.26 g/cc

The difference in bulk density relates to a difference in "particle density" of mineral soil material versus organic soil material. The average particle density of mineral soil material is 2.65 g/cc, which approximates the density of quartz. Conversely, the average particle density of organic soil material is 1.25 g/cc. Organic soil material weighs less than mineral soil material, so it will lower the bulk density of a mineral soil when added, as it reduces the overall weight of the soil.

CHEMICAL COMPONENTS OF SOIL

1. Cation Exchange Capacity (CEC)

Some plant nutrients and metals exist as positively charged ions, or "cations", in the soil environment. Among the more common cations found in soils are hydrogen (H+), aluminum (Al+3), calcium (Ca+2), magnesium (Mg+2), and potassium (K+). Most heavy metals also exist as cations in the soil environment. Clay and organic matter particles are predominantly negatively charged (anions), and have the ability to hold cations from being "leached" or washed away. The adsorbed cations are subject to replacement by other cations in a rapid, reversible process called "cation exchange".



Cations leaving the exchange sites enter the soil solution, where they can be taken up by plants, react with other soil constituents, or be carried away with drainage water.

The "cation exchange capacity", or "CEC", of a soil is a measurement of the magnitude of the negative charge per unit weight of soil, or the amount of cations a particular sample of soil can hold in an exchangeable form. The greater the clay and organic matter content, the greater the CEC should be, although different types of clay minerals and organic matter can vary in CEC.

Cation exchange is an important mechanism in soils for retaining and supplying plant nutrients, and for adsorbing contaminants. It plays an important role in wastewater treatment in soils. Sandy soils with a low CEC are generally unsuited for septic systems since they have little adsorptive ability and there is potential for groundwater.

2. Soil Reaction (pH)

By definition, "pH" is a measure of the active hydrogen ion (H+) concentration. It is an indication of the acidity or alkalinity of a soil, and also known as "soil reaction". The pH scale ranges from 0 to 14, with values below 7.0 acidic, and values above 7.0 alkaline. A pH value of 7 is considered neutral, where H+ and OH- are equal, both at a concentration of 10-7 moles/liter. A pH of 4.0 is ten times more acidic than a pH of 5.0.

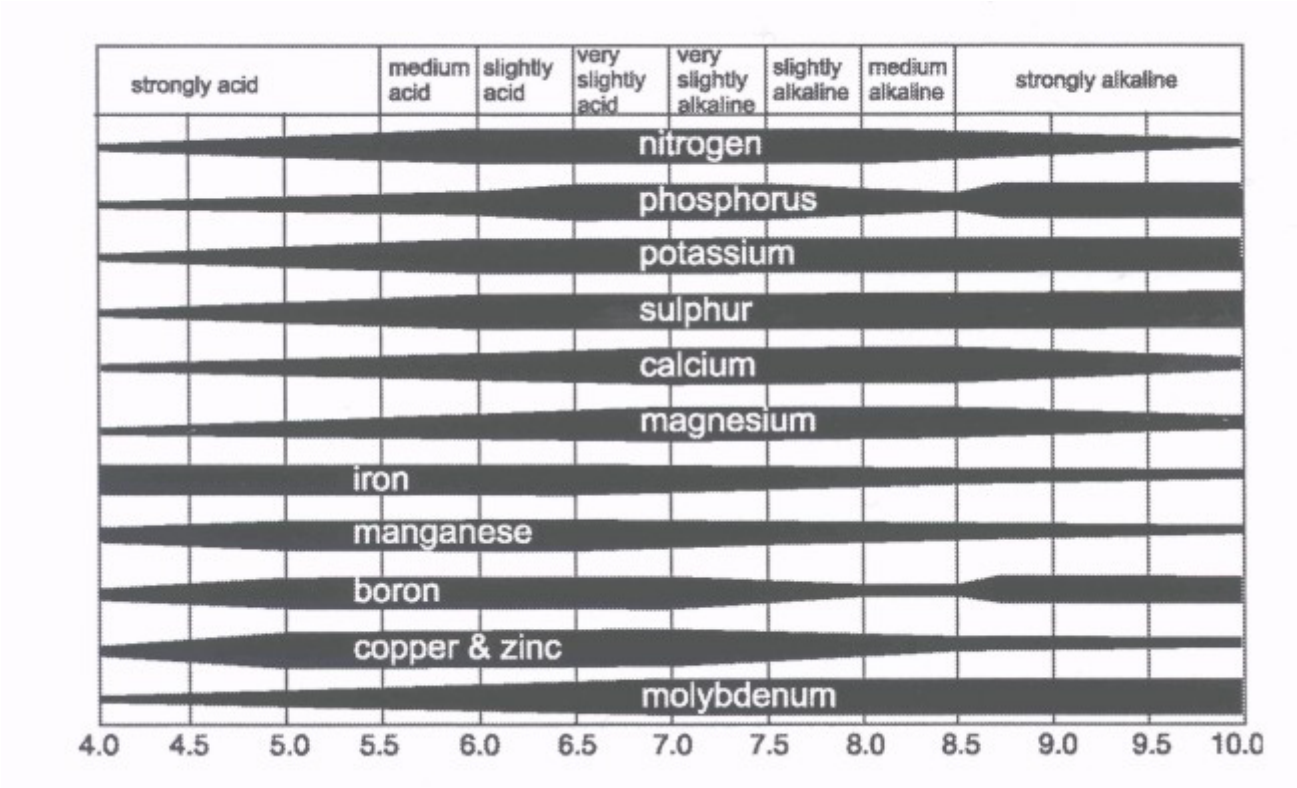
The most important effect of pH in the soil is on ion solubility, which in turn affects microbial and plant growth. A pH range of 6.0 to 6.8 is ideal for most crops because it coincides with optimum solubility of the most important plant nutrients. Some minor elements (e.g., iron) and most heavy metals are more soluble at lower pH. This makes pH management important in controlling movement of heavy metals (and potential groundwater contamination) in soil.

In acid soils, hydrogen and aluminum are the dominant exchangeable cations. The latter is soluble under acid conditions, and its reactivity with water (hydrolysis) produces hydrogen ions. Calcium and magnesium are basic cations; as their amounts increase, the relative amount of acidic cations will decrease.

Factors that affect soil pH include parent material, vegetation, and climate. Some rocks and sediments produce soils that are more acidic than others: quartz-rich sandstone is acidic; limestone is alkaline. Some types of vegetation, particularly conifers, produce organic acids, which can contribute to lower soil pH values. In humid areas such as the eastern US, soils tend to become more acidic over time because rainfall washes away basic cations and replaces them with hydrogen. Addition of certain fertilizers to soil can also produce hydrogen ions. Liming the soil adds calcium, which replaces exchangeable and solution H+ and raises soil pH.

Lime requirement, or the amount of liming material needed to raise the soil pH to a certain level, increases with CEC. To decrease the soil pH, sulfur can be added, which produces sulfuric acid.

Soil pH can hinder or assist in the release of some soil nutrients. A chart below shows the availability of essential plant nutrients under certain pH levels. The wider the bar the more available that nutrient is to plants. The thinner the bar, the less available that nutrient is for plant uptake.



Soil pH

References:

Brady, N.C. 1990. The Nature and Properties of Soils. Macmillan Publishing Company, NY, NY.

Soil Physical and Chemical Properties. USDA Natural Resources Conservation Service, New Jersey. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/nj/home/?cid=nrcs141p2_018993

Soil Survey Staff, 2003. Keys to Soil Taxonomy. USDA-NRCS.

BEST OF THE PENN STATE FLOWER TRIALS 2018

Sinclair Adam, Extension Educator-Horticulture & Flower Trials Director Penn State Extension

In 2018, 999 cultivars were tested in the Penn State Flower Trials. Plants were tested at the Southeast Agricultural Research and Extension Center, at Hershey Gardens (Dauphin County), at North Park (Allegheny County) at PSU Ag. Progress Days, and the Penn State Arboretum (Centre County). Plants were potted into five-gallon pots during the fourth week of May 2018 and shipped to the collaborative sites. Plants were rated four times during the growing season for uniformity, flowering, foliar quality, and overall growth. Results were posted on the Penn State Flower Trials web pages.

Agastache 7 cultivars

Best Performance: Sunrise Yellow- Green Fuse Botanicals
Sunrise Blue- Green Fuse Botanicals
Sunrise Violet- Green Fuse Botanicals
Sunrise Red- Green Fuse Botanicals

Angelonia 18 cultivars

Best Performance: AngelMist Spreading White-Ball FloraPlant
AngelMist Spreading Berry Sparkler-Ball FloraPlant
Alonia Bicolor Violet-Danziger Flower Farm
AngelMist Spreading Bluebird-Ball FloraPlant
Archangel Dark Purple-Ball FloraPlant
Archangel Raspberry-Ball FloraPlant
AngelFace Perfectly Pink-Proven Winners

Argyranthemum 13 cultivars

Best Performance: Golden Butterfly-Proven Winners
Pure White Butterfly-Proven Winners
Grandessa Yellow-Suntory Flowers
Alessia Yellow-Selecta One

Artemesia 1 cultivar:

Best Performance: Makana Silver-Terra Nova Nurseries

Begonia 44 cultivars

Best Performance: BabyWing Bicolor-PanAmerican Seed
Senator iQ Rose-Sakata Seed America
Megawatt Pink Bronze Leaf-PanAmerican Seed
Megawatt Rose Bronze Leaf-PanAmerican Seed
BabyWing Red-PanAmerican Seed
BabyWing White-PanAmerican Seed
Tophat White-Syngenta Flowers
Senator iQ Rose Bicolor-Sakata Seed America
Dragon Wing Pink-PanAmerican Seed

Sinclair Adam is a Penn State Extension Educator in Horticulture, and Penn State Flower Trials Director. He holds a B.S. in Plant and Soil Science from Univ. of Wyoming, and a M.S. in Plant and Soil Science from the Univ. of Vermont. Sinclair has been an Adjunct Professor at Univ. of Vermont, a Senior Lecturer at Temple University, a Research Fellow at Temple University, and has taught at the Barnes Foundation. Sinclair has also served in the horticultural industry for over 30 years, and holds 15 plant patents on Phlox, Tiarella, and Chrysanthemum selections.

Tophat Pink-Syngenta Flowers
Senator iQ Pink-Sakata Seed America
Senator iQ Scarlet-Sakata Seed America
BabyWing Pink-PanAmerican Seed
BabyWing White Bronze Leaf-PanAmerican Seed
Megawatt Red Green Leaf Imp.-PanAmerican Seed
Tophat Scarlet-Syngenta Flowers
Megawatt Red Bronze Leaf-PanAmerican Seed
Dragon Wing Red-PanAmerican Seed
Megawatt Pink Green Leaf-PanAmerican Seed
Big Rose Green Leaf-Ernst Benary of America
Big Rose Bronze Leaf-Ernst Benary of America

Bidens 9 cultivars
Best Performance: Bidy Boom Red-Dummen Orange
Bee Happy-Ball FloraPlant
Beedance Yellow-Suntory Flowers

Brachyscome 1 cultivar
Best performance: Fresco Purple-Danziger Flower Farm

Bracteantha 8 cultivars
Best Performance: Hello Rose-Cohen Propagation Nurseries
Hello Orange-Cohen Propagation Nurseries
Hello Yellow-Cohen Propagation Nurseries
Hello Compact Yellow-Cohen Propagation Nurseries

Browallia 2 cultivars
Best Performance: Endless Illumination-Proven Winners

Calendula 2 cultivars
Best performance: Lady Godiva Yellow-Proven Winners
Lady Godiva Orange-Proven Winners

Calibrachoa 54 cultivars
Best performance: Bloomtastic Blue Quartz-Dummen Orange
MiniFamous Uno White-Selecta One
MiniFamous Uno Yellow-Selecta One
Conga Deep Yellow-Ball FloraPlant
MiniFamous Uno Pink-Selecta One
Lia Melon-Danziger Flower Farm
Cabaret White-Ball FloraPlant
Kabloom White-PanAmerican Seed
Conga White-Ball FloraPlant
MiniFamous Uno Violet Star-Selecta One
Lia White-Danziger Flower Farm
Bloomtastic Fuchsia-Dummen Orange
Colibri Lemon-Danziger Flower Farm
MiniFamous Neo Apricot Strike-Selecta One

Cruze Control Yellow-Green Fuse Botanicals
Cruze Control Orange-Green Fuse Botanicals
MiniFamous Neo White + Yellow Eye-Selecta One
MiniFamous Uno Pink Strike-Selecta One
MiniFamous Neo Orange + Red Eye-Selecta One
Lia Bubblegum-Danziger Flower Farm
Aloha Nani Golden Girl-Dummen Orange
Conga Rose Kiss Improved-Ball FloraPlant
Unique Golden Yellow-Kientzler North America
Bloomtastic Serenity-Dummen Orange
Bloomtastic Pink Flare-Dummen Orange
Cabaret Bright Red-Ball FloraPlant
Cabaret Midnight Blue-Ball FloraPlant
Lia Yellow-Danziger Flower Farm
Superbells Holy Cow-Proven Winners
Bloomtastic Rose Quartz-Dummen Orange
Cabaret Golden Yellow-Ball FloraPlant
Lia Blue-Danziger Flower Farm
Can-Can Bumble Bee Pink-Ball FloraPlant
Kabloom Yellow-PanAmerican Seed
Cruze Control Pink Delicious-Green Fuse Botanicals

Calibrachoa Dbl. 9 cultivars
Best Performance: MiniFamous Uno Double Pink Tastic-Selecta One
MiniFamous Uno Double Chiffon-Selecta One
MiniFamous Uno Double Light Pink-Selecta One
Superbells Double Chiffon-Proven Winners
MiniFamous Uno Double White-Selecta One
MiniFamous Uno Double Rose Chai-Selecta One
MiniFamous Uno Double Lemon-Selecta One

Calibrachoa hyb. 9 cultivars
Best Performance: Callie Coral-Syngenta Flowers
Cabrio Yellow-Syngenta Flowers
Cabrio Amethyst-Syngenta Flowers
Callie Eclipse Lavender-Syngenta Flowers
Cabrio Pink-Syngenta Flowers

Canna 8 cultivars
Best Performance: Cannova Bronze Orange-Ball Ingenuity
Toucan Dark Orange-Proven Winners
Toucan Coral-Proven Winners
Cannova Bronze Scarlet-Ball Ingenuity

Carex 2 cultivars
Best Performance: ColorGrass Carex Bronco-PanAmerican Seed
ColorGrass Carex Phoenix Green-PanAmerican Seed

Celosia 14 cultivars

Best Performance: Kelos Fire Magenta-Beekenkamp
Kelos Atomic Neon-Beekenkamp
Kelos Fire Orange-Beekenkamp
Intenz Dark Purple-Ball Ingenuity
Kelos Atomic Violet-Beekenkamp
Kelos Fire Purple-Beekenkamp
Kelos Fire Pink-Beekenkamp
Kelos Fire Lime-Beekenkamp
Kelos Fie Red-Beekenkamp
Kelos Atomic Purple Pink-Beekenkamp
Kelos Fire Scarlet-Beekenkamp
First Flame Purple-PanAmerican Seed

Cleome 3 cultivars

Best Performance: Senorita Rosalita-Proven Winners

Coleus 32 cultivars

Best Performance: ColorBlaze Apple Brandy-Proven Winners
Main Street Broad Street-Dummen Orange
FlameThrower Chipotle-Ball FloraPlant
FlameThrower Salsa Verde-Ball FloraPlant
FlameThrower Serrano-Ball-FloraPlant
Premium Sun Crimson-PanAmerican Seed
Main Street River Walk-Dummen Orange
Great Falls Niagara-Dummen Orange
FlameThrower Salsa Roja-Ball FloraPlant
Main Street Pink Ocean Drive-Dummen Orange
ColorBlaze Golden Dreams-Proven Winners
Premium Shade Kong Jr. Scarlet-PanAmerican Seed
ColorBlaze Royale Cherry Brandy-Proven Winners
ColorBlaze Torchlight-Proven Winners
ColorBlaze Chocolate Drop-Proven Winners
Great Falls Angel-Dummen Orange
Main Street Chartres Street-Dummen Orange
Great Falls Iguazu-Dummen Orange
Great Falls Alamare-Dummen Orange
ColorBlaze Sedona Sunset-Proven Winners
Pinkplosion-Ball FloraPlant
Premium Sun Mighty Mosaic-PanAmerican Seed
ColorBlaze Strawberry Drop-Proven Winners
Main Street Sunset Boulevard-Dummen Orange

Combinations 54 selections

Best Performance: MixMasters Vindaloo Vision-Ball FloraPlant
MixMasters The Whole Enchilada-Ball FloraPlant
MixMasters Tiki Masala-Ball FloraPlant
Plug & Play Melba Parfait-PanAmerican Seed

Plug & Play Summer Candy-PanAmerican Seed
Plug & Play Ink'd-PanAmerican Seed
Plug & Play Shining Stars-PanAmerican Seed
Plug & Play Summer Smoothie-PanAmerican Seed
TioMio Zamba-Kientzler North America
MixMasters Tart Deco-Ball FloraPlant
Plug & Play Airbrush'd-PanAmerican Seed
Kwik Kombos Pink Limeaide-Syngenta Flowers
Plug & Play Seaside Delight-PanAmerican Seed
MixMasters Peppery Perfection-Ball FloraPlant
MixMasters Shindig-Ball FloraPlant
MixMasters Tea Party-Ball FloraPlant
Plug & Play Berry Sparkler-PanAmerican Seed
Plug & Play Berry Burst-PanAmerican Seed
Kwik Kombos Tequila Sunrise-Syngenta Flowers
MixMasters Summer Fest-Ball FloraPlant
Plug & Play Sun Jewels PanAmerican Seed
MixMasters 5 Alarm Chili-Ball FloraPlant
Plug & Play Christmas In July-PanAmerican Seed
Plug & Play Cherry Jam-PanAmerican Seed

Combinations Hanging 54

Best Performance: MixMasters The Whole Enchilada-Ball FloraPlant
Plug & Play Summer Candy-PanAmerican Seed
MixMasters Peppery Perfection-Ball FloraPlant
Kwik Kombos Tequilia Sunrise-Syngenta Flowers
Plug & Play Summer Smoothie-PanAmerican Seed
Mixis Heaven Scent-Danziger Flower Farm
Kwik Kombos Pink Limeaide-Syngenta Flowers
Mixis Purple Reign-Danziger Flower Farm
MixMasters Shooting Comet-Ball FloraPlant
Mixis Heyday-Danziger Flower Farm
Mixis Morning Dew-Danziger Flower Farm
MixMasters Tiki Masala-Ball FloraPlant
MixMasters Vindaloo Vision-Ball FloraPlant
MixMasters 5 Alarm Chili-Ball FloraPlant
Plug & Play Peach Melba Parfait-PanAmerican Seed

Coreopsis 1 cultivar

Best Performance: Electric Sunshine-Darwin Perennials

Dahlia 25 cultivars

Best Performance: Dalaya Red-Selecta One
Labella Medio Red-Beekenkamp
Labella Maggiore Purple-Beekenkamp
City Lights Golden Yellow-Selecta One
City Lights Lavender Pink-Selecta One
City Lights Purple-Selecta One

Dianthus 3 cultivars
Best Performance: Floral Lace Picotee Imp.-PanAmerican Seed
Floral Lace Lilac-PanAmerican Seed

Euphorbia 2 cultivars
Best Performance: Diamond Mountain-Proven Winners
Diamond Frost-Proven Winners

Evolvulus 1 cultivar
Best Performance: Blue My Mind-Proven Winners

Geranium IS 18 cultivars
Best Performance: Calliope Medium Crimson-Syngenta Flowers
Calliope Large Hot Rose-Syngenta Flowers
Calliope Medium Hot Rose-Syngenta Flowers
Calliope Medium Pink Flame-Syngenta Flowers
Calliope Medium Violet-Syngenta Flowers
Calliope Large Rose Mega Splash-Syngenta Flowers
Calliope Medium Dark Red-Syngenta Flowers
Calliope Large Dark Red-Syngenta Flowers
Calliope Medium White-Syngenta Flowers
Moxie! Pink-Syngenta Flowers
Big EEZE Pink-Dummen Orange

Geranium zonal 11 cultivars
Best Performance: Brocade Fire Night-Dummen Orange
Super Moon Red-Selecta One
Brocade Cherry Night-Dummen Orange
Everlast White-American Takii
Marginata Salmon Experimental-American Takii

Gerbera 5 cultivars
Best Performance: Garvenia Sweet Memories-Florist Holland

Gomphrena 2 cultivars
Best Performance: Truffula Pink-Proven Winners
Fireworks-PanAmerican Seed

Helichrysum 1 cultivar
Best Performance Silver Threads-Selecta One

Hypoestes 4 cultivars
Best Performance: Hippo White-Proven Winners
Hippo Pink-Proven Winners
Hippo Rose-Proven Winners
Hippo Red-Proven Winners

Iberis 1 cultivar
Best Performance: Summer Snowdrift-Darwin Perennials

Impatiens hybrida 7 cultivars

Best Performance: SunPatiens Vigorous Orchid-Sakata Seed America
SunPatiens Vigorous Rose Pink-Sakata Seed America
SunPatiens Vigorous Red-Sakata Seed America
SunPatiens Compact Hot Coral-Sakata Seed America

Impatiens New Guinea 29 cultivars

Best Performance: Paradise Light Pink-Kientzler North America
Clockwork Rose-Ball FloraPlant
Clockwork Appleblossom-Ball FloraPlant
Paradise Electric Orange- Kientzler North America
Paradise Cabano-Kientzler North America
Wild Romance Red 1826-Dummen Orange
Wild Romance White-Dummen Orange
Paradise Rose Flair-Kientzler North America
Tamarinda Max Wild Salmon-Dummen Orange
Paradise Dark Lavender-Kientzler North America
SunStanding Helios Neon Red-Dummen Orange
Clockwork Cherry Strike-Ball FloraPlant
Clockwork Lavender-Ball FloraPlant
Paradise Light Rose-Kientzler North America
SunStanding Apollo White Cloud-Dummen Orange
SunStanding Purple-Dummen Orange
Magnum Lavender-Dummen Orange
SunStanding Helios Magenta-Dummen Orange
Wild Romance Blush Pink-Dummen Orange
Harmony Radiance Hot Pink-Danziger Flower Farm

Ipomoea 7 cultivars

Best Performance: Sweet Caroline Kiwi-Proven Winners
SolarTower Lime-Ball FloraPlant
Spotlight Lime Heart-Ball FloraPlant
SolarPower Lime Heart-Ball FloraPlant
SolarTower Black-Ball FloraPlant
Spotlight Black Heart-Ball FloraPlant
Sweet Caroline Raven Imp.-Proven Winners

Lantana 23 cultivars

Best Performance: Little Lucky Pot of Gold-Ball FloraPlant
Luscious Royale Cosmo-Proven Winners
Luscious Citrus Blend Imp.-Proven Winners
Luscious Royale Pina Colada-Proven Winners
Havana Sunshine-Dummen Orange
Havana Sunrise-Dummen Orange
Lucky Sunrise Rose-Ball FloraPlant
Havana Full Moon-Proven Winners
Bloomify Red-Ball FloraPlant
Lucky Red-Ball FloraPlant

Luscious Berry Blend-Proven Winners
Luscious Marmalade-Proven Winners
Havana Gold- Dummen Orange
Havana Red Sky- Dummen Orange
Luscious Pinkberry Blend-Proven Winners
Havana Red-Dummen Orange
Bloomify Rose-Ball FloraPlant
Little Lucky Orange-Ball FloraPlant

Lobularia 8 cultivars
Best Performance: Easy Breezy Pink-Ball FloraPlant
Passionaria White Imp-Ball Ingenuity

Mandevilla 3 cultivars
Best Performance: Sun Parasol Apricot-Suntory Flowers
Sun Parasol Designer White-Suntory Flowers

Marigold 8 cultivars
Best Performance: Super Hero Spry (AAS Winner)-Ernst Benary of America
Super Hero Yellow-Ernst Benary of America
Super Hero Deep Orange-Ernst Benary of America
Super Hero Harmony-Ernst Benary of America
Super Hero Orange Flame-Ernst Benary of America

Mercardonia 1 cultivar

Best Performance: GoldDust-Proven Winners

Melampodium 1 cultivar
Best Performance: Jackpot Gold-American Takii

Ocimum 1 cultivar
Best Performance: Amazel-Proven Winners

Osteospermum 15 cultivars
Best Performance: Bright Lights Yellow-Proven Winners
Bright Lights Double Moonglow-Proven Winners
Bright Lights Pink-Proven Winners

Pentas 9 cultivars
Best Performance: BeeBright Pink-Syngenta Flowers
BeeBright White-Syngenta Flowers
Lucky Star Raspberry-PanAmerican Seed
Lucky Star White-PanAmerican Seed
BeeBright Lipstick-Syngenta Flowers
BeeBright Violet-Syngenta Flowers
Lucky Star Dark Red-PanAmerican Seed
Lucky Star Pink-PanAmerican Seed
BeeBright Red-Syngenta Flowers

Pepper 2 cultivars

Best Performance: Snackabelle Red-PanAmerican Seed
Habanero Primero Red-PanAmerican Seed

Petchoa 6 cultivars

Best Performance: SuperCal Premium Caramel Yellow-Sakata Seed America
SuperCal Premium Cinnamon-Sakata Seed America
SuperCal Premium French Vanilla-Sakata Seed America
SuperCal Premium Sunray Pink-Sakata Seed America

Petunia 114 cultivars

Best Performance: Supertunia Morning Glory Charm-Proven Winners
Supertunia Lovie Dovie-Proven Winners
Tea Rose Morning-Beekenkamp
Blanket Blue Star-Green Fuse Botanicals
Supertunia Blue Skies-Proven Winners
Supertunia Violet Star Charm-Proven Winners
ColorRush Blue-Ball FloraPlant
ColorRush Pink-Ball FloraPlant
Main Stage White-Selecta One
Dekko White-Syngenta Flowers
Main Stage Pink Vein-Selecta One
Supertunia Indigo Charm-Proven Winners
Tea Purple Vein-Beekenkamp
Easy Wave Silver-PanAmerican Seed
Supertunia Pink Star Charm-Proven Winners
ColorBlitz Blue Stardust-Ball FloraPlant
Dekko Sky Blue Improved-Syngenta Flowers
Supertunia Sangria Charm-Proven Winners
Tea Pink- Beekenkamp
Tea Purple Green Edge-Beekenkamp
Tea White-Beekenkamp
TX-895 Trilogy Lime-American Takii
Dekko Star Rose-Syngenta Flowers
Supertunia Hot Pink Charm-Proven Winners
ColorBlitz Rose Stardust-Ball FloraPlant
Dekko Star Coral-Syngenta Flowers
ColorBlitz Ocean Blue-Ball FloraPlant

Petunia Double 1 cultivar

Best performance: Veranda Compact Double Sugar Plum-Kientzler North America

Phlox 6 cultivars

Best Performance: Gisele Hot Pink-Selecta One

Platycodon 3 cultivars

Best Performance: Pop Star White-Ernst Benary of America

Portulaca 4 cultivars

Best Performance: Cupcake Upright Orange Zest-Dummen Orange
Cupcake Upright Lemon Zest-Dummen Orange
Cupcake Upright Magenta-Dummen Orange
Cupcake Upright Lavender-Dummen Orange

Rudbeckia 3 cultivars

Best Performance: SmileyZ Garden-Plants Nouveau
SmileyZ Happy-Plants Nouveau

Salvia 14 cultivars

Best Performance: Rockin Playin' The Blues-Proven Winners
Grandstand Purple-Green Fuse Botanicals
Grandstand Red-Pink Lipstick-Green Fuse Botanicals
Mystic Spires Improved-Ball FloraPlant
Rockin Golden Delicious-Proven Winners
Big Blue-Pan American Seed
Skyscraper Dark Purple-Selecta One
Skyscraper Pink-Selecta One
Mysty-Ball FloraPlant

Scaevola 6 cultivars

Best Performance: Surdiva White Improved-Suntory Flowers
Scampi Blue-Green Fuse Botanicals
Surdiva Blue Violet-Suntory Flowers
Surdiva Fashion Pink-Suntory Flowers
Surdiva Sky Blue-Suntory Flowers

Sedum 1 cultivar

Best Performance: Lemon Coral-Proven Winners

Tomato 2 cultivars

Best Performance: Garden Gem-Proven Winners

Verbena 43 cultivars

Best Performance: EnduraScape Pink Bicolor-Ball FloraPlant
EnduraScape White-Ball FloraPlant
EnduraScape Blue Improved-Ball FloraPlant
Cadet Upright Hot Pink Wink-Ball FloraPlant
Vanessa Bicolor Purple-Danziger Flower Farm
EnduraScape Dark Purple-Ball FloraPlant
Firehouse Red-Ball FloraPlant
Firehouse White-Ball FloraPlant
Superbena Red-Proven Winners
Empress Sun Red-Dummen Orange
EnduraScape Red-Ball FloraPlant
Vanessa Bicolor Pink-Danziger Flower Farm
Empress Sun Pink Star 01-Dummen Orange
Vanessa White-Danziger Flower Farm

Vinca 28 cultivars

Best Performance: Soiree Ka-wa-i-i White Peppermint-Suntory Flowers
Soiree Ka-wa-i-i White Peppermint-Kientzler North America
Soiree Ka-wa-i-I Coral-Suntory Flowers
Soiree Ka-wa-i-I Red-Suntory Flowers
Tattoo Black Cherry- PanAmerican Seed
Tattoo Raspberry-PanAmerican Seed
Soiree Ka-wa-i-I Red-Kientzler North America
Titan Polka Dot-PanAmerican Seed
Mega Bloom Purple-AmeriSeed Inc
Tattoo Papaya-PanAmerican Seed
Soiree Ka-wa-i-i Lavender-Kientzler North America
Valiant Apricot-PanAmerican Seed
Titan Apricot-PanAmerican Seed
Titan Punch-PanAmerican Seed
Valiant Punch-PanAmerican Seed
Valiant Pure White-PanAmerican Seed
Titan Dark Red Imp.-PanAmerican Seed
Soiree Ka-wa-i-i Pink-Suntory Flowers
Valiant Lilac-PanAmerican Seed
Soiree Ka-wa-i-I Pink-Kientzler North America
Valiant Burgundy-PanAmerican Seed
Titan Rose-PanAmerican Seed
Soiree Ka-wa-i-i Light Purple-Suntory Flowers
Soiree Ka-wa-i-I Lavender-Suntory Flowers

Zinnia 2 cultivars

Best Performance: Elegance Scarlet-AmeriSeed Inc.
Profusion Lemon-Sakata Seed America

Zinnia double 5 cultivars

Best Performance: Double Zahara Bright Orange-PanAmerican Seed

INSECTS OF PERENNIALS & THEIR MANAGEMENT

Sinclair Adam Extension Educator & Flower Trials Director Penn State Extension

Quite a wide range of insects can be troublesome on herbaceous perennials. Each group of these pests has its own season of impact, and management strategy.

Aphids: Over 4000 species have been identified and described, some 30 of which are problems in greenhouses. Incomplete metamorphosis. Aphids in general are small (about 1/8" long) and are soft bodied insects with long legs and antenna. Many species vary in color depending on their food source. Aphids use their piercing and sucking mouthparts to extract juices from plant tissue, and deposit fecal material rich in sugars that become the basis for sooty mold growth on the plant parts below where they are feeding. Aphids have been documented as virus vectors transmitting a wide range of virus diseases from one plant to another. Symptoms include stunting and deformation of plant tissue, as well as yellowing of the plant parts they feed upon. Both sexual and asexual reproduction occurs with many species of aphids. Where asexual reproduction occurs, offspring are usually all female, and numbers can rise rapidly. Commonly Green Peach Aphid (*Myzus persicae),* Melon or cotton aphid (*Aphis gossypii),* Foxglove aphid *(Aulacorthum solani),* Potato aphid (*Macrosiphum euphorbiae),* Root aphids *(Pemphigus spp.),* and Milkweed aphid *(Aphis nerii)* are some of the most common. *Macrosiphoniella sanborni* (Chrysanthemum aphid), can also be problematic in greenhouse and nursery operations.

Scouting should be done regularly, and since aphids are wingless in many cases, sticky cards may not be the best method of detection. A weekly inspection with a hand lens is preferable. Crops that are overfertilized will be attractive to aphid populations, and weeds can be alternative host plants for aphid populations.

Chemical control is possible with a wide range of products available to choose from:

Abamectin-contact/translaminar	Avid/Minx
acephate-contact	Orthene
acetamiprid-contact/translaminar	Tristar
azadiractin-IGR	AzaGuard
Beauveria bassiana-Bio	BotaniGard
bifenthrin-contact	Talstar
chloropyrifos-contact	Duraguard
Chromobacterium-Bio	Grandevo PTO
cyantraniprole-systemic	Mainspring
cyfluthrin-contact	Decathelon
dinotefuran-contact/systemic	Safari 20 SG
fenoxycarb-IGR	Preclude TR
fenpropathrin-contact	Tame EC
flonicamid-contact/systemic	Aria
horticultural oil-contact	SuffOix-X
imidacloprid-systemic	Marathon
insecticidal soap-contact	M-Pede
Isaria fumosorosea-Bio	Preferal
s-kinoprene-IGR	Enstar
methiocarb-contact	Mesurol

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neem oil-contact	Triac 70
permethrin-contact	Astro
pymetrozine- systemic/trans	Endeavor
pyrethrin-contact	Pyganic
pyrifluquinazon-contact/trans	Rycar
pyriproxyfen-IGR	Distance
rosemary & peppermint oil-contact	Ecotec
soybean oil-contact	Golden Pest Spray
spriotetramat-systemic	Kontos
tau-fluvinate-contact	Mavrik
thiamethoxam-systemic	Flagship
tolfenpyrad-contact	Hachi-Hachi

Be sure to read the product label before using the chemical and follow all instructions and restrictions. Resistance to insecticides has been demonstrated with aphids and other insects, so be sure to use a sound chemical rotational scheme of application to avoid building a resistant population of aphids.

Biological control is also possible using a number of effective Biological Control Agents (BCA's). Each BCA will have its preferred range of operational conditions and care must be exercised in selecting the best BCA for an operation's conditions, time of year, and environment. It is recommended that an operation work closely with the supplier of BCA's to ensure success. The number of companies producing and distributing BCA's continues to grow, and new BCA's are coming onto the market place regularly. Aphid predators include Ladybird beetles, Green lacewings, predatory midges, and Hover flies. Parasitoids include wasps such as *Aphidius colemani* & other species, *Aphelinus abdominalis* will eat the smaller aphid species, and parasitize the larger ones. Banker plants can be strategically used to support populations of BCA's in the greenhouse, nursery, and field.

Beetles: 350,000-400,000 species known, and more to be discovered. Beetles undergo complete metamorphosis. Adult beetles and larval stages use chewing mouthparts to cause plant damage. In scouting look for chewed leaves and small holes, that indicate damage.

Scarab beetles include Japanese beetle, Asiatic garden beetles, and Oriental beetles, and damage a wide range of herbaceous and woody plants. All beetles have a larval stage that is a grub, beetle larvae can be identified by the hairs on their rear end called rasters. Adult beetles are fairly easy to identify using a good guidebook or online resources, and to identify a grub species you can use the fact sheet from UMass located at: (https://ag.umass.edu/sites/ag.umass.edu/files/fact-sheets/pdf/white_grub_ID.pdf)

Flea beetles, some of the smaller beetle species, typically overwinter as adults, and eggs are deposited on the foliage or in the soil around plant roots. Larvae feed on plant roots, and adults attack the foliage. Some species have one generation per year, some have two. The most damage is done by the overwintering adults. Flea beetles attack a wide range of plants and can also vector plant disease. The holes left in dicot foliage look like shot holes, usually between leaf veins. On monocots the damage runs parallel to the leaf veins.

Cucumber beetles feed on roots, stems, fruit surfaces, leaves, and flowers. Spotted is mare of a problem on ornamentals than striped. Both forms are vectors of plant diseases including Fusarium, virus diseases, & bacterial wilts. Floating row covers have been shown to be effective in vegetable crops. A number of insecticides have been shown to be effective, and planting after June 15, usually results in the beetles that did overwinter being disbursed to other areas.

Blister beetles are in the family *Meloidae*, containing about 2500 species. These beetles feed on a wide range of plants often eating only the flower parts, but some species attack foliage as well. Some species are nocturnal others diurnal. Larvae are predators attacking bees, and grasshopper and blister beetle eggs. Eggs are laid in masses typically under stones or food plants of the adults. Adults live for three or more months.

Black vine weevil (BVW) has become a problem with plant in Saxifragaceae and others. This small weevil not only trouble perennials but also *Rhododendron, Taxus,* and other woody plants. Adults feed on plant foliage, but the larval stage is feeding on root and crown tissue. They overwinter as immature larvae in the soil. Adults emerge from late May through June. Adults can lay up to 500 eggs over a 14-21-day period. These are placed by host plants and hatch in 10-14 days into larvae which feed on plant roots. One generation per year occurs in PA. BVW is very destructive on plant roots and containerized plants may seem to be in good condition but the crown and foliage has been detached by feeding injury from the roots. Adult injury is the notching of leaves in "c" shaped injury. Chemical control can be used when 21 days after feeding on the foliage is observed. BVW will feed on the foliage for 21-28 days before laying eggs. Evening applications are best due to their nocturnal behavior. Beneficial nematodes can be used on the larval stages.

Lily Leaf Beetle: This imported pest, has become problematic in the northeast and Mid-Atlantic states. The insect overwinters as an adult in plant debris or soil near host plants preferring cool moist conditions. Adults emerge in late spring to early summer. Females lay orange eggs in an irregular line on the undersides of leaves, flower buds, and flowers. Larvae cover themselves with a fecal shield of moist black material to deter predators. Hand picking of egg masses and larvae is an effective control, but the practitioner should wear gloves. Some resistant varieties have been discovered by Univ. of ME: *Lilium henryi* 'Madame Butterfly', *Lilium speciosum* 'Uchida', and *Lilium* 'Black Beauty'. Parasitic wasps also have been shown to be effective, but not yet commercially available.

Japanese beetle: One of the most devastating pests in the eastern USA, first found in 1916 in NJ. Adults emerge from the ground in June and are most active for about four to six weeks. This insect feeds on over 300 species of plants, consuming leaves, flowers and feeds between the veins skeletonizing the foliage. They are strong fliers and can travel for several miles. Females lay eggs two to three inches into the soil in a suitable area. A female will lay 40-60 eggs. For the next ten months the beetles are in the soil. Grubs grow to about one inch and feed on plant roots, surviving in a wide range of soil types. The grubs will travel downward in the soil as temperatures drop for the winter. As temperatures warm up, they will travel upward in the soil then pupate for four to six weeks and emerge from the soil in June. Both larvae and adults damage plants, and adults leave a pheromone lure to other beetles as they feed.

Control of beetles can be accomplished with chemicals:

Acephate
Acetamiprid
Azadiractin
Beauveria bassiana
Bifenthrin
Chloropyrifos
Cyantraniprole
Cyfluthrin
Dinotefuran
Fenpropathrin
Imidicloprid
Insecticidal soap
Isaria fumosorosea
Permethrin
pyrethroid
pyrethrin
rosemary & peppermint oil
spinosad
tau-fluvinate
thiamethoxam

Some good bio-insecticides are also available, and *Steinernema feltiae.*

Caterpillars: 177500 species of *Lepidoptera* are known globally. *Lepidoptera* undergo complete metamorphosis. Almost all are plant feeders. Typical greenhouse species include: armyworms, imported cabbage worm, diamondback moth, leaftiers, leafrollers, loopers, tobacco budworm, salt marsh caterpillar, and European corn borer. In outdoor settings, more species could be involved. European corn borer can lay eggs on herbaceous perennials adjacent to corn fields. Scouting can be very important and look for feeding injury & frass. Eliminating weeds that serve as alternate hosts is a good cultural control. Bio control options include *Bacillus thuringiensis, Beauveria bassiana, and Trichogramma* wasps. Other bio control agents would include birds, and predatory bugs.

Chemical control:

- Acephate
- Acetamiprid
- Azadirachtin
- *Bacillus thuringiensis*
- *Beauveria bassiana*
- Bifenthrin
- Chlorfenapyr
- Chlorpyrifos
- *Chromobacterium subtsugae*
- Cyantraniprole
- Cyfluthrin
- Diflubenzuron
- Fenoxycarb
- Tolfenpyrad
- Fenpropathrin
- Insecticidal soap
- *Isaria fumosorosea*
- Methoxyfenozide
- Novaluron
- Permethrin
- Pyrethrin
- pyrethroid
- Pyridalyl
- Rosemary & peppermint oil
- Soybean oil
- Spinosad
- Tau-fluvinate

Fungus gnats: These insects develop in moist organic matter such as potting soil and can be problematic in propagation greenhouses. The life cycle typically takes 21-28 days and is temperature dependent. Females can lay up to 200 eggs, which hatch out in 5-6 days. Larvae feed for about 14 days before becoming pupae. Overlapping generations can make control difficult. Yellow sticky cards placed close to the potting media are a good scouting tool, and potato slices (or wedges) placed on the growing media are good to monitor the larval stage. Check these potato slices on 48-hour intervals for insect population density and replace potato slices when they get too old.

Cultural control can be effective if practices reduce breeding areas. Avoid overwatering and reduce moisture under the greenhouse benches. Inspect incoming material for fungus gnats (both larval & adult stages). Fungus gnats can come into the operation on the potting medium.

Commercially successful Bio control has been used to control populations of fungus gnats. BCA's such as *Stratiolaelaps scimitus* (a predatory mite) or rove beetles are used to control the soil stages of fungus gnats, and the nematode *Steinernema feltiae* has been demonstrated to be quite successful. These bio controls should be applied before the gnats are out of hand. Check on the viability of these BCA's prior to deploying them in the greenhouse or nursery, and work closely with your BCA suppliers.

Chemical control:

- Bifenthrin
- Chlorfenapyr
- Chloropyrifos
- Cyfluthrin
- Cyromazine
- Diflubenzuron
- Dinotefuran
- Horticultural oil
- Imidicloprid
- Insecticidal soap
- S-kinoprene
- Permethrin
- Pyrethrin
- Pyriproxyfen
- Rosemary & peppermint oil
- Soybean oil
- Spinosad
- Thiamethoxam

Shore Flies: These insects are sometimes mistaken for fungus gnats but are larger and have five distinct white spots on their wings. These too can be monitored using yellow sticky cards. Soil dwelling predators such as Rove beetles and *Stratiolaelaps* can do a good job of control. One of the best approaches to managing shore flies would be to control algae in the greenhouse or nursery. Algae is the main stage food source for shore flies and reducing the greenhouse or nursery moisture will also help significantly in control.

Chemical control: same as with fungus gnats (see above), and with large populations use both a larvicide and an adulticide.

Leafhoppers: One of the most abundant groups of insects, leafhoppers and planthoppers outnumber all species of birds, mammals, reptiles, and amphibians. Many are host specific and are named for their host plant (potato leafhopper, rose leafhopper, etc). They can be difficult to control due to their mobility.

Bio- & Cultural control: Since many overwinter as eggs in plant tissue by composting the plant debris (or disposing of it offsite) the population can be reduced. Generalist predators will help such as green lacewings, ladybird beetles, pirate bugs, and assassin bugs.

Chemical control:

Acetamiprid	Insecticidal soap
Azadiractin	Neem oil
Beauveria bassiana	permethrin
Bifenthrin	pyrethrin
Buprofezin	pyrethroid
Chloropyrifos	pyrifluquinazon
Cyfluthrin	Rosemary & peppermint oil
Dinotefuran	Soybean oil
Fenpropathrin	spirotetramat
Flonicamid	tau-fluvalinate
horticultural oil	thiamethoxam
imidicloprid	tolifenpyrad

Leafminers: Generally, the pests of perennials are in *Diptera,* but important species can be in *Hymenoptera,* or *Lepidoptera.* They feed on the internal leaf tissue and are protected by the leaf surfaces which they are feeding between. Adult leafminers in the family *Agromyzidae* resemble house flies about ¼" long. Females insert eggs into leaf tissue, as these eggs hatch into larvae, the larvae will tunnel through the leaf tissue in a serpentine or blotchy pattern.

Larvae will then drop to the ground and burrow into the soil/potting medium. Life cycle length depends on temperature and host plant. Sixty-four days at 59 degrees F, but only fourteen at 95 degrees F.

Control: Bio control limited, *Diglyphus spp.* wasps occurs widely in North America, now available from some insect rearing suppliers.

Chemical:

Abamectin	diflubenzuron	permethrin
Acephate	dinotefuran	pyrethrin
Acetamiprid	fenoxycarb	S-kinoprene
Azadirachtin	horticultural oil	pyrethroid
Bifenthrin	imidacloprid	Rosemary & peppermint oil
Chlopyrifos	Insecticidal soap	Soybean oil
Cyantraniprole	*Isaria fumosorosea*	spinosad
Cyromazine	novaluron	thiamethoxam

Mealybugs: Often a problem on long term crops (cut flowers, orchids, & foliage plants). Several species are often involved. Mealys enter the environment on a contaminated plant, and then spread to other plants. Plant injury involves stunting, yellowing, and distortion of foliage. They also excrete a copious amount of honeydew, which grows sooty mold fungi. Reproduction is by eggs, but in greenhouse settings live birth can occur as with long-tailed mealybug. Up to 500 eggs per female/ year. Early detection is important, so scouting is paramount. Mealys feed on phloem and can have up to 8 generations per year in greenhouse settings, up to two for outdoor environments. Life cycle is 25-60 days.

Bio-control: *Anagyrus pseudococci* (parasitoid) attacks citrus mealy both second and third larval stages. *Cryptolaemus montrouzieri* (mealybug destroyer) prefers temps above 60 degrees F and should be released in the evening. Products such as Distance & Aria can be used with MB Destroyer safely. Cultural control: Scout for incoming mealys to an operation, and blast off plants with forceful water spray-which will frequently break off the mouthparts.

Chemical control:

Acephate	imidicloprid
Acetamiprid	insecticidal soap
Azadirachtin	*Isaria fumosorosera*
Beauveria bassiana	s-kinoprene
Bifenthrin	neem oil
Buprofezn	permethrin
Chloropyrifos	pyrethrin
Chromobacterium subtsugae	pyrethroid
Cyfluthrin	pyrifluquinazon
Dinotefuran	pyriproxyfen
Fenoxycarb	rosemary & peppermint oil
Fenpropathrin	soybean oil
Fenpyroximate	spirotetramat
Flonicamid	tau-fluvalinate
Horticultural oil	thimethoxam

Scale: Some 8000 species are described. Appearance is variable, both armored and soft scales affect plants. Adult females are wingless and will insert mouthparts into vascular tissue. Males are winged and lack functional mouthparts. Soft scale males may be winged or without wings. Some armored scales are only female and give birth to live young. Armored scales tend to feed on woody plants, soft scales on herbaceous plants.

Control: Bio control is limited and can be problematic due to the large number of scale species that may occur simultaneously. Predators would include green lacewings, *Rhizobius* beetles and lady bird beetles.

Chemical: The best way to control scale is when the crawler stage is active, and when nymphs are present, these stages leave the insects relatively unprotected. Repeat applications are usually needed. Systemic chemicals will be more effective on soft scales than on armored scales.

Products: see Mealybug list (except for *Beauveria bassiana, Isaria fumosorosera,* permethrin, pyrifluquinazon, & tau-fluvalinate).

Mites: Spider mites are in the *Acari* family *Tentranychidae* which includes about 1200 species. They live on the underside of plant foliage and cause damage by feeding injury to the foliage. Two spotted spider mites proceed from egg to nymphs, and then to adults. The entire life cycle is 5-20 days depending on temperature. Females can lay several hundred eggs, with overlapping generations per year. Symptoms include leaf bleaching, damage to chloroplasts and mesophyll tissues, stippling, and browning of leaves. All mites are wingless. Broad mites and cyclamen mites are very difficult to see without magnification and can be hard to find in plant tissue. These mites will cause distortion of leaf tissues with broad mites causing leaves to curl downward & cyclamen mites causing tissue to curl upwards. Both

Broad mite and Cyclamen mite can move on air currents, but they have different temperature ranges. Broad mites prefer temps 70-80 degrees F while cyclamen mites are favored by temperatures close to 60 degrees F.

Control: Bio-control has been effective using predatory mites. A number of beneficial mites are available commercially, and each species has its preferred temperature and humidity range. Selection of BCA's will therefore depend on crop and cultural conditions. Cultural control: remove weeds, dispose of old plants, & avoid overfertilization.

Predatory mite preferences:

Phytosieulus persimilis-	65-80F RH 60%+
Mesoseiulus longipes-	70-90F RH 40%
Neoseiulus fallacis-	50-80F RH 60-90%
Neoseiulus californicus-	wide temp & RH range
Galendromus occidentalis-	80-100F RH>50%

Chemical Control:

Abamectin	fenpyroximate tau-fluvalinate
Azadirachtin	hexythiazox
Acequinocyl	horticultural oil
Bifenazate	insecticidal soap
Bifenthrin	*Isaria fumosorosea*
Chlorfenapyr	methiocarb
Clofentezine	neem oil
Chlorpyrifos	pyrethrin
Chromobacterium subtsugae	pyrethroid
Cyflumetofen	pyrideben
Etoxazole	rosemary & peppermint oil
Fenazaquin	soybean oil
Fenoxycarb	spiromesifen
fenpropathrin	spriotetramat

True Bugs: Plant bugs feed on a number of host plants including weeds in N. America. There are some 50,000-80,000 spp. mostly plant feeders, but some important predators are in this group (such as pirate bugs, assassin bugs, & wheel bugs). Not only do the plant feeding species damage plants directly, they may also vector serious virus diseases. Tarnished plant bug (*Lygus lineolaris)* is the most common and can affect greenhouse or outdoor plants. Females insert eggs into flower and foliage parts, causing these parts to swell. Eggs hatch in 7-10 days and new nymphs emerge. TPB's can complete their life cycle in 3-4 weeks. They overwinter as adults in detritus, potting media, and old plants. Feeding injury is caused by extraction of plant fluids & injection of toxins in the bug's saliva. *Leptoglossus sp.* Leaf-footed bugs Adults overwinter in debris emerge in late spring & feed on various hosts. Lay eggs which hatch in 5-7 days (about 200 each) Typically about 3 generations/year.

Control: Cultural control would include weed management, clean culture, and site management. Biological control is limited, but some naturally occurring predators will attack true bugs.

Chemical:

Acetamiprid	horticultural oil	thiamethoxam
Azadirachtin	imidicloprid	
Beauveria bassiana	*Isaria fumoserosea*	
Bifenthrin	permethrin	
Chlorpyrifos	pyrethrin	
Chromobacterium subtsugae	pyrethroid	
Cyfluthrin	soybean oil	
Flonicamid	tau-fluvalinate	

Spittle bug: Classified as froghoppers, the spittle bug is the nymphal stage. In this phase, the insect produces a foam from plant juice that hides it from predators, buffer them against temperature changes, & protects the insect from drying out. These insects can jump 100 times their own length.

Control: see above (True bugs).
Lace bug: Family *Tingidae* about 2000 species. Usually host specific, and very destructive to plants. The wings resemble lace. Feed on plants by sucking sap from the underside of the leaf. Leaves take on a bronzed or silvery appearance. They complete their lifecycle on the same plant having one or two generations per year. Overwintering as adults mostly, but some will overwinter as eggs.

Control: see above (True bugs).
Whiteflies: 15000 species worldwide. The primary species of whitefly in greenhouses is *Trialeurodes vaporariorum. Bemisia tabaci* (sweet potato or silverleaf whitefly) & *Trialeurodes abutilonia* (banded whitefly) can become greenhouse or outdoor problems in fall. Plants infested with whiteflies can transmit these insects to outdoor crops. These insects do not usually overwinter out of doors in the northeast. Greenhouse whitefly is most active at 75 degrees F, Sweet potato whiteflies prefer 80 degrees F. Development from egg to adult takes 14-40 days depending on temperature, host plant & whitefly species. Female of Greenhouse whitefly lay about 20 eggs in a small circle. Sweet potato whitefly lays about 200 eggs in a random pattern, and the banded wing whitefly lays eggs randomly. These insects can attack a wide range of plants. Scouting is critical, and for greenhouse plants yellow sticky cards are used. One sticky card per 500-1000 sq. feet is recommended.

Control: Cultural- Avoid overfertilization, inspect plants coming in from other sources, remove residual plants that may carry over insects.

Biological: *Encarsia formosa* a parasitoid is effective against greenhouse whitefly but will also work on sweet potato whitefly. This wasp prefers temperatures 70-80- degrees F, an RH of 50-80%. *Eretmocerus eremicus* is a wasp that also is an effective parasitoid of whiteflies. Release *Eretmocerus* early in the crop cycle. *Amblyseius swirskii* is a predatory mite that is effective against a number of problem insects including whiteflies. It can also feed on pollen in the absence of prey insects. *Delphastus pusillus* a tiny lady bird beetle is an effective predator of whiteflies operating happily at 75-80 degrees F. Both *Beauveria bassiana & Isaria fumosoroseus* effective entomopathogenic fungi for whitefly control.

