2008 Strawberry Twilight

University of Maryland
Wye Research and Education Center
May 21, 2008

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

Thank You

Dr. Anne DeMarsay, University of Maryland
Dr. Harry Swartz, University of Maryland
Mr. Michael Embrey, Apiary Specialist, University of Maryland
Dr. Fumiomi Takeda, USDA, Appalachian Fruit Research Station

For Your Cooperation and Advice

Many Thanks to

Maryland State Horticultural Society; Funding Support
Dr. Fumiomi Takeda, USDA; Funding Support
Nate Nourse of Nourse Farms, Simon Parent of NOVA Fruit, and Jim Ballington of NC State; Plant Material Suppliers
Russell Brinsfield, WREC Center Head and
Tom Miller, Maryland Cooperative Extension Regional Extension Director; Administrative Support

Special Thanks to

Raymond Harrison
Danny Poet
Rachel Bozarth
Jon South
Natalie North

without whose help this project could not have been done,

and

Debby Dant
for designing and preparing this booklet.

Cover photo of WREC berries, 2008 harvest, courtesy of Danny Poet*

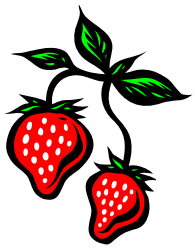

Table of Contents

2006-07 Annual Strawberry Plasticulture Variety Trial Results

Michael J. Newell

Faculty Research Assistant and Horticultural Crops Program Manager
University of Maryland Wye Research and Education Center
Queenstown, Maryland 21658

Objective

Continued variety and propagation techniques for the annual plasticulture strawberry production system.

Plot design

All treatments were replicated four times in a complete randomized block design. 10 plants per replication

Culture

Two tip-plugging dates July 1 and August 1 2006
48 cell tray packs
Pre-bedding fertility 16-8-8 @ 350Kg/hectare +112.5 Kg Mono-ammonium phosphate/hectare
High-beds 20cm high x 75 cm wide at shoulder
Centered single drip tape 1.7 liters/hr/emitter at 30cm spacing
Field planted on September 8 2006
Overhead irrigation 2 hours on September 1st and 2nd for establishment
Daily drip applications or as needed using soil tensiometers @15 and 30cm
Insect and disease management as needed
Runners removed in November 16 2006
Deploy 1oz/sqyd floating row cover (FRC) for over-wintering, November 30
Remove FRC March 7 2007, clean off dead plant material
Fertigate w/ 17Kg nitrogen + 0.7Kg solubor
10-40% bloom on April 3rd 2007
Use FRC to cold protect April 9 -17 2007, no visible bloom damage
May 10th first harvest
June 10th last harvest

Results

A mild Fall and Winter provided very good growing conditions for the annual strawberry plasticulture system. However a low of 10f on March 8th 2007 which tied the winters lowest temperature, killed many of the primary flower buds that had not yet emerged out of the crown. This contributed to the smaller fruit size then would have been expected from the first fruit harvested and led to a smaller overall average fruit size.

Despite this loss of early fruit, yields were fairly decent. The "standard" Chandler, tip-plugged on August 1st yielded 1.25 lbs/plant which is slightly higher than the average yield for this variety. Evie-2, a day-neutral type from the UK yielded the highest at 1.8 lb/plant with decent fruit size, followed by Camarosa at 1.69 lb/plant. Although Carmine and Ventana both yielded well, these California varieties have never had the flavor in my opinion to compete with Chandler. I am impressed with the performance and quality of Daraselect. By and far the best quality in flavor and shape was the day-neutral from California Albion, however it was the lowest yielder in the context of this management system.

Variety	Plug date	Marketable yield (gr/plant)	Average Fruit size (grams)	Cull weight(grams)
Raratan	August 1	503 de	11.8 de	49.6 ab
Carmine	July 1	601 bcd	11.2 e	56.9 a
Carmine	August 1	666 bcd	11.2 e	52.4 ab
Evie-2	August 1	838 a	13.6 b	42.4 bc
Chandler	August 1	583 bcd	11.5 e	40.1 bc
Camarosa	August 1	768 a	13.1 bc	42.1 bc
Ventana	July 1	665 b	16.0 a	35.4 c
Ventana	August 1	664 b	15.3 a	35.2 c
Albion	August 1	265 f	16.2 a	4.5 d
Daraselect	August 1	541 cd	11.3 e	34.4 c
Daraselect	July 1	623 bc	12.8 bcd	43.8 abc
Bish	August 15	404 e	12.2 cde	35.4 c
Treasure	August 15	553 cd	13.2 bc	35.5 c
Chandler	August 15	502 ce	12.3 cde	43.6 abc
		(454 grams = 1 pound)	(28 grams = 1 ounce)	Means followed by the same letter(s)within a column are not significantly different at the 5% level (Duncan multiple-range t-test)

Varieties Grown On Plastic At WYE 2007-08

*** 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

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. First year at Wye in the field.

Galleta - (NC 93-05)- New NC State release, early. First 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. Limited availability

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

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. First time at Wye. Off-season high tunnel potential

NC-03-06 – NC State day-neutral selection. First time at Wye. Off-season high tunnel potential

Varieties Grown In High Tunnel

Albion – Day neutral from California. Excellent, size and quality. Disappointing yield in field and tunnel. Potential summer production in cooler areas.

Carmine – Florida release, good size and self life. Flavor has been OK in Fall atWye, but Spring flavors have been poor in both field and tunnel

Chandler – Does well in tunnel for Spring production. Do not over water or over fertilize for optimum flavor. Best as pick your own or same day sales. Skin gloss is lost when put into a cooler.

Camarosa – High quality fruit and high yielder, needs to fully ripen on plant. Vigorous plants, fruit has good shelf life.

NC-03-05 – NC State day-neutral. Did poorly in Wye tunnel Fall 2007. Spring 2008 yield is good

NC-03-06 – NC State day-neutral. Did poorly in Wye tunnel Fall 2007.

Seascape – California day-neutral. Did poorly in Wye tunnel Fall 2007. Better suited for cooler areas.

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

Ventana – Vigorous plant and high yielder, but flavor has been flat in Wye tunnels and field systems.

2007- 08 Plasticulture Trial

Many strawberry growers continue to express interest in the plasticulture system of production. However the cost of producing strawberries in an annual system can now exceed $10,000.00 per acre and there are limited varieties available for this system. The use of plastic is an attractive practice because it can aid in weed control, keep the fruit cleaner and enhance the earliness in production.

Many varieties continue to be bred for the traditional eastern "matted row" system and these varieties can have more unique flavors and possibly extend the harvest season. An alternative to the annual plasticulture system which uses actively growing transplants (plugs or bare-rooted fresh dug plants) is to use bare-rooted dormant plants. East and West cost nurseries have these plants available well into the summer in most years. Some of the concerns have been about high plant mortality during establishment with this system and that this transplant type needs to be hand set.

