



# High Tunnel Tree Fruit and Grape Production for Eastern Growers

By Guy K. Ames  
NCAT Horticulture  
Specialist  
Published March 2016  
©NCAT  
IP514

## Contents

- Introduction: Why and How High Tunnels Could Help .....1
- What Is a High Tunnel and What Does It Do and Not Do?.....2
- Fruit Diseases in High Tunnels .....3
- Insect and Mite Pests .....3
- Pollination .....4
- What Fruit Crops Look Profitable for High Tunnel Culture? .....4
- Additional Production Considerations .....6
- Economics .....8
- Conclusion ..... 10
- References ..... 10
- Further Resources .....11

High tunnels make possible organic production of tree fruits and table grapes in the eastern United States, where greater rainfall (compared to the West) makes organic field production very difficult. This publication identifies fruits that hold the most potential for profitable high tunnel culture. It also identifies several limitations and potential pitfalls growers must recognize if such a venture is to be profitable.



*Sweet cherry trees in a high tunnel. The yellow-capped boxes in the background are bumblebee colonies for pollination purposes. Photo: Greg Lang, Michigan State University*

## Introduction: Why and How High Tunnels Could Help

Almost all of the domestic organic table grapes and tree fruits—peaches, plums, apples, sweet cherries, and more—sold in the United States comes from the West. Why? In the eastern half of the United States, organic production of perennial fruits, especially table grapes and tree fruits, is complicated by myriad insects and diseases. The commercial fruit-growing districts in the western United States are arid, and pest and disease pressure is much lower relative to the East. In contrast,

the greater rainfall and humidity in the East allow pathogens and pests to flourish.

Further complicating the scenario are cosmetic standards, some formalized and some de facto, based on western-grown fruit that does not have to endure the increased disease and insect pressure in the East. These cosmetic standards can be ignored by gardeners and homesteaders growing their own fruit, but consumers accustomed to unblemished fruit grown in the West may look askance at eastern-grown organic fruit, which will almost always look significantly less than perfect.

ATTRA ([www.attra.ncat.org](http://www.attra.ncat.org)) is a program of the National Center for Appropriate Technology (NCAT). The program is funded through a cooperative agreement with the United States Department of Agriculture's Rural Business-Cooperative Service. Visit the NCAT website ([www.ncat.org](http://www.ncat.org)) for more information on our other sustainable agriculture and energy projects.



Biorationals: Ecological Pest Management Database  
Cherries: Organic Production  
Climate Change and Perennial Fruit and Nut Production: Investing in Resilience in Uncertain Times  
Grapes: Organic Production  
Greenhouse IPM: Sustainable Aphid Control  
Greenhouse IPM: Sustainable Thrips Control  
Greenhouse IPM: Sustainable Whitefly Control  
Organic Certification Process  
Peaches: Organic and Low-Spray Production  
Planning for Profit in Sustainable Farming  
Plums and Apricots: Organic Production  
Season Extension Techniques for Market Gardeners  
Sustainable Season Extension: Considerations for Design  
Tree Fruits: Organic Production Overview

## What Is a High Tunnel and What Does It Do and Not Do?

High tunnels are polyethylene-covered metal, wood, or plastic frameworks used by farmers to extend the growing season or otherwise ameliorate environmental conditions. Though they may superficially look like conventional greenhouses, they are not heated through winter and are not expected to harbor cold-tender crops through harsh winters. Also, the polyethylene cover on a high tunnel is much cheaper than the glass or rigid acrylic coverings of conventional greenhouses (see photo on page 3).

Properly managed, a high tunnel can allow a grower to get her product to market before her competition in the spring and can extend a crop's market season into late fall or winter. By keeping untimely frosts (but not major freezes), rain, hail, and excess wind off crops, the grower can also reduce losses from pests, disease, and environmental damage, and that is the primary focus of this publication.

To even hope to achieve fruit conforming to the visual standards of the marketplace, the eastern organic grower will have to spend much more time and money than his or her western counterpart and often will still fall short. A good example of this difference is the disease sooty blotch on apples (see photo), which is ubiquitous across the East but can be found only rarely if at all in the arid West. Likewise, a key insect pest of almost all tree fruit in the East, the plum curculio, does not occur in the West and has proven very difficult to control organically.

In theory, then, if an eastern grower could employ a technique that would allow him or her to grow organic fruit that looked as good as the fruit coming from the West, and if that technique didn't cost any more than transporting western fruit to eastern markets, then eastern organic fruit production could be competitive in the marketplace. Growing grapes and tree fruits in high tunnels could be that technique. (The perennial, non-woody fruits strawberries, raspberries, and blackberries have already proven themselves consistently profitable in high tunnels, so these crops are not discussed in this publication.)