Chemical:

Abamectin
Acephate
Acetamiprid
Azadirachtin
Beauve
Bifenthrin
Buprofezin
Chromobacterium subtsugae
Cyantraniprole
Cyfluthrin
Diflubenzuron
Dinotefuran
Etoxazole
Fenazaquin
fenoxycarb
fenpropathrin
flonicamid
horticultural oil
ria bassiana
insecticidal soap
Isaria fumosorosea
s-kinoprene
neem oil
novaluron
permethrin
pyrethrin
pymetrozine
pyrethroid
pyridaben
pyrifluquinazon
pyriproxyfen
rosemary & peppermint oil
imidacloprid soybean oil
spiromesifen
spirotetramat
tau-fulvalinate
thiamethoxam
tolfenpyrad

Grasshoppers: Order *Orthoptera,* generaly in wet years not as bad as in dry years. Typically, in the Mid-Atlantic states a transitory problem. In the west a serious problem. All grasshoppers lay eggs in the soil. Difficult to control due to high mobility as adults. Some species prefer grasses, other broadleaved plants. Differential grasshopper, migratory grasshopper, two striped grasshopper , red legged grasshopper, & clearwinged grasshopper can be garden pests.

Control: Carbaryl, acephate, permethrin, diflubenzuron, *Nosema locustae* bait.

Thrips: Some 6000 species described. More than 12 species affect greenhouse crops, more potentially outdoors. The most important are greenhouse thrips (*Heliothrips haemorrhoidalis)*, western flower thrips (*Frankliniella occidentalis)* onion thrips (*Thrips tabaci),* and chili thrips (*Scirtothrips dorsalis).* Western Flower Thrips deposit eggs into plant leaves, which hatch in about one week. Nymphs are wingless and feed on plant leaves, and flowers. First and second instar nymphs feed for 2-4 days and move into the potting media to pupate. Thrips can also pupate in the flowers. Lifecycle duration from egg to adult takes 2-4 weeks based on temperature. In addition to feeding injury, deposits of fecal material on foliage and flowers occur. Thrips are good at getting into cryptic spaces in plants making control more difficult. Adult thrips are poor fliers but will be moved by air currents and greenhouse fans. Scouting for thrips can be done using sticky cards, and by tapping plant parts and flowers over a white paper. Blowing into flowers can stimulate thrips activity and make detection easier.

Control: Cultural: Weeds should be removed from the growing areas as they can harbor thrips. Any sign of virus should be rogued and probably tested by a lab. Thrips move virus diseases readily. Remove plant debris from the growing area.

Biological: Predatory mites (*Amblyseius cucumeris, A. swirskii, A. limonicus, Stratiolaelaps scimitus)* Minute pirate bugs *(Orius spp).,* Entomopathogenic nematodes (*Steinernema feltiae),* & Bio-Insecticides (*Beauveria bassiana, Isaria fumosoroseus)* are effective controls if managed properly.

Chemical:

- Abamectin
- Acephate
- Acetamiprid
- Azadirachtin
- *Beauveria bassiana*
- Bifenthrin
- Chlorfenapyr
- Chlorpyrfos
- *Chromobacterium subtsugae*
- Cyantraniprole
- Cyufluthrin
- Dinotefuran
- Fenoxycarb
- Flonicamid
- horticultural oil
- imidicloprid
- insecticidal soap
- *Isaria fumosorosea*
- s-kinoprene
- methiocarb
- *Steinernema feltiae*
- novaluron
- pyrethrin
- pyrethroid
- pyridalyl
- Rosemary & peppermint oil
- soybean oil
- spinosad
- taufluvalinate
- tolfenpyrad

Earwigs: (*Forficula auricularia*)

Control: permethrin, dalamethrin, acetamiprid, & carbaryl.
Sawflies: In USA Solomon seal sawfly & columbine sawfly

Control: acephate (Orthene), Bifenthrin (Talstar), carbaryl (Sevin), insecticidal soap (M-Pede) malathion (Malathion), permethrin.

EASY WAYS TO INCREASE NUTRIENT EFFICIENCY

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Growers are always looking at ways to increase overall efficiency, cut chemical and labor costs, reduce shrink, and get the most bang for their buck. There are four easy ways to increase nutrient efficiency, and accomplish the points above. By knowing your water quality, matching your fertilizer program to your crops and water quality, grouping plants by pH and EC requirements, and monitoring in-house pH and ECs; you can achieve great results and reduce some inputs.

Where to start:

The key to any successful fertilizer program is getting your water tested first. Having your water tested by a reputable horticulture lab in December or January will get you off on the right foot. Once you have a current water test, talk to a technical rep, fertilizer supplier, or extension agent about how to proceed. You will also need to think about your space and the needs of your crops. Remember, everyone's water is different. Just because a fertilizer works for your neighbor doesn't mean it will work for you.

Choosing Your Fertilizer Program:

Look at your water test for the following items: pH, alkalinity, calcium, magnesium, sodium and chloride. If you have low alkalinity water with little calcium and magnesium, a neutral or basic fertilizer is a better option. You will also need a fertilizer with some calcium and magnesium. If you have high alkalinity you will need an acidic fertilizer. High alkalinity can cause a gradual increase in media pH, and you may need to consider acidification with a mineral acid. The industry standard is sulfuric acid, it is cost effective, easy to source, and adds much needed sulfur. The chart below will get you started in choosing your general purpose or grower formulas.

Water Type	Alkalinity	Fertilizers to Consider
Very Low Alkalinity or Pure Water	<60 ppm	17-4-17 , 15-5-15, 13-2-12
Low Alkalinity	60-100 ppm	21-5-20 with 15-5-15,17-4-17,16-2-15
Moderate Alkalinity	100-160 ppm	21-5-20 + Extra Mg, 25-5-15 with extra Mg, 20-3-19 Petunia FeED 16-2-15, 15-15-15 Geranium+ Extra Mg
Moderately High Alkalinity	150-200 ppm	21-5-20, 25-5-15, 21-8-18, 20-3-19 Petunia FeED *may need acid injection as well
High Alkalinity	180> ppm	21-5-20 + Mg, 25-5-15, 20-3-19 Petunia FeED * acid injection is almost always necessary

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Grouping plants based on EC and pH requirements:
Cultivar culture sheets hold a wealth of knowledge, from temperature requirements, diseases, and nutrient needs, it's all there. Using these sheets will help you group your like crops together. For the ease of fertilizing, it is best to group plants with similar EC and pH requirements together. These are the groups that are helpful. Low and moderate pH requirements can be grouped together.

Low pH (5.4-5.8) **Moderate pH** (5.8-6.2), **High pH** (6.2-6.8)

Low EC (under 1 ms/cm), **Moderate EC** (1.0-1.5 ms/cm), **High EC** (1.5 ms/cm and over)

	Low EC	**Moderate EC**	**High EC**
Media pH under 6.2	Bacopa	Calibrocha	Angelonia
	Begonia	Celosia	Guara
	Browallia	Gerbera	Ipomoea
	Coleus	Petunia	Lantana
	Gazania	Zinnia	
Media pH above 6.2	**Low EC**	**Moderate EC**	**High EC**
	Canna	Galliardia	Portulaca
	Impatients	Geranium	Geranium
	Marigolds	Pentas	

In-house Monitoring of EC and pH:
By setting up a weekly testing regimen of Pour-Throughs in-house, you can make good growing decisions. NC State has an excellent Pour-Through resource that many growers utilize. Early detection of a media pH or EC issues can prevent costly deficiencies and toxicities down the road. At the Penn State Trial in Landisville, weekly monitoring has been implemented the last 2 years with great success. It may seem daunting at first, but you know the old adage, "an ounce of prevention is worth a pound of cure".

5 Take Homes:

1. Know your water quality
2. Match your feed program to your crops and water quality
3. Group your plants by pH and EC
4. Monitor in-house pH and EC
5. Grow less quantity, but larger plant sizes and higher quality

MANAGING PLANT GROWTH AND DEVELOPMENT WITH PGRS

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Plant growth regulators (PGRs) are chemicals that are designed to affect plant growth and/or development. Although there is much scientific information on using PGRs on ornamental plants, it is not an exact science. Achieving the best results with PGRs is a combination of art and science – science tempered with a lot of trial and error and a good understanding of plant growth and development under your environmental and production conditions.

Integrated Growth Regulation

For best results, PGRs should be handled as production tools, like water and fertilizer. PGRs should be an integrated part of your crop production cycle, used in conjunction with a number of non-chemical control options to manipulate plant growth and development so well-proportioned, compact plants are produced. Options might include:

- Selecting shorter growing cultivars if they meet market demand
- Reducing or withholding water or fertilizer
- Manipulating growing conditions (higher light, greater spacing, lower temperatures, root restriction)
- Pinching or pruning to affect growth, shape, and/or branching

Optimizing plant growth control requires an understanding of the effects of environmental and cultural conditions on plant growth. Experience and on-site trials will allow you to combine chemical PGRs with a number of non-chemical control options to manipulate plant growth to produce high quality, compact plants.

PGR Options

Most of the PGRs used in the greenhouse or nursery are used to regulate shoot growth of containerized crops by inhibiting the production of gibberellins, the primary plant hormones responsible for cell elongation. The primary growth retardant products used in the greenhouse and/or nursery are paclobutrazol, uniconazole, daminozide, chlormequat chloride, ancymidol and flurprimidol. These growth retardants also increase the tolerance of plants to temperature and drought stress as well as to the stresses of shipping and handling, thereby improving shelf-life and extending plant marketability.

However, additional PGR products are available to enhance plant branching which improves plant architecture, provides some growth regulation, improves pot fill and thereby may reduce crop time. Configure (BA, benzyladenine, Fine Americas, Inc.) is a cytokinin product that enhances branching in a wide variety of floricultural crops. While growth retardants inhibit synthesis of gibberellins, we can apply gibberellins, alone or in combination with cytokinins, to enhance plant growth and development. In some crops, ethephon improves branching and/or provides growth regulation, and also eliminates flowers and buds on many crops.

Tank Mixing Configure with a Plant Growth Retardant to Improve Branching

Growth retardants can control overall growth and improve toning of herbaceous perennials but frequently result in less branching. In our studies, we have found that branching of many of the herbaceous perennials can be enhanced with applications of Configure. We evaluated tank mix combinations of Configure with Dazide (daminozide, Fine Americas, Inc.) for effects on growth control and branching of herbaceous perennials. Tank mixes are generally

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designed to provide a more efficient or positive effect as in additive, enhanced, or synergistic effects.

For the study, unrooted cuttings were purchased and rooted; growth regulators were applied just after liners were removed from mist (roots visible on all sides). All growth regulators were applied as a single foliar spray at the label-recommended volume of 1 gallon per 200 sq. ft. We tested: *Agastache* 'Tutti Frutti' and *Gaura* 'Whirling Butterflies' with the following treatments:

- Untreated control
- 500 ppm Configure
- 2,500 ppm Dazide
- Tank Mix = 500 ppm Configure + 2,500 ppm Dazide

Finished liners were evaluated for height and/or width, shoot dry weight and number of branches at 3 weeks after treatment. An additional set of liners was potted into quart pots and finished plants were evaluated 5 weeks after potting.

***Agastache* 'Tutti Frutti'** liners treated with Configure alone were 45% shorter than untreated liners but had more branches and comparable shoot dry weight. Dazide alone greatly reduced plant growth with final liner height 70% shorter than that of untreated plants, with fewer branches and 30% less shoot dry weight. The Tank Mix of Dazide + Configure controlled liner height while increasing the number of branches over that of liners treated with Configure alone. In addition, the shoot dry weight of liners treated with the Tank Mix was 35% greater than that of liners treated with Dazide alone, resulting in liners of comparable mass to that of untreated plants.

In the finished *Agastache* plants, 5 weeks later, the number of branches on plants treated with Configure or the Tank Mix was still greater than that of the untreated or Dazide-treated plants. In addition, shoot dry weight of the finished plants was also affected by the growth regulators. While plants treated with Dazide alone had 20% less mass than untreated plants, those treated with the Tank Mix had 20% greater mass than untreated plants, while maintaining height control. Flower height of the plants treated with any of the growth regulators was 25% less than that of untreated plants.

***Gaura* 'Whirling Butterflies'** liners treated with Configure alone or in the tank mix with Dazide flowered about 10 days after untreated plants. However, since this was primarily during the liner rooting phase, it may have been advantageous. Shoot dry weight of the liners was not significantly affected by the growth regulator applications.

In finished *Gaura* plants, there were no differences in plant height or shoot dry weight, but plants treated with Dazide alone still had the fewest number of branches (10 per plant) and plants treated with Configure alone had the greatest number of branches (20.8 per plant) at 8 weeks after treatment.

In summary, we found no evidence of synergism, which we would define as an improvement in both growth regulation and branching, when using Configure and growth retardants together in these tank mixes. However, we generally found a positive effect on plant branching when Configure was combined with the plant growth retardant. In addition, Configure tended to increase dry weight accumulation by plants treated with the Tank Mix as compared to plants treated only with the growth retardant. Combining Configure with growth retardant applications may improve branching and mass of the finished plants without reducing the growth regulation effects of the growth retardants.

Check Plants

How well does the PGR really work? The only way to confirm the efficacy of a PGR is to leave a few representative plants untreated for comparison. These "check plants" offer a valuable insight into ways to adjust future PGR applications.

Integrating chemical growth regulators into your production practices will help control undesirable plant stretch and help ensure a well-proportioned, highly marketable crop.

MANAGEMENT OF HEAD ROT DISEASES IN BROCCOLI AND CAULIFLOWER FEATURING NEW RECOMMENDATIONS FOR ALTERNARIA LEAF SPOT

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Alternaria leaf spot vs. Downy mildew: Can you tell the difference?

Lesions/spots first appear on lower frame leaves, which turn yellow. To determine which disease is present, look at the lesions on the older lower frame leaves. Alternaria leaf spot (ALS) will have circular small, dark/brown spots with concentric rings (target spots) on the upper surface of leaf. When humidity is high, lesions can be covered with a sooty black mass of spores. ALS lesions are papery and eventually fall out leaving a shot hole appearance. Downy mildew (DM) causes irregular, yellow to brown spots on the upper side of the leaves with a grayish, white mildew on the underside of the leaves that occurs during cool, moist conditions.

As soon as ALS and DM lesions are evident on older leaves, spores can spread to marketable portions of the crop, where they can cause economical crop loss. ALS and DM can also make the heads more susceptible to soft rot bacteria and other storage rots, especially in cabbage and broccoli. In broccoli, DM and ALS both appear as dark discoloration of the beading, of which ALS is slightly darker and more sunken. In cauliflower, both DM and ALS appear as black sooty spots. A distinguishing feature between the two diseases is that only DM causes a grayish/brownish internal discoloration in these crops when the heads are cut open. In Brussels sprouts, ALS appears mostly as small black spots.

Optimum temperatures for DM are 50 to 60 °F while ALS is favored by 75° to 82°F; however, if leaf wetness is prolonged for 20 hours of more, ALS can produce many spores outside of the optimum range of temperatures. Both diseases survive in soil and crop debris and can be spread onto plants from splashing soil and over longer distances aerially. Additionally, ALS can be spread by flea beetles.

Ad hoc on-farm fungicide evaluation for control of ALS in broccoli in 2018.

The hot and humid weather with heavy rainfall from remnants of hurricanes during August 2018 was the perfect storm for ALS to rage out of control in brassica crops across the Northeast. In September, an ad hoc small-plot replicated trial was set up in Penfield, NY in the same field where a grower had just lost 85% of the last broccoli planting. The grower's fungicide spray program included 4-5 weekly sprays of Bravo Weather Stik (WS) and Quadris. In a new planting, three weeks after transplanting and one week after the grower made a single fungicide application of Bravo WS 1.5 pt, the ad hoc fungicide trial began. Broccoli (c.v. Emerald Crown) plants were about 1 ft tall and 2 ft wide and lower frame leaves had 2-3 ALS lesions per leaf.

Treatments included fungicides labeled on broccoli, 1) Bravo WS 1.5 pt (= highest label rate), 2) Quadris 11.2 fl oz (= medium rate), 3) Quadris Top 14 fl oz (= highest label rate, same a.i. as Quadris 11.2 fl oz), 4) Endura 9 oz (= highest rate), 5) Switch 14 oz (= highest label rate), 6) Inspire Super 20 fl oz (= highest label rate), 7) Viathon 2 pt (only rate), and 8) Luna Experience 8.6 fl oz (= highest label rate). Merivon 9 fl oz was also included in the trial; although it is not labeled in broccoli, Priaxor has the same active ingredients as Merivon and is labeled in broccoli. Other treatments included Tanos 8 oz (= high rate), which is not labeled on broccoli, but has activity on Alternaria diseases in other crops, and Previcur Flex, which was requested by the grower cooperator (although not expected

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to have activity on ALS). These fungicides belong to Fungicide Resistance Action Committee (FRAC) groups M5, 3, 7, 9, 11 and 27. An untreated control was also included. The trial was arranged in a randomized complete block design with four replications. Each plot consisted of a single 15-ft row of broccoli (= ~15 plants) with an untreated row of broccoli on each side and 2-ft untreated section on each end. Fungicides were applied with a CO_2 pressurized backpack sprayer at 40 gal/A and 24-31 psi using a single TeeJet 8004 VS flat fan nozzle. Treatments were applied weekly on Sep 9, 17, 24 and 30.

On Sep 30, Oct 4, 8 and 10, each mature head was harvested and examined for ALS. In ALS-infected heads, ALS severity was rated on a scale of 1 to 6, where 1 = very minor, 2 = minor, 3 = minor-moderate, 4 = moderate, 5 = moderate-severe, and 6 = severe. Heads with no obvious symptoms were sniffed and if foul odor was detected, they were rated as infected with very minor severity. Oct 10, all remaining heads whether they were mature or not, were harvested and assessed for ALS. On Oct 8 & 10, from six randomly selected plants per plot, one leaf from each of the lower, middle and upper canopy was plucked and number of ALS lesions greater than 3 mm was counted. Differences among treatments were analyzed using General Analysis of Variance and Fishers Protected LSD test with 5% significance.

Trial Results (Table 1). ALS pressure was very high in the trial. At harvest, the untreated control resulted in 98% unmarketable heads with moderately severe ALS. Tanos (FRAC 27, 11), Previcur Flex (FRAC 28), Viathon (FRAC 3, 33) and Bravo WS (FRAC M5) were not significantly different than the untreated control and failed to control ALS. Merivon (FRAC 7, 11) was the best treatment with only 3% ALS-infected heads at harvest (= 97% control), which was not significantly different than Switch (FRAC 9,12; 12% ALS-infected heads = 88% control). Quadris (FRAC 11), Inspire Super (FRAC 3, 9) and Luna Experience (FRAC 3, 7) significantly reduced ALS-infected heads to 41%, 46% and 47%, respectively. Quadris Top (FRAC 3, 11) and Endura (FRAC 7) reduced ALS-infected heads to 23 % and 25%, respectively, which was not significantly different than Switch, but significantly less than Quadris, Inspire Super and Luna Experience. At harvest, average number of ALS lesions per leaf in the untreated were 157, 99 and and 27 in the lower, middle and upper canopy, respectively for a total of 283. All treatments had significantly lower ALS lesions on the leaves than the untreated, including Bravo, which had 69%, 53% and 34% fewer ALS lesions per leaf in the lower, middle and upper canopy, respectively. Luna Experience, Merivon and Endura had the fewest ALS lesions on the leaves and also the lowest ALS severity ratings in the heads at harvest. If heads with very minor ALS (= not likely detected by harvest crew) are considered to be marketable, then in addition to Switch (14% ALS), Endura (11% ALS), Quadris Top (17% ALS) and Luna Experience (22% ALS) were not significantly different than the best treatment Merivon (3% ALS).

The results of this trial indicated that the fungicides that the grower had been using, Bravo WS and Quadris had some activity on ALS, but that there are other fungicides that work much better under high ALS pressure. ALS isolates from the field where the trial was conducted are being analyzed for fungicide resistance to Quadris, as ALS resistance to Quadris has been reported. Use of the most effective fungicides can result in 85% or more marketable heads under very high ALS pressure. Most importantly, the most effective fungicides belong to several different FRAC groups (3, 7, 9, 11 and 12), which may be rotated to manage fungicide resistance. Remember that Merivon is not labeled in brassicas, instead, its "sister" fungicide Priaxor with same active ingredients is labeled on brassicas.

Here is an example of an effective ALS fungicide program that abides by best fungicide resistance management practices and PHI:

Weeks 1 & 2: (1-2 weeks & 2-3 weeks after transplanting, prior to ALS infection) – **Bravo WS** 1.5 pt (FRAC **M5**, PHI = 7 days)

Week 3 (pre-heading, large canopy): **Switch** 14 oz (FRAC **7, 11**; PHI = 7 days). No activity on DM.

Week 4 (heading begins): **Switch** 14 oz (FRAC **9, 12**; PHI = 7 days). No activity on DM.

Week 5 (harvest begins): **Priaxor** 8.2 fl oz (FRAC **7, 11**; PHI = 3 days)

Week 6 (during harvest**): Endura** 9 fl oz (FRAC **7**; PHI = 0 days). No activity on DM.

Table 1. Evaluation of selected fungicides for control of Alternaria Leaf Spot (ALS) in broccoli, Penfield, NY, 2018.

Treatment and Rate/acre	FRAC[1] Group	PHI[3] (days)	Total No. ALS Lesions per Leaf (n=6) (Oct 8 & 10)				% heads unmarketable due to ALS	ALS head severity (scale: 1-6)[4]		% heads ALS (without very minor severity)
			Lower Canopy	Middle Canopy	Lower Canopy	Total				
Merivon 9 fl oz* + NIS[2]	7, 11	3	22 c[5]	3 ef	0.1 d	25 d	3 d	1.63	V.min/min	3 c
Switch 14 oz + NIS	9, 12	7	39 c	7 cd	0.2 d	46 c	12 cd	2.0	Minor	14 bc
Quadris Top 14 fl oz + NIS	3, 11	1	28 c	9 de	1.0 cd	38 cd	23 c	2.0	Minor	17 bc
Endura 9 oz + NIS	7	0	28 c	4 ef	0.7 cd	32 cd	25 c	1.45	V.min/minor	11 bc
Quadris 11.2 fl oz + NIS	11	0	107 b	22 c	2.8 c	131 b	41 b	1.88	Minor	30 bc
Inspire Super 20 fl oz + NIS	3, 9	7	31 c	6 ef	0.7 cd	37 cd	46 b	1.79	Minor	29 b
Luna Experience 8.6 fl oz + NIS	3, 7	7	14 c	2 f	0.2 d	16 e	47 b	1.53	V.min/min	22 bc
Viathon 2 pt + NIS	3, 33	7	36 c	8 de	1.3 cd	45 cd	98 a	2.49	Min/min-mod	84 a
Bravo WS 1.5 pt	M5	7	109 b	53 b	9.3 b	171 ab	98 a	3.45	Min-mod/ mod	95 a
Tanos 8 oz + NIS	11, 27	Not labelled	115 b	42 b	9.5 b	167 b	98 a	2.68	Min/min-mod	88 a
Previcur Flex 1.2 pt + NIS	28	Not labelled	113 b	45 b	9.4 b	168 ab	100 a	3.67	Min-mod/ mod	95 a
Untreated	--	--	157 a	99 a	27.2 a	283 a	98 a	3.80	moderate	91 a
P value (α=0.05)			***0.0000***	***0.0000***	***0.0000***	***0.0000***	***0.0000***	***0.0000***		***0.0000***
Transformation6										

*"sister" fungicide of Merivon with same active ingredients, Priaxor (8.2 fl oz = highest rate, PHI = 3 days) is labelled in brassica crops.

[1]**FRAC:** Fungicide Resistance Action Committee.

[2]**NIS**: non-ionic surfactant: Dyne-Amic 0.25% v/v, used with fungicides that have translaminar or systemic activity to improve efficacy.

[3]**PHI:** pre-harvest interval.

[4]**ALS head severity scale: 1** = Very minor (V.min); **2** = Minor; **3** = Minor-Moderate (min-mod); **4** = Moderate; **5** = Moderate-Severe (mod-sev); **6** = Severe.

[5]Numbers in a column followed by the same letter are not significantly different, Fisher's Protected LSD test with 5% significance (P<0.05).

[6]transformation used to normalize data, non-transformed values are presented.

MANAGEMENT OF HEAD ROT DISEASES IN BROCCOLI AND CAULIFLOWER FEATURING NEW RECOMMENDATIONS FOR ALTERNARIA LEAF SPOT

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Coupling both the increase in broccoli and cauliflower acreage across the region and more persistent wet weather has led to an increase in the incidence and severity of head rot diseases. These diseases, caused by several different oomycete, bacterial and fungal pathogens, include black rot, bacterial soft rot, downy mildew and Alternaria leaf spot. In general, head rot is characterized by water-soaking and discoloration of individual or small groups of florets. They are easily exacerbated by presence of free moisture on the heads as a result of rain, dew or heavy fog. Below is a description of each disease to aid in diagnosis and understanding the disease cycle as well as recommended management practices. Determining which disease(s) is leading to the head rot is important for augmenting future management practices. Additional strategies for the in-season management of Alternaria leaf spot will also be discussed during the presentation.

BACTERIAL HEAD ROT can be caused by many different species of soft rotting bacteria that affect a wide array of crops. Symptoms initially start as small water-soaked spots on the immature groups of florets where water collects. These areas quickly become necrotic and black to brown in color and spread covering entire sections of the head. As the soft rot develops the head becomes soft and slimy and can develop an off-odor. Even after harvest and in cold storage disease can continue to progress.

Selection of cultivars with more dome-shaped rather than flat heads that more able to shed water are a little less susceptible. However, management primarily relies on integrated cultural practices that reduce plant wetness by maximizing air circulation and drying. Avoid overfertilization of the plants too. In some cases, surfactants can increase bacterial rots so minimizing the applications of products with surfactants once the disease is observed can help. Keep in mind that many insecticides come already formulated with a surfactant. When harvesting cut stems at an angle so they shed water and dry out. Soft rot that develops on these surfaces can be splash dispersed onto the nearby heads. Minimize plant injury during cultivation, spraying, etc. and insect damage which can serve as ports of entry for the bacteria.

BLACK ROT is caused by the bacterial pathogen *Xanthomonas campestris* pv. *campestris* and has been a common problem for growers for over 100 years. It is primarily a disease of the above ground portion of the plant however, the bacteria can enter through the roots and move systemically within the plant. Plants can become infected at any stage of growth. Typically symptoms initially appear at the margin of the leaves where the bacteria enter into the hydathodes (natural opening) located along the leaf edge. However, the bacteria can also enter through

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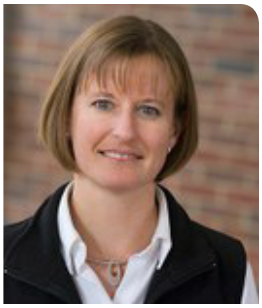

wounds following heavy rain, hail, insect feeding or mechanical injury. Depending on the weather conditions, symptoms may be visible within 8 to 12 days or it may take up to 40 days for symptom expression. Foliar lesions are usually yellow and V-shaped from the leaf margin towards the mid-rib. As the disease progresses, the veins in the yellow tissue will become dark in color and can extend from the leaves into the main vein. Optimal conditions for disease development are warmer temperatures from 77 to 86°F and free moisture either from rain, fog, dew or irrigation. Extended periods of warm wet weather favor rapid pathogen spread and disease development. Black rot can predispose the plants to bacterial soft rot.

The bacterial pathogen can survive from season to season in crop residue, cruciferous weeds and on seed. The bacteria are not thought to survive long in the soil in the absence of host plant tissue. The bacteria associated with the seed will infect the cotyledon leaves (first leaves following germination) and then the first true leaves through the hydathodes. As the bacteria multiply inside the leaf they move through the xylem (water conducting tissue) towards the stem. During the growing season, the bacteria are moved between plants through rain or irrigation splashing, blowing of detached leaves, insects, cultivation equipment or people working in the field especially when the plants are wet.

Once planted in the field, copper is still the primary management tool however it provides minimal efficacy when conditions are favorable. Therefore, the emphasis needs to be placed on management prior to planting. Scout transplants and rogue symptomatic ones as well as those in the surrounding flats which are likely infected but not yet showing symptoms. Keep the transplant production area clean and disinfest transplant trays and other equipment between uses. Harden plants off by reducing water and fertilizer rather than by topping them mechanically. If you are not growing your own transplants talk with your supplier to understand what measures he/she has in place to manage black rot. In the field, rotate a minimum of three years between cole crops to allow the crop residue to thoroughly decompose and eliminate cruciferous weeds in and around the field which can harbor the bacteria. Implement practices that reduce potential leaf wetness and water splash during the season and avoid field activities when the plants are wet. As will bacterial disease on other vegetable crops, fixed copper will help slow disease spread in the field from splash dispersed bacteria but will not help manage disease development once the bacteria are inside the plant.

DOWNY MILDEW on cole crops is caused by the oomycete pathogen *Hyaloperonospora brassicae*. This pathogen can infect many plants in the brassica/ cole crop family including broccoli and cauliflower. Similar to downy mildew on other vegetable crops, this pathogen favors cool wet weather (temperatures 50 to 59°F and daytime temps below 75°F) so this disease is most common early in spring on young plantings or later in the growing season on mature fall crops. Fall disease outbreaks are more problematic in our region. Purple to yellowish-brown lesions will develop on the upper leaf surface and under favorable conditions, grayish-white sporulation will become visible on the lower leaf surface. Younger leaves may yellow and drop-off while older leaves may become tan and leathery. Stems can also become infected and develop lesions on the surface and brown streaking internally in the vascular system. It can infect the heads causing small, dark sunken spots which then become perfect points of entry for soft rot bacterial pathogens.

The pathogen survives overwinter as mycelium on crop residue and as thick-walled oospores (overwintering survival structures) in the crop debris. The spores that are produced on the lower leaf surface can be moved between plants by rain splash or carried longer distances (similar to cucurbit downy mildew) by the wind. There is some evidence that the pathogen may be seed borne but it is currently not thought to be an important source of the pathogen.

Successful management of this disease includes practicing a 3-year rotation out of all cole crops in addition to managing weeds especially mustards both in and around the field. Disc under crop residue to facilitate rapid decomposition thus, reducing the ability of the pathogen to survive. Manage downy mildew on transplants by improving air circulation, minimizing overhead irrigation and leaf wetness and using fungicides. Scout regularly and rogue out the initial symptomatic plants to reduce the spread of secondary inoculum. Fungicides recommended for downy mildew on other crops like cucumber including Presidio, Revus, and Zampro are also recommended on broccoli, cauliflower and other cole crops. In addition, FRAC code 11 fungicides like Cabrio and Quadris are recommended

because the pathogen has not developed fungicide resistance like with cucurbit downy mildew. Actigard, which functions to boost the defense response in the plant, is also recommended but should be applied preventatively or tank-mixed with another effective fungicide with the onset of symptoms.

ALTERNARIA LEAF SPOT AND HEAD ROT is caused by the fungal pathogen *A. brassicae and Alternaria brassicicola* and affects all brassica crops as well as weeds such as mustard. Affected leaves are often purplish in color and the lesions start as small dark spots that can expand into 2 to 3-inch tan lesions with a concentric ring pattern. The concentric ring pattern results from changes in the environmental conditions that either favor or disfavor the production of spores. Affected broccoli and cauliflower heads have small black to brown discolored spots that can easily colonized by secondary soft rotting bacteria. The disease is favored by extended periods of wetness and temperatures between 75 to 82°F.

The pathogen survives readily on crop residue and cruciferous weed and it may also be seedborne. Many of the cultural practices recommended for the other diseases will also help to manage Alternaria leaf spot. Some research has shown that mulches and other barriers that reduce soil splash can help with disease management. Protection of the broccoli and cauliflower heads is important especially once symptoms are observed in the field. Previous research from New York found differences in fungicide sensitivity between fungal isolates collected from different fields. The isolates also varied in their ability to cause disease. Despite these differences, fungicides programs that include the broadspectrum protectant fungicide active ingredients chlorothalonil (FRAC code M5) and azoxystrobin (FRAC code 11). The results from additional trials conducted in 2018 will be discussed.

PASA'S DIVERSIFIED VEGETABLE APPRENTICESHIP (DVA) PROGRAM

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SUMMARY

ABOUT THE DIVERSIFIED VEGETABLE APPRENTICESHIP (DVA)

Diversified Vegetable Apprenticeship (DVA) is a new formal apprenticeship that pairs beginning farmers with master growers to provide a guided pathway toward mgbbbbanaging or starting a vegetable farm. The program operates in Pennsylvania and surrounding areas.

DVA benefits both beginning and experienced growers: Apprentices acquire the skills they need to manage or start their own vegetable farm, while master growers gain a committed employee invested in farming as a career.

WHAT IS A "FORMAL" APPRENTICESHIP?

A formal apprenticeship is registered and accredited with the Department of Labor at either the state of federal level. Formal apprenticeships are paid and offer a combination of structured on-the-job training and related theoretical instruction tailored to industry requirements.

The goal of a formal apprenticeship is to cultivate skilled workers who are trained in all aspects of an occupation.

WHY SHOULD *FARMERS* PARTICIPATE?

1. A RELIABLE EMPLOYEE

Your apprentice will support your farm's labor needs over the course of 18 months as they acquire on-the-job training and grow increasingly skilled with your mentoring. Apprentices also become more proficient as they complete 200+ hours of off-farm related technical instruction (RTI)—a requirement for graduating from Diversified Vegetable Apprenticeship. If you and your apprentice agree to it, you also have the option to hire your apprentice after they graduate.

2. HIRING SUPPORT

Hiring qualified employees who are eager to learn and invested in the success of your farming business can be difficult. Through Diversified Vegetable Apprenticeship, you'll have access to a pool of pre-qualified apprentice candidates who we've vetted through a formal application process.

3. EDUCATIONAL SUPPORT

We'll provide you with educational support throughout the apprenticeship period, including training resources and access to workshops and events catered to Diversified Vegetable Apprenticeship. You'll also receive discounted registration to qualifying PASA events, including our year-round workshops and farm tours, and our annual conference.

Dan Dalton is the Three Rivers Hub Manager and Diversified Vegetable Apprenticeship (DVA) Program manager for the Pennsylvania Association for Sustainable Agriculture (PASA). He manages educational programming, member outreach, and research coordination in western Pennsylvania and the DVA Program statewide.
Dan holds a master's degree in international development from the University of Pittsburgh focusing on agriculture and rural development. He has worked as an agronomist, advising farmers on how to manage their soils more sustainably, as a vegetable grower, and as an educator teaching agroecology.

WHY SHOULD *APPRENTICES* PARTICIPATE?

1. ON-THE-JOB TRAINING

You'll complete 2,784 hours of on-the-job training alongside a master grower over the course of 18 months on a working farm with a proven track record. PASA staff will regularly meet with you to ensure you're on track to successfully complete the apprenticeship program, and to provide you with additional support as needed.

Through your training, you'll gain experience in these 15 core competency areas for vegetable farming:

1. Administration
2. Personnel management
3. Soil fertility
4. Tillage and field prep
5. Seedling production
6. Planting crops
7. Field crop production
8. Irrigation
9. Weed control
10. Pest and disease control
11. Harvest
12. Post-harvest handling
13. Product distribution
14. Marketing
15. Equipment and machinery maintenance

2. RELATED TECHNICAL INSTRUCTION

You'll complete 216 hours of related technical instruction (RTI) on topics best learned off farm or that require more advanced training. Your RTI may include attending workshops, field days, conferences, farm tours, formal classes, and farmer networking opportunities. Areas of RTI include:

- Farm business planning & financial management
- Tractor safety & maintenance
- Small engine repair
- Integrated pest management

3. PROGRESSIVE WAGE

Your apprenticeship is paid. Plus, you'll receive a scheduled raise every six months, with demonstrated progress on your training objectives.

PROGRAM DETAILS:

TOTAL LENGTH: 18 months, minimum
TOTAL HOURS: 3,000
ON-THE JOB TRAINING: 2,784
RELATED TECHNICAL INSTRUCTION: 216
PAY RAISES: Every six months - With demonstrated progress

RUTGERS SPECIALTY PUMPKIN™ HABANERO PEPPER*

Albert Ayeni, Tom Orton, James Simon, and Martin Zorde
Department of Plant Biology, Rutgers' SEBS, 59 Dudley Road New Brunswick, NJ 08901
Contact: Albert Ayeni, 848-932-6289; aayeni@sebs.rutgers.edu

Background and General Description: Habanero peppers (Capsicum chinense, Jacq) are a rich source of Vitamins A and C, minerals, antioxidants and fiber. Their unique flavor and taste separate them from other peppers. The high capsaicin content (measure of heat level) offers relief for joint aches and pains; and discomfort associated with inflammations and other irritations. These attributes are unknown to most of Mid-Atlantic residents. Habanero peppers are popular food items in Africa, Asia, and Central and South America. Due to the rapidly growing ethnic populations in the Mid-Atlantic region from these parts of the world there is growing demand in the fresh and processing markets for habanero peppers yet to be met locally. Increased production of habanero peppers offers higher income to the grower, enhances the agricultural economy of the Mid-Atlantic region and gives consumer access to better nutrition and health derived from increased consumption and utilization of habanero peppers and by-products.

Figure 1: The Rutgers' Pumpkin™ Habanero

The Rutgers Pumpkin™ Habanero (RPH) pepper came out of the Exotic Pepper Project led by Albert Ayeni, Tom Orton and Jim Simon in the Dept. of Plant Biology, Rutgers School of Environmental and biological Sciences, New Brunswick, New Jersey (NJ). The pepper is a natural cross between African and Latin American habanero peppers grown together in the field at Rutgers Ag Research and Extension Center (RAREC), Upper Deerfield, NJ and Rutgers Horticulture Farm 3, East Brunswick, NJ between 2010 and 2016. It was first observed in 2011 as a unique habanero with an attractive pumpkin-like shape, medium fruit size and comes in yellow, orange or red color. It was released to the public as an open-pollinated cultivar in April 2017 (https://news.rutgers.edu/news/pumpkin-habanero-pepper-plant-debuts-rutgers-day/20170420#.XBGjKvZFzL8.)

Compared to other habanero peppers in our collection, RPH is a small/medium size plant, 20-30" tall, has a spreading growth habit, early fruiting and high yielding (100-120 fruit/plant; >12 t/acre in sandy loam soil with organic matter >1.8%, pH 6-7). The fruit size ranges from small to large (0.4-0.8oz/fruit and average of 0.5oz), pumpkin-like in shape, with color ranging from yellow to red. On the Scoville Heat Unit (SHU) scale, the heat level is <50,000, considered very mild in the habanero pepper group but higher in pungency than jalapeno or cayenne types. Heat is concentrated in the placenta and seed while the fruit flesh is practically heatless and has tangerine flavor and crunchy texture.

Field Production and Crop Protection: RPH thrives in sandy loam/loamy sand soils with organic matter level >1.8 % and pH 6-7. Under high organic matter (2% or more), fruit size and total fruit yield are significantly higher than at lower soil organic matter proportions. Transplants should be started in the greenhouse nursery in March and transplant to the field in Mid-May to early June (no later than June10). RPH seeds germinate slowly and non-uniformly over a 21-day period in a greenhouse/hoop house environment set at 75-85oF day and 65-70oF night temperatures. To reduce weed management problems and minimize moisture stress, we cultivate RPH on raised beds under black

Albert Ayeni (Ph.D. Cornell University) is Ethnic Crop Research Specialist and Asst. Teaching Professor at Rutgers' Department of Plant Biology, New Brunswick, New Jersey. He works on the agronomy and marketing of select ethnic crops with focus on adding these "new" crops into the bread basket of a diverse and changing demographic in New Jersey and beyond. He leads the Exotic Pepper Project at Rutgers School of Environmental and Biological Sciences. Ayeni is a member of the Ethnic Crop Research Group comprising several faculty from Rutgers University, University of Florida and the University of Massachusetts. Among his recent accomplishments with Drs. Tom Orton and Jim Simon (Rutgers Department of Plant Biology) is the release of Rutgers PumpkinTM Habanero pepper to the public in 2017. Ayeni currently works on exotic peppers, roselle, okra, amaranths and tigernuts at Rutgers University.

plastic mulch. Plants are spaced 18" within the row and 36-48" between the row. Depending on soil test results, the use of NPK fertilizer may be necessary for good plant growth and development. For more information on nutritional management, please refer to the Mid-Atlantic Vegetable Guide Section F "Bell Pepper" (https://njaes.rutgers.edu/pubs/publication.php?pid=e001). In our organic plots at Rutgers Hort Farm 3, with 1.8% organic matter, RPH has exhibited vigorous foliar growth and high fruit yields without additional soil fertilization. Irrigation is applied as needed to minimize water stress. In our production environments, RPH has not shown any significant response to insects or diseases except late in the season when ripe fruit left unharvested for several weeks may exhibit anthracnose-like symptoms. RPH is an early relative to most other habanero cultivars with the first harvest due as early as mid- to late August. Harvesting is done manually and repeated every 2-3 weeks after the first harvest until the frost terminates the life of the crop in late October/early November

Yield and Some Yield Components: RPH yields heavily, producing 100-120 fruit/plant, and each fruit ranging from weighing 0.4-0.8 oz. A plant may produce 3-4 lbs of fruit in a growing season Compared to seven other habanero peppers in our studies RPH ranks highest in fruit number per plant and comes a close second in total fruit yield/plant. Fruit size is among the smallest and averages 0.5 oz/fruit (Figure 2).

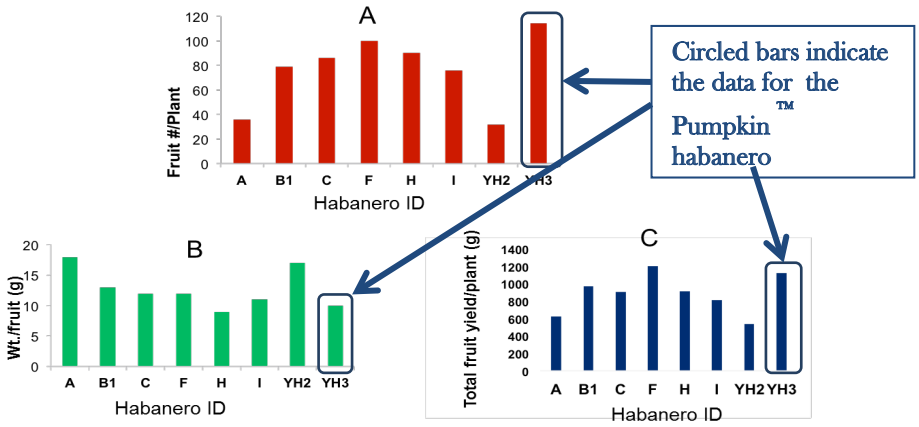

Figure 2: Fruit number/plant (A), weight/fruit (B) and total fruit yield/plant (C) in organically grown Habanero selections at Rutgers' Hort Farm 3 in 2016. Plants were grown from 8-week old transplants

Harvesting and Postharvest handling: RPH is an early maturing habanero pepper compared to other habanero selections. If RPH is transplanted in June, the first harvest will start at the end of August or early September. On a scale of 1-5, RPH has a relatively long shelf life, or ripe fruit durability (RFD), with a rating of 4 out of 5. RFD is a term used to describe the longevity of the ripe fruit on the plant before it starts to deteriorate. A habanero selection in which the ripe fruit starts to deteriorate within two weeks after ripening is given a RFD of 1, while the one in which the fruit retains integrity beyond 4 weeks is given a RFD of 5. Field studies have shown that in RPH a fruit that ripens in August may retain integrity for 4 weeks before it starts to deteriorate. Harvesting is done manually by picking the fruit with or without the peduncle. Picking with the peduncle is recommended if the fruit is to be stored for a long period before processing or use. Without the peduncle, the fruit has a much shorter shelf life. At room temperature (75-85oF) and low relative humidity (<75%) freshly harvested fruit may retain integrity for three weeks and in cold storage (40oF) the shelf life may increase to 4 weeks.

Phytochemistry of RPH fruit: RPH fruit has low levels of capsaicinoids (the heat principles in the fruit) compared to other habanero selections in our studies, making it more acceptable to populations that have low threshold levels for heat tolerance. On the Scoville Heat Unit (SHU) scale, RPH fruit measures between 30,000-50,000 heat units, very low compared to scotch bonnet, a common habanero in the United States, that measures >250,000 SHU units or Carolina reaper that measures >2 million SHU units. The fruit is also rich in fiber, antioxidants, minerals, and Vitamins A and C, making it a highly nutritious and healthy vegetable.

Market opportunities: RPH has significant market opportunities, for example fresh market especially the famers markets, bodegas, ethnic grocery stores/restaurants (African, Asian, & Latino); the processing market including the pepper hot sauce, pepper powder, pepper flakes, dry pepper fruit, beverage flavoring, candy flavoring, etc.; the seed and seedling market; and the pharmaceutical industry for pain and other health management interventions. The ornamental industry is another market into which RPH may be introduced to show the remarkably attractive appearance when the plant carries fully ripe fruit.

Conclusion: Rutgers' Pumpkin™ habanero has impressive nutritional value and qualities that will make it a strong component of the NJ and the Mid-Atlantic fresh chili pepper market in the coming years. It may be grown successfully in New Jersey and the mid-Atlantic. The fruit combines an attractive shape with a crunchy tangerine like heatless flesh to make it a unique preference for those considering adding a little spiciness to their diet. There are several market options and opportunities to explore, ranging from the fresh market, processing market, to the seed/seedling, candy, pharmaceutical and ornamental industries. These market opportunities need to be developed.

Source of Seed: Please contact Ms. Anna Molinski, Program Coordinator, Rutgers SEBS and NJAES Research, New Brunswick, NJ 08901; 848-932-4206; annamol@njaes.rutgers.edu .

The Rutgers PumpkinTM Habanero

USE OF BIOLOGICALS/MICROBIALS IN CROP PRODUCTION:

Denny Wildman

Microbials, the "Unseen, Unsung" heroes of agriculture – with the power to put more money in your pocket. Yes, the biological science of microbials is very complex. But, like all of creation, there is a natural order that allows us to apply this science to benefit our vegetable crops. In our discussion, we'll expand our knowledge of biologicals and the importance of healthy soil in empowering microbials to do their work as intended.

Together, we'll explore how soil health and microbials work hand in hand in that all important area where the roots interface with the soil. We will look at actual examples where just a basic understanding and application of microbials improved water management, nutrient exchange, and overall yield at harvest time. Bottom line, it takes a microbial community to get the job done.

Denny Wildman

- Raised on the family dairy farm, where he still farms with his son and family.
- Studied Soil Science, Plant Biology, and Ag Engineering at State University of NY, Cobleskill College of Agriculture and Technology
- Founded Advanced Ag East LLC --- where for 40 years has assisted growers understand the language of the plant, and the science of preserving yield.
- Founding member of the International AG Associates Conference – now in their 25th year
- Crop Consultant and Field Researcher for several leading edge Agri-Business companies
- Married to wife, Beth, (3 children, and 5 grandchildren)

LATE SEASON SWEET CORN INSECT MANAGEMENT

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Corn earworms (CEW) are arguably the most important pest of late planted sweet corn. As a result, insect management efforts are focused on protecting ears from CEW damage. This has traditionally been accomplished with frequent foliar applications of broad spectrum insecticides that have not only protected ears from CEW but also provided control of many secondary pests. While CEW continues to be the driver species dictating silk spray schedules, greater attention needs to be given to secondary pests for several reasons.

The first reason is the reduction in CEW and European corn borer (ECB) populations due to the widespread adoption of transgenic crops containing Bacillus thuringiensis (BT) as evidenced by historical black light and pheromone trap catches. This reduction in pest pressure has allowed for a reduction in silk sprays that are timed further apart. Consequently, secondary pests may not be exposed to insecticide residues that help to keep populations suppressed.

The second reason is that silk spray programs typically rely on broad spectrum insecticides such as pyrethroids (Group 3A) to control CEW and other ear invading insect pests. However, CEW susceptibility to pyrethroids has declined based on vial testing. Research conducted in Delaware in 2018 documented approximately 43% of adult CEW moths exposed to cypermethrin survived. With this in mind, silk spray programs should incorporate insecticides with different modes of action such as diamides (Group 28) or spinosyns (Group 5) for resistance management and to protect ears from damage. However, these other insecticide groups are not broad spectrum and do not provide control of many secondary pests such as stink bugs.

Lastly, stink bugs, including the invasive brown marmorated stink bug (BMSB) is a secondary pest that has become more of a concern because of their potential to cause significant injury to sweet corn. Stink bugs use their piercing-sucking mouthparts to feed on developing ears causing kernels to become collapsed, sunken, or discolored. The timing of infestation has been shown to influence the severity of damage. Infestations occurring prior and during pollination resulted in collapsed kernels and infestations occurring during blister and milk stage resulted in sunken and discolored kernels (Figure 1). Based on our findings, BMSB damage approximately one kernel per day, per bug (Figure 2). In comparison, the native brown stink bug was found to cause similar levels of damage when infestations occurred during the milk stage.

Bill Cissel is the Integrated Pest Management (IPM) Extension Agent at the University of Delaware. He has a B.S. degree in Agronomy from Delaware Valley University and a M.S. in Entomology from the University of Delaware. He conducts applied research and extension demonstrations on various insect pests of vegetable and field crops. Prior to working as an Extension Agent, he worked as a private crop consultant providing pest and nutrient recommendations in MD, DE, NJ, and PA. He is a native of Cecil County, Maryland where he currently resides with his wife, Amanda and three children, William (7), Noah (5), and Abigail (3).

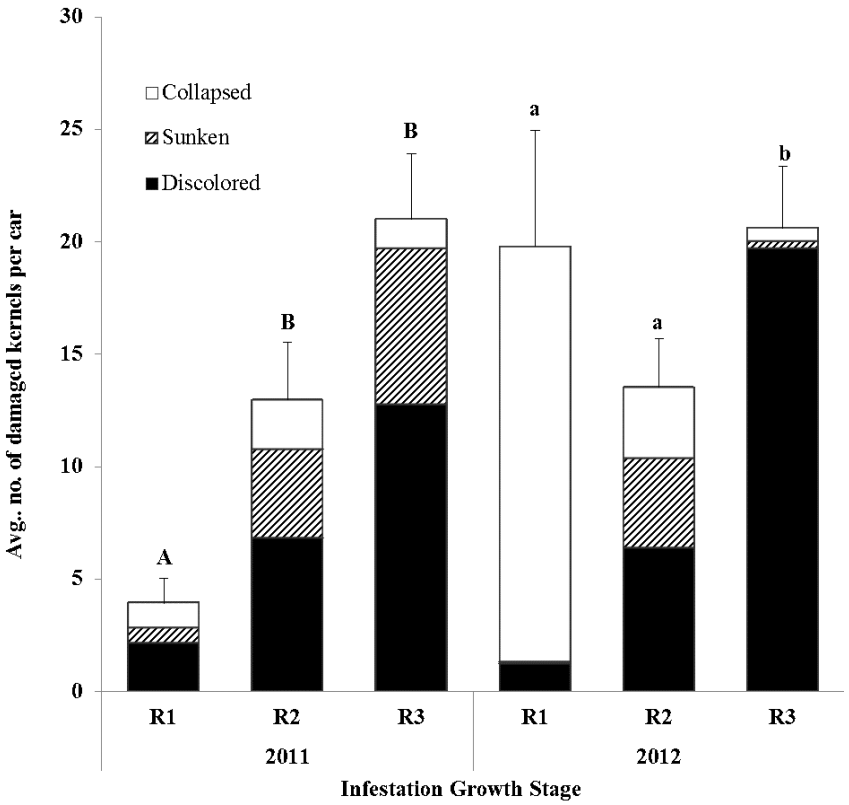
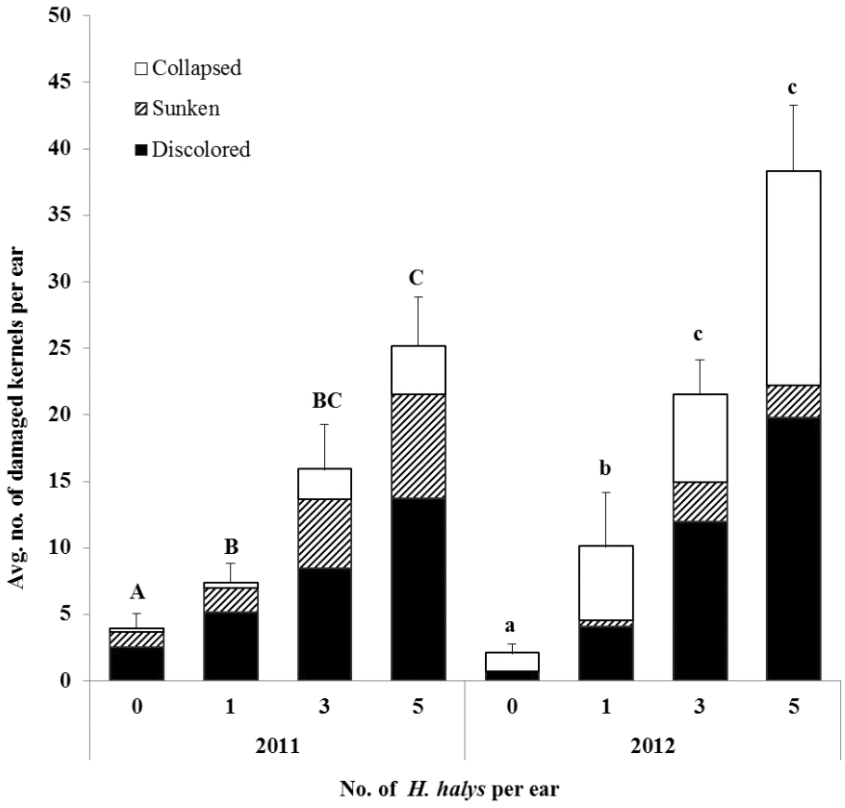


Fig. 1. Effect of BMSB infestation timing (plant growth stage) on kernel damage (collapsed, sunken, and discolored kernels) for 2011 and 2012. R1, R2 and R3 represent silking, blister and milk growth stages, respectively. Sweet corn ears were bagged and artificially infested with BMSB for 7 d. Bars within each year with a letter in common are not significantly different (Tukey-Kramer test, $P < 0.05$). Error bars show SEM.