The objectives for this trial are to examine if plant mortality can be reduced using white plastic mulch and if sprinkler irrigation for establishment is beneficial. In addition, can Fall fruit production of the day-neutral variety "Seascape" be enhanced by either of the two afore mentioned establishment procedures.

Methods:

Nine varieties of dormant bare-rooted plants were received on July 2nd 2007. These plants were set into 32 cell trays with a peat-based soil less media. These plants would serve as well established control plants. Pre-bed fertility consisted of 250 lbs 16-8-8 + 100 lbs of DAP per acre .Field plastic mulch was laid on July 10 on formed beds, 8 inches tall x 30 inches wide. The 2nd delivery of plants was received on July 23 and field planted immediately. We used a home-made planting bare (described by NC State) to aid in inserting the roots without "J-hooking" the roots and minimally disturbing the plastic. One plot received overhead sprinkled irrigation consisting of 15 minutes of irrigation, 6 times per day beginning at 10:30 AM and each hour until 3:30 PM. This was continued for 7 days. This would be compared to a non-overhead irrigated plot. On August 6th the control plants that were established in 32 cell trays were field planted with no overhead irrigation. Only 8 ounces of starter transplant water was applied at planting. All plots received drip irrigation under the plastic after planting.

Varieties and source:

Bare-rooted dormant plants, Nourse Farms, Massachusetts.

- Allstar
- Bish
- Chandler
- Daraselect
- Eros
- Jewel
- KRS-10
- Ovation
- Seascape

4 week old plug plants, USDA, Keaneysville, WV

- Chandler

6 week old plugs, NC State

- NC 03-05
- NC 03-06
- Galleta (NC 93-05)

Cold-stored dormant, super plugs, NOVAfruit, Ontario, Canada
Chandler
Eros

Establishment results in the following table.

Brief summary of table:

Mortality: Decreased with the use of white plastic, misted black plastic or the use of plugs (except Novafruit super plugs).
Crown #: Appears to be variety dependent, but misted black mulch had generally higher crown #'s
Runner #: Generally they all produced large #'s of runners, but somewhat more in the misted white plastic treatment
Fall Yield: Seascape, NC 03-06 and NC 03-05 were the only varieties that had a Fall harvest. Plug established plants had the greatest Fall yields.

This data and Spring harvest data will be statistically analyzed upon completion of the trial.

I would like to thank the *Maryland State Horticultural Society* for support of this project.

2007-08 Fall Measurement Summary Table

Variety	Bish	Allstar	Jewel	Ovation	Chandler	Daraselect	Eros	KRS-10	Seascape	NC 0305	Galleta	NC 0306
Mulch color	white	white	white	white	white	white	white	white	white	white	white	white
Establishment	mist	mist	mist	mist	mist	mist	mist	mist	mist	mist	mist	mist
Mortality %	0	4	4	4	8	0	0	0	16	0	0	0
Crown# per plant	3	2.3	2.2	2.7	1.7	2.8	2.4	2.7	4.7	2.7	1.2	2.2
Runner# per plant	16	12.6	9.2	14.6	10.3	13.2	8.1	13.3	3.3	0.4	0	1.7
Fall yield (gram)	0	0	0	2.1	0	4.3	0	0	4.4	11.8	0	53.6
Variety	Bish	Allstar	Jewel	Ovation	Chandler	Daraselect	Eros	KRS-10	Seascape	Chandler-old	mm	ChandlerUSDA
Mulch color	white	white	white	white	white	white	white	white	white	white	mm	white
Establishment	no mist	no mist	no mist	no mist	no mist	no mist	no mist	no mist	no mist	no mist	mm	no mist
Mortality %	4	16	0	0	4	0	4	8	33	0	mm	0
Crown# per plant	2.6	2.1	2.2	2.9	2	2.6	2.4	2.7	3.7	1.5	mm	1.1
Runner# per plant	14.5	10.1	8.5	14.7	10	12.1	7.1	10.8	4	5.8	mm	7.3
Fall yield (gram)	0	0	0	0	0	0	0	0	3	0	mm	0
Variety	Bish	Allstar	Jewel	Ovation	Chandler	Daraselect	Eros	KRS-10	Seascape	ChandlerNOVA	ErosNOVA	ChandlerUSDA
Mulch color	white	white	white	white	white	white	white	white	white	white	white	white
Establishment	Plug	Plug	Plug	Plug	Plug	Plug	Plug	Plug	Plug	Plug	Plug	Plug
Mortality %	0	0	0	0	0	5	0	0	0	33	70	16
Crown# per plant	2.3	2.2	2.2	3.3	1.7	1.7	2.4	2.8	2.9	2.8	2.9	1
Runner# per plant	10.6	7.8	7.5	14.4	10.3	8.4	6.7	10.3	3.7	13.1	3.8	6.8
Fall yield (gram)	19.9	0	0	0	0	0	0	13.7	60.4	11.1	0	0
Variety	Bish	Allstar	Jewel	Ovation	Chandler	Daraselect	Eros	KRS-10	Seascape	NC 0305	Galleta	NC 0306
Mulch color	black	black	black	black	black	black	black	black	black	black	black	black
Establishment	mist	mist	mist	mist	mist	mist	mist	mist	mist	mist	mist	mist
Mortality %	0	12	8	4	12	0	0	8	45	0	0	0
Crown# per plant	2	1.8	1.7	2.9	1.8	2.3	2.3	2.5	5.1	2.4	1.1	2.3
Runner# per plant	12	7.7	6.8	13.5	8.5	10.2	5.5	9.6	2.6	1	0	1.7
Fall yield (gram)	0	0	0	2.1	0	0	0	0	3.1	251	0	43.7
Variety	Bish	Allstar	Jewel	Ovation	Chandler	Daraselect	Eros	KRS-10	Seascape	Chandler-old	mm	ChandlerUSDA
Mulch color	black	black	black	black	black	black	black	black	black	black	black	black
Establishment	no mist	no mist	no mist	no mist	no mist	no mist	no mist	no mist	no mist	no mist	no mist	no mist
Mortality %	8	25	21	9	25	9	21	41	75	6	mm	0
Crown# per plant	2.4	1.8	2.2	3.6	1.9	2.1	2.2	2.8	1.9	1.2	mm	1
Runner# per plant	10.5	8.2	4.4	12.1	6.9	8.9	5.7	7.9	0.6	4.7	mm	5.4
Fall yield (gram)	0	0	0	0	0	0	0	0	0	0	0	0
Variety	Bish	Allstar	Jewel	Ovation	Chandler	Daraselect	Eros	KRS-10	Seascape	ChandlerNOVA	ErosNOVA	ChandlerUSDA
Mulch color	black	black	black	black	black	black	black	black	black	black	black	black
Establishment	Plug	Plug	Plug	Plug	Plug	Plug	Plug	Plug	Plug	Plug	Plug	Plug
Mortality %	0	0	0	0	0	5	0	0	0	33	70	16
Crown# per plant	1.8	1.8	2	3.1	1.8	1.9	2.2	2.9	2.6	2.5	2.1	1
Runner# per plant	10.7	7.3	7.4	14.8	10.8	9.8	4.3	10.1	2.5	12.2	3	5.6
Fall yield (gram)	10	0	0	2.1	0	0	0	13.7	60.4	11.1	0	0