### Constructing High Tunnels

The construction of high tunnels is beyond the scope of this publication, but information is widely available in books and publications, online, through the Natural Resources Conservation Service, and from manufacturers of high tunnel components. ATTRA has several publications and a video related to high tunnels and their construction (go to [www.attra.ncat.org](http://www.attra.ncat.org) and search for "high tunnel").

A high tunnel can take a lot of worry out of a production scenario, but it is not without its own imperatives. First among these is the daily maintenance required. Rain does not fall in the high tunnel, so irrigation is up to you. Unless you utilize temperature-sensitive timers and mechanical retractors, you'll be the one raising and lowering the side coverings or otherwise accommodating the need for temperature control, and you'll probably have to do this at least twice a day. Because the few pests that are common to high tunnels tend to have a rapid reproduction rate, during the growing season you should be doing pest monitoring regularly, probably daily. In short, though you've taken some of the uncertainty out of growing, the cost is increased vigilance and labor. In fact, one high tunnel workshop presenter analogized the labor requirements of a high tunnel to

*Fly speck and sooty blotch are two largely superficial disorders of apples that are favored by humid growing conditions in the eastern United States. These two diseases are not present in the West. Photo: Robyn Metzger, NCAT*





*Putting the finishing touches on a high tunnel intended for table grapes at the University of Arkansas research farm. Note the grape trellis already in place. Building trellises is best done before the tunnel goes up. Photo: Susan Alman, University of Arkansas*

those of a dairy: you will be attending to the needs of either at least twice a day, seven days a week.

## Fruit Diseases in High Tunnels

For the organic grower, the main benefit high tunnels offer is the ability to exclude and inhibit disease. Splashing, blowing rain is the main vehicle for spreading most fruit diseases. Moreover, most fungal diseases require free water (as opposed to just high humidity) on the plant surface for the conidia or spores to germinate and infect the plant. Thus, where rain can be excluded, potentially devastating diseases like brown rot can be almost eliminated. Even if an errant *Monilinia* spore (causal organism of brown rot) blew in, there wouldn't be water on the fruit to allow the spore to germinate and penetrate the fruit. In practice, however, Dr. Gregory Lang, Michigan State University tree fruit specialist, points out

*Brown rot is the bane of stone fruit growers nationwide, but is especially difficult to control organically in the East. Photo: Molly Giesbrecht, Texas A&M Agri-Life Extension Service, Bugwood.org*



that though fruit cracking, brown rot of fruit, and bacterial canker are greatly reduced in tunnels, they are not eliminated (Lang, 2009). Water and humidity management are issues still being addressed. Lang suggests siting any new high tunnels away from other stone fruit production areas where spores might be abundant and blow into the tunnel.

The one notable exception to the generalization that fruit diseases are dependent on free water is powdery mildew, which does fine with just high humidity and is the one consistent disease problem on plants in greenhouses and high tunnels.



*Powdery mildew on cherry. Photo: www.utahpests.usu.edu*

Luckily, powdery mildew is not terribly difficult to control organically with many different materials approved by OMRI (the Organic Materials Review Institute). Organic control is possible with sprays of sulfur, but the "softest" organic control is probably with baking soda products like Kaligreen™ and Milstop™. See ATTRA's *Biorationals: Ecological Pest Management Database* for more information on these and other OMRI-approved products for plant disease control (<https://attra.ncat.org/attra-pub/biorationals/>).

## Insect and Mite Pests

Though high tunnels are often left open at the ends, and sides are lifted for ventilation, surprisingly few insect pests move in. No one knows exactly why this is so, but honeybees seem to have difficulty navigating in high tunnels (see the section below on pollination), so it might be because the poly cover interferes with sun-based navigation or otherwise disrupts normal light. Whatever the reason, the key pests of fruit crops outside of high tunnels usually don't become key pests inside. That's not to say, however, that pest problems don't occur.

**F**or the organic tree fruit grower, the main benefit high tunnels offer is the ability to exclude and inhibit disease.

The pests that seem to be most problematic in high tunnels are the same ones that often become problematic in greenhouses: white flies, aphids, and mites. These pests have high reproduction rates, some can reproduce without males (i.e., only one female is necessary to start a population explosion) and, in the absence of their natural enemies, can quickly multiply to pest status.



**The black cherry aphid is a good example of a pest with a high reproductive potential: the kind of pest that can be especially troublesome in a high tunnel situation. Photo: Eugene E. Nelson, Bugwood.org**

A relatively new pest that has proven troublesome on some high tunnel crops is the spotted winged drosophila (SWD). The SWD is a very small gnat or “vinegar fly,” and cherries are one of its preferred hosts. Like other high tunnel pests, this insect’s small size and high reproductive rate help it achieve pest status quickly, often before the grower has detected its presence. Extremely fine mesh screen (18 mesh or finer) will exclude the SWD, but mesh this size will also impede air flow, so fans may have to be used to augment air circulation. Spinosad-containing insecticides are another organic option. For more detailed information refer to the publication *Integrated Pest Management of Spotted Wing Drosophila with Emphasis in High Tunnel Grown Fall Bearing Primocane Raspberries* (Pinero and Byers, 2013). If pests are getting in, small-mesh screen can be used to block them at the ends and along the raised sides, though this represents another monetary investment. Such screen can be bought from high tunnel supply companies.