Fig. 2. Effect of BMSB infestation density on kernel damage (collapsed, sunken, and discolored kernels) for 2011 and 2012. Sweet corn ears were bagged and artificially infested with BMSB at densities of zero, one, three, and five bugs per ear for 7 d. Bars within each year with a letter in common are not significantly different (Tukey-Kramer test, $P < 0.05$). Error bars show SEM



SWEET CORN TRIALS COMPARING NON-B.T., B.T., AND STACKED B.T. VARIETIES

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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. IPM programs monitoring CEW moth numbers 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 latter 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 repeated in 2018 (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.

In 2018, all field plots contained the isogenic bicolor hybrids 'Providence' (non-B.t.), 'BC0805' (Attribute - Cry1Ab) and 'Remedy' (Attribute II – Cry 1Ab, Vip3A). Plots at Wye River and Beltsville, MD, Pittstown, NJ, Rock Springs, PA, Georgetown and Newark DE, Geneva and Riverhead, NY, Abingdon, Blacksburg (data not included), Painter and Suffolk, VA, and Vincent, OH (conducted by WVa) also contained the isogenic hybrids 'Obsession' (non-B.t.) and 'Obsession II' (Performance Series – Cry1A.105 +Cry2Ab2).

Kris Holmstrom has managed the Rutgers Cooperative Extension Vegetable Integrated Pest Management (IPM) Program's north and central New Jersey operations for 32 years. The outreach portion of his work involves training program technicians in insect and disease identification and working directly with commercial vegetable growers to develop strategies to manage these pests in environmentally and economically sound ways. Research activities include investigating the effect of transgenic corn on European corn borer populations and allium leaf miner management in New Jersey Kris holds a B.S. in Plant Science and an M.S. in Plant Pathology from Rutgers University.

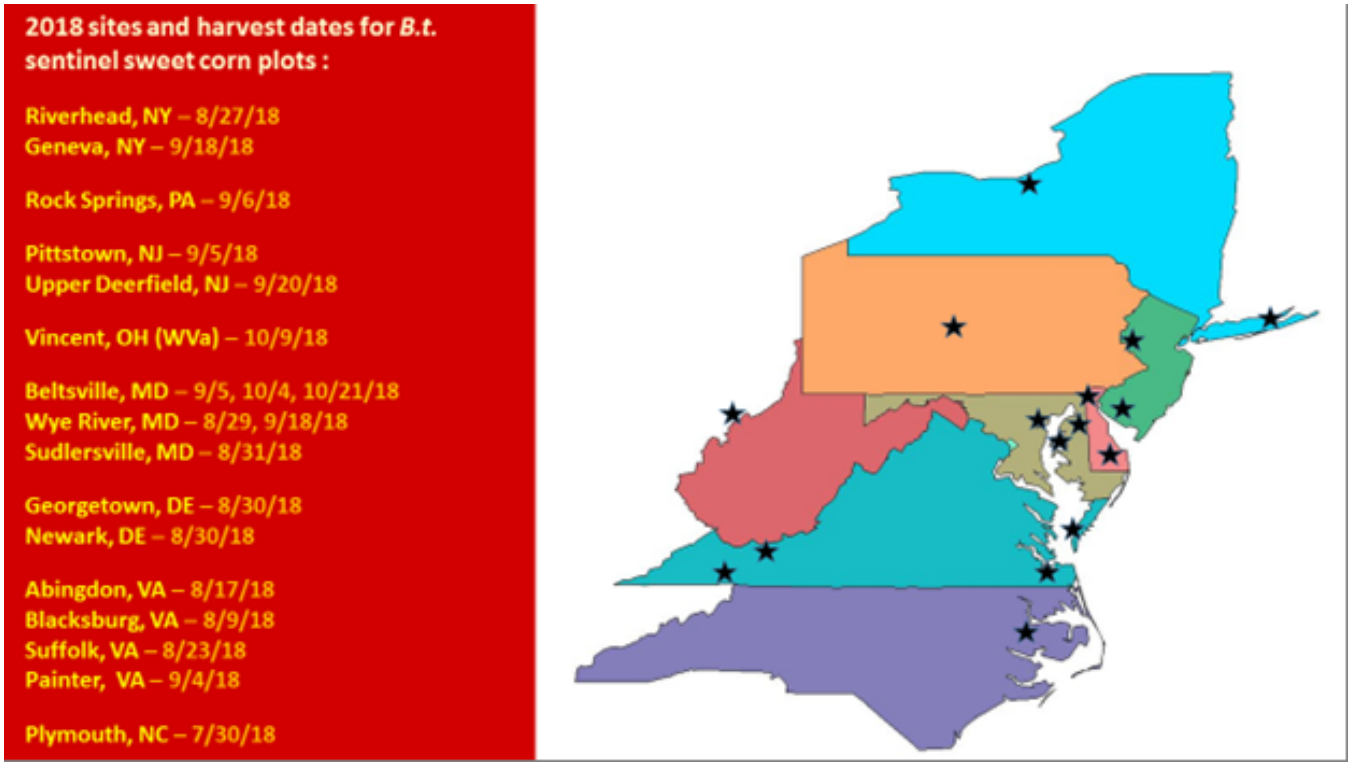

Fig. 1 2018 Sweet Corn Sentinel Plot Sites

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 some sites had lower overall infestation rates (Pittstown, NJ and Rock Springs, PA, Suddlersville, MD), 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.

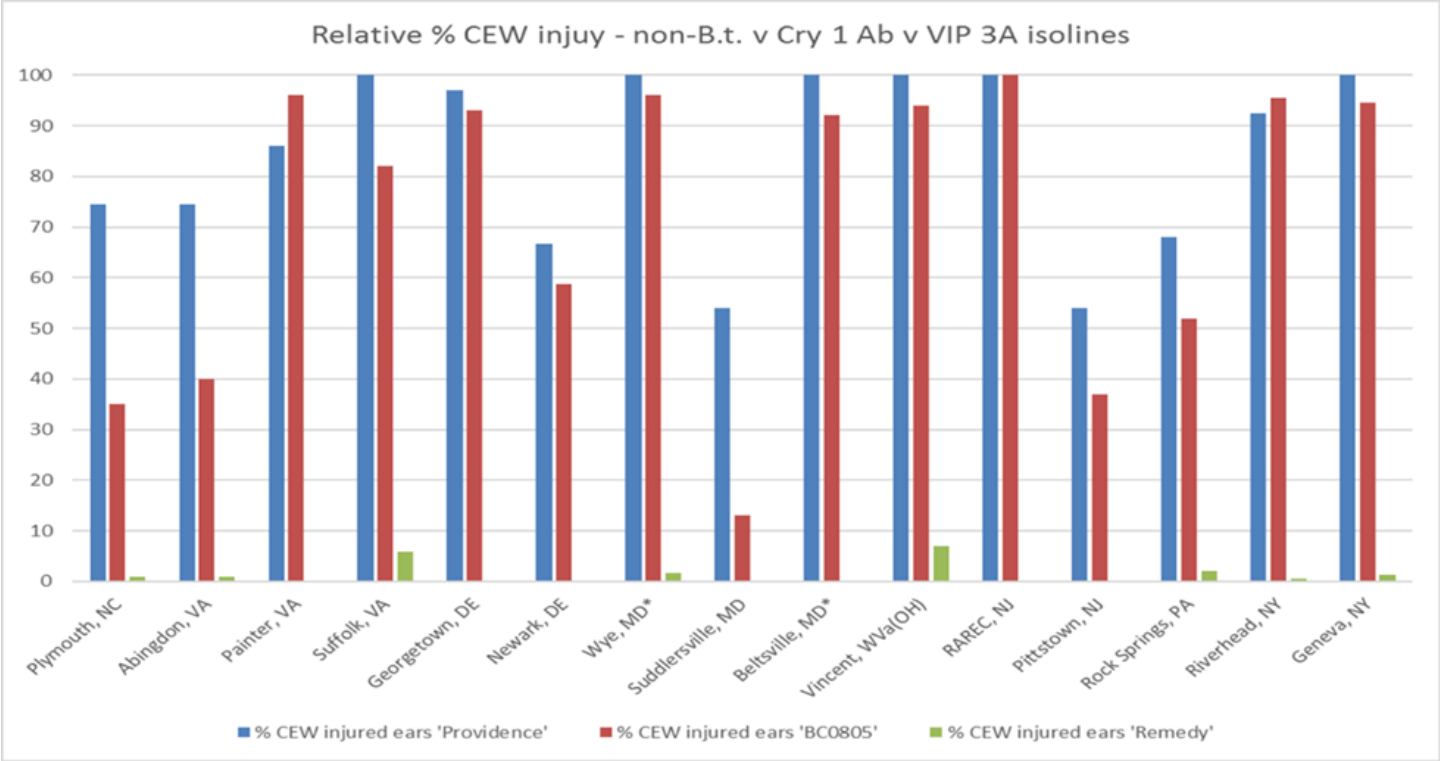

Figure 2. CEW injury – non B.t., Attribute I and Attribute II

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

The 11 sites in the mid-Atlantic region 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 2018 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. At times, there appears to be a slight decrease in CEW ability to survive on sweet corn expressing Cry toxins in some northern (inland) sites in this study. This may be due to susceptible individuals migrating from areas where resistance has yet to develop to the degree it has in the southeast.

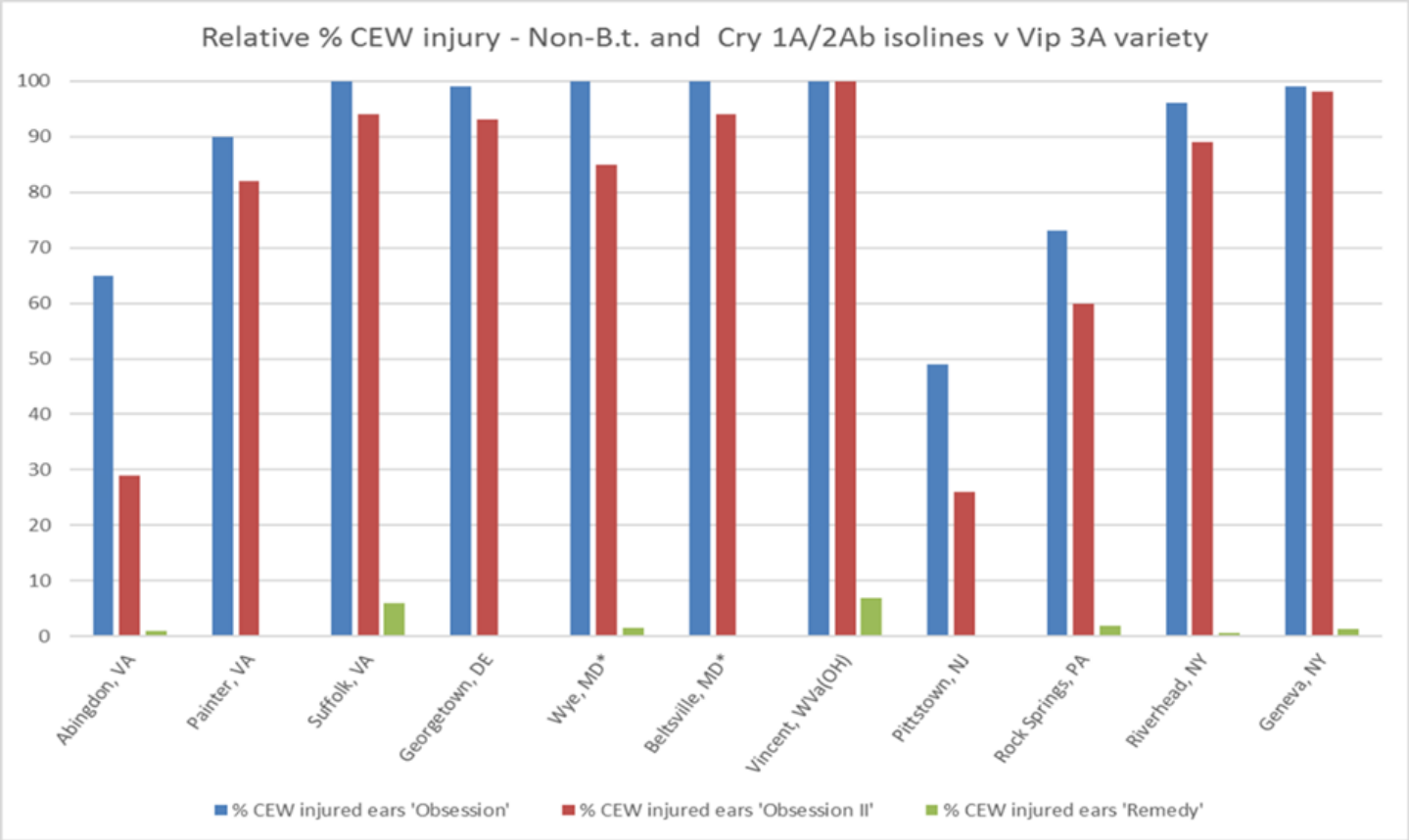

Figure 3. Ear damage from CEW – Performance Series

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. The low levels of CEW infested ears in the 2018 Attribute II (Remedy) plots in this study represent a significant increase prior years, including 2017. Additionally, in infested ears, CEW larvae survived longer in 2018 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 Bt derived toxins. Sentinel studies in the mid-Atlantic region are essential in monitoring changes in CEW population susceptibility to Bt derived toxins. The cooperators 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.

* The author wishes to acknowledge Dr. Galen Dively (Uinv. Of MD) for organizing the 2017-18 sweet corn sentinel plot projects, as well as conducting efficacy work on genetically engineered sweet corn since its inception.

EFFECTIVE WEED CONTROL IN SWEET CORN

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Sweet corn growers have many more weed management tools at their disposal now, compared to 10-15 years ago. Although more products are now available, weed control in sweet corn can still be a challenge (see Table 1.). However, over the past few years some newer herbicide products have been labeled for use in sweet corn that could provide effective control of problem weed species. Historically, weed control in sweet corn has primarily been limited to soil-applied materials. In addition to some newer preemergence herbicides, other postemergence products are also currently available. Products such as Acuron, Armezon Pro, Anthem, Liberty, Revulin Q, Solstice, Verdict, and Zidua now can be used in sweet corn production. These products generally provide effective weed control and exhibit good crop safety in field corn, however some research has been conducted with them in sweet corn in Pennsylvania and the Mid-Atlantic region. Initial results of these studies have found that: 1) under heavy weed pressure, a full rate of residual herbicide followed by a postemergence application was needed for consistent weed control; 2) the newer herbicides (Acuron, Revulin Q, Solstice, Liberty, and Armezon Pro) performed comparable to Lumax, Accent, and Impact in terms of crop safety and yield and; 3) across two years and two locations, a trend was observed for more sweet corn injury and a negative effect on yield with Zidua and Verdict plus atrazine. Also, with more weeds becoming herbicide resistant it is critical that growers use other effective modes of action to combat this problem. Some of these new products can help.

Newer GMO sweet corn varieties that are resistant to Roundup and Liberty are currently available for use. These varieties can be valuable since glyphosate and Liberty (glufosinate) provide broadspectrum weed control with no soil residual issues that could interfere with rotational crops. Due to the increasing number of glyphosate resistant weed species, Roundup Ready sweet corn varieties may be less attractive. However, treatments that include Liberty in LibertyLink variety may still have utility.

Table 1. Effect of common sweet corn herbicides on selected weeds

Weeds	Bicep II Mag	Lumax	Impact/ Armezon	Laudis	Callisto	Accent Q	Cadet	Sandea
Giant foxtail	9	9	7	8	N	9	N	N
Lg. crabgrass	9	9	8	8	8	7	N	N
Fall panicum	9	9	8	6	N	9	N	N
Yellow nutsedge	8+	8+	7	7	7+	6	N	9
Lambsquarters	9	9	9	9	9	6	8	N
TR Lambsquarters	7	9	9	9	9	6	8	N
Nightshade	9	9	9	9	9	N	6	6
Pigweed	9	9	8+	8+	8+	9	8+	9
Common ragweed	8+	9	7+	7+	8	6	6	8+
Smartweed	9	9	9	9	9	8	N	8
Velvetleaf	8+	9	9	9	9	7	9	9

Dwight Lingenfelter is an extension agronomist/weed scientist in the Dept. of Plant Science at Penn State since 1994. He is responsible for developing various materials for Extension purposes, including revising portions of The Penn State Agronomy Guide, presenting practical information at county and statewide Extension meetings and field days, and generally contributing to other weed science Extension and research needs in mainly agronomic and some vegetable crops. He also coordinates the annual Penn State Agronomic Field Diagnostic Clinic and coaches the PSU collegiate weed science team and is a member of several professional societies and serves on various committees. He received BS and MS degrees in Agronomy from Penn State. He also worked for a period with a major ag chemical manufacturer and as a crop consultant.

Cocklebur	8+	8+	8+	8+	8+	7	N	9
Ann. morningglory	8+	8+	7+	7	7+	7	7	6
Canada thistle	7	7+	7	7	8	6	6	8 (+2,4-D)

Weed control rating scale: 9 = 85-95%; 8 = 75-85%; 7 = 65-75%; 6 = 55-65%; N = no activity

Glyphosate-resistant marestail/horseweed

Glyphosate-resistant marestail (Conyza canadensis) or sometimes called horseweed, is a problem in most crops throughout the state including, agronomic and horticultural row crops, orchards, vineyards, and many other areas such as roadsides, non-crop areas, and other natural or idle areas.

Marestail has received increased attention due to the identification of glyphosate and ALS resistant populations around the country. Marestail is a member of the aster or sunflower family. It starts out as a small rosette and as it grows upright its hairy leaves whorl around a central stem. Mature plants become 2 to 5 feet tall producing numerous small daisy-like flowers. Marestail is a prolific seed producer (>100,000 seeds/plant) and the seeds are wind dispersed much like dandelion. Marestail has traditionally been considered to have a winter annual life cycle. It typically germinates in the fall and overwinters as a rosette then bolts and sets seed by summer. However, there is another biotype of marestail that can also be found in our region. This one doesn't germinate until early spring and completes its lifecycle by late summer. The two different lifecycles can cause problems when managing marestail especially when trying to grow crops planted either earlier or later in the growing season. This too can pose problems when selecting burndown and residual herbicide programs depending on the cropping system. A few things to consider when managing marestail: first, its seeds are very small and it does not tolerate tillage. If the seed can be buried at least a quarter of an inch, germination is drastically decreased. Also, once marestail gets to be taller than 6 inches, it is difficult to control with herbicides. Herbicide applications in the fall or early spring when it is in the rosette stage are best.

The number of herbicides that are effective on marestail is rather limited in vegetable production systems. However, certain sweet corn herbicides can provide control of marestail. Here are some suggestions: In no-till sweet corn, paraquat plus a triazine herbicide, and glufosinate plus atrazine applied burndown for control of emerged seedlings and residual control of glyphosate- and ALS-resistant horseweed. 2,4-D and Sharpen can be used in the burndown program but it is best to wait 7-14 days before planting otherwise crop injury can occur. If using atrazine alone or in premix products such as Bicep, Lumax, Acuron, etc, it will provide good residual control of marestail but does not control it if its emerged. 2,4-D is an effective postemergence herbicide if it is applied before marestail reaches 4 inches tall. Otherwise, for small, emerged marestail, foliar-applied HPPD inhibitors (e.g., Callisto) plus atrazine are effective. Liberty (flufosinate) is very effective on marestail postemergence, so consider a LibertyLink variety if it's a problem.

Cover crops (e.g., cereal rye) can help to suppress marestail growth during the winter and spring months allowing for fewer and smaller marestail making the burndown herbicide program more effective. Also, if using a cereal cover crop, 2,4-D or dicamba can be applied in the fall to control small marestail seedlings or 2,4-D could be applied in the spring when the rye is less than a foot tall to control to obtain control of marestail. Then the rye can continue to grow before it is terminated and/or rolled down before sweet corn planting.

For those using a tilled seedbed, marestail usually is not an issue in this setting since the tillage process controls existing seedlings and buries the seeds deep enough to manage them for that growing season. However, using effective residual herbicides can insure none will establish while the crop is growing.

Other issues in sweet corn production

As more producers are using no-till farming techniques for vegetable production, herbicide programs play a key role in effective weed management. Yet many growers want to move to the next level and produce sweet corn in no-till setting and without the use of long residual herbicide such as atrazine. Atrazine continues to be a very effective yet economical herbicide for broadleaf weed control in sweet corn. Over half of the herbicides labeled for use in sweet

corn contain atrazine or recommend atrazine as a tank-mix partner. Pennsylvania producers likely use atrazine on a high percentage of the sweet corn acres. Despite its wide acceptance by producers, atrazine use in crop production systems is a controversial issue for various reasons including environmental issues and resistant weeds. In addition to these concerns, atrazine can cause problems with rotational crops, especially vegetables, and cover crops after sweet corn production. Many growers have inquired about herbicide programs that do not contain atrazine to potentially alleviate carryover problems with successional crops. Other herbicides such as mesotrione (Callisto), topramezone (Impact/Armezon), and pyroxasulfone (Zidua) also, potentially can leave residues causing injury to rotational crops. However, these can vary depending on use rates, soil types, rainfall, and other environmental conditions.

Atrazine does improve control of certain weed species (as is well documented through various research) and is still a very effective yet economical herbicide for broadleaf weed control in sweet corn, including no-till systems. However, depending on weed species present, reducing the rate of atrazine or eliminating it could be possible if there are concerns about carryover to rotational crops, especially vegetables, and cover crops following field or sweet corn production. Problems with atrazine residues causing injury to rotational crops varies depending on use rates, soil types, rainfall, and other environmental conditions. However, simply replacing atrazine with another product such as an HPPD- or PPO-inhibiting herbicide (Acuron, Zemax, Callisto, Impact/Armezon, Laudis, Verdict) will not necessarily eliminate the aforementioned concerns. Several of these types of products have stringent crop rotation restrictions as well. Only a few herbicides have short rotations for a multitude of crops. Liberty can have a good fit in sweet corn production in a LibertyLink sweet corn system. Roundup Ready varieties also can have a good fit as well. However, limited variety options, cost of these technologies (e.g., seed tech fees), resistant weed species (esp. glyphosate), and customer acceptance may limit their widespread use.

Postemergence herbicides should only be used in sequence after a soil-applied herbicide. Total-post weed control is not recommended because sweet corn seedlings are very non-competitive with weeds, and weather conditions that prevent postemergence herbicide application may delay weed control until it is too late to prevent loss. Having a soil-applied herbicide down improves overall weed control, provides additional herbicide modes of action for resistance management, and provides some insurance in case postemergence herbicides cannot be sprayed on time. In previous Penn State research, a two-pass system provided more effective weed control overall compared to a single application timing especially in no-till systems. Spray the post treatment when weeds are small (<3 inches tall). For best results, fields with heavy populations of annual grasses (foxtail, crabgrass, panicum) will require a PRE followed by POST herbicide program for consistent control.

Depending on the program, common ragweed may require a two-pass program for adequate control. Also, control of annual morningglory and Palmer pigweed are two species that could be a problem depending on which herbicide program is used. Palmer amaranth and waterhemp are becoming a problem in PA. These noxious pigweeds are very aggressive and can be difficult to control in certain cropping systems. There are certain herbicides in sweet corn that provide control of Palmer and waterhemp including atrazine, acetochlor-products, Lumax, Zidua, Callisto, Impact/Armezon, Laudis, Liberty 280, 2,4-D and a few others. Again, two-pass systems work best with Palmer amaranth since it has a long germination period. And control of these weeds after sweet corn harvest may be necessary to stop seed production and additional spread.

OPTIMIZING STARTER/POP UP FERTILIZERS IN SWEET CORN

Dr. Gordon Johnson, University of Delaware

Sweet corn responds to starter fertilizer with improved yields. Of the nutrients that can be provided in a starter fertilizer, research has shown nitrogen (N) and Sulfur (S) to be the most beneficial, followed by phosphorus (P). In sweet corn it is common to include all three in starter fertilizer, although P does not always show a response.

While dry fertilizers were the standard years ago, many growers have switched to liquid formulations for ease of handling and blending with other nutrients. Applications of nitrogen (N) and sulfur (S) are common in starter fertilizers, as they have been shown to be quite effective at increasing early season growth for corn planted in sandy, low organic matter soils. Commonly used N containing liquid starter fertilizer products include UAN (30 or 32%), ammonium polyphosphate (10-34-0 or 11-37-0), and ammonium sulfate (8-0-0-9S). Sulfur should be included in a starter fertilizer, and at rates high enough to sustain the corn crop through V5. Ammonium sulfate will supply both N and S and should be used instead of ammonium thiosulfate (S not immediately available to the plant). Ammonium sulfate has a strong acidifying effect, which can make certain micronutrients more available in high pH fields, averting deficiencies.

Researchers typically agree that application of starter P can be beneficial and improve crop growth when soil test P concentrations are below critical levels (low to moderate P). It is recommended to apply 20 to 40 lb P2O5 in the starter band, for soils testing low or medium in soil test P. The efficacy of starter P is variable when soil test P in the optimum or high ranges. On high phosphorus soils an N only starter will usually provide similar starter response without adding extra P to an already high P soil.

We are finding some potassium (K) deficiencies in sweet corn in the region. Potassium fertilizer in starters scan be beneficial but rates should be limited. If soil K levels are high, K in starter fertilizer is not necessary.

We usually do not see a response to boron (B) in sweet corn so it is generally not recommended in starter fertilizer. Fields that receive B broadcast applications (1-2 lbs/A) at least once every 2 years should have sufficient B for sweet corn growth. If B has not been broadcast in the rotation it can be added to starter fertilizer, but the rate should be very low to avoid B toxicity (1/8 lb/A, or less). Zinc is usually not added to starter fertilizer for sweet corn except on high pH soils or soils with excessive P.

It is important to be careful in how close you place starter fertilizer to the seed. A concern with sweet corn starter fertilizer is reduction in stands due to fertilizer salt injury. This will reduce the productivity in fresh market sweet corn in particular where obtaining stands is critical. Processing sweet corn can tolerate some stand loss without yield effects. The standard recommendation is to place starter fertilizer 2″ to the side and 2″ deep. This provides a concentrated band for early uptake (plant roots will proliferate around the band); and the band will be far enough away not to cause salt injury to germinating seedlings.

Suggested rates for starter fertilizer nutrients in sweet corn are shown below:

N = 20 lbs/A (10-20 lb/A range)
P = 20 lbs/A (15-20 lb/A range)
K = 10 lbs/A (10-15 lb/A range) only if K is not testing high in soils
S = 10 lbs/A (10-15 lb/A ange)
Zn = 1 lb/A (none if Zn levels in soil are sufficient)
B = 0.125 lbs/A (none if you apply broadcast B in previous crops).

Dr. Gordon Johnson is the Extension Vegetable and Fruit Specialist at the University of Delaware stationed at the Carvel Research and Education Center near Georgetown, DE. He conducts applied research and provides extension programming in vegetable, fruit, and specialty horticulture crops. He has his B.S., degree in Agronomy from the University of Maryland, M.S. degree in Horticulture from Clemson University and his Ph.D. in Plant Science from the University of Delaware. A native of Gettysburg, PA he and his wife Yacintha reside in Denton, MD.

Fertilizers can injure germinating seedlings by salt effects. Inorganic fertilizers are manufactured in the form of salts that disassociate into ionic forms in water. As salts, fertilizers have high osmotic potential when concentrated in solution. When a high concentration of dissolved salts surrounds a seedling, moisture moves out of the seedling into the dissolved salt solution in the soil through osmosis. Therefore, cells will shrink and eventually can loose enough water to disrupt normal activities, and, in severe cases, die.

The second way that fertilizers can injury seedlings is by ammonia (NH3) toxicity. Starter or popup fertilizers that contain urea can release ammonia under certain soil conditions (high pH, dry soils, low organic matter) in the process where urea-N fertilizer is converted in to ammonium (NH4). Ammonia (NH3) is a toxic gas (the odor you smell when opening a bottle of household ammonia or that you smell in urine) that can kill plant cells if it is in high concentration. Ammonium (NH4) is not toxic and is one of the forms that plants take up nitrogen in.

The Case Against Popup Fertilizer in Sweet Corn

Popup fertilizer is fertilizer at a low rate that is placed in the seed furrow in contrast to starter fertilizer which is commonly placed in a band 2 inches to the side of the seed, two inches in depth. Many studies have been done on popup fertilizer over the years with inconsistent results. Commonly, no yield benefit is found. The risk of salt injury, especially in dry, sandy soils, may out-weigh any potential benefit from the fertilizer. Starter fertilizers in a 2x2 band have a much lower risk of injury to seedlings.

If popup fertilizer is used, the rate must be kept below 10 pounds of N + K2O per acre and only low salt index fertilizers should be used.

INSECT CONTROL UPDATE FOR PEPPERS

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In the mid-Atlantic U.S., peppers can be attacked by several arthropod pest species that can impact marketable yield of this valuable commodity. As a result, many conventional growers repeatedly apply synthetic pyrethroid insecticides (Table 1) to protect the fruit from damaging worm pests and bugs.

Table 1. Pyrethroid (IRAC Group 3A) Insecticides Registered for Use on Peppers in the U.S.

Product Name	Product Rate	Active Ingredient(s)	PHI (d)	REI (h)
Asana XL	5.8 to 9.6 fl oz/A	esfenvalerate	7	12
Baythroid XL	1.6 to 2.8 fl oz/A	beta-cyfluthrin	7	12
Bifenthrin 2EC, others	2.1 to 6.4 fl oz/A	bifenthrin	7	12
Capture LFR	3.4 to 6.8 fl oz/A	bifenthrin	7	12
Danitol 2.4EC	10.67 fl oz/A	fenpropathrin	3	24
Hero EC	4.0 to 13.0 fl oz/A	zeta-cypermethrin + bifenthrin	7	12
Lambda-Cy, others	1.92 to 3.84 fl oz/A	lambda-cyhalothrin	5	24
Mustang Maxx	2.24 to 4.0 fl oz/A	zeta-cypermethrin	1	12
Permethrin 3.2EC, others	4.0 to 8.0 fl oz/A	permethrin	3	12
Tombstone, others	1.6 to 2.8 fl oz/A	cyfluthrin	7	12
Warrior II	0.96 to 1.92 fl oz/A	lambda-cyhalothrin	5	24

Pyrethroids are a popular tool because they provide "a lot of bang for the buck"; they kill the broadest spectrum of pests and are generally cheap. However, growers should be aware that repeated use of these insecticides has some problems. First, several insect pest populations have developed resistance to pyrethroids including Colorado potato beetle, two-spotted spider mite, beet armyworm, green peach aphid, melon aphid, western flower thrips, and (most recently) corn earworm. All of which can attack peppers. Use of pyrethroids also destroys natural enemies, which can lead to resurgences of secondary pests such as aphids (see Fig. 1). Thus, it is important that vegetable growers avoid complete reliance on these chemicals for pest management. Implementing IPM practices through pest scouting and minimizing the impact on natural control agents is clearly a more sound and sustainable approach. Today there are many selective insecticides that provide effective control of target pests on vegetables in the U.S. We have evaluated the efficacy of many of these insecticides over the past decade in Virginia. Results of some of our most recent insecticide efficacy trials are presented.

Tom Kuhar is a Professor and Vegetable IPM Specialist in the Department of Entomology at Virginia Tech. Dr. Kuhar's research focuses on the ecology and integrated pest management of insect pests of potato and vegetable crops. He has published over 100 peer-reviewed papers and 6 book chapters on insect pest management in agricultural crops. He received his B.S. degree in biology from Towson, University, Towson, MD in 1992 and his Master's (1996) and Ph.D. (2000) degrees in entomology from Virginia Tech. He formerly worked as a postdoctoral research associate at Cornell University, Ithaca, NY researching alternative methods for managing vegetable pests. A native of Baltimore, MD, he and his wife, Stacey, who have two children, Daniel (15) and Brianna Marie (14).

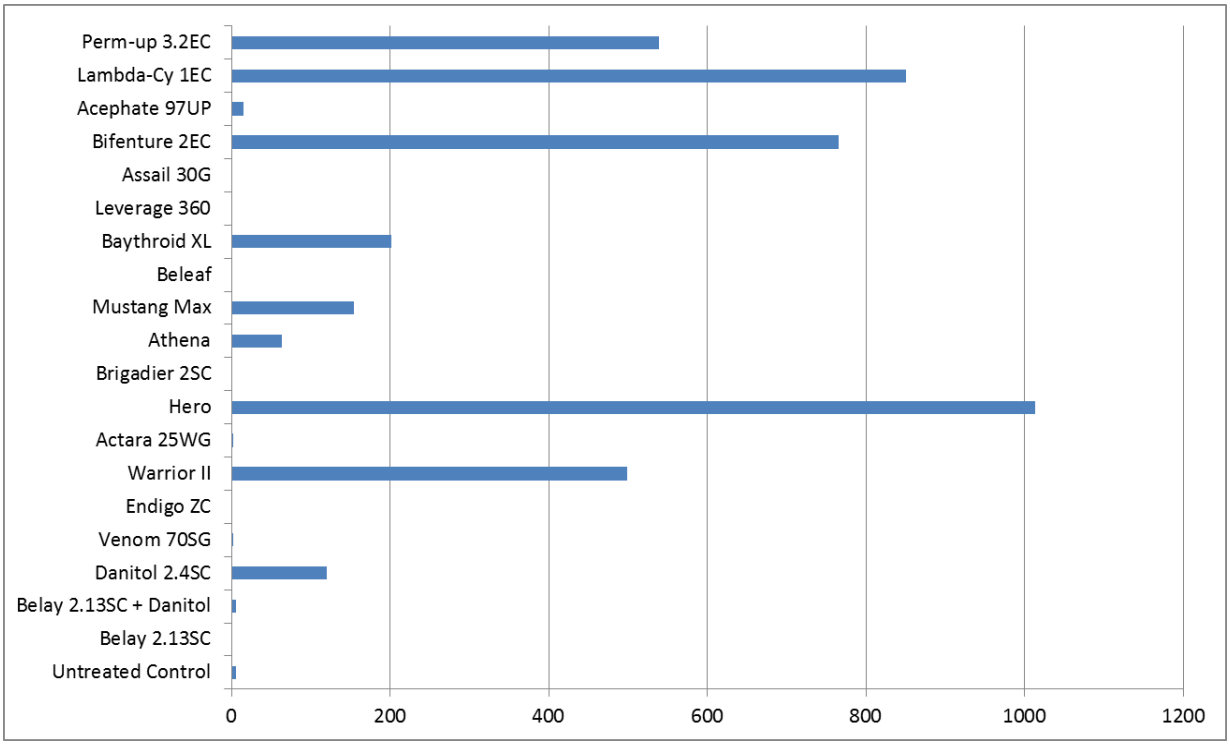

Fig. 1. Densities of green peach aphids per 20 leaves in bell peppers after three weekly applications of various insecticides in Whitethorne, Virginia.

In recent years, the invasive brown marmorated stink bug (BMSB) has become one of the most damaging pests of peppers in the Mid-Atlantic. The bugs typically infest peppers during fruiting from mid-July to late September. Both BMSB nymphs and adults insert their piercing mouthparts into fruit, which can result in white cloudy scarring, fruit abortion, or fruit rot if pathogens enter the feeding site. We evaluated the efficacy of three selective insecticides, Closer, Beleaf, and Harvanta to protect peppers from stink bugs (Table 2).

Table 2. Summary of efficacy of foliar insecticides (4 weekly applications) for the control of stink bugs in bell peppers; Virginia Tech Kentland Research Farm, Blacksburg, VA.

		% stink bug damaged fruit	
Treatment	**Rate / acre**	**13-Aug (3 DAT3)**	**24-Aug (7 DAT4)**
Untreated Control		18.0	31.0 a
Harvanta 50SL	16.4 fl. oz	16.0	13.0 ab
Closer SC	5 fl. oz	13.0	7.0 ab
Beleaf 50SG	2.8 oz	19.0	24.0 ab
Bifenture 2EC	6.4 fl. oz	6.0	2.0 b
P-value from ANOVA		ns	0.0162

Green peach aphids can be particularly problematic, particularly once populations are flared from pyrethroid sprays. Heavy densities can result in copious amounts of honey dew building up on leaves and fruit. We evaluated the efficacy of four selective insecticides including Closer SC, Movento, PQZ, and Aza-Direct + M-Pede for control of green peach aphids and reducing stink bug damage to fruit (Table 3). Insecticide were apply once on September 17.

Table 3. Efficacy of insecticides for the control of aphids and stink bug damage in bell peppers, Whitethorne, VA. Insecticides were applied only once (Sep 17).

Treatment	Rate / Acre	Mean no. of green peach aphids			Percentage stink bug/ lygus bug damaged fruit	Mean % sooty mold/sticky fruit From honey dew
		20-Sep	24-Sep	3-Oct		
Untreated control		233.8	216.3	236.5 a	30.0	21.3
Closer SC + NIS	1.5 fl.oz + 0.25% v/v	7.3	4.3	0.8 c	15.0	1.3
Closer SC + NIS	2 fl. oz + 0.25% v/v	3.8	3.8	2.5 bc	8.8	0.0
Movento + MSO	4 fl. oz + 0.25% v/v	39.5	6.0	5.3 abc	2.5	0.0
PQZ	3.2 fl. oz	21.5	12.5	34.0 ab	1.3	1.3
Aza-Direct + M-Pede	12 fl. oz + 1% v/v	285.8	304.0	104.0 a	3.8	16.3
Aza-Direct + M-Pede	20 fl. oz + 2% v/v	29.5	44.8	38.3 ab	5.0	0.0

Thrips are another pest that can build up in high numbers in flowers resulting in cosmetic scarring of pepper fruit. They also can be challenging to control. In Virginia Beach, we evaluated the efficacy of the spinosyn Radiant, along with the diamides Harvanta and Verimark for control of thrips in flowers (Table 4).

Table 4. Efficacy of insecticides for the control of thrips in bell peppers, Virginia Beach, VA

Treatment	Rate / acre	Cumulative thrips* per 10 blossoms over four weekly samples	
		Adults	Larvae
Untreated Control		12.5 a	3.3
Radiant + NIS (0.5%)	6 fl. oz	5.3 b	1.8
Harvanta 50SL	11 fl. oz	9.0 ab	2.8
Harvanta 50SL	16.4 fl. oz	5.0 b	1.3
Verimark	10.5 fl. oz	9.0 ab	2.5

*86% flower thrips; 14% tobacco thrips

CHRONICLES OF A PERENNIAL COVER CROP'S JOURNEY INTO MANAGING PESTS

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Over the past several years, the Hooks Lab in the Entomology Department at the University of Maryland has been conducting research on incorporating perennial cover crops into vegetable production systems as a tool for managing multiple pest complexes simultaneously. Cover crops can potentially serve many benefits to different cropping systems, depending on how they are managed. Legume cover crops can provide a nitrogen source to the following crops if they are incorporated into the soil as a green manure. Alternatively, annual cover crops can be killed and maintained on the surface as an organic mulch, which can provide weed suppression benefits and reduce erosion during the growing season. In some cases, annual cover crops can be chosen such that they senesce naturally ahead of planting the cash crop, which are known as dying mulches. Perennial cover crops can potentially offer several additional benefits to vegetable cropping systems, including reducing areas of bare soil and erosion, supporting beneficial arthropod populations, and competing with weed plants between crop rows, among others. When perennial cover crops are used as ground-cover alongside cash crops, they are generally referred to as "living mulches."

Figure 1. Two-row strip tiller.

The cover crop species that has received the most attention from this research has been red clover (*Trifolium pratense*). Red clover is a low-growing legume, and therefore can provide a nutrient benefit to the succeeding vegetable crop through biologically fixed, organic nitrogen, and its low-growing stature makes it an ideal pairing for inter-cropping with vegetable crops. Red clover seeds are easy to source for planting, as it is commonly used as a forage crop for livestock and honeybees or as a rotation crop in organic agriculture to improve soil nitrogen and organic matter content. Red clover has flowers that not only support honeybees, but also attract a wide diversity of insect pollinator species. Red clover is reported to bloom from late spring through mid-summer, but under typical Mid-Atlantic growing conditions, will bloom throughout the summer and into fall. In addition, red clover will tolerate being mowed, either with a rotary mower or a flail mower, which allows the living mulch to be suppressed ahead of planting the cash crop, which further limits competition between the two. Other perennial clover species are available commercially, such as white clover (*Trifolium repens*) and strawberry clover (*Trifolium fragiferum*), and these species may provide similar benefits as red clover. However all research results presented here are derived from experiments using red clover.

Our work testing the benefits of living mulches in vegetable production has typically been paired with strip tillage to kill and incorporate the clover within the rows where the crop is to be planted, while leaving the rest of the clover undisturbed. We have employed various techniques to achieve this strip tillage, depending on the scale of the individual experiment. On the small scale, we have used walk-behind rototillers to kill and incorporate the red clover in strips of 1.5' - 2' in width. Typically the clover needs to be mowed ahead of using these small implements, as long

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clover stems will wrap around the tines of the tiller. For larger scale experiments we have used a two-row strip tiller manufactured by Bigham Brothers Inc. (Lubbock, TX). This is a single-pass tillage implement that incorporates a straight coulter, followed by row cleaners, a deep shank, two offset wavy discs, and a rolling basket (Fig. 1). In a single pass, this tool will kill and incorporate the clover, and prepare a bed approximately 11" in width for planting (Fig. 2).

Figure 2. Strip-tilled red clover plots.

Some of our initial work testing red clover as a living mulch in bell pepper plantings was designed to determine whether the living mulch could effectively reduce abundance of stink bugs and their associated feeding damage on pepper fruits. We were specifically interested in the impact that the living mulch would have on the ability of brown marmorated stink bug (*Halyomorpha halys*) to locate pepper plants to feed and reproduce. Other results from scientific literature suggest that simply inter-planting pepper plants with the living mulch should effectively disguise the cash crop, and effectively protect it from the pest insect. However, results from the field trial showed that there was no significant difference in the rates of stink bug feeding damage measured on peppers planted in either the living mulch or bare ground. By contrast, there was a significant difference in the rate of peppers infested with European corn borer larvae (*Ostrinia nubilalis*). A similar experiment was then conducted using cucumber as a test crop, rather than peppers, since cucumbers have a greater mix of specialist and generalist insect pests in the Mid-Atlantic States. Results of this experiment showed that both specialist insect species, such as the striped cucumber beetle (*Acalymma vittatum*), and generalist insect species, such as spotted cucumber beetle (*Diabrotica undecimpunctata*) were found in lower abundance on cucumber planted in the living mulch when compared to the bare-ground control. The results of these experiments suggest that clover living mulch can be an effective way to reduce insect pest pressure within vegetable crops. The exact mechanisms causing the lower abundance of herbivores was not tested in these experiments, and therefore it could be the result of crop plants being hidden among the clover background, increased natural enemies supported by the clover companion plant, or a combination of the two.

In addition to the work testing the effect of living mulch on insect herbivores and natural enemies, our lab has tested the benefits of using living mulch to suppress weed pests in vegetable crops. Previous work in our lab has tested weeds can be suppressed in vegetable crops by managing killed grass cover crops as an organic mulch on the soil surface. Results from this initial work showed that organic mulches from killed cover crop residues can suppress weeds when compared to bare ground, but that weed suppression declines over time as the cover crop decomposes. Full-season weed control is not likely to result from organic mulch alone. In contrast, living mulches are plants that can actively compete through the growing season with weed species, and therefore can potentially provide better weed suppression as compared to cover crops that are killed and maintained on the soil surface as an organic mulch. Living mulches are not prone to decomposition through time, and therefore will not lose their effectiveness in weed suppression by the end of the growing season. Therefore, clover living mulches can potentially provide a means to reduce the amount of tillage and either between-row cultivation or herbicide application required to suppress weeds between crop rows.

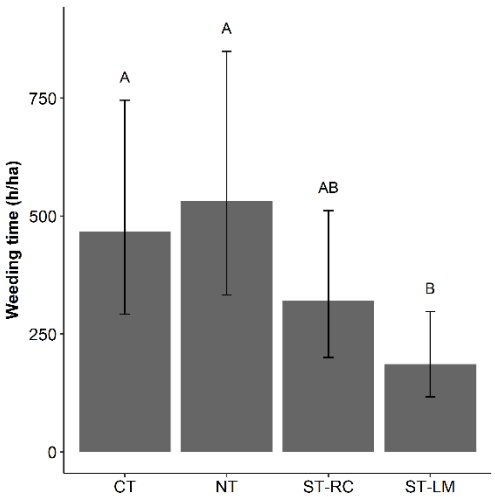

Figure 3. Total weeding time between crop rows.

We performed a field experiment to test the effectiveness of red clover as a living mulch in suppressing weeds in a bell pepper crop grown using organic practices. The strip-tilled, red clover living mulch treatment (ST-RC) was compared to an annual crimson clover (*Trifolium incarnatum*) and rye (*Secale cereale*) cover crop mixture managed using different practices. Two

treatments maintained the killed cover crop residue on the surface, and pepper plants were either transplanted into the residue with no-tillage (NT) or strip-tillage (ST-RC). The final treatment was a conventionally tilled control (CT) where residues were incorporated using a rototiller. Results from the first year of this experiment showed that the living mulch treatment had a significant impact on reducing weed pressure. Time spent weeding was significantly reduced in the living mulch treatment, and the red clover effectively suppressed weed germination and growth (Fig. 3). Importantly, the red clover living mulch suppressed species of perennial weeds as well as the conventional tillage treatment, whereas the other reduced tillage treatments had a relatively high proportion of perennial weed species. Even in the absence of hand-weeding, weed biomass was significantly reduced in the living mulch treatment. Finally, total marketable yield production was highest in the conventional tillage treatment, slightly lower in the living mulch treatment, and lowest in the organic mulch treatments. This reduction in yield was likely due to shading causing cooler soil temperatures and a delay in pepper plant growth and reproduction.

These studies show that applications of clover as a living mulch can have several benefits to pepper production systems. Clover adds a level of plant diversity to the crop system, and reduces the amount of bare soil present, which can have direct and indirect effects on pest and beneficial insect species. The living mulch presents a way to effectively reduce weed pressure throughout the growing season, while reducing the total amount of tillage. This reduction in tillage could have additional long term soil health benefits that were not measured in these short-term studies. Additionally, reducing tillage may reduce operation costs. Potential drawbacks of living mulches include the added complexity of having to manage two plant species within the same field. As a living plant, the clover can potentially compete directly with the crop plant, and this competition needs to be minimized for the system to be successful. Finally, living mulches may in some instances attract pest species to the crop plant, which would increase damage to the crop. However, most of the results of our work suggest that clover can provide many benefits to vegetable crops when used as a living mulch.

BELL PEPPER VARIETY SCREENING FOR BACTERIAL LEAF SPOT

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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. Phytophthora blight caused by *Phytophthora capsici* is the number one disease. Phytophthora continues to be a concern among growers, but with proper management and tolerance varieties growers are learning to live with the disease.

BLS on the other hand has become more of a concern over the last ten 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. Most commercial bell pepper varieties grown in the Mid-Atlantic region are resistant to races 1-3 which have been the main races found in the Northern United States. Until recently growers in New Jersey have managed BLS with a combination of resistant varieties and chemical control. In 2004, growers reported that resistant varieties were being infected with BLS. A series of screening trials were carried out to determine if other races may be present in the state. It was determined that race four was found in Southern New Jersey, but not in the Northern part of the state. Since 2004 varieties e.g. 'Turnpike', 'PS0994-1819', 'Vanguard' and 'Tomcat' have been released with resistance to race 4. There are no recommended cherry, sweet frying, hot or banana type peppers resistant to race 4. Bell pepper growers should continue to use a combination of resistant varieties and chemical control while specialty pepper growers only have management and chemical control.

In 2013, growers again noticed BLS showing up on varieties which were resistant to races 0-5. Differential studies were established to determine if additional races were present in New Jersey. Plots were setup in the Southern and Northern parts of the state with a series of varieties with resistance to different races from no resistance to resistances to all known races. As in previous differential studies, it was determined that other races were prevalent in South Jersey, but not North Jersey. The only varieties that did not express any symptoms were those resistant to all races. Races 6 and 10 could not be distinguished from one another since they are closely related and if there is resistance to race 6 there is resistance to race 10. This screening trial has been repeated twice with similar results.

In 2016 we started screening varieties and advanced breeding line for resistance to all races of bacterial leaf spot. In 2017 the trial was carried out in a grower's field where BLS has been a problem for several years. 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 5 ft. between beds center to center. The plots were transplanted June 16. All cultural practices such as staking/tying, fertilization and pest management was carried out by the grower.

Based on seed company information, the entries '9325', 'Skyhawk', 'Tracer', 'Raven' and Prowler had resistance or intermediate resistance to all known races; 'Paladin' no resistance; 'Turnpike' resistant to 0-5 and 7-9; 'Revolution' resistant to 1-3 and 5. The plots were rated on a weekly basis for BLS by counting plants. The first BLS was observed on July 18 in the following entries (3 of 4 plots): 'Paladin', 'Turnpike', and 'Revolution'. By the end of the harvest season all entries except '9325' had BLS symptoms. All the symptoms were on leaves and none observed on the fruit during harvest.

Wesley Kline has been an agricultural agent for Rutgers Cooperative Extension in Cumberland County since 1996. He is responsible for the commercial vegetable and herb program with special interest in integrated pest management, nutrient management and food safety. Prior to joining Rutgers Cooperative Extension, Dr. Kline worked in Central America as a private consultant with the United States Agency for International Development, a private research foundation, and independent growers. Born and raised on a dairy farm in Clearfield County, Pennsylvania, he received his B.A. from Salem College, Salem, West Virginia and M.S. and Ph.D. from Cornell University. He and his wife Shirley live in Stow Creek, New Jersey.

The entries were harvested 5 times starting 54 days after transplanting from August 9 to September 29. 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.). Data is summarized in table 1 for all five harvests.

Table 1. Percent Marketable and Marketable Yield (28 lb. boxes) per Acre – 2017 - Vineland, NJ

Variety/Lines	X large	Large	Medium	% marketable	Total Marketable
Turnpike	997 a	556 cd	82 bc	98.6 a	1635 a
Prowler	615 c	761 ab	113 b	94.9 c	1488 ab
Skyhawk	637 bc	678 abc	119 ab	97.5 ab	1434 abc
Paladin	430 d	821 a	170 a	97.7 ab	1422 a-d
Revolution	804 b	490 d	47 c	96.5 bc	1341 bcd
Raven	610 cd	582 cd	94 bc	96.9 abc	1285 bcd
Tracer	562 cd	531 cd	81 bc	98.4 ab	1174 cd
9325	504 cd	603 bcd	57 c	98.3 ab	1163 d
LSD	**183.6**	**160.6**	**52.9**	**2.0**	**265.9**

Note: The same letters in the same column are not statistically different from one another.

'Turnpike' had statistically more boxes of extra large peppers and had the greatest number of total boxes per acre. However, for total boxes it was not statistically different from 'Paladin', 'Prowler', or 'Skyhawk'. As mentioned above '9325' showed no BLS symptoms by the end of the trial but had the lowest yield. It had statistically lower yields than 'Turnpike', 'Prowler' and 'Skyhawk'.

In 2018, a differential study was carried out in Northern New Jersey looking at eleven varieties. All the following varieties showed symptoms of BLS in at least two replications: 'Antebellum', 'Green Machine', 'Playmaker', 'Aristotle', '9325', 'Paladin', 'Tracer', 'Raven', 'Turnpike', 'Declaration' and '1819'. There were no fruit symptoms and most leaf symptoms were slight.

There are several varieties available that have resistance to BLS that could be evaluated by growers (see table 2). However, a grower can not rely on just a resistant variety but must have a complete management package including clean seed; disinfected stakes; not working in the field when wet and chemical applications. We have seen over the last ten years BLS strains involve thus a compete disease management program is needed to produce a quality pepper. If Phytophthora is a concern and last year's varieties showed symptoms of BLS select varieties with BLS resistance and Phytophthora tolerance.

Hot Water Seed Treatment

Seed hot water heat treatment is a good management tool for growers who save their own seed or purchase non treated seed. Most seed that is purchased is treated with chlorine which will control BLS if it is on the seed coat, but does not if the BLS is in the seed coat. Seed companies normally do not hot water treat pepper seed.

If a grower plans to treat their own seed care is needed or the germination could be affected. Two water baths are required with one for preheating (100°F for 10 minutes) and the second (125°F for 30 minutes) to the effective temperature to kill the bacteria. Immediately after removing the seed from the second bath it needs to be rinsed in cool water and dry dried. The seed can then be treated with a fungicide if desired. It is not recommended to treat pelleted seed since the pellet will dissolve. If primed seed is purchased do not heat it or the germination will be lowered. Any hot water treated seed should be planted that year. There are good factsheets available that will explain the procedure for treating seed. Do not treat seed on a stove, but infest in the right equipment!

