

Progress Report to the Southern Region Small Fruits Consortium

Title: Evaluating Protected Culture for Season Extension in Small Fruits

Research Report SRSFC Project 2007-09

Principle Investigators:

Jeremy A. Pattison
Virginia Tech, Southern Piedmont AREC
2375 Darvills Road
Blackstone, VA 23824
Tel: 434-292-5331 Fax: 434-292-5623
E-mail: jpfruit@vt.edu

Tony K. Wolf
AHS AREC
Virginia Tech, 595 Laurel Grove Rd
Winchester VA 22602
Tel: 540-869-2560 Fax: 540-869-0862
E-mail: vitis@vt.edu

Objective:

To optimize strawberry production practices under protected culture to provide season extension and increased fruit quality.

Justification:

Strawberry production in the southeastern and mid-Atlantic United States primarily uses the annual hill plastic mulch system known as plasticulture. Several advantages of this cultural system include: earlier and longer harvests, cleaner fruit, and increased quality and yields. Under the growing conditions found in the Southeastern US, the majority of the field season suitable for strawberry production is utilized. However, despite the increased seasonal pattern that plasticulture provides, the harvest season is relatively short compared to other major strawberry producing regions of the country. Protected fruit production is routine in many European countries because of the advantages associated with earlier fruit and higher marketable yields, and in the case of containerized cultural systems, elimination of soil fumigation. Here we are defining the off-season to include the **fall** as well as **early spring**. Fall fruit is not a traditional season for strawberries in this region despite the presence of optimum climate during this time of the year. Production research has focused on optimizing spring yields and great progress has been made over the past 20 years. The demonstrated success of protected culture in other areas of the world has opened new possibilities for production research in the southeastern US. Holiday fruit (thanksgiving and possibly Christmas) should allow for the development of a viable local market outlet for high-valued, off season fruit.

Materials and Methods:

Two locations were chosen for studying protected in the 2006-07 season to represent diverse growing conditions that can be found across the state. The Southern Piedmont AREC is located in Blackstone, VA (37.06N -78.01W, 394' above sea level and USDA hardiness zone 7a). The Alson H. Smith jr. AREC is located in Winchester VA (39.18N - 78.18W, 800 ft elevation and USDA hardiness zone 6b).

Southern Piedmont AREC

A multi-bay Haygrove high tunnel was erected during the early spring of 2006. Bays are 24' wide by 200' long. Trials for the 2006-07 season focused on cultural comparisons between unprotected field culture to two methods of production inside the high tunnel (conventional ground plasticulture and soil-less culture) (Fig. 1).



Figure 1. Conventional outdoor trial, left; conventional plasticulture in tunnel, center; soil-less culture in tunnel, right.

Plug plants of Camarosa, Chandler and Everest were obtained from commercial nurseries and planted by hand. For the conventional ground plots, both outside and inside the tunnel, rows were 5' on center with a staggered double row of plants set 12" x 14" (17,424 plants/A). Plots were fumigated with methyl bromide (200lbs/A). Soil-less plots inside the tunnel were also on 5' row centers but consisted of a staggered triple row of plants set at 12"x14" (26,136 plants/A) (Fig. 2). Conventional outdoor plots were also established with the same three cultivars including Sweet Charlie, Festival and border plots of Albion. All plot sizes for each trial was 24 plants. Plants were established over three dates (9/15, 9/29 and 10/10). Each trial was set up as a split plot design replicated four times (whole plot is planting date and sub-plot is cultivars). Plots were harvested twice a week and data collection consisted of Marketable and unmarketable yield, average berry weight, and sugar content ($^{\circ}$ brix).



Figure 2. Plot design for soil-less culture in the high tunnel.

Alson H. Smith AREC, Winchester, Virginia

The experimental design was similar to that at SPAREC with few modifications. The high tunnel structure used at Winchester was a 30' x 90' traditional ploy hoop/greenhouse fitted with a single layer of 6 mil plastic. Chandler and Sweet Charlie plants were evaluated for total and marketable yield and average fruit weight effects over three planting dates. Plots size was 16 plants in 4 bags set in a staggered double row configuration (12" in row x 14" between row spacing). The same two cultivars were also evaluated under field conditions in an adjacent field plot with the same planting dates.

Summarized Results for 2006-07:

The 2006-07 growing season at Blackstone consisted of below normal temperatures during September, October and February and above normal temperatures during December, January and March. Precipitation was above normal for September, October and November and generally normal for the remaining of the strawberry growing season. A summarized harvest data table can be found at the end of this document (Table 1.).