Because high tunnels are semi-closed systems, naturally occurring beneficial insects, like lady beetles, don’t often find their way inside. However, by virtue of the same relatively closed system, introduced beneficials cannot easily disperse into the outside environment, so you might get more biological pest control for your money. Sources

and more information on beneficial organisms that combat many pests common to greenhouses and high tunnels can be found in ATTRA’s Biorationals Database (<https://attra.ncat.org/attra-pub/biorationals/>) as well as in ATTRA’s three-part publication series on integrated pest management in greenhouses.

## Pollination

Because honeybees (and some other insects, including some important pests) have problems navigating in high tunnels—presumably because the plastic cover interferes with their sun-based navigation system—high tunnel growers will have to provide pollination either by hand, or, more commonly, by purchasing bumblebee colonies. This will add a little more than \$100/tunnel to the expense side of your ledger, but hand pollination is simply uneconomical (Spivak, 2012). Look online to find sources of bumblebees. Be aware that bumblebee colonies will live and work for about four to five weeks, so plan delivery accordingly.

Peaches and tart cherries are self-pollinating, so you do not have to have more than one variety in a tunnel; nevertheless, it is still advisable to provide bumblebees so that pollination is complete. Sweet cherries, plums, apricots, apples, and pears require cross-pollination, so be sure to provide a compatible pollinizer for your main variety in each tunnel.

Table grapes have a “self-contained” pollination system, so nothing needs to be done to insure pollination for grapes.

## What Fruit Crops Look Profitable for High Tunnel Culture?

It bears repeating here that the premise of this publication is that high tunnels allow for organic production of certain fruits that have, otherwise, resisted organic culture in most of the eastern United States. Furthermore, this publication assumes that locally and organically grown fruit will receive premiums for being organic and possibly for being local. Foremost among the candidates for high tunnel production are seedless table grapes, sweet cherries, peaches, nectarines, and plums. Research has already indicated that these perennial fruits can be grown successfully and organically in high tunnels, but can the operator turn a profit? Because the high tunnel system represents another sizeable investment for the grower, some woody fruit crops might be more

economically suited than others, returning relatively more profit per investment dollar. Several factors—some on the cost side of the ledger, some on the income side—could impact the economic viability, including the following:

- the normal market value (high-value crops make the most sense to begin with; i.e., the returns must pay for the investment in the high tunnel system in reasonable time)
- premiums for being organic and/or local and/or early to market
- length of time before plants bear their first crop (though this cost can, in some cases, be ameliorated by growing a secondary annual crop between young trees)
- the inherent growth characteristics of the species or variety of fruit (e.g., dwarf trees are better suited than standard trees. Some species of fruit trees, like pears, do not currently have a dependably dwarfing rootstock, so are not ideal candidates for tunnel production)
- relative yield and quality increases due to being grown in the tunnel (included here is protection from birds as well as frost protection, which can often make the difference between a crop and no crop at all).

Considering these factors, *sweet cherries* on free-standing, dwarfing rootstocks seem to top the list. Organic sweet cherries are among the highest-valued fruit crop. Dwarfing rootstocks exist (see ATTRA's *Cherries: Organic Production*) that are free-standing and that bring the tree into bearing faster than standard rootstocks, sometimes the year after planting. And individual cherry size is larger when the fruit is grown in a high tunnel, bringing another premium valuation (Lang, 2009). Indeed, the sweet cherry is probably the most studied tree fruit in university-sponsored high tunnel research and the most tried tree fruit in high tunnels among early-adopting private growers.

Another way cherries could benefit from high tunnel production is bringing the crop in earlier. Getting cherries to market just a week or two ahead of the competition, which the tunnel can allow, usually results in significant price premiums.

Bacterial canker on trunks and low limbs is a serious threat to cherries. This disease, spread by rain and splashing soil, is the single biggest cause of tree death in most cherry growing areas, even

the West. High tunnel culture can come close to eliminating the threat of bacterial canker.

Another big factor encouraging production of sweet cherries in high tunnels, though not related strictly to organic production, is the tendency of sweet cherries to crack when there is significant rain within two weeks of harvest. Some cultivars crack worse than others, but this is a threat among all cultivars as they approach harvest. Being able to control the water going to the cherry crop during this final ripening period gives growers with cherries in high tunnels a big advantage over field-grown cherries. However, this advantage is not automatic: if heavy rains occur during or near harvest and drainage around the high tunnel is such that the soil covered by the tunnel becomes saturated, fruit cracking will still occur. Ditching and/or berming the high tunnel site could be necessary if simple siting doesn't provide proper drainage of rain water.