Table 2. Commercially Available Varieties with Resistance or Tolerance to Bacterial Leaf Spot or Phytophthora

Seed Company	Variety	BLS Race Resistance	Phytophthora Resist/Tolerant
Harris Moran	Skyhawk	1-10	----
	Raven	1-10	----
	Tracer	1-10	----
	Prowler	1-10	----
	Declaration	1-3, 5	Tolerant
	Revolution	1-3, 5	Tolerant
Sakata	Samurai	1-10	----
	Ninja	1-10	----
	Mercer	1-3, 7, 8	Tolerant
Seminis	Autry	1-10	----
	Antebellum	1-10	
	Green Machine	1-10	----
	Playmaker	1-10	Tolerant
	Archimedes	1-3, 7, 8	Tolerant
	Aristotle	1-3	Tolerant
	Turnpike	1-5, 7, 9	Tolerant
	1819	1-5	Tolerant
	9325	1-10	
	3255	1-10	
Syngenta	Standout	1-10	----
	Paladin	----	R/T
	Intruder	1-3	Tolerant
	Tomcat	1-5, 7, 9	-----
United Genetics USA	Green Flash	1-10	----
	Galleon	1-10	----
	Mariner	1-10	----

2018 POTATO GERMPLASM EVALUATION TRIALS IN PENNSYLVANIA

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We evaluate and select new potato varieties that have adaptation to Pennsylvania potato growing regions and have qualities that are suitable for either processing or tablestock use. In 2018, we obtained and evaluated 217 potato varieties/breeding clones on agricultural research fields at the Russell E. Larson Agricultural Research Center at Rock Springs in Centre County, and on two potato growers' farms in Northampton County and Erie County, respectively. These varieties/clones include white-skinned, red/purple-skinned, and russet-skinned cultivars from different breeding programs including USDA, University of Maine, Cornell University, Colorado State University, University of Wisconsin, Idaho and Michigan State University, and private companies such as HZPC, Solanum International, Hanse seed, Real Potatoes and Charlie Higgins. The trials were harvested in October and we are assessing yield, tuber size and shape, internal and external defects, skin color, texture, specific gravity, overall appearance, and French fry, chip, and culinary qualities. High quality potato varieties and breeding clones for processing, fresh market, and specialty uses will be selected and introduced to Pennsylvania growers and industry.

Pennsylvania growers have expressed their interests in early season and creamy varieties. In 2018, we had an early season/creamy variety trial with about 30 varieties at the Russell E. Larson Agricultural Research Center at Rock Springs. The trial was harvested in October and we are in the process of tuber evaluation. Early season variety is a rapidly growing segment of specialty fresh market potato production.

Pennsylvania growers and industry have expressed their interests in growing russet potatoes in Pennsylvania. In 2018, we obtained about 70 russet potato varieties from all US and Canada potato breeding programs and evaluated them in three locations in Pennsylvania. All trials were harvested in October and we are in the process of evaluation. We expect to identify 2 to 3 russet potato varieties with good qualities for Pennsylvania growers.

A spacing trial with three new varieties planted at 8 inches, 10 inches and 12 inches were conducted at the Russell E. Larson Agricultural Research Center at Rock Springs in 2018. The trial was harvested in October and we are in the process of evaluation.

We had several disease trials to select disease resistant potato varieties and breeding clones in 2018. 370 varieties and advanced breeding lines were evaluated at Rock Springs for early blight resistance and resistant clones were identified. 565 varieties and advanced breeding lines were evaluated at Rock Springs for late blight resistance and resistant clones were identified. 275 varieties and advanced breeding lines were evaluated at Rock Springs for common scab resistance and resistant clones were identified. We had two other disease management trials in 2018. A potato late blight fungicide trial with 12 treatments was conducted at Rock Springs. A potato early blight fungicide trial with 18 treatments was conducted at Rock Springs.

We will present the results of our 2018 field trials and discuss promising potato varieties with high qualities for fresh market and for processing under Pennsylvania field conditions.

Xinshun Qu is an Associate Research Professor in the Department of Plant Pathology and Environmental Microbiology at The Pennsylvania State University. His research focuses on potato germplasm evaluation and potato disease management.

INSECT CONTROL UPDATE FOR POTATOES

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Wireworms are the soil-dwelling larval stage of click beetles. Planting potatoes into fields with high densities of these insects can result in tubers with entry holes and surface scars from wireworms burrowing into them and feeding. Such feeding injury can significantly impact marketability of the potato crop. Because of their occurrence in the soil and the unpredictability of damage from year to year, wireworms are one of the most difficult insect pests to control for potato growers. My lab has evaluated wireworm control tactics in the field for almost 20 years, and has helped to provide efficacy data for the registrations of some insecticides such as Regent, Capture LFR (bifenthrin), and Movento for wireworm control in potatoes. Much of this information on wireworm biology and management in potatoes can be found in the 2015 Virginia Coop. Ext. Fact Sheet: https://pubs.ext.vt.edu/2812/2812-1026/2812-1026.html

Still, the performance of insecticides at protecting potato tubers from wireworm damage can be quite variable. In 2018, we conducted an experiment to examine exactly how the current registered soil insecticides actually reduce damage to tubers, i.e., which ones appear to kill the wireworms versus possibly repel them? This is important because an insecticide that repels wireworms from the treated seed piece may not provide effective protection for the daughter tubers developing later. We tested some of the most popular wireworm insecticides currently used: Capture LFR (bifenthrin), Regent (fipronil), Platinum (thiamethoxam), and Mocap EC (ethoprop) applied at high label rates. We also tested a mixture of Platinum + Regent and a couple of new products Ethos XB (bifenthrin) and Majestene (a biological organically-approved insecticide).

On 7 May and 4 Jun, planter boxes (35.75" x 6.6") were filled with a mix of soil and sand. One potato seedpiece was placed on one side of the box. A furrow was created in the center of each box and insecticides were applied over an 8" band using a one nozzle boom powered by a CO2 sprayer set at 30psi. Opposite from the seedpiece area, 3 wireworms were introduced into each planter box.
On 24 May and 15 Jun, the seed piece was removed and examined for damage. The portion of soil on each side (seedpiece area / wireworm area) were searched for the presence of wireworms to determine whether they crossed the insecticide barrier in search for the seedpiece.
A tuber was put back in place of the seedpiece and additional evaluations of tuber damage and wireworm location and mortality were conducted 10 to 15 days later.

Table 1. Summary of container bioassay of the effects of soil-applied Insecticides on wireworms with potato tubers, 2018.

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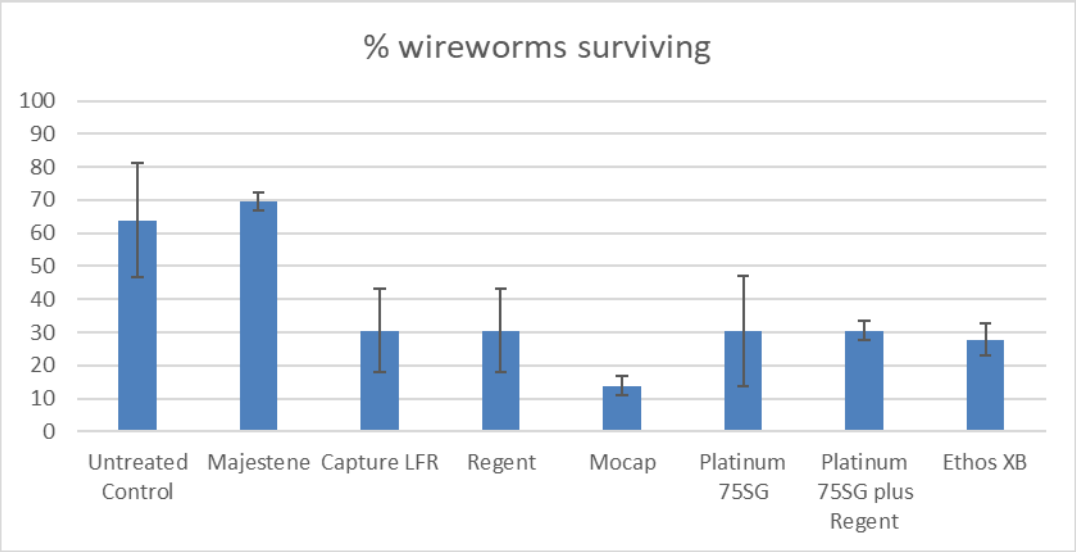
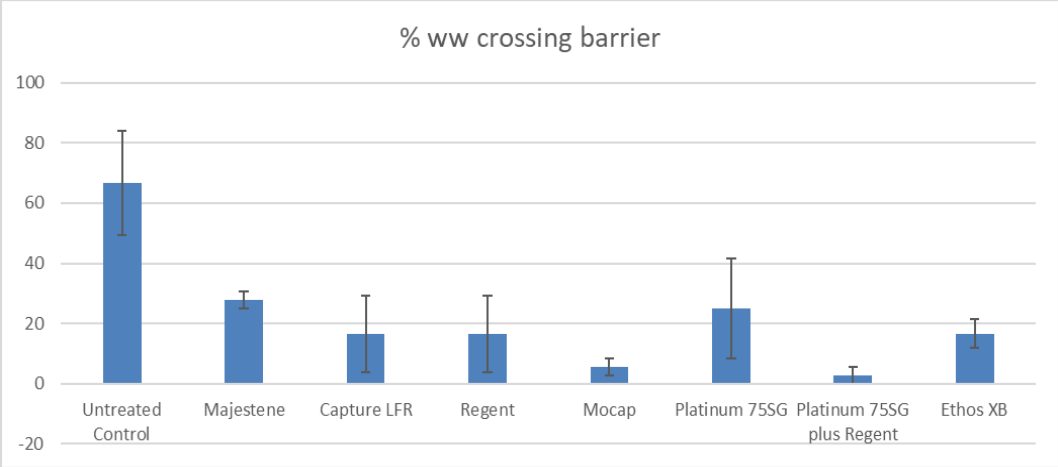
Treatment	Rate per acre	% wireworms crossing the insecticidal barrier	% surviving wireworm	% tuber damage
Untreated Control		67	64	100
Majestene	2 gallons	28	69	75
Capture LFR	25.5 fl. oz	17	31	0
Regent	3.2 fl. oz	17	31	50
Mocap	1 gallon	6	14	0
Platinum 75SG	2.67 oz	25	31	50
Platinum 75SG plus Regent	2.67 oz + 3.2 fl. oz	3	31	0
Ethos XB	16 fl. oz	17	28	25





Also in 2018, we conducted a field efficacy trial to evaluate the same insecticide treatments discussed previously plus a new diamide insecticide (Harvanta) on potatoes. The experiment was conducted at the Virginia Tech ESAREC, Painter, VA on Bojac Sandy Loam soil. Potatoes (variety 'Superior') were planted 6 April 2018. The experiment had 9 treatments arranged in a RCB design with 6 replicates. Individual plots were 2 rows x 20 ft with unplanted guard

rows. All insecticides were applied in-furrow at planting at 20 gpa using a single nozzle boom equipped with an 8003VS spray tips powered by a CO2 backpack sprayer at 20 psi.

On 5 Jul, all plots were harvested and tubers were weighed. 100 tubers were selected from each plot and the number of wireworm and white grub damaged tubers was recorded. All data were analyzed using analysis of variance procedures. Means were separated using Fisher's LSD at the 0.05 level of significance.

Results

Total yield data was significant with Harvanta 50SL, Platinum 75SG, and Platinum 75SG + Regent having significantly higher yields than the untreated control (Table 2).

Soil insect pest pressure was moderate with an average of 20% damaged tubers in the untreated control (Table 2).

All treatments had significantly lower % wireworm damage, grub damage and total % damage than the untreated control (Table 2).

No signs of phytotoxicity were observed.

Table 2. Summary of efficacy of Soil-applied Insecticides for the Control of Soil Insects in Potatoes; ESAREC, Painter, VA 2018

Treatment	Rate / acre	Total Yield (in cwt)	% wireworm damage	% grub damage	% total damaged tubers
1. Untreated control		200.8 cd	6.3 a	13.7 a	20.0 a
2. Majestene	2 gallons	210.7 cd	2.7 b	2.7 bc	5.3 b
3. Capture LFR	25.5 fl. oz	209.8 cd	1.8 bc	2.5 bc	4.3 b
4. Regent	3.2 fl. oz	239.9 abc	0.8 bc	2.0 bc	2.8 bc
5. Mocap EC	1 gallon	161.7 d	0.5 c	2.2 bc	2.7 bc
6. Harvanta 50SL	27.5 fl. oz	237.1 ab	1.0 bc	2.0 bc	3.0 bc
7. Platinum 75SG	2.67 oz	281.7 ab	1.2 bc	1.7 bc	2.8 bc
8. Platinum 75SG + Regent	2.67 oz + 3.2 fl. oz	298.7 a	0.2 c	0.7 c	0.8 c
9. Ethos XB	16 fl. oz	216.1 cd	2.0 bc	3.7 b	5.7 b
P-value from Anova		0.0011	<0.0001	<0.0001	<0.0001

POTATO DEMAND – LATEST TRENDS IN THE INDUSTRY

Lela Reichart, VP of Strategic Business Development, Sterman Masser Inc

An opportunity to learn about what is trending in the potato industry, as growers and business operators consider many elements of their business strategy. This is an opportunity to learn valuable insights, recent data from retail and industry data analysis. Did you know? Potatoes have the second highest household penetration of all vegetables – only 1% behind lettuce (which includes bagged lettuce). With the ever expanding food options both in the produce section and in other side dishes, this is real testament to the love consumers have for potatoes.

A few key highlights include an examination of potato acreage is showing signs of a steady increase which correlates to the increasing demand across various segments. Increased demand can be attributed to an increase of menu penetration of potatoes by 2% over the past 5 years. Additionally, potatoes are on 70.5% of entrees. Potatoes have also made huge gains in Appetizer up 17% in the past 10 years and are now part of almost half (47%) of all appetizers served. According to Foodservice operators the top two reasons to menu potatoes are consumer demand and their versatility.

One important market fundamental is that consumers are now spending more of their food dollars in bars/restaurants than in the supermarket. This is also true for potatoes as more of your crop goes to Food service than retail. This in no way means retail has declined in importance. In fact, its importance is growing as new packaging and innovative presentation of convenience items continues to grow.

Innovation continues to be at the forefront for driving increased demand as consumers find potatoes more convenient to prepare for meal time. 2017 has seen the largest number of total potato introductions at 2,240. The increase is being driven by ready-made meals and snacks both nationally and globally.

Global markets continue to be positive for potato exports. The trajectory of U.S. potato exports over the past 20 years has been positive. With world demand for potatoes up 23% in the past five year. Some of this growth is from price increases, but the volume of potatoes leaving the U.S. has grown substantially. In fact exports now account for roughly 20% of all potatoes grown in the U.S. The top three markets for US potatoes are Japan, Canada and Mexico, making trade policy and the farm bill important to the continue positive trend.

In summary, several leading factors will continue to impact demand. These include: growth of sales of different potato types and sizes and Increase in specific variety packaging along with the shift to smaller pack sizes; growth in convenience items at retail & foodservice: fresh, fresh cut, frozen and dehydration; along with continued reduction in waste and shrink throughout the system from field to shed to processing to stores to restaurants to consumers and positive trade policy and global demand. *(Potatoes USA)*

Lela Reichart currently serves at the Vice President of Strategic Development at Sterman Masser, Inc. in Sacramento, Pennsylvania. She joined the company in 2016 following a career at the Pennsylvania Department of Agriculture, as the Director of Marketing and Economic Development.

She is passionate about agriculture; with more than 25 years of experience in the industry. She not only advocates for agriculture; she also gets to live it every day as the principal owner of a 176 acre farm in Adams County where she and her husband Brian and their two children, Ryderlee and Artem have an orchard; and row crops.

She is active in her community, serving on the Hamilton Township Planning Commission Board, Delone Catholic School Board and is a member of the Friends of Farm Show board. She is committed to supporting the future of Pennsylvania agriculture for future generations to come.

Her hobbies include gardening, reading and traveling with her family and friends.

POTATO DISEASE UPDATE

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Current information about disease occurrence and disease management practices is important for improving a crop production program.

Dickeya and Pectobacterium causing blackleg in the Northeast in 2018

Blackleg has been the disease of greatest concern in recent years since a new pathogen, *Dickeya dianthicola,* was found associated with occurrences of blackleg and soft rot that were more devastating than those caused prior by *Pectobacterium* (previously known as *Erwinia*). Subsequently, new species of *Pectobacterium*, notably *P. parmentieri* (pka *P. wasabiae*), were found associated with severe occurrences. These bacteria are more tolerant of cold than *D. dianthicola*. *P. parmentieri* has been associated with major losses in storage.

Monitoring occurrence of these bacteria in diseased potato samples is a goal of a new national project. 2018 is the first year *D. dianthicola* has not been detected in NY since first confirmed there. *Pectobacterium parmentieri* and *P. carotovorum* were detected. Affected varieties were Envol, Andover, Montreal and Waneta. *D. dianthicola* was detected in PA (5 of 17 samples with blackleg symptoms) in varieties Red Norland, Kennebec, and Norwis. There were several confirmed occurrences of *D. dianthicola* in Norwis in NJ and 1 case in RI. *Pectobacterium* was confirmed in Dark Red Norland and Atlantic in NJ. Please assist the monitoring effort by promptly reporting observations of blackleg symptoms to your extension specialist so that samples can be submitted for testing.

The main management practice for *D. dianthicola* is planting pathogen-free seed. More information is at http://vegetablemdonline.ppath.cornell.edu/NewsArticles/Potato-Dickeya.html.

Late blight in the Northeast in 2018

While there were few occurrences of late blight last season in the U.S., despite conditions being favorable (frequent rain) in several areas, there were noteworthy occurrences. A new genotype (US-25) was detected in upstate NY. It is especially noteworthy because US-25 is mating type A2 whereas US-23, the dominant strain in the Northeast for the past 6 years, is mating type A1. This is important because if these two genotypes occur together, the pathogen could produce a specialized spore (oospore) that enables the pathogen to survive in soil without living plant tissue and oospores form as a result of sexual reproduction, thus they are an important way to increase genetic diversity. Infested tubers is how the pathogen normally survives. Also US-25 is insensitive to mefenoxam, whereas US-23 is sensitive and so can be managed effectively with Ridomil fungicides. US-25 was found on tomato but determined to also be able to infect potato.

Late blight caused by genotype US-23 was found 7 Oct on Long Island. This first occurrence in an area is noteworthy for its extreme lateness, especially considering it was an atypically wet season there which should have provided favorable conditions for late blight to develop much earlier. The source of inoculum for this outbreak and the one in 2017, which started in late Aug to early Sep, was not determined. Since 2009 first observations on Long Island

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have typically been in June. No late blight was found in 2015 or 2016. Unexpected occurrences serve as a reminder to remain vigilant about late blight through the end of the season even when there are no reported occurrences anywhere nearby.

Information about late blight is available at http://www.usablight.org/ and http://blogs.cornell.edu/livegpath/extension/tomato-late-blight/.

Phytophthora nicotianae, the "late blight mimic"

It is important to be aware that there is a pathogen related to *P. infestans* that causes very similar leaf spots because this pathogen is not as aggressive at least partly reflecting the fact it does not produce many spores. This is another reason to promptly have suspect late blight symptoms checked. See photos at http://blogs.cornell.edu/livegpath/gallery/potatoes/. Since these pathogens are related, same fungicides are expected to be effective. *P. nicotianae* has a much larger host range that includes over 300 plant species. The tuber rot it causes is soft, spongy, with watery texture of infected tissue similar to pink tuber rot commonly caused by P. erythroseptica, but lacking the typical pink color which develops and intensifies after exposure of the cut, infected tuber surface to air that is diagnostic of P. erythroseptica infection. Russet cultivars are less susceptible to P. nicotianae than red and white cultivars.

Early blight and brown leaf spot

There are two species of *Alternaria* that infect potato foliage. *A. solani* causes early blight. Symptoms of brown leaf spot caused by *A. alternata* are much smaller spots which can be overlooked and confused for ozone injury or early blight when spots coalesce. See https://www.canr.msu.edu/news/brown_leaf_spot_in_potatoes_plan_for_this_early_blight_look_alike_in_2013. Compared to *A. solani, A. alternata* has a larger host range and smaller spores enabling it to more easily be moved to another potato crop.

Managing early blight is challenged by the fact the pathogen has proven more adept at developing resistance than was expected. *A. solani* has developed resistance to three chemical classes of fungicides in the U.S. Resistance to QoI (FRAC 11) fungicides was detected in 2001, after 2.5 growing seasons of commercial use. The resistance mutation (F129L) that developed in *A. solani* is different from the one found in most QoI resistant pathogens (G143A), which conveys total loss of disease control. QoI fungicides exhibit reduced control against QoI-resistant *A. solani* that is similar to protectant fungicides. Resistance to boscalid, the first SDHI (FRAC 7) fungicide, was detected in 2009, the fifth year of use. The five resistance mutations conveying resistance to boscalid that have been characterized in *A. solani* impact efficacy of other SDHI fungicides partially to completely, except those containing fluopyram (Luna brand). Resistance to the AP (FRAC 9) fungicide pyrimethanil, an active ingredient in Scala and Luna Tranquilty, was detected in ID in 2010, which was five years after first registration. Isolates resistant to multiple fungicides did not exhibit significant fitness penalties compared to sensitive isolates in laboratory studies, therefore they are expected to be able to compete and persist in the pathogen population when these fungicides are not used. Isolates with one of the SDHI resistance mutations were more aggressive than sensitive isolates. A recent survey revealed that multi-fungicide resistant isolates are common: over 95% of isolates examined from several states (but none in the Northeast) and years had mutations conferring SDHI resistance and most also had mutations for QoI resistance. Loss in sensitivity to DMI (FRAC 3) fungicides was documented in 2010-2012, but *A. solani* isolates examined more recently (2013-2015) were fully sensitive. Resistance to MBC (FRAC 1), QoI, and SDHI fungicides have been detected in *A. alternata.*

Challenges and impacts of a wet growing season

Rain during the growing season creates conditions favorable for disease development while rain late in the season also affects harvest timing and storage. Wet soil conditions are favorable for several bacterial and oomycete pathogens that infect tubers: *Dickeya* and *Pectobacterium* (soft rot), *Phytophthora erythroseptica* (pink rot), *Pythium* (Pythium leak), *Phytophthora infestans* (late blight), and *Phytophthora nicotianae* (see above). Infected tubers may be asymptomatic at harvest with symptom development and pathogen spread occurring in storage (except for *Dickeya*). When soil is saturated with water for prolonged periods, lenticels, which are the breathing pores of a tuber, can enlarge in an effort to acquire oxygen, and they can provide an entry point for soft rotting bacteria. Delayed harvest

because of wet soil provides time for further disease development, including by other pathogens.

Managing tuber rots starts with selecting fields with good drainage. Implement practices to improve drainage like subsoiling, and avoid over-irrigating late in season to manage field moisture. Harvest at least 10 days after vines are killed and when there is the right amount of soil moisture for cushioning and temperature is 50-65 F. Soil should be free of clods. Ensure good skin set and tuber maturity at harvest. Good skin set occurs when pulp temperature is below 60 F. Clean and sanitize harvesting equipment. Limit damage during harvest. Harvest infected or wet areas last. Having cooling air is important when harvesting on warm days. Apply post-harvest fungicides such that complete coverage is obtained; phosphorous acid fungicides are effective against oomycete pathogens. Stadium fungicide is effective for silver scurf and Fusarium dry rot. Never wash tubers before placing in storage. Dry wet tubers; using forced hot air is recommended to reduce lenticel spot. In storage use ventilation to remove CO_2 and provide oxygen, which is needed for healing wounds. Warm tubers under ventilation to promote wound healing and suberization. Proper suberization will close lenticels quickly, protecting the tuber from pathogen entry. Then gradually cool down tubers to limit condensation. High humidity (90-99%) will facilitate curing and minimize weight loss. But fans should be run without humidity initially when cool to cold (40-60 F) and wet at harvest. Cure at 50-55 F and 90-95% relative humidity for 2-3 weeks. Cool down to this temperature at 2-3 F per week for table stock and 1-2 F for processing potatoes. When pink rot, Pythium leak or soft rot is present, cure at 45-50 F until tubers are dry.

Some new fungicides

Potato seed and at-planting treatments:

CruiserMaxx Vibrance Potato. fludioxonil (FRAC 12) + difenoconazole (FRAC 3) + sedaxane (FRAC 7). 12 hr REI. Seed treatment for Fusarium dry rot, Rhizoctonia, + silver scurf.

Elatus. benzovindiflupyr (7) + azoxystrobin (FRAC 11). 12 hr REI. Especially effective for Rhizoctonia canker, also labeled for black dot and silver scurf. Apply in-furrow at planting.

Velum Prime. fluopyram (FRAC 7). 12 hr REI. Especially effective for nematodes, also labeled for early blight and white mold. Apply in-furrow during planting.

Luna Tranquility. fluopyram (FRAC 7) + pyrimethanil (FRAC 9). 12 hr REI. 7 d PHI. Labeled diseases include early blight, brown spot, black dot, and white mold.

Miravis Prime. pydiflumetofen (FRAC 7) + fludioxonil (FRAC 12). 12 hr REI. 14 d PHI. Labeled diseases include early blight and white mold. Accumulates in the wax layer of leaves and then translocates through them. Apply up to 3 times with no more than 2 sequential uses before rotating to a fungicide in a different FRAC group such as or Omega Top MP when white mold or late blight also a concern.

Omega Top MP. difenoconazole (FRAC 3) and fluazinam (FRAC 29). 14 d PHI. These ingredients are active for early blight plus brown spot plus black dot and late blight plus white mold, respectively. This fungicide is a good choice when there is a need to manage diseases in both groups; there are products with just a DMI fungicide (Quash) or fluazinam (Omega). Omega Top MP is marketed as a multipack case. Section 2(ee) label has tank-mix directions.

Orondis fungicides (Opti, Ultra, and Gold). oxathiapiprolin (FRAC 49) plus chlorothalonil, mandipropamid, or mefenoxam, respectively for the three formulations. 4 hr REI. 14 d PHI. Good for late blight (Orondis Opti, Ultra) and pink rot and Pythium leak (Orondis Gold). Protects existing and developing leaves due to systemic, translaminar movement and redistribution. Rainfast within 30 minutes after spray deposits have dried.

Fungicides expected to be registered for use on potatoes in the near future include Aproach for managing early blight and white mold.

Please Note: The specific directions on fungicide labels must be adhered to -- they supersede these recommendations, if there is a conflict. Check labels for use restrictions. Any reference to commercial products, trade or brand names is for information only; no endorsement is intended.

STEM END DISCOLORATION IN CHIP POTATOES: ITS CAUSE AND POSSIBLE SOLUTIONS

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A common tuber quality defect in chipping potatoes is stem-end chip defect (SECD), a localized, post-fry accumulation of dark color near the vasculature at the basal (stem end) of the tuber. This defect has not had its economic value quantified but has been reported to affect between 5 to 25% of the crop annually. The causes of this defect are both genetic and environmental. Growing regions on the eastern half of the country, such as Michigan, New York, and the Mid-Atlantic tend to have more severe defect levels than other parts of the country but incidence is sporadic.

Researchers tend to group SECD and sugar end defect in fry processing potato varieties together because both contain a localized dark pattern that occurs at the stem end of the fried tuber and they share many of the same physiological processes. Sugar end defects are also referred to as jelly ends, dark ends, translucent ends, and glassy ends. Sugar end defect develops in response to moderate heat and drought stress during early and middle bulking stage. There are instances where the incidence of sugar end in russet class potatoes is expressed differentially across abiotic stress treatments and growing environments.

Environmental causes of SECD include early to mid-season heat stress but the expression of this defect is not consistent. Trait severity correlates with the number of nights where the nighttime low temperature is greater than 70° F. Even short periods of heat stress can result in SECD trait expression. Irrigation and soil moisture management are effective strategies to minimize trait expression. Avoid dry soil during periods containing hot days and warm nights. SECD expression is also associated with infection by *Verticillium* species. Proper length of rotations or chemical controls could aid in reducing SECD. Other factors that influence SECD severity are potassium and calcium nutrition and making sure levels are adequate. The interaction of all of the aforementioned factors result in grower experiences shifting greatly even within the same variety and growing practices.

There is a genetic component to sugar end defect and SECD expression. Large differences have been observed among russet cultivars in their susceptibility to sugar end defects. Tightly controlled studies have measured a high degree of inheritance for sugar end in russets and SECD in chipping varieties. This was observed in a controlled environment greenhouse study held at University of Wisconsin-Madison in which dozens of commercial varieties were treated with conditions to induce the defect. There are several chipping varieties that are resistant to SECD development. This level of variety effect has been observed in other genetic studies and field observations. Choosing to grow the right variety can reduce this defect.

The genetic control of this defect is associated with enzymatic changes. Vacuolar acid invertase has a sizable increase in activity in sugar end defect tissue. Increased severity of SECD is also accompanied by increased amounts of *Vinv* activity. It has been postulated that an environmental stress event results in either a disruption of carbohydrate production from the vines, translocation of carbohydrates from the basal end of the tuber to the apical, a shift in sink strength that favors the vines, or starch degradation in the basal end as a result of the disruption of carbohydrate flow. The latter theory is additionally supported by a shift of enzymes in the basal tissue away from starch accumulation toward glycolysis and starch mobilization. Interestingly, Innate Potato varieties have a lower incidence of SECD scores in environments that normally cause severe defects.

Curtis Frederick is the Senior Agronomist for Sterman Masser's Inc. since March of 2017. His role involves variety development, research, and education in order to aid the creation of safe, high quality, potato products. He earned his B.Sc. At Penn State (Horticulture '09) and then worked in South Africa as a research project manager and agronomist for the Dr. Jonathan Lynch Root Lab. While there, he not only worked on the root systems of maize and dry beans, but also became engaged to his wife, Rebecca. Curtis later earned his PhD in 2017 in the Plant Breeding and Genetics Program at the University of Wisconsin-Madison under the advising of Dr. Paul Bethke. His research focused on storage quality traits of processing potatoes. A native of Sugarloaf, PA, Curtis and his wife now live in his hometown. They are both taking an active role in his family farm, Haz-Wald Farms, and Curtis is excited to perform research relevant to Pennsylvania's potato industry.

Storage management has an effect on the level of SECD observed. Harvest time ratings of SECD can change after a period of time in storage. In fact, SECD is not always present at harvest and glucose, fructose, and sucrose assays taken at that time do not reliably predict the severity of the defect. Reconditioning, or warming of the bulk pile temperature, can reduce severity of the SECD rating. This occurs because the reducing sugar content decreases as a result of respiration or starch synthesis, and the defect becomes less severe with time. This response is commonly observed in the cultivar Snowden but there is evidence that this does not occur in all years or locations. Additionally, there are strong varietal differences in SECD development in storage and their ability to recondition.

WILD AND MANAGED POLLINATORS DOING THE JOB IN CUCURBITS

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Among the objectives in the Integrated Crop Pollination (ICP) Project (www.icpbees.org) were measures of the species composition and visitation rate of bees. Resources for growers are at http://icpbees.org/tools-for-growers/ and http://icpbees.org/wp-content/uploads/2014/05/Integrated-Crop-Pollination-for-Cucurbita-crops.pdf (Ullmann et al. 2017). Portions of earlier write-ups of this work and from the web resources are also reproduced here.

Cucurbits crops include 4 genera: (i) squash/pumpkin, (ii) cantaloupe/muskmelon, (iii) cucumber, and (iv) watermelon. Most require movement of large, sticky pollen grains to set quality fruit. In cucumber, a few cultivars set fruit without pollination. Bees pollinate cucurbits, but the species that do the job varies among crops, landscapes, and geographic region. In addition to honey bees, multiple wild species contribute important pollination services [28 in cucumber in Indiana (Smith 2013); wild bees provided full pollination in ~90% of small, diversified farms in NJ and eastern PA (Winfree et al 207a, b)]. The presence of both honey bees and wild bees ensure resiliency in pollination services.

In Pennsylvania, during studies conducted for 3 years, we recorded an amazing total of total of 37 bee species, from 4 families and 15 genera, visiting pumpkin flowers in Pennsylvania. The overwhelming majority of the pollination services came from two wild species - the squash bee (*Peponapis pruinosa*) and one species of bumble bee, the common eastern bumble bee (*Bombus impatiens*) – and the honey bee. This has also been seen in NY (Artz and Nault 2011, Artz et al 2011, Petersen et al 2013), MA (Alder and Hazzard 2009), and VA (Shuler et al 2005, Julier and Roulston 2009). Using the visitation rates we measured, and estimates of the pollen deposited per visit, pollen required, and flower lifetime, we could estimate whether each of these bee species were 'doing the job' of providing pollination services. Honey bees, bumble bees, and squash bees independently provided ~9.3x, ~12.75x, and ~1.7x the number of required visits in these studies (Table 1).

Table 1. Visitation rate thresholds: bee visits to a female flower to achieve optimal yield assuming (i) a 4-hour flower lifetime receptive for pollination, (ii) the pollen requirement, and (iii) the pollen deposition rate for that bee. Visitation Rate Observed is the average bee visits to a female flower we measured in Pennsylvania pumpkin fields. Total Visits Estimated is the visits per female flower we measured in Pennsylvania pumpkin fields, assuming a steady visitation rate across the 4-hour flower lifetime. On average, observed visitation rates exceeded thresholds for the three most active pollinating taxa. Honey bees, bumble bees, and squash bees independently provided ~9.3x, ~12.75x, and ~1.7x the number of required visits, respectfully.

The squash bee is a specialist - it requires pollen from squash/pumpkin to rear its larvae. It is a solitary bee, which nest and overwinters in the soil. It emerges in late June or early July. Having squash flowers present may help ensure colonization. Although you may find adults occasionally taking nectar from other plant species, most of plant species in which you find squash bees is in squash/pumpkin flowers. Ensuring these crops are in the landscape is important to building populations over time. Landscapes with no-till had higher populations of squash bees, grassy areas, and exposed soil, could serve as nesting sites, and sufficient soil moisture may help with nesting.

The common Eastern bumble bee is a generalist. Diverse and continuous floral resources are important. Overwintered queens are establishing nests in late March, April, and May. Queens are finding and building nests, laying eggs, keeping the brood warm with body heat, provisioning brood with pollen sometimes mixed with nectar, and rearing

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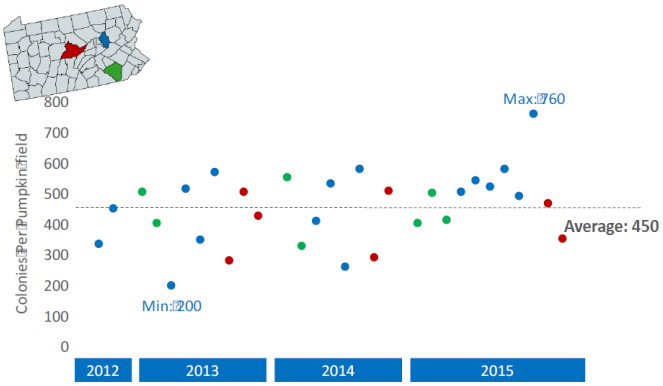
the first generation of brood. She needs plentiful, diverse, and high quality floral resources throughout the season, and in proximity to her nest especially during that time of colony establishment. Carley McGrady optimized a genetic method that allowed us to estimate the number of common eastern bumble bee colonies that send foragers into commercial pumpkin, by counting 'sisterhoods'. We measured approximately 450 colonies sending foragers into commercial fields. Additional genetic analyses showed lots of genetic variation and mixing for this species, which are good signs for a resilient population.

Pollinator Taxa	Citation	*Cucurbita* type	Visitation Rate Threshold	Visitation Rate Observed	Total Visits Estimated
Honey bee	Nicodemo et al, 2009	C. maxima 'Exposição'	1 every 15 mins	1 every 1m 36s	~150
Bumble bee	Artz & Nault, 2011	C. pepo 'Mystic'	1 every 30 mins	1 every 2m 21s	~102
Squash bee	Artz & Nault, 2011	C. pepo 'Mystic'	1 every 15 mins	1 every 8m 52s	~27

Conservation with IPM. Our bumble bee and squash bee numbers in Pennsylvania and neighboring states, represent an amazing and valuable abundance of wild bees that are strongly contributing to the valuable ecosystem service of pollination. Landscapes that provide abundant floral resources in proximity to good nesting sites are essential to conserving these bees. Balancing crop protection needs with efforts to sustain pollinators is difficult. Limiting neonicotinoids to seed-treatments minimizes the residues that show up in nectar and pollen. Squash/pumpkin flowers close by mid-day, so limiting all foliar sprays to after the flowers have closed, is certainly helpful. For the other crops, spraying as late in the day, or at night, minimizes the residue on the flowers that the bees could contact the next day. Only spraying when scouting indicates the need helps, using selective aphicides and miticides can reduce the risk to bees. Some fungicides enhance the toxicity of some insecticides to bees.



Each point represents the number of bumble bee colonies visiting a pumpkin field. The number of colonies is along the y-axis. Our results show a minimum of 200 colonies visiting a single field and a maximum of 760. The overall average was 450 colonies per field, represented by the horizontal dotted line. The points are arranged along the x-axis by year, starting with 2012 and ending with 2015. Blue dots indicate fields from Columbia County, green dots indicate Lancaster County and red dots indicate Centre County.

Alder, L. S., and R. V. Hazzard. 2009. Comparison of Perimeter Trap Crop Varieties: Effects on Herbivory,Pollination, and Yield in Butternut Squash. Environ. Entomol. 38(1): 207- 215

Artz, D. R., C. L. Hsu & B. A. Nault. 2011. Influence of Honey Bee, Apis mellifera, Hives and Field Size on Foraging Activity of Native Bee Species in Pumpkin Fields. Environ. Entomol. 40: 1144-1158

Artz,D. R., & B. A. Nault. 2011. Performance of Apis mellifera, Bombus impatiens, and Peponapis pruinosa (Hymenoptera: Apidae) as Pollinators of Pumpkin. J. Econ. Entomol. 104(4): 1153-1161

Julier HE, Roulston TH. 2009. Wild bee abundance and pollination service in cultivated pumpkins: farm management, nesting behavior and landscape effects. J. Econ. Entomol. 102: 563-573.

Petersen JD, Reiners S, Nault BA. 2013. Pollination Services Provided by Bees in Pumpkin Fields Supplemented with Either Apis mellifera or Bombus impatiens or Not Supplemented. PLoS ONE 8(7): e69819. doi:10.1371/journal.pone.0069819

Shuler RE, Roulston TH, Farris GE. 2005. Farming practices influence wild pollinator populations on squash and pumpkin. J. Econ. Entomol. 98: 790-795.

Smith, Bentley, Reynolds. 2013. Wild bees visiting cucumber on midwestern U.S. organic farms benefit from near-farm semi-natural areas. JEE. 106: 97-106.

Ullmann, K., Cane, J., Fleischer S., Treanore, E., McGrady, C. 2017. Integrated crop pollination for squashes, pumpkins, and gourds. Project Integrated Crop Pollination. ProjectICP.org http://ento.psu.edu/publications/integrated-crop-pollination-for-squashes-pumpkins-and-gourds

Winfree, R., N. M. Williams, J. Dushoff, and C. Kremen. Kremen. 2007a. Native bees provide insurance against ongoing honey bee losses. Ecology Letters 10: 1105–1113ell Publishing Ltd

Winfree, Rachael, Neal M. Williams, Hannah Gaines, John S. Ascher, and Claire Kremen. 2007b. Wild bee pollinators provide the majority of crop visitation across land-use gradients in New Jersey and Pennsylvania, USA Journal of Applied Ecology

WILD AND MANAGED POLLINATORS DOING THE JOB IN STRAWBERRIES

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Strawberries are a high-value specialty crop that are produced for a number of different markets in the northeastern US including processing, fresh-market and u-pick. The success of a strawberry crop is, in many ways, dependent on both the beneficial and pest insects that they interact with in a given agroecosystem. Strawberry is a labor- and capital-intensive crop, so maximizing production through integrated pest and pollinator management strategies is essential.

Strawberry flowers have both anthers which produce pollen grains and stigmas which receive pollen grains to produce seeds (Figure 1). A single strawberry flower can have over 300 stigmas. **Each stigma must receive a grain of pollen in order to produce a well-formed fruit.** Primary flowers, which bloom earlier in the season, have the highest number of stigmas with decreasing numbers on secondary, tertiary and quaternary flowers (Figure 2). As a result, the primary flower produces the largest fruits and fruit size decreases from later order flowers.

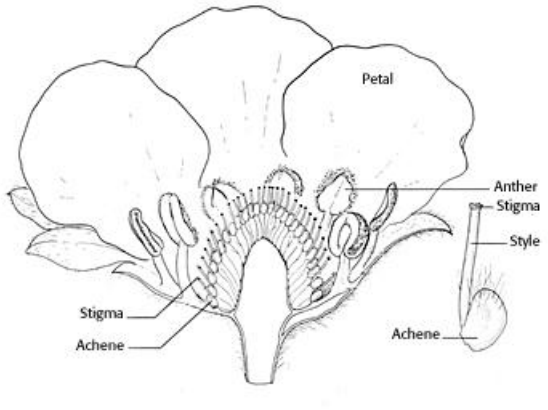


Figure 1. A strawberry flower showing male and female parts

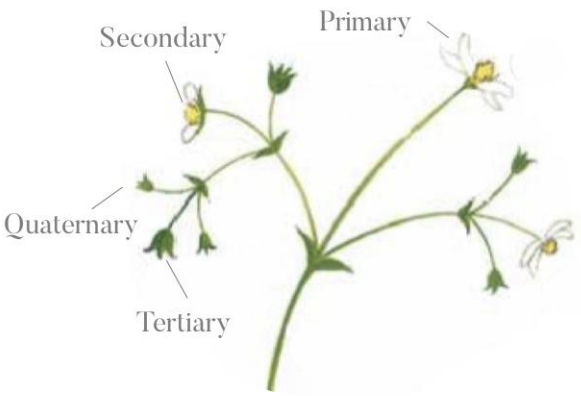


Figure 2. A strawberry inflorescence showing the flower orders.

Strawberry varieties are produced by taking clones from a mother plant. It is common to plant several varieties in order to prolong the fruit harvest window and to hedge against pests and diseases. The majority of strawberry varieties are self-fertile, meaning their own pollen can be used to produce well-formed fruit. This trait is beneficial because growers can plant whole fields of a single variety and still get high yields of well-formed fruit that results from autopollination. These results suggest that not all strawberry varieties are equally dependent on pollination. For example, varieties such as Camarosa and Camino Real (commonly grown in North Carolina) can produce high yields of well-formed fruit in the absence of pollinations.

Dr. Heather Grab is currently a USDA National Institute of Food and Agriculture Postdoctoral Fellow working with Dr. Katja Poveda in the Department of Entomology at Cornell University in Ithaca, NY. She completed her PhD with Dr. Greg Loeb at the New York State Agricultural Experiment Station where she researched strategies to promote both pollination and the biological control of pests in New York State strawberry production systems. Heather is a native of Pennsylvania and grew up right here in Hershey, PA. Along with her husband, she manages a small farm in the Finger Lakes where they raise pastured pork and poultry. Learn more about Dr. Grab's work at landscape-agroecology.com

Strawberry is sometimes thought to be a crop that does not require insect pollination in order to set fully formed fruit. However, recent studies in New York as well as in Europe, Canada, and elsewhere have consistently found that **insect pollination can reduce malformations and improve berry size by 40% or more.** The benefits of insect pollination extend well beyond fruit size alone. Insect pollination has been found to increase sweet flavor, extend shelf life of fruit, and even reduce the prevalence of grey mold (*Botrytis cinerea*). Some strawberry varieties are more dependent on pollination than others, but a larger survey of varieties is needed before we can say definitively which varieties are the most and least pollinator dependent.

Figure 3. A small wild bee collecting pollen from a strawberry flower

Figure 4. A hover fly feeding on strawberry pollen and nectar

Strawberry flowers are visited by a diverse community of insects. The most common groups visiting strawberry vary by region. In New York, the community is dominated by wild bees (Figure 3) while the community is comprised mostly of flies in North Carolina (Figure 4). Flies feed on both the nectar and pollen of strawberry flowers. Bees, on the other hand, actively collect large quantities of pollen from strawberry flowers which they use to feed their offspring. In the process, the bodies of both flies and bees become covered in pollen grains which they either spread (1) from the anthers to the stigma of the same flower (common behavior in flies) or (2) from flower to flower in the strawberry field (common behavior in bees).

With so many flower visitors, you might be wondering who is the best pollinator? Surprisingly, the answer is that many groups are about equal on a per visit basis, but they complement each other. This way the best pollination is achieved when many species are working flowers together. Notice that the smaller pollinators in Figures 3 & 4 are mostly contacting the stigmas around the base of the flower. Alternatively, larger pollinators like bumble bees (Figure 5) land right on the top of the flower and tend to deposit pollen on the stigmas that will form the tip of the strawberry fruit. **When strawberry flowers receive visits from multiple pollinator groups, they are more likely to set a large, well-shaped fruit (Figure 6 middle).**

Figure 1. Bumble bees often land on the top of strawberry flowers

How do you know if you are getting enough pollination in your strawberries? To assess the level of pollination in your strawberry crop, you will need to take a close look at several of your fruits, ideally multiple fruits from each of the varieties that you grow.

Figure 6. Strawberry fruit showing examples of poor pollination (left), good pollination (middle) and damage by pest feeding (right).

A well-pollinated strawberry fruit will be large and symmetrical with large evenly spaced seeds covering the whole surface of the fruit (Fig 6 middle). When some of the stigmas of a strawberry flower do not receive pollen grains, they will form clusters of tiny seeds and the fruit tissue in that area is much less developed (Fig 6 left). Poor pollination often results in a misshaped, unsymmetric fruit. However, these results highly depend on the strawberry variety.

Some types of pest damage can be easily confused with poor pollination! Damage from the Tarnished Plant Bug, a pest that feeds on developing seeds, can also cause clusters of seeds and malformed fruits (Fig 6 right). Pest damage can be distinguished from poor pollination by the size of the seeds in the affected area. **Poor pollination always results in very tiny seeds relative to the seeds in other areas of the fruit** while pest damage happens after pollination so the seeds from a pest damaged fruit are usually similar in size between the malformed area and other areas of the fruit.

How can you promote strawberry pollinators on your farm? Nearly all strawberry pollinators need access to other habitats in order to complete their life cycle. For bees, natural habitats around farms provide nesting sites and alternative floral resources (pollen and nectar) from other plant species. In the case of syrphid flies, adjacent natural areas can provide alternative prey (such as aphids) during their larval stage. Habitats that support pollinators include forests, woodlots, yards and gardens, fallow fields and pastures. In New York, we found that farms with more agricultural cover and less natural habitat had a lower abundance and diversity of wild bees pollinating their strawberry fields.

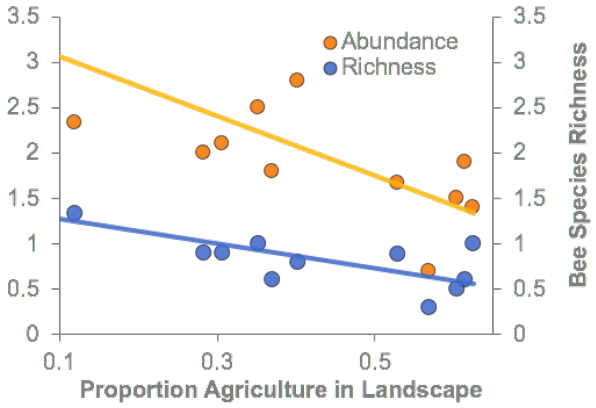


Figure 7. Fewer strawberry pollinators in landscapes with fewer natural habitats and more agriculture.

If your farm has plenty of natural habitat around your field (at least 50%), then there is a good chance you will have enough pollinators to meet your needs. If not, one way to augment the alternative resources that bees need is to plant field margins with a mix of diverse perennial flowering plants. These plantings attract and support a variety of pollinator groups. You will get the most benefit from establishing a pollinator planting if there is at least 35% natural habitat in the area around your farm which serves as a source for attracting pollinators to the field. If you farm has less than 35% natural habitat of your fields are large (more than 8 acres) you might consider renting or purchasing managed pollinators if you are finding consistent evidence of poor pollination

The most common managed pollinator is the european honey bee, Apis mellifera. They have large hives of up to 60,000 workers. Recommendations for stocking densities vary from 0.5 to 10 hives per acre with an average of 3.5 hives per acre. These recommendations are generally higher than other crops because strawberry blooms during the cool spring season when honey bees are less active and because honey bees often prefer other flowers even when placed in blooming strawberry field. **Alternative managed pollinators include the common eastern bumble bee, Bombus impatiens, and the mason bees in the genus Osmia.** Both Bumble bees and Osmia can be purchased from commercial suppliers. A recent trial in New York suggests that **supplementing pollination with Bumble bee colonies can provide a modest increase in strawberry yields.**

Figure 4. A hover fly feeding on strawberry pollen and nectar

In all cases, it is important to protect pollinators from exposure to pesticides. Many insecticides can impair the ability of pollinators to visit flower efficiently and to reproduce which can impact the supply of pollinators available in the next season. Even chemicals like fungicides, which are not thought to be toxic to bees, have been found to negatively impact pollinator populations. Fungicides may alter the microbiome of pollinators, reducing their ability to extract nutrition from their diets and increasing their susceptibility to parasites and pathogens. **To protect your pollinators and their pollination services, pesticide applications should be avoided during the bloom period.** If pesticides must be applied during bloom (often the case for fungicides), they should be applied in the evening (past 6pm) when pollinator activity is low. Evening application ensure that bees will not forage on the flowers for many hours compared to early morning sprays which increase the likelihood that pollinator will come into contact with residues as they begin foraging in the morning.

INTRODUCING THE PENNSYLVANIA POLLINATOR PROTECTION PLAN

Charlie Vorisek
Vorisek's Backyard Bee Farm, llc 15834 Linesville Rd, Linesville, Pa. 16424

Managed Pollinator Protection Plans (MP3)

In June 2014, President Obama announced an Executive Order directing all federal agencies to review and implement policies to promote pollinator health. The memo directed the US Environmental Protection Agency (EPA) to engage state agencies in developing state pollinator protection plans as a means of mitigating the risk of pesticides to bee and other managed pollinators.

In late 2015, the Pa Dept of Agriculture conducted a survey of beekeepers and non-beekeepers to gage the perception of problems, policies and thoughts on pollinator issues. Questionnaires went out to people in the PaPlants database with accounts prior to 2012.

Returned, were 621 responses from 1,128 beekeepers (55%) and 621 responses from 4,097 non-beekeepers (15%). Among beekeepers, this closely represented actual registration records. Over 85% of registered beekeepers have 10 or fewer colonies. Less than 1% have over 250 colonies.

An invited stakeholder meeting was held in January 2016 at PDA. The momentum seemed to fade. In September 2016, PDA presented a draft that was primarily adopted from North Dakota and Wisconsin plans. Pa State Beekeepers Association and Penn State Center for Pollinator Research requested that Penn State take lead in writing a Pennsylvania specific plan.

In January 2017, PSU presented a 'Roadmap for Pennsylvania Pollinator Protection Plan" or "P4" with the leadership of Christina Grozinger and Harland Patch. The plan was completed in Oct 2017, reviewed and rolled out publicly at the 2018 Pa Farm Show.

The plan is housed on a Penn State website. P4 utilizes hundreds of additional and reliable sources through hyperlinks. Penn State will routinely verify links and maintain integrity.

Pennsylvania Pollinator Protection Plan (P4) has 5 Chapters.

Chapter 1) Introduction gives an overview of importance of pollinators relative to Pa agriculture. Currently, the status of Pa pollinators is very good, with over 480 surveyed species. P4 looks at all native pollinators as well as managed honeybees. Pennsylvania has on of the most diverse cropping systems in the United States. Our diverse landscapes offer many fencerows, edges, forests and micro climates that benefit forage and nesting.

Chapter 1 also explores pollinator declines. Historically, annual honeybee colony losses were around 10-15%. Currently, on a national level, beekeepers loose 40%. Recent surveys of Pa beekeepers have losses ranging from 20-90% in different counties. Statewide losses are 52%. Top causes of decline are considered Pests and Pathogens, Habitat Loss and Pesticide Use.

The goal of P4 is to summarize challenges and opportunities related to supporting healthy pollinator populations and provide practical approaches to conserving and expanding those populations.

Charlie Vorisek is past-president of the Pennsylvania State Beekeepers Association and currently president of the Northwestern Pa Beekeepers. His beekeeping began with his daughter's FFA enterprise in 1992. He and his wife, Cathy, went full time beekeeping in 2009. They operate Vorisek's Backyard Bee Farm, where they operate over 200 colonies on more than 20 locations in Crawford, Erie and Venango Counties. They offer crop pollination service, produce and sell honey and hive products to the local markets and festivals.
Charlie serves on the Apiary Advisory Board to the Pa Dept of Agriculture. He also serves on the Pennyslvania Farm Bureau 'Fruit, Vegetable and Apiary Commodity Committee' and represents Pennsylvania Farm Bureau on the board of the Penn State Center for Pollinator Research. He was appointed by Sec Russell Redding to help write the Pennsylvania Pollinator Protection Plan

Chapter 2) Forage and Habitat looks at challenges and opportunities over various landscapes. The chapter is broken down to Urban and Suburban Areas, Roadsides and Right of Ways, Agricultural Areas and Natural Areas.

