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Micro Tunnels in Vegetable Crops: Beyond Season Extension

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Introduction

To improve sustainability, yield, and fruit quality, farmers use intensive production systems such as mulches, floating row covers as well as micro tunnels and high tunnels to protect against cold temperatures, rainfall, excessive radiation, and extend the production season (figure 1) (Arancibia 2009 and 2012; Carey et al. 2009; Pool and Stone 2014). These systems involve an increase in production cost, so farmers usually grow high-value specialty crops to ensure a return on investment.

Figure 1. Micro tunnels (front) covered with spun-bonded fabric and insect nets. High tunnel in back. Summer 2015, Richmond, Virginia.

In the case of micro tunnels or floating blankets, farmers primarily use them early in the spring and then remove them after the risk of freezing has passed. However, this practice doesn't allow farmers to take advantage of the full benefits of the technology. Micro tunnels enhance vegetative growth, increase yield, and improve water and nutrient use efficiency. In addition, insect nets and row covers can exclude insects from the crop and reduce pest damage. In short, micro tunnels can improve productivity and land use efficiency.

Here we discuss the benefits of using micro tunnels as protected systems for season-long production of vegetable crops in Virginia with the purpose of improving the sustainability of small and medium-sized operations.

Micro Tunnels and Type of Cover

Micro tunnels are non-permanent structures that are easy to assemble and disassemble with each crop. This mobility offers an advantage over high tunnels because it allows for rotations with cover crops or other field crops to improve and maintain soil health and productivity. However, this requires an increase in labor costs to set up and remove the structures. A detailed description of the different types of structures is presented in the following VCE publication (https://www.pubs.ext.vt.edu/SPES/SPES-355/SPES-355.html).

Micro tunnels can be of various heights and covered mainly with three types of plastic materials: perforated or slit plastic film, spun-bonded fabrics, and insect nets, depending on the purpose of their use. Plastic film increases the temperature, but its use in micro tunnels is limited to small plant crops because of water condensation that promotes suffocation and decay of the foliage in contact with the film. This problem is rare with spun-bonded fabrics because they are permeable and allow airflow with little condensation inside the tunnel; the condensation dissipates easily after sunrise. Spun-bonded row covers are semitransparent plastic fabrics of various thickness (0.5 to 3 ounces per square yard) used as floating blankets (figure 2) or as micro tunnels (figure 3) over hoops made of wire (No. 6 or 9), PVC, metal pipe, or other supporting material. The thickness of the spun-bonded row cover directly influences the level of protection against cold temperatures, but it also influences the strength of the material. Row cover selection also affects the the stability of the tunnel. Heavy fabrics (1.5 to 3 ounces per square yard) cost more, but are stronger and can maintain warmer temperatures under the tunnel in a freezing or near freezing event. Lightweight fabrics are less costly, but rip easily, so they require careful handling during installation and removal. In addition, lightweight row covers can protect crops from insect pests (partially) and organic growers use them for this purpose.

Insect nets made of plastic material also exclude insects of various sizes depending on the mesh (Bell and Baker 2000). Insect nets of fine mesh (small holes) can block insects as small as whiteflies and thrips and are mainly used to cover air inlets in greenhouses to block insects from reaching the crops inside and avoid virus infection. It is important to mention that, insect nets and row covers can help to reduce insect pressure in vegetable production, but they wont exclude the pest completely from the crop and if left unattended, insect colonies will grow vigorously under the protective structure due to the lack of natural enemies and convenience of the environment.

Figure 2. Spun-bonded floating blanket over strawberries in early spring production. Westmoreland County, Virginia.

Figure 3. Spinach production under micro tunnels with spun-bonded row cover over wire hoops in early spring for direct sale market. Westmoreland County, Virginia.

