2009 Strawberry Twilight

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University of Maryland
Wye Research and Education Center
Queenstown, Maryland

UNIVERSITY OF MARYLAND
COLLEGE OF AGRICULTURE AND NATURAL RESOURCES
Agriculture Experiment Station
Wye Research and Education Center

MARYLAND COOPERATIVE EXTENSION
UNIVERSITY OF MARYLAND
COLLEGE PARK • EASTERN SHORE

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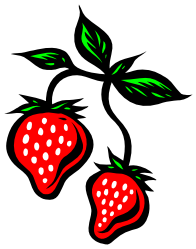
Original photo of WREC berries, 2009 harvest, courtesy of Danny Poet*



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Varieties Grown On Plastic At WYE 2008-09

*** Description of varieties are from Breeder notes and nursery catalogs with some comments on performance at Wye. These descriptions and reported yields throughout this book do not guarantee how they may look or perform at your location. Always trial new varieties.**

Outdoor field plots

Albion – University of California release, day-neutral (ever-bearing)**.** Resistant to Verticillium wilt (*Verticillium dahliae*) and Phytophthora crown rot (*Phytophthora cactorum*), and relatively resistant to Anthracnose crown rot (*Colletotrichum acutatum*). Low Spring yields at Wye. Fall production potential. Good size, shape, color. Firm berry. Possible Summer production in Western Maryland.

Allstar - 1981 USDA release, late mid-season, resistant to red stele. Large, firm, light colored fruit. Has performed well in the annual plasticulture system in mid-Atlantic region. Has always looked a little rough in Wye trials.

Bish - NC State release. As early as Chandler, but has lower yields in trials at Wye. Fruit holds up well and looks good out of cooler. Flavor has been variable at Wye.

Chandler - Standard for annual plasticulture system. Needs Winter protection with row covers. High yields and good flavor is possible with high management. Not suited for all regions in mid-Atlantic. Flavor can be flat if over-fertilized and cool harvest season.

Daraselect - Developed in France. Performs well in both the annual plasticulture system and matted row system. Yielded similar to Chandler at Wye in 2007. Good flavor, rough looking, >50 gram king fruits.

Eros - An Allstar hybrid, mid to mid-late season. Resistant to red stele and tolerant to some leaf diseases. 2nd year at Wye in the field.

Galleta - (NC 93-05)- New NC State release, early. 2nd year at Wye. Fruit looks and sizes well, but flavor has been flat.

Jewel – 1985, New York release. Widely adapted. Does well in matted row. Susceptible to root diseases and powdery mildew.

KRS-10 - New Nova Scotia release. Late season. Very good fruit size. Limited availability

Nyoho – Release from Japan

Ovation - USDA release, Late season. Very resistant to red stele and good tolerance to foliage diseases. Low yields in the past at Wye due to bud clipper damage. Very vigorous plants.

Palomar – New (2009) release from University of California. Early flowering for possible Fall fruiting here in East. Susceptible to Phytophtophora root and crown rot. Plant size is small. First year at Wye.

Seascape - Day-neutral release from California. Potential for Summer/Fall production in cooler areas. Spring yields have been high at Wye. Flavor not great.

NC-03-05 - NC State day-neutral selection. 2nd year at Wye. Off-season high tunnel potential. Early Spring yielder.

NC-03-06 – NC State day-neutral selection. 2nd year at Wye. Off-season high tunnel potential. Early Spring yielder.

Strawberry Festival – Good potential for Fall production. Susceptible to *Anthracnose* fruit and crown rot.

Sweet Charlie – Early fruiting, low acid, good flavor. Can be soft. Possible Fall fruiting.

Varieties Grown In High Tunnel

Strawberry Festival – Good potential for Fall production. Susceptible to *Anthracnose* fruit and crown rot. Problems with Botrytis crown rot in Wye tunnel.

EVALUATION OF THE USE OF BARE-ROOTED DORMANT PLANTS IN AN ANNUAL PLASTICULTURE SYSTEM

Michael Newell
Wye Research and Education Center

This project was made possible with grants from the Maryland State Horticultural Society.

Background

Limited varieties available as plug plants and the expense associated with the cost of growing and shipping plugs has increased the interest in using other available varieties in the annual plasticulture system of growing strawberries. There are many eastern-bred varieties available as dormant bare-rooted plants that are primarily used in the perennial matted-row system. However not all eastern-bred varieties are suitable for the annual system because these varieties are bred to produce runners as the means of increasing the number of flower producing crowns per acre. Varieties bred for the annual system are selected for their capacity to produce branch or side crowns as the method of increasing the number of crowns per acre in a short period of time. Several Maryland growers have begun using bare-rooted dormant plants grown on plastic. The number one reason given for using this system was weed control and almost all planned on carrying the planting over for a second year harvest. The objective of this trial was to evaluate varieties for use in an annual system, using methods already developed for this system using the variety Chandler. If we were to plant in the Spring we may develop to many branch crowns which lead to smaller berry size, if we plant to late we do not get enough branch crown development.

Methods

Nine varieties were selected from Nourse Farms inventory for trial. These nine (Allstar, Bish, Chandler, Daraselect, Eros, Jewel, KRS-10, Ovation and Seascape) were selected based on past performance in other plasticulture trials. Planting beds were prepared as recommended for the annual system and either white or black plastic mulch was used. As a post-planting treatment to reduce mortality, plots would either be intermittently overhead irrigated for several days or receive no overhead irrigation. As a control group, these nine selections were received in early July 2007 and were planted into a 48 cell tray-packs. These would be well rooted plants and receive no post-planted overhead irrigation. The second group of plants were received on July 23 and directly field planted as bare-rooted dormant plants and one of these two groups received the overhead and one group did not.

Standard plasticulture practices were followed and pesticide controls were used to keep the plots insect and disease free. A 1.0 oz/sqft floating row cover (FRC) was deployed in December of 2007 and removed in early March of 2008. Several frost events necessitated redeployment of the FRC and I feel confidant that no cold damage affected flowering. 2008 harvest began on May 9th.

Collected data includes:

Post-plant mortality
Fall fruiting
Fall crown development
Fall runner production
Spring yields.

Experimental design:

Split-spilt randomized plot with four replications of six plants each.
Main plot is post-plant establishment
Sub-plot is mulch color

Results

Post-planting mortality (Table 1):

Air temperatures during the 10 days following planting was typical for our location with daytime highs in the upper 80's to 90's and bright sunshine. Reduced soil temperatures at the 2 inch depth were realized in both the white plastic and the black plastic that received post-planting overhead irrigation. However with the exception of the variety Seascape, plant mortality was less than 10%.

Runner Production (Table 1):

As expected, the number of runners produced was larger than we see when we plant plugs in early September. When to remove these runners is a management issue and removal of all runners at some point before Spring growth is desirable to reduce potential insect and disease problems.

Fall crown development (Table 1)

The development of branch crowns in the Fall is crucial for greater Spring yields in this type of growing system. Generally 1 -2 branch crowns developed on most of the varieties during the Fall growing period. Although the development of this number of branch crowns is what we hope for when growing the variety Chandler, during this season it did not translate into high yields. Interestingly, we had our usual Chandler plug plants planted and they also had a lower Spring yield (0.8 lbs/plant). What we have observed over the years is that if Chandler has a poor harvest, then most all varieties we are growing on plastic have a poor harvest. In most instances, assuming we do everything right, low yields are usually a result of a severe late Winter weather event that damages flower buds ever before they emerged from the crown.

Year of planting Fall fruit production (Table 1)

Seascape was the only variety that showed any Fall fruiting and this was an extremely low Fall harvest yield.

Spring yields (Table 2)

Despite generally low yields, several varieties did stand out. KRS-10, a late season variety from Nova Scotia, had the overall highest yields (1.1 lb/plant) and average fruit size (0.7 oz). Seascape also did well with 1.4 lb/plant, however Seascape always does well for us in the annual system, but fruit quality has been poor. Chandler as a bare-rooted plant did better than our plugged Chandler. Galletta also produced more than 1.0 lb/plant with decent fruit size.

