Looking inside high tunnel with ChromatiNets

High tunnel covered with red, yellow and pearl ChromatiNets at Charleston SC

Title: Enhancing the Productivity and Fruit Quality of Forced Strawberries through Manipulation of Light Quality in High Tunnels

Progress Report
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Research Proposal

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Objective: To investigate season extension and forcing fall/winter 'Sweet Charlie' strawberries in high tunnels with photoselective nets (ChromatiNets) for the Thanksgiving through New Year's holiday season and residual spring yields through May.

Justification: In the U.S. from November through February, there is a lucrative market for strawberries since domestic supply is low and demand is high. During this time, unit price for strawberries is at its highest point during the year but forced strawberry yields in fall/winter are much lower than traditional spring harvests and increasing forced yields would provide greater profitability.

Environmental manipulation provides a viable choice for crop improvement. Physiological processes from seedling emergence to fruit production depend on both light quantity and quality. Information on the effect of light quality is minimal, since light quality alteration is difficult under field conditions. Strawberry growth and productivity are dependent on photosynthesis. The use of filters to change spectral distribution of the natural sunlight may directly influence photosynthesis by changing light absorption and/or the quantum yield of photosynthesis. Previous published studies of light quality on strawberry growth and flowering showed decreasing far red to red ratio promoted flowering, while blue and far red light enrichment delayed flowering and stimulated stolen development**.** New technology has been developed to enrich the light environment in the field. ChromatiNets® were developed by the Israelites (distributed by Polysack, Inc, San Diego, CA) and are a series of colored nets with special optical properties which improve the utilization of solar radiation by agricultural crops. ChromatiNets® enable growers (especially with ornamentals) to control growth, such as leaf size, branch length and plant height in plants, as well as the rate of maturation and flowering. These nets manipulate light quality, composition, and scatter light throughout the plant canopy; the transmitted light is composed of a mixture of natural, unmodified light passing through holes and spectrally-modified light passing through threads. These nets are available in a variety of colors and shading intensities for use during the heat of summer

(highest shading) or in winter (lowest shading). Israeli scientists have worked with these nets on many ornamental and tree fruit crops but not strawberry. Based on previous work with other crops, the following are general and potential plant growth modifications due to the ChromatiNets: yellow nets - increase only vegetation, pearl nets - increase branching, red nets - increase vegetation and fruiting, blue nets – increase dwarfing.

Important Note: *Presently, in the 2nd year of research in 2008-2009 forcing season, we recently planted the conditioned plants in the high tunnels and are beginning the forcing growing season. We expect to finish by May, 2009 the 2nd year's work. At this time last year in the first year's work, I was in the same timeframe and did not have any data to report at the due date of the report. In this report though, I will fully report the results of the 1st year's work but have to wait till this time next year to report the 2nd year's work. The following methods are basically the same for each year.*

Methodology: ***The 2008-2009 research proposed is still in progress.*** I evaluated the yellow, pearl, and red ChromatiNets (24% shade factor – lowest available) and an unnetted control. . These nets have the best advantage to enhance growth. Blue nets have been reported to increase dwarfing and I did not include this net since I felt blue would not enhance strawberry growth in our application. The goal of the 1st year's work was to determine the advantage of ChromatiNets on strawberry yield performance as a forced fall/winter crop. In the 2nd year's work, we attempt to replicate the experiment to validate the 1st year's results. A high tunnel (~96 feet x 14 feet x 7 feet) located at the Charleston Experiment Station was prepared for the strawberry work. By June 29, 2007, the entire ground surface in the high tunnel was covered with drip tubing and then clear plastic. The high tunnel was sealed closed until Sept 1st to solarize the soil and to kill weed seed and pathogens (done in lieu of methyl bromide fumigation). Irrigation was added periodically to increase a steaming action under the plastic.

Virus free strawberry daughter tip, grown by a Canadian grower, were grown as plugs in our greenhouses using common plug production technology. Daughter tips were planted in the greenhouse plug trays on July 27. On Aug 24th, the plugs were artificially conditioned until Sep 12th in a walk-in growth chamber to shift plants from vegetative to reproductive state. The conditioning treatment exposed the plugs to a 12-hr day/night cycle with a 75° F day/ 55 °F night. The soil in the high tunnel was fertilized with about 600 lbs 10-10-10/acre and rototilled. Drip tubing was placed between each row and the beds were covered with reflective mulch.

