

2005 Report: to Southern Region Small Fruit Consortium

Title: Micro-Encapsulated Phase-Change Chemicals Embedded in Floating Row Covers to Increase Frost Protection of Strawberries

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Objectives: To evaluate the capacity of fabric covers containing micro-encapsulated phase-change chemicals (PCM's) to provide increased freeze protection for strawberries compared to currently available floating row covers.

Justification: Plasticulture production of strawberries is often limited by cool temperatures in the Southeast. Frost in the spring often damages flowers or flower buds and cold autumn and winter temperatures can reduce growth of late summer/fall planted strawberries and thus influence yields the following spring.

Row covers can be beneficial for strawberries by reducing loss of re-radiated heat from soil and water surfaces. Currently used covers are comprised of a thin mesh of white synthetic fibers which entrap heat and serve as a barrier to wind and insect. Technologies now exist for use of temperature-modulating phase-change chemicals (PCMs) and for micro-encapsulation. Phase-change chemicals are those which absorb/release radiant energy over a relatively wide temperature range when compared to traditional melt and freeze points. Fabrics containing PCMs may retain and trap more heat than currently used floating row covers. Thus, the PCM fabric may provide more cold protection.

Methodologies: 'Sweet Charlie' strawberry plants were established on raised black plastic beds in the fall of 2004 and again in 2005. Temperature sensing equipment was calibrated and prepared for field installation. Conventional floating row cover fabrics were purchased to use as controls to compare the PCMs against for heat retention and frost protection as described in the proposal for this project. Temperatures were recorded below the row covers by sensors placed directly beside and in contact with crowns.

Results and Conclusions: The company that was to supply the PCM's in an encapsulated form once again reported production delays and did not supply the materials as promised in time for application. We decided to make our own fabric covers and contracted the use of production

facilities in the Cotton Incorporated Textile labs at North Carolina State University. We produced fabric with the PCM materials bonded by cross linked latex for the spring crop of 2005. The PCM treated fabric maintained temperatures 2 C warmer than the fabric without PCM on four separate nights in the spring field trials. There was no difference in strawberry yield among the treatments. The temperatures did not get low enough to freeze the strawberry flowers under the untreated cloth. Given this 2 C temperature effect of the latex cross linked PCMs and the failure of the company to produce the encapsulated PCMs as promised, we re-evaluated our approach for the fall of 2005. We created our own PCM materials (oil based rather than salt based PCMs) and had our material encapsulated by a company in MN. We lab tested the product on a small scale and found that we achieved about a 1.7C temperature advantage with the first product (in cold chamber test). Since our goal is to achieve a minimum of a 3-4 C temperature advantage we increased the formula weight of the PCM materials three fold (bonding more PCM to the fabric). We then produced row covers with micro-encapsulated PCMs (bound to cross linked latex on the fabric) at the Cotton Incorporated Textile Lab facilities at NCSU in Raleigh. On November 21, 2005 we established these covers on strawberry plantings ('Sweet Charlie') at the Knoxville Research and Education Center. We have two PCM, two untreated row cover and one uncovered treatment (each replicated four times) in this field experiment. We have placed temperature sensors in the four replications of each treatment at the crown level. The strawberries were established on raised plastic beds in October, 2005. We will monitor temperatures under these treatments throughout the winter of 2006 and take yield data next spring. We have had one night with temperatures approaching the desired range since we placed the fabric and the results are shown in Figure 1. The temperature was higher under the PCM treated fabric for this single freezing event. Note that when the air temperature (untreated control) was near -3 C the temperature under the 2X rate of the PCM latex bound to the fabric was near +1 C. Given this early indication we plan on continuing to improve our PCM and lab test it to get a better product to field test.

We feel that based on the facts that there was a temperature advantage in the lab with the new PCM materials and that we were successful in adhering these PCM materials to row covers (based on microscopic observation that the micro-capsules were adhered to the cloth) there is an excellent chance that we will see the desired temperature advantage in the field this winter. Based on the timing of this type of research (fall planting and spring harvest) and the calendar year reporting for the Small Fruit Consortium we will not have the completed data for this project until late spring of 2006 (after strawberry harvest). We will file an addition to this report at that time with the data we collect this winter and spring. We are not asking for renewed funding for this project this year because we feel that the data we will get this winter/spring will give us the background data we will need to write larger grants if the concept works in the field. We plan on writing a grant in 2006 for the US EPA program on environmental and energy savings in agriculture. We appreciate the funding from the Consortium and assure you that it has been critical in helping us get this concept from an idea into a field testable product. We will continue to develop the product and use the data we gained from this funding to help us apply for larger grants next year.