Microenvironmental Conditions

Row covers can modify the microenvironment under the tunnel into more favorable growing conditions that reduce overall plant stress. Micro tunnels effectively increase air and soil temperatures, protect crops against cold temperatures and mild freezes, and promote vegetative growth early in the spring (figure 4) and late in the fall (figure 5) (Arancibia and Evans 2015; Arancibia and Motsenbocker 2008). The level of protection depends on the thickness of the row cover and outside daytime growing conditions. Manufacturers' specifications may indicate the temperature differences the material can offer between inside the cover and outside (2 degrees F to 10 degrees F), but environmental conditions may play a role in their performance. Therefore, farmers use micro tunnels in the spring and fall mainly to protect warm-season crops against cold temperatures and potential mild freezes (figure 6). An additional benefit of the increased temperature under the tunnel is the enhanced vegetative growth in comparison to what occurs in an open field, which may increase yield (Fig 4, 5 and 6).

Figure 4. Growth difference in spring lettuce grown under open field (left) micro tunnels (right). Spring 2017. Eastern Shore AREC, Painter, Virginia.

Figure 5. Growth difference and quality after a freezing event in cilantro grown under micro tunnels and open field. Winter 2015. Eastern Shore AREC, Painter, Virginia.

Figure 6. Growth difference in cucumbers grown under micro tunnel in comparison to open field. Spring 2016. Eastern Shore AREC, Painter, Virginia.

In temperate climates as well as in tropical areas, farmers rarely use micro tunnels and covers after the risk of a freezing event has passed and during the summer. The perceived benefit of tunnels as a season extension appears to end when the risk of freezing has passed. In addition, the increased temperatures inside the tunnel during hot sunny days are perceived as stressing conditions and therefore a barrier to growing under tunnels later in the spring and during the summer. Nonetheless, tunnels can still enhance vegetative growth in warm-season crops such as cucurbits and some solanaceous crops and some leafy vegetables during the summer and in tropical areas. We have measured average maximum air temperatures around 100 degrees F and extremes above 110 degrees F under the tunnel during the summer in Virginia, and vegetative growth continues without stress symptoms (figure 7). Furthermore, in warmer areas such as Louisiana and the Virgin Islands, maximum air temperatures under the tunnel may reach 120 to 140 degrees F, which may seem very stressful, but again, vegetative growth was faster and plants larger without stress symptoms in comparison to open field (figure 8) (Arancibia 2012; Arancibia and Motsenbocker 2008). Microenvironmental conditions indicate that in spite of the increased temperature under the tunnel, reduced light intensity and wind results in less evapotranspiration (Arancibia 2009 and 2012). This reduced water stress in the peak hours of sunny and or windy days appears to be the reason for the milder conditions that result in enhanced vegetative growth. Furthermore, crops under tunnels require less irrigation water due to the decrease in evapotranspiration.

Figure 7. Growth difference in cucumber grown in under micro tunnel and open field. Summer 2015. Eastern Shore AREC, Painter, Virginia.

Preliminary studies suggest that crops under tunnels may use 30 to 40 percent less irrigation water than those in an open field. Therefore, micro tunnels can increase the crop's water use efficiency and save water in areas where it is limited and/or expensive, such as in an urban area. It is important to notice that further research is necessary to validate the feasibility of micro tunnels in different regions during summer months, as although vegetative growth might be enhance, flowering and fruit set might be affected by excessive temperatures.

Figure 8. Growth difference in Puerto Rican sweet pepper grown under micro tunnel and open field. Summer 2007. UVI-AES, St. Croix, U.S. Virgin Islands.

Production and Use Efficiency

The enhanced vegetative growth under micro tunnels may result in earlier harvest and increased yield of cool- as well as warm-season crops. Although some winter crops can withstand freezes and can grow during the winter and early spring, the increased temperature and reduced evapotranspiration under the tunnel enhance growth, production, and earliness (figure 4). In fact, in northern states, farmers use micro tunnels inside high tunnels as an additional protection layer against extremely cold temperatures to promote growth of cool-season crops. Similarly, the more favorable conditions under the tunnel enhance vegetative growth of warm-season crops such as cucurbitaceous, solanaceous, and other fruiting crops in spring as well as summer, which results in larger plants at the time of cover removal than open field plants (figures 6, 7, and 8). These larger plants can set and sustain more fruit and increase yield in comparison to open field (Arancibia 2012; Arancibia and Motsenbocker 2008) as long as conditions are not detrimental to the reproductive stage of the plant. Using micro tunnels, however, may be challenging in crops that require insects for pollination, so timing for cover removal is critical.