The high tunnel was covered with 24-foot wide ribbons of the ChromatiNets, leaving about 4 feet distance between nets as well as an uncovered, non-netted portion of the tunnel for a control. Plugs were planted Sept. 12 and spaced 12 inches apart in rows with 18 inches between rows. There are 6 rows planted in the high tunnel with a 4-foot walkway in the middle. We also planted conditioned plants outside beside the high tunnel on a mulched, drip-irrigated bed for comparison. Standard strawberry production practices are used.

High tunnels were vented to maintain day temperatures in the range of 75 to 86°F. Air temperatures inside and outside tunnels were monitored. Since our target market starts near the Thanksgiving holiday, we encouraged vegetative growth with weekly fertigation of 5 lbs N/acre. Surprisingly, our harvest season began before Halloween. We harvested berries twice weekly and graded according to USDA quality standards. We took subsamples and recording refractometer readings to judge berry sugar levels.

Harvests continued through the winter until late February when the high tunnel was opened and plants allowed to acclimatize to ambient temperatures. Plants were hedged then hand pruned, and mulched area between rows was mopped with a 10% bleach solution and then plants sprayed with insecticide and fungicide. Normal spring berry production began again about mid-March 2008 and all plots were harvested to determine residual bonus spring production. Yield data included fruit yield (fresh weight and numbers of marketable and cull berries at each harvest and total yield) and sugar level. The first year's work was completed by middle May, 2008.

Results: The data from fall forcing and residual spring harvests have not shown any great increase in marketable yield (lbs and numbers) under ChromatiNets (Table 1). The unnetted controls have produced much higher yields (lbs and numbers) of all treatments and apparently, the colored nets suppressed overall yield. Averaged over the growing season,, berry weight was higher with the pearl ChromatiNet and the no net control in contrast to the other treatments. It is noted in Table 1 that within each Chromatinet color (columnar data) over harvest period, there are occasions and nuances when yield is better during a period with a certain ChromatiNet (significant net x harvest season interaction), but these differences are not considered important and do not warrant the use of the nets. It is probable that in winter, the shading factor overwhelmed any light quality enhancement and possibly, in longer days and warmer, brighter months, the ChromatiNets may show an advantage. These nets produce remarkable results in Israel during the summer months on other crops. These nets were developed for summer crops

in desert regions of the world and winter use in our area may just not have any beneficial effect in winter forcing, yet they may be beneficial at other times. There were no differences among any of the ChromatiNets and unnetted control in cull berry production and refractometer readings.

In relation to the practice of forcing without any nets, we were surprised to produce marketable berries before Halloween (Table 1). We feel, however, that this was undesirable since the plants stopped bearing in November and missed the Thanksgiving market. In the future, we will remove all flowers as well as runners (we removed these always as SOP) and allow the plants to set flowers only before the Thanksgiving holiday. We have forced strawberries over many years and always felt "lucky" to get the plants to produce by Thanksgiving but to get berries by Halloween never happened before. Even for Christmas holiday season, our berry production was slow. We feel that allowing the plants to produce berries too early, stunted them for weeks before recovering and setting more fruits. The plants began to produce heavily in January and February. By the end of February, however, the plants were "worn out" looking, exhibited a lot of diseased foliage and because of this, the forcing season was terminated. In the month of March, the high tunnels were opened, and the plants were mowed, cleaned up, sprayed with fungicides/insecticides and allowed to acclimate to outside temperatures. Beginning in April, we were able to harvest residual spring berries until May 19. As far as residual yields (lbs) in April, 2008, the no net treatment and yellow ChromatiNet excelled in lbs per tunnel; in May, all net and no net treatments, yielded similarly.

Since the price of strawberries varies throughout the winter, we determined very simplistically, the gross value of production with each treatment based on prices quoted by the Columbia SC terminal prices. Table 2 shows that value summarized over the entire production system was highest with the no net controls. Of course, there were nuances of results within each of the months of the harvest season. For example, value was greatest for pearl ChromatiNets in Nov, no nets were superior Jan through Apr, but yellow ChromatiNets excelled in May. It must be noted, however, that outside production was greater than all nets and no net controls in Apr and May.

