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Specialty Crops for High Tunnel Production in Texas

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High tunnel production is on the rise. It has been shown to increase yields, improve quality and extend the growing season. However, buying and constructing high tunnels can be expensive, and crop production costs are typically higher when using them. What you grow in your tunnels will depend on your market and customer preferences, as well as its potential to pay off startup costs as quickly as possible (Figure 1).

You can grow many crops in tunnels, but the top five vegetables are tomatoes, peppers, cucumbers, leafy greens and herbs, and crucifers. Small fruit crops also perform well in tunnels. These crops include strawberries, raspberries, blackberries, and blueberries. Recently, tunnel production has come to include stone and pome fruits such as dwarf peaches, cherries, apples, and plums. Finally, some producers are growing nursery ornamental container crops, as well cut flowers. Crop rotation is just as critical for crops grown inside high tunnels as with those grown in open fields.

Crop varieties developed for greenhouse production may also grow well inside high tunnels. Your seed supplier can suggest varieties that do well in tunnels. In Texas, heat tolerant varieties should perform better under tunnels. Experiment with several varieties before committing to full-scale production of any particular crop.

Vegetables

High tunnel cropland is prime real estate, so be selective about which crops to grow. Warm-season vegetables can be grown earlier and later in the season under high tunnel production. Cool-season crops can be produced even during winter's extreme cold (Figure 2). Transplanting vegetables on plastic mulch in high tunnels can often get you to harvest 6 to 8 weeks sooner than field production.

Tomatoes are the vegetable most commonly grown in high tunnels—this is largely because early and late tomatoes command premium prices (Figure 3). Bush and vine-type tomatoes can be grown under high tunnels; however, the vining types may not produce as well in hot Texas summers. Bush varieties have comparatively higher, earlier yields and in some areas, they can be terminated by July to start a fall crop. Shading the crop can cool the growing environment and may extend production when temperatures are high.

Determinate bush-type tomatoes are a good choice for spring production in high tunnels for Texas. Indeterminate varieties grow better inside high tunnels where they are protected from winds (Figure 4). When fully developed, bush varieties can yield 8 to12 pounds or more of marketable fruit per plant. Depending on size and variety, a high tunnel with 400 tomato plants can yield 6,000 pounds, or more, of marketable tomatoes. Research trials with six tomato varieties at Texas A&M AgriLife in Lubbock reported that the average high tunnel yield was 36 percent higher than yields from open field production.

The high tunnel environment allows you to transplant tomatoes earlier and garner higher yields. Trials at the Lubbock high

FIGURE 1. Tomatoes growing in a typical 30 ft x 96 ft high tunnel located on the Texas High Plains (photo by P. Porter).

FIGURE 2. High quality Pak Choi growing inside high tunnel (photo by R. Wallace).

FIGURE 3. Determinate tomato (var. 'Celebrity') growing on a trellis inside a high tunnel (photo by R. Wallace).

FIGURE 4. Indeterminate type tomato (var. 'Cherokee Purple') trellised inside a high tunnel (photo by R. Wallace).

FIGURE 5. Bell pepper (variety 'Gold Crown') have better growth and yield when grown inside a high tunnel (photo by R. Wallace).

FIGURE 6. Leafy greens nearing harvest time on November 6 inside high tunnels (photo by R. Wallace).

FIGURE 7. Trellised cucumbers growing inside a high tunnel in mid-summer at Lubbock (photo by R. Wallace).

FIGURE 8. Fruit trees transplanted inside high tunnels (photo by M. Nesbitt).

tunnels showed that transplanting early, on March 16, produced yields by May 30 compared to open field tomatoes transplanted on April 20.

Peppers and lettuce are also excellent crops for high tunnel production (Figure 5). Research shows that bell peppers produced an average 8 pounds of fruit per plant in high tunnels. Research also shows that bell peppers produced in high tunnels may average 44 percent higher yields with fewer culls compared to peppers grown in the open field.

While lettuce is an excellent crop for high tunnels, hot temperatures inside the tunnels will cause the lettuce to develop flower heads prematurely and become bitter (Figure 6). The number of days to lettuce harvest can increase or decrease depending on variety; but leafy lettuce has performed better than head lettuce when grown in tunnels in the early spring.