White versus Black plastic (Table 3)

Several varieties yielded better when black plastic was used. Galletta, Seascape and Chandler all had higher Spring yields when grown on black plastic. Bish Allstar, Eros and Daraselect all yielded better when planted on White plastic. With the remaining varieties yielding equal amounts on both black and white plastic.

First harvest date (Table 4) was minimally affected by mulch color.

Table 1. Fall data

Mulch color	White	White	White	Black	Black	Black
Irrigation, post plant	Yes	No	No	Yes	No	No
Plant Type	Bare-root	Potted	Bare-root	Bare-root	Potted	Bare-root
% mortality	3.6	<1	7.6	8.9	<1	26
Crown # Per plant	2.5	2.3	2.5	2.3	2.4	2.3
Runner # Per plant	10	8.8	10	7.6	8.9	7.2
Fall yield Per plant (g)	1.0	10.4	0	0	9.5	0
7/31-8/6 soil temp f (3”)	71.4	--------	77.1	73.9	-------	79.8

Table 2. Marketable Spring Yields (grams per plant)
White versus Black Mulch

Variety	Mulch	Yield/plant	Fruit size	Mulch	Yield/plant	Fruit size
Bish	Blk	391	17.0	White	468	15.7
Allstar	Blk	151	13.5	White	168	13.4
Jewell	Blk	306	12.7	White	308	14.8
Ovation	Blk	299	15.6	White	288	15.5
Chandler	Blk	474	16.8	White	422	16.3
Daraselect	Blk	313	19.3	White	376	19.8
Eros	Blk	380	15.7	White	445	16.1
KRS-10	Blk	520	19.8	White	522	21.9
Galletta	Blk	483	28.8	White	299	20.8
Seascape	Blk	649	16.4	White	441	15.8
Chandler plug	Blk	404	16.5	White	364	16.8

Table 3. First harvest date
White versus Black Mulch

Variety	Mulch	Date	Mulch	Date
Seascape	Blk	May 15	White	May 19
Bish	Blk	May 17	White	May 18
Chandler	Blk	May 17	White	May 18
Galetta	Blk	May 20	White	May 17
Daraselect	Blk	May 21	White	May 20
Allstar	Blk	May 23	White	May 20
Jewell	Blk	May25	White	May 25
Eros	Blk	May 27	White	May 27
Ovation	Blk	May 30	White	May 31
KRS-10	Blk	June 2	White	June 3

Table 4. Increase in Spring Yield
Black versus White mulch
negative number = white mulch had higher yields)

Variety	*
Bish	-17%
Allstar	-10%
Jewell	0
Ovation	0
Chandler	11%
Daraselect	-17%
Eros	-15%
KRS-10	0
Galletta	39%
Seascape	32%

2009 Carry-over plot
2nd year

GATE ↑

ROW>>	6	5	4	3	2	1	
	BP	BP	WP	WP	BP	WP	**key**
	11	1	12	11	2	3	bare-rooted
	9	3	10	7	4	1	**1….BISH**
BLK 1	8	5	8	9	6	2	**2….ALLSTAR**
	10	7	6	5	12	4	**3….JEWEL**
	BP	BP	WP	WP	BP	WP	**4….OVATION**
	12	11	1	2	1	9	**5….CHANDLER-NOURSE**
BLK2	9	8	3	4	4	10	**6….DARASELECT**
	7	5	6	5	6	12	**7….EROS**
	3	2	7	8	10	11	**8…..KRS-10**
	WP	WP	BP	BP	WP	BP	**9….SEASCAPE- NOURSE**
	5	4	12	11	1	6	plugs
BLK 3	8	3	8	9	7	1	**10….Chandler-NOVA**
	11	6	10	7	12	3	**11….EROS-NOVA**
	2	10	2	5	9	4	**12….USDA Aug plug**
	WP	WP	BP	BP	WP	BP	
	1	2	3	4	5	6	
BLK 4	7	8	9	10	11	12	
	4	6	1	2	3	5	WP =White plastic
	10	12	7	8	9	11	BP = Black plastic
	WP	WP	BP	BP	WP	BP	
	1	2	3	4	5	6	
	7	8	9	10	11	12	bare-rooted
BLK 1	4	6	1	2	3	5	**1….BISH**
	10	12	7	8	9	11	**2….ALLSTAR**
	WP	WP	BP	BP	WP	BP	**3….JEWEL**
	5	4	12	11	1	6	**4….OVATION**
BLK2	8	3	8	9	7	1	**5….CHANDLER-NOURSE**
	11	6	10	7	12	3	**6….DARASELECT**
	2	10	2	5	9	4	**7….EROS**
	BP	BP	WP	WP	BP	WP	**8…..KRS-10**
	12	11	1	2	1	9	**9….SEASCAPE- NOURSE**
BLK 3	9	8	3	4	4	10	**plugs**
	7	5	6	5	6	12	**10….NC 03-05**
	3	2	7	8	10	11	**11….Galleta**
	BP	BP	WP	WP	BP	WP	**12…NC 03-06**
	11	1	12	11	2	3	
BLK 4	9	3	10	7	4	1	
	8	5	8	9	6	2	"= IPM trial
	10	7	6	5	12	4	

2008/09 Carry-over Plot Details

2007

Plant bare-rooted plants in July
Plant plug-plants in September
Insect and disease management
Floating row cover for over-wintering

2008

Harvest Spring
Begin management for 2nd year harvest, minimal inputs until September
Crown thin to 3 crowns September
Additional maintenance, fertility applications, fungicide sprays for leaf disease control, insect monitoring. Runner removal.
Floating row cover for over-wintering

2009

Floating row cover for frost damage prevention
Insect sprays at pre-bloom for bud weevil and tarnished plant bugs
Fungicide sprays at 10%, 50% and full bloom for grey mold control
Spring fertigation = 30 lbs nitrogen
Harvest Spring

Report on 2008-2009 USDA-UMD Strawberry Research at Wye REC

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Michael Newell, University of Maryland, WREC, Queenstown, MD
Kimberly Lewers, Genetic Improvement of Fruits and Vegetables Lab, USDA-ARS, Beltsville, MD, and
John Enns, Genetic Improvement of Fruits and Vegetables Lab, USDA-ARS, Beltsville, MD

Regional production of strawberries will enable growers to harvest fruit at higher maturity stage and reduce the time between harvest and consumption to assure higher quality fruit. In the mid-Atlantic coast region, new management strategies and strawberry cultivars are needed to increase off-season fruit production which would open niches for alternative and value-added products that small farms can provide. The need to develop alternative strawberry production systems is driven by: 1) high labor inputs and production costs associated with cultivation, 2) higher profit potential for niche-market driven fruit production, and 3) the loss of registered pesticides.

The physiological state of plug transplants and nursery conditions in which transplants are produced affect whether flower induction and inflorescence differentiation occur during the propagation phase or shortly after field establishment. Our previous research on flowering (Takeda et al., 2006; Takeda and Newell, 2006) should be taken as a guideline for starting preliminary and exploratory physiological studies. We have identified several facultative short-day type cultivars (e.g. 'Carmine' (Chandler et al., 2004), 'Camarosa' (Voth et al., 1994), and 'Chandler' (Voth and Bringhurst, 1984)) that can be manipulated to flower or remain vegetative in fall.

The objective of 2008-2009 plasticulture studies in high tunnel and outdoor plots was to improve the understanding of mechanisms that control flowering in strawberries and enhance fall fruiting in short-day type cultivars. This research focused on the effect of altered light environment during transplant production phase. Also, seedlings produced from the following crossings: 'Carmine' x 'Chandler', 'Carmine' x 'Bish', 'Bish' x 'Carmine', 'Bish' x 'Chandler', 'Chandler' x 'Carmine', and 'Chandler' x 'Bish', were evaluated for fall flowering capacity in outdoor plots.