	WP	WP	BP	BP	WP	BP		**GATE**
	1	2	3	4	5	6		**key**
	7	8	9	10	11	12		**1….BISH**
BLK 1	4	6	1	2	3	5		**2….ALLSTAR**
	10	12	7	8	9	11		**3….JEWEL**
	WP	WP	BP	BP	WP	BP	**N**	**4….OVATION**
	5	4	12	11	1	6	**O**	**5….CHANDLER-NOURSE**
BLK2	8	3	8	9	7	1		**6….DARASELECT**
	11	6	10	7	12	3	**M**	**7….EROS**
	2	10	2	5	9	4	**I**	**8…..KRS-10**
	BP	BP	WP	WP	BP	WP	**S**	**9….SEASCAPE- NOURSE**
	12	11	1	2	1	9	**T**	
BLK 3	9	8	3	4	4	10		**10….Chandler (Older Nourse)**
	7	5	6	5	6	12		**12…Chandler USDA Aug Plug**
	3	2	7	8	10	11		
	BP	BP	WP	WP	BP	WP		
	11	1	12	11	2	3		
BLK 4	9	3	10	7	4	1		
	8	5	8	9	6	2		
	10	7	6	5	12	4		
	BP	BP	WP	WP	BP	WP		
	11	1	12	11	2	3		
	9	3	10	7	4	1		
BLK 1	8	5	8	9	6	2	**P**	
	10	7	6	5	12	4	**L**	Center plug block only
	BP	BP	WP	WP	BP	WP	**U**	**10….Chandler-NOVA**
	12	11	1	2	1	9	**G**	**11….EROS-NOVA**
BLK2	9	8	3	4	4	10		**12….Chandler USDA Aug plug**
	7	5	6	5	6	12	**B**	Center plug block only
	3	2	7	8	10	11	**L**	
	WP	WP	BP	BP	WP	BP	**O**	
	5	4	12	11	1	6	**C**	
BLK 3	8	3	8	9	7	1	**K**	
	11	6	10	7	12	3		
	2	10	2	5	9	4		
	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		
	10	12	7	8	9	11		
	WP	WP	BP	BP	WP	BP		
	1	2	3	4	5	6		
	7	8	9	10	11	12		
BLK 1	4	6	1	2	3	5		
	10	12	7	8	9	11		
	WP	WP	BP	BP	WP	BP		Mist Block only
	5	4	12	11	1	6	**M**	**10….NC 03-05**
BLK2	8	3	8	9	7	1	**I**	**11….Galleta**
	11	6	10	7	12	3	**S**	**12…NC 03-06**
	2	10	2	5	9	4	**T**	Mist Block only
	BP	BP	WP	WP	BP	WP		
	12	11	1	2	1	9		
BLK 3	9	8	3	4	4	10		
	7	5	6	5	6	12		
	3	2	7	8	10	11		**WP = White Plastic**
	BP	BP	WP	WP	BP	WP		**BP = Black Plastic**
	11	1	12	11	2	3		
BLK 4	9	3	10	7	4	1		
	8	5	8	9	6	2		
	10	7	6	5	12	4		

Report on 2007-2008 High Tunnel Studies

Fumiomi Takeda*
USDA-ARS
Appalachian Fruit Research Station
Kearneysville, WV 25430

Michael Newell
University of Maryland
Wye Research and Education Center
Queenstown, 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 are needed to produce improved planting materials and 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 this research 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. When plug plants are made in early July and kept in propagation trays at high density their leaf canopy can shade the crown. Manipulation of transplants growth and morphology in the nursery phase improves fruit production in fall and early winter.

Materials and Methods:

Study 1. 'Carmine' and 'Strawberry Festival' tips purchased from Lassen Canyon Nursery were plugged in cell packs on 1 July. On July 30, 50 cell-pack tray plants were FedExed to Kennedy Space Center. There the plants were grown for 4 weeks in Controlled Environment Chamber with red light illuminating the crowns. After 4 weeks of light treatment, transplants were established in soilless media grow bags under high tunnel.

Study 2. On 1 July and 1 August, runner tips were harvested from 'Albion', 'Camarosa', 'Carmine', 'Strawberry Festival', and 'Ventana' mother plants growing in greenhouse and plugged into 50-cell transplant containers and misted for rooting.
Rooted transplants were established on two dates in August (mid and late August) at the University of Maryland, Wye Research and Education Center (WREC) in Queenstown, MD. Sstrawberry plants were planted in soilless media grow bags under high tunnel.

Results

The results of this study suggested that red light from LED lamps with maximum wavelenght at 662 nm, directed at the crown delayed flower bud induction in 'Strawberry Festival' strawberry transplants (Table 1). Flower bud emergence was observed in only 17% of

* Research Horticulturist and Lead Scientist. e-mail: fumi.takeda@ars.usda.gov

plants compared to 38% of control (unlit) plants on 19 Septemer (data not presented). 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 (Takeda and Newell, 2006a; 2006b; Takeda, 2008). 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 begin in March and end well before outdoor planting begins in May.

Fall and spring yield data are summarized in Table 2 (not statistically analyzed). Fruit were harvested from 3 Oct. to 19 Dec. 2007. July 1 plugged 'Carmine' and 'Strawberry Festival' plants produced more fruit in fall than those plugged on August 1. 'Ventana' plants did not produce fruit in fall. There was no correlation between plant yield and berry size in the fall.

In spring 2008, fruit was harvested from 8 "April to 14 May. Observations indicate that fruits of Carmine and Strawberry Festival, two cultivars from Florida, were smaller than those of Albion and Ventana, two cultivars from California. Strawberry Festival produced many symmetrical berries and its fruit quality was good. Ventana plants did not have ripe fruit until 23 April, late compared to other cultivars, but appeared to be highly productive with good fruit size. Fall fruiting did not depress fruit production in spring.

July-plugged transplants can be conditioned to bloom as early as September. In a production system with plasticulture, rowcover, and high tunnel for environmental modifications, these plants will produce fruit from October to late December and following spring, enabling growers to obtain two strawberry harvests within a year from one planting.

