University of New Hampshire Cooperative Extension

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Research Summary – Using Low Tunnels for Overwintering Crops

by Becky Sideman, Ruth Hazzard, Amanda Brown and Lisa McKeag

Vegetable specialists at the University of New Hampshire and University of Massachusetts, together with several grower-cooperators located throughout New England, evaluated the potential for low tunnels to be used for overwintering hardy vegetable crops that require minimal winter protection. The goal of the project was to determine if low tunnels could effectively protect crops, and which crops are most able to survive and grow marketable leaves or roots for early spring sales. We acknowledge financial support from Northeast SARE Project LNE 1027 – Expanding Winter Harvest and Sales for New England Vegetable Crops and the NH and MA Agricultural Experiment Stations. We appreciate the support and collaboration of our many grower partners and project collaborators at Communities Involved in Sustaining Agriculture and Seacoast Eat Local.

Over a period of four years (2009-2013), we established low tunnels at the NH Agricultural Experiment Station's Woodman Farm in Durham, NH and the UMass Crops Research Farm in Deerfield, MA. Both sites are zone 5B. These low tunnels were used for a variety of experiments, some replicated and some merely observational. In this report, we share general observations and lessons learned from our work using low tunnels to overwinter crops.

About Our Low Tunnels

Tunnel bows. Our low tunnels were constructed from 10'-long bows made of 0.5" diameter polyvinyl chloride (PVC) or electrical metallic tubing (EMT). For EMT bows, the QuickHoops benders (Johnny's Selected Seeds, Albion ME) were used to bend the metal. Metal EMT bows were spaced 4-5' apart, and were pushed into the ground at least 6" on either side. PVC bows were space 2.5-3' apart, and were reinforced by sliding each end over a 12" rebar groundpost, pounded at least 6" into the ground. These bows result in low tunnels ranging from 3-5' tall, and 3.5-6' wide (See photo, right – PVC bows in front, EMT bows in back).

Low tunnel bows constructed of PVC (front) and EMT (back).

Coverings. We have worked with many types of coverings on the low tunnels. We found that the combination of heavy weight (1.25 oz/square yard) rowcover and 6 mil polyethylene resulted in both the greatest buffering against very cold winter temperatures and the greatest crop survival. Effects of different coverings on temperatures are described in detail in the research report entitled '***Effects of low tunnels on winter temperatures***'. In all cases, we constructed the low tunnels in two phases; we began by adding the rowcover in the fall when temperatures fell

into the mid to upper 20s, and then added the plastic later in the fall, when nighttime temperatures fell into the lower 20s or teens. Because temperatures fluctuate widely in the fall and vary from year to year, the optimum time to add covers is both subjective and unpredictable. In general, it is important to secure the plastic cover before the ground freezes. Coverings should be at least 10-12 inches wider on each side than the actual above-ground length of the tunnel hoop in order to have sufficient material to secure the cover.

Tunnel construction & site selection. Our research farm sites experience relatively high winds, as well as significant snow accumulation. One of the most challenging aspects of setting up low tunnels is securing the coverings against wind. We tried many things, but found that the most reliable method is to bury the edges, and that putting on the outer plastic cover before the ground freezes is key. Wrestling with covers that have blown off quickly makes low tunnels an unappealing technology, so this aspect of tunnel construction should be done carefully. When the low tunnels were placed closely enough together that burying with soil was not feasible (as in the photo, right, taken at UNH), we found that sandbags effectively held the rowcover and plastic in place. Using plenty of sandbags and making sure than ends were secured well seems to be critical for success. Sandbags did not work well at UMass, where tunnels were widely spaced and the field is very exposed. Leaving a full bed width between tunnels so that soil can be thrown over the edges using a tractor and disk can reduce labor, but throwing shovelfuls by hand also works. As this technology becomes more widely used, commercial innovations in cover fastenings, such as loop and cord systems, will likely become available.

At UNH, low tunnel ends were secured tightly, by anchoring to rebar end posts.