In Study 1 (Cooperator: Michael Newell), 'Strawberry Festival' tips produced in a greenhouse at ARS Kearneysville, WV were plugged into 50-cells on 2 July. On July 28, 50 cell-pack tray plants that were plugged on 2 July were FedExed to Kennedy Space Center. There the plants were grown for ~ 4 weeks in Controlled Environment Chamber with or without red light illuminating the crowns and fertigated with High or Low N nutrient solutions. After 4 weeks of light and fertilization treatments, transplants were established in annual plasticulture system at Wye Research and Education Center (WREC) in Queenstown, MD. The high tunnel was erected over these plants in October. Ripe fruit were harvested in October, November, December 2008, and in January, March, April, and May 2009.

July-plugged transplants started to flower around September 15 and the first harvest occurred on Oct. 13. Harvesting continued weekly until January 5, 2009. Highest early yields were produced by plants that were grown without red light illumination in August and fertilized with low Nitrogen nutrient solution. The total fall- and early winter yields averaged from 154 g (1/3 lb) 117 g (1/4 lb) per plant. Some plots averaged nearly ½ lb per plant. Spring harvest began in mid March and continued until mid May (rain or shine). Average yield per plant in the spring was 1-1/3 lb. Allowing plants to bloom and produce fruit before winter did not depress their spring yields. With proper fungicide applications, the cull percentage (small and diseased fruit) was only 8% under the tunnel. A fall crop and an early spring crop can be obtained by planting specially prepared short-day cultivars in late August and growing them under a high tunnel. The spring harvest was prolonged (~2 months) and fruit rot was minimal.

Study 2 (Cooperators: Michael Newell) Runner tips from 'Sweet Charlie' and 'Strawberry Festival' were plugged into 50-cell packs on 2 July and 30 July. These plants were maintained in a greenhouse at ARS Kearneysville, WV until August 28. The rooted transplants were established in a plasticulture system on August 28 at WREC. Ripe fruit are being harvested in spring 2009.

Study 3 (Cooperators: Kimberly Lewers and John Enns) More than 600 individual seedlings produced from reciprocal crossing of 3 parents ('Bish', 'Carmine', and 'Chandler') were evaluated for fruit quality in May and June 2008 in a seedling field at USDA Beltsville, MD. Runner tips were collected in late June from ~33 individual plants that were rated "good" for firmness, size, color, and taste and plugged in 50-cell packs. These plug plants were maintained in a greenhouse at ARS Kearneysville, WV until August 28. The rooted transplants were established in plasticulture on August 28 at WREC. Four selections (KB 2, KB 7, KB 8, and KB 11) bloomed and produced ripe fruit before late November. Several horticultural characteristics of KB selections are being made in Spring 2009.

Study 4 (Cooperator: Michael Newell). Runner tips of 'Albion', 'Palomar', Seascape', and 'Nyoho' were plugged in 50-cell packs on 2 July. Plug plants were maintained in a greenhouse at ARS Kearneysville, WV until August 28. The rooted transplants were established in plasticulture system on August 28 at WREC. Ripe fruit were harvested in November and December 2008 and in spring 2009.

The results of this study suggested that red light from LED lamps with maximum wavelength at 662 nm, directed at the crown delayed flower bud induction in 'Strawberry Festival' strawberry transplants. Significantly more control plants bloomed in October and November than the transplants that were lit in August with red LED light. By late November, 95% of unlit plants had open flowers compared to only 54% of transplants that were lit with red LED light.

Although the foregoing work with red light was done with one cultivar, we have ample evidence to show that fall flowering is inducible in several short-day strawberry cultivars by advancing the plugging date to early July and maintaining transplants at high density until late August. The ratio of red to far red radiation differed widely in light received by the leaves and that received by shaded crowns of strawberry transplants in 50-cell pack trays. This shift in red to far red light within a canopy of strawberry transplants appears to play a role in the mechanism controlling flower bud induction. It seems that results of this study are useful for the discussion on strawberry transplant propagation techniques and the significance of shade-imposed mechanism, operating through the phytochrome system, initiates reproductive development in short-day strawberries.

Transplants of some short-day cultivars started as plug plants in early July have the capacity to flower and fruit in the fall and the following spring, enabling growers in the mid-Atlantic coast region to harvest strawberries twice (fall and spring) within one year from a single planting. High tunnel production extends harvest season to December and accelerates strawberry growth in spring that harvesting can start in March and end well before outdoor planting begins in May.

Fall and spring harvests were possible from 'Strawberry Festival' plants produced as plug plants in early July. Fruit were harvested from 'Strawberry Festival' plants in a high tunnel beginning in October. From October to early January, yield per plant ranged from 1/4- to nearly 1/2- lb per plant. Many open flowers and green fruit were damaged in January and February 2009 when the temperatures under a heavy row cover dropped to ~ 26 – 28 °F.

2008/09 Annual Plasticulture Map

GATE ↑

Row 1	Row 2	Row 3	Row 4
KB 2	KB 14	KB 12	KB 25
			KB 26
KB 3		KB 13	
	KB 15		
		KB 27	
			KB 29
KB 7			
	KB 16		
		KB 28	
KB 8	KB 18		KB 23
	KB 19	KB 10	
KB 9			KB 30
	KB 20		
		KB 11	

SF 2 J	SC 30 J	SF 30 J	SC 2 Jul
A	**D**	**B**	**C**
SC 30 J	SF 30 J	SF 2 J	SC 2 J
D	**B**	**A**	**C**
SC 2 J	SF 2 J	SF 30 J	SC 30 J
C	**A**	**B**	**D**
SF 30 J	SC 2 J	SF 2 J	SC 30 J
B	**C**	**A**	**D**
PA	**AL**	**SE**	**AL**
Al	**PA**	**PA**	**SE**
SE	**SE**	**AL**	**PA**
NY	**NY**	**NY**	**NY**

= seedling block

KB=seedlings, plugged on 2 July
Crosses made with 3 short-day cultivars with high fall flowering potential(Carmine, Chandler, and Bish) if plug plants are started in early July"

KEY
SF = Strawberry Festival
SC = Sweet Charlie
PA = Palomar
AL = Albion
SE = Seascape
NY = Nyoho

PA, AL, SE, and NY were plugged on 2 July.

SF and SC were plugged either on July 2 or July 30.

Improving the Management of Strawberry Sap Beetle in Small Fruit

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Introduction

The strawberry sap beetle (SSB) is probably one of the most significant insect pests in small fruit in the mid-Atlantic. The small, brown adults are approximately 1/16 inch in length and appear in strawberry fields as berries ripen. The adults and larvae prefer to feed on over-ripe fruit but will also damage marketable berries. The beetles are widespread and present on most fruit producing farms, but seem to be a significant problem only in certain locations. Likely contributing to SSB abundance is the trend to produce an increasing diversity of fruits and vegetables on a farm to support lucrative farm stands and U-pick operations, where sanitation is difficult to maintain when customers harvest the product. Understanding SSB movement from suitable overwintering habitat into strawberry fields and the extent of subsequent colonization of alternate crops is critical in developing new management strategies. At the present time there are only moderate or poor control strategies for management of this pest. Current recommendations include applications of pyrethroids, field sanitation, and renovating very soon after harvest. Labeled pyrethroids have not provided sufficient control and are broad spectrum, potentially disrupting predator populations that provide pest control. SSBs are not resistant to pyrethroids, but have a tendency to feed underneath fruit where they are unlikely to come into contact with the insecticide. The focus of this research is to improve SSB management through a better understanding of beetle movement. The second year will take the results obtained from this study and develop new management tactics for SSB.

Methods

1. Overwintering location and colonization of strawberry fields in early spring

Problem: Beetles are thought to overwinter as adults in wooded areas, but how much they overwinter in fields of strawberry or other crops is still unclear.