Table 1. Effect of illuminating transplant crowns with red LED lamps for 16 h·day^{-1} from 1 to 27 Aug. on transplants of 'Strawberry Festival' strawberry that bloomed in October, November, and December. Transplants were established inside a high tunnel in grow bags on 29 August.

	Flowered transplants (%)			
Treatment	3 Oct.	24 Oct.	27 Nov.	17 Dec.
Control	70.3	83.0	95.7	95.7
Red light	37.3*	45.7*	58.3*	62.3*

***** Indicates the value was significantly less than control (P=0.05).

Study 2.

Table 2. Summary of fall and spring harvest. Effects of plugging and planting dates on yield and fruit size.

Cultivar	Plugging date	Planting date	Yield (g/plant) Fall	Fruit wt (g/fruit) Fall	Yield (g/plant) Spring	Fruit wt (g/fruit) Spring
Albion	1 July	16 August	70	16	337	18
	1 July	30 August	82	13	216	16
	16 July	16 August	45	18	207	19
	30 July	30 August	48	14	285	22
Carmine	1 July	16 August	63	14	**508**	14
	1 July	30 August	**110**	13	**430**	16
	16 July	16 August	11	11	271	12
	30 July	30 August	43	19	371	15
Strawberry Festival	1 July	16 August	73	14	269	15
	1 July	30 August	67	16	272	16
	16 July	16 August	0	--	280	14
	30 July	30 August	4	12	298	17
Ventana	1 July	16 August	13	13	**440**	18
	1 July	30 August	70	20	368	17

SARE Research: Day Neutral Strawberries in the NE
2nd Annual Report

Willie Lantz, University of Maryland Extension, Garrett County, MD
Kathy Demchek, Department of Horticulture, Penn State University

Strawberry producers in the eastern United States primarily use spring bearing cultivars, which produce a crop for a relatively short period of time. Harvest is finished by the end of June; however, with large urban populations nearby, the demand for fresh strawberries is strong throughout the summer. Until recently the small size and poor quality of day neutral strawberry cultivars have prohibited day neutral strawberry production from filling a portion of this market. Many growers are looking for ways to produce fruit during the summer months to meet the demand by the consumers.

This project was designed to introduce cool area farmers to new varieties of day neutral strawberries, which have the potential to produce heavy yields of fruit with very desirable flavors and also to provide information on the best nitrogen fertilization levels, plant propagation methods, growing techniques and variety selection. The information will be useful for those growers in the warmer areas of the mid-Atlantic region who are producing crops over winter in glasshouses or tunnels. It can also be adapted to growers in the Chesapeake area who want to provide customers with fruit during the off season, particularly the fall and early winter under protected row cover culture.

In 2006, our research indicated that first-year spring-planted everbearers had only a modest increase in yield in response to N applications, either as compost or liquid fertilizer through trickle. In Garrett C o. MD, with cooler weather (elevation >2500ft), weekly applications of liquid N showed higher yield responses, while in central PA (Penn State's Horticulture Farm at Rock Springs, PA; elevation 1500 ft), with warmer climate, the compost was more favorable, in terms of yield. The use of tunnels did not increase the yield over the entire year in Garrett Co., however, the crop was earlier in the tunnel. Everest was twice as productive as Seascape, over 15000 lbs/acre; however, the Seascape flavor was preferred.

Results in 2007

During 2007, the project completed three separate research projects. The first project was conducted at Penn State's Horticulture Farm at Rock Springs, PA. The first year everbearer field was carried over to determine the effect of the nutrient treatments on a second year planting. The research also provided information about yield on second year day neutral strawberry plantings. The second part of the research was conducted on two farms in Garrett County, Maryland. This experiment compared fall planting versus spring plantings. Two types of fall plants were established, plugs and fresh dug plants, and two types of spring plants, plugs and bare root dormant plants were compared. One location was inside a high tunnel. The third part of 2007 research project investigated the effect of removing flower blossoms after planting spring plug plants. This tested whether the general recommendation to remove the flower blossoms for one to four weeks after planting helped the plants grow more vigorously before starting fruit production and resulted in larger fruit size. Removing flower blossoms is a labor intensive activity. This research was carried out on two cooperating farms in Garrett County.

The experiment on compost rates and liquid nitrogen fertigation in a 2nd yr field at Penn State

Treatments consisted of compost at rates to provide 0, 400, and 800 lb of total N/acre (0, 40, and 80 lb of N/acre/year assuming a 10% mineralization rate) and 0, 1 and 2 lb of N/week/acre as 20-10-20 inorganic soluble fertilizer with micronutrients. Compost was applied in 2006 at planting. In 2007, fertigation treatments were applied once per week from May 22 through October 9.

Fruit production and harvest occurred in three relatively distinct flushes, the first occurring from May 23 to July 6, the second from July 20 to Aug. 31, and the third from Sept. 7 to Oct. 27. Yield data were analyzed separately within the three flushes to detect whether there were changes in the plants' nutrient needs as the year progressed, and were also analyzed as totals for the year.

The early and mid-summer harvests were the largest, averaging 9985 and 9185 lb/acre in total yields across all treatments. The fall harvest was the smallest, averaging 6651 lb/a. During the first harvest flush, the only significant difference among treatments was that when the inorganic fertilizer rate of 1 lb N/acre/week was applied, the highest compost rate resulted in the highest yields. During the second harvest flush, if no compost was applied, both rates of fertigated N resulted in higher yields compared to no fertigated N. There were no significant differences among treatments within the third harvest flush.

There were no relative changes in treatment effects through the year, therefore the flush-specific effects were also found in treatment differences for total annual yield. In total yields for the season, when no compost was applied, applying either soluble fertilizer rate resulted in higher marketable, unmarketable, and total yields than if no N were fertigated. If compost at either the 400 lb or 800 lb total N/a rate were applied, there was no significant difference in marketable, unmarketable, or total yields among nitrogen fertigation rates, though yields numerically tended to be highest at the 1 lb N/acre/day rate. There was no yield improvement obtained by increasing the N to 2 lb N/a/week fertigation rate, whether compost was applied or not.

The highest compost application rate either produced or to tended to produce higher marketable, unmarketable, and total yields than either applying no compost or the lower amount of compost. Whether this yield increase is due strictly to nitrogen, other nutrients, or improvements in such factors as soil structure, aeration, or water infiltration is not known. The soil at this site is heavy with a large clay component. It appeared that the percentage yield increases that resulted from applying compost were greatest (25%) when no inorganic fertilizer was applied, even though the statistical significance was lower. This could indicate that was greater variability among individual plot performance when no compost was applied.

Percentage marketable fruit and mean berry weight was not significantly different among any of the treatments. Mean berry size was smaller in 2007 than in 2006, presumably due to a large number of branch crowns on the two year old plants.