Even with cover, brown rot on sweet cherries has still been recorded in some Michigan State research (Lang, 2009). Employing only drip irrigation should help, as might techniques to improve air circulation, but high humidity common to high tunnels can still foster some disease problems, like brown rot and powdery mildew.

Profitability of sweet cherry or any other fruit crop produced in high tunnels is highly dependent on good management. With cherries, this means using the latest dwarfing rootstocks and training systems to get the most out of the small area protected by the high tunnel. Probably because of the potential for profit, sweet cherries are receiving considerable attention from researchers. To tap into this valuable research, access [www.giselacherry.com](http://www.giselacherry.com), a collaborative project of Win Cowgill (Rutgers Cooperative Extension), Lynn Long (Oregon State University), Jon Clements (UMass Extension), Greg Lang (Michigan State University), and Gisela, Inc.

Dr. Lang is probably the leading researcher in the United States for tree fruit production in high tunnels. To keep up with his research with cherries, peaches, and other fruits, go to [www.hrt.msu.edu/assets/PagePDFs/greg-lang/2015-Tree-Fruits-in-Tunnels-IHC.pdf](http://www.hrt.msu.edu/assets/PagePDFs/greg-lang/2015-Tree-Fruits-in-Tunnels-IHC.pdf).

*Seedless table grapes* also look like a very good candidate for high tunnel culture. The extra expense of trellising grapes is a mark against them, but this is more than compensated by the

earlier bearing of grapes grown in high tunnels (they are ready to crop the year after planting instead of two to three years later when grown outdoors). Also, early research indicates that grapes experience huge benefits in quality and yield when grown in tunnels.



**High tunnel-grown grapes in University of Arkansas research yielded three times the fruit of the same variety grown outside the tunnel. Photo: Susan Alman, University of Arkansas**

University of Arkansas research recorded that under high tunnels, grape vines filled their trellis space and were ready to bear the year after planting, compared to two to three years when grown in open field conditions. In the following two years, the field-grown grapes lost their crops to freezing temperatures one year, and in the other year, the high tunnel vines produced more than three times as many grapes by weight as the vines in the field (Garcia, 2014). Yields of tunnel-grown wine grapes were similarly double compared to outdoor-grown grapes in Pennsylvania research (Casey, 2013).

Arkansas researchers did see some black rot and grape berry moth damage in the high tunnel, but very, very little, and this is negligible for many markets, especially direct retail such as farmers markets.

**Peaches and nectarines** are probably right behind sweet cherries, most years, in the value of the harvested crop. They are also exceedingly difficult to grow organically in the East because of brown rot, plum curculio, and other threats. Though consistently and adequately dwarfing rootstocks for peaches have eluded breeders, training systems have been developed to keep the trees very small yet highly productive. Some, but not all, of these systems rely on trellises to aid in the placement and support of trunks and fruit-bearing limbs.

V-shaped training on peaches appears to be most optimal tree shape for use in Texas (Texas Fruit Growers Association, 2014) and also in New York (Hoying et al., 2007), and it fits well into a high tunnel growing system.

The Texas researchers enumerated some lessons learned:

1. Early planting—even if only 14 days earlier—is very beneficial for extra first-year growth.
2. Marketable fruit can be produced on one-year-old trees. Early training reduces first-year yield.
3. Much lower disease and insect pressure in high tunnel. No “free water” or rain on fruit eliminates brown rot.
4. Mites and mildew increase possible in high tunnel vs. open field, but we have good controls, both organic and chemical.
5. V-shaped training on peaches appears to be most optimal tree shape for Texas.
6. Chemical-free or organic production in peaches is much more workable in high tunnels.
7. Hail caused 50% loss on outside trees; no damage in tunnel.
8. Fruit can be four to five weeks earlier than field production.

**Plums, apricots, and their crosses** are stone fruits for which frost control is as important as disease control when considering the value of a high tunnel system. Apricots, especially, are notorious in the East for blooming too early and losing their crops to spring frosts. A properly managed high tunnel can help apricots and other stone fruits set a viable crop by protecting them from frost damage.