Micro tunnels can improve nutrient and land use efficiency due to the greater yields generated than open field crops. The increase in vegetative growth and yield with similar fertilization rates suggests that crops grown under tunnels have a greater nutrient use efficiency: more produce (biomass) per unit of fertilizer added or nutrient available in the soil. Similarly, the enhanced vegetative growth under tunnels results in earlier harvest, particularly in leafy vegetables. Shortening the time from planting to harvest may allow additional harvest events and/or crop cycles within the season. Therefore, the increase in production and the additional income per unit of land under tunnels can improve land use efficiency, which is particularly important in small-sized specialty crop operations and in urban agriculture.

Micro tunnels can extend the production season of warm- as well as cool-season crops, so the production and supply period is longer than in the open field. Micro tunnels allow planting much earlier in the spring than open field by increasing temperature and protecting against mild freezes (figures 4 and 6). However, long periods of cold temperatures may still affect warm-season crops, since most of them are susceptible to chilling temperatures (between 32 and 55 degrees F). Symptoms of chilling temperature injury are whitening, stunted growth, and even death of young transplants. In the case of cool-season crops, tunnels can extend the production season further into the winter and early spring since they can tolerate chilling temperature and, in many cases, freezing events (figure 5). In addition, micro tunnels covered with shade cloth can extend production of some cool-season crops into the summer by providing less-stressful conditions. Therefore, micro tunnels can help in maintaining the supply of produce for a long time and sometimes year-round in Virginia. This is advantageous in marketing, since buyers and consumers prefer and value a continuous supply of quality produce.

Insect Pests and Viral Diseases Transmitted by Insects

Spun-bonded row covers and insect nets are physical barriers against insect pests as well as viral diseases transmitted by insects. Insect nets of lower mesh (larger gaps in the netting) can partially exclude large insects such as butterflies and moths, bugs, beetles, and others from the crop and reduce feeding injury (figure 9) (Arancibia 2007). However, most virus-transmitting insects are small. Aphids, whiteflies and thrips transmit the most common viruses affecting vegetable crops. Row covers and insect nets of fine mesh (smaller gaps) can help prevent small virus-transmitting insects and reduce the direct feeding injury as well as the incidence of viral diseases transmitted by these vectors. Therefore, tunnels covered with spun-bonded fabrics and insect nets can reduce the use of insecticides, benefiting conventional as well as organic producers of specialty crops.

Figure 9. Differences in growth and pest-feeding injury in kale grown under low tunnels covered with row cover (top), insect net (middle), and no cover (bottom) without insecticide applications. Fall 2016. Eastern Shore AREC, Painter, Virginia.

Planting and Tunnel Installation

Installing micro tunnels immediately after planting the crop would achieve maximum benefits. Leaving the crop uncovered one or more days may allow pests to land on the plants, reducing the expected protection. Plants should be pest-free at the time of planting and/or tunnel installation. When transplanting on hot summer days, however, irrigation is critical because the small root system of the transplants may not be sufficient to keep up with the water needs even under the tunnel. Therefore, irrigation one or more times a day may be necessary to promote plant establishment. On the other side, if planting under excessively hot conditions (above 80 from more than 4 hours), the full installment of the micro tunnel is not recommended, as the seedling establishment might be affected. In such conditions, it might be beneficial to sacrifices the insect protection properties of the structure and only focus on rainfall protection by slightly opening both sides of the tunnel to allow more ventilation and only maintaining the top part. Additionally, plastic mulch selection plays a key roll to help maintain a low temperature of the soil. White and reflective mulches should be selected for summer crops when using micro tunnels.