Table 1

Inorganic N	0 lb/a/week	1 lb/a/week	2 lb/a/week	p(F) inorg. N*
Compost				
	Marketable Yield (lb/a)			
None	14,292 B**	17,944 b A	17,822 a A	0.002
400 lb total N	16,971	17,920 b	16,174 b	0.55
800 lb total N	18,717	19,192 a	18,202 a	0.77
p(F) compost*	0.23	0.01	0.006	
	Unmarketable Yield (lb/a)			
None	7,898b B	9,453 A	9,947 A	0.02
400 lb total N	9,120ab	10,252	10,363	0.39
800 lb total N	9,895a	11,269	11,222	0.35
p(F) compost	0.04	0.14	0.14	
	Total Yield (lb/a)			
None	22,838 B	27,397b A	27,769b A	0.001
400 lb total N	26,092	28,172b	26,537c	0.65
800 lb total N	28,612	30,461a	29,425a	0.61
p(F) compost	0.11	0.03	0.006	
	Marketable Fruit (%)			
None	64.9	64.9	63.5	0.63
400 lb total N	63.7	62.9	60.1	0.25
800 lb total N	64.0	62.1	61.2	0.54
p(F) compost	0.93	0.22	0.27	
	Mean Berry Weight (g)			
None	9.4	9.6	9.9	0.16
400 lb total N	9.6	9.8	9.5	0.46
800 lb total N	9.6	9.9	9.9	0.37
p(F) compost	0.77	0.25	0.39	

*p(F) inorg. N indicates the probability of means of inorganic N fertigation treatments being different from each other within each compost treatment. p(F) compost indicates the probability of compost treatments being different from each other within each inorganic N treatment.

**Means were separated using Fisher's Protected LSD test. Means followed by different letters are significantly different at the 0.05 probability level. Lower case letters are used to denote differences among fertigated inorganic N levels. Upper case letters are used to denote differences among compost treatments.

Summary: The bottom line is that high yields could be obtained by applying the highest rate of compost alone with no need for additional inorganic nitrogen. If no compost is applied, an inorganic nitrogen rate of 1 lb of N/acre/week is sufficient to produce high yields. Both compost and inorganic N at 1 lb of N/acre/week may be applied for maximum yields, but the increases in yield relative to applying either N source alone are not likely to be economically significant. An economic analysis is underway to determine the most economical methods of producing the highest yields.

Planting Time and Propagation Method for Variety: 'Evie 3'

Fall plug plants and fresh dug day neutral strawberries were planted in mid September 2006. Spring planted plugs and dormant bare root plants were planted the first week of May 2007. The plants were planted in two 20 plant blocks on raised beds covered with plastic mulch.

Fall planted plants established well and were protected through the winter with heavy floating row covers in the outside planting. Fall planted plants planted outside started to fruit on May 29th as compared to spring planted plants which began on July 4th. At the high tunnel site, blossoms were removed on the fall planted plants until the spring plants were planted.

In Table 2 below, the yield difference between the four types of nursery stock were not significantly different in the tunnel planting; however, fall plants did out produce the spring plantings in yield (weight/plant). Outdoors, the fall plug plants significantly out performed the fall dug plants. Both types of fall plants out performed the spring planted plants by a wide margin. The fruit size on the spring dug (dormant) plants was also significantly less than the other planting methods.

Table 2 - Plant Timing/Type Experiments

	Site 1 – High Tunnel			Site 2 - Outside	
	Wt per plant (g)	Mean Berry Wt. (g)		Wt per plant (g)	Mean Berry Wt. (g)
Fall dug	667	10.0		176b	10.0a
Fall plug	551	8.2		274a	11.3a
Spring dug	177	8.7		23c	5.7b
Spring plug	333	9.6		63c	11.7a
p(F)	0.0648	0.46		0.0037	0.008

These results indicate that planting fall plug plants should be a more productive method of growing day neutral strawberries. However, fall plantings will require more labor to protect plants from winter injury. Early spring yield may not happen each year due to late frosts. In the high mountains of the east, water for overhead irrigation for frost protection is difficult to obtain. Protection with floating row covers is feasible, but this also increases the costs of production.

At this time, fall plug plants are also not commercially available. A local grower will be establishing a nursery for fall plug production during the 2008 growing season. The cost for the fall plugs is unknown at this time but is not expected to excess that of spring plugs (about $.33 per plant). Early spring production from fall planted plants may also not provide as high a return on fruit production as it will be competing with June bearing plants and price will be depressed.

Summary: From 2007 data, fall planted plugs will provide the highest yield potential for producers but may not provide the highest profit margin. Additional research needs to be conducted to determine the cost of production and anticipated returns on fruit production on fall versus spring plantings. The experiment also needs to be repeated at more locations

and using different varieties. Yield on spring planted plants at both locations were much lower than other spring planted locations. In 2008, we will continue to compare fall planted plugs and spring planted plugs. These data will help add confidence to our recommendations.

Flower Blossom Removal

In this research, 'Seascape' day neutral strawberry plants were planted the middle of May 2007. The plants were planted on raised beds covered with plastic mulch. Two parallel rows were planted on the top of a 30" wide bed with 6' from the center of one bed to the center of the other bed. The plug plants were planted 12" apart in each row. After planting, three groups of 20 plants were randomly selected from each of three rows. Blossoms were removed up to three different dates after planting.

Fruit production for the various treatments began on:

Treatment #1= remove blossoms until June 1st – fruit ripe July 2nd,
Treatment #2= remove blossoms until June 14th – fruit ripe July 10th,
Treatment #3= remove blossoms until July 2nd – fruit ripe July 17th.

While the treatments did have an affect on when plants started to fruit; treatments had no effect on total annual fruit production (weight/plant). The only significant difference found was that of mean berry weight at site 101. At this site, the mean berry weight was significantly lower for treatment #3. This result seems to be random and is contrary to that experienced in other everbearing regions.

Table 3 - Blossom Removal Experiments

	Site 101			Site 102			Combined*	
	Wt per plant (g)	Mean Berry Wt. (g)		Wt per plant (g)	Mean Berry Wt. (g)		Wt per plant (g)	Mean Berry Wt. (g)
#1 Removed until June 1	835	9.0a		413	10.5		624	9.8
#2 Removed until June 14	845	8.7a		440	9.7		642	9.2
#3 Removed until July 2	815	8.3b		481	11.1		648	9.7
p(F)	0.79	0.0162		0.29	0.28		0.68	0.33
Site 101							832a	10.4a
Site 102							445b	8.7b
p(F)							<0.0001	0.0439

- Site by blossom removal treatment interaction not significant, so sites can be combined (interaction sig. at p(F) = 0.32 for wt per plant, and 0.089 for mean berry wt, respectively).