## **Additional Production Considerations**

### ***Double Cropping While Trees Mature***

Because grapes and fruit trees do not bear until they are mature, there is time when the tunnel could be sitting unproductive while you are paying for it as well as the maintenance of the plants

## Growing Tree Fruits and Grapes Are Information- and Labor-Intensive Endeavors

Though a high tunnel can facilitate pest and disease management on tree fruits and grapes, growing such woody perennials is significantly more complicated than growing most annual crops from seeds. In fact, because you're growing them in the tight, prescribed area of a high tunnel, cropping efficiency becomes even more important than when these fruiting plants are grown outdoors. This means that you will almost certainly need to adopt modern intensive techniques that rely on dwarfing rootstocks (where available, there are good ones for cherries and apples; no reliable ones for peaches or pears). For instance, there are many different dwarfing cherry rootstocks (see ATTRA's publication *Cherries: Organic Production*), each for specific conditions or purposes. And you will have to adopt the right training system for the varieties and the market you choose: arcane-sounding training systems with names like Kym Green Bush, Spanish Bush, Steep Leader, Super Slender Axe, Tall Spindle Axe, Upright Fruiting Offshoots, Upright Fruiting Offshoots "Y" Trellis, and Vogel Central Leader. Each has its own advantages, disadvantages, proponents, and detractors. Often, a particular training system requires trellises or cables to accomplish its goals. And, always, the labor necessary has to be informed and detail-oriented.

Viticulture (grape growing) is yet another world. First, the trellis needs to be very, very sturdy because the grapes are not free-standing: the trellis will actually be holding up the weight of hundreds of pounds of fruit. And pruning grapes correctly and adequately is an absolute must, whether indoors or outdoors. Novice grape growers rarely seem to believe the degree to which grape wood is removed during annual pruning, and quality and yield will suffer if pruning is not correct. Fruit nutrition, maturation, and harvest all have to be well understood to produce a quality product.

In short, growing tree fruits and/or grapes are not endeavors that should be entered into without study and, preferably, experience. An abundance of books, videos, articles, and Cooperative Extension bulletins can aid in your education, but, as the saying goes, there is no good substitute for experience, so try to get some! (Consult ATTRA's Sustainable Farming Internships and Apprenticeships database at <https://attra.ncat.org/attra-pub/internships/>.)

inside it. One way growers compensate for such "dead time" is to interplant annual plants such as vegetables, flowers, or herbs. Even young nursery trees have been intercropped between rows of fruit trees in high tunnels.

However, in practice, grapes and most fruit trees in high tunnels are exceptionally vigorous and often begin bearing in high tunnels the year of, or the year after, planting (Garcia, 2014; Hill Country Fruit Council, 2013), so double cropping might be economically unnecessary and, perhaps, a hindrance to the primary operation.

### Soil Nutrition

Without rain or overhead irrigation, some bulky organic fertilizers—e.g., compost—will not readily break down and move into the soil. And because the fruit crops we're discussing are perennials, cover crops cannot be relied upon for nutrition after the initial planting. This emphasizes the need for pre-plant consideration of nutritional needs of the plants, beginning with a soil test. For instance, adjusting soil pH with lime or sulfur should occur before the tunnel's cover goes on.

Likewise, if soil organic matter needs improvement, cover crops or applications of manures or composts should happen before the high tunnel is covered. Allow time for breakdown and mechanical or natural incorporation of these into the soil.

Post-planting nutritional needs are going to be met with fertigation (running liquid fertilizers in the irrigation system), by precision hand-application of compost or pelletized organic fertilizers, or by hand-application of liquid organic fertilizers via watering buckets or hoses with fertilizer attachments. Regarding fertigation, liquid organic fertilizers, like fish emulsion or compost tea, have a reputation for clogging or gumming up the drip emitters (manufacturers of some of these products are now touting some formulations as "fertigation friendly" in order to address this problem). In such cases, proper filtration is the first line of defense. If clogging still occurs, there is an organically acceptable cleaner, Cleardrip-O. (See the Further Resources section for ordering information.)

*Fertigation in Organic Vegetable Production Systems* (Miles et al., 2015) is an excellent primer on

organic fertigation, as relevant to perennial fruits as it is to vegetables. It discusses the necessary equipment, fertigation products, how to calculate rates, and more.

If you're going to apply dry fertilizer materials, they will have to be placed where the soil is wet from the irrigation; otherwise, the nutrients from such materials will not move into the root zone to be available to plant roots.

Lastly, it's advisable to remove the plastic cover every winter in order to ensure that the trees meet their chill requirement but also to allow rain to rinse out excess salts from the fertilizers. This is also a time when manure or compost could be applied with some confidence that it will be "washed" into the soil by rain and melting snow. Compost, especially compost made from plant matter and not animal manure, contains less salt and so should be considered a superior organic fertilizer material for most high tunnel applications.

### ***Irrigation***

While under cover, the trees or vines will be dependent on the grower for water. There are many ways to supply water, but anything that gets the foliage or fruit wet will be undoing the big advantage of growing fruit under cover. In fact, you should do whatever you can to keep the humidity down to no higher than it is outside the tunnel. (Venting near the top at both ends of the tunnel is advisable.) Even microsprinklers might be too much moisture! Most growers choose standard drip irrigation. An excellent way to begin understanding the ins and outs of drip irrigation is to access the University of Wisconsin Cooperative Extension's *Crop Irrigation* (Panuska and Sanford, no date).