Field Trial (SPAREC)

Harvest began on April 12 and continued to June 20. The effect of planting date and cultivar significantly influenced all measured yield and fruit criteria. Main effects (planting date and cultivar) were significant for average fruit weight. There was a trend for increased average fruit size from early to late transplanting. When averaged over all planting dates, Camarosa produced the largest average berry size (18.1 g) followed by Chandler and Festival (17 g and 16.4 g, respectively). Sweet Charlie (14.3 g) and Everest (11.5g) ranked fourth and fifth, respectively.

There was a significant planting date x cultivar interaction for marketable and unmarketable yield and sugar content (brix^o). For most cultivars, marketable yield was highest on the first and second planting date with a significant decrease on the last date. Festival displayed a rather different pattern with the highest yield occurring for the second planting date and the lowest on the first and last dates. The highest yielding cultivars, Chandler and Camarosa, had similar marketable and unmarketable yields when compared within each planting date. Unmarketable yield was greatest for Chandler and Camarosa on the early planting date and significantly decreased with later planting dates. Sweet Charlie and Festival showed no significant difference in unmarketable yield between the first and second planting dates however, a significant reduction occurred on the last planting date.

The interaction between planting date and cultivar for brix illustrated that not all cultivars responded similarly to planting dates. Chandler, Camarosa and Festival produced significantly sweeter fruit for the last planting date compared to the first. Planting date did not influence brix values for Sweet Charlie or Everest.

Late planting negatively impacted marketable yield for all cultivars tested. Festival and Sweet Charlie showed no marketable yield advantage for an earlier planting date, rather, a decrease in fruit size resulted. This appears to be in conflict with current planting date

recommendations for Sweet Charlie where an earlier establishment date is preferred relative to Chandler. Growers looking to optimize production with respect to planting dates and/or cultivar choice will need to strike a balance between yield, fruit size and fruit sugar levels with economics in mind. To this end, it appears that during the 2006-07 growing season at Blackstone, Virginia, all cultivars displayed optimum yield characteristics when planted on September 29.

High Tunnel Trials SPAREC Blackstone, Virginia

Fall fruiting was not realized at this site to any appreciable degree. The percentage of plants blooming per plot on November 20 ranged from 15 to 100%. However, during late December row covers were not applied over a frost event and all potential production was lost. Plants recovered to a minor degree and began to flower in mid January, however, only yield estimates for fall/early winter production could be made and are not presented in this report.

The spring harvest began on April 2 and continued to June 20. For the soil trial, planting date and cultivar significantly influenced marketable and unmarketable yields, and berry weight. Planting date 1 and 2 were found to be the highest yielding for both marketable (15,627 and 13,952 lb/A, respectively) and unmarketable yield (4,277 and 3,807 lb/A, respectively). Both planting dates resulted in 73% marketable yield. Camarosa and Chandler produced the highest marketable yields (17,820 and 17,631 lb/A, respectively) and Everest produced the least (3,410 lb/A). Camarosa produced the highest unmarketable yield followed by Chandler then Everest (4,425, 3,686 and 2,297 lb/A, respectively). Percent marketable yield was highest for Chandler and lowest for Everest (75 and 36%, respectively).

Average berry weight for the last planting date (12.5 g) was significantly greater than the first planting date (11.1 g). Chandler produced the largest berry followed by Camarosa then Everest (14.1g, 12.6g and 8.6g, respectively). Sugar content showed significant cultivar effects only. Everest had the highest sugar levels followed by Camarosa and Chandler, which were statistically similar.

For the soil-less trial, Marketable yields for Camarosa and Chandler were the highest in the trial and did not differ within planting dates or among the two cultivars. Everest was the only cultivar to have significant variation in marketable yield within planting date and produced higher yields on the first and second date with a significant decrease on the third date. Everest also ranked highest for unmarketable yields and Camarosa produced the least (4197 and 3423 lb/A, respectively). Percent marketable yield ranged from 81% for Camarosa to 46% for Everest. Yields appear to be substantially higher compared to the soil trial, however, this is a reflection of plant density not an increase in per plant productivity (Table1 and Fig. 2)).

Planting date did not influence berry weight or brix for the soil-less trial. Averaged over all planting dates, Camarosa had the largest berry followed by Chandler then Everest.

Cultivar ranking for brix was the same as in the soil tunnel trial, however mean brix values were reduced 10 to 13%.

In general, yield was reduced in both tunnel trials relative to the field trial. Plants continued to flower all winter despite having the tunnel in a fully vented condition to promote semi-dormancy. Periodic cold events of below 10°F destroyed all flowers and some developing buds. Flowers destroyed during the mid-winter were the spring's crop and resulted in a significant reduction in the early spring yield. Strategies for this year are focusing on ways to minimize the mid-winter loss of spring production.