Forage and Habitat explores terrain for suitable food sources and nesting sites. Native pollinators nest in the ground and in woody plant stems. Offering this array of nesting and flowering species helps ensure suitable habitat. In turn, these native pollinators will enhance pollination services for fruit, vegetables and non-crop forage needed by these pollinators. Studies have shown exponential pollinating services as various species compete to forage. Honeybees, bumble bees and Orchard bees are among managed species. Different bee species specialize in different plants and are needed for efficient procreation of those plant species.

As we explore hyperlinked information, we find sources such as 'Sustaining Native Bee Habitat for Crop Pollination' from USDA sites.

Chapter 3) Best Practices for Pesticide Use. It is strongly recommended that pesticides be used only as part of an Integrated Pest Management or IPM approach. As intervention with biological and chemical systems increase, the risk of affecting non-target species is greater. Adjust spray timing for night if possible. Include buffer zones between treatment and pollinator habitat. Choose tank mixes carefully to avoid synergistic impacts on pollinators. Repeated use of pesticides can often lead to pest resistance, requiring new and more lethal products.

A case study, Chapter 3, page 12: Negative Impacts of Prophylactic Pesticide Use, demonstrated ineffective neonicotinoid seed treatments in soybeans. The systemic pesticide had no effect on slugs. However, the predator beetle died when eating the slugs. Yield in this situation was lower than no seed treatment.

Exploring hyperlinks in Chapter 3 finds a publication of Wild Pollinators of Eastern Apple Orchards and how to conserve them. Lists of chemical products and toxicity levels are easy to follow. Also color photos index of common native bees in your orchard.

Chapter 4) Best Practices for Beekeepers. The chapter is intended to guide beekeepers in education, registration, apiary locations, considerations for landscapes, disease and pest control. It is essential that beekeepers are managing correctly. Lastly, beekeepers are given recommendations in reducing pesticide exposure.

P4 is Pennsylvania-specific for pollinators in the many landscapes across this state.

UN-FUNDED, NOT REGULATORY…IS VOLUNTARY http//ento.psu.edu/P4

PUMPKIN WEED MANAGEMENT

Dwight Lingenfelter
Penn State University, Dept. of Plant Science, 116 ASI Building, University Park, PA 16802

Pumpkin farmers are continuously battling weeds in commercial production systems. Some common weeds include:

Annual grasses such as giant foxtail, large crabgrass, and fall panicum

Annual broadleaves: common lambsquarters, common ragweed, velvetleaf, pigweed species (including Palmer amaranth and waterhemp), cocklebur, eastern black nightshade, marestail, and common chickweed

Perennials: Canada thistle, horsenettle, bindweed, yellow nutsedge, quackgrass

The number of pumpkin herbicides (Tables 1-4) is rather limited compared to other crops but with some creative thinking about using them, adequate weed control can be obtained. Since pumpkins are grown in a variety of ways (i.e., tilled seedbed, raised beds, no-till, on plastic, on rolled rye, direct-seeded, transplanted, etc.) not all these herbicides can be used effectively in all settings.

There are not many potentially new herbicide options on the horizon for use in pumpkin. Reflex 2L is not yet labeled for use in pumpkin in Pennsylvania, however it does have a special label for use in the DelMarVa states. Reflex would be good addition to control eastern black nightshade, lambsquarters, pigweed, ragweed, others. Penn State weed scientists have recently provided data and petitioned Syngenta for a Reflex pumpkin label for the state; we hope a label is forthcoming. Other potential candidates include Chateau and Sharpen for row-middle weed control is certain vine crops. However, we are still awaiting approval.

On another topic, the use of cover crops in vegetable systems, including pumpkins, has been on the rise. In recent years, an increasing number of growers are direct-seeding pumpkins in no-till systems, often into a cover crop (usually cereal rye) in order to reduce dirty pumpkins at harvest, provide some weed suppression, and reduce fruit rot. In no-till systems, growers cannot use tillage to give initial weed control or cultivation to provide in-season control, and therefore must rely on herbicides. Additionally, some weed control can occur in the rye prior to crop establishment. For example, spray 2,4-D (1 pt/A) in fall or early spring to kill marestail or other winter annual weeds. Than allow the rye to continue to grow and terminate it with glyphosate near planting. The rye can be rolled to make a nice surface and then plant directly into it. Also, as more farmers are using no-till, effective burndown herbicide programs are critical to the establishment of the crop.

Management of weeds in cucurbits

The backbone of many weed control programs includes herbicides. Below are tables for vine crop herbicides and the efficacy ratings for selected herbicide on certain weeds.

Dwight Lingenfelter is an extension agronomist/weed scientist in the Dept. of Plant Science at Penn State since 1994. He is responsible for developing various materials for Extension purposes, including revising portions of The Penn State Agronomy Guide, presenting practical information at county and statewide Extension meetings and field days, and generally contributing to other weed science Extension and research needs in mainly agronomic and some vegetable crops. He also coordinates the annual Penn State Agronomic Field Diagnostic Clinic and coaches the PSU collegiate weed science team and is a member of several professional societies and serves on various committees. He received BS and MS degrees in Agronomy from Penn State. He also worked for a period with a major ag chemical manufacturer and as a crop consultant.

Table 1. Cucurbit crop herbicide summary

Herbicide	Cucumber	Summer squash	Winter squash	Pumpkin (ornamental)	Watermelon	Cantaloupes
Soil-applied						
Command	**XXX**	**XXX**	**XXX**	?	**XXX**	**XXX**
Curbit	**XXX**	**XXX**	**XXX**	**XXX**	**XXX**	**XXX**
Prefar	**XXX**	**XXX**	**XXX**	**XXX**	**XXX**	**XXX**
Prowl H2O (row middles)					**XXX**	**XXX**
Sandea	**XXX**	**X**	**X**	**X**	**XXX**	**XXX**
Sinbar					**XXX**	
Strategy	**XXX**	**XXX**	**XXX**	**XXX**	**XXX**	**XXX**
Postemergence						
Aim	**XXX**	**XXX**	**XXX**	**XXX**	**XXX**	**XXX**
Poast	**XXX**	**XXX**	**XXX**	**XXX**	**XXX**	**XXX**
Prowl H2O (row middles, before vine run-off)					**XXX**	**XXX**
Sandea	**XXX**		**XXX**	**XXX**		**XXX**
Select / Max	**XXX**	**XXX**	**XXX**	**XXX**	**XXX**	**XXX**

XXX= labeled for use in that crop
X=labeled for use but not recommended due to injury concerns

Table 2. Cucurbit crop preemergence soil-applied herbicide options

Herbicide	Pump -kin	Water- melon	Canta- loupes
Command	?	**XXX**	**XXX**
Curbit	**XXX**	**XXX**	**XXX**
Dual Mag.	|||	|||	
Prefar	**XXX**	**XXX-U**	**XXX-U**
Prowl H2O		|||	|||
Sandea	**X**	**XXX-U**	**XXX-U**
Sinbar		**XXX-U**	
Strategy	**XXX**	**XXX**	**XXX**

XXX= labeled for use in that crop
X=labeled for use but not recommended due to injury concerns
XXX-U=under plastic
|||=row-middle application

Table 3. Cucurbit crop postemergence herbicide options

Herbicide	Pump -kin	Water- melon	Canta- loupes
Aim (hood/row middles/around vines)	|||	|||	|||
Poast	XXX	XXX	XXX
Sandea	X	|||	XXX
Select / Max	XXX	XXX	XXX
Gramoxone (hood/row middles)	|||	|||	|||

XXX= labeled for use in that crop (some products require the use of hooded sprayers, refer to product label)
|||=row-middle application

Table 4. Vine crop herbicide efficacy

Weeds	Command (pre)	Curbit (pre)	Strategy (pre)	Prefar (pre)	Dual Mag. (pre)	Sandea (pre)	Sandea (post)	Aim (post)	Sinbar (pre)	Select/Poast (post)
Giant foxtail	G	-	G	G	G	N	N	N	F	G
Crabgrass	G	G	G	G	G	N	N	N	F	G
Yellow nutsedge	N	N	N	N	F-G	F	G	N	P	N
Lambsquarters	G	P-F	G	F-G	P	F-G	N	G	G	N
Nightshade	-	P	P	N	G	N	N	G	G	N
Pigweed	N-P	F	F	F	G	G	G	G	P	N
Common ragweed	P-F	N	F	N	N	G	G	F	G	N
Smartweed	G	P	G	N	P	F	F	-	G	N
Velvetleaf	G	P	G	N	P	G	G	G	G	N
Cocklebur	N-F	N	N-F	N	N	G	G	P	-	N
Morningglory	P	P	P	N	N	F	F	F	G	N
Galinsoga	F	N	F	N	G	G	G	-	G	N
Purslane	G	F-G	G	F	F-G	F	P	-	G	N

Weed control rating scale: G = Good; F= Fair; P= Poor; N = no activity

2500 POUND GIANT PUMPKINS? WHAT DO THESE GROWERS KNOW ABOUT GROWING VINE CROPS THAT YOU DON'T?

Tim Parks
Parks Garden Center Canfield, Ohio

Communication & Education:
Go to the experts in your crop research, learn all you can, share what you know, let the ideas flow.

The 5 Limiting Factors:
Seeds & Genetics: buy the best you can, can be pricey at the front end, but gives full potential for success, and a return on your investment. One Giant Pumpkin Seed can cost $1,500, but if you grow the next world record from it what was its value.

Nutrition: Don't be a MORE-ON; balanced nutrition is proven to be far more effective than just putting more on, establish correct pH for your crop, spoon-feed through the season as needed instead of a one and done spring application of nutrients. Giant Pumpkin philosophy and recommendations for successful vine crop nutrition can lead to Giant Pumpkins gains of 50-60 lbs. per day at peak. Some benchmarks—1,000 lbs. by August 1, 1,200lbs. more by September 1, keep it gaining;200-300 lbs. more by October 1.

Environmental Factors: We can't control the weather-but we can make some modifications for our crops depending on the weather we get. Giant Pumpkin Growers are masters of manipulating their environs to suit their Giant Pumpkin, get their tips. Also, choose wisely when siting your crops, paying special attention to soil texture, and topography.

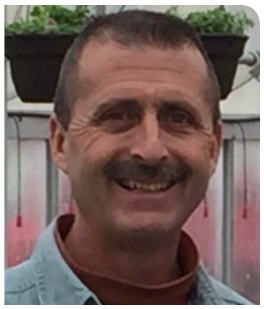
Cultural: Know your pests, treat with a rotation of active ingredients to avoid the development of pest resistance, continuing education on best product rotations for specific pests.

Soil Biology and Application of Biological Products: Mycorrhizae, Essential, Recover, and Companion (by Growth Products) Liquid Humates (kelp, fish emulsion) can all contribute to a healthy rhizoshere. A typical Giant Pumpkin Growers 3- year rotation would include year 1: mustard summer, winter rye with mycorrhizae. Year 2. Sudanex with mycorrhizae summer, winter rye and mycorrhizae winter. Year 3. Existing Rye into giant pumpkin planting. Rotation will greatly decrease disease pressure.

Western Labs Website offers a Giant Pumpkin tutorial on nutritional adjustments that would be valuable for any vine crop grower.

Some Commercial Take Aways:
Always choose superior genetics for your crop varieties.
Soil Test; understand how read and interpret results; follow directions to achieve balanced soil nutrition.
Know your pests; treat them accordingly.
Crop Rotation and good soil biology play a huge part in a healthy Rhizosphere.
Biologicals will benefit your program, don't be afraid to use them in your arsenal.

Tim Parks owns and operates Parks Garden Center in Canfield, Ohio. Parks Garden Center is a 40 year old 7 days a week, year round retail operation that self produces ornamental bedding and perennial plants, pumpkins, gourds, and a full compliment of other fall crops including 20,000+ chrysanthemums. They also blend, bag, and market their own brand of birdseeds in house. Parks Garden Center has been the host site for the OVGPG (Ohio Valley Giant Pumpkin Growers) Weigh-Off for the last 25 years. Tim also grows Giant Pumpkins, but more importantly developed a passion for educating fellow gardeners and growers at various seminars in North America on the subjects of growing giant pumpkins and many other gardening subjects. The Ohio Valley Giant Pumpkin Growers have won the World Wide Competition for The Top Ten Heaviest Pumpkins 9 out of the last 13 years. Tim and his wife Sheila have two grown children, and two grandchildren, and live half a mile from where they were raised in Canfield, Ohio.



VINE CROP DISEASE MANAGEMENT IN THE NEXT WET YEAR

Beth K. Gugino
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Managing diseases during wet weather is exceptionally challenging. Not only does the wet weather create ideal conditions for disease spread and development, it limits our ability to get into the field and apply fungicides and may reduce fungicide efficacy if rain-fast intervals are not achieved. Excessive periods of rain will also shorten the time intervals between applications and wash products off the leaves. In addition, excessive prolonged rain and flooding stresses the crop rendering it more susceptible to disease. Roots in saturated soils are unable take-up the necessary oxygen and nutrients to sustain growth. Physical damage to the plants during severe storms creates easy ports of entry for disease causing pathogens.

In cucurbit crops there is no shortage of diseases that are favored by either cool or warm wet weather. In the spring if cooler weather persists then seed and seedling diseases become an issue. Direct seeded crops that sit in the cold soil, are slow to emerge and thus more susceptible to diseases such as Pythium seed and seedling rot, even if the seed is treated. Planting into black plastic can help to warm the soils but can come at an added cost especially as more cucurbit crops like pumpkins are being planted into no-till or reduced till fields. In our region we are more likely to have disease problems that are favored by warm wet weather. These include bacterial diseases such as angular and bacterial leaf spot that are easily splash dispersed during rain events and whose bacterial populations multiply rapidly under warmer temperatures. Foliar fungal diseases such as anthracnose, gummy stem blight and oomycete diseases such as Phytophthora blight and downy mildew.

Although weather forecasting has significantly improved over the years, we are not yet able to predict the weather far enough so that we can start planning for the predicted wet season during the winter. Therefore, we must make sure that good preventative disease management practices are always in place to make disease management as easy as possible under less than ideal conditions. So, below are a few key recommendations to help improve crop and farm resiliency under persistent wet weather conditions:

Be aware of the diseases that are likely to be most problematic under wet conditions. Some of these include: downy mildew, Phytophthora blight, gummy stem blight, and anthracnose as well as the bacterial diseases angular and bacterial leaf blight. Fruit rots resulting from the fruit being in direct contact with the soil can also be more common. Maintain a thorough scouting program.

Have a fungicide program plan in place prior to the beginning of the season. Think through how you are going to manage for fungicide resistance by rotating FRAC codes and tank mixing with a broadspectrum protectant fungicide. When disease pressure is high, select the most effective products even if this means increased input costs. Be familiar with the labels and know the limits on numbers of applications and amount of active ingredient that can be applied in a season. In a wet year, you will likely be spraying more frequently and more quickly reach legal application limits.

Beth K. Gugino is an Associate Professor in the Department of Plant Pathology and Environmental Microbiology at The Pennsylvania State University located at University Park, PA. Her extension and research program focus on the identification, epidemiology and management of vegetable diseases important to the Pennsylvania and the Northeast region. She received her B.S. in Horticulture and M.S. and Ph.D. in Plant Pathology from The Pennsylvania State University. She was a post-doc at the New York State Agricultural Experiment Station with Cornell University working with diseases of vegetable crops and soil health for four years before returning to Penn State in June 2008.

Every year take steps to improve your overall soil health by incorporating the use of cover and green manure crops, rotating in season-long soil building crops (if possible) or using other organic materials to build up soil organic matter. Improve soil drainage especially in lower lying areas of the field or planting permanent grass strips or water ways to divert water out of the field to a non-ag field location. Determine if or where your hardpan is and deep rip just below that level to improve drainage or include a cover crop such as tillage/daikon radish whose roots can penetrate that compacted layer. Improved soil health will also help to reduce the negative effects of compaction in the drive rows when having to use equipment under less than ideal field conditions.

If not already using mulches consider incorporating them into your vine crop production system. These will not only help reduce soil and rain splash within and between plants, the mulch will create a barrier preventing direct contact between the fruit and the soil thus reducing potential fruit rots and helping to keep the fruit clean.

Keep good field notes on cultivar performance under different weather and field conditions to help inform cultivar selection and crop rotation. Also keep a running history of disease issues in each field to anticipate what problems might arise.

COMMON PESTS OF PUMPKIN AND THEIR MANAGEMENT

Gerald Brust, IPM Vegetable Specialist

Striped cucumber beetles and squash bugs are two of the most consistent pests of pumpkins and squash in our area. The biggest problem with these pests and why control sprays at times do not work well is that they are consistently hiding at the base of the plant where they feed on the stem (fig. 1). Sprayers usually are set up to cover a lot of leaf canopy and do not do a very good job of putting chemical down in the plant hole. This stem feeding can be severe enough that either pest alone could cause some wilting, but with both feeding on this relatively small area of the stem they can cause considerable damage (fig 2). It is hard enough to kill squash bug adults with a good cover spray, but when only small amounts of spray are reaching them down in the plant hole they will not be controlled. Often it is possible to walk by plants and even inspect them and still see no beetles or squash bugs, as they will stay down at the base of the plant when it is hot and only move when the base is exposed. It is possible to have as much as 20% of the plants wilting due to squash bug and cucumber beetle feeding. The same problem can occur in watermelon fields with both striped cucumber beetles and squash bugs feeding on plants down in the plant hole. If this type of feeding has occurred in your fields insecticide applications (pyrethroids such as Warrior, bifenthrin, Hero, Mustang Maxx, etc.) must be directed down at the base of the plant with greater water volume (80-100 gal/a) and spray pressures (75-125 psi) than normally used.

Fig. 1 Cucumber beetle feeding at base of plant

Fig. 2 Severe feeding on pumpkin stem by striped cucumber beetle and squash bugs

A new invasive disease vectored by squash bugs in our area is called Cucurbit yellow vine decline or disease (CYVD). The bacterium *Serratia marcescens*, is the causal agent. While it is not common, it is something we should watch for in our pumpkins and other vine crops. Plants will develop a bright yellow color to them in which some of the leaves are dead but there is little wilting. When a cross section is cut at the base of the stem on these particular plants the interior of the stem shows a distinct yellow-brown coloration of the phloem (fig. 3). This honey-colored phloem is one of the characteristics of the disease. The squash bug feeds with its needle-like mouth parts in the phloem, where carbohydrates (sugars) are transported throughout the plant. Once the bacteria get into the phloem they begin to multiply and eventually clog this tissue. The bacteria survive the winter in squash bugs and can be spread to young plants in the spring when the bugs colonize and feed on cucurbit crops. This is a disease we just need to watch for at this time no actions are needed. If you suspect you might have it please get a sample to your state diagnostic

Gerald Brust is the IPM Vegetable Specialist at the University of Maryland located at the Central Maryland Research and Education Center near Upper Marlboro, MD. He is responsible for developing new IPM programs for insect pests and new nutrient management programs for vegetables for Maryland and mid-Atlantic growers. Before coming to Maryland he worked for four years for a private consulting company in south Florida developing bioIPM programs for the company's vegetable grower clientele. Prior to Florida he worked for Purdue University developing IPM programs for Midwestern vegetable growers. His wife, Karen Rane is the Director of the University of Maryland's Diagnostic Laboratory and their two children are in grad school. He has an MS degree from The Ohio State University and his PhD from North Carolina State University.

clinic for verification as it is difficult to positively identify this bacterium except through a series of laboratory tests.

Aphids can physically cause damage to pumpkins by sucking large amounts of sugars out of the pumpkin. But by far they do the most damage to a field of pumpkins by vectoring (transmitting) viruses such as Watermelon mosaic virus-2 (WMV) (fig. 4), Zucchini yellow mosaic virus (ZYMV), Cucumber mosaic virus (CMV) and Papaya ringspot virus-W (PRSV). Once a plant is infected with a virus it cannot be cured. If the virus infection takes place before fruit set there is only a small chance that a pumpkin fruit will ever develop on that plant. The most common aphid species that land in pumpkin fields in our area are corn leaf aphid, green peach aphid, melon aphid, cowpea aphid, potato aphid, and sunflower aphid. Only green peach aphids and melon aphids are good vectors of mosaic viruses while potato aphids are weak vectors, and corn leaf aphids are unable to vector this virus. The weeds that are found to contain WMV are shepherd's purse, Virginia pepperweed, field bindweed, dandelion, purple deadnettle, and goldenrod. Growing resistant varieties is the best most economical way to manage viruses, spraying weekly insecticides will not prevent these viruses from entering your field.

Fig. 3 Honey colored phloem (arrows)

Fig. 4 WMV infected pumpkin leaves

Squash vine borer adults emerge from June through July from cocoons that overwintered in the soil. They typically lay their small (1/25 inch), oval, brown eggs singly on stems or leaf stalks near the base of the plant (85% of all eggs are laid on the first 2 ft of vine). Eggs hatch in 7-10 days. Upon hatching, the larvae immediately bore into the stem, leaving small almost invisible entrance holes and yellowish frass. After feeding for about a month the borers exit from the stem and burrow into the soil. They overwinter in a cocoon and pupate in the spring. There are 1-2 generations per year in the mid-Atlantic. Larvae damage plants by cutting the water and nutrient conducting lines. As a result, plants start to wilt or leaves begin to turn yellow and eventually brown around the leaf margins. Other pests also cause wilting symptoms such as squash bugs, aphids, bacterial wilt which is vectored by the striped cucumber beetle or several root diseases (which are quite prevalent in Maryland). In order to determine if the squash vine borer is causing the wilting, look for a large swollen stem and large amounts of yellowish-green frass extruding from holes. If these symptoms exist, split the stems apart with a sharp knife to look for the larvae. If several larvae have infested a plant, the plant may collapse and die. If you rotate away from last year's pumpkin or squash crop by about ¼ mile or so you will greatly reduce any squash vine borer problems. If you do not or can't rotate out of the last years field then at the first sign of adult moth flight, usually in mid-June or so, you will need to direct a spray of pyrethroid to the base of a pumpkin plant, as you would if trying to control squash bugs or striped cucumber beetle.

PENNSYLVANIA CANTALOUPE VARIETY TRIAL

Elsa Sánchez, Professor of Horticultural Systems Management
Tim Elkner, Senior Extension Educator, Horticulture
Tom Butzler, Senior Extension Educator, Horticulture
Bob Pollock, Extension Educator, Horticulture
Carla Burkle, Extension Educator, Horticulture
Francesco Di Gioia, Assistant Professor of Vegetable Crop Science
The Pennsylvania State University Department of Plant Science and Extension

Selecting which cultivar to grow is critical to successful commercial production. When a cultivar suited to an area and having high yield and quality for market is grown, growers can make a profit. In 2018 we evaluated muskmelons. Muskmelons are an important crop for diversified vegetable operations in Pennsylvania. Between 2007 and 2012 the number of farms growing muskmelons increased by 13% from 480 to 549. Acreage devoted to muskmelon has increased 28% from 805 to 1,121. Nationally Pennsylvania ranks 5th in number of farms and 10th in acreage planted in muskmelons (2012 Census of Agriculture).

This study was conducted in central Pennsylvania at Pennsylvania State University's Russell E. Larson Research Center in Pennsylvania Furnace, in southeastern Pennsylvania at Pennsylvania State University's Southeast Research and Extension Center in Manheim and in western Pennsylvania in Indiana County on a grower's farm.

Twenty-three to 24 muskmelon cultivars on their own rootstocks and 2 grafted cultivars (see Table 1) were evaluated in a conventional plasticulture system. At all sites, 4-week-old transplants were set in rows spaced 6 feet apart with 2 feet between plants in a row. Four plots of each cultivar were planted with each plot consisting of 6 plants. Data were collected from all 6 plants.

Pests were managed following recommendations in the 2018 Commercial Vegetable Production Recommendation guide.

Melons were harvested from July 31 to August 28 at the western site, August 4 to 29 at the central site, and July 13 to August 13 at the southeastern site.

The standard used was 'Aphrodite' based on conversations with growers.

Data were analyzed by site using the mixed procedure and means were separated at the 5% level using pdiff.

Table 1. Cultivars and seed sources of muskmelon cultivars evaluated in 2018.

Cultivar	Source
SVMF 7641	Seminis, St. Louis, MO
Sun Blushed	Seminis, St. Louis, MO
Afterglow	Seedway LLC, Mifflinburg, PA
Aphrodite	Seedway LLC, Mifflinburg, PA
Atlantis	Seedway LLC, Mifflinburg, PA
Goddess	Seedway LLC, Mifflinburg, PA
Minerva	Seedway LLC, Mifflinburg, PA
Shockwave	Seedway LLC, Mifflinburg, PA
Sugar Cube	Seedway LLC, Mifflinburg, PA
Verona	Seedway LLC, Mifflinburg, PA
Accolade	Syngenta, Greensboro, NC
Astound	Syngenta, Greensboro, NC
Athena	Syngenta, Greensboro, NC
Aphrodite	Syngenta, Greensboro, NC
ME 4858	Syngenta, Greensboro, NC
Atlantis	Sakata, Morgan Hill, CA
Avatar	Sakata, Morgan Hill, CA
Infinite Gold	Sakata, Morgan Hill, CA
Ariel	Syngenta, Greensboro, NC
Accolade	Clifton Seed, Faison, NC
Carousel	Clifton Seed, Faison, NC
Lani	Clifton Seed, Faison, NC
Fiji	Clifton Seed, Faison, NC
Majus	Rupp, Wauseon, OH
Tirreno	Rupp, Wauseon, OH
Ambassador	Rupp, Wauseon, OH
Aphrodite/Flexifort	Grafted entry
Aphrodite/RS841	Grafted entry

Results

Yield

An excessively wet growing season made for a tough year for growing muskmelons. Many melons rotted before reaching maturity and some cultivars did not yield any mature fruit.

Western Site

Mean number of marketable melons produced by each cultivar ranged from 0.00 to 1.92 per plant (Table 2). 'Lani', 'SVMF 7641', and 'Shockwave' produced fewer melons (0.00 per plant for all three cultivars) compared to 'Aphrodite' (1.25). The number produced by all other cultivars was not different than 'Aphrodite'. Grafted cultivars averaged 1.00 per plant for Aphrodite/Flexifort and 1.21 for Aphrodite/RS841.

Mean weight of marketable melons produced by each cultivar ranged from 0.00 lb to 8.90 lb per plant. Weights from 'Lani', SVMF and 'Shockwave' were lower (0.00 lb for all three cultivars) than from 'Aphrodite' (5.77 lb). All other cultivars were not different than 'Aprhodite'. Aprodite/Flexifort averaged 7.12 lb per plant and Aphrodite/RS841 8.90 lb per plant.

Mean number of unmarketable melons produced by each cultivar ranged from 0.00 to 1.29 per plant. All cultivars were not different than 'Aprodite' (0.67). Aprodite/Flexifort averaged 0.42 per plant and Aphrodite/RS841 0.25.

Mean weight of unmarketable melons produced by each cultivar ranged from 0.19 lb to 5.59 lb per plant. Unmarketable weight from 'Ambassador' was higher (5.59 lb) compared to 'Aphrodite' (2.47 lb). All other cultivars were not different than 'Aprodite'. Aprodite/Flexifort averaged 2.85 lb and Aphrodite/RS841 1.45 lb.

Central Site

Mean number marketable melons produced by each cultivar ranged from 0.00 to 3.96 per plant (Table 3). 'Lani' and 'Tirreno' produced more melons (3.96 and 3.17 per plant, respectively) compared to 'Aphrodite' (1.25). The number produced by all other cultivars was not different than 'Aphrodite'. Grafted cultivars averaged 1.38 per plant for Aphrodite/Flexifort and 1.17 for Aphrodite/RS841.

Mean weight of marketable melons produced by each cultivar ranged from 0.00 lb to 14.81 lb per plant. All cultivars were not different than 'Aprhodite' (7.44 lb). Aprodite/Flexifort averaged 10.87 lb per plant and Aphrodite/RS841 8.18 lb per plant.

Mean number of unmarketable melons produced by each cultivar ranged from 0.00 to 1.50 per plant. 'Fiji' produced more unmarketable melons (1.50 per plant) compared to 'Aphrodite' (0.50). All other cultivars were not different than 'Aprodite'. Aprodite/Flexifort averaged 0.38 per plant and Aphrodite/RS841 0.25.

Mean weight of unmarketable melons produced by each cultivar ranged from 0.00 lb to 6.19 lb per plant. All were not different than 'Aprodite' (2.91). Aprodite/Flexifort averaged 1.2 lb and Aphrodite/RS841 1.51 lb.

Southwestern Site

Mean number of marketable melons produced by each cultivar ranged from 0.00 to 2.50 per plant (Table 4). 'Sugar Cube' produced more melons (2.50 per plant) compared to 'Aphrodite' (1.25) and 'Shockwave', 'Lani', 'Fiji', 'Infinite Gold' and SVMF7641 produced fewer melons (0.21, 0.13, 0.08, 0.04, and 0.00, respectively). The number produced by all other cultivars was not different than 'Aphrodite'. Grafted cultivars averaged 1.17 per plant for Aphrodite/Flexifort and 1.42 for Aphrodite/RS841.

Mean weight of marketable melons produced by each cultivar ranged from 0.00 lb to 12.83 lb per plant. 'Shockwave', 'Lani', 'Fiji', 'Infinite Gold', and SVMF7641 produced a lower weight (1.27 lb, 4.02 lb, 0.39 lb, 0.16 lb and 0.00 lb, respectively) than 'Aphrodite' (9.40 lb). The weight produced by all other cultivars was not different than 'Aphrodite'. Grafted cultivars averaged 11.27 lb for Aphrodite/Flexifort and 12.09 lb for Aphrodite/RS841.

Mean number of unmarketable melons produced by each cultivar ranged from 0.00 to 1.58 per plant. 'Goddess' and 'Sugar Rush' produced more than 'Aphrodite' (0.38). All other cultivars were not different than 'Aprodite'. Aprodite/Flexifort averaged 0.71 per plant and Aphrodite/RS841 0.46.

Mean weight of unmarketable melons produced by each cultivar ranged from 0.00 lb to 8.74 lb per plant. 'Goddess' produced a higher weight (8.74 lb) than 'Aphrodite' (2.92 lb). All other cultivars were not different than 'Aprodite'. Aprodite/Flexifort averaged 5.97 lb and Aphrodite/RS841 4.32 lb.

Yearly environmental conditions can affect results; therefore, we are proposing to evaluate the same muskmelon cultivars again in 2019 to update current recommendations.

Table 2. Mean marketable and unmarketable number[z] and weight per plant of 25 muskmelon cultivars evaluated in Indiana, Pennsylvania (western site) in 2018.

Cultivar	Marketable yield		Unmarketable yield	
	Number	Weight (lb)	Number	Weight (lb)
Accolade	0.75 b-g	3.94 a-e	0.33 cd	1.15 bcd
Afterglow	1.29 a-d	5.87 a-d	0.54 a-d	1.85 bcd
Ambassador	0.50 c-g	2.63 b-e	1.29 a	5.59 a
Aphrodite	1.00 a-f	5.77 a-d	0.67 a-d	2.47 bcd
Aphrodite/Flexifort	1.00 a-f	7.12 abc	0.42 bcd	2.85 a-d
Aphrodite/RS48	1.21 a-d	8.90 a	0.25 cd	1.45 bcd
Ariel	1.08 a-e	5.77 a-d	0.38 cd	1.80 bcd
Astound	1.46 ab	7.22 ab	0.29 cd	1.01 cd
Athena	0.63 b-g	3.15 b-e	0.21 cd	0.77 cd
Atlantis	1.17 a-d	5.88 a-d	0.08 d	0.47 d
Avatar	0.79 b-g	6.25 abc	0.08 d	0.43 d
Carousel	1.33 abc	7.34 ab	0.38 cd	1.93 bcd
Fiji	0.08 fg	2.76 b-e	1.25 ab	2.45 bcd
Goddess	0.75 b-g	3.72 a-e	0.33 cd	1.36 bcd
Infinite Gold	0.08 efg	0.41 de	0.72 a-d	2.69 a-d
Lani	0.00 g	0.00 e	0.54 a-d	1.50 bcd
Majus	0.79 b-g	3.32 b-e	1.04 abc	3.85 abc
ME4858	1.42 abc	7.75 ab	0.42 bcd	1.68 bcd
Minerva	0.58 b-g	3.08 b-e	0.17 d	0.74 d
Shockwave	0.00 g	0.00 e	0.46 a-d	2.03 bcd
Sugar Cube	1.92 a	4.09 a-e	0.42 bcd	0.85 cd
Sun Blushed	0.38 d-g	1.90 cde	1.04 abc	4.18 ab
SVMF 7641	0.00 g	0.00 e	0.04 d	0.19 d
Tirreno	1.17 a-d	5.54 a-d	0.63 a-d	2.24 bcd
Verona	0.88 b-g	6.42 abc	0.29 cd	1.54 bcd

[z]Values are the mean of 4 replications; data were analyzed using the mixed procedure and means were separated using pdiff; values followed by different letters within a column are significantly different at the 5% level; 'Aphrodite' was considered the standard; values in green are statistically higher than 'Aphrodite' and red lower.

Table 3. Mean marketable and unmarketable number[z] and weight per plant of 25 muskmelon cultivars evaluated in Pennsylvania Furnace, Pennsylvania (central site) in 2018.

Cultivar	Marketable yield		Unmarketable yield	
	Number	Weight (lb)	Number	Weight (lb)
Accolade	1.90 a-f	10.49 a-d	0.22 bc	1.39 b
Afterglow	3.08 abc	14.40 a	0.13 c	0.38 b
Ambassador	0.58 ef	2.66 de	0.13 c	0.50 b
Aphrodite	1.25 c-f	7.44 a-e	0.50 bc	2.91 ab
Aphrodite/ Flexifort	1.38 b-f	10.87 a-d	0.38 bc	1.20 b
Aphrodite/RS48	1.17 def	8.18 a-e	0.25 c	1.51 b
Ariel	2.29 a-e	13.38 ab	0.04 c	0.23 b
Astound	2.21 a-e	13.20 ab	0.00 c	0.00 b
Athena	2.71 a-d	9.90 a-d	0.08 c	0.33 b
Atlantis	0.59 ef	2.90 cde	1.17 ab	6.19 a
Avatar	1.63 b-f	13.02 ab	0.33 bc	2.68 b
Carousel	1.75 b-f	9.18 a-d	0.08 c	0.60 b
Fiji	1.50 b-f	12.63 ab	1.5 a	0.00 b
Goddess	2.21 a-e	11.10 a-d	0.5 bc	2.15 b
Infinite Gold	0.00 f	0.00 e	0.00 c	0.00 b
Lani	3.96 a	8.91 a-e	0.00 c	0.00 b
Majus	1.46 b-f	6.81 a-e	0.42 bc	1.76 b
ME4858	2.08 a-e	13.80 ab	0.04 c	0.26 b
Minerva	1.67 b-f	11.68 abc	0.33 bc	2.03 b
Shockwave	1.71 b-f	9.27 a-d	0.00 c	0.00 b
Sugar Cube	2.19 a-e	5.43 b-e	0.00 c	0.00 b
Sun Blushed	1.96 b-e	11.22 a-d	0.21 c	1.41 b
SVMF 7641	2.75 a-d	12.00 ab	0.00 c	0.00 b
Tirreno	3.17 ab	14.81 a	0.00 c	0.00 b
Verona	1.54 b-f	10.60 a-d	0.25 c	1.34 b

[z]Values are the mean of 4 replications; data were analyzed using the mixed procedure and means were separated using pdiff; values followed by different letters within a column are significantly different at the 5% level; 'Aphrodite' was considered the standard; values in green are statistically higher than 'Aphrodite' and red lower.

Table 4. Mean marketable and unmarketable number[z] and weight per plant of 25 muskmelon cultivars evaluated in Manheim, Pennsylvania (southeastern site) in 2018.

Cultivar	Marketable yield		Unmarketable yield	
	Number	Weight (lb)	Number	Weight (lb)
Accolade	1.50 bcd	10.04 a-e	0.33 d-g	2.17 b-g
Afterglow	1.46 bcd	8.89 a-f	0.38 c-g	2.15 b-g
Ambassador	0.96 cde	5.98 ef	0.92 bc	5.34 abc
Aphrodite	1.25 b-e	9.40 a-f	0.38 c-g	2.92 b-g
Aphrodite/ Flexifort	1.17 b-e	11.27 abc	0.71 b-e	5.97 ab
Aphrodite/RS48	1.42 bcd	12.09 ab	0.46 c-g	4.32 b-e
Ariel	1.13 b-e	7.67 b-f	0.63 b-f	5.07 abc
Astound	1.58 bc	9.83 a-e	0.38 c-g	2.38 b-g
Athena	1.75 b	10.94 a-d	0.42 c-g	2.90 b-g
Atlantis	1.21 b-e	8.33 b-f	0.23 d-g	1.66 c-g
Avatar	1.29 b-e	12.83 a	0.42 c-g	4.06 b-f
Carousel	1.29 b-e	10.68 a-d	0.5 c-g	3.44 b-g
SVMF 7641	0.00 g	0 h	0.08 fg	0.74 d-g
Fiji	0.08 fg	0.39 h	0.13 fg	0.25 fg
Goddess	1.21 b-e	7.08 c-f	1.58 a	8.74 a
Infinite Gold	0.04 g	0.16 h	0.00 g	0.00 g
Lani	0.13 fg	4.02 h	0.17 efg	0.60 efg
Majus	1.38 bcd	7.96 b-f	0.79 bcd	4.21 b-e
ME 4858	0.71 ef	5.19 gf	0.58 b-f	4.79 bc
Minerva	0.92 de	7.92 b-f	0.46 c-g	3.97 b-f
Shockwave	0.21 fg	1.27 gh	0.29 d-g	1.89 c-g
Sugar Cube	2.50 a	6.63 def	0.71 b-e	1.87 c-g
Sugar Rush	1.50 bcd	7.46 c-f	1.08 ab	4.55 bcd
Sun Blushed	1.17 b-e	7.10 c-f	0.58 b-f	3.05 b-g
Tirreno	1.33 b-e	7.05 c-f	0.46 c-g	2.60 b-g
Verona	1.08 cde	9.22 a-f	0.58 b-f	5.34 abc

[z]Values are the mean of 4 replications; data were analyzed using the mixed procedure and means were separated using pdiff; values followed by different letters within a column are significantly different at the 5% level; 'Aphrodite' was considered the standard; values in green are statistically higher than 'Aphrodite' and red lower.

GROWING GREENHOUSE TOMATOES - GUIDELINES FOR THE NEW GROWER

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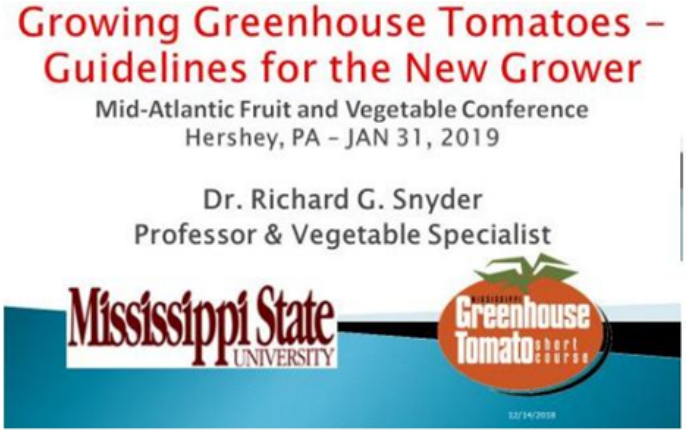

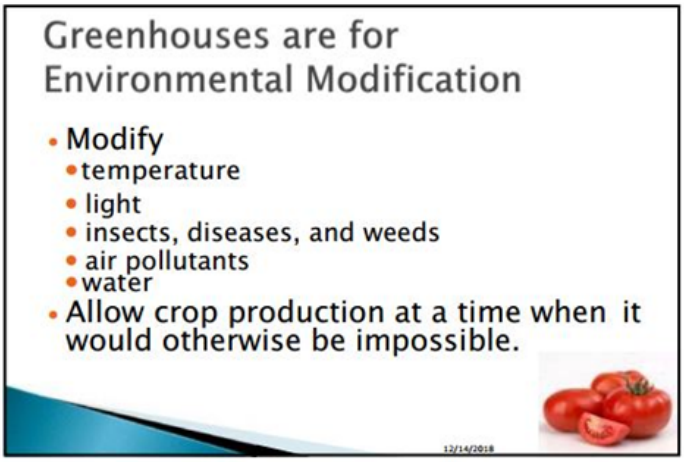

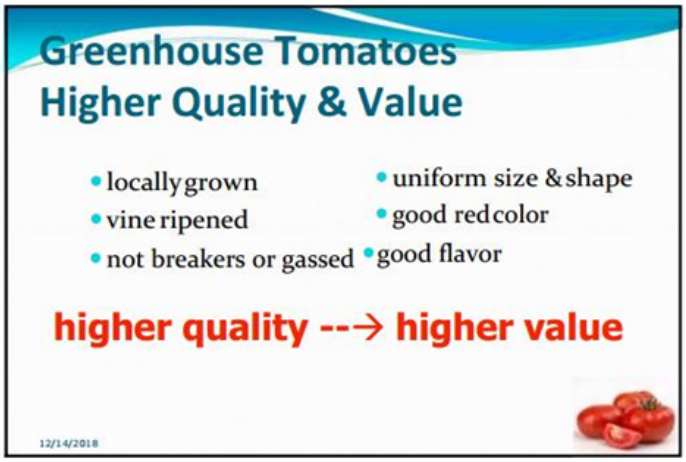

Dr. Rick Snyder has been a Professor and Extension Vegetable Specialist at Mississippi State University since 1988, specializing in greenhouse vegetable Extension and research. He has coordinated the annual Greenhouse Tomato Short Course (http://www.greenhousetomatosc.com) for 28 years in Jackson, Mississippi each March, a national conference for greenhouse growers, and has written numerous publications on greenhouse tomatoes including the Greenhouse Tomato Handbook. Originally from Connecticut, Dr. Snyder earned his B.S. degree in Horticulture at the University of Connecticut, M.S. in Greenhouse Vegetables at Ohio State University, and Ph.D. in Vegetable Crops at Cornell University. Snyder has served as Secretary/ Treasurer of the American Greenhouse Vegetable Growers Association, on the Board of Directors of the American Society for Plasticulture, and coordinated Greenhouse Tomato Seminars in Montreal (1995), Denver (1996), San Juan, Puerto Rico (2003), and Trinidad (2010). He has been an invited speaker in 21 states as well as in Mexico, and has served as the greenhouse vegetable columnist for American Vegetable Grower Magazine since 1998.

U.S. Food Crops Grown Under Protection

Year	Number of Operations	Sales in U.S. Dollars (millions)
1998	1015	$223
2009	1476	$553
2014	2521	$797

USDA Census of Horticultural Specialties

Production acres greenhouse vegetables

	Canada	USA	Mexico
Tomato	432	408	1,951
Cucumber	282	105	330
Pepper	296	61	550
Total	1,010	574	**2,831**

Hickman, 2011; Greenhouse Vegetable Production Statistics

U.S. Food Crops Grown Under Protection

Crop	Production (tons)	Hydroponic production (tons)	Value ($million)
Total	260,966	165,557	796
Cucumbers	36,310	33,101	78
Herbs (cut fresh)	17,761	3,811	71
Lettuce	10,965	7,719	56
Peppers	3,851		6
Strawberries	353		1
Tomatoes	**96,265**	**82,797**	**401**
Other	95,461	36,791	184

USDA 2014 Census of Horticultural Specialties

Growers

- Growers have a lot to learn before getting into the hydroponic tomato business.
- But, that is just the beginning.
- *continue learning every year.*

Small, family-run business

Huge, multi-acre range

Same Concepts

Grow, then Sell Tomatoes

- Don't even think about growing greenhouse tomatoes unless you have a market to sell them
- Investigate the market in your area first
- Wholesale?
- Retail?
- Small grower?
  Sell locally
- Have alternative buyers

Get Educated

- Greenhouse Tomato Short Course
- Extension publications
- Books
- Newsletters
- Visit growers
- Internet
- Facebook page

The Greenhouse Structure

- See vendor list in Greenhouse Tomato Handbook
- Listen to speakers at GHSC
- Determine size
- Site location
- Sales on site?
- Plan for drainage
  - 1-2% slope

Learn The Language

- See the Greenhouse Tomato Growers' Glossary
- Learn the terminology
- Feel free to suggest words to add if you find other terms you don't know

Cluster? Peduncle? EC? PPM? Calyx? Internode? IPM? Truss?


Greenhouse Tomato Growers' Glossary

12/14/2018

Start Small

- Start with 1 or 2 bays
  - Not 6
  - Not 12
  - Not 5 acres

"Well you said start small..."

Who will do all the work?

- Labor - yes there is work to do
- Average 20 hours per week per bay over the life of the crop
  - Do it all by yourself?
  - Family labor?
  - Hire part-time labor?
  - Hire full-time labor?
- Be sure labor is available when you need it.

Temperature Control

- Heaters (64° F min)
- Fans (keep it under 90° F)
- Vents
- HAF
- Shade Materials?
- Pad & Fan system?
- Fogging?

How Many Plants?

- Plant Population
- **5 square feet per plant**
  - Length X width / 5 = number of plants
  - 24 X 96 ➔ 460 plants 30 X 96 ➔ 576 plants
- 3 or 4 plants for 2 cubic foot lay-flat bag
- 2 plants per 5 or 7 ½ gallon upright bag
- 14 inches between stems in the row

Notice the "V-formation"

12/14/2018

Variety

- Choose a good variety.
- Pick a greenhouse variety.
- Look for
  - Good yield & size
  - Red color
  - Excellent disease resistance
  - Free of disorders

For Greenhouse Production

In most cases ....

- Red
- Indeterminate
- Beefsteak type
- Roma, cherry, grape - *if good market exists.*
- Greenhouse variety – not field or home garden type which are not well adapted to greenhouse conditions.
- ***Can deviate from this based on market demands.***

12/14/2018

Greenhouse Tomato Varieties

- Big Dena (Syngenta)
- Trust (De Ruiter / Seminis / Monsanto) – being phased out!
- Geronimo (De Ruiter / Seminis / Monsanto)
- Torero (De Ruiter / Seminis / Monsanto)
- Rebelski (De Ruiter / Seminis / Monsanto)
- Touché (Paramount Seeds)
- Foronti (De Ruiter / Seminis / Monsanto)
- Tanager (Yuksel Seeds)
- Frederik (new – Paramount Seeds)
- Blitz, Quest, Matrix, Clarance, Ambiance, Tresco, Match, Heritage, Starbuck
- Cluster types – Success, Tradiro
  - Komeett (new – Paramount Seeds)
  - Endeavour (new – Rijk Zwann)
  - Orangaro (new – Paramount Seeds)

12/14/2018

Choose a good growing medium

- Pine bark (composted fines)
- Perlite
- Coconut coir
- Rockwool
- Peat-lite mixes
- Soil
- Sand (no!)
- Newer Alternatives

Have the right tools

- Pollinator or bumblebee hive
  - (Class A, B, or C depends on greenhouse size)
- pH meter
- EC meter
- High/low thermometer

Design A Good Irrigation System

- Not as simple as it sounds
- Get help from an irrigation engineer
- Choose proper emitters
- Use filters
- Plan for fertigation
  - Bulk tank
  - Injector

Fertility & Nutrition

- Use a greenhouse hydroponic tomato fertilizer
- Use correct pH (5.6-5.8)
- Get regular tissue analysis

Tissue Analysis
How to Take Sample

- Snap off 10 to 12 leaves total
- Not more than 1 per plant
- Randomly selected from throughout greenhouse
- Choose leaf just above golf ball sized fruit
- Send to laboratory for analysis

12/14/2018

What Makes Good Tomato Flavor?

- Correct fertility
  - Not too weak
  - Increasing EC improves flavor
- Correct pH
  - Lower pH (more acid) improves flavor
- Maturity - vine-ripened
- Lots of sun
  - Plants turn sunlight into sugar
  - More sun → more flavor

12/14/2018

Have A Support System*

- Wire Height
  - Average – 7 feet high
  - Higher for the taller grower
  - Lower for the shorter grower
- Be sure it has good support
  - 600 plants with fruit load can weigh 3 to 4 tons!
- 3 feet apart in V-formation over row
- Tie strings to wire above and clip to base of plant

*note: this does not refer to group therapy, but that may be useful as well

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Tomato Pruning & Training
for the greenhouse

- Train to 1 main stem!
- Remove suckers once/week
- Tie top of string to horizontal wires overhead
- Tie or clip bottom of string to base of plant
- Attach under a leaf, NOT under flower cluster or fruit which can cause damage.
- Once per week, either add plant clip OR twist string around stem, *always in the same direction.*

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Maintain Your Equipment

- Heaters
  - Should be ready in advance of need
- Fans
- Vents
- Emitters
- Injectors
- Pumps

12/14/2018

Be A Worrier!

- Check your work.
- Use pH and EC meter to check nutrient solution daily and after mixing.
- Use a gallon jug at 1 emitter to check volume per day.
- Walk the greenhouse every day.
  - Look for wilting plants.
  - Look for critters.

12/14/2018

Use Diagnostics Resources When Needed

- Local County Agent or Area Horticulture Agent
- Extension Vegetable Specialist
- Digital diagnostics (pictures)
- Diagnostics laboratory (samples)
- Friends in the business

You Are Not ONLY A Grower

You Are Also A…

- Seller
- Marketer
- Promoter
- Industry Representative

Know Your Product – What's So Good About It?

- Vine-ripened
- Good red color
- Great flavor
- Locally grown
- Not breakers or gassed
- Uniform size and shape
- Nutrition & health benefits
- Excellent quality

higher quality --→ higher value

12/14/2018

Sell Quality

- Grade your fruit well.
- Do not sell cull or #2 and #1 fruit to same buyer.
- Build your reputation for high quality.
- Keep your customers happy.
- Aim for repeat business!
- Develop a brand name customers associate with high quality.
- Logo!

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Know When to Harvest

- Red – same day retail
- Light red – retail and close wholesale
- Pink – wholesale close and mid range
- Turning – wholesale long range
- Breaker – never
- Green – NEVER EVER
  - Well, except for fried green tomatoes

Use Stickers for Promotion

Cost per sticker

For round 3/4 inch label…

- 0.2 cents per sticker (i.e. 5 for a penny; including the plate charge)

Publication Resources

- Greenhouse Tomato Handbook
- Tomato Troubles: Common Problems with Tomatoes *(NEW!)*
- Greenhouse Tomato Growers' Glossary
- Environmental Control for Greenhouse Tomatoes
- Greenhouse Tomatoes – Pest Management in Mississippi
- Budget For Greenhouse Tomatoes

All are on the web site

12/14/2018

Greenhouse Tomato Handbook

MISSISSIPPI STATE UNIVERSITY EXTENSION

Greenhouse Tomato Handbook

Also available in Spanish

Internet Resources

- **Greenhouse Tomato FAQ**
  http://extension.msstate.edu/crops/commercial-horticulture/greenhouse-tomatoes
- **Facebook**
  www.facebook.com/GreenhouseTomatoShortCourse

12/14/2018

Greenhouse Tomato Survival Kit
10 DVD Set

http://greenhousetomatosc.com (click DVD tab)

12/14/2018

Thanks for coming.

Questions?