Summary: producers need not remove flowers after the plug plants are planted in Spring. This will represent a savings in the labor required to establish spring planted day neutral strawberry plants. The only advantage to flower removal would be to delay fruit production to target a certain market. This research demonstrates that removing the flowers neither hurtsor helps overall production; however, it should be noted that flowers were removed when plants were in the plugs at the nursery. We continue to recommend flower removal at the nursery.

Ongoing 2008 Research

In 2008, we have begun our day neutral strawberry variety and selection trials at Penn State and Garrett Co. The trials include: 5 selections from the Edward Vinson Program, 5 from Five Aces Breeding, 2 from the University of California at Davis, 2 from North Carolina State University and 1 from the USDA-Beltsville; however, not all material is represented at both locations due to a few plant shortages. We also are comparing silver, white and black plastic mulches in Garrett Co.

A Note on Marketing

This year, we will try to test market our mountain grown everbearer fruit at some eastern Maryland chain supermarkets as “local produce”. The availability of some of the wild species derived material (so called synthetic octoploids from Five Aces Breeding) for this test will give us our first determination as to their marketability. Using both the off season production and the gourmet quality of varieties exclusively grown by our growers, we hope to receive a premium for this produce. Supermarkets have cautioned us that fruit should be available every week of the year and should be produced within 200 miles of the market. Thus, it may be necessary to produce from late May to late October in the mountains and rely on a fall-winter-spring crop from glasshouses and fields on the Eastern Shore or Piedmont of the mid-Atlantic.

Sap beetles in strawberries

Gerald Brust, IPM Vegetable Specialist
May, 2008

Sap beetles have emerged as a significant pest in strawberries in much of the Northeast. Adults appear in strawberry fields as the 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 all Maryland farms, but seem to be a significant problem only in certain locations. Sap beetles are in the family Nitidulidae and 9 species can be found in small fruit or vegetable fields, but only 4 are major problems in Maryland: The strawberry sap beetle, *Stelidota geminata*, two species of picnic beetles, *Clishchrochilus quadrisignatus* and *C. fasciatus.* and the Dusky sap beetle, *Carpophilus lugubris.*

Description: Adults: The Strawberry sap beetle is a small, oval, brown and slightly mottled beetle less than 1/8 inch long. Picnic beetles are larger and may have four orange blotches on their back. All sap beetles have short wings and thus the end segments of the abdomen are exposed.

Eggs: Small, whitish and are laid singly on various stages of fruit.

Larvae: Mature larvae are 1/8 to 3/8 inch long depending on species. Creamy, white larva has a stout body with 3 pairs of short legs near the front. Pupae: Brown pupae are found just under the soil surface.

Life cycle: All of the sap beetles in Maryland overwinter as adults in protected places such as decaying vegetation, debris or fruit buried in the ground and in wooded areas. In the spring, picnic beetle adults come out of hibernation and mate. Egg laying begins in April and continues in May and June. Females lay 5 to 15 eggs per day, scattered at random near decomposing plant material rather than on the material itself. Larvae develop in spilled grain, corn ears, waste onion piles, and soil saturated with juices and food material in contact with the soil. When mature larvae leave their food, wander through the soil and change to the pupa stage. Adults then emerge in June and July. The cycle from egg to adult takes about 30 to 35 days. There is usually one or two generations per year.

Newly emerged adults do not lay eggs but mass anywhere food is grown. They are a general nuisance, attracted to sweet or fermented plant juices. Beetles are found on cracked tomatoes, damaged sweet corn ears, overripe muskmelons, strawberries, and raspberries.

The life cycle of the dusky sap beetle is about 30 days with three to four generations per year. Some females lay more than 300 eggs and live as long as 147 days. The strawberry sap beetle primarily attacks strawberries. Sap beetles also disseminate organisms that cause rots in the fruits. Some sap beetles bore into the fruit, devour a portion, and lay eggs. Larval damage is usually only slight and often goes unnoticed.

Control Measures

Sanitation: It is helpful to harvest sweet corn, tomatoes, melons, berries and other produce immediately as soon as they ripen. Remove any damaged, diseased, and overripe fruits and vegetables from the area at regular intervals. The collecting of apples, peaches, melons, tomatoes, and other decomposing fruits and vegetables and by burying deep in the soil or destroying is needed to eliminate beetle food sources. Having several of these food sources—vegetables, small fruit and tree fruit will compound the problem of trying to control the pest. Bare soil, less straw mulch and dry conditions discourage sap beetles. Also prompt removal of foliage and bed renovation after harvest together with rototilling the middles to disturb pupation sites will help break the cycle. Insecticides may be used but are not as effective as the cultural control measures just described.

Baits: Research has shown that picnic beetles prefer banana, whole wheat bread dough, and muskmelon. As a bait, muskmelon rinds or pineapple scraps, sprinkled with a pesticide, kills the strawberry sap beetle

and other scavenger beetles attracted to the fruits and vegetables. A few trials using this control program will be conducted this year in growers' commercial strawberry fields. Precautions need to be followed to keep treated baits away from humans, domestic animals and other non-target organisms. Bait trapping shows some promise in the reduction of beetle populations. Place traps several feet away from the edge of a field that beetles are moving into. Discard trap contents frequently, every three or four days, and re-bait traps with pineapple scraps and a bait consisting of stale beer, vinegar, molasses and water with yeast.

Chemical sprays: Strawberries can be protected somewhat with repeat sprays of Brigade or Danitol as sap beetles begin to enter the fields. Treat three to five days before the first picking date. Brigade and Danitol however, have not provided sufficient control and are broad spectrum, potentially disrupting predatory mite populations that provide spider mite control. The inadequate control is not due to the beetles' resistance to pyrethroids but rather their habit of feeding underneath fruit where they are unlikely to be contacted by insecticide. The focus of our current work is improving sap beetle management through a better understanding of beetle biology. This includes examining how cultural practices and the habitats surrounding strawberry fields (wooded areas and alternate food sources) influence the size of the beetle population. Carbaryl (Sevin) does not control sap beetles.

Where do beetles go after strawberry harvest?