Experiment 1: Adult SSB can be sampled in the field by using traps baited with whole wheat bread dough (food-odor traps). Traps will be placed along the edges of wooded areas near strawberry fields and along the border and in the strawberry field in early spring. Beetle activity is influenced by temperature with little movement of SSB when the minimum temperature is below 60^{o}F, therefore when the traps go out will depend on temperatures. Traps will be run for a 24 hr period when temperatures are conducive for beetle movement and will be run every 5-7 days over the course of the spring. When traps are placed in the field, strawberry fruit also will be monitored to see when the beetles are first detected in the field. Traps and field monitoring will be done at two commercial farms that have strawberries and other small fruit as well as vegetable crops and at 2 research stations located at the Wye, and in Keedysville, MD. By monitoring which traps in a strawberry field are most heavily inundated it should be possible to determine where beetles moved from and whether traps can detect beetles before they are found in the field.

2. Beetle movement after strawberry harvest

Problem: Where do beetles go after strawberry harvest?

Adults emerging from strawberry fields should move out and search for other food sources such as raspberries, blackberries, blueberries, cherries, pumpkins, melons, and various vegetables. In Maryland SSB is a major pest later in the season as it moves out of strawberry and into small fruits, especially raspberry. Therefore it is important to know when and in what numbers they move from strawberry fields in late spring into other crops.

Experiment 2: Traps will be placed around the edge of strawberry fields and along edges of raspberry, blackberry and peach fields near the end of strawberry harvest. Traps will be baited and checked for SSB every 5 days over the course of two months. The other fruit crops also will be monitored for SSB. Weather conditions will be recorded at each site to determine if temperature can be used to predict beetle movement.

Problem: Sap beetles also have a male-produced aggregation pheromone, which is attractive to both male and female SSB and could be included in a trap along with a food odor. This pheromone has not been reliable (consistent in attracting SSB) up to this point in time, but should be tested to determine if it is worth using.

Experiment 3: The aggregation pheromone will be tested on two of the farms in half the traps in a field. Farms that have several strawberry fields with sufficient distance between fields so that the pheromone will not interfere with the food-odor baited traps will be used in this study. Trapping procedures will be conducted as discussed in experiment 1 and 2 above.

There also may be other sap beetle species that are important as pests in these farm systems. This study will also monitor these other species in the food-odor traps.

Other directions for controlling SSB

The strawberry sap beetle is very mobile across a farm scale, able to use a wide range of crops as food sources, and is not easily contacted by commonly used insecticides. The most promising option is development of a trap-and-kill technique where attractive traps with insecticide could be set up in the early spring before strawberry ripening with the idea of reducing the numbers of beetles entering strawberry fields. This method can then be used again at the end of strawberry season as other fruit ripens on the farm and beetles move out of the strawberry field into these other crops. What is needed first is information about the movement of the SSB across the farm landscape over the course of a season and how efficacious the traps are in attracting the beetles compared with the crop. The trap-n-kill method will be experimented with on a limited basis this first season and on a much larger scale next season.

Using *Beauveria bassiana* in High Tunnel Pest Management

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Summary: In 2007 we undertook a limited number of trials in HTs using the biopesticide-*Beauveria bassiana*, (Naturalis L) ATCC strain and (BotaniGard) GHA strain, alone and in combination with an Azadirachtin (Azadirect, a neem concentrate) drench of plants with applications of diatomaceous earth. Azadirect did not have much of an effect alone or in combination with any other treatment and because of its expense we decided it would not be used in future studies. *B. bassiana ATCC* strain worked well in the early part of the season (when it was cooler), but less well as it became warmer. However, *B bassiana GHA* strain worked much better in the warmer periods than the *ATCC* strain. *B bassiana* also seemed to work better when combined with diatomaceous earth (DE). What we think is occurring with the interaction of *B. bassiana* and DE is that the diatomaceous earth is causing tiny pin-pricks in the cuticle of the aphids and mites which allows the *B. bassiana* fungus a place to enter and infect the pest. Worms were easily controlled in all HTs by using the new threshold and the organic insecticide Entrust. In one organic research HT we released two natural enemies over the course of the season in the hopes of controlling first aphids and then later in the season mites. Our preliminary work showed that *B. bassiana* can work with the aphid midge, *Aphidoletes aphidimyza* (i.e., midge continued to feed and reduce aphid numbers as *B. bassiana ATCC* was used) but did not work well with the mite predator *Phytoseiulus persimilis* (i.e., *B. bassiana* infected predatory nymphs and adults resulting in little biocontrol).

Introduction: Vegetable growers have needed new and alternative methods to bring more money into their operations without investing much capital. The use of a high tunnel (HT) has worked well for many growers, but especially small farms to increase on-farm profits. Because HTs extend the vegetable growing season growers are able to supply customers with high quality fresh produce earlier and later into the spring and fall then is normally possible. Although HTs are relatively inexpensive to construct and use there is an increase in the amount of management that goes into their operation. There are few guidelines available for growers to use regarding how to manage their insect problems because so little is known about how best to manage pests in HTs.

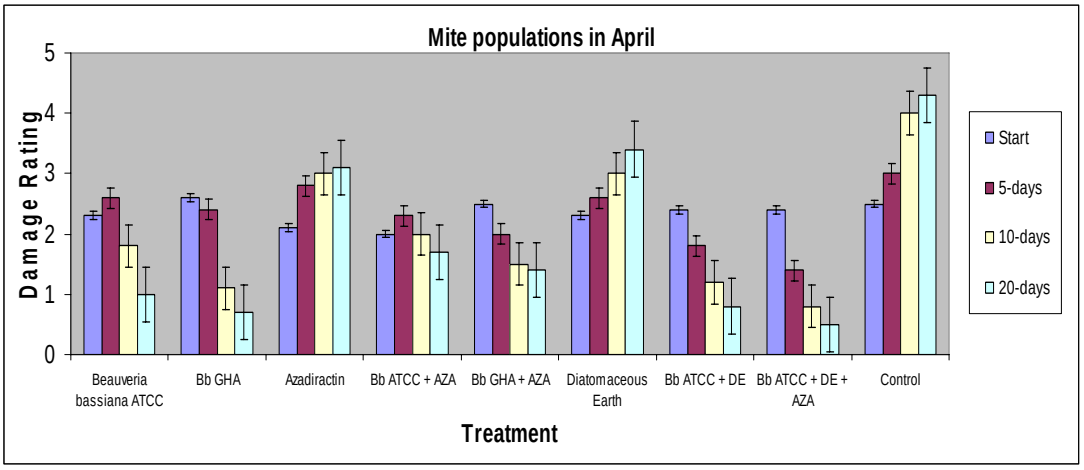
Results: *B bassiana* reduced twospotted spider mites, *Tetranychus urticae* (Figs.1&2) and green peach aphids *Myzus persicae* (Figs.3&4) by an average of 83% compared with other organic insecticides or the control. Some strains of *B. bassiana* worked better than others when the temperature began to rise in the HTs. *B. bassiana strain GHA* worked better in controlling aphids and mites than did *strain ATCC* in August as compared with April. Using Azadirachtin alone or in combination with *B. bassiana* did not increase the control of aphids or mites as compared to using *B bassiana* alone. Because of its expense Azadirachtin does not appear to be a cost effective method of control for aphids and mites at this time. Diatomaceous earth alone did not significantly reduce aphid or mite populations, but when combined with *B bassiana* did an excellent job of aphid and mite control (Figs.1, 2, 3 and 4).