Above: At UMass, 100'long low tunnels were secured at each end with rope linking the end hoops with a wooden stake at each end of the tunnel. Note transplants in 3 rows, 4" apart in rows, on black plastic, and soil securing tunnel edge in background.

Left: Tunnels separated by a full bed width to allow tractor access for burying edges with soil. Redfire Farm, Montague, MA

Other helpful tips that we have learned from our own experiences and from growers include the following:

- Keep the tunnels small (e.g. less than 40' long), at least to start. While we have successfully used low tunnels over 100' long, the longer tunnels do catch wind more easily, and if one does come apart, you lose more crops in a large tunnel than in a smaller one.

- Secure the ends of the tunnel covering very well, so that wind cannot get underneath. We gather the plastic end together, wrap it tightly with twine, and tie it to a rebar post pounded as deeply into the soil as possible. (See photo, page 1, top right).

- Orient the tunnel so that the length of the tunnel runs in parallel to (rather than perpendicular to) prevailing winds reduces the changes of the cover blowing off.

  Other options for very windy sites include using the wider, less upright tunnel structure (3 ft tall, 6 ft wide) to reduce wind resistance, or establishing a windbreak upwind from your low tunnels to reduce the chances of them blowing apart.

- We have not experienced entire low tunnels collapsing from snow accumulation, but in both of our sites we have secured the last one or two hoops with rope that is fastened to the rebar stake (see photo) for added tunnel integrity. In NH, we have had the ends cave in during spring when the ground is very wet and the ground posts move easily in the soft ground (See photo, Bottom Right). Avoiding very wet areas can help reduce this problem.

- Temperature management in spring involves checking tunnels on warm, sunny days in March to monitor daily maximum, and removing plastic if T exceeds 85 or 90 F. In one year, we used wireless sensors to monitor tunnel temperature without opening the tunnel which helped us decide when to remove the plastic. Note that, to get accurate daytime temperatures, temperature probes must be inside a radiation shield or they will measure high temperatures inaccurately.

Winter access. Low tunnels are best suited for crops that are planted in the fall and not harvested until spring, when covering can be removed. Late fall harvest is feasible if done before the ground freezes or snow accumulates, and is worthwhile for greens with marketable leaves that would otherwise die back during winter. Once snow cover arrives, access is difficult. If sandbags are used to secure the covering, they can be removed, but covers may be frozen to the ground. If edges are buried, another strategy is needed. One strategy is to install tarp zippers on the tunnel. Tarp zippers are stick-on zippers that can be found in the painting supplies section of hardware stores. While these provide access to the tunnels, the zippers do not stick well to plastic during winter cold temperatures, and this can result in undesired gaps in the low tunnel. Lastly, the small size of the low tunnels makes movement inside without damaging the crop difficult.

Crops for overwintering. Over the years that we have used low tunnels for overwintering, we have experimented with several crops, with varying degrees of success. Brief descriptions for each crop follow. For details on UMass trials with Brassica greens, spinach carrots, onions, and beets and more on tunnel construction, please see the UMass Winter Production, Storage and Sales web site.

Spinach – We have included 'Space', 'Tyee' and 'Spargo' in different low tunnel experiments. We observed excellent winter survival. Leaves that were large but not harvested in the fall were mostly killed or damaged during the winter, but plants put out new healthy leaves in the spring without bolting and were ready for harvest in March-April. Significant aphid infestations were observed in one out of two years at both UMass and UNH.

Mustard – Mixed mustard greens (obtained from R. Hazzard, UMass) showed excellent survival in low tunnels, and grew rapidly in spring, ready for harvest as large bunched greens in March-April. Plants varied in speed of bolting, which suggests that there is potential to select for varieties that may be slower to bolt.

Kale – Both 'Siberian' (see photo, Right). and 'Red Russian' kale showed excellent survival in low tunnels, and grew rapidly in spring, ready for harvest as large bunched greens in March-April. In the UMass trial, bolting occurred in mid-April, and earlier seedings (8/29) produced higher yields compared to later (9/14, 9/26)

'Siberian' kale in low tunnel in early March

Mizuna/Tatsoi – Greens of the *Brassica rapa* group bolted and flowered in early March, even before conditions were suitable for removing the covers. Because they bolt so rapidly, they are not suitable for overwintering in tunnels.