GREENHOUSE TOMATO PROBLEMS & SOLUTIONS

Richard Snyder
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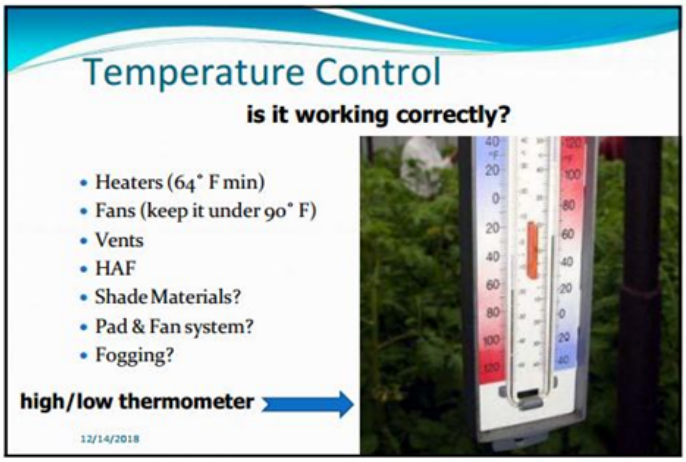
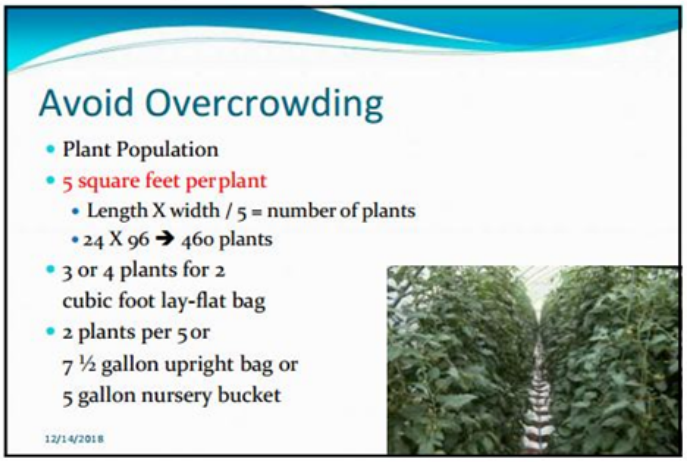
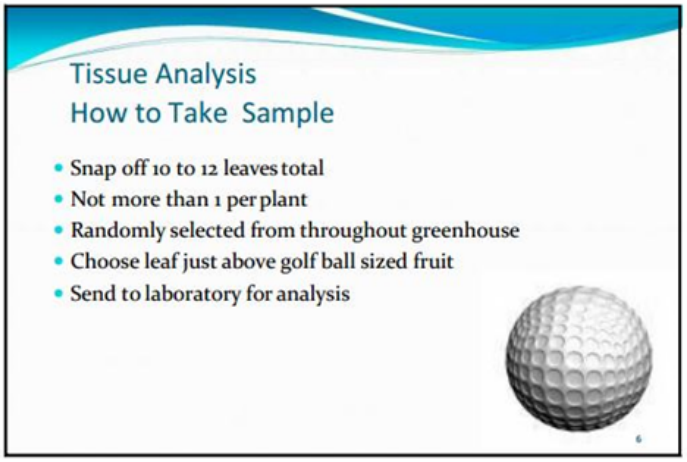
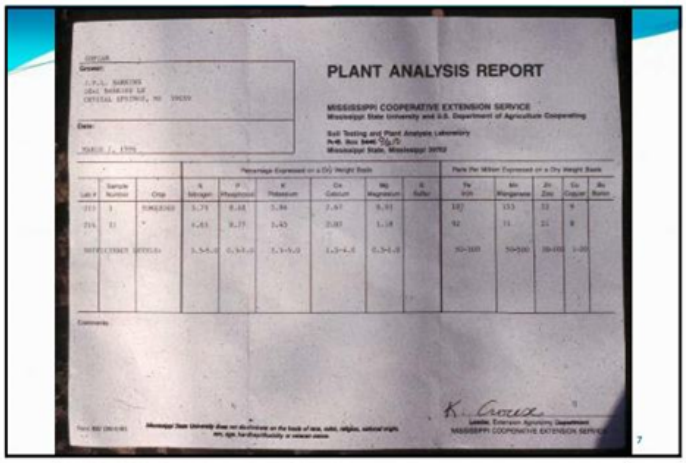
P.O. Box 231, Crystal Springs, MS 39059 / Rick.Snyder@msstate.edu





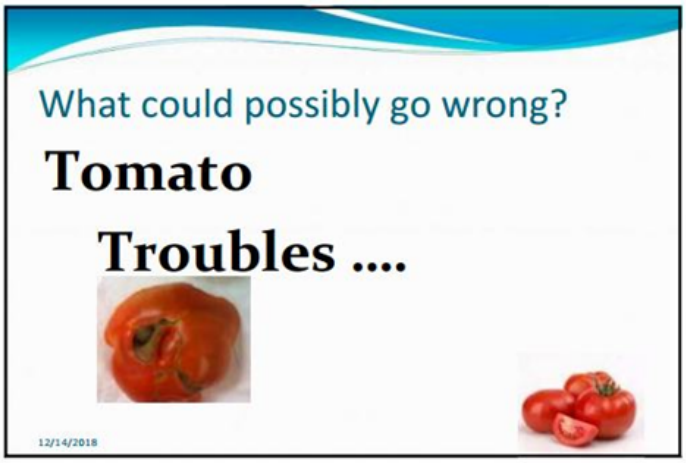


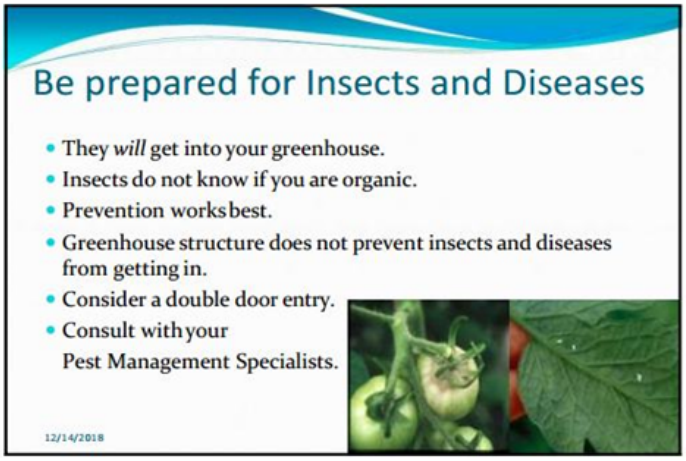
Dr. Rick Snyder has been a Professor and Extension Vegetable Specialist at Mississippi State University since 1988, specializing in greenhouse vegetable Extension and research. He has coordinated the annual Greenhouse Tomato Short Course (http://www.greenhousetomatosc.com) for 28 years in Jackson, Mississippi each March, a national conference for greenhouse growers, and has written numerous publications on greenhouse tomatoes including the Greenhouse Tomato Handbook. Originally from Connecticut, Dr. Snyder earned his B.S. degree in Horticulture at the University of Connecticut, M.S. in Greenhouse Vegetables at Ohio State University, and Ph.D. in Vegetable Crops at Cornell University. Snyder has served as Secretary/ Treasurer of the American Greenhouse Vegetable Growers Association, on the Board of Directors of the American Society for Plasticulture, and coordinated Greenhouse Tomato Seminars in Montreal (1995), Denver (1996), San Juan, Puerto Rico (2003), and Trinidad (2010). He has been an invited speaker in 21 states as well as in Mexico, and has served as the greenhouse vegetable columnist for American Vegetable Grower Magazine since 1998.

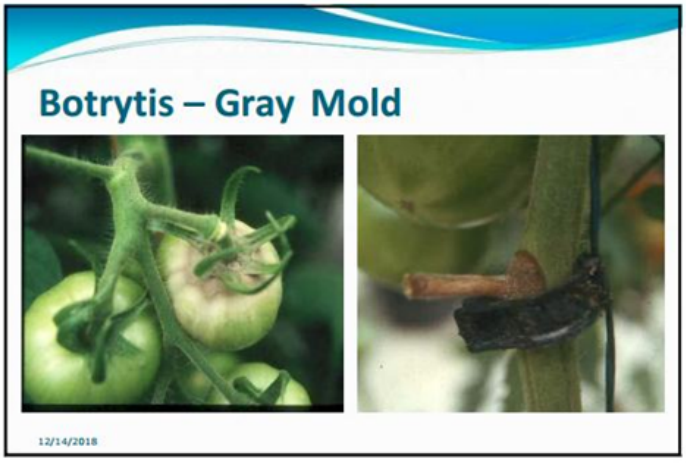

PLANT ANALYSIS REPORT

MISSISSIPPI COOPERATIVE EXTENSION SERVICE

Soil Testing and Plant Analysis Laboratory







Tomato Spotted Wilt Virus

- Numerous dark spots
- Begins on younger leaves
- Leaves droop (wilt)
- Fruit with ring spots
- Plants eventually die

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Target Spot / Early Blight

- Leaf lesions appear like a target (bull'seye).
- Starts on lower leaves.

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Disease Management in the Greenhouse Environment

- Environment is hot and humid.
- Moist leaf surfaces promote disease development.
- Maximize ventilation!
- Cooling and drying will avoid disease and cure it faster.
- Remove lower leaves to improve air movement.
- Use HAF fans.

12/14/2018

What is it?

12/14/2018

Blossom-End Rot

- Blossom-end brown to black, dry, sunken, leathery
- Lack of calcium *in the fruit*
- Keep calcium level up in fertilizer (150 to 200 ppm)
- If water source is high in Ca, use less from fertilizer.
- *Nitrogen*
  - *Do not overfertilize with nitrogen.*
  - *Do not use too much ammonium.*
- Avoid uneven water (dry periods)
- Don't let plants wilt.
- *Need young, actively growing roots for calcium uptake.*

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What is it?

12/14/2018

Fruit Cracking/Splitting

- Radial cracking
- Concentric cracking
- Avoid sharp changes in water.
- Avoid wilting.
- Splitting is only skin deep.

12/14/2018

What is it?

12/14/2018

Catfacing

- Irregular, malformed fruit, especially on the bottom; crevices, scars, etc.
- Caused mainly by cool temperature (early fruit especially); can be caused by very high temperature, too.
- Some varieties more susceptible
- Fruit still tastes fine.

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Leaf Roll

- Often starts at the bottom and moves up.
- This is *not* a disease; it is physiological.
- Usually occurs with wet soils, high fertility.
- Looks bad, but does not reduce yield or fruit quality.

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Blossom Drop

- Flowers fall off --> reduces yield
- Temperature too high or too low
  - Day temp above 90° or night temp above 75°F interferes with fruit set.
  - Night temp above 64°F is ideal in greenhouse.
- High humidity
- Too much or too little nitrogen
- Any stress can cause flower drop.

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Small Tomatoes

- Fertility?
- Water?
- Poor Pollination?
  - Slice fruit transversely.
  - Check for seed numbers.
  - Other symptoms: angular, flat-sided fruit.

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What is it?

12/14/2018

Leaf Yellowing – Interveinal

- Upper Leaves
  - Iron deficiency – starts at base of leaflets
  - Manganese deficiency – starts at tips of leaflets
- Lower Leaves (or mid range)
  - Magnesium deficiency is most common culprit, especially at or after 4th cluster set.

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Leaf Yellowing – Not Interveinal

- Nitrogen deficiency – general yellowing
- Senescence – bottom leaves turn yellow
  - Natural death, promoted by aging and shade
- Disease
  - Most often Early Blight / Target Spot
    - First, small brown circles on lower leaves
    - Then, larger brown circles
    - Then, yellow leaves
    - Leaf drop
    - Finally, it progresses up the plant

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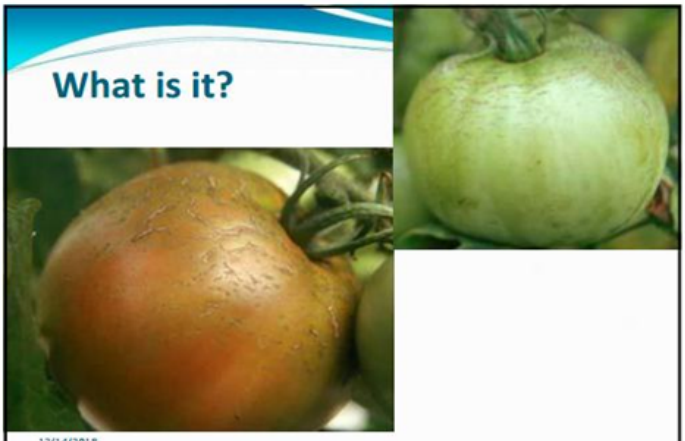
Uneven Ripening

- Green stripes, streaks, blotches, stars, shoulders, etc.
- May be caused by high fertility (N), low potassium, high temperature (lycopene killed), viruses, white flies.
- Maintain correct fertilizer.

12/14/2018

What is it?



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Russetting

- Many, very fine cracks on fruit surface
- Causes water loss; poor shelf life
- Believed to be due to
  - Moisture on fruit surface
  - Topping plant along with all suckers
- Use HAF fans.
- Leave 2 leaves above highest cluster at topping.

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Sun Scald

- White blistered area on fruit
- Can turn leathery, can be invaded
- From fruit exposed to the sun
- Keep good leaf cover.
- Do not prune too heavily.
- When topping, leave 2 leaves at top.

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Wilting – several possible causes

Abiotic (physical damage)

Biotic (disease)

Carbon Monoxide / Ethylene

Use a Vented Heater ONLY

- Heaters must be vented to the outside with a stack.
- Do not use any space heaters in the greenhouse which exhaust into the greenhouse.
- Do not use so-called "100% efficient heaters".
- Ventless heaters may be ok for chickens, but NOT for tomatoes.
- Ethylene and carbon monoxide in exhaust gas will kill flowers, severely reducing yield.

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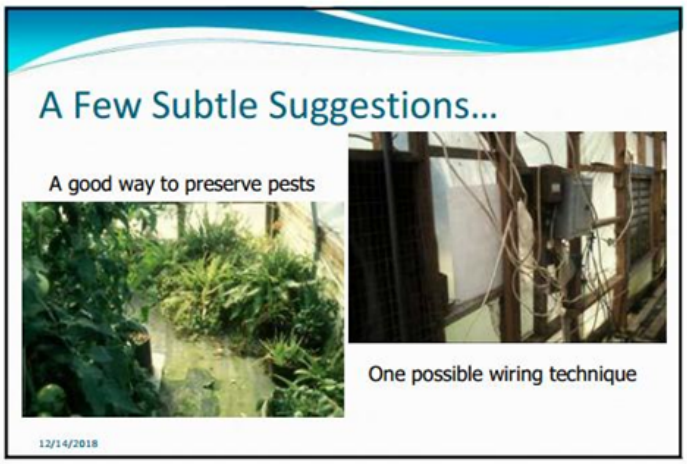
Cold Damage--Oedema

Spray Injury / Burn


What is it?


A Few Subtle Suggestions...
A good way to preserve pests
One possible wiring technique
12/14/2018


Use Diagnostics Resources When Needed.
Local County Agent or Area Horticulture Agent
Extension Vegetable Specialist
Digital diagnostics
Diagnostics laboratory
Email list
Friends in the business


Publication Resources
Greenhouse Tomato Handbook
(Guía del cultivo del tomate en invernaderos)
Tomato Troubles: Common Problems with Tomatoes
Greenhouse Tomato Growers' Glossary
Environmental Control for Greenhouse Tomatoes
Greenhouse Tomatoes - Pest Management in Mississippi
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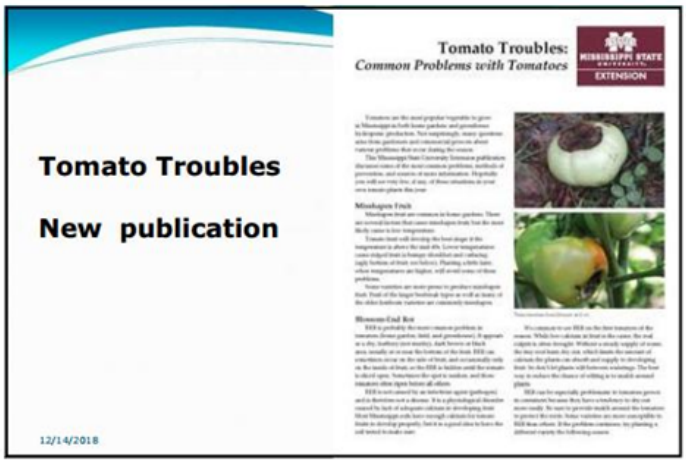
Tomato Troubles
New publication
12/14/2018
Tomato Troubles:
Common Problems with Tomatoes
MISSISSIPPI STATE UNIVERSITY
EXTENSION


Internet Resources
Greenhouse Tomato FAQ
http://extension.msstate.edu/crops/commercial-horticulture/greenhouse-tomatoes
Facebook
www.facebook.com/GreenhouseTomatoShortCourse
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Greenhouse Tomato Survival Kit
10 DVD Set
SURVIVAL KIT
SURVIVAL KIT
http://greenhousetomatosc.com (DVD tab)
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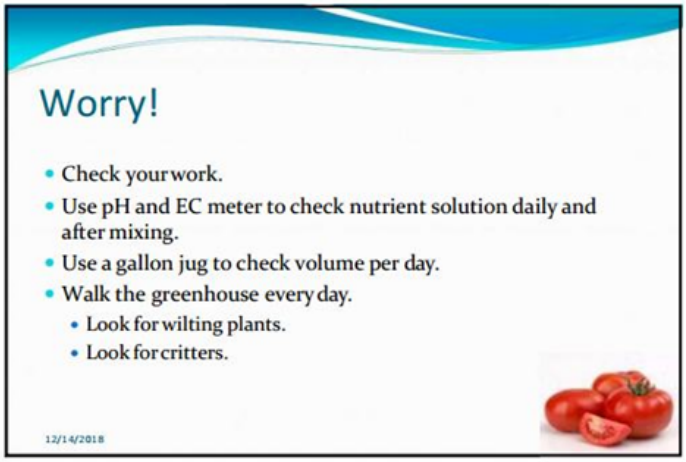
Worry!
Check your work.
Use pH and EC meter to check nutrient solution daily and after mixing.
Use a gallon jug to check volume per day.
Walk the greenhouse every day.
Look for wilting plants.
Look for critters.
12/14/2018


Questions?
Thanks for coming!

USING BIOPESTICIDES TO MANAGE GREENHOUSE VEGETABLE INSECTS, MITES AND DISEASES

Steve Bogash, Territory Business Manager, Marrone Bio Innovations

Proactive growers that pay careful attention to fine details can effectively manage most greenhouse pests using a biologically-based fungicide program. Management at the level necessary to make this work well requires the coupling of good sanitation practices and active management of ventilation as well as other BMP's along with the biological fungicides, insecticides, and miticides. Diseases like Late blight may require specific systemic materials that are outside of those considered to be biological, but Late blight is an unusual disease indoors. The practices described in this article are largely based on growing vegetable transplants in greenhouses as well as producing fruiting tomatoes, peppers and cucumbers under high tunnel and greenhouse conditions. Most of these biological materials have broad enough labels or specific formulations that enable them to be applicable in ornamental greenhouse production.

Direct application of beneficial fungi and/or bacteria to soil, potting media, and plant foliage is a practice which is rapidly catching on with producers. The methods and philosophy of using biofungicide drenches such as Actinovate AG™ RootShield Plus™ and TerraGrow™ are distinct from our past practices of starting with "sterile" media and fighting to keep it clean. We've typically fought the plant disease wars through the application of various chemical fungicides in rotation as we attempt to slow the development of resistance. With materials such as these drenches application is required prior to any suspected infection as these materials boost plants abilities to prevent infection.

Biopesticides have unique modes of action (MOA) that can provide levels of pest management not possible with our traditional fungicides, insecticides and miticides. Some are living organisms, others are plant and microbial extracts. However, they are different enough from conventional pesticides that their application requires strict adherence to the labeled application instructions. Often pH, tank mixing, and surfactant instructions are very precise in order to reach maximum efficacy. Even with these challenges, field experience has proven that these biological materials can provide pest management in situations where traditional chemistries have failed to do so. Also, since they are living or extracts from living materials, many of these biological materials have short storage lives and specific storage instructions. Consult the label and manufacturer for storage instructions and active lifespan.

How biological fungicides / bactericide work (modes of action):

Direct Competition: Before infection can occur, the pathogen must gain access to the root zone, then penetrate plant tissue. An effective biofungicide will grow faster than the pathogen and out compete it for nutrients and space.

Antibiosis: Some biological materials produce chemical compounds such as antibiotics and toxins that kill or inhibit pathogen growth. These compounds can prevent germination of fungal spores or restrict growth.

Predation and or Parasitism: Some materials such as Actinovate AG, Root Shield Plus, and TerraGrow™ claim that their materials actively seek out pathogens and destroy them.

Induced Resistance: While plants do not have immune systems like animals, they do have defense mechanisms. Certain biological controls such as Regalia™ will induce plants to produce defensive compounds such as salicylic acid

Steve retired as a Horticulture Educator and Researcher, PSU Cooperative Extension in June 2016. Since retiring, Steve joined Marrone Bio Innovations as their NE / Mid-Atlantic Product Development and Territory Business Manager. His territory runs from Raleigh, NC to Caribou, ME to the Western edge of OH. He now oversees several dozen university and private research company product trials as well as many on-farm demonstration trials using Marrone Bio Innovation products for pest management. Steve and his wife Roberta live in Harrisburg, PA and are renovating a home near the Susquehanna river built in 1933.

(similar to aspirin) and jasmonic acid. These biological pathways (SAR and ISR) turn on levers throughout plants that produce tougher plants, numerous fungitoxic and bacteritoxic compounds that travel throughout the plant and stimulate the plants own defense mechanisms prior to infection.

Disease Management Materials:

-Regalia™: (extract of Reynoutria sachalinensis). This material turns on a plants ISR biological pathways making for an overall tougher organism that is primed to fight many plant pathogens. This material has long been the base in the authors high tunnel and greenhouse protective programs. Tank mixes well with coppers and many other materials for greatly enhanced efficacy.

-Actinovate® AG: (ai: Streptomyces lydicus) The label claims efficacy on Fusarium, Rhizoctonia, Pythium, Phytophthora, and Verticillium. Used as both a root drench and foliar material. Very effective in control of specific root-borne diseases.

-Stimplex®: (extract of North American seaweed, listed AI is kinetin, a source of cytokinens) Research indicates that Stimplex and other seaweed extracts have the potential to initiate plant defense systems as well as initiate the production of cytokinens, a hormone that can boost the initiation of blossoms.

-Stargus™: (B. amyloliquefaciens strain F727) Rhizobacterium that colonies in the soil for Fusarium and other soil-borne disease prevention. On above ground plant, fruit and flower surfaces, lipoproteins and peptides created by the bacteria provide disease control.

-Double Nickel™: (B. amyloliquefaciens strain D747) Very similar MOA's to B. subtillus. Lipoproteins and peptides from bacteria provide surface control for many diseases including Powdery mildews.

-Cease® (B. subtillus strain QST 713) The spent substrate and media from this bacteria coat plant surfaces preventing many diseases. Good tank mix partner with Regalia to provide additional MOA's beyond ISR.

-RootShield Plus®: (Trichoderma harzianum strain T-22, and T. virens) preplant inoculant. These specific fungus develops a symbiotic relationship with plant roots and will continue to grow with the plant. Preventative for Rhizoctonia, Pythium and Fusarium. Also enhances the uptake of many plant nutrients. Must be kept refrigerated when not using.

-TerraGrow® :(Trichoderma spp + specific bacteria). Very similar in use to RootShield plus, but with added beneficial bacteria. Claims to be shelf stable for 1 year at normal storage temperatures.

-Coppers: (Kocide®, Badge®…….) Coppers have long been used as fungicides and bactericides and are an important component of any disease management program. Of these formulations, few have an OMRI label. The primary drawback of coppers is the tendency to stain leaves and flowers. Also, increasingly bacterial diseases demonstrate a resistance to coppers. Good tank mix partners with multiple modes of action. Both Kocide and Badge have OMRI listed versions.

-Insecticidal Soaps: (M-Pede® and others) potassium salt of fatty acids, warning label, 12 hour REI (mucous membrane irritant), works by perforating fungal membranes. Some Powdery mildew control, but not very helpful after inculant pressure reaches high levels, and the moisture and temperature conditions are near ideal for disease development. Also, be careful of overapplication as soap can damage leaf and stem cuticle. Very effective in managing soft-bodied insects and mites so long as coverage is complete.

Insect and Mite Management Materials

-Grandevo® WDG and CG (Chromobacterium Subtsugae strain PRAA4-1-T): Provides insect and mite management through repellency and agitation, gut disruption, and reduced fecundity. While slow to kill pests, they stop feeding rapidly, so the damage stops quickly. Good tank mix partner with Venerate and azadirachtin materials. Best efficacy is with a pH neutral spreader – sticker. Safe with beneficial insects

-Venerate™ CG and XC (Burkholderia spp. strain A396: Acts as a stomach poison, interferes in molting and de-

grades insects exoskeleton. Good tank mix partner with Venerate and azadirachtin materials. Best efficacy is with a pH neutral spreader – sticker. Safe with beneficial insects.

-Botanigard®, Mycotrol®, BioCeres®: (B. Bassiani): This is a living fungus that penetrates insect and mite exoskeletons through a penetration peg, then kills by spreading throughout the pest. Under ideal humidity conditions, the fungus will 'bloom' once the insect is dead and infect other insects. Not recommended with bumblebee pollinators or beneficial insects as not at all selective.

-Azadarachtin / Neem oil extracts: (Aza-Direct®, Aza-Guard™, Molt-X®,…): Provides repellency and acts as a juvenile growth hormone. Best when used with a tank partner such as pyrethrum, Grandevo or Venerate. Must be fresh as these materials degrade within a year of production. Not recommended with beneficial insects

-Oils: There are many horticultural oils on the market. Read all label instructions as there are often specific instructions based on temperature, plant stage and time of year as there is the potential to burn sensitive plant parts like flowers. Very broad spectrum and non-selective, so not useful with beneficial insects.

Our biopesticide toolbox and understanding of the best use practices for these materials continues to grow. These new modes of action are providing control for tough pests like Wester flower thrips that are now resistant to many conventional chemistries. When used with conventional materials, many make strong tank mix partners and are providing new resistance management strategies. With so many biopesticides to pull from, we can now manage many pests using solely these materials.

FARMER PERCEPTIONS OF RASPBERRY AND STRAWBERRY PRODUCTION IN TUNNELS: MANAGEMENT AND MARKETING IMPLICATIONS

Dr. David Conner
Univ. of Vermont, 205H Morrill Hall, 146 University Place, Burlington VT 05405

Growers are increasingly interested in the use of high and low tunnels to grow raspberries and strawberries. Previous research suggests a host of potential benefits to using tunnels, including improved yield and quality of berries. Much of the research has been conducted on university research plots. This project used interviews of 10 farmers who are currently using tunnels to produce berries to understand grower experiences. The farmers lived in a total of eight states: Michigan, Arkansas, New York, Kansas, Arizona, West Virginia, Minnesota and Wisconsin. Two were women; the rest were men. Area in tunnel cultivation ranged from a single tunnel of 1600 to 14,000 ft^2 under multiple bays. Results are highlighted below.

Production

- Growers report improved yield, larger and higher quality berries, and fewer culls.
- The tunnels serve as a valuable risk management tool, protecting the berries from extremes of cold, hail, torrential rain and wind. In some cases, the growers did not believe berry production would have been possible without tunnels on their farms.
- Farmers face different pest pressures in tunnels than in outdoor production. Predators like lacewings and predatory mites were effective. Certain fungal diseases can be worse in tunnels, presumably due to ventilation difficulties mentioned below. Growers recommend even more proactive scouting in tunnels than in field production to stay ahead of problems.
- Similarly, a more proactive nutrient management effort is suggested, including conducting both soil and tissue tests more frequently than in field production. High productivity and higher overall temperatures were thought to cause faster cycling of nutrients.
- The major challenges mentioned by the farmers are difficulties with mechanization and ventilation. It is difficult to fit machinery into the tunnels so more hand weeding is needed. Large scale production with tunnels may be difficult. Farmers must also be vigilant to monitor tunnel temperature and ventilate as needed.

Marketing

- Many farmers cited marketing benefits to tunnel use. The larger, quality berries are in high demand: the quality and consistency of the berries creates a branded product that people specifically request.
- By extending the season, the tunnels make berries available outside of field production periods and the berries can bring a price premium.
- Furthermore, having extended season berries can attract customers to the farmers' farm stand or U-pick operation and facilitate sales of apples, cider, jellies, jams and other products.

David Conner grew up in central Pennsylvania and holds a PhD in Agricultural Economics from Cornell and Masters in Extension Education from UVM. His professional interests span the economics of sustainable food systems from farm to fork. David lives in Burlington with his three children. In his spare time he enjoys spending time with his family, especially hiking, making music and gardening

Implications

- Start small. Try out tunnels on a small, manageable, lower-risk scale.
- Expect a learning curve. Things move faster in a tunnel; be prepared to learn.
- Key research needs include improved ventilation and automation.
- Growers with these attributes are most likely to be successful with tunnels:
    - small scale,
    - relying on direct and other local markets,
    - in geographic areas with strong local food markets.
- Early adopters in an area may gain most benefit.

For more information on production of berries in tunnels, visit www.tunnelberries.org.

Additional details will be available in the full article:

Conner, D. and Demchak, K. (Accepted for publication October 2, 2018). Farmer Perceptions of Tunnels for Berry Production: Management and Marketing Implications. *HortTechnology.*

This work is based upon research supported by the U.S. Department of Agriculture, National Institute of Food and Agriculture, Section 7311 of the Food, Conservation and Energy Act of 2008 (AREERA), Specialty Crops Research Initiative under Agreement 2014-51181-22380.

NOVEL CULTURAL MANAGEMENT TECHNIQUES FOR JAPANESE BEETLE AND SPOTTED WING DROSOPHILA (SWD) IN HIGH TUNNEL RASPBERRIES.

Maria Cramer, Kathy Demchak, Richard Marini, and Tracy Leskey

This research was conducted at Penn State's High Tunnel Research and Education facility as part of the Specialty Crop Research Initiative project "Improving the Protected Culture Environment for Berry Crops." In this part of the project we focused on pest management; how qualities of plastic films can impact pest presence, and how cultural techniques such as harvest frequency and use of attracticidal spheres interacted with plastic type to affect SWD infestation.

The effects of UV-blocking plastic films on insects.

Plastic films that have different light-transmittance properties can affect plants and pests. Ultraviolet (UV) light is important for insect navigation, so plastics that block UV light may interfere with their movement. Past studies with greenhouses found that films that block UV-A light can reduce whiteflies, thrips, and aphids. UV-A light was found to trigger dispersal, and without it, some insects may not spread and cause damage. In 2016 and 2017 we investigated whether different plastics affected populations of Japanese beetles and SWD.

Types of plastics we investigated.

We looked at plastics that transmitted different amounts of the UV-spectrum. UV-light is light that we can't see, with shorter wavelengths than "visible light", the range used for photosynthesis. However, insects see and use UV light in the UV-A range (the part of UV closer to visible). UV-B light is important for plants and fungi but is not the part of UV that affects insects. All of our plastics blocked some amount of UV-A, ranging from 26% to 93%.

Effects on Japanese beetles.

We found that plastics that blocked more UV-A light did reduce numbers of Japanese beetles on the plants. Our high tunnel films that blocked the most UV-A had 75-94% fewer beetles compared to those that blocked the least. In these tunnels Japanese beetles were extremely scarce and caused minimal damage while being removed every 4-5 days by hand. All of the plastic films reduced Japanese beetles compared to uncovered raspberries (at the minimum, reducing them 44%). Japanese beetles are known for being especially dependent on bright sunlight in order to fly. They tend to feed on leaves that are in direct sunlight, and usually are most active on sunny days. Light intensity is important for host selection, and our research suggests that one aspect of that is the amount of UV-A light present. It is likely that the reason for this is the ability to navigate to the host.

While the most UV-blocking plastic used in this research is not commercially-available, one of our partially-blocking plastics is. Further, any tunnel is better than field production. We also found that the commercially-available "Kool Lite +" plastic does not decrease Japanese beetles more than "TuffliteIV."

Effects on SWD.

We found that SWD tended to be more abundant in field plantings than in the tunnels in 2016 and more abundant in the tunnels than in the field in 2017. This could have been due to a number of factors: temperatures were generally higher in 2016, and the high tunnels may have been too hot for SWD. SWD have a developmental threshold around 86 °F, so with higher temperatures the tunnels were probably too hot for them for longer periods. They're still present in tunnels because they "hunker down" in lower portions of the canopy to avoid the heat, but their development is favored by cooler temperatures. They also may have been more abundant in the tunnels in 2017 because fruit yields were much higher in the tunnels. The abundance of fruit may have attracted more of them. Also, the plants in the tunnels were very large and provided a humid, shady environment which SWD prefers.

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The different plastics didn't affect the numbers of SWD in the tunnels, although there was a trend of the most UV-blocking plastic having the lowest numbers in 2016, but the highest in 2017. It isn't clear from this whether UV-blocking plastic is actually changing SWD preference for certain tunnels, but it seems unlikely since the trends were different in the two years.

Based off of these results, it appears that high tunnels can have lower SWD numbers than in the field, but the tunnels need to be carefully managed for sanitation. Pruning out excess growth may help, and all ripe and overripe fruit should be removed quickly. The benefits from growing in tunnels might depend high temperatures as well.

Combining UV-blocking plastic, attracticidal sphere, and harvest interval for controlling spotted wing drosophila in high tunnels.

There are a number of control approaches to SWD that are less disruptive than spraying insecticides, but they don't provide complete control on their own. We initially hypothesized that UV-blocking plastics might be such a control and that they could be combined with other partial controls to eliminate SWD infestation without sprays.

Attracticidal spheres.

Attracticidal spheres are a technology being developed by the USDA for SWD. They are round spheres, like those used as sticky spheres for apple maggot, with a cap made of wax, sugar, and a pesticide. When rain wets the wax cap, the sugar melts, coating the sphere and carrying the pesticides. SWD is attracted to the shape and color of the sphere and when the flies land they feed on the sugar and are poisoned. Spheres have been effective in field raspberries, but we wondered whether they would work in high tunnels without rainfall. A drawback to the spheres is that they are still in development and aren't currently available. They also are being developed with the pesticide Delegate and are unlikely to be available with an organic active ingredient.

Harvest interval.

Shortened harvest intervals have also reduced SWD infestation. At the research farm we harvest three times per week, but other studies and many growers harvest every other day or daily to reduce the amount of time that SWD can lay eggs in the fruit. We wondered if the combining daily harvest with the other treatments might bring infestation to a tolerable level.

Impact on marketable fruit.

Our proportion of marketable fruit was significantly higher (17-32%) when fruit were harvested daily. Spheres and the type of plastic used didn't impact the proportion of marketable fruit. Daily harvest probably increased the proportion of marketable fruit because less fruit was infested. Most of the fruit we considered unmarketable was the characteristic "melting", overly soft fruit associated with SWD infestation, but also included fruit that was simply missed in an earlier harvest, affected by mold, or that was considered too small, crumbly, or misshapen.

Impact on infestation.

We found that using spheres and harvesting daily consistently decreased the amount of fruit that was infested. Fruit harvested daily tended to be about 28-30% less infested. Despite only extracting larvae from marketable fruit, more larvae were present in fruit picked three times a week, even without outward signs of infestation.

Using spheres also decreased infestation from 31-48%. Without spheres we had 50-65% infestation of the fruit, and with spheres it was 26-45%. This showed that the spheres do work in the tunnels. Our procedure of initially spraying them with a spray bottle of water, and then spraying them more on hot, dry days seemed to be sufficient. We also found that during rain or particularly humid and overcast weather the spheres were kept wet by moisture in the air and were even dripping sometimes. The spheres had some impact on non-target pests. We frequently saw other flies, and occasionally lady beetles and moths feeding on or poisoned by the spheres. It is likely, however, that the impact of the spheres was less significant than applying a pesticide spray to the entire planting.

Plastic didn't impact infestation of the marketable fruit or the number of adult SWD captured in vinegar traps. When we investigated how infested the unmarketable fruit was, we found that UVT plastic that transmitted UV

plastic had lower infestation rates (46% lower). This may mean that SWD not only don't need UV-light to navigate, but that they may prefer to avoid it for activities like oviposition. Although it's hard to make a conclusion from these results, it seems likely that the standard plastics in use in our area are as good as any for SWD control.

Impact of time.
We found that infestation decreased over time. We repeated the experiment twice, and both times infestation started off high and then fell. This was true with all of our treatments, which may have been a "spillover effect," with one treatment decreasing SWD in treatments nearby. Another reason why infestation might have decreased was that during our experiments we harvested more regularly and removed all fallen fruit. Our heightened level of sanitation probably decreased infestation. This is encouraging, because it suggests that if treatments and sanitation are maintained throughout the season, SWD numbers and infestation can be kept lower.

More information on plastics, sources, and this research can be found on Tunnelberries.org

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NEWER RASPBERRY VARIETIES FOR HIGH TUNNELS

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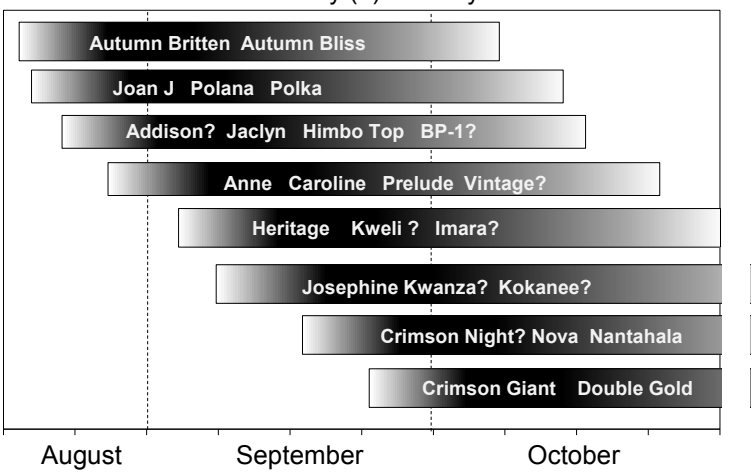
Raspberry varieties are either primocane fruiting (bear on the current year canes in the fall) or floricane fruiting (bear on two year-old canes in the summer). Of course, some primocanes can be retained over winter and fruited as floricanes the following summer. Growing plants for primocane plus floricane fruit is refered to as double cropping. Quite a few primocane varieties have become available recently in addition to a few floricane types. Primocane fruiting types are popular because pruning costs are low, but fruit also ripen late in the season when spotted wing drosophila populations are high.

The information below is from multiple bay high tunnels in southern Michigan. I think the information is generally applicable to areas with similar climates. Some varieties were grown in the ground whereas others were grown in 3 gallon pots of media. One general observation we have made is that relative differences between types tend to be similar whether in open fields or tunnels or grown in the ground or in containers. The work is part of the Tunnel-Berries project (www.tunnelberries.org), funded by a grant from NIFA Specialty Crop Research Initiative.

HARVEST TIMES

Primocane fruiting varieties need to ripen early enough in the fall to yield well for your region. Earlier maturing types are best for short growing season locals, and early and later maturing types are suitable where seasons are longer. The chart below provides general harvest times for primocane fruit in southern Michigan. Move the bars to the right in more northern locations. As a general rule of thumb, early primocane fruiters produce shorter canes that have less fruiting potential as floricanes, so they are not as good as later maturing types that produce taller canes that can yield more in the following year.

General harvest times for primocane raspberries in high tunnels in southern Michigan. Relative harvest volumes increase with bar darkness. Varieties followed by (?) are only estimated.



Early Primocane types

Joan J matures a little earlier than Polka. Berries have excellent flavor and firmness but their darker red color may not appeal to some customers. Plants have modest vigor and cane height, and canes are thornless.

Polka has performed best for us. It is high yielding and has a relatively long fall cropping season. Berries are large

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and firm and have an attractive medium red, glossy surface. Polka produces abundant canes that are only medium in height. The plants are very susceptible to damage from potato leafhoppers.

Himbo Top matures a few days after Polka. Berries are large and lighter red, but have an average flavor and are less firm, so they may not pack and ship well. Canes are very vigorous and fruit are easy to see and pick.

Autumn Britten and **Autumn Bliss** are two older types. They are among the earliest maturing, but I think the varieties above offer higher yields and/or superior fruit quality. **Jaclyn** has very flavorful, firm berries but is not grown widely because yields are modest and berries are dark red.

Mid-season primocane types

Caroline been a popular variety because it is extremely productive and has an outstanding flavor. Berries get relatively little gray mold but they are a little soft. Plants produce abundant canes that are medium in height.

Anne is the best yellow-fruited variety we have tested. Berries are a little soft but are large with a unique pleasant flavor. Yields are moderate and plants are not excessively vigorous.

Heritage is an old variety that fruits later than Caroline or Anne. It is a consistent producer but has mostly been replaced varieties with larger fruit. Heritage fruit have some tolerance of gray mold.

Imara and **Kweli** are new varieties from Europe. Based on potted plants in tunnels, both look to be very productive with excellent fruit quality. Fall harvest falls in the late mid-season (perhaps similar to Heritage), but **Imara** is a little earlier than **Kweli. Imara** produces very firm, uniform medium red, glossy berries. **Kweli** is also very firm but perhaps a little darker red. Both appear to be good choices for double cropping since the primocane and floricane yields and quality are excellent.

Vintage is a new mid-season primocane fruiting variety from Oregon. Berries are a uniform lighter red with excellent flavor. **Vintage** fruit appear a little softer and the productivity and harvest times in Michigan are not yet clear.

Addison is a new variety developed in Maryland. We have limited observations to date, but Addison seems to be productive with large, firm fruit. Flavor was excellent, but the berries are a dark red, similar to **Josephine**. Fruiting season appeared similar to Heritage. Plants are moderately vigorous.

Late Season Primocane Types

Varieties maturing later than Heritage should be considered only in longer season areas and/or high tunnels. Further north, fall fruiting will begin too late to realize good yields. **Josephine** is a very productive variety with excellent flavor and fruit size. The dark red color has limited Josephine acceptance. **Kwanza** is a new European type that produces very large light red berries with excellent flavor. Yield potential from floricanes seems very high but primocane yields will be low unless the growing season is long. The drupelets are very large, giving the berries a lumpy appearance. **Crimson Night** and **Double Gold** are two interesting new late types from Cornell University. They are likely too late to grow in most of Michigan (unless under tunnels), but both produce firm, flavorful fruit. **Crimson night** is a very dark red and **Double Gold** is a yellow berry with a pink tint. **Kokanee** is a new variety from Oregon that we only observed briefly in pots. **Kokanee** appeared to ripen in the late season. Primocane berries were large, light red, and very flavorful.

Floricane Fruiting Types

Relatively few floricane fruiting varieties have been released lately. **Prelude** and **Nova** are good early season types. **Prelude** berries are a little smaller but have a slightly better flavor than **Nova**. **Nova** canes may have a little more cold hardiness than **Prelude** canes. Both varieties produce some primocane fruit. **Encore** is an excellent late season variety, with large, firm and flavorful berries. Canes are hardy enough for most sites designated USDA Hardiness zones 5 and 6. **Tulamagic** is a mid-season variety with promise, but has not received adequate testing to recommend widely.

HIGH TUNNEL DESIGN CONFIGURATIONS FOR MID-ATLANTIC BERRY PRODUCERS

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- **What is a High Tunnel?**
  - *It is a Plant factory*. Allows for a controlled environment for a specific plant that maximizes productivity and quality of that plant. Plants grown in the soil in beds, either raised or not. Primary purpose is season extension.
  - *As in any business, before you invest in this factory, you need to make sure you can get your desired Return on Investment (ROI).* ROI is anticipated revenues minus anticipated expenses = profit over a specific period of time. These profits are applied to your original investment until at some point your investment is paid off.. The more you invest, the longer it takes to pay off this investment.

- **Anticipated Revenue**
  - *Know your market (customer).* What need is there that only you can satisfy? What can you grow and why will customers buy it from you?
  - *Know your plant.* You need to grow the highest quality and most prolific plant. How will you accomplish this?
  - *Know your commitment.* How much time will you personally be able to commit to the growing of this plant? Will you be a full time or part time grower?
  - *Know your anticipated revenue*. Given the answers to the above questions, how much $ do you anticipate making off the sale of these plants?

- **<u>Building Your High Tunnel Production System</u>**
  - *Your choice of features for your "plant factory" will determine the expenses you incur*. There is a general tradeoff between material investment and labor costs. The more you invest in the quality of your systems and their automation the less in labor costs.
  - Before talking to a greenhouse manufacturer or distributor know what you want to do and let these experts guide you through the decision-making process that satisfies these goals. They should do more listening than talking
  - *The Structure*. Various designs cost more or less dependent upon what you want the structure to do for you. The larger the structure, the lower the cost per square foot. Given the plant you're growing, there is an optimum size and desired features. Features include: height, width, snow load, wind load, support trusses, etc.
  - End walls
    - Wood, plastic and polycarbonate are most common examples. Various degrees of insulation properties for retaining heat and transparency of light. Each has its own longevity and associated cost of replacement.
    - Doors: what is coming in and out of this structure? How much space to you need?

Mike Marett, Vice President & Owner, Rimol Greenhouse Systems
- Responsible for Operations, Finance and Research & Development
- Only other former position was United States Navy (Retired)
- Bachelors Degree from The Ohio State University and Masters from Southern New Hampshire University
- Originally from New London, Ohio
- Wife, Cindy and two grown children and one attending Penn State University
- Has 3000 sq ft of high tunnel space on an acre plot, with small farm stand and two commercial veggie accounts and a passion for growing.

- Roof Covering
  - Soft "Poly" Plastic and hard polycarbonate plastic are two most popular. "Poly" is cheaper but does not last as long and requires labor to replace. Two layers have different features than one Mike Marett layer.
  - Polycarbonate is relatively more expensive but lasts a very long time
- Ventilation
  - Keeping the plant at it's optimal temperatures is one of the most important requirements of growing.
  - Options are mechanical (forced air movement) and natural air circulation.
    - Mechanical use fans.
    - Natural methods include rollup sides, doors, end wall shutters and roof ridge vents.
- Heating
  - Typically not part of a High Tunnel Production System. But can be periodically used on the front and back end of a growing system to be used as an emergency safeguard to protect plants from extreme cold temperatures and/or humidity.
  - Natural and propane gas are most popular. Oil and wood also used
  - Unit takes up space within structure and structure must be capable of supporting weight if hung from roof.
- Environmental Controls.
  - The ventilation and heating systems discussed above can be controlled by a variety of control systems in order to optimize the specific environment for your plant. These systems can also control other factors such as humidity, wind speed, light and can even monitor plant health and security.
  - More capability equates to more cost but less worry.

- **Make Your Decisions and Move Forward**
  - Once you know the specifics of what you want to do and have assigned $ and "quality of life" factors to each decision, do you move forward?
  - Whatever you choose, be prepared to fail, learn from your mistakes by talking to others and research. Try new methods and products until you find what works for you. There is no one "right way". There is only "your way".

Above all, you must have a passion for what you are doing and have fun doing it.

CULTURAL AND CONVENTIONAL WEED MANAGEMENT STRATEGIES FOR BLUEBERRIES

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Blueberries are slow growing plants that do not compete well with weeds. Since they are long-lived plants, perennial weeds always become problems in older fields. Birds often spread noxious weeds such as Virginia creeper, poison ivy and brambles by dropping seeds. I will review a few aspects of cultural and chemical blueberry weed management here. Before using any herbicide, make sure it is legal for your state; some labels vary by location.

The standard weed management system for blueberries in Michigan includes early season applications of judiciously chosen pre-emergent herbicides. Some growers use organic mulches to suppress weeds and some have begun planting on raised beds covered with weed barrier fabric. Row middles are usually maintained in a cover such as fall planted annual rye or permanent sod.

NEW PLANTINGS

Take advantage of the pre-plant period to eliminate perennial weeds from the site. Often a combination of cover cropping, cultivation and Roundup applications do best. Once bushes are planted, use herbicides judiciously because small plants are more susceptible to herbicide injury than large plants.

Safer preemergent herbicides for new plants include Surflan, Trellis and Devrinol. Trellis will be most useful for control of annual broadleaf weeds (common lambsquarters, ragweed, black nightshade and smartweed) whereas Surflan and Devrinol are stronger on annual grasses. Apply these before weeds emerge in the spring.

If grasses become a problem in young plantings, consider Fusilade (non-bearing only), Poast or SelectMax. Apply these to young, actively growing grasses for best results. Glyphosate products can be used in new plantings, but I would avoid them. Even a small amount of glyphosate on blueberry leaves or stems will kill plants or delay growth for several years.

In years two or three, plants are still small and easily injured, but several more effective preemergent herbicides can be used with caution. These include several older materials such as Princep, Karmex, Sinbar, and Solicam, and some new ones such as Dual Magnum, Matrix and Sandea.

ESTABLISHED PLANTINGS

Quite a few herbicides are available for established plantings. In addition to older materials (Princep, Karmex, Sinbar, Solicam, Casoron), several new products are available. The key is to choose products that best match the mix of weeds. Think first about combinations that provide suppression of grasses and broadleaf weeds. Princep and Karmex are stronger on broadleaf weeds, whereas Sinbar and Solicam are effective on grasses. If preemergent herbicides are chosen properly, annual weeds can be controlled adequately with an application in April or May.

NEWER PRODUCTS

Zeus XC (sulfentrazone) is labelled for blueberries that have been in the field for 3 years or longer. This preemergent herbicide should be applied before weeds emerge in the spring, or tank mix with a burndown herbicide such as Gramoxone or Aim. Do not apply after petal fall unless a shielded sprayer is used. Zeus controls sedges and selected broadleaf weeds and grasses, including blueberry weeds such as annual grasses, several pigweeds, smartweeds, black nightshade, and yellow nutsedge.

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Chateau (flumioxazin) has been labeled on blueberries for a few years and now has a 7 day pre-harvest interval. Chateau controls a wide range of annual broadleaf and grass weeds. Chateau also provides some burn-down of small weeds if combined with surfactant or crop oil concentrate (COC). It will also damage green blueberry tissues if sprayed directly.

Sandea (halosulfuron) provides preemergent and postemergent control of many broadleaf weeds such as pigweed, ragweed, smartweed, and even yellow nutsedge. Treat nutsedge when 3-5 leaves are present. Two applications with non-ionic surfactant are most effective. The second application may need to be after harvest. Rates are 0.5 to 1.0 oz per acre and no more than 2 oz per year. Do not use on 'Elliott' bushes less than 3 years in the field. PHI is 14 days.

Dual Magnum (s-metolachlor) is another effective herbicide on nutsedge, but has a 28 day PHI. Use only on bushes established at least one year.

Stinger (clopyrolid) is primarily a postemergent herbicide that is strong on weeds in the composite and legume families, such as thistle, asters, dandelion, goldenrod, ragweed, clovers, and wild bean or groundnut, but also controls nightshades, smartweeds, wild buckwheat and plantain. Stinger is only labeled for blueberries in some states and has some odd timing restrictions (see chart). Stinger is a growth regulator type herbicide and is most effective when weeds are up and growing.

Matrix (rimsulfuron) controls a broad spectrum of annual grasses and broadleaf weeds. Do not use Matrix on sand soils or on bushes less than a year in the field. Apply 4.0 oz per acre once per year with non-ionic surfactant. Avoid contact with growing shoots and leaves. This product has the same mode of action as Sandea, so don't use these products together or sequentially. PHI is 21 days.

RESISTANCE MANAGEMENT

Herbicides kill weeds by disrupting specific plant processes, and they are classified based on these modes of action. If herbicides with the same mode of action are used repeatedly, resistant weed populations may develop. To avoid resistance, rotate between or use combinations with different modes of action.

REDUCED- AND NON-CHEMICAL APPROACHES

Here are some thoughts for organic growers or those wanting to avoid herbicides as much as possible. First, make sure all perennial weeds are removed from the site before planting, using cover cropping, repeated tillage and/or glyphosate applications. Weeds such as quackgrass, c

canada thistle, virginia creeper and milkweed are very hard to eradicate once blueberries are planted.

Mulching with bark and wood chips suppresses some weeds but also benefits blueberries in other ways. Surface mulch can control annual weeds effectively but many perennial weeds (e.g. quackgrass, thistle) are actually promoted by mulch. This is why it is so important to eradicate perennials before planting blueberries. Add a 2-4 inch deep layer of mulch under the bushes and supplement this as the mulch degrades. Pine or other conifer products are preferred but any locally available, economical material may suffice as long as it does not contain black walnut or weed propagules (seeds, roots). Mulched plantings usually require hand weeding as well. One caution; pulling large weeds from near blueberry bushes can disrupt blueberry roots and set plants back. Try to remove weeds when they are smaller and take care not to damage bushes.

Raised beds covered with woven weed barrier fabric are becoming more common in many areas. Fabrics control most weeds in the plant row, last many years and are permeable to rain so irrigation is simplified. Gravel or wood chips may be needed to suppress weeds in the planting holes. Growers in Michigan install trickle irrigation under the fabric. There is a learning curve for managing nutrition and water. Wood or bark mulch around the plants will help suppress weeds coming up in the planting holes.

Weeds between blueberries can also be controlled non-chemically with specialized tilling equipment such as rotary hoes (e.g. WeedBadger). The hoe moves in and out to till between the bushes. Some growers have used this system over years. Although herbicides are avoided, tilling is very time consuming and can damage roots or occasionally

whole plants. Rotary hoeing does not control perennial weeds that eventually establish in or next to the crown of the bush.

Lastly, several organically approved herbicides are on the market. From my experiences, these have limited value in blueberries. They are relatively weak burn-down chemicals that kill small annual weeds but do little to larger weeds or perennials. They also need to be applied repeatedly and are expensive.

LOW TUNNELS FOR STRAWBERRY PRODUCTION: STRUCTURES, MANAGEMENT, AND OUTCOMES

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Low tunnel systems can be purchased as a kit or homemade, but all systems tend to contain the same standard components: hoops, plastic for covering hoops, a tie-down material for holding plastic to hoops (usually twine or bungee elastics), and an anchor object for the ends of tunnels. There is also at least one commercial system that also comes with grounding stakes to hold individual hoops in place.

>> Hoops

Hoops are inserted into the ground with one leg on each side of the bed to create a tunnel frame approximately 2-3' above plants. Hoops can be purchased/built in a number of sizes and materials. The most common hoops are wire stainless or galvanized steel, which are available precut or in coils, as well as in a variety of wire diameters (gauge). Wire diameter will affect hoop durability, longevity, and possibly ease of management (depending on what width of plastic is being used. Common wire thicknesses are ~1/8" (10-gauge) smooth galvanized steel, 3/16" stainless steel, and ¼" stainless steel. Researchers in Maryland recommend ¼" for its durability during snow/ice storms, but 3/16" has been used with acceptable results in Pennsylvania as long as plastic is removed for the winter.. If cutting your own hoops, be sure to factor in at least an extra 6-12" on each leg that can be inserted into the ground to stabilize hoops.