Although the tunnel trials were lower yielding as compared to the field trial, an interesting result was observed. Marketable yields and berry size in the soil trial under the tunnel displayed a negative response to later planting dates as was found in the field trial. However, the soil-less trial did not respond in a similar way, rather, planting date had no effect on yield or berry size for Camarosa and Chandler.

Field and Tunnel Trials at Alson H. Smith AREC Winchester, Virginia

The Easter freeze significantly impacted the outdoor planting at Winchester as only row covers (1.2 oz/yd²) were used for protection. This severely shortened the harvest season which started on May 9 and continued through June 8. Marketable yields of Chandler ranged from 13,584 to 6,656 lb/A for the first and last planting date, respectively. Sweet Charlie also had low yields ranging from 10,482 to 7,055 lb/A.

Harvest in the tunnel trial began on March 27 and continued to May 22. Marketable yields of Chandler ranged from 8,268 to 10,238 lb/A for the first and last planting date, respectively. Marketable yields of Sweet Charlie ranged from 6,508 to 9,369 lbs/A for the first and last planting date, respectively. Later planting dates yielded higher in the tunnel which is in contrast to the field results. These data sets are still under analysis.

Discussion of SPAREC results

Concerning season extension, the fall failure was the cause of management and will be closely monitored this season. Spring fruiting patterns were not much different in the tunnel for either trial compared to conventional field production. As mentioned earlier, the extended propensity of flowering in the high tunnel over the mid-winter likely set the timing of spring bloom later in the season and reduced total yield. As a result, production was only advanced by two weeks for Chandler and Camarosa, which was still inferior to the early harvest pattern for the first planting date of sweet Charlie in the field (Fig. 3). Also of particular interest were the similar peaks in production for Camarosa and Chandler in both the tunnel and field. If this is a stable, yearly trend, the main advantages protected culture has to offer from a season extension capacity is in the very early spring, the late fall and early winter. Main season overlap could be beneficial during periods of inclement weather (rain) to maintain a steady flow of high quality fruit however the increased cost of production may make this questionable. Tunnel production is considerably more management intensive than field culture and improvements in yield

and season harvest patterns can likely be improved through better management which will be gained by experience.

Impact Statement:

The above work has been initiated in response to the growing strawberry industry in the mid-Atlantic and Southeastern US in effort to extend the harvest season and maximize production per acre. The results of this study have highlighted that protected culture is dramatically different than field production with respect to management and the resulting system's productivity. We are continuing to improve upon this and have made some modifications for the 2007-08 study and hope to have production recommendations for growers in the near future.

Table 1. Marketable yield, fruit weight, and sugar content of strawberry cultivars grown under field and two high tunnel conditions during the 2006-07 season.

Cultivar	Planting Date	Marketable Yield (lbs/A) ^z			Berry Weight (g) ^y			⁰ Brix ^x		
		Field	HT-soil	HT-bags	Field	HT-soil	HT-bags	Field	HT-soil	HT-bags
Sweet Charlie	9/15	23,643	-	-	12.9	-	-	6.1	-	-
	9/29	23,187	-	-	14.3	-	-	6.4	-	-
	10/10	16,328	-	-	15.8	-	-	6.4	-	-
Festival	9/15	18,970	-	-	14.7	-	-	6.0	-	-
	9/29	24,165	-	-	17.0	-	-	6.2	-	-
	10/10	16,904	-	-	17.6	-	-	6.5	-	-
Camarosa	9/15	26,930	19,784	25,891	16.4	11.9	13.0	5.8	7.2	6.0
	9/29	27,835	18,703	28,304	17.7	12.5	12.9	6.2	6.9	6.2
	10/10	17,638	14,989	27,911	20.4	13.5	13.7	6.2	7.1	6.1
Chandler	9/15	28,643	22,857	26,769	14.7	13.5	12.2	5.6	6.9	6.0
	9/29	28,161	18,905	24,929	17.6	13.7	11.5	5.7	6.7	6.0
	10/10	18,574	11,238	25,536	18.8	15.0	13.0	6.6	6.9	5.9
Everest	9/15	12,155	4,337	12,730	10.0	8.1	9.7	7.0	8.1	7.2
	9/29	11,379	4,373	12,496	10.5	8.9	10.0	7.2	7.8	7.4
	10/10	8,271	1,690	8,397	14.0	8.8	9.6	7.1	8.4	7.4
Significance										
Planting date		***	**	ns	***	*	ns	***	ns	ns
Cultivar		***	***	***	***	***	***	***	***	***
Planting date x cultivar		**	ns	*	ns	ns	ns	*	ns	ns

(-) cultivar was not tested in this trial.