Vine crops including melons, watermelons, cucumbers, and other specialty melons are also excellent crops to grow in high tunnels. Such crops are best grown on trellises to maximize space. These crops require bees for pollination to increase yields; so if populations are low, you may need to purchase seasonal bees (Figure 7). In some areas, vine crops can be a profitable second planting following spring-planted tomatoes.

High tunnels modify their environments and protect crops from adverse climate. However, that modified environment also protects insects and diseases. Insects and mites must be controlled early and continuously. Major pests in high tunnels include aphids, thrips, whiteflies, spider mites, and cucumber beetles among others. Whether you use synthetic or organic pesticides, you must monitor weekly to detect pests early and control them effectively to produce a profitable crop.

Perennial fruits

Any fruit plant that will fit in a high tunnel can be produced in Texas. These include papaya, citrus, peach, cherry, blueberry, and blackberry species (Figure 8). High tunnels produce crops earlier, extend the harvest season, and protect species that can be damaged by winter freezes. They also protect crops from untimely

rains, hail, damaging dust, wind-scarring and even birds which can reduce fruit yield and quality. Production costs are typically higher for fruit crops grown in tunnels, but can usually be recaptured with early or off-season sales, or with crops that are not traditional in your area.

High tunnels in Texas protect commercial fruit crops in two ways. They protect deciduous fruits from spring frosts and evergreen fruits from extreme low winter temperatures.

Tunnels protect temperate fruit crops such as peach, plum, apple and blueberry against early frosts and allow you to get them to market earlier. Temperate fruit crops go dormant in early winter and can survive low winter temperatures in Texas. These crops generally require little winter chilling to produce fruit, but are at risk for frost injury when they bloom in the spring.

Peaches are the most important temperate fruit crop in Texas. The probability of moderate crop loss from low spring temperatures ranges from 12 to 33 percent—one year in eight to one year in three—depending on region. The panhandle and areas north of Interstate 20 are at greatest risk for crop damage.

Once necessary chill hours have been met, tunnels for growing peach, blueberry, or other temperate fruits need to be fully enclosed only in late winter or early spring (Figure 9). The plastic cover greatly reduces the potential for frost damage to blooms or fruit. Additional heating measures such as stored or freezing water, radiant lighting, or heaters can be added for severe freezes. By closing the tunnel sides and end walls at nights or during cold days, the fruit crop cycle can be accelerated to produce earlier maturing varieties and higher market prices (Figure 10). This strategy is appropriate to all the stone fruits: peaches, plums, apricots, sweet cherries, apples and pears, blackberries, and rabbiteye—as well southern highbush—blueberries.

FIGURE 9. Dwarf fruit trees inside tunnel with plastic cover removed due to heat (photo by M. Nesbitt).

FIGURE 10. High production of early Texas-grown peaches on May 23 (photo by D. Rohrer).

The second strategy for fruit production in Texas high tunnels is to protect annual or perennial fruits that cannot survive low winter temperatures experienced at their location. Most of Texas from Midland-Odessa to Crystal City lies in USDA Plant Hardiness zones 8A, 8B, and 9A. These zones have average low temperatures of 10°F to 25°F. Extreme low temperatures in Texas are unpredictable and pose a significant economic risk to commercial production of tropical fruits (banana, papaya, pineapple) as well as some Mediterranean and subtropical fruit crops (Table 1).

Table 1. Fruit crops with winter survival risk in Texas

Crop	Critical temperatures (°F)*
Citrus (general)	23–28
Cold hardy citrus	12–23
Olives	9–17
Pomegranates	12–14
Figs	15–20
Avocados (Mexican)	17–20

*Critical temperatures are listed as a range, with serious injury or complete death usually falling within the given range. Severity of injury depends on the type of frost or freeze experienced (advective or radiational), absolute low temperature experienced, hours at or near the absolute low, and preconditioning factors (acclimation) which weaken or strengthen a plant's ability to survive.

FIGURE 11. Double protecting fruit crops from extreme cold with hoops and row covers (photo by R. Wallace).

FIGURE 12. Texas-grown dwarf peach trees with closer than typical spacing (photo by D. Rohrer).

FIGURE 13. Y trellis training and string support for heavier fruit production in Texas-grown peaches (