Alternative hoop materials include ½" - ¾" electrical conduit tubing (EMT) and polyvinyl chloride (PVC). In NH, we have used both for overwintering vegetable crops but not yet in strawberry production systems. We have installed PVC over 12" pieces of rebar that were hammered into the ground on both sides of the bed. EMT can be purchased precut and bent from suppliers, or in straight pieces bent using a hoop bender. In NH, we have found that EMT can be difficult to insert into the ground, especially after the first year of use due to soil buildup inside the conduit. However, there may be tricks for managing this challenge. Additionally, commercial growers and suppliers have built completely above-ground low tunnel systems with conduit that are very stable, and also allow for the low tunnels to be moved over various plantings throughout the season. For those looking to invest in a low tunnels system that is sturdy and already has had many of the kinks worked out, at least one commercial system made of 5/16" diameter galvanized steel hoops is available.

TIPS: *A distance of 5' between hoops is recommended by commercial manufacturers. While this may seem close and it is certainly tempting to increase this distance, plastic will be more likely to blow off hoops if the spacing is increased. Hoops can be placed in the field anytime but are bothersome to navigate when planting by hand and would completely prevent mechanical transplanting. Thus, we recommend waitinguntil after planting to install them.*

>> Plastic

Plastic selection, plastic attachment, and plastic management are all important

components to building and managing a low tunnels system. The width of the plastic will depend on the hoop size.

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For the most complete protection, plastic which reaches the ground comfortably on the both sides is best. For overhead protection only, a thinner strip of plastic can be used down the ridge of the tunnel. It is important to be able to easily keep the sides of tunnels raised for ventilation. Thicker (>3 mil) plastics are heavy and will sometimes fall (if not rolled up), whereas lightweight plastics (1-2 mil) are pleasant to handle during installation and tend to remain in place when raised and lowered. It is also possible to acquire thin plastic films which are the correct width for some commercial low tunnel hoops. It should be noted, however, that thin films likely need to be replaced annually or bi-annually.

Plastic must be secured to low tunnel hoops in some way, usually with twine (not sisal) or bungee elastics. The tie-down material can be one long piece that runs the length of the low tunnel and crisscrosses back and forth between hoops, or a separate piece for each hoop. The tie-down material also needs to be secured to each hoop. For home-made wire hoops, polyethylene piping or semi-ridgid rubber pipe can be purchased and cut into small ~6" pieces, and a hole drilled perpendicularly through the tubing. The leg of the hoop is then placed through this hole and if the hole drilled is small enough, the tubing will remain snugly at the base of the hoop as an attachment point for the tie-down material. Other materials, such as rebar hooks, have been installed at the base of hoops and used for this same purpose. It is also possible to acquire hoops with a small "peg" at the base for attaching twine or bungee elastics. Another option for holding plastic in place is to use a second set of hoops that are placed over the plastic (adjacent to the first set of hoops). Challenges to this method have been reported though, specifically when it comes to ensuring plastic is held in place and does not slide off tunnels.

Since temperatures can be significantly higher under low tunnels when the sides are closed, especially when it is sunny or in the summer, it is important tunnels remain vented to prevent excessively high temperatures. There are several approaches to this. Venting both sides will allow for more air flow and keep temperatures comparable to outside low tunnels, while venting just one side makes it quick and easy to lower plastic for rain. Plastic can also be kept at the ridge of the tunnels and only lowered for rain. This may be a good strategy for producers who do not have the ability to check on the tunnels frequently, but are willing to deploy labor to lower sides periodically. However, sides must be quickly lowered when it does rain in order to reap the benefits of the low tunnels. Additionally, when we have used this method in NH and PA, wind has blown plastic completely to ground level on several occasions.

TIPS: Take caution not to damage plastic during the cutting or installation process. Dragging plastic over rocks, stakes, etc. can compromise the film enough that it can (and will!) split once

the plastic is installed over hoops and there is tension on it.

<u>The most important installation step</u> is tight installation of the tie-down material (twine, bungee elastics) at each hoop. This removes slack, keeps the plastic taut, prevents water accumulation, and prevents plastic from being blown off the hoops. A good rule of thumb is that each hoop should look like a small "wave".

The height in which the plastic is lifted on low tunnels (especially straight-sided hoops) will affect the tunnels ability to shed water during rain events. If plastic is raised too high (above the eave of the hoop) water tends to accumulate on the top of the tunnel and can stretch plastic.

Outcomes & Economics

Plastic covered low tunnels are well-suited to protect fruit during the long growing season of day-neutral strawberry varieties, but may also be useful in protecting the short and valuable June-bearing (short-day) crop. Research conducted in Minnesota, Maryland, and the Northeast shows that low tunnels can have a number of positive effects on strawberry production, including:

1. Protecting fruit marketability by keeping water of plants and fruit
2. Reduced disease incidence
3. Increased total marketable yields and fruit size
4. A higher percent of marketable fruit

5. Extended fruit production
6. Reduced runner emergence

It is important to note that not all these benefits are observed at every location and in every year, but low tunnels do seem to consistently increase the percent marketable yield, reduce direct water damage to fruit, and reduce fruit rots. Yields also tend to be higher under low tunnels, especially in the last month of the season. In 2016, for example, marketable yield of 'Albion' was similar between open beds and low tunnels in NH, but nearly double under low tunnels in PA, resulting in an additional $9,182 in revenue per acre under low tunnels (based on the reported rate of $2.90/lb; USDA, 2016). System costs vary significantly, but a high-quality kit costs approximately $20,000/acre. Thus, it is possible that low tunnels will pay for themselves over time through increased production. Alternatively, it is reasonable to assume that an acre of strawberries can net $43,500/acre (based on 15,000 lbs/acre at $2.90/lb). It is important to consider the price you can obtain for strawberries on your farm, as well as labor costs and labor availability for management. If the initial cost of the system can be absorbed/covered, low tunnels will then serve as a form of crop insurance and help support late-season production when local strawberries are not available.

We have just published a Low Tunnel Production Guide with pictures of all the systems and tips described. It can be downloaded for free at: https://extension.unh.edu/resource/low-tunnel-strawberry-production-guide

For additional information, please visit the "TunnelBerries" project web site - www.TunnelBerries.org

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DAY-NEUTRAL VARIETY PERFORMANCE IN NH AND PA UNDER OPEN FIELD AND PROTECTED CULTURE CONDITIONS

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Day-neutral strawberry cultivars can be grown successfully in an assortment of production systems. Usually they are grown in a plastic-mulched raised-bed system in open fields, but quality can be improved by growing them under low tunnels or high tunnels, and occasionally they are grown in greenhouses as well. Performance of some of the more commonly-grown day-neutral varieties in trials in New Hampshire and Pennsylvania is presented here.

Exp. 1: Day-Neutral Variety Trial

Production Methods

New Hampshire: In 2017, we conducted an experiment comparing day-neutral variety performance on both open beds and under low tunnels, using the varieties: 'Albion', 'Aromas', 'Monterey', 'San Andreas', 'Seascape', and 'Portola'. The experiment was conducted in Durham, NH (USDA Hardiness Zone 5b). Dormant bare rooted plants were planted on April 28, 2017 into raised beds covered with black plastic mulch and a single line of drip irrigation. The plant spacing was 16" between plants within row, and 12" between double staggered rows, for a total of 13,068 plants per acre (based on 5' bed spacing). The first flush of flower trusses was also removed to encourage plant establishment. Plants began fruiting 9 weeks after planting and were harvested June 28 – Nov. 8, with data collected 2x per week. The field was fertilized with 60 pounds/acre of N and P pre-plant, and 5 lbs N per week through the drip irrigation system (beginning six weeks after planting). Low tunnels were covered with a 1.5 mil transparent film that contained holes on the lower 12" of both sides. Tunnels were left fully vented for the majority of the growing season and only closed for rain and during the entire month of October. Harvests were conducted 2x per week. Plants were obtained from Nourse Farms, Whately, MA (with the exception of 'Aromas').

Pennsylvania: In 2014, an experiment evaluating low tunnel plastic types and day-neutral varieties was established on June 6 and 7 at Penn State's Horticulture Research Farm at Rock Springs, PA (USDA Hardiness Zone 6a). Varieties were the same as those used in New Hampshire, with the exception that 'Aromas' was not included and an additional variety, 'Sweet Ann', was included. Plants were 12" apart in staggered double rows 12" apart using black plastic-mulched raised beds on 6' row centers. Plastic films being tested could not be applied until July 25; thus blossoms were removed until that time so that yields reflected treatment effects. Tunnels were fully vented for the duration of the trial. Plants were harvested from Aug. 18 – Nov. 8 with data collected 3x per week until mid-October, and 2x per week thereafter The field was fertilized with 60 pounds/acre of N broadcast preplant incorporated, and 2 lbs of N per week applied through drip irrigation. Low tunnels were covered with a clear 4-mil covering. Plants were obtained from Lassen Canyon Nursery in Redding, CA.

Varieties Tested

The varieties described here are nearly all from the Univ. of California breeding program. 'Albion' was released in 2004 and quickly became a major variety in the California strawberry industry, though acreage has fallen off recent-

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ly. It can perform well in Eastern states, though yields may vary considerably depending on management. 'Seascape' was released in 1990, and has been popular with eastern growers for its sweet flavor. 'Monterey' and 'San Andreas', both of which have 'Albion' as a parent, were released in 2008. 'Monterey' is now a major variety in California, along with other proprietary varieties. 'Portola' was released in '2007'. 'Aromas' was released in 1997, and had been found to produce large very firm fruit with only fair flavor in PA. Because these varieties were not bred for the humid, rainy conditions in the eastern U.S., all are moderately to very susceptible to diseases, in particular powdery mildew and fruit anthracnose. 'Sweet Ann' was released through the private breeding program at Lassen Canyon Nursery.

Results

Variety effects: 'Albion' was one of the highest yielders in NH, where it produced a high percentage of marketable fruit, but was one of the lower producers in PA, though berry size was very large (Table 1). 'Seascape' was moderately productive in total yields; however, its small size and susceptibility to splitting and softening when conditions are rainy resulted in a low percentage of marketable fruit, especially in PA. 'Monterey' was among the highest in total and marketable yields in both states; fruit anthracnose and powdery mildew susceptibility were its main issues in PA. 'San Andreas' was similar to 'Albion' in that its performance was better in NH than in PA, though its large size and good flavor made it a favorite with harvesters in PA. 'Portola' produced the least total and marketable yields of all of the cultivars in NH. Conversely, it was the second best producer in PA, but its soft fruit, light color, extreme susceptibility to fruit anthracnose, and mild flavor made it a less-than-desirable cultivar. 'Sweet Ann' remained vegetative in the planting year, possibly due to the environmental conditions to which it had been exposed in California. This has not been the case with eastern planting stock of 'Sweet Ann', and in a later experiment in NH, 'Sweet Ann' was among the highest yielding (data not shown).

Low tunnel effects: In both states, total yield of all cultivars, except for 'Seascape' in PA, either changed very little, or decreased when under low tunnels. However, with all varieties and in both states except for 'Monterey' in PA, the % of fruit that was marketable increased by 4 to 10 percentage points under low tunnels compared with open beds. An important note: in NH, the marketable yield for each did not differ between open beds and low tunnels, but the percent marketable was statistically greater under low tunnels.

Table 1. Yield, percent marketable fruit, and mean berry weight in New Hampshire (2017) and Pennsylvania (2014) variety trials on raised beds. Low tunnels were covered with 1.5-mil or 4.0-mil clear plastic in New Hampshire and Pennsylvania, respectively.

	New Hampshire		Pennsylvania			New Hampshire		Pennsylvania	
	Open Field	Low Tunnel	Open Field	Low Tunnel		Open Field	Low Tunnel	Open Field	Low Tunnel
	Total yield per plant (lb)					% marketable fruit			
Albion	1.14	0.99	0.44	0.42		77	85	60	67
Seascape	1.18	0.79	0.70	0.83		62	67	52	59
Monterey	1.18	1.00	1.17	1.02		71	79	69	70
San Andreas	0.93	0.71	0.49	0.53		75	80	62	72
Portola	0.94	0.67	1.27	1.09		67	73	62	66
Aromas	1.07	1.04	---	---		67	81	---	---
	Marketable yield per plant (lb)					Mean Berry Wt. (g)			
Albion	0.88	0.84	0.26	0.28		13.5	12.8	20.6	20.5
Seascape	0.73	0.53	0.36	0.49		10.9	10.8	14.8	14.4
Monterey	0.84	0.79	0.81	0.71		13.4	13.5	18.4	18.5
San Andreas	0.70	0.57	0.30	0.38		14.9	13.0	22.2	21.7
Portola	0.63	0.49	0.78	0.69		11.8	10.7	19.4	17.6
Aromas	0.72	0.84	---	---		12.6	13.2	---	---

Second-year Spring Yield

In NH and PA, after fruiting ended in November, plastic was removed from tunnels and stored in the barn, and plants were mulched with straw or floating row covers, respectively, for the winter. Hoops and other low tunnel components were left in the field. In the spring in NH, mulch was removed and low tunnels were re-erected on April 3, 2018. At this point, we lowered the sides of tunnels to create warmer temperatures around plants and encourage plant growth. Tunnel plastic in PA was redeployed just prior to the first harvest as this was when row covers were no longer needed for frost protection. The first harvest in NH in the second year was May 20, 2018 and harvests continued through July 2, 2018. Harvest in PA took place from May 22 to June 10. During this period, average per plant yields for NH and PA, respectively, were: Albion: 0.12 and 0.05 lbs; Aromas: 0.37 lbs in NH only; Monterey: 0.08 and 0.07 lbs; Portola: 0.13 and 0.06 lbs; San Andreas: 0.31 and 0.20 lbs; Seascape: 0.26 and 0.20 lbs. In PA, Sweet Ann produced 0.13 lbs per plant. Aromas and San Andreas produced approximately an additional 1/3 lb per plant during this early season period in NH. An important note: varieties differed in their winter survival rate, and few 'Monterey' plants survived the winter in NH.

Exp. 2: Effects of mulch color and low tunnel covering plastic type on 'Albion'

While 'Albion' has potential to produce very high yields, it also can yield poorly. Its fruit appearance (size, shape, and color) and flavor are excellent, and this alone is enough to make it a preferred cultivar among growers. While 'Albion' fruit is produced in flushes on individual plants, plants tend not to fruit heavily or at exactly the same time, resulting in fairly even production.

Coordinated trials were conducted in 2016 and 2017 evaluating plastic mulch types (no mulch film, black mulch, or white-on-black film), in combination with various plastic films (uncovered, Tufflite IV, and KoolLite Plus, and 3 others not reported on here). In NH, 'Albion' produced comparable marketable yield on white-on-black and black mulch, but significantly more on plastic mulch than unmulched/bare-ground beds. Low tunnels did not increase marketable yields in NH, but the percent marketable yield was greater under low tunnels than open beds, by as much as 18% for unmulched beds in 2017. 'Albion' yield was strongly affected by mulch type in PA in 2016, with white-on-black producing the highest yields, and low tunnels also increasing yields regardless of plastic cover type (Table 2). KoolLite Plus tended to produce higher yields than Tufflite TIV in PA, but the effect was not statistically significant. The greater effects of low tunnels in this PA trial compared to the one above was likely due to the fact that more substantial tunnels with greater coverage were used in this trial than in the one above.

Table 2. 'Albion' total berry yield per plant (lb) and marketable fruit (%) in New Hampshire and Pennsylvania in uncovered and low tunnel raised bed production, and in high tunnel containerized production in PA in 2016 and 2017.

	New Hampshire						Pennsylvania					
Plastic Covering	Uncovered		Tufflite IV		KL Plus		Uncovered		Tufflite IV		KL Plus	
2016												
Low tunnels	lb	%	lb	%	lb	%	lb	%	lb	%	lb	%
No mulch	1.00	68	0.80	81	0.92	83	0.44	46	0.48	65	0.54	65
Black	1.11	71	1.01	81	0.88	83	0.66	45	0.91	59	0.93	62
White on Black	1.21	72	0.80	83	0.99	87	0.84	30	1.03	59	1.24	54
High tunnels									1.31	89	1.41	87
2017												
Low tunnels	lb	%	lb	%	lb	%	lb	%	lb	%	lb	%
No mulch	1.08	63	1.13	85	1.40	81	0.47	47	0.53	52	0.58	55
Black	1.57	76	1.45	84	1.51	85	0.56	43	0.51	55	0.62	50
White on Black	1.40	76	1.16	85	1.39	85	0.48	25	0.85	47	0.90	50
High tunnels									2.02	74	1.85	75

Exp. 3: Effects of high tunnel covering plastic type on 'Albion'

In high tunnel containerized production in PA, where soilless media (2:1 peat:perlite) and constant-feed fertilizer (100 ppm N) was used, total yields were much higher than in the field in both 2016 and 2017. 'Albion' did not have a preference for one plastic type over the other in the high tunnels, perhaps because with the low plant height (at ground level), effects were influenced by light coming in through the open sides of the tunnel. With earlier planting in 2017 (early May instead of early June as in 2016), total yield near 2 lbs/plant was achieved.

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DOES PLASTIC TYPE MAKE A DIFFERENCE TO HIGH TUNNEL RASPBERRIES?

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There are many plastic cover types available for use on high tunnels, and when reading literature from the manufacturers, they each sound like the best one to buy. When comparing apples to apples, or in this case, one 6-mil plastic film cover to another, does using one type of cover instead of another make any difference? Price per square foot of cover can vary quite a lot, and so can shipping costs, so it can easily cost 50% more to cover a tunnel with one type of plastic rather than another.

This has been a recurring question ever since we started growing raspberries in high tunnels. So, we began work that would help to answer this question in 2015 as part of the Specialty Crop Research Initiative "Optimizing Protected Culture Environments for Berry Crops" (www.tunnelberries.org).

We identified films that were available to growers in North America – over 50 plastics with an assortment of names and characteristics – and analyzed them for their light transmittance characteristics. It turned out that when considering light, they fell into some broad categories. We picked three that varied the most in visible and IR (heat)-transmitting characteristics, added 2 experimental ones that affected UV light, and installed each of these on three of our 17' x 36' tunnels. We also kept three uncovered, so a total of 18 tunnels were included in our study. The tunnels were covered with only one layer of plastic.

Terms Used to Describe Plastic Films. Before discussing the films we installed, it might help to understand terminology used in descriptions of their characteristics.

"Clear" means that light passes through the film without being scattered, so you can see through a "clear" plastic quite well. "Diffusing" films scatter the light, and shapes are more difficult to distinguish when looking through the plastic. Logically, one would assume that a "clear" plastic would allow more light to pass through than a "diffusing" plastic, but both can let in very similar amounts of light. You'll feel less hot in a tunnel covered with a diffusing plastic because the sunlight is spread out, and thus is less intense in any one spot. Thus, the entire plant canopy, especially when plants are tall, receives some light. Theoretically, photosynthesis should be higher as a whole in a tunnel covered with a diffusing plastic. In specification sheets for plastics, you'll often see the terms "clarity" and "haze" used when talking about these characteristics.

"Light transmission" or "light transmissivity". This is the term that tells you how much visible light – which covers the same wavelengths used in photosynthesis – gets through, and is expressed as a percentage of the light hitting the plastic that enters the tunnel. Most tunnel films transmit a high percentage of visible light, usually around 90%.

Films also vary in how much and what types of UV light – the wavelengths responsible for tanning,sunburn, and skin cancer – is transmitted, and how much IR radiation (heat) is transmitted either into the tunnel during the day (which also is affected by visible light) and out of the tunnel at night.

Plastic Tunnel Coverings Tested. Films tested were Berry Plastics Tufflite IV™ (TIV), RKW-Klerks KoolLite Plus (KLP), Ginegar Sunsaver (GSS), and two experimental plastic films, one which transmitted most of the UV light (UVT), and one which was opaque to UV light (UVO). Of these films, all were highly diffusing except for TIV. All transmitted about 85-90% of the visible light, except for KLP which transmitted about 70%. KLP also blocked some

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short-wave IR to keep tunnels cooler during the day compared to other plastics. TIV and UVT transmitted about 80% of UV-A and UV-B light, KLP blocked UV-B light but allowed most of the UV-A through, and GSS blocked some of the both.

Plants of 'Josephine' and 'Polka' raspberries were planted in grow-bags to avoid confusing differences in plastics with differences in soil nutrients in each tunnel. Plants have been growing in the tunnels since June of 2016, and data has been collected on them ever since.

Plastic covers and raspberry growth, in theory. Raspberries prefer cool to moderate temperatures, so theoretically since tunnels can get quite hot during the summer, the expectation was that plants in tunnels covered with KLP might perform best. Even though visible light levels were lower under KLP, it is generally accepted that because raspberry plants reach "light saturation" at fairly low light levels, the light reduction wouldn't matter as there would still be plenty of light reaching the plants. Further, we expected that covers that allowed direct light through would result in plants that heated up too much during the summer, and this would negatively affect their growth, so perhaps TIV-covered tunnels would be too hot and yield less. Another theory was that with diffusing plastics, since all of leaves on the entire plant receive some light, whole plant photosynthesis would be higher under a diffusing plastic, resulting in higher yields. We thought we might see some differences in spotted wing drosphila activity based on temperatures, or perhaps reduced levels of whiteflies and thrips when UV light was blocked.

What actually happened? First, to put things in perspective, it's important to note that plants in tunnels covered with any kind of plastic outyielded plants that were not covered. For 'Josephine', total yields in tunnels were 2.5 to 3 times as high as outside yields, and for 'Polka', yields were 4 to 5 times greater, depending on the plastic type. Improvements were even greater when considering marketable yields. It's likely that differences in nutrition accounted for some of the difference between indoor and outdoor yield, since plants were grown in pots, and the potting media in outside plants was subjected to some leaching from rain.

Differences between tunnels, however, were due entirely to plastic type and its range of effects. Varieties responded slightly differently. 'Polka' raspberries under Tufflite IV significantly outyielded those under any other plastic when statistical tests were run. 'Josephine' plants under the various plastics did not produce significantly different amounts, though plants under TIV and the UVO were among the higher yielding. These tended to be the warmest tunnels. When marketable yield was considered, the same overall trends still held numerically. Berry size was larger under all plastics than no plastic for both cultivars. There were some differences in percentage of marketable fruit between plastic types, but they were minimal. One exception was that on two dates in early Sept. 2018 when it was very hot, there was a larger proportion of 'Polka' fruit showing symptoms of sunscald under TIV plastic than under other plastics, though the amount of sunscald in all of the tunnels was much less than for plants with no cover. Though all of the data for 2018 has yet to be entered and analyzed, it appears that the same trends are still holding through Fall 2018.

High Tunnel Yield	Raspberry (5/26/17 – 11/8/17)				6/13/18–7/16/18	
	Total Yield		Marketable Yield		Total Yield	
	Josephine	Polka	Josephine	Polka	Josephine	Polka
	lb/lin ft = lb/plant					
Plastic						
None	1.22	0.92	0.61	0.30	0.73	0.27
Tufflite TIV	3.58	4.64	2.35	2.58	1.78	1.23
KoolLite Plus	3.01	3.96	1.85	2.23	1.37	1.18
Gin Sunsaver	3.34	3.94	2.19	2.26	1.52	0.92
UV Transmitting	3.42	3.67	2.11	2.17	1.42	--
UV Opaque	3.57	3.72	2.30	2.03	1.65	--
p(F)*						
Plastic	<0.0001		<0.0001		not yet analyzed	
Cultivar	0.0531		0.82		not yet analyzed	
Plastic x cv	0.0384		0.14		not yet analyzed	

*Numbers less than 0.05 mean results are statistically significantly different.

When looking at temperatures in the tunnels, it is likely that in the summertime, when tunnels are fully vented, some of the negative effects that could occur from high temperatures are moderated. So, it's possible that the majority of differences are due to what happens to the plants in the spring in the fall, when warmer temperatures are spurring growth rather than in the summer.

Regarding the differences between varieties – where magnitude of effects was greater with TIV on 'Polka' than for any other treatment combination – effects may have been influenced by plant architecture. 'Polka' is a shorter "branchier" variety that had a more globose shape, and tended to intercept a lot of the light that hit the plants. 'Josephine' is a taller more upright plant, and perhaps diffusion was more important to it, but not important enough to make up for other effects. It should be noted that this may have important implications for how to best trellis different raspberry varieties, or perhaps other crops. KLP plants tended to be cooler than plants under other plastics, and perhaps the reduction in light levels was simply too much.

Regarding pest complexes, the biggest differences were in Japanese beetle populations, where all plastics decreased their numbers, but those that blocked UV light resulted in the largest decreases. This could have large implications for future pest management tactics. Regarding spotted wing drosophila, there are other cultural management tactics in tunnels that have bigger effects than plastics, though there is still a lot of work to be done in this area. (See results for both of these pests in the summary by Maria Cramer.)

The bottom line. First, we should point out that we are talking about raspberries here – we don't know whether the same differences would occur with vegetable crops. Regarding raspberries: 1) Any plastic is better than no plastic. 2) The plastic that was the least expensive to obtain in PA (TIV) either resulted in higher yields, or equivalent yields, to any other plastic. So there appears to be no yield-related reason to pay for a more expensive plastic. 3) If you are trying to manage plants as pesticide-free or organically, at least for Japanese beetle control, you may want a film that blocks UV light possibly in combination with diffusing light. 4) If you own more than one tunnel, you might want to try different plastics on your tunnels in the same year to be able to make a comparison on your own farm. 5) If you live in an area warmer than central PA, consider the results cautiously, since factors like sunscald will probably become more important to you if using a non-diffusing plastic. But if you live in a cooler area, you probably don't want to go with a plastic that reduces temperatures. 6) As always, there is more work to do, and over time, we will likely better understand the reasons for the results better, so stay tuned!

For more results on this project, visit www.tunnelberries.org

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POTENTIAL OF THE STRAWBERRY ADVISORY SYSTEM FOR TIMING FUNGICIDE APPLICATIONS IN THE MID-ATLANTIC

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The Strawberry Advisory System (StAS) was developed to better time fungicide applications by monitoring infection risks of Botrytis fruit rot (BFR) and anthracnose fruit rot (AFR) based on leaf wetness duration and temperature. Users can virtualize the real-time infection risks at AgroClimate (http://agroclimate.org/tools/sas/) or through the smartphone app SAS. Free subscriptions of email and/or text-message are also available to get timely alerts for fungicide applications when AFR or BFR infection risk reaches medium or high level (Fig. 1A). According to 39 field trials conducted in Florida and South Carolina from 2009 to 2014, no significant differences were found in BFR/AFR incidences, yield and number of marketable fruit between the StAS and calendar-based treatments in each trial. However, the number of fungicide applications was reduced by 50% on average when using the StAS in comparison with the calendar-based spray schedule (Cordova et al., 2017).

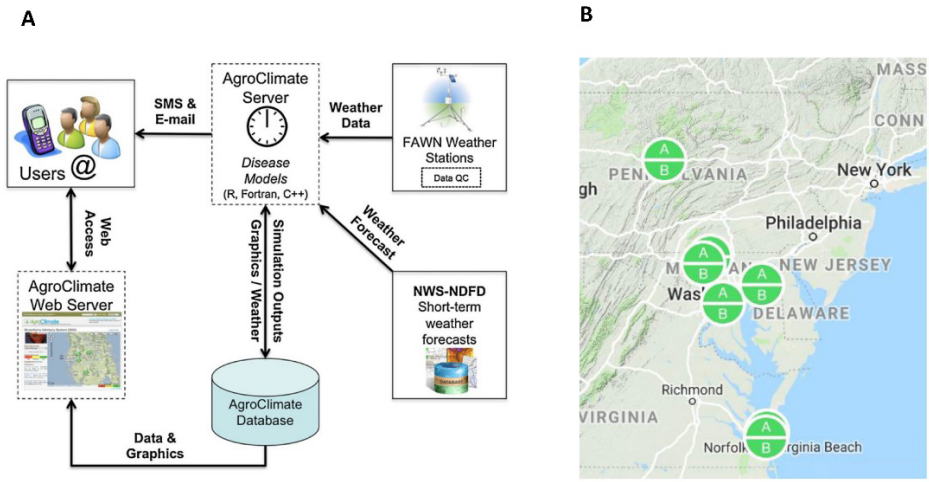

Figure 1 The Strawberry Advisory System (StAS). (**A**) The infrastructure of the StAS (adapted from Pavan et al. 2011); (**B**) StAS weather stations installed in the Mid-Atlantic.

The StAS has been very successful in limiting fungicide applications in Florida, suggesting a potential for a wider adoption. In 2016, a first StAS trial in the Mid-Atlantic was conducted at Western Maryland Research and Education Center (WMREC) on plasticulture strawberries (C.v. Chandler). The trial was repeated in 2017. Across the two years, StAS reduced fungicide applications by 50% on average. No difference was found between the StAS and the calendar-based treatments in AFR/BFR incidences, and marketable fruit yield. However, a trial conducted in Virginia in the 2016-17 season, as part of the StAS validation in the Mid-Atlantic, resulted in a negative outcome. The StAS treatment was associated with increased Botrytis and anthracnose severity compared to calendar sprays at all four locations. Higher AFR and BFR incidences were found in all sites in the StAS plots, except AFR incidence was identical at farm A site 2 (Table 1). The poor performance of the StAS may have resulted from delays in StAS sprays due to saturated soil conditions during certain days. Unlike FL, many fields in the Mid-Atlantic that have received more than an inch of rain are often too soft and wet to spray within 48 hours, a timeframe required by the StAS. In order

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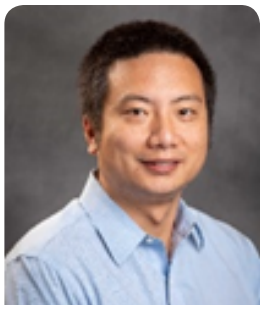

to address this issue in the following season, a spray was always made right before a likely rain event that may result in more than 1-inch of rain, if no applications were made in the last 5 days. As a result, no significant difference in BFR and AFR incidences was observed between the StAS and calendar-based sprays in the 2017-18 season (Table 1).

Table 1. Comparison of disease incidence between SAS and Calendar-based treatments, based on efficacy trials conducted in Virginia during 2016-17 and 2017-18 seasons[a].

Farm	Field	Treatment	Incidence (%)			
			2016-17		2017-18	
			BFR	AFR	BFR	AFR
A	Site 1	StAS	21	34	5.7	2.3
		Calendar-based	12	22	5.4	1.8
A	Site 2	StAS	26	24	7.1	8.2
		Calendar-based	10	24	8.1	8.6
B	Site 3	StAS	8	10	4.0	3.0
		Calendar-based	5	6	4.7	1.3
C	Site 4	StAS	9	27	13.0	7.3
		Calendar-based	4	23	7.0	5.3

[a] A, B, or C represents different farms. Strawberry varieties including Chandler, Camarosa, and Ruby June were used for the trials. BFR and AFR stand for Botrytis fruit rot and anthracnose fruit rot, respectively. The trials were conducted on plasticulture-grown berries.

Efforts have been continuously made to evaluate the StAS efficacy in Maryland. During the 2017-18 season, the validation trials were conducted at two commercial farms on matted-row strawberries and one research farm on plasticulture strawberries. BFR incidence was found significantly higher in the StAS treatment compared to GSD treatment at farm AA. It is noteworthy that one StAS application was missed at farm AA, which may have contributed to the higher BFR incidence (Table 2). At farm BB, No significant difference was observed; however, the StAS resulted in one more application (Table 2). At farm CC, significant difference was only found in AFR incidence, but marketable yield of GSD was not statistically different from the StAS (data not shown). All StAS sprays in the trials were successfully made within 48 hours after an alert of moderate/high infection risk.

Table 2. Comparison of disease incidence between SAS and GSD treatments, based on efficacy trials conducted in Maryland during 2017-18 season[a].

Production system	Farm	Treatment	Incidence (%)		Number of sprays
			BFR	AFR	
Matted-row	AA	StAS	6	0	4
		GSD	0.1	0	7
	BB	StAS	7	0	5
		GSD	8	0	4
Plasticulture	CC	StAS	1	<0.1	6
		GSD	0.7	0.4	9

[a] AA, BB, or CC represents different farms. Strawberry varieties including Earliglow, Flavorfest, Allstar, and Chandler were used for the trials. BFR and AFR stand for Botrytis fruit rot and anthracnose fruit rot, respectively. GSD stands for grower standard.

To date, there are 7 StAS weather stations installed in Maryland, Virginia, and Pennsylvania (Fig. 1B). Based on the current results, the StAS may not completely applicable to Mid-Atlantic strawberry fields. In addition to the difference in soil condition noted above, StAS may have been challenged by difference in cultural practices. In areas outside FL and CA, floating row covers are used to protect berries from frost damage during winter and spring, or to accumulate growing degree-days during fall. The StAS uses on-farm weather stations for model input (i.e. temperature and leaf wetness), which are not capable of monitoring environmental variables under row covers. Similarly, matted-row strawberry production system uses straws for frost and winter protection, which in turn alternates environmental conditions for the plants. In spite of shortcomings described here, appropriate use of the StAS will aid in decision-making, especially during flowering and fruit maturing when plants are highly susceptible and row-covers or straws are not deployed

STRAWBERRY FLOWER MAPPING: UNDERSTANDING PLANT DEVELOPMENT AND ITS EFFECT ON YIELD

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In much of the US temperate zone strawberries are grown using either the plasticulture or matted-row system. It doesn't matter which system is used, the basic goal for strawberry growers is to progress from planting a single dormant crown or a plug plant with three or four leaves on it to harvesting a beautiful 5 or 6 crowned plant full of fruit. Whether or not that goal is reached depends on meristems, groups of cells in regions of a plant where growth takes place. Cells in meristems divide and take on different functions to produce new organs such as leaves or flowers depending on where they are located on the plant and their environment.

Consider a single crowned strawberry plant. It has two types of meristems: a single terminal (apical) meristem and many axillary meristems, those found at the juncture of a leaf and the crown. The terminal meristem can remain dormant, produce leaves, become floral or produce leaves and then become floral. The axillary meristems are a little more complicated. They have a 'several step' developmental process. An axillary meristem can either remain dormant or produce two leaf primordia and then develop via one of three options. The internodes of the two-node bud can (1) remain dormant, (2) both internodes can elongate producing a runner or (3) neither internode elongates, thus forming a two-node branch crown with a terminal meristem and two axillary meristems. The terminal meristem can develop as described for the original main crown terminal meristem (remain dormant, produce leaves, become floral or produce leaves and then become floral) while the axillary meristems can develop as described above (remain dormant, both internodes elongate producing a runner or neither internode elongates, forming a two-node branch crown with a terminal meristem and two axillary meristems).

Ordinarily most folks do not think of a two-node axillary meristem as a branch crown, but that's just what it is. Only the terminal meristem of a two-node axillary meristems can become floral. Axillary meristems do not become floral directly, and as such, all inflorescences are technically terminal, even though they may appear axillary due to the short nature of a two-node branch crown. When the two-node branch crown has produced more leaves and then become floral it is more recognizable as a branch crown with a terminal floral meristem.

Even though most management decisions in strawberry production depend on the status of the meristems in each plant, this information is not readily available. Decisions rely on experience from previous seasons even though floral status varies significantly with season, plant source, cultivar, photoperiod and temperature.

The technique called 'flower mapping' provides an estimate of strawberry plant quality with respect to the number and position of floral meristems (buds) on a plant. In Europe, companies offer flower-mapping for $5.00 (US) per plant for a simple description of the floral status of the terminal meristem up to $50.00 per plant for a complete description of all meristems. The usefulness of flower mapping in European strawberry production is well documented but its value in US production has not been demonstrated. Floral status goals for plants at different stages

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of development are available for European production systems and growers utilize flower mapping to estimate plant quality with respect to production potential. Plant management can be modified to improve plant floral quality if necessary.

Once you understand the few options that a meristem has for development, you begin to understand how useful flower mapping can be. It allows you to know which option each of these meristems has become, allowing you to modify your production practices accordingly to alter the balance of meristems in each category.

While the optimum floral status for plants in different production systems has been vaguely and indirectly identified in many studies, floral stage goals need to be identified, described, summarized and verified. If this information were available via flower mapping, it could be used as a tool by growers to better manage their crop and potentially improve yield and sustainability. I have recently started a new HATCH research project devoted to developing such floral profiles. Hopefully in the years to come, I'll be able to provide this information.

The primary factors that determine meristem fate include genetics and the environment. Genetic control depends on whether you are evaluating a short-day or a long-day cultivar. Long-day cultivars were formerly known as day-neutrals, but enough evidence has been published suggesting that there are two flowering types among commercial cultivars: short-day and long-day cultivars. None of our commercial cultivars are day-neutral. The environmental factors regulating meristem fate are photoperiod, temperature and nitrogen nutrition.

Short day cultivars form flower buds when the daylength is shorter than a defined critical value. As the temperature increases, the daylength needed to trigger flower formation becomes shorter. Thus with our hot summer days, daylengths are too long for flower formation in short-day cultivars. However, development of initiated flower buds occurs under long days, so flowers formed the previous fall under short days, develop as the days grow warmer and longer in the springtime. During autumn, short days trigger floral formation and short days with warm temperatures (not cool!) trigger dormancy development which must be removed with chilling. After chilling, short-day cultivars will not initiate more flower buds, thus they do not form new flower buds in the spring. Only flower buds that were already there, often in a microscopic form, will develop.

Long-day cultivars form flower buds when the daylength is longer than a defined critical value. As the temperature increases, the daylength needed to trigger flower formation also increases. Thus with our hot summer days, our daylengths are marginal and often not long enough (when it's really hot) for flower formation. Development of already formed flower buds occurs under long days. That's why production of long-day cultivars such as 'Albion' is quite sporadic during the summer. As days begin to cool during late summer, daylengths are sufficient for both flower bud formation and development, thus plants begin to flower and fruit for a fall crop. During autumn, short days with warm temperatures (not cool!) trigger dormancy development which must be removed with chilling and plant productivity gradually declines.

In both short and long day cultivars, the response to photoperiod is both qualitative and quantitative. And that's what makes flowering in strawberries so complex. The qualitative response is like an on/off switch while the quantitative response is an increasing flowering response to conditions favorable for flower formation. There is growing evidence that these responses to photoperiod and temperature can be altered with nitrogen fertilization.

Other responses to photoperiod and temperature include runner formation and branch crown production. In short-day cultivars, runner formation is enhanced with long days and high temperatures. In long-day cultivars, short days and high temperatures favor runner production. Notice that flower formation and runner production are antagonistic to each other in both flowering types. In short-day cultivars, branch crown formation occurs when days are too short for runner formation yet too long for flower formation. In long-day cultivars, branch crowns form when days are too long for runner formation yet too short for flower formation.

To illustrate how complex the situation is, let's look at the effects of nitrogen on flower formation in both cultivar types. If nitrogen is provided a week before floral formation begins (short days for short-day cultivars and long days for long-day cultivars), floral initiation in both short and long day cultivars is reduced. If nitrogen is elevated about a week after initiation has been triggered, flower initiation is enhanced. If nitrogen is elevated too long after the initiation trigger, (2 weeks or more after the trigger) floral initiation is neither enhanced or reduced. If you knew when your plants were shifting from vegetative to floral meristems, you could provide a slight boost in nitrogen fertilization a week later that would ultimately enhance yield.

Another example: In the late summer when you plant plugs in the plasticulture system, you want your meristems to remain vegetative, producing branch crowns. Once you have a plant with five or six branch crowns, you would like meristems to transition to the floral status. If you could flower map and noticed that you were finding too many floral meristems too early, you might be able to alter the growing environment (with row covers, irrigation or nitrogen), enough to stop further floral initiation temporarily until you obtained better branch crown production.

Ultimately flower mapping will enable growers to assess meristem status at different points during the growing season to evaluate production potential. If the balance of meristems is not where it should be, steps can be taken to try and alter the balance to the desired status. As progress is made in flower mapping research and floral status goals established and verified for several production systems, the technique of flower mapping can be illustrated so that you might be able to use it in your operations. All it takes is a steady hand, some patience and a dissecting scope. I have utilized an inexpensive digital scope from Amazon that connects to your laptop or phone and costs around $40.

PUTTING FLAVOR AND DISEASE RESISTANCE FIRST IN A STRAWBERRY BREEDING PROGRAM

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For over 100 years, the USDA strawberry breeding program in Beltsville, MD, has made major contributions to the development of the strawberry as a crop. From the start, the emphasis has been on fruit quality and natural disease resistance. The first goal was strawberries that stayed red in canning or freezing, instead of turning brown. The next goal was to develop strawberries firm and tough enough to ship from the nation's main production areas in Tennessee and Kentucky to early grocery stores in Chicago, giving birth to a strawberry industry. When strawberry fields were threatened by red stele disease, USDA cultivars were the first to have natural resistance and were credited with saving the fledgling industry. The breeding program continues to emphasize fruit quality and natural disease resistance. All potential new cultivars are compared with existing cultivars in replicated plots in fields without fumigants or fungicides, are measured for fruit BRIX (percent soluble solids, a reflection of sweetness) and pH (a measure of tartness) at every harvest, and are evaluated after two weeks of storage for physiological damage and fruit rots.

Consumers sometimes complain about store-bought strawberry flavor and seem unaware that there are differences in flavor based on cultivar. Since it was released from the Beltsville program in 1975, the cultivar, Earliglow, has been known as the flavor standard for strawberry, though it rarely is available in grocery stores. In 2018, 'Earliglow' was compared with nine other cultivars evaluated for fruit quality, including flavor. The cultivars included San Andreas, commonly found in grocery stores today; Chandler, sold in grocery stores for many years prior; and some newer cultivars. The strawberries from the different cultivars were compared for appearance, flavor, and texture by a panel of trained individuals. The strawberries also were analyzed with instruments that measure several components of fruit quality, such as color, glossiness, size, texture, sugar content, and acid type and content. Both the trained panel and the instruments detected noticeable differences between the ten cultivars. Overall acceptability was most closely associated with sweetness, strawberry flavor, and overall flavor. The panel rated the USDA cultivar, Flavorfest, superior to all other cultivars, including 'Earliglow' in several categories: overall quality, overall flavor, overall texture, and overall aroma before tasting, fruity aroma, strawberry aroma, and strawberry flavor, juiciness, large size, and sweetness. The panel assessment for both size and sweetness were supported by actual measurement of strawberry length, width, and percentage soluble solids.

Kim Lewers has been the strawberry breeder and geneticist with the USDA's Agricultural Research Service at Beltsville, Maryland since 2001. She develops improved cultivars while studying inheritance of important traits. Dr. Lewers enjoys supporting the strawberry industry and other strawberry researchers as Chair of the North American Strawberry Growers Research Committee and Chair of the Small Fruits Crop Germplasm Committee. Her husband also works with the USDA-ARS. She has two grown children: a son in the US Marine Corps, and a daughter who is an aerospace engineer. She thoroughly enjoys her three granddaughters, two in Maryland, and one she's not hugged yet in Okinawa

'Flavorfest' strawberry.

'Flavorfest' is a mid-season cultivar with high yield and large fruit. Developed without fumigants or fungicides, it has natural resistance to field diseases encountered during development, including anthracnose fruit rot caused by *Colletotrichum acutatum*. 'Flavorfest' has tolerated recent heavy rains better than most cultivars. 'Flavorfest' has been widely available for several years as bare-root plants, and was sent in 2018 to the USDA's Clean Plant Network location in North Carolina to better enable access to plug-plant producers. Bare-root and plug-plant producers unable to find 'Flavorfest' plants from their usual sources can contact the Director of the Clean Plant Network's NC location, Dr. Christie Almeyda, Micropropagation and Repository Unit (MPRU), Department of Entomology and Plant Pathology, North Carolina State University, Campus Box 7903, Office: (919) 515-6822, Cell: (509) 879-4297, cvalmeyd@ncsu.edu.\

A new cultivar, called Keepsake, is the first cultivar to result from our increased effort to improve shelf life. Compared with other current cultivars and breeding selections evaluated after two weeks in cold storage, 'Keepsake' strawberries had a low proportion of degraded and decayed fruits. The fruits have outstanding flavor with very high soluble solids and moderate acidity. They have a pleasing texture and are juicy when eaten. 'Keepsake' has consistently provided competitive yields and low field decay with no fumigation or fungicides in annual plasticulture at Beltsville, MD. 'Keepsake' fruits are attractive with good size, color, gloss, and a showy calyx. They are quite firm, and tough enough for handling. 'Keepsake' is expected to be best adapted to the Mid-Atlantic and Northeastern US and adjacent areas. Available Spring 2019, most plants will go to nurseries for propagation. A plant patent application for 'Keepsake' has been filed by the USDA-ARS (docket number 126.18). Licensing information can be obtained through the USDA-ARS Office of Technology Transfer (Brian.Nakanishi@ARS.USDA.GOV).

'Keepsake' strawberry.

Like all USDA-Beltsville cultivars, 'Earliglow', 'Flavorfest', and 'Keepsake' are resistant to anthracnose fruit rot. All new seedlings and selections are grown in fields without fumigants or fungicides. Susceptible seedlings and selections are discarded, resulting in cultivars naturally resistant to diseases present in the test fields prior to release. There are few cultivars currently available for sale that are resistant to anthracnose fruit rot. In addition to all cultivars from our USDA - Beltsville program (such as 'Earliglow', 'Flavorfest', 'Keepsake', and 'Allstar'), 'Galletta' from North Carolina State University, and 'Sweet Charlie' and 'Sweet Sensation' from Florida State University are the only other cultivars known resistant to anthracnose fruit rot. Some Mid-Atlantic growers expressed concern for winter hardiness of cultivars developed in more southern states. In Beltsville trials, 'Galletta' and 'Sweet Charlie' have been successful, and 'Sweet Sensation' will be evaluated Spring 2019.

Another kind of anthracnose, commonly called anthracnose crown rot (*Colletotrichum gloeosporioides*), has been known for many years to survive from Florida through North Carolina, and in 2018, it was confirmed in Maryland. There are no cultivars currently available for sale that are resistant to anthracnose crown rot caused by *Colletotrichum gloeosporioides*. The Beltsville breeding program is responding by crossing with resistant selections from a collaboration with our USDA researchers in Poplarville, Mississippi, and developing a greenhouse screen to kill susceptible seedlings. Meanwhile, several researchers and extension agents in the Mid-Atlantic are collaboratively monitoring this disease, it's movement, and its ability to persist in the more recent hot and rainy summers of the Mid-Atlantic region. If you suspect you have strawberry plants infected with anthracnose crown rot, please contact Dr. Mengjun Hu, Assistant Professor, Grape and Small Fruit Pathology, 4291 Fieldhouse Drive, University of Maryland, College Park, MD 20742, Office: (301) 405-5586, Cell: (301) 892-0213, mjhu@umd.edu.

GOLDENBERRIES : A NEW SUPERFRUIT FOR NORTH AMERICA

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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°F, goldenberries can be grown as an annual in temperate regions. They have a very long growing season and should be started in the greenhouse and transplanted outdoors as soon as the threat for frost is over.

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.

A two-year Northeast Region SARE project 'LNE18-362- Goldenberries: 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.

With a long enough growing season, they are productive anywhere tomatoes can be grown. If your growing season is not long enough for selections currently available, they also grow well in greenhouse culture.

Goldenberry was first described by Linnaeus in 1753 and 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 generally 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. Plants generally produce 150 to 300 flowers / fruits per plant.

Seeds must be obtained from a reliable source or extracted and saved from season to season from superior fruit. 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 can be propagated using stem cuttings. The resulting plants are less vigorous than seedlings, however they flower and fruit earlier. We have not evaluated this potential for shorter season climates, but it is a viable option to investigate.

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 height 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. There is evidence in the literature that cross pollination within goldenberry is rare and cross pollination between species (i.e. goldenberry with ground cherries or tomatillos) is even rarer (Menzel, 1951). Thus any particular genetic line will stay true to type if 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 easily 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 are great plain just as they are harvested, they 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.

Goldenberries are highly nutritious. A serving of goldenberries (100 g) provides approximately 75 calories, 0.3g protein, 0.2g fat, 19.6g carbohydrate and 4.9g fiber (National Research Council, 1989). 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.

There are numerous internet reports suggesting that since goldenberries are in the nightshade family, plant tissues and green fruit are poisonous. Green tissues including unripe fruit do contain solanine (Lampe and McCann, 1985) which can cause gastroenteritis and diarrhea, thus consumption of unripe fruit should be avoided.

References:

Lampe, K. F., McCann, M. A. (1985). AMA Handbook of poisonous and injurious plants. American Medical Assoc. Chicago, Ill., USA. 432 pp.

Legge, A.P., (1974). Notes on the history, cultivation and uses of *Physalis peruviana* L. Journal of the Royal Horticultural Society, 99(7):310-314.

Morton, J.F., (1987). Fruits of Warm Climates. Miami, USA: J.F. Morton, 517 pp.

Menzel MY. (1951). The cytotaxonomy and genetics of Physalis. Proceedings of the American Philosophical Society, 95:132-83.

National Research Council (NRC) (1989). Goldenberry (Cape Gooseberry). Lost crops of the incas: Little-known plants of the andes with promise for worldwide cultivation (pp. 240–251). Washington D.C.: National Academy Press.

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CANE MANAGEMENT TO IMPROVE YIELD AND EARLINESS OF PRIMOCANE-FRUITING BLACKBERRIES

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Commercial fresh blackberry production is increasing in several areas of the United States (California, Midwest, and on the Atlantic Coast from Massachusetts to Florida). However, imports of blackberries from Central America (Mexico and Guatemala) still dominate the US fresh market between December and late May. With introduction of high tunnel production for blackberries in Mexico, blackberries from Mexico are now available almost all 12 months, but price for fresh blackberries tend to rise during May to December as the imported volume of blackberries from Mexico drops. US blackberry growers can use a variety of cultural practices, cultivars, and environment (regional differences in climate and growing environments such as high tunnels) to extend their season and improve productivity during the peak price period.

Primocane-fruiting cultivars Prime-Ark® 45 and Prime-Ark® developed by the University of Arkansas are primocane-fruiting blackberries with shipping-quality fruit recommended for the commercial market. Now growers in the Southeastern US and coastal California, where winter conditions are relatively mild and growing season is long, have the option of growing them as floricane-fruiters (e.g. in spring to summer) and primocane-fruiters (e.g. fall to winter) or manage them as either floricane or primocane fruiters based on marketing objectives. Currently, management practices for primocane-only fruiting include mowing of canes after harvest in the fall and in spring and summer tip pruning of primocanes to increase branching and yields. In more northern regions with shorter growing season, primocane-fruiting blackberry production has been limited due to late fruiting and short harvest season. Fall frosts can damage fruit and end the harvest season before the crop reaches its full potential. In all these types of climate, the development of alternative training methods that could increase yields and harvest season of primocane-fruiting blackberries would benefit growers.

Previously, we had demonstrated in a series of studies that in floricane-fruiting blackberries had shown that lateral shoot numbers could be increased by bending the primocanes. The objectives of this study were to examine the influences of cane management and leaf removal on primocane development of 'Prime-Ark®-45' and 'Prime-Ark®-Traveler' primocane-fruiting blackberry. Studies were conducted in Kearneysville, WV on 'Prime-Ark 45' and 'Prime-Ark Traveler' to determine the effects of primocane bending and defoliation on flowering and fruiting season. From June to August, the primocanes of mature, primocane-fruiting blackberry 'APF-45' and 'Prime-Ark Traveler' were defoliated, bent and forced to grow horizontally for 3- to 4.5-ft on a trellis wire at ~28-inch height, and then soft-tipped.

Our findings indicated that leaf removal stimulated axillary buds to push. The shoots that developed on bent primocanes were reproductive and produced a cluster of flowers one month after bending and defoliation. Of the two cultivars evaluated in this study, 'Prime-Ark Traveler' responded more favorably to the alternative primocane management by developing more fruiting shoots on bent primocanes. We also observed that the initial flush of spring-emerging primocanes produced more fruit and responded differently to cane bending then the primocanes that emerged later. Alternative cane management techniques provide new options to produce fruit during attractive market windows and to extend the season to increase productivity

[1]The authors are Research Horticulturist and Horticulturist, respectively.

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UNDERSTANDING HERBICIDE MODES OF ACTION AND INJURY ON BLUEBERRIES

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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. Thus, an efficient weed management program in blueberries will essentially rely on use of herbicides. Relying on various herbicides has many advantages, including weed control and cost effectiveness when used appropriately, elimination of blueberry bark or root damages associated with soil cultivation, and reduction of rodent injury by suppressing vegetal ground cover. However, herbicides, when used improperly, can also cause severe crop injury. This presentation will cover some of the basic information about herbicide modes of action and will examine in detail the different type of crop injury associated with herbicides labeled for weed control in blueberry.

Herbicide mode and site of action

The term "mode of action" refers to the sequence of events from absorption into plants to plant death, or, in other words, how an herbicide works to injure or kill the plant. The specific location the herbicide affects is called the site or mechanism of action. To be effective, herbicides must:

1. Adequately contact plants,
2. Be absorbed by plants,
3. Move within the plants to the site of action without being deactivated,
4. Reach toxic levels at the site of action.