In a series of studies at Cornell University by Rebecca L. Loughner, it was found that: Adults emerging from the strawberry fields may 1) stay in the strawberry field to overwinter 2) return to woods to overwinter, or 3) search for other sources of food. To help determine if beetles are remaining in the strawberry field or leaving for wooded areas, attractive traps were placed in 3 strawberry fields and associated wooded edges after renovation. Traps were placed in the field for 24 hours each week from mid-July to mid-September. The number of adults caught per trap peaked around mid-August. Mean number of SSB per trap was similar across the 3 strawberry fields; however the mean number varied with wooded edge. Despite the similar number of beetles emerging from strawberry fields, it seems the beetles may be more likely to move to certain wooded edges. SSB continued to be caught later in the woods than in the field, again suggesting the beetles are moving to wooded areas for overwintering. Beetles emerging from strawberry fields potentially have enough time to produce a second generation of beetles if they are able to find an adequate food source. SSB is not considered to be an economically important pest in crops such as apples, raspberries, blackberries, blueberries, cherries, pumpkins, melons, and various vegetables; however SSB adults and sometimes larvae have been reported in these crops. If SSB emerging from strawberry fields move to these other crops to feed and reproduce, the numbers of beetles present to infest strawberries the following spring may increase. Addressing whether SSB presence in late season crops is a concern for SSB management in strawberry was conducted with two studies in combination: 1) a laboratory assay to evaluate SSB reproduction on potential alternate food crops and 2) a field study to quantify the number of SSB adults per unit area in various crops. In the laboratory assay, 20 adult SSB were provided with one of the following food sources continuously: apple, blueberry, corn, cherry, raspberry, or strawberry. The larvae, pupae, and adults in each cage were counted after 5 weeks. Although reproduction was much lower on apple and corn, the beetles reproduced on all food sources. The beetles were also present in all crops sampled in the field. The ability of the beetles to reproduce on a wide variety of food sources and to find these sources in the field provides the opportunity for the beetle population to increase in size substantially in late summer. It is unclear, however, whether a late summer increase in SSB numbers results in a greater number of SSB surviving the winter.

New directions for controlling sap beetles

Sap beetles are quite mobile on a farm scale, able to use a wide range of crops as a food source, exists in a system where changes to cultural practices would be difficult, and is not easily contacted by current insecticide application methods. The most promising option is development of a trap-and-kill technique where attractive traps could be deployed in the early spring immediately before strawberry ripening with the idea of reducing the number of beetles entering the strawberry fields. Sap beetles have a male-produced aggregation pheromone, which is attractive to both male and female beetles and could be included in a trap along with a food odor and insecticide. Traps for related beetle species are much more attractive when a food odor and pheromone are presented in combination; therefore current work in this area is focusing on identifying the chemical components of the strawberry sap beetle's specific aggregation pheromone.

Alternatives to Chemical Fumigation for Strawberry Production

Anne DeMarsay, Harry J. Swartz, and Mike Newell

The phase-out of methyl bromide and growing interest in organic/sustainable approaches to strawberry production have led to the exploration of alternatives to fumigation for controlling weeds and soilborne pathogens. Researchers have tested (1) soil solarization, (2) rotation with other crops that produce natural fumigant chemicals, and (3) the use of biocontrol organisms that are antagonistic to soilborne pathogens. None of these methods alone is as effective and long-lasting as fumigation; however, an integrated approach using a combination of these methods may hold promise. Much of the research on these alternatives to fumigation has been done on the West Coast and in Spain and Greece. While there has been some research on crop rotation to suppress weeds and soilborne pathogens in New York and the Midwest, no one has previously tested these methods in combination in the mid-Atlantic region, under our climatic conditions and on our soils.

In a preliminary experiment in 2007 at the University of Maryland's Wye Research and Education Center, we looked at the effects of a rapeseed cover crop and soil solarization, singly and in combination, on (1) the germination of three species of weed seeds and (2) the population of *Verticillium dahliae*, the causal agent of Verticillium wilt, in the soil. As shown in Figure 1, we laid out 12 plots measuring 12 x 25 feet with four treatments: bare ground (control), plastic tarp over bare ground, rapeseed, and plastic tarp over rapeseed. Each treatment was replicated three times. 'Dwarf Essex' rapeseed was planted on June 14. Bare-ground plots were treated with herbicides to keep them weed-free. Pre-treatment soil samples were taken from all plots on August 30 to test for the presence of *Verticillium*. The rapeseed was then mowed, chopped, and incorporated into the soil and plastic tarps laid immediately on the plots to be solarized. The bare-ground plots were also tilled just before the plastic tarps were laid. Before tarping, we buried packets containing 17 milkweed seeds and 100 seeds each of curly dock and foxtail on moistened cotton in the six plots with rapeseed. We also buried two thermo-dataloggers.

Figure 1. 2007 rapeseed/soil solarization plots at WREC.

On October 3, we removed the tarps, took soil samples from each plot, and retrieved the weed seed packets and dataloggers. The treated weed seed packets and control packets—packets containing the same types of weed seeds in the same numbers that were held in the greenhouse—were germinated on trays of potting mix under mist in a University greenhouse. Seedlings were counted and removed after a week. The trays were then refrigerated until December 3 to meet the chilling requirements of some weed species, and again placed under mist in the greenhouse for a week to see whether there would be additional germination. Seedlings were then counted again.

Although the experiment was conducted late in the season, between August 30 and October 3, temperatures in the solarized plots reached hourly average temperatures of more than 100° F at a depth of five inches where the weed packets were buried. These temperatures are high enough to kill the microsclerotia of *Verticillium dahliae*, the resistant form of the fungus that can survive in the soil for many years. Although the field had been planted in strawberries several years before and had a history of *Verticillium* infestation, we were unable to recover any microsclerotia from the pre-treatment soil samples. This result suggested that the population of *V. dahliae* had fallen to low levels. The weed seeds did respond to the treatments. Germination after one week in the greenhouse is shown in Table 1 below.

	Weed species		
Treatment	Dock	Foxtail	Milkweed
	N = 100	N = 100	N = 17
Control	53%	3%	94%
No tarp (avg 3 plots)	46%	0%	0%
Tarp (avg 3 plots)	4%	1%	0%

Table 1. Germination rate of seeds on October 10, 2007 (1 week after planting)

The rapeseed-only treatment alone killed all but one of the milkweed seeds, and the combination of rapeseed and solarization (tarp) reduced initial germination of the curly dock by about 90%. Foxtail, which is a warm-season grass, germinated poorly under all conditions. After two months of chilling and an additional week in the greenhouse under mist, total germination for all weed species is shown in Table 2 below. Chilling sharply increased the germination rate in the control trays of curly dock and foxtail. After chilling, it also became apparent that solarization *increased* the germination of the foxtail seeds that had been buried in the soil beyond that of the control seeds. Because foxtail is a warm-season grass, the high soil temperatures produced by solarization appear to have improved its survival. For curly dock, the rapeseed-only treatment reduced germination after chilling by 44%. The addition of solarization further reduced germination by about 37%, and the combination of methods decreased the germination of curly dock after chilling by more than 90%.

	Weed species		
Treatment	Dock	Foxtail	Milkweed
	N = 100	N = 100	N = 17
Control	88%	39%	94%
No tarp (avg 3 plots)	49%	32%	0%
Tarp (avg 3 plots)	6%	87%	0%

Table 2. Total germination rate of seeds on December 10, 2007 (after 2 months of chilling and 1 week growing under mist)

On April 29, 2008, more than six months after the end of the 2007 experiment, treatment effects were still evident in the plots. As shown in Figure 2, plots treated with both rapeseed and solarization the previous fall had far fewer naturally seeded weeds than the control plots.