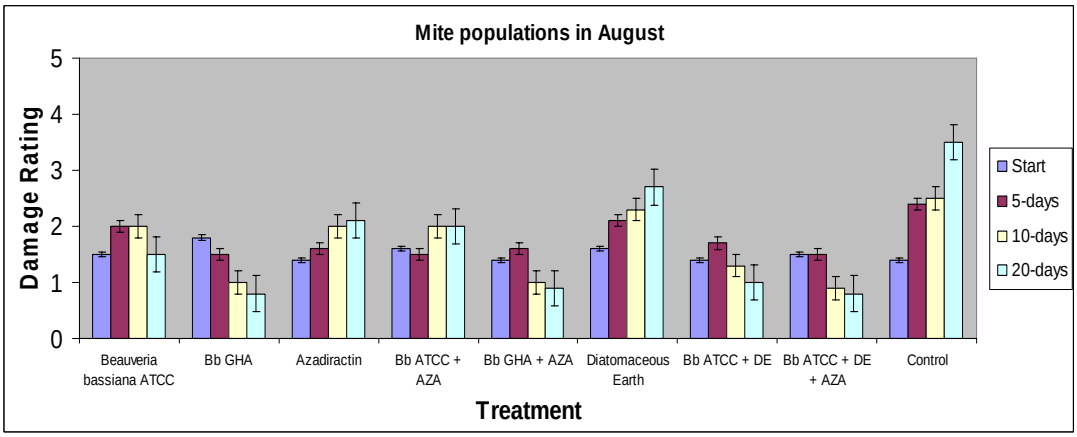
In one HT we examined the use of biocontrols (aphid midge, *Aphidoletes aphidimyza* and the mite predator *Phytoseiulus persimilis)* and their compatibility with *B. bassiana*. After several releases throughout May of the aphid midge and several applications of *B. bassiana* we were able to recover aphid midge larvae from aphid infested leaves (Figs.5&6). Even weeks after 98% of the aphid population was killed we still found midges on a few leaves. The predatory

mite did not do as well. After several releases and applications of *B. bassiana* in August we could rarely find any *Phytoseiulus persimilis* on treated leaves. We were, however, able to find the mite predator to some extent on non treated mite-infested leaves.

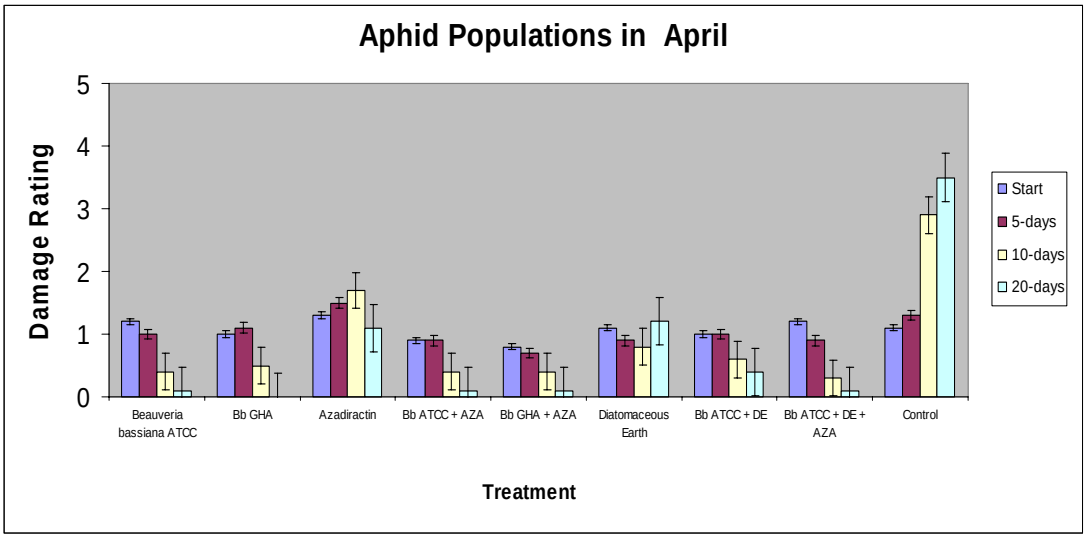
Yields of tomatoes were usually not significantly different from one another between any of the treatments and varied to a great extent between HTs. One variety of tomato *Mountain Fresh+* was compared among the HTs to try and reduce variability (Fig. 7). There was a trend for Bb GHA strain to have greater yields compared with most of the other treatments. The control and DE treatments had significantly ($p<0.05$, orthogonal contrasts, SAS, 2008) more culls than the other treatments. Treatments GHA alone and GHA with Azadirect had the lowest number of culls of any treatment.

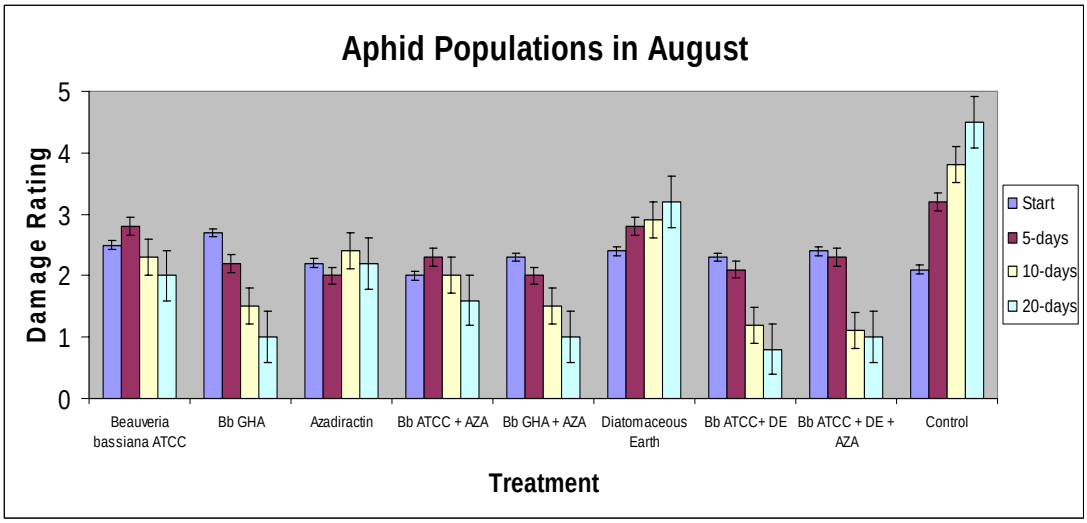
Figs. 1 and 2 Comparison of two strains of *B. bassiana* and other organic treatments in the control of two spotted spider mites, *Tetranychus urticae* in high tunnels in April and August, 2007. Columns represent the number of days after treatment started. Damage rating is from 0-5 where: 0 = no damage and 5 = plant killed.



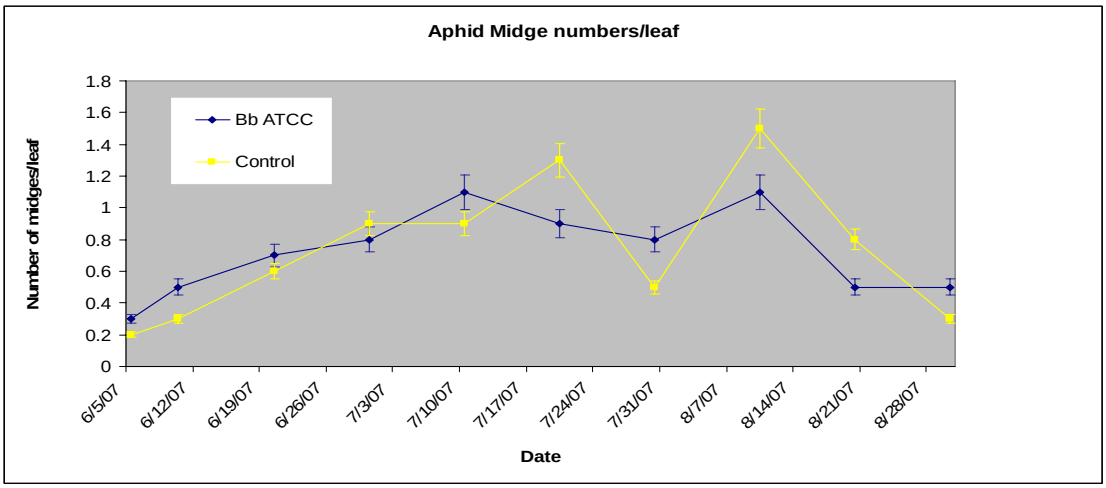


Figs. 3 and 4 Comparison of two strains of *B. bassiana* and other organic treatments in the control of green peach aphid (*Myzus persicae*) in high tunnels in April and August, 2007. Columns represent the number of days after treatment started. Damage rating is from 0-5 where: 0 = no damage and 5 = plant killed.