Using regular, chlorinated drinking water from a public water system is probably the best for a drip system but, depending on the source, can be expensive. If you choose to use a non-conventional water source (well, pond, or stream) or if you're going to fertigate, you must have a good water filtration system or the emitters will clog.

Remember, even during dormancy, the trees under cover are dependent on you for water. If the soil gets too dry during dormancy, trees can die. Soil water-monitoring devices are available and probably a good idea, because few farmers have experience with a semi-closed system like a high tunnel. A wide variety of devices at a wide

range of prices is available. (Search online for "soil water monitoring devices.")

University of Kentucky research aims to find ways to collect rainwater off of high tunnels and use low-pressure drip emitters to deliver it to the crop inside the tunnel (Morgan, 2014).

### **Economics**

The big question, of course, is whether a grower can make money growing fruit in a high tunnel. The quick answer is "yes." The simple truth of that is in the thousands of acres dedicated to fruit culture in high tunnels in China. There are 40,000 acres of just peaches and nectarines being grown in greenhouses and high tunnels in China (Layne et al., 2013). And in the United States there is now enough experience with brambles, strawberries, and annual vegetables in high tunnels to be able to generalize that there are higher marketable yields and earlier harvesting within high tunnels. Being first on the market with a given fruit type usually means premium prices, so higher gross returns compared to open field production can reasonably be assumed.

Another quick indicator of the potential profitability of high tunnel fruit production is that in many years, whole crops of unprotected stone fruits are lost to untimely frosts that a high tunnel crop could avoid. Likewise, in cherries it is not uncommon for half or more of a crop to be lost to fruit cracking caused by rains near harvest. A properly sited and drained high tunnel could bring those losses close to zero. For a crop that can be worth approximately \$30,000 per acre, a 50% avoidable loss is quite significant!

Nevertheless, this is not a low-input system, and returns have to cover: 1) costs of construction of the high tunnel itself (materials and labor); 2) an irrigation system; 3) maintenance costs; 4) the non-productive time before long-lived fruit plants start bearing; and 5) the risks of damage to the tunnel itself from extreme weather events.

### ***Cost of the Tunnel Itself***

The initial cost of the tunnel (materials and labor) is generally going to be the greatest expense. Typical tunnels are 20 to 30 feet wide and 100 to 200 feet in length, with a height of 9 to 15 feet in the center. Costs can vary, but a factor of \$1 to \$3.50 per square foot of the ground area covered is a

common approximation (Jett, 2013; Lent, 2016). So, a 30-foot wide, 100-foot long high tunnel (a little more than .1 acre) will likely cost \$3,000 to \$10,500. Detailed budgets for constructing high tunnels are easy to find on the Internet.

## Cost of an Irrigation System

An irrigation system can be as inexpensive as some leaky pipe hooked up to a garden hose, using water from a public system. Even this system should be turned on and off with a simple, inexpensive timer installed between the faucet and the hose. If public water is too expensive and/or the water available is from a well, pond, or stream, a filtration system will be necessary. If you're using emitters in a drip system, you'll have to have gates and regulators to maintain the proper pressure (to keep from "blowing" emitters) and in order to know how much water you're delivering to the plants. As discussed elsewhere, you're also likely to want to invest in a fertigation system with the requisite filters and injectors/regulators. So, costs for an irrigation system can vary widely. As mentioned in the Irrigation section, an excellent start to understanding drip irrigation systems, including costs, can be found in the University of Wisconsin's *Crop Irrigation* (Panuska and Sanford, no date).

### NRCS Cost Share

The Natural Resources Conservation Service (NRCS) of the United States Department of Agriculture (USDA) may be able to underwrite the major share of the cost of a high tunnel for individual growers through the Environmental Quality Incentives Program (EQIP). There is even a separate funding pool for organic growers. Growers have to meet certain qualifications and agree to follow certain guidelines, but these are not onerous, and having the better part of a high tunnel system paid for by the NRCS significantly shifts an economic analysis in favor of a tunnel. For more information, contact your local NRCS office or go to this NRCS website: [www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/financial/eqip/?cid=stelpdb1046250](http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/financial/eqip/?cid=stelpdb1046250)

## Maintenance Costs

"Maintenance" is a huge category and includes your and your helpers' time, replacement of damaged plastic, pruning the trees or vines, rolling the plastic cover up or down as the situation requires, organic pesticide applications, and almost anything else not covered in the initial costs of the

tunnel, plant purchases, trellis (if required), and irrigation system.

One of the most demanding aspects of maintenance is temperature regulation. If you don't install automatic systems (another expense), someone has to roll the sides up or down or otherwise make sure the tunnel stays within the temperature range desired by you and the plants. You or somebody will have to attend to these needs probably every day, and probably twice a day. Whether you count it or not, your time is money, and you're in business.