Conclusions:

1. The data from fall forcing and residual spring harvests have not shown any great increase in marketable yield (lbs and numbers) with ChromatiNets.
2. The unnetted controls produced much greater yields (lbs and numbers) of all treatments and apparently, the ChromatiNets are suppressing overall yield.
3. Average berry weight over all harvest months was higher with the Pearl ChromatiNet and the no net control in contrast to the other treatments.
4. There were nuances when yield is better during a time period with a certain ChromatiNet (significant net x harvest month interaction), but these differences are not considered important and do not warrant the use of the nets.
5. It is probable that in winter, the shading factor overwhelms any light quality enhancement and possibly, in longer days and warmer, brighter climates, the colored nets may show an advantage.
6. There were no differences among any of the ChromatiNets and unnetted control in cull berry production and refractometer readings.
7. Since the price of strawberries varies throughout the winter, we determined that value summarized over the entire production system was highest with the no net controls.
8. Yields from Apr through May were greater in outside plots versus all ChromatiNets and the no net controls.
9. ChromatiNets may hold promise for summer production in high light intensity for other small fruits yet the shading effect during low light winter months, we feel, overwhelmed the light enhancement these nets are noted for in Israel.

Impact Statement

Forcing in high tunnels is a viable specialty production cultural system that can produce offseason strawberries in the coastal area of the Southeast. Adding ChromatiNets is not warranted by their negligible effect on strawberries in the winter months.

Table 1. Marketable yield [a] of 'Sweet Charlie' strawberries forced in high tunnels using ChromatiNets in the 2007-2008 harvest season.					
ChromatiNets + controls					
Harvest period	**Red**	**Yellow**	**Pearl**	**No Net**	**Outside**
Marketable weight per tunnel (lbs)					
Oct 29 to Nov 29, 2007	73 jk	86 j	98 ij	90 j	---
Dec 3, 2007 to Jan 3, 2008	9 kl	6 l	10 kl	8 kl	----
Jan 7 to Jan 31	205 bc	132 fgh	135 fg	246 b	---
Feb 4 to Feb 28	204 bcd	197 cde	196 cde	366 a	---
Apr 4 to Apr 28	152 def	181 cde	151 ef	196 bc	325
May 1 to May 19	72 hij	108 fgh	97 fghi	75 ghij	142
Total	715 B	710 B	687 B	981 A	467 C
Marketable number per tunnel					
Oct 29 to Nov 29, 2007	2,651 h	3,196 h	3,614 gh	3,179 h	---
Dec 3, 2007 to Jan 3, 2008	187 i	204 i	237 i	198 i	---
Jan 7 to Jan 31	4,307 ef	2,552 h	2,717 h	4,631 de	---
Feb 4 to Feb 28	6,067 c	5,880 cd	5,891 cd	10,989 a	---
Apr 4 to Apr 28	5,880 c	6,732 bc	6,732 c	7,236 b	10,188
May 1 to May 19	2,634 fgh	3,708 e	3,708 efg	2,628 fgh	4,824
Total	21,726 B	22,272 B	21,537 B	28,861 A	15,012 C
Marketable berry (grams)					
Oct 29 to Nov 29, 2007	12.2 hi	11.6 i	12.1 hi	12.1 hi	---
Dec 3, 2007 to Jan 3, 2008	21.0 c	14.3 efg	19.5 d	19.1 d	---
Jan 7 to Jan 31	22.5 b	23.5 ab	24.1 a	24.9 a	---
Feb 4 to Feb 28	14.7 ef	14.9 e	15.0 e	15.2 e	
Apr 4 to Apr 28	21.1 hi	12.5 hi	12.4 hi	12.7 hi	14.7
May 1 to May 19	12.4 hi	13.2 fgh	12.9 ghi	12.8 hi	13.4
Average	15.1 B	15.0 B	15.5 A	15.7 A	14.1 C

[a] Yields calculated on a "tunnel" basis from fall and winter forcing season. Area of a tunnel was 1,344 sq feet or .03 acre.

Table 2. Value ($) per tunnel (area) of 'Sweet Charlie' forced marketable yields in high tunnels using ChromatiNets 2007-2008.

ChromatiNets + controls						
Harvest season	**$ per pound [a]**	**Red**	**Yellow**	**Pearl**	**No Net**	**Outside**
Oct 29 to Nov 29, 2007	3.25	$237	$280	$319	$293	0
Dec 3, 2007 to Jan 3, 2008	2.94	$26	$18	$29	$24	0
Jan 7 to Jan 31	2.88	$590	$380	$389	$708	0
Feb 4 to Feb 28	1.93	$394	$380	$378	$706	0
Apr 4 to Apr 28	1.54	$234	$279	$233	$302	$501
May 1 to May 19	1.70	$123	$184	$166	$128	$241
Total		$1,605	$1,521	$1,513	$2,160	$742

[a] Prices are Columbia SC terminal prices gathered from SC market news, the SC Fresh Fruit and Vegetable Report. If sold at Farmer's Market, Road Side Stand or pick-your-own would reap higher income than terminal market prices.