Figs. 5 and 6 Number of immature aphid midges per tomato leaf in Bb ATCC and control treatments and Number of aphids on leaves in Bb ATCC, Midge, Bb ATCC+ Midge and control treatments.



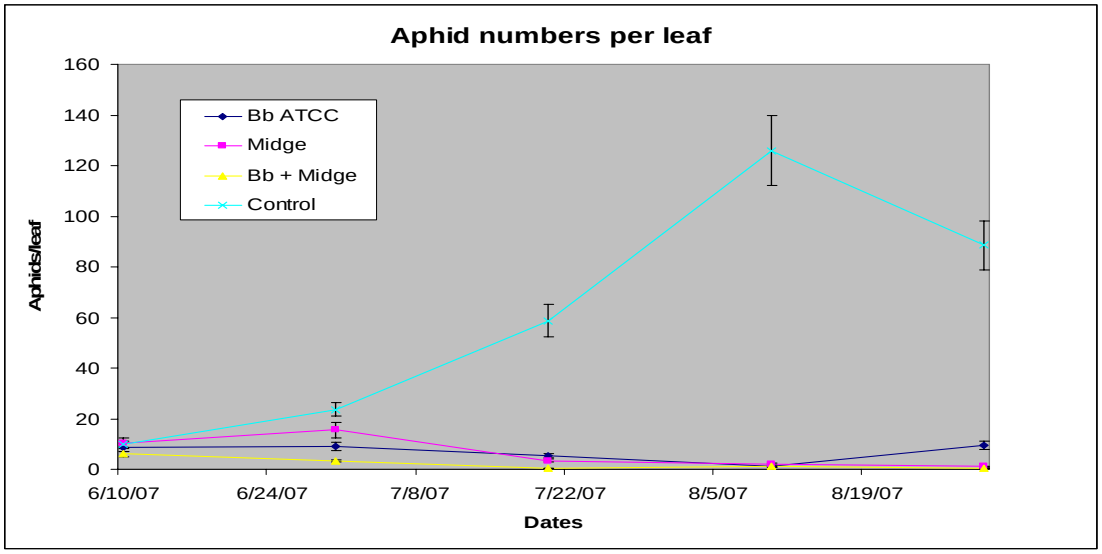
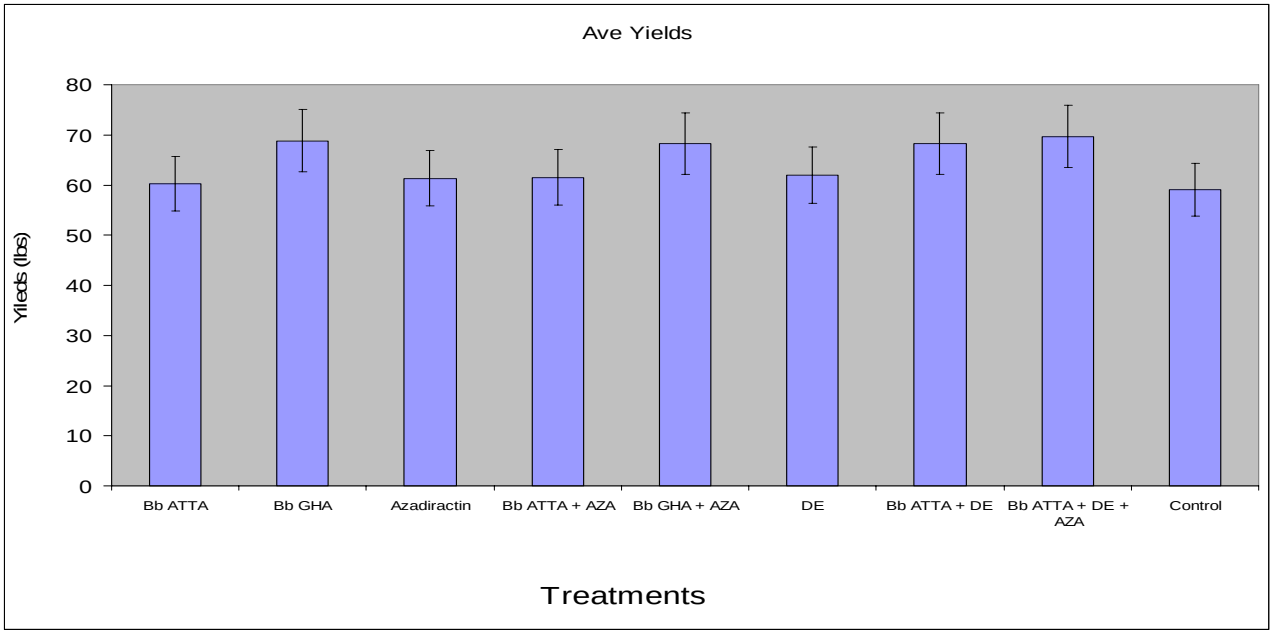


Fig. 7 Average total tomato yield by Sept. 15 from 4 HTs with 9-different treatments



Figs 8 and 9. Aphid and a Western flower thrips infected with *B. bassiana strain GHA*

Causes of Misshapen Strawberries

Kathy Demchak
Penn State Horticulture

Every year, I'll get several calls about misshapen berries. There are a lot of possible causes, so if you notice strange strawberry shapes, check over this list, and see if some of these items apply to your situation – that could help with sorting out the cause of the problem. In cases where a weather event or a spray is suspect (see below), the berry shape improves in a few days, indicating that a short-lived event was responsible.

1) Some cultivars just do that. There can be bumps, folds, crinkles, and hollow berries that split open at the tip. This happens more frequently with cultivars that are known for a huge size. Cabot, Camarosa, and Albion tend to do this, and almost always, it's just with the primary berries. Mesabi also may have misshapen berries, but to a lesser extent, and low boron could also play a role (see below). Once you are producing secondary and tertiary berries, this becomes less of a problem, possibly because more pollen is available – source of pollen and timing of pollen release also may play a role.

2) Environmental conditions during bloom that would have affected pollination. This can be temperatures below freezing, which can damage flower parts. A hot dry spell can cause the stigmas (located on the yellow "cone" in the center of the flower) to dry out, and therefore, the pollen doesn't stick. In the case of cold temperatures, the berry may appear folded, or the tip may be affected. With hot dry temperatures, pollen may stick only where the stigmas touch the anthers. The anthers are located in a circle around the stigmas. In extreme cases, the berry may end up shaped like a doughnut.

3) Damage to the flower from a mixture of spray materials applied during bloom. I've only suspected this in cases where more than 3 or 4 materials were applied in a tank mixture at one time. There is some indication in the literature that when high calcium concentrations are applied to flowers (much higher than those found when labeled directions for nutritional supplements are followed), pollen viability is affected. So, you might want to measure. More often isn't better.

4) Low boron or zinc. Both are involved in pollen tube growth, so incomplete pollination takes place. Bad pollination = no seeds, and when seeds don't develop, the fruit doesn't enlarge. The seeds produce the growth regulator that causes the berries to expand. This is one reason why we like to see growers use tissue analysis. Low boron is more likely to be a problem on sandy soils. Boron levels in the soil should be above 1.5 pounds per acre, or 0.75 ppm, and tissue levels should be between 30 and 70 ppm.

5) Seed destruction (seeds may only be hollowed out) from an insect, mostly likely tarnished plant bugs. Adult tarnished plant bugs fly away fast, so it's possible to miss the problem until you see the green nymphs crawling around. Usually tarnished plant bugs are a bigger problem where you have weeds, on which they multiply. Long-necked seed bugs are occasionally a problem, and as the name implies, look like they have a long neck. They are dark brown, slender, and have tiny little heads. They move really fast and hide under leaves. Both tarnished plant bugs and long-necked seeds bugs cause a "button-berry" shape most commonly, but other shapes are possible.