## Time Before the Trees or Vines Begin Bearing

Luckily, this factor turns out to be less significant than at first thought, before actual research and experience: it turns out that by virtue of being in the tunnel, most woody perennial fruit crops begin bearing far earlier than the same crop grown outside of the tunnel. In fact, most of the crops discussed in this publication begin bearing the year after planting! Still, if you're scheduling loan repayments for a high tunnel, you can't forget that you probably won't see any returns before a year or two after planting.

## Cost of Unanticipated Damage to the Tunnel

Farming is a risky business. The purpose of the high tunnel is to make it less risky by ameliorating the dangers of disease, insects, frost, hail, and untimely rain. However, sometimes the tunnel itself is the object of damaging events. Chief among these are high winds and heavy snow loads. Hail can sometimes also be damaging. Proper construction and maintenance should be the first line of defense. For instance, in high snowfall areas, Gothic-style framing is preferred because it is less likely to accumulate large snow loads.

## Returns

Detailed enterprise budgets for organic tree-fruit and grape production in high tunnels do not yet exist and perhaps that is because the very best systems with the attendant variables have yet to be determined. However, detailed budgets for fruit crops do exist in important fruit-growing states, and these budgets are easily accessed by searching for "peach (or cherry or grape) enterprise budget" plus your state or a state with a similar climate.

**N** RCS cost shares can underwrite most of the cost of a tunnel.

These budgets will generally use an acre as the standard production unit. Since a 30-foot by 100-foot high tunnel covers a little less than .1 acre, using the .1 factor should get you in the ballpark for very rough estimates. So, for instance, if a conventionally grown cherry crop is worth \$30,000/acre (a common figure for conventionally grown cherries; this is returns before costs are subtracted), .1 of that would be \$3,000. But of course this doesn't account for multiple differences between field and high tunnel production, both good (more profit) and bad (more costs) or any differences between conventionally and organically grown product.

And, even more importantly, these estimates cannot account for the variables in the costs of your particular management, good or bad, and the vagaries of the market, and the arbitrariness of the weather (hard freezes, large hail, heavy snows, and big winds can result in unbudgeted costs).

Nevertheless, with 1) an NRCS-underwritten tunnel, 2) marketable crops possibly two to three times the yield of outdoor-grown crops, 3) consistent frost protection sometimes saving entire crops, and 4) the possibility of price premiums for local, organically grown fruit where once there was none, it seems clear that a good manager could make substantial profits with high tunnel-grown fruit.

## Conclusion

Profitable high tunnel culture of table grapes and certain tree fruits holds significant promise for organic growers, especially in the eastern United States, where organic culture of these fruits has proven very difficult. The main benefit for organic growers is disease and insect control, but other benefits, like earliness to market and reducing rain-induced cracking of cherries and peaches, are also attainable.

## References

- Casey, R. "Quantity and Quality in a High Tunnel." *Wines and Vines* June 2013.  
[www.winesandvines.com/template.cfm?section=features&content=119364](http://www.winesandvines.com/template.cfm?section=features&content=119364)
- Garcia, Elena, D.A Dickey, S.E. Frey, and D.T. Johnson. 2014. Increasing Economic and Environmental Sustainability of Table Grapes Using High Tunnel Advanced Production. Unpublished manuscript. University of Arkansas.
- Hill Country Fruit Council. 2013. Texas Fruit Growers Association High Tunnel Fruit Project.  
[www.texaspeaches.com/High-Tunnel-Peaches.html](http://www.texaspeaches.com/High-Tunnel-Peaches.html)
- Hoying, Stephen, Terence L. Robinson, and Robert L. Anderson. 2007. More Productive and Profitable Peach Planting Systems.  
[www.nyshs.org/pdf/fq/2007-Volume-15/Vol-15-No-4/More-Productive-and-Profitable-Peach-Planting-Systems.pdf](http://www.nyshs.org/pdf/fq/2007-Volume-15/Vol-15-No-4/More-Productive-and-Profitable-Peach-Planting-Systems.pdf)
- Jett, Lewis. 2013. Production and Economics of High Tunnel Vegetables and Strawberries.  
[http://anr.ext.wvu.edu/commercial-horticulture/high-tunnels/high\\_tunnel\\_vegetables\\_and\\_strawberries](http://anr.ext.wvu.edu/commercial-horticulture/high-tunnels/high_tunnel_vegetables_and_strawberries)
- Lang, Gregory. 2009. Undercover Research: Growing Sweet Cherries Under High Tunnels in Michigan.  
[http://cherries.msu.edu/uploads/files/2009\\_NW\\_orchard\\_show/OrchardShow09G-Lang.pdf](http://cherries.msu.edu/uploads/files/2009_NW_orchard_show/OrchardShow09G-Lang.pdf)
- Layne, Desmond, Zhigiang Wang, and Liang Niu. 2013. Protected cultivation of peach and nectarine in China. *Journal of the American Pomological Society*. Vol. 67, No.1. p.18-28.