The size of hoops and width of the cover vary, and selection depends on the crops and cultural practices. The height of the tunnel is 1.5 to 2 feet for small plants, but can be taller and in some cases as tall as a walk-in tunnel (with metal hoops) for larger plants. The distance between hoops is 4 to 5 feet apart along the row. At both ends of the tunnel, two crossed hoops may provide more stability against wind. During installation, lay the cover over the crop and hoops and avoid sliding the fabric, which could damage the small plants. Row covers and nets come in rolls, so hold the fabric at one end while carrying and unrolling the cover down the row by hand or by a tractor. The row cover as micro tunnel or as floating blanket should be tight and secured around the borders to avoid wind getting underneath and blowing them away, and to prevent openings that would allow insects to reach the crop. Mechanized installation of micro tunnels uses soil to secure the row cover, similar to laying down plastic mulch. Shoveling soil by hand is also effective to secure the row cover (figure 3). Alternative methods to secure the row covers and nets are sand bags, bags filled with gravel, or tubing of 6 or more inches in diameter filled with water. Plastic pins (figure 2) and concrete blocks may also be used to secure blankets.

Summary

Among the main challenges that vegetable farmers and urban agricultural producers face are cold temperatures early in the spring and late in the fall, as well as pests, water supply and cost, and wind that affects crop growth and production throughout the season. Micro tunnels covered with spun-bonded fabrics may overcome these limitations to some degree since they improve the crop's microenvironmental conditions, and reduce evapotranspiration and water requirements. In addition, row covers and insect nets act as physical barriers against pests. Therefore, micro tunnels enhance plant growth and increase yield, and they may reduce the time crops need to reach commercial size or maturity. In doing so, they can increase harvest events and/or crop cycles per unit of space, and, consequently, improve productivity as well as water, nutrient and land-use efficiency. However, the additional cost in materials and labor to set up and remove the micro tunnels after each crop, and the reduced durability of the fabric — especially the lightweight row cover — may be barriers to adopt this protected production system. Nonetheless, micro tunnels are more affordable than high tunnels in the short term, so more farmers may have access to this technology with a positive impact in the sustainability of their operations. Finally, by extending the production season, micro tunnels can help growers maintain a continuous supply of produce, which is advantageous in marketing and critical for the success of specialty crop industry and urban agriculture in Virginia.

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References

Arancibia, Ramón. 2007. "Rowcover Reduces Insect Infestation and Increases Growth and Yield of Cucumber in the U.S. Virgin Islands." Abstract. *HortScience* 42, no. 4 (April): 850.

Arancibia, Ramón A. 2009. "Microclimatic Factors Associated with Enhanced Plant Growth Under Rowcover." Abstract. *HortScience* 44, no. 4 (July): 1132.

Arancibia, Ramón A. 2012. "Rowcovers in Vegetable Crops Production in Tropical and Temperate Climates." Abstract. *HortScience* 47 (9): S107-108.

Arancibia, Ramón and William Evans. 2015. "Rowcover Modified Microclimatic Conditions and Increased Cilantro Yield in Virginia." Abstract. *HortScience* 50: S198.

Arancibia, Ramón A. and Carl E. Motsenbocker. 2008. "Differential Watermelon Fruit Size Distribution in Response to Plastic Mulch and Spunbonded Polyester Rowcover." *HortTechnology* 18, no. 1 (January-March): 45-52.

Bell, Michelle L. and James R. Baker. 2000. "Comparison of Greenhouse Screening Materials for Excluding Whitefly (Homoptera: Aleyrodidae) and Thrips (Tysanoptera: Thripidae)." *Journal of Economic Entomology* 93, no. 3 (June): 800-804.

Carey, Edward E., Lewis Jett, William J. Lamont, Terrance T. Nennich, Michael D. Orzolek, and Kimberly A. Williams. 2009. "Horticultural Crop Production in High Tunnels in the United States: A Snapshot." HortTechnology 19, no. 1 (January-March): 37-43.

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