6) Poor pollination from a lack of pollinators, or damp rainy weather during bloom, which discourages pollinators from flying. More pollination usually results in bigger fruit regardless. Each blossom should receive 16 to 25 bee visits for complete pollination.

Winter Injury And Cool Temperatures Create Ideal Conditions For Botrytis In Strawberries*

Dr. Frank Louws, Extension Plant Pathologist, North Carolina State University
*Reprinted from the Southern Region Small Fruit Consortium Plasticulture Advisory March 2005, Vol. 6, No. 8

Winter injury has left many dead leaves that will serve as a major source of Botrytis spores in the early spring season. Likewise, a number of plantings recently experienced freeze injury to emerged blooms. These dead flowers can become infected with Botrytis; the pathogen can grow down the peduncle and into the upper crown tissue to cause a Botrytis crown rot (Figure 1). Once in the upper crown, the pathogen can move from tissue to tissue and rot off many petioles and flower clusters, even getting into the fleshy portion of the crown in severe cases.

Large plants, cool wet weather, and no control measures favor crown rot. A number of farms have recently observed crown rot problems appearing.

Other farms are concerned about the impact Botrytis may have on developing fruit. Most instances of Botrytis fruit rot start during the bloom phase so management programs during bloom are critical - especially during cool wet seasons. Several of these farms have removed dead and dying leaves from the tops of the beds. This practice can be very helpful, especially on farms that do not use fungicides. Removal of dead leaf material is almost always helpful but can be costly. The economic returns for leaf removal has not been determined but many growers find that leaf removal can be part of a program that includes hand weeding and lifting plants from under the black plastic during the same field pass. Most of our production area is well past the optimum time for hand removal of dead and dying leaves. Recent questions have centered on the use of fungicides.

The fungicides of choice to manage the crown rot phase are those with systemic activity. Thus, SwitchTM, RovralTM and possibly PristineTM should offer good suppression of crown rot. SwitchTM is a combination product of two chemicals - a systemic and a protectant and should offer good control of Botrytis crown rot. There remains a restriction that a crop for which SwitchTM is not registered cannot be grown for 12 months after the last application (see label for registered crops). RovralTM is also a systemic fungicide with superior eradicant activity. Growers are allowed one use per season and it may not be applied "after first fruiting flower". Thus, if the flowers have been frost killed, Rovral may be used (this restriction is primarily based on crop residue concerns). From our research, we know 5-12% of the Botrytis population may be resistant to this class of fungicides, therefore, tank mixtures of Rovral with Captan for broad spectrum control are recommended. Pristine also offers excellent Botrytis control and is

partially systemic. This is a premixed product that offers Botrytis and anthracnose control. Growers, who have a concern with anthracnose, may wish to save strobilurin applications for early bloom sprays. Only 4 (Abound, Quadris) to 5 (Cabrio, Pristine) applications of a strobilurin are allowed per season. To date (and very thankfully), we have not recorded concerns with anthracnose in any of our major suppliers of plants.

After and application is made for the crown rot phase, growers should implement a fungicide scheduling program.

Strawberry Fruit Disease Control

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Reprinted from the Rutgers Plant and Pest Advisory May 2009

Strawberry – Anthracnose fruit rot -Strawberry anthracnose can be extremely destructive during warm, wet weather causing significant fruit rot. Symptoms of Anthracnose include blackish-brown circular spots on maturing green fruit and soft, sunken (flat) circular lesions on ripe fruit. On ripe fruit, lesions can expand rapidly and are often covered with a pinkish-orange spore mass. Spores are spread from infected to healthy fruit with splashing water. Control of Anthracnose always begins with a 7 to 10 day preventative spray program no later than 10% bloom and/or prior to disease development. For control apply the following combinations:

#1) captan (M3) at 4.0 lb 50WP/A plus Pristine (pyraclostrobin + boscalid, 11 + 7) at 18.5 to 23.0 oz 38WG/A
#2) captan 5(M3) at 4.0 lb 50WP/A plus Abound (azoxystrobin, 11) at 6.0 to 15.5 fl. oz 2.08F/A or Cabrio (pyraclostrobin, 11) at 12.0 to 14.0 oz 20EG/A
#3) Captevate (captan + fenhexamid, M3 + 17) at 3.5 to 5.25 lb 68WDG/A

For subsequent applications:
Alternate: captan (M3) at 4.0 lb 50WP/A plus Abound (azoxystrobin, 11) at 6.0 to 15.5 fl oz 2.08F/A, or Cabrio (pyraclostrobin, 11) at 12.0 to 14.0 oz 20EG/A with captan (M3) at 4.0 lb 50WP/A, or Captevate (captan + fenhexamid, M3 + 17) at 3.5 to 5.25 lb 68WDG/A

To help manage fungicide resistance development, do not make more than 2 consecutive applications of either; Pristine (pyraclostrobin + boscalid, 11 + 7), Cabrio (pyraclostrobin, 11) or Abound/Quadris (azoxystrobin, 11) before switching to another fungicide chemistry.

Strawberry – Botrytis (Gray Mold) and Blossom blight – can cause serious losses in strawberry plantings in high tunnels and the field if not controlled properly. Development is favored by moderate temperatures (59 to 77 F) with prolonged periods of high relative humidity and surface wetness. Control of Gray mold begins with preventative fungicide applications. Apply at 5 to 10 percent bloom and every 10 days until harvest. During periods of excessive moisture, spray intervals of 5 to 7 days may be necessary. Rotate fungicide chemistries to aid fungicide resistance management.

Application #1: captan (M3) at 4.0 lb 50WP/A plus Topsin M (thiophanate-methyl, 1) at 1.0 lb 70WP/A or Switch (cyprodinil, 9) at 11.0 to 14.0 oz. 62.5WG/A
Application #2; Elevate (fenhexamid, 17 -See restrictions) at 1.1 to 1.5 lb 50WDG/A, or Pristine (pyraclostrobin + boscalid, 11 + 7) at 18.5 to 23.0 oz 38 WG/A
Application #3: captan (M3) at 4.0 lb 50WP/A plus Topsin M (thiophanate-methyl, 1) at 1.0 lb 70WP or Switch (cyprodinil, 9) at 11.0 to 14.0 oz. 62.5WG/A

For subsequent applications, alternate:
Captan (M3) at 4.0 lb 50WP/A, or Captevate (captan+ fenhexamid, M3 + 17) at 3.5 to 5.25 lb 68WDG/A, or Switch (cyprodinil, 9) at 11.0 to 14.0 oz. 62.5WG/A or Pristine (pyraclostrobin + boscalid, 11 +7) at 18.5 to 23.0 oz 38 WG/A, or Thiram (M3) at 4.0 to 5.0 lb 65WSB/A

Strawberry – Leather rot

In New Plantings:
Aliette (fosetyl-Al, 33) at 2.5 to 5.0 lb 80WDG/A. Begin 14 to 21 days after planting and continue on a 30 to 60 day interval as long as favorable disease conditions occur, or Ridomil Gold (mefenoxam, 4) at 1.0 pt 4E/A. Make one application at transplanting plus an additional application at fruit set or 30 days before harvest.

In Established Plantings:
Aliette (fosetyl-Al, 33) at 2.5 to 5.0 lb 80WDG/A, or
Ridomil Gold (mefenoxam, 4) at 1.0 pt 4E/A. Apply in spring before first bloom and repeat once in the fall.

STRAWBERRY VARIETIES FOR THE ANNUAL PLASTICULTURE SYSTEM WHY WE PREFER CHANDLER

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For many in the mid-Atlantic region, the annual plasticulture system for growing strawberries has proved to be an economically viable system. Others have become frustrated with this high-input, high-management system, because success relies on timely inputs, coordination with plant suppliers and dealing with whatever Mother Nature throws at us. The annual system is a package deal starting with site-selection, field rotations or fumigation, optimum planting dates and plant density, variety selection, Fall and Spring fertility management, floating row cover (FRC) management for Fall growth, Winter cold and Spring frost protection. Improper management in any of these areas leads to lower yields. Depending on an individual growers circumstance, it is possible to have nearly $10,000.00/acre invested before the first berry is harvested.