^z Marketable yields extrapolated to lbs per acre using 17,424 plants/A for the field and high tunnel soil trials (HT-soil) and 26,136 plants per acre for the high tunnel soil-less trial (HT-bags).

^y Average berry weight over the entire harvest season calculated from 25 berry samples collected from each plot during each harvest.

^x ⁰Brix represents a season average by sub-sampling 10 uniform berries from each weekly harvest.

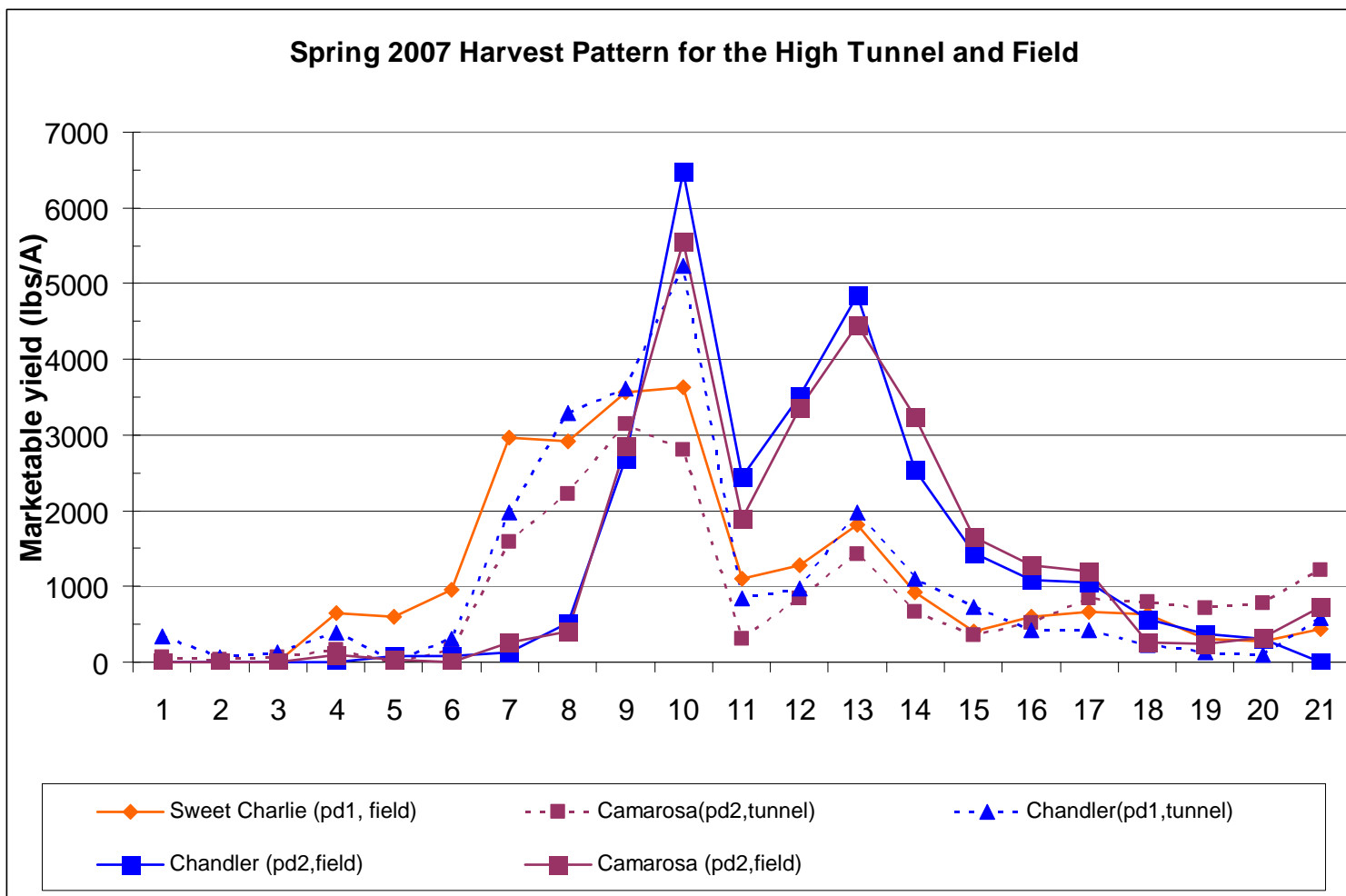


Figure 3. 2007 spring harvest pattern for the best performing cultivars and planting dates in the high tunnel (dashed lines) and field (solid lines) with respect to both yield and season extension. Harvest days on the x axis begin on April 2, 2007 (1) and terminate on June 20, 2007 (21). Fruit was harvested twice a week.