Broccoli – We tried several cultivars of purple sprouting broccoli (including 'Santee'), and 'Happy Rich' green sprouting broccoli. Survival in low tunnels was generally poor, and yields on plants that did survive were quite low.

Onions – We have evaluated several varieties of onions in low tunnels. While all showed excellent survival, some bolted whereas others bulbed well in the spring. A more detailed explanation of this work is shown in the UNH report "***Overwintering onions in low tunnels***", and the UMass winter production website.

Lettuce – In one year, the cultivars 'Winter Density' and 'Nevada' remained marketable into December. By late December, heads showed a high incidence of necrosis, possibly due to freeze-thaw damage. Additional experimentation would be required to determine the conditions in which lettuce may perform well in this system.

Cilantro – In one year, the cultivar "Santo" grew well and produced harvestable yields in both December and in March (see photo, right). While cilantro showed promise for this system, additional work is needed before this can be recommended.

Cilantro in low tunnel in early March

Swiss Chard – In one year, 'Yellow' and 'Rhubarb' Chard showed high percentages of survival and good growth in very early spring (March). However, neither variety was marketable due to severe aphid infestation. With improved insect management, chard may work in this system.

Carrots – In one year, 'Napoli' carrots were seeded on three dates (9/19, 10/3, 10/10) in tunnels at UMass. Among seeding dates, survival was highest for the 2nd date, and bolting was lowest for the 3rd date, and yield of marketable roots was highest for the 2nd date though the yield difference was not significant. Managing bolting through later planting is important with carrots, and small differences in seeding date influence bolting. Growers have experimented with pushing seeding date even later into November, in order to avoid bolting, and consider carrots to be a good candidate for low tunnels.

Beets – 'Red Ace' beets were seeded on the three dates (see carrots) in one year at UMass. Survival was best for the 10/3 seeding date, but all plants bolted before marketable roots formed. Although a different variety may do better, growers have reported similar poor results for beets.

Other lessons learned:

Weeds – the low tunnel environment is perfect for winter annual weeds (e.g. shepherd's purse, chickweed). These weeds germinate in fall, grow through the fall and winter, and bloom inside low tunnels in late winter or early spring. Further, weeds such as shepherd's purse can serve as excellent hosts for aphid pests (see photo, right). As a result, it is important to manage winter annual weeds, including rotation ground used for low tunnels to prevent buildup of winter annual weed populations. In most of our experiments, we used black plastic mulch for weed control.

Aphids on shepherd's purse in low tunnel.

For direct-seeded crops, a late cultivation before covers are applied can be used to knock back winter annuals.

Vertebrate pests – While low tunnels offer protection against deer, they are perfect protected environments for other pests. We have occasionally observed feeding damage from voles and woodchucks on older leaves of spinach in late winter. While new growth has observed without any subsequent damage, management of these pests may be necessary in some sites, and some growers have reported observing damage by voles.

Harvest protection & timing – Crops grown under low tunnels are protected from full sun and wind, and are more tender than crops grown outside. We found that removing the low tunnel coverings for harvest on a windy, sunny spring or fall day could result in unmarketable crops. The tender leaves suffered wind and sunburn, and wilted and dessicated quickly. Leaving row cover in place after plastic is removed in spring allowed crops to adjust gradually to a less sheltered environment and harden off. However, we learned that we needed to plan harvests on calm, preferably overcast, days.

In conclusion, we have found that low tunnels present several unique challenges, as compared with high tunnel and field growing, but at the same time offer a low-cost overwintering solution for some valuable early spring crops, especially spinach, kale, onions, and carrots.

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With any questions, please contact Becky Sideman (becky.sideman@unh.edu, 603-862-3203) or Ruth Hazzard (rhazzard@umext.umass.edu).