Understanding herbicide mode of action is helpful in knowing what groups of weeds are controlled, specifying application techniques, diagnosing herbicide injury problems, and preventing herbicide-resistant weeds. A common method of grouping herbicides is by their modes of action. Although a large number of herbicides are available in the marketplace, several have similar chemical properties and the way they control the weed. Two or more families may have the same mode of action and will be listed under the same group number (Table 1).

Origin of herbicide injury

Herbicides can injure foliage, shoots, flowers, and fruits. If injury is severe enough, it may affect yield, produce poor fruit quality, and occasionally cause plant death. Herbicide symptoms may be visible for a few days to several years depending on the herbicide involved, plant species, stage and rate of growth, environmental and soil conditions, and cultural practices. In addition, herbicides may reduce non-target plant vigor, increase susceptibility to disease, and shorten the life cycle of a plant. Crop injury may be caused by aerial drift (physical or vapor drift) at the time of herbicide application or soon thereafter, soil carryover, soil-adsorbed herbicide becoming airborne as a result of soil disturbance, contaminated tank or herbicide misapplication.

Preventing herbicide injury

Always carefully read the herbicide label and follow directions and recommendations for the best application method. When applying herbicides, avoid the use of highly volatile formulations of herbicides in any area near sensitive crops. Do not spray herbicides when wind is blowing toward sensitive plants or when temperature inversions are likely. It is important to properly select nozzles that will minimize the production of fine droplets and eventually

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use shielded booms. Reduce the speed at which you spray the herbicide as higher speed may increase the risk of herbicide drift. Consult the label for recommended cleaning agents when cleaning out the spray equipment. Rinsing with just water may not remove the residue and the herbicide may remain tightly adsorbed in the sprayer through several loads. Further loads that contain other herbicides, oils, fertilizers, or basic pH blend may cause the herbicide to desorb, disperse into the spray solution, and damage susceptible crops.

Table 1. Common herbicide mode of action classes and examples for blueberry

Mode of action (effect on plant growth)		Site of action	Herbicide group #	Active ingredient	Trade name(s)
Lipid (fatty acid) inhibitor (meristem)		ACCase enzyme	1	-dim -fop	Poast® / Select® Fusilade®
Amino acid biosynthesis inhibitor		ALS enzyme	2	halosulfuron rimsulfuron	Sandea® Matrix® / Solida®
Seedling growth inhibitor	root & shoot	Microtubule	3	oryzalin pronamide	Surflan® Kerb®
	shoot	Long-chain fatty acids	15	napropamide	Devrinol®
Photosynthesis inhibitor	mobile	Photosystem II	5 / 7	isoxaben terbacil simazine hexazinone diuron	Trellis® Sinbar® Princep® Velpar® Karmex®
	contact	Photosystem I	22	paraquat	Gramoxone®
Amino acid biosynthesis inhibitor		EPSP enzyme	9	glyphosate	Roundup®
N-metabolism disrupter (contact)		GS enzyme	10	glufosinate	Rely®
Pigment inhibitor (bleaching)		PDS enzyme	12	norflurazon	Solicam®
		HPPD enzyme	27	mesotrione	Callisto®
Cell membrane disrupter (contact)		PPO enzyme	14	flumioxazin sulfentrazone	Chateau® Zeus®
Cell wall synthesis inhibitor		Plant meristems	20	dichlobenil	Casoron®

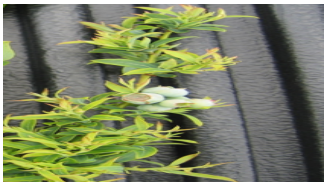
Common symptoms of herbicide injury on blueberry

Preemergence herbicides

Norflurazon Carotenoid inhibitor	Leaf **veins turn white or pinkish white**. Current-season shoots may turn white (bleaching) Symptoms usually appear first on lower branches. Norflurazon is persistent in the soil, so excessive rates may not result in symptoms until late in the season or the following year.	
Simazine Photosystem II	Symptoms are similar to those of iron chlorosis with **interveinal yellowing, browning and necrosis along leaf edges**. Bushes with mild to moderate symptoms survive but grow poorly for several years.	

Diuron Photosystem II	The first apparent symptom is an **interveinal pale green/yellow color**. Brown areas will later appear between the main veins in the middle of leaves and will extend to the leaf margins. Plants can show some stunting but will usually recover.	
Terbacil Photosystem II	Injury symptoms appear as **irregular chlorotic patches on leaves that will later turn brown** and die. Leaves curl and eventually drop from bushes. Severely affected bushes may drop all leaves and die by the following spring.	
	Injury symptoms appear in the form of abnormal shoot growth with reduced internodal growth as well as **leaf stunting, crinkling, chlorosis and marginal necrosis**. Severe fruit damages appear as equatorial russeting, splitting, and abnormal development of the fruit calyx.	
Flumioxazin Cell membrane disrupter	Symptoms of soil-adsorbed herbicide becoming airborne appear as **reddish spots that will turn brown and necrotic** later in the season. This is usually associated with leaf crinkling and young leaves taking on a red coloration.	

Postemergence herbicides

Glyphosate Amino acid biosynthesis inhibitor	Because glyphosate can be absorbed and move throughout the plant, severe injury or plant death may occur the following year. Branches produce **stunted growth with small, narrow, chlorotic leaves**. Symptoms may persist for 1 to 3 years.	
Paraquat Photosystem I inhibitor	Paraquat injury will stay confined to treated parts. **Brown necrotic spots** develop on sprayed leaves that may drop depending on the severity of the injury. Green bark on young canes can show reddish-brown lesions, resulting in stunted growth or death if much of the bark surface is injured.	
Glufosinate Nitrogen metabolism disrupter	Injury symptoms appear as leaf of green bark burning within several hours following exposure. **Leaves crinkling and reddening** followed by complete necrosis are frequent symptoms as well as **bark cracking** on young green stem exposed to glufosinate.	

Information and pictures from "**A Pocket Guide to IPM Scouting in Highbush Blueberries**" by A. Schilder, R. Isaacs, E. Hanson, B. Cline and M. Longstroth, available at http://shop.msu.edu/product_p/bulletin-e2928.htm

TRAPPING FOR SWD VS. INFESTATION IN BLUEBERRIES

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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.

Spotted wing drosophila (SWD), *Drosophila suzukii* Matsumura (Fig. 1), is an invasive vinegar fly that can damage many fruit crops including blueberry, cherry, raspberry, blackberry, and strawberry. Native to Southeast Asia, SWD was first detected in the continental USA in 2008. It has since established in many states across the country and was found in the Northeast USA in 2011 (Michel et al. 2015). Unlike most Drosophila, SWD females are equipped with a large serrated ovipositor which can saw through the soft skin of many ripening small fruits to lay eggs.

Fig. 2. SWD standard trap.

Trapping

Early detection of SWD flies is necessary for growers to time insecticide applications and prevent fruit infestation. Traps used for monitoring should be placed in the field at least two weeks before fruit ripening and should be monitored weekly. Traps should be placed at a height about half way up the bush canopy and close to developing fruit, preferably along the edges of the field that have wooded borders. These traps may be purchased or simply made by hand. Home-made traps can be made by cutting two round holes on both sides of the upper portion of a clear 32 oz. deli cup, and glueing a piece of 1/8" mesh material over those holes (Michel et al. 2015). A lure can be hung from the lid over a solution of apple cider vinegar with a drop of scentless soap (Fig. 2). There are three commercial SWD lures available for purchase from Trécé, Scentry, and Alpha Scents. Inspect the trap solution and strain weekly for SWD males and females.

Fruit inspection

To inspect fruit for SWD larvae a simple salt flotation test can be performed. This is a good method for evaluating the effectiveness of your SWD management program and ensuring the quality of your product. It can also be used to determine when to initiate management programs. The method consists on placing berries in a plastic bag or on a baking pan, add a salt solution [1/2 cup of salt per 2 quarts (2 L) of water], and gently press the berries (Michel et al. 2015). Salt water will irritate any larvae present out of the fruit and they will float to

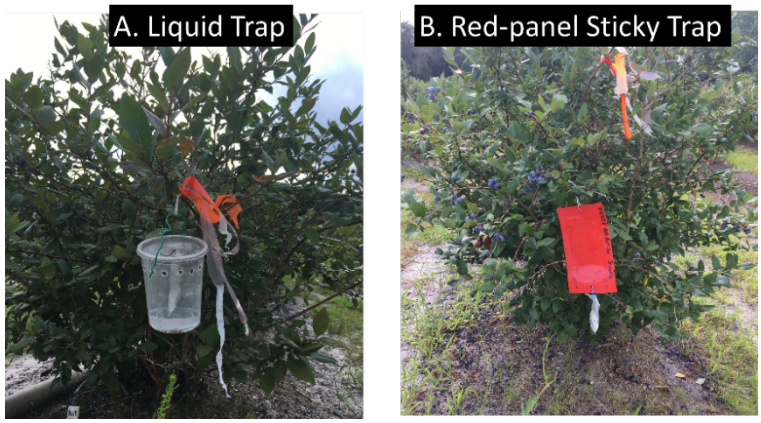

Fig. 3. Trap types: liquid (standard) trap (A) and dry, red-panel sticky trap (B).

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the surface of the salt water. Cover all berries, screen, and weights with the saturated salt solution so any larvae are free to float to the top and be seen. After 10 minutes it is safe to assume no more larvae will surface. See also Van Timmeren et al. (2017) for details on the salt extraction method.

On-going research

In 2018, studies were conducted in New Jersey to compare the efficacy of two different trap types, a standard, liquid trap baited with the Scentry lure and a dry red-panel sticky trap baited with the Scentry lure (Fig. 3), on SWD captures.

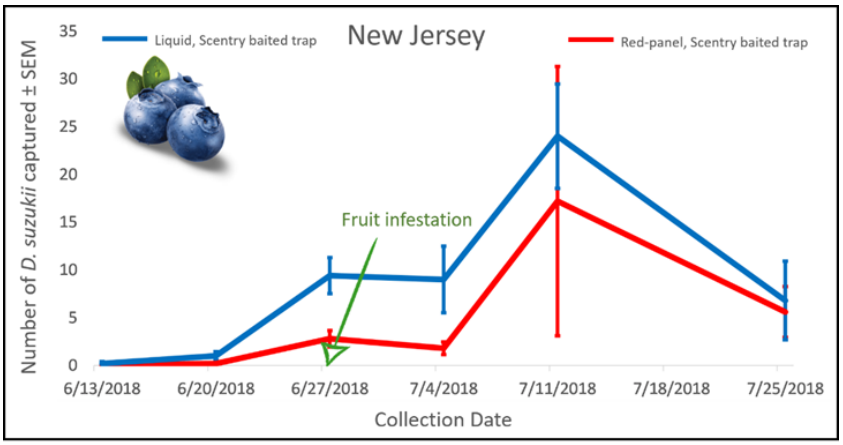

Fig. 4. Comparison of a liquid (standard) trap and a dry, red-panel sticky trap for monitoring SWD flies in blueberries in New Jersey. Both traps were baited with a Scentry lure.

Trapping in experimental blueberry fields: This study was conducted in five blueberry fields in New Jersey that were either organic or not sprayed for SWD. Four treatments were compared: A. the liquid (standard) trap (see above) with a Scentry lure, B. the dry, red-panel sticky, trap with a Scentry lure, C. an unbaited liquid trap, and D. an unbaited dry, red-panel sticky trap. Traps were placed at least 10 m from each other and checked weekly for SWD males and females for seven weeks from 13 June-25 July 2018. In addition, fruit was collected weekly to assess fruit infestation. Results show that SWD first catch in the liquid baited trap was on 13 June and first catch in the red-panel baited trap was one week after, on 20 June (Fig. 4). No flies were captured in either control trap type. Both trap types captured similar numbers of SWD males and females. Fruit infestation was first detected on 27 June, 1-2 weeks after first trap capture.

Trapping in commercial blueberry fields: We established a network of 71 trap locations on commercial blueberry farms across the two NJ blueberry production counties, 51 in Atlantic County and 20 in Burlington County. Traps consisted of the red sticky card baited with the Scentry lure. Only adult males were monitored on the traps. Traps were placed on field edges by woods borders and checked every 7 days from late June through all of July. SWD flies were first found in mid June and increased throughout the growing season in Atlantic County, but peaked in Burlington County during mid July (Fig. 5).

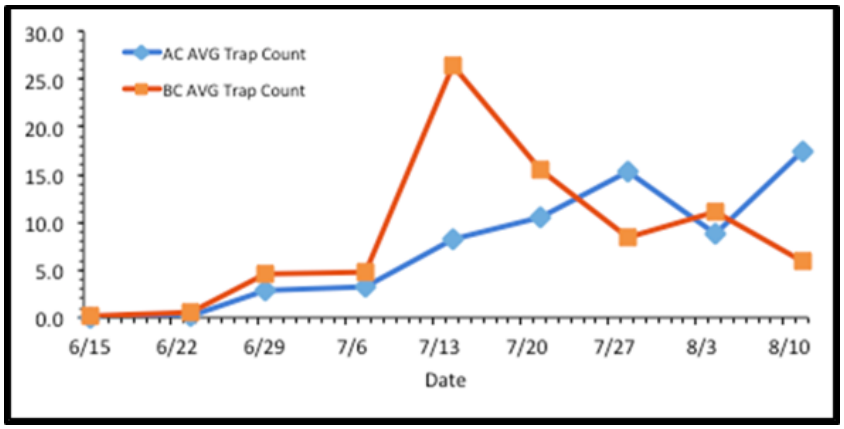

Fig. 5. Program-wide demonstration of red-panel sticky traps for SWD in commercial blueberry fields in New Jersey: Atlantic (AC) and Burlington (BC) Counties. Only males were counted.

In addition, we compared the efficacy of the liquid traps with the red sticky trap (both baited with the Scentry lure) for monitoring SWD males. The study was replicated in six commercial blueberry farms with five traps of each type at each site. The sticky red traps caught less SWD males than the standard liquid traps, but first male capture was still during the same week (Fig. 6).

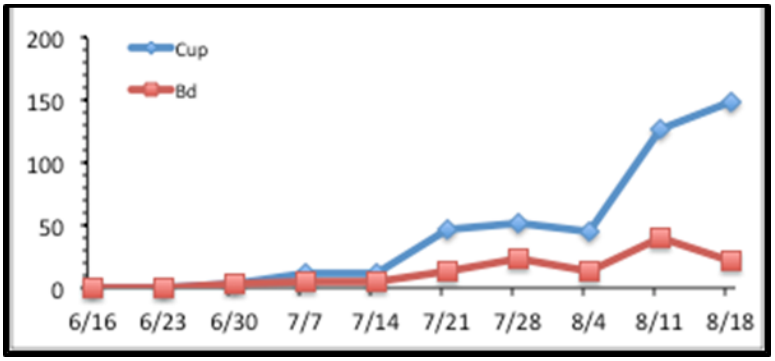

Fig. 6. Comparison of a liquid (standard) trap (Cup) and a dry, red-panel sticky trap (Bd) for monitoring SWD flies in commercial blueberries in New Jersey. Both traps were baited with a Scentry lure. Only males were counted on sticky traps.

In summary, first captures of SWD were either on the same week or one week later between Scentry-baited red sticky traps and the standard liquid trap. Both traps detected SWD before infested fruit was first detected, indicating that they can provide early warning. Therefore, dry, red-sticky traps can be used for rapid detection of SWD males in the field; however, their performance will likely depend on the crop and regional growing conditions.

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References

Michel, C., Nielsen, A., Polk, D., and Rodriguez-Saona, C. 2015. Spotted Wing Drosophila: A Key Pest of Small Fruits in New Jersey. New Jersey Ag. Exp. St. Cooperative Extension Fact Sheet FS1246.

Van Timmeren S, Diepenbrock LM, Bertone MA, Burrack HJ, Isaacs R. (2017). A filter method for improved monitoring of *Drosophila suzukii* (Diptera: Drosophilidae) larvae in fruit. Journal of Integrated Pest Management doi: 10.1093/jipm/pmx019

PROCUREMENT WHOLESALE BUYER/PANEL PRESENTATION

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First and foremost, food safety and traceability are crucial to HelloFresh as a meal kit company who ships fresh food to our customers in every zip code. Our supplier food safety requirements for growers include a GFSI audit and a COI.

The next key criteria for our suppliers is their attention to detail, proving they can meet our specs with every delivery. At HelloFresh, our goal as a meal kit company is to help make cooking at home fun, simple, and delicious. We deliver convenience and a great experience with our meal kit boxes, giving customers all the pre-portioned ingredients needed for each recipe that they select. Every week and in every customer's box, we must deliver the correct produce variety, portion, and quality. This consistency starts with our supplier's products.

Aligning on expectations is another key to successful partnerships; we are able to include small and large scale suppliers as long as they can deliver against their commitments. At HelloFresh, we plan our recipes and budgets well in advance, and we also secure our sourcing in advance. Suppliers often appreciate our unique ability to provide longer lead times due to our careful planning processes. However, with this benefit comes the expectation to deliver orders in full and on time. When a supplier commits to a future week's order and then, ultimately, shares close to the delivery date that he is unable to deliver, that is one of the worst scenarios for my buying team. We trust our suppliers to be transparent about their capacity and capabilities to deliver.

Once we are aligned with suppliers on specifications and expectations, delivering to our facilities and providing flexibility are key capabilities for our east coast suppliers. Timely delivery is crucial, as having our ingredient inventory stocked is just the first step in our complex supply chain. Another facet of delivery for us is flexibility. At HelloFresh, we are the market leader in a brand new channel. Change happens rapidly at a new, growing business, so our best supplier partners are ready and willing to adapt with us. To modify orders to match our forecasted needs. To help quickly turn around additional product. To work with us to develop a new product or pack size. At HelloFresh, we are constantly innovating in order to delight our customers, and our top suppliers are pleased to grow with us and be a part of the journey.

For suppliers to go above and beyond, we highly value suppliers with packing and processing capabilities as well suppliers that help us develop ideas to optimize our value per portion. As mentioned previously, HelloFresh delivers pre-portioned ingredients in our meal kits. Our portion sizes are often times smaller than traditional retail. A grower that is capable of packing and pre-portioning for us is at a great advantage. Additionally, we are always looking for ways to improve the value, cost and quality, of each customer's serving of a recipe. Suppliers that understand our business model well enough to suggest special opportunities for us to adjust our specs to our advantage, develop promotional pricing, suggest optimal varieties, are highly valued as HelloFresh partners.

Jacqueline Soria is an Associate Produce Strategy Manager at HelloFresh. She manages all aspects of the supply chain for herbs, bagged lettuces, tree fruit, and citrus. Jacqueline grew up in Bergen County, New Jersey. After completing her undergraduate degree at Northwestern University, Jacqueline worked for General Mills as a Financial Analyst in supply chain analytics before joining the HelloFresh procurement team in New York in 2017. Jacqueline has completed the Cornell University Future-Leaders-In-Produce Program and is a part of the Step Upp Class of 2019 through the Southeastern Produce Council.

TRENDS IN FRUIT AND VEGETABLE CONSUMPTION IN THE UNITED STATES

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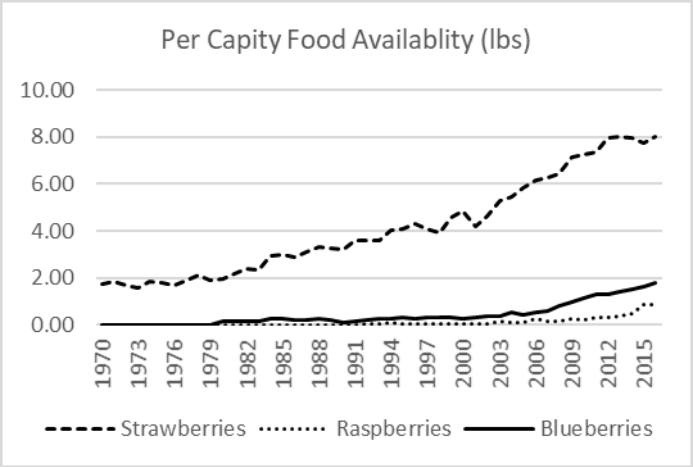
	% of Respondents meeting Recommendations	
	Fruit intake	Vegetable intake
New York	14	9.6
Maryland	14	9.0
Delaware	12.5	8.6
New Jersey	12.1	8.3
United States	12.2	9.3
Pennsylvania	11.7	8.4
Virginia	10.9	7.6
West-Virginia	7.3	5.8

Percentages of adults meeting federal fruit and vegetableintake recommendations per day;
Source: CDC, 2017

The Center for Disease Control (CDC) recommends that "Adults should consume 1.5–2.0 cup equivalents of fruits and 2.0–3.0 cups of vegetables per day." However, CDC survey results show that most adults do not achieve this recommendation – on average, only 12.2 percent of adults in the US meet the fruit intake and 9.3 percent the vegetable intake recommendations. In the Mid-Atlantic region, West-Virginia ranks last with only 7.3% and 5.5% of adults meeting the fruit and vegetable intake recommendations respectively. Overall, woman (15.1%), adults aged 31–50 years (13.8%), and Hispanics (15.7%) are more likely reach the intake recommendation for fruit.

However, trends like the flexitarian and the paleo diets are expected to increase the demand for fruits and vegetables. *Flexitarians* are consumers that primarily follow a vegetarian diet but will occasionally eat meat. Meanwhile, within the *Paleo* diet, lean meats, nuts and fruits and vegetables are consumed, while "modern" foods like dairy products, grains and legumes are limited. Consumers are also looking for added benefits by consuming "superfoods." This list is ever changing, but some of these include berries, swiss chard, microgreens, collard greens and even dandelions. Substitution for supposedly healthier options is still trending, for example using processed cauliflower as rice substitutes, mashed cauliflower as pizza "dough" or mashed yellow turnips instead of mashed potatoes.



Source: USDA, ERS; Adjusted for losses

Availability of Fruits and Vegetables

The healthy food trend is contributing greatly to an increase in berry consumption. Consumers are looking for healthy snacks that do not need much preparation and berries fit the bill. Blueberry and raspberry use are on the rise. Strawberry per capita use has increased from 4.86 lbs. in 2000 to 8.03 lbs. in 2017 (per capita availability, adjusted for losses). Vegetable per capita use is also on the rise (see graph below for selected vegetables). After the introduction of baby carrots at the end of the 80's carrot consumption has levelled out to 7.3 lbs in 2017. However, bell peppers, broccoli and sweet potato use have increased steadily over the years, with bell pepper being one of the more popular vegetables.

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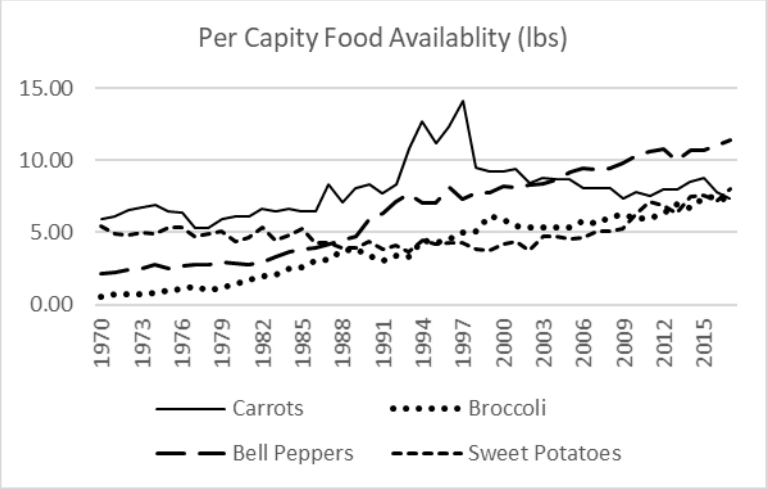
Pesticide Concerns

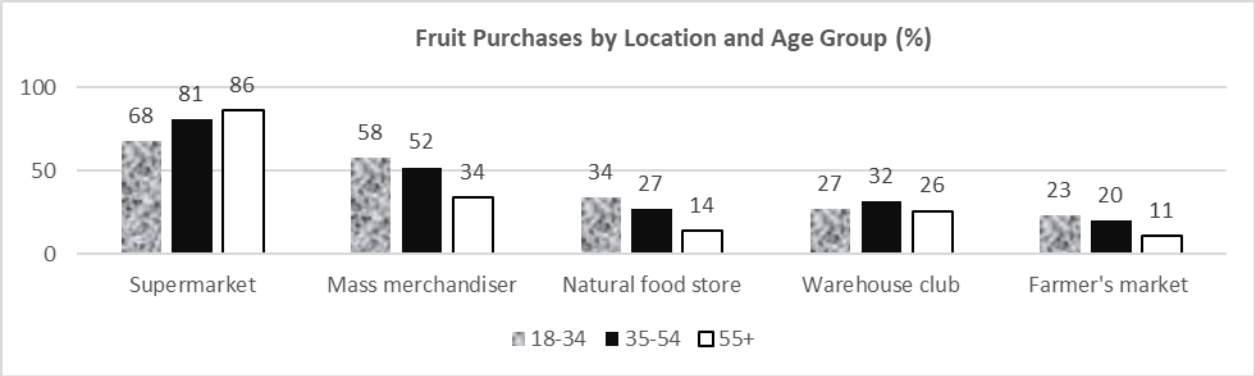
Some consumers that are concerned about pesticides look at the Environmental Working Group for recommendations. The 2018 "Shopper's Guide to Pesticides in Produce™" lists the most "contaminated" conventional fruits and vegetables (in order – top 10): strawberries, spinach, nectarines, apples, grapes, peaches, cherries, pears, tomatoes and celery (https://www.ewg.org/foodnews/full-list.php). Annual release of the list typically garners widespread media attention. However, much of the news coverage does not mention that the US Department of Agriculture (USDA) also keeps record of pesticide residues and its Pesticide Data Program (https://www.ams.usda.gov/datasets/pdp). For all fruits and vegetables tested, the residues are almost always at levels below the US Environmental Protection Agency's set human tolerance limits.



Source: USDA, ERS; Adjusted for losses

Shopping for Fruits and Vegetables

Younger consumers frequent the farmers' market more often than older generations and buy more fruit at mass merchandisers and the natural food stores. The supermarket is still the place older generations (55+) turn to for fruit purchases. Fruits are also increasingly bought at non-traditional outlets such as dollar -, drug -, and convenience stores and at online retailers. Eight percent of younger consumers indicated that they had bought fruits online, in the 55+ group it was only one percent.



Source: Mintel: Fruit -US-June 2018; Survey of 1,899 internet users.

Ugly produce

Food waste is an issue consumers have become more aware of due to the impact on their budget as well as in increasing desire to having their food more sustainably sourced. For example, San Francisco based companies Imperfect Produce and Full Harvest buy imperfect produce from producers. Imperfect Produce then delivers customized boxes of imperfect organic and conventional produce directly to consumers at 30% below retail price (www.imperfectproduce.com). Focusing on companies, Full Harvest is a company that buys imperfect and surplus produce from farms that food and beverage companies then purchase from their marketplace for further processing at a price that is 10-40% less that wholesale (www.fullharvest.com). Hungry Harvest is a Mid-Atlantic company that sources produce from farmers and wholesalers and delivers produce boxes to customers from Maryland to Detroit (www.hungryharvest.net).

Some take home points:

Be ready to provide informed replies to your customer's questions about pesticides.

If you join the trend to reduce food waste (offering "ugly" produce either directly to customers or wholesale), make customers aware of it through your marketing.

Encourage the 5-a-day recommendation; many people want to eat more fruits and vegetables and a reminder might just be what they need.

Source:

CDC (2017): Disparities in State-Specific Adult Fruit and Vegetable Consumption — United States, 2015; Internet source: https://www.cdc.gov/mmwr/volumes/66/wr/mm6645a1.htm?s_cid=mm6645a1_w#suggestedcitation

THE ART OF DIRECT MARKETING - CATCHING THE CUSTOMERS EYE

Rose Robson, Robson's Farm
Wrightstown, NJ

The majority of what our brain processes is visual. If you were going to work on one aspect of your business from a marketing standpoint visuals would be the place to focus your efforts. Research suggests that 60% of buying decisions are based on color. Color not only of the itemitself but of the display as well. When I re-started the family farm my mom asked what color I was going to paint the little farmstand she got for me. I said I'm thinking purple. She looked at me in horror and said, "How about red." Red, like every other farmstand in America? No way! People recognize the purple farmstand and it was a good way to separate myself from my neighbors. I also grow a large array of purple produce. Purple: Kohlrabi, potatoes, beans, cauliflower, etc. Essentially if it comes in purple I grow it to play into the brand. Growing purple produce and other unusually colored vegetables plays into customers decision to buy. It's a double edge sword because some people don't want vegetables in colors that are unfamiliar. They want red tomatoes, green peppers, and black eggplant. However at the farmers market customers are looking for new things. They are there for not just groceries but for the experience. By playing with color you are giving an experience. Whether people are opposed or interested it slows them down. It starts a conversation. The longer you have a shopper at your table or in your farm store the more likely they are to buy. You want to slow customers down as often as possible. When thinking of display you want to accentuate what you're selling. If you distract the customers eye it's harder for them to make buying decisions. Solid backgrounds are best.

Classic patterned red and white check tablecloths that I often see at the markets are a poor choice for selling on. It takes the focus (mostly on a subconscious level) off what's on the table to what's covering the table. Black table clothes or black walls behind displays make colors pop. White also works as well. I take a lot of photos on the purple farmstand as a backdrop and I've been shocked how the purple works with most things. So if you have a unique color scheme going on use it to make your branding fluid.

Signage should be concise, easy to read and professionally done. Ordering vinyl signs online is not very costly and they look great. Poorly written sings, spray painted signs, rushed painted signs are harder for customers to process and could cause confusion and loss of sale. Embrace the diversity of your customers. If you have a large amount of customers from one county or region that come to your farm have signage be both in English and their native language. This helps customers feel celebrated and appreciated. These people are supporting you so you should make the effort to show them that you notice them, their culture and want them to feel welcome.

Digital signage works wonders! A local business in my town got a digital sign that actually drove me into the store to inquire about an event they were having. They told me that a lot of people commented on the digital sign and how eye catching it is. There is a lot of evidence that digital signs are worth the investment.

Aside from visuals there are a few other things you can do to enhance customer experience, create loyalty and boost sales. Talk tracks are critical so staff is educated and speak using your voice and rhetoric and not their own when representing your business. Answers to commonly asked questions should be written down with answers you would give as the business owner provided. All employees should memorize these answers so when asked they can give customers not only give correct information but give information in a clear manner that makes them seem knowledgeable. This is part of building trust with customers.

As the business owner it's important to be the face of your business. No matter how busy you are you need to be present some of the time. Pick 1 day a week to commit to being at your farmstand to greet customers and get to know

Rose is the Owner of Robson's farm in Wrightstown, NJ. She has a degree from university of South Carolina in Journalism and mass communication. After bouncing around to several sales jobs in pharmaceuticals and medical devices she came home to New Jersey and re-started her family's farm 6 years ago. She is a member of the NJ Ag leadership program and the NJ Farm Bureau Young Farmers and Ranchers, as well a member of the National Young Farmers Coalition, American Specialty Cut Flowers Growers Assoc. and Burlington Soil Conservation District.

them. Go to your tailgate markets once a month to drop in, say hi!, and cultivate relationships. No matter how busy or how long the line is you should still try to make a meaningful connection with each customer. Ask them how they are and take that moment to make eye contact. While you're making change comment on something they bought. For example you could say, "Oh you picked out my favorite heirloom tomato, Amana Orange! I love making tomato grilled cheeses with them. You'll have to let me know what you think of them next week." Always leave the door open to continue the conversation. Next week when you see them follow up. The is makes the customer feel valued and noticed. From there the relationship will build and it will be less of just tidbits and more meaningful conversation.

I have a strong interest in language. I am also fortunate to have farmers markets where we have diverse clients. With my customers who speak english as their second language I always try to greet them in their native language and encourage them to teach me a new word each week at the market. If you take an interest in people they will take an interest in you. Give to get is something so important. A great way to build followers and attract people who haven't visited is to give. Host a free class. Do informational videos that answer commonly asked questions about certain crops, give free chocolates, or water. If you give you will get.

Along that same thinking loyalty rewards are a nice perk for shoppers. This can easily be done with a punch card. I used to do a bring your own bag punch card. The 10th time the shopper used their own reusable bag they got a dollar off their purchase. Little things like this add up and build on a likable, personable image you want to convey.

FERNBROOK FARMS - THE CREATIVE EVOLUTION OF A DIVERSE FARM BUSINESS

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Fernbrook Farms is a 230-acre property located in Chesterfield, NJ in Burlington County and is protected under the farmland preservation program. The farm has been in the Kuser family since the 1890's. Fernbrook Farms is an example of a very diverse operation composed of four distinct branches - Fernbrook Nursery – a wholesale tree nursery established in 1982; The Inn at Fernbrook Farms established in 1996; Fernbrook Farms Environmental Education Center established in 2005 and Fernbrook Farms Community Supported Agriculture established in 2007. This presentation will provide an overview of the hows and whys the farm evolved over the years, and the successes and challenges along the way. We'll discuss how we reach out and communicate with a diverse customer base and facilitate a discussion on managing a diverse farm business.

Fernbrook Nursery was established in 1982 when Larry decided that the nursery business would be lucrative enough to be a sustainable business model. The idea formed after several years of growing and selling Christmas Trees while teaching during the year. Larry's passion for growing things turned Fernbrook Farms into a farm. Today, the Nursery sells wholesale a wide variety of plants from Virginia to Maine. Through the years, many lessons have been learned about the nursery business through Christmas Trees, retail, and landscaping to name a few.

The Inn at Fernbrook Farms is a unique manor house, built in the 1760's, appointed with antique furniture, features 7 bedrooms, 6 baths, multiple fireplaces, and a billiards table. In addition, the estate has 9 acres of extensive lawns and gardens, an outdoor hearth and a summer-house, providing multiple venues for a picturesque wedding. The Inn at Fernbrook Farms is the perfect setting for all celebratory events featuring natural yet sophisticated amenities, customized cuisine, and dreamscape grounds that can accommodate up to 1,000 guests per day. The Inn at Fernbrook Farms emphasizes a setting of rich values, focusing on fresh picked produce and top-tier event arrangements.

The Environmental Education Center is a non-profit 501-c-3 organization with a mission is to provide hands–on educational experiences for all young people by exploring the complex interconnectedness of our natural world. Our purpose is to educate children about food, agriculture, and the environment. We believe people should make meaningful connections with our natural world in order to become responsible stewards of local and global sustainability.

Larry Kuser - Larry 'Farmer Q' Kuser moved to the farm in 1974 and has been actively running the farm since 1982. Prior to farming, Farmer Q was a high school math and science teacher and coach.. Farmer Q has never given up his love of teaching or his involvement in the community. He has been an adjunct teacher at Mercer County Community College, Rutgers University School of Continuing Education and the New York Botanical Gardens. He has given lectures for the Master Gardeners programs and the New Jersey Association of Landscape Architects. In 2014, he was inducted into the NJ Nursery & Landscape Association's Hall of Fame. He serves on the Board of Directors of the New Jersey Community Forestry Council, a past member of the New Jersey Nursery and Landscape Association Board, the Burlington County Board of Agriculture, and past president of the Chesterfield Township Environmental Commission. Farmer Q is a graduate of Cornell University and has a Masters degree in Education from Fordham University.

Brian Kuser- Son of Larry 'Farmer Q', has been involved in outdoor education since 1996. During his years at Bates College in Maine, Brian spent his summers working at Keewaydin Camps in Vermont where his love of experiential environmental education was founded. After graduating Bates with a degree in mathematics, Brian started teaching at New England boarding schools while continuing to spend his summers at camp in Vermont. Brian took a couple winters off from the indoor classroom and spent several seasons teaching in the outdoor classroom at Keewaydin Environmental Education Center and Hulbert Outdoor Center where he focused on environmental education and teambuilding activities. After a stint teaching abroad in Thailand, Brian returned to the US in 2007 where he began teaching at the Montclair Kimberley Academy. Brian spent 6 years teaching high school math at MKA while spending his summers as the Summer Camp Director at Fernbrook Farms. In 2013, Brian left the indoor classroom for good and joined the year-round staff at Fernbrook Farms as the Director of Education.

The way the farm currently blends agriculture, horticulture, education, hospitality, and community, makes a Community Supported Agriculture (CSA) a natural fit at Fernbrook Farms. Our CSA is dedicated to connecting families to the sources of their food by making delicious, healthy, chemical-free food accessible to all. This is an exciting trend that has been reinvigorating many small farms and providing a way for tens of thousands of consumers to get connected with a farm in their neighborhood. This exciting trend has also caused the food industry think about ways they can connect consumers with their neighborhood.

Fernbrook Farms is a farm that will forever be a place for friends and families to come together, learn, laugh, and create stories.

KEEP IT LEGAL: LEGAL CONSIDERATIONS FOR MARKETING YOUR FARM ON SOCIAL MEDIA

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The Internet, and especially social media, may feel like the Wild West most of the time, but just because you "found it on the Internet" doesn't mean you can use it. Real-World laws like trademark and copyright protections, privacy and data collection protections, and the rules and regulations of the Federal Trade Commission and other consumer and employee protection agencies still apply in the digital and virtual worlds. If you're promoting, advertising, comparing or selling products online, you must adhere to those rules and regulations or risk the very real-world consequences.

Knowing the rules is the best way to minimize the risk of litigation and public backlash in an arena where news travels fast. In this program, you will learn how to minimize the risk of infringing on others' copy and trademark rights as well as how to protect your own intellectual property, how to avoid violating privacy and data protection laws, how to comply with federal and state advertising laws as well as labeling laws, sales tax laws and food safety recalls, how to handle negative reviews, and how to evaluate your business' social presence and procedures to better understand your business' potential exposure so you can reduce it.

Copyright and Trademark Protections

Copyright and trademark infringement are the most common risks connected with using social media in sales and marketing. Laws relating to who owns the content being shared, when and where sharing is appropriate and what limits may be imposed on sharing often raise issues relating to trademark or copyright infringement. As a general rule, in order to minimize the risk of at the very least having to remove all infringing content or at worst being sued for infringement, always do as much as you can to identify the creator of any non-original material that you use, obtain their permission to use the material, and give them attribution, quote them, cite them or, even better, provide a link in your post to their original work.

Trademarks

A trademark is an identifying mark used in connection with particular goods or services.

A trademark can take many forms including a word, name, symbol, device, sound, fragrance, color or "trade dress" of a food product packaging. The purpose of a trademark is to inform the public about the source of goods or services. Unless you have express permission or license to use a trademark other than your own, do not use it and do not try to confuse consumers by imitating it.

Nicole Cook is the Environmental and Agricultural Faculty Legal Specialist with the Maryland Agriculture Law Education Initiative at the University of Maryland Eastern Shore. Nicole received her Bachelor of Science degree at the University of Iowa and her Juris Doctor degree from Northeastern University School of Law. She also holds Master of Law in Agricultural and Food Law and Policy from the University of Arkansas School of Law. Nicole practiced as a trial attorney and as in-house corporate counsel for several years before completing her LL.M. in Agricultural and Food Law. She served briefly as a Senior Advisor for the USDA's Risk Management Agency before joining ALEI. Nicole focuses much of her work on food safety, risk management planning, urban agriculture, aquaculture, new and beginning farmer sustainability planning and preparation, and farm marketing and intellectual property

Copyrights

If you aren't using pictures you took yourself, then, by default, you're using copyrighted work created and owned by someone else. Copyrights protect original works of authorship including literary, visual, written, dramatic, artistic, and musical works such as pictures, graphic art works, cookbooks, films, TV shows and movies, and songs. Copyrights do not protect facts, ideas, systems, or methods of operation. They protect the way those things are expressed.

Copyrights attach at the time of creation. They protect both published and unpublished works. There is no requirement to use the "©" symbol to protect copyrights in a creation. Copyrights give the owner of the copyrights the exclusive right to reproduce the copyrighted work, display the copyrighted work publicly, prepare derivative works based on the copyrighted work, and distribute copies of the copyrighted work to the public by sale, rental or lending and/or to display the image. So, don't assume that just because you found a picture online it's yours for the taking. The general rule is that, unless the work is in the "public domain" or has been deemed by a court to be "fair use," you can't use a copyrighted work without express authorization from the copyright owner.

Privacy and Data Collection Protection

Privacy Laws

It may seem simplistic to point out that before you can send marketing emails or messages, you need to collect the contact information of your customers or potential customers. Yet, the actual process of collecting the information is far more complex than it seems, particularly if you're trying to collect it in a legally compliant manner.

Your Privacy Policy

Most jurisdictions around the world have privacy legislation in place that requires you to notify people before you collect their personal information. This includes someone who is already a customer, although the UK has some slightly more permissive laws for people who have already purchased something from you. In the US, traditionally, two bodies have acted to protect the rights of those online: the Federal Trade Commission (FTC) and state attorneys general, but there is no overarching privacy law that applies to the collection of data.

You should be aware, however, that California has a piece of legislation that covers online privacy – California Online Privacy Protection Act (OPPA). If you have an online store or if you're marketing to people online in the US, you're quite likely to have customers or potential customers in California, so you should take care to comply with this law. The OPPA requires you to disclose:

1. The kinds of information your website or online marketing tactics collect;
2. How the information may be shared;
3. The process your customers can follow to review and change the information you have about them; and
4. Your policy's effective date and a description of any changes since then.

The easiest way to comply is to set up a Privacy Policy on your website and require your customers or website users to agree to it when you collect information from them. And then, once you've collected the data, keep it with a reputable cloud storage provider to protect yourself from liability in the case of a data loss.

To make sure your customer's or user's agreement will stand up legally, use a clickwrap method. A clickwrap method is where your customer or user has to click "I Agree" to your Privacy Policy in some way. This could be when they sign up to receive your marketing messages or when they make a purchase on your website.

Security and Cloud Storage

One simple way to protect customer privacy when you collect information is to use security mechanisms such as SSL. SSL means that the connection between your website and the user's browser is secure when data is transmitted. Ensure that any websites you use with your customers have SSL enabled.

Another potential security issue is the storage of customer data. A popular way for many online businesses and marketing companies to store data is to use cloud storage providers. To reassure your customers that you are keeping their data safe, always choose a reputable provider. And, preferably, choose a reputable provider within your own jurisdiction. This is because some jurisdictions have legal requirements that data should either not be transferred out (or must be accessible even if it is stored overseas) or should be transferred only to jurisdictions with similar legal protections for the data in place. If you overlook this fact and store data with a cloud storage provider in another jurisdiction that has inadequate protections, you may be in breach of your local laws.

It's also important to reassure your customers that once you've collected their information, you will keep it secure. Your users need to feel they can trust you. You can show them you are trustworthy by informing them about how you will protect and store their information. If you use a cloud storage provider, you need to ensure that your Privacy Policy and/or your website's Terms of Use cover the situation in which a cloud storage provider has a privacy breach and your customers' data is released. You want to ensure that you are not liable if a third party (the cloud storage provider) has a data leak. To maintain customer trust, use only reputable providers and be transparent about whom your customer data is stored with.

Using Pictures of Customers/Attendees

Taking photos of people at an event and sharing the photo on social media sites is fairly low-risk. However, the more places you share the photo (*i.e.*, in a blog post or in promotional material) the higher your risk becomes as more and more people view the image. There also tends to be more backlash when they are photos of children. If you want to cover your bases for utilizing photos of customers/attendees at an event or business in social media, be sure to clearly post signs that say that by attending the event they are implying consent unless otherwise documented.

Read Social Media Platforms' Community Standards or Rules

Look at the Terms of Service or other similar guidelines posted by the social media platform(s) that you are using. Platforms are private companies. They can take down your page or posts if they determine that you violated their rules of conduct. It doesn't really matter whether you actually in fact did infringe on someone's trademark or copyright.

Rules and Regulations of the Federal Trade Commission and Other Consumer Protection Bodies

Marketing and advertising on the Internet is subject to the same laws as any other medium. Unfair, deceptive or misleading advertising is prohibited, which means that any marketing must tell the truth and not leave out any relevant information that a consumer would be interested in. A claim can be misleading if relevant information is left out or if the claim implies something that's not true. If you do get into trouble with the FTC or any other consumer protection body, be prompt and clear in your communication with them. Aim to work together toward a solution right away, as it may help you avoid prosecution.

Other regulators on the advertising front that you may need to keep in mind are the Advertising Self-Regulatory Council, which governs the National Advertising Review Board, and the Children's Advertising Review Unit (CARU). If any of your marketing is targeted at children, be sure that you are fully aware of CARU's guidelines.

Endorsements

The FTC conducts investigations and brings cases involving endorsements made on behalf of an advertiser under Section 5 of the Federal Trade Commission Act, which generally prohibits deceptive advertising. The Federal Trade Commission revised its Endorsement Guides to include social media to make sure endorsements are honest and not misleading. An endorsement must reflect the honest opinion of the endorser and can't be used to make a claim that the product's marketer couldn't legally make. When bloggers and others write online about products and services, disclosure is key. If they are family or an employee, or if they were paid and/or received free items by a company and then wrote about these items, that relationship must be disclosed in a way that is clear to the reader.

Contests

Another common practice in social media marketing is offering contests. Social media contests have become quite popular among companies trying to build awareness of their brand. But, this can be quite dangerous, as well, given the wide variety of laws pertaining to contests in the US. Some states prohibit certain types of raffles, others require that giveaways involve games of knowledge not chance, and others may require a gambling license. Unfortunately, with the multi-state and multi-national nature of the Internet, one can easily cross borders, particularly in social media, and inadvertently run afoul of these laws when running any sort of contest. Be sure to check with an attorney

DISCLAIMER: This information is intended to provide general information and should not be construed as providing legal advice. It should not be cited or relied upon as legal authority. State laws vary. You should contact your attorney to obtain advice with respect to any particular issue or problem.

MICRO-INFLUENCERS AND SOCIAL MEDIA

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A long-valued piece of promotion within a marketing strategy is building positive word-of-mouth among consumers. In 2012, Nielson reported that 92% of consumers trust recommendations from friends and family. While traditionally word-of-mouth recommendations occurred in-person, social media platforms have provided a new, different, and evolving space for this same type of recommendation process to take place.

As social media sites have matured, business profiles have been added and algorithms adapted to generate advertising revenue for the give social media site and value for the businesses spending their marketing funds. At the same time, the general population of social media users has also become more sophisticated in their understanding of and receptiveness to social media marketing. A 2015 report from marketing firm Mintel found that 49% of respondents believed that "companies probably give people an incentive to post positive reviews about them" and 57% agree that "they're suspicious of a company/product that has only positive online reviews" (Mintel, 2015). At the same time, 50% of respondents think their online reviews influence others' choices (Mintel, 2015).

In response to concerns about transparency and data privacy, social media platforms have implemented changes to ensure increased transparency with advertising and sponsored content. Emerging from this, influencer marketing has become a focus for businesses, with great growth in its use in the past several years. Influencer marketing can be described as "the practice of encouraging individuals with strong social media reach over your target audience to post positive content relating to your brand" (Vgenopoulos).

Influencers can be grouped into the following categories – celebrity, mega, macro, micro, and nano – primarily due to their celebrity status or follower numbers. While the table below provides some guidance regarding categorization and follower count, there does not appear to be a universally accepted measurement.

Types of Influencers	Follower Count
Celebrity Influencer	
Mega-influencer	> 1,000,000
Macro-influencer	> 25,000
Micro-influencer	< 25,000
Nano-influencer	< 5,000

As small businesses, the likelihood of landing a celebrity or mega-influencer is slim. However, don't overlook the possibility of developing relationships with micro- or nano- influencers within your community or region. It's not uncommon to be able to identify individuals that your customers respect and want to emulate. Who these individuals are, for you and your business, will depend on your product(s), location, target customer groups, and other factors, but you likely have an idea.

Sarah Cornelisse is a Sr. Extension Associate at Penn State University in the Department of Agricultural Economics, Sociology and Education, working in agricultural entrepreneurship and business management. Sarah has interest in small scale dairy entrepreneurship and marketing, the use of social media for farm and food business marketing, and business and marketing planning and decision making. Originally from western New York, Sarah earned a B.A. in Mathematics at SUNY Geneseo and M.S. degrees in Agricultural Economics and Animal Science, both from Penn State University.

Micro- and nano- influencers have the following identified characteristics:

- Individuals "have a large following compared to their peers and have demonstrated experience and success in running their social media accounts—they tell a story, have an eye for good content, and usually rack up likes and comments" (Mintel, 2018).
- The individual is viewed as a credible, trusted source. "Influencers were seen as more impactful compared to an average person based on the following characteristics: more credible and believable (94% vs. 83%), more knowledgeable (94% vs. 84%), and better at explaining how the product works or could be used (92% vs. 83%)" (Kirkpatrick).
- Individuals are relatable to their audience. Think about mommy bloggers. These individuals typically are going through the same, or similar, experiences as their followers.
- Micro- and nano- influencers have a smaller community of followers. These smaller communities typically mean that they have a closer relationship with followers and may feel a responsibility to followers to be authentic and transparent, thus building a level of trust. Nano-influencers have six times the engagement rate of influencers (Talbot).
- Specialization in a topic. For individuals seen as an expert or highly skilled in something (baking, cooking, crafting, etc.), their followers are more likely to trust recommendations that fall in their area of expertise.

Why consider influencer marketing? Not only do a majority of people seek out the opinions and recommendations of others (friends and family) before making purchases, 67% are "at least a little more likely to purchase a product after a friend or family member shared it via social media (Kapadia). Think of the potential return if you can tap into even a small number of nano-influencers with high follower (friends and family) engagement.

Here are some ideas on how to use micro- and nano-influencers to benefit your business.

- If they're a known customer or user of your products, ask them to share how they use your products on their social media.
- Invite them to special events in hopes they will write something positive about your business.
- Start a paid business relationship with the influencer(s). Micro- and nano- influencers can provide cost effective marketing, with high percentages charging less than $250 per post (Wiltshire). However, the Federal Trade Commission (FTC) requires that paid relationships be transparent with appropriate wording in the post, such as the use of the hashtag, "#ad."
- Connect with causes that you believe in. Influencers who are also connected are likely to share info about these causes and you/your business may benefit as a result.
- Promote influencer(s) by mentioning them in your posts or imbedding their content in yours.

Success with micro- and nano- influencer marketing comes from building a relationship with the influencer(s). Make sure that they understand your business and values and will represent them well. It is important that posts from influencers seem genuine and fit with the rest of their posts and social media activity. Influencer marketing is predicted to continue to expand as millennials, in particular, are behind its growth. Almost a majority (47%) "of millennials say their purchase decisions are influenced by social media" (Roesler) and one study found that "73% of Millennials see it as their responsibility to guide friends, peers, and family toward smart purchase decisions" (eMarketer).

References

eMarketer. 2012. Brand Advocates: Scaling Social Media Word-of-Mouth. Retrieved from https://www.emarketer.com/public_media/docs/brand_advocates_scaling_social_media_word_of_mouth.pdf

Kapadia, A. (2016). Numbers Don't Lie: What a 2016 Nielsen Study Revealed about Referrals. Business 2 Community. Retrieved from https://www.business2community.com/marketing/numbers-dont-lie-2016-nielsen-study-revealed-referrals-01477256/

Kirkpatrick, D. (2016). Micro-influencers have major impact on buying behavior. Marketing Dive. Retrieved from https://www.marketingdive.com/news/micro-influencers-have-major-impact-on-buying-behavior-study/416579/.

Mintel. (2015). American Lifestyle 2015. Retrieved December 10, 2018 from Mintel Reports database.

Mintel. (2018). Nano-Influencers. Trend Observation, International. Retrieved December 10, 2018 from Mintel Reports database.

Nielsen. (2012). Consumer Trust in Online, Social and Mobile Advertising Grows. Retrieved from https://www.nielsen.com/us/en/insights/news/2012/consumer-trust-in-online-social-and-mobile-advertising-grows.html

Roesler, P. (2015). How social media influences consumer buying decisions. The Business Journals. Retrieved from https://www.bizjournals.com/bizjournals/how-to/marketing/2015/05/how-social-media-influences-consumer-buying.html?page=all.

Talbot, K. (2018). From Nano Influencers to Instagram Entrepreneurs: 3 Hot Trends in Influencer Marketing. Forbes. Retrieved from https://www.forbes.com/sites/katetalbot/2018/11/25/from-nano-influencers-to-instagram-entrepreneurs-3-hot-trends-in-influencer-marketing/#39ba781e74dd

Vgenopoulos, K. (2017). Influencer Marketing: What it is and How You Can Harness It. Retrieved from https://miappi.com/influencer-marketing-what-is-it/

Wiltshire, E. (2018). 4 Reasons Why Micro-Influencers are Key [Infographic]. Social Media Today. Retrieved from https://www.socialmediatoday.com/news/4-reasons-why-micro-influencers-are-key-infographic/525023/

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- Distinctive extra-large handles

Moon Light F1 Pumpkin

- Powdery mildew resistant
- Fruit average 18 lbs..
- Large vine
- White, flat fruit excellent for stacking

Summit F1 Pumpkin

- Powdery mildew resistant
- Fruit average 30 to 40 lbs.
- Semi-bush plant
- Large, dark orange fruit with good ribbing

Daybreak F1 Pumpkin

- Powdery mildew resistant
- Fruit average 25 lbs., some fruit to 50 lbs.
- Large vine
- Multi-colored, flat fruit excellent for stacking

Millionaire F1 Spaghetti Squash

- Powdery mildew resistant
- Fruit average 7 to 12 lbs.
- Semi-bush plant
- Excellent eating quality