Figure 2. 2007 treatment plots at WREC on April 29, 2008. *L:* control plot (no rapeseed or tarping). *R:* Plot treated with rapeseed and solarization.

The most numerous weed species were chamomile and wild garlic, followed by shepherd's purse, bluegrass, and chickweed. Rapeseed alone was more effective in reducing germination of wild garlic, while solarization alone was more effective in inhibiting chamomile. In both cases, however, the combination of rapeseed and solarization resulted in the greatest reduction in the number of plants (data not shown).

Table 2 on the next page shows the effects of each of the 2007 treatments on two measures of weed germination and growth in spring 2008: (1) the average percentage of the ground area of a plot covered by weeds; and (2) the average biomass (wet weight) of the weeds in a plot. Interestingly, solarization alone apparently stimulated the growth of warm-season grasses. While the tarp-only treatment decreased the ground area covered by weeds by 28% compared to the control, the biomass of weeds was virtually the same. The rapeseed-only treatment was more effective in reducing biomass than ground cover: biomass was reduced by 40% but the area covered by little more than 3%. The combination rapeseed/solarization treatment was effective in reducing both weed germination and growth. This treatment reduced the area covered by weeds by 86% and the biomass of weeds by 76% compared to the control.

	Measures of weed germination & growth	
Treatment	Ground area covered (%)	Weed biomass (lbs/200 sq ft plot)
Bare ground (avg 3 plots)	93	13.9
Rapeseed only (avg 3 plots)	90	8.3
Tarp only (avg 3 plots)	67	14.0
Rapeseed and tarp (avg 3 plots)	13	3.3

Table 3. Weed germination and growth in 2007 treatment plots on April 29, 2008.

The results of this experiment lead us to believe that this inexpensive rapeseed cover crop and solarization treatment may become the foundation of a practical preplanting program for strawberry growers who are seeking an alternative to chemical fumigation.

In 2008, we are continuing this research at the Wye REC. Our objectives are as follows:

- To investigate the effects of solarization and a rapeseed cover crop on the biocontrol fungus *Talaromyces flavus*, and to isolate a heat-stable *Trichoderma* species that could be used as a biocontrol agent in future trials.
- To determine whether solarization and rapeseed treatments are as effective in the raised beds that are standard in strawberry production as they are in the flat strips in which most research on these methods has been conducted.
- To investigate whether an oxygen-releasing soil conditioner, calcium peroxide, can increase the rate of decomposition of rapeseed in the soil, with and without solarization. Our hypothesis is that increased oxygen will increase the rate of composting, thereby raising temperatures in the rapeseed treatments. Peroxide in high concentration can also kill soilborne pathogens.

Chronic Sublethal Effects on Honeybees - A Factor in CCD?

Dr. Galen Dively and Michael Embrey
University of Maryland, Dept. of Entomology

Colony collapse disorder (CCD) has caused much concern among beekeepers nationwide. While the extent and causes of CCD are unknown, many believe that honeybees have reached a tipping point wherein the colony can no longer protect itself from a barrage of problems. The CCD Working Group developed an action plan of research that addresses four categories of factors that impact bee and colony health:

1) new or re-emerging pathogens
2) bee pests
3) environmental and nutritional stresses
4) pesticides

This project will address the latter category and examine the sublethal effects of pesticides, which is one of the priority areas identified by the HBHI Task Force for funding.

We will focus on Imidacloprid which is widely used on cucurbits and other crops pollinated by bees. On cantaloupe, cucumber, and watermelon crops, this systemic pesticide is soil applied either at planting or as split treatments at planting and again at 2-5 weeks later through drip irrigation. The split treatment regime is common in Florida, California, Arizona, and Texas, where the bulk of cucurbit production is centered and where insect pests, such as aphids and whiteflies, require longer residual activity of systemic control. The labels for Imidacloprid products used on cucurbits state that the insecticide should not be applied directly to the foliage during bloom. However, many cucurbits produce flowers within 2-3 weeks after transplanting and thus are likely to be exposed to split treatments applied during or close to bloom.

As a systemic insecticide, Imidacloprid accumulates primarily in the vegetative parts of plants and much less in fruiting structures. However, it is possible that low levels of Imidacloprid in pollen and nectar may sublethally expose honeybees, which could lead to chronic effects. Residue analysis studies have detected Imidacloprid at levels of 2-5 ppb in pollen and >1.5 ppb in nectar of seed-treated corn, sunflowers and rape. These levels result from very low rates of seed dressings applied many weeks prior to bloom. Thus, it is reasonable to assume that higher residues of Imidacloprid may be present in pollen and nectar of cucurbits with higher rates applied closer to bloom. The low label rate of Imidacloprid (Admire Pro, 7 oz. per acre) on cucurbits is around 25 times higher than the acre equivalent amount of Imidacloprid applied as a seed dressing. Most sublethal studies have shown that Imidacloprid may cause disorientation and associative learning problems in honey bees at levels above 20 ppb. However, some recent studies suggest that bee behavior is affected at levels between 3-16 ppb. None of these studies examined chronic effects of dietary exposure to Imidacloprid over multiple brood cycles.

In this project, we will employ a functional colony experiment to examine potential chronic effects of sublethal exposure to Imidacloprid on the colony performance and behavior of honeybees. This work will compare colonies fed an Imidacloprid-treated diet over multiple broods with control colonies fed untreated diet. The test period will represent a realistic exposure regime that pollination colonies might be subject to during a typical growing season.

The Mid-Atlantic Berry Guide for Commercial Growers

Produced by the Pennsylvania State University in cooperation with Rutgers University, the University of Delaware, the University of Maryland, Virginia Tech, and West Virginia University. (2005)

Electronic Version

The *Mid-Atlantic Berry Guide* is available as a free download in PDF format at:

http://pubs.cas.psu.edu/PubTitle.asp?varTitle=berry+guide.

Ordering Information for Printed Copies

Printed copies of *The Mid-Atlantic Berry Guide for Commercial Growers* may be ordered from the Marketing and Media Services office of the College of Agriculture and Natural Resources, University of Maryland, for $18.00 plus $7.00 for shipping and handling. Send a fax to Mr. Loc Hoang at (301) 314-9210 with your name, shipping address, phone number, the title of the publication, and the number of copies requested. No P.O. boxes, please. You will be sent a copy with an invoice and payment instructions. If you have questions, call Mr. Hoang at (301) 405-2476.

Updated Berry Guide Pesticide Tables for 2007

Updated pesticide tables for 2007 for the *Mid-Atlantic Berry Guide* are available as free downloads in PDF format at the Penn State Small Fruits Web site:

http://hortweb.cas.psu.edu/extension/smallfruits/berry_guide_updates.html.