Impact Statement:

Field test completed in spring of 2005 showed a temperature difference between the fabric with the PCM and the fabric without PCM of 2 C. However, in earlier lab simulation experiments the

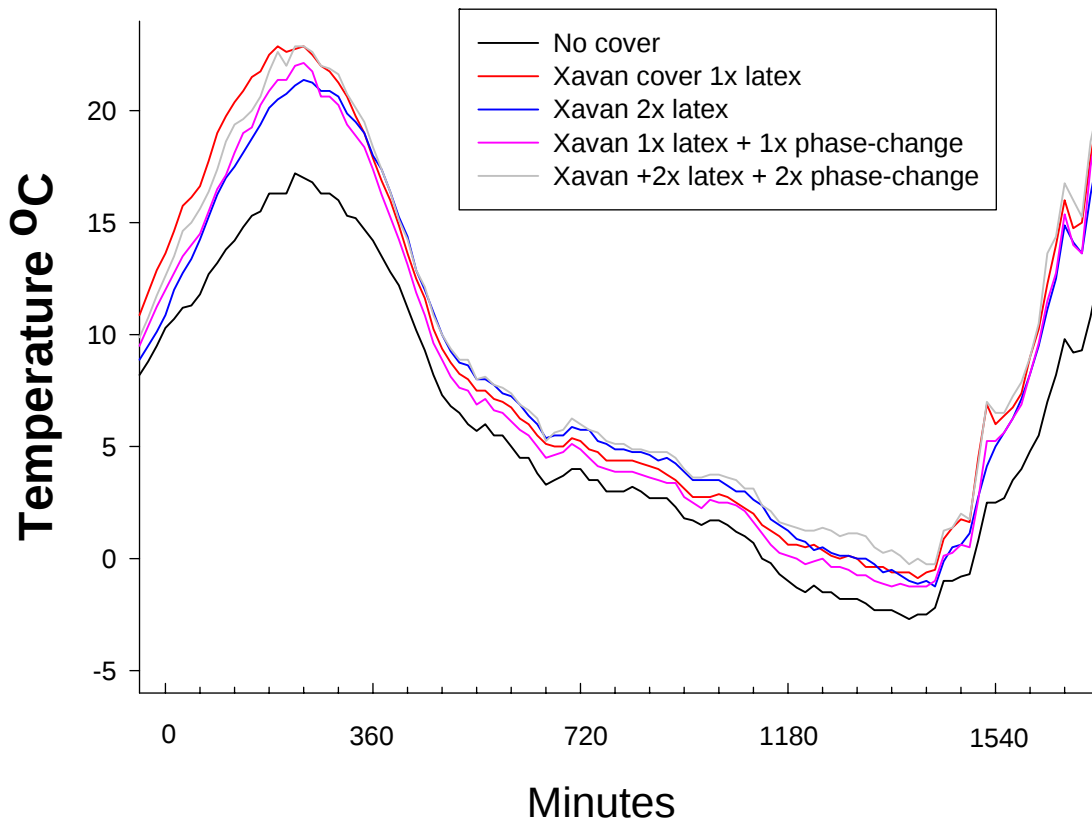
PCM materials maintained a 2-4 C temperature differential over untreated materials. The lab experiments were completed with latex cross linked applications of the PCMs. This may provide an alternative method of application of the materials. If the PCMs are effective in field experiments (in encapsulated or latex linked form) they should be directly applicable to frost protection for strawberries. In lab experiments this fall with encapsulated PCMs we observed a 1.7 C temperature difference due to the encapsulated PCM. This small, but significant, temperature increase was explained by a relatively small number of Micro-capsules attached to the cloth (as observed under a microscope). Based on these data we tripled the weight of PCM encapsulated and bound to the cloth for the fabric we placed in the field this fall. We have only had one night with temperatures in the range of the phase change this fall and the results are shown in Figure 1.

We believe that with improved encapsulation and binding to the row cover fabric the desired 3-4 C temperature increase at the critical freezing temperatures (for Strawberry flowers) is possible. We are continuing to work on the PCM materials and blend new materials for encapsulation. Our intent is to perfect the material and then apply for grants to complete field testing of the concept.

If the encapsulated PCM materials are successful in maintaining the flower temperatures at 3-4 C above the critical kill temperatures in the spring these materials have significant commercial implications for frost protection.

Figure 1.

Effect of phase-change cover on ground temperature
around 'Sweet Charlie' strawberries, 25 Nov. 2005, Knoxville, TN



* 0 Minutes= 12 am.