*Grapes growing in a high tunnel at the University of Arkansas. Photo: Margo Hale, NCAT*

Lent, Chris. Agriculture Specialist, National Center for Appropriate Technology. Personal communication, 2016.

Miles, Carol, Jonathan Roozen, Elizabeth Maynard, and Timothy Coolong. 2015. Fertigation in Organic Vegetable Production Systems.

<http://articles.extension.org/pages/29712/fertigation-in-organic-vegetable-production-systems>

Morgan, Christy. 2014. A Kentucky Professor Works to Improve Irrigation Efficiency, Soil Health in High Tunnels. <http://blogs.usda.gov/2014/09/16/a-kentucky-professor-works-to-improve-irrigation-efficiency-soil-health-in-high-tunnels/>

Panuska, John and Scott Sanford. No date. Understanding Crop Irrigation. University of Wisconsin Cooperative Extension.

<https://fyi.uwex.edu/cropirrigation/drip-irrigation/>

Pinero, Jaime C., and Patrick Byers. 2013. Integrated Pest Management of Spotted Wing Drosophila with Emphasis in High Tunnel Grown Fall Bearing Primocane Raspberries. LUCE Integrated Pest Management Program.

<http://ipm.missouri.edu/meg/2013/8/Integrated-Pest-Management-of-Spotted-Wing-Drosophila-with-Emphasis-in-High-Tunnel-Grown-Fall-Bearing-Primocane-Raspberries/SWD.article.pdf>

Spivak, Marla. 2012. Managing Pollination in High Tunnels. <http://hightunnels.cfans.umn.edu/files/2012/11/16-Pollination.pdf>

Texas Fruit Growers Association. 2014. TFGA High Tunnel Peach Project.

[www.texaspeaches.com/High-Tunnel-Peaches.html](http://www.texaspeaches.com/High-Tunnel-Peaches.html)

## Further Resources

### Websites

Cornell High Tunnels

[www.hort.cornell.edu/hightunnel/index.htm](http://www.hort.cornell.edu/hightunnel/index.htm)

*One of the most comprehensive high tunnel sites on the Web.*

HighTunnels.org

<http://hightunnels.org/>

*Everything high tunnels: videos, construction, materials sources, organic, listserv, articles, statistics and much, much more.*

## Publications

Fruiting Wall Training Systems and High Tunnel Opportunities for Nectarines, Apricots, and Plums. 2012. By Gregory Lang, Tiffany Lillrose, and Tammy Wilkinson. Michigan State University, E. Lansing, MI.

*This is a poster that summarizes some of the innovative training systems being researched for high tunnels. Also, go to [www.cherries.msu.edu](http://www.cherries.msu.edu)*

The Grape Grower: A Guide to Organic Viticulture. 2002. By Lon Rombough. Chelsea Green Publishing, White River Junction, VT.

*A comprehensive guide to growing grapes, including trellising, pruning, fertilization, varieties and more.*

Rainwater Catchment from a High Tunnel for Irrigation Use. 2012. By Shawn Shouse and Linda Naeve. Iowa State University Extension and Outreach, Ames, IA. [www.leopold.iastate.edu/sites/default/files/pubs-and-papers/2012-01-rainwater-catchment-high-tunnel-irrigation-use.pdf](http://www.leopold.iastate.edu/sites/default/files/pubs-and-papers/2012-01-rainwater-catchment-high-tunnel-irrigation-use.pdf)

*Information on constructing a do-it-yourself high tunnel rain water collection system.*

## Individual/Organizational Contacts

Michigan State University Horticulture/Dr. Greg Lang

[www.hrt.msu.edu/greg-lang/pg7](http://www.hrt.msu.edu/greg-lang/pg7)

[www.cherries.msu.edu](http://www.cherries.msu.edu)

*Dr. Lang is a leader in high tunnel research, especially fruit trees in high tunnels, but also organic fruit production, cherry training systems, and more.*

## Suppliers

Earthwise Organics

956-207-0500

[info@earthwiseagriculture.net](mailto:info@earthwiseagriculture.net)

[www.earthwiseagriculture.net/bm-clear-drip-o.html](http://www.earthwiseagriculture.net/bm-clear-drip-o.html)

*Clear-drip-o.*

**High Tunnel Tree Fruit and Grape Production for Eastern Growers**

By Guy K. Ames, NCAT Horticulture Specialist

Published 2016

Tracy Mumma, Editor • Robyn Metzger, Production

This publication is available on the Web at:

[www.attra.ncat.org](http://www.attra.ncat.org)

IP514

Slot 541

Version 032516