Variety selection is an important component for success with the annual system. Plants need to produce several side-branch crowns by growing later into the Fall and resuming growth in the early Spring. Varieties need to be cold-hardy. The annual system is usually planted as a raised-bed. The raised-bed, covered tightly with black plastic is required to promote the extended plant growth required to achieve high yields. Varieties need to continue to grow at lower temperatures and light levels and sustain minimal cold damage to leaves and crowns. However these raised beds can make the plants more susceptible to cold injury compared to the traditional matted-row with straw mulch. Varieties also need to be selected based on the desired harvest season, marketing options (direct sales or shipped) and consumer preference.

Presently, most mid-Atlantic annual plasticulture success stories have come from growers who grow varieties developed from breeding programs in Florida or California. Varieties such as Chandler, Camarosa and Sweet Charlie have been bred specifically for the annual system for conditions in those states. We are fortunate that research in the mid-Atlantic and cooperating plant suppliers have been able to adapt these varieties for some of the mid-Atlantic growing conditions. In comparison, most all of the eastern bred varieties are developed for the perennial matted row system and using these varieties in the annual system do not always produce the high quality and high yields that we see with the Florida or California varieties.

Transplants made from runner tips (plug plants) have been the preferred plant type for the annual system. Established transplants make for ease of planting, rapid field establishment and can be held over until field planting conditions are ready. However, plug plants for September planting are

the single most expensive component in establishment of the annual system. Other transplant types such as fresh-dug and cut-off plants can sometimes be substituted for plug plants at a reduced cost, but these plant types are generally not available until later in September/early October. Although less expensive than plug plants, planting and post-planting management is more involved, and more research is needed to evaluate the use of these plant types in the mid-Atlantic.

Another approach to the annual system using plug-plants is the use of dormant bare-rooted plants. In many ways this system is similar to the plug–plant system, except that the dormant bare-rooted plants are planted in July instead of September. Many plant nurseries that supply the matted-row growers have these plants available into the summer, and many more varieties are available. If having varieties with unique varietal characteristics for direct sales is important, this system may be a viable alternative. The major drawbacks would be the hand-setting of the bare-rooted plants on plastic in the heat of July and the possibility of significant plant mortality. Although these plants are much less expensive than plugs to purchase, the economics of the additional labor cost would need to be considered.

Summarized in the following tables are yield results from past years variety trials conducted at the University of Maryland Wye Research and Education Center in Queenstown. All trials were replicated four times, planted in a randomized fashion and each plot consisted of 6 or 8 plants per replication. All trials were planted according to the “Chandler model” with the exception of a trial utilizing summer planted dormant bare-rooted plants (Table 3).

The “Chandler model” for our region consists of these criteria;
*Fumigated or long rotation fields
*Pre-plant fertilizer of 60 lb nitrogen + 30 lb Phosphorous + Potassium + Boron based on soil test.
*8 inch x 30 inch firm ,crowned-shaped beds with a single drip tape and black plastic.
*30 day plug-plants, planted in early September in a double staggered row 12 inch x 12 inch apart using a water-wheel transplanter .
*Overhead irrigation for plant establishment immediately after planting
*Monitor/treat for leaf disease and insect pest
*Runners removed in late November
*1.2 or 1.5 oz/sqyd FRC deployed in mid December,
*FRC removed late February for plot clean up and insect pest evaluation.
*At first leaf push, begin spring fertility program and continue based on foliar nutrient analysis. Total nitrogen rarely exceeds 100 lb/a
*Overhead sprinkler and/or FRC used for frost/freeze protection when buds first visible or sooner.
*Fungicides for Botrytis beginning at 10% bloom, monitor for insect pest.
*drip irrigation management for plant health and berry flavors.

Historic Yields (lbs per plant)
of Common Plasticulture Varieties
Queenstown, MD

						Year									
Cultivar	93	94	95	96	97	98	99	01	02	03	04	05	06	07	Avg
Chandler	0.9	0.78	1.33	0.57	1.22	1.76	0.61	1.3	1.75	0.98	1.3	1.2	0.90	1.28	1.13
S. Charlie	-	0.34	-	0.69	1.3	1.06	0.49	0.66	0.76	0.73	-		0.68	-	0.74
Camarosa	-	-	-	0.98	1.14	1.62	0.53	1.32	1.14	-	1.3		1.03	1.69	1.19
Allstar	-	-	-	-	1.85	1.08	0.53	-	1.12	-	1.1			-	1.13
Planting Date	9/19	9/23	9/22	9/7	9/5	9/5	9/4	9/12 ch 9/4 sc	9/3	9/5	9/9	9/1	9/8	9/8	

"-" not all varieties planted each year

Table 1.

Annual Plasticulture System Yields over the past 4 seasons.

2006-07	Lbs/plant	Fruit size (oz)	First harvest
Raratan	1.10	0.42	5/14
Carmine	1.46	0.40	5/10
Vantana	1.46	0.54	5/10
Albion	0.53	0.57	5/10
Evie 2	1.84	0.48	5/14
Daraselect	1.19	0.40	5/14
Chandler	1.28	0.41	5/10
2005-06			
Galletta	0.81	0.75	5/1
Azara	0.89	0.59	4/25
Ovation	0.96	0.77	5/11
Bish	1.12	0.61	4/28
Chandler	0.90	0.62	5/1
2004-05			
Treasure	1.90	0.65	5/16
Bish	1.62	0.70	5/16
Gemstar	1.54	0.82	5/19
Strawberry Festival	1.20	0.62	5/13
Chandler	1.28	0.65	5/16
2007-08			
Galletta	1.06	1.02	5/9
Chandler	0.88	0.58	5/9

Table 2.

*Most of these varieties are available as plug plants from southern plant suppliers

First Year Harvest Yields from Annual Plasticulture System
using Dormant Bare-Rooted Plants 2007-08

Variety*	lbs/plant	Fruit size (oz)	First harvest
Bish	0.86	0.60	5/9
Allstar	0.33	0.48	5/9
Jewell	0.67	0.45	5/15
Ovation	0.65	0.55	5/27
Chandler	1.04	0.60	5/9
Daraselect	0.68	0.68	5/9
Eros	0.83	0.56	5/15
KRS-10	1.14	0.70	5/27
Galletta	1.06	1.02	5/9
Seascape	1.4	0.58	5/9
Chandler plug**	0.88	0.58	5/9

Table 3.

*Dormant plants planted July 23
**Chandler plug planted August 31

Top reasons to grow Chandler:

- Available locally as plug plant from late August–early October (ease of establishment)
- Responds well to Fall applied light weight FRC to promote crown development
- Responds well to Spring applied FRC to advance harvest
- Fruit is produced on long trusses (ease of harvest)
- Four-six week harvest season (longer than most eastern-bred varieties)
- Good to excellent berry size, firmness, color and flavor (high consumer acceptance)
- Early, but not the earliest berry (avoidance of frost)
- Relatively cold hardy
- Most studied plasticulture variety

Strawberry Production Resources on the internet

Mid-Atlantic Berry Guide
http://pubs.cas.psu.edu/freepubs/MAberryGuide.htm
http://smallfruits.psu.edu/ (Updates for the MAberry guide)

New Jersey guides
http://njaes.rutgers.edu/pubs/publication.asp?pid=E288

Midwest
http://www.hort.purdue.edu/hort/ext/sfg/sfg_sprayguide.html

Virginia
Good article for management of carry-over plasticulture systems
http://www.ext.vt.edu/news/periodicals/commhort/1997-06/1997-06-03.html

North Carolina
http://www.ncstrawberry.com/

Maryland
http://www.grapesandfruit.umd.edu/Strawberries/StrawberryPlasticultureManuscript.pdf

Past Wye Research Center twilight meeting articles
http://www.wrec.umd.edu

Good article on high tunnel production
http://www.hightunnels.org/PDF/Growing_Strawberries_in_High_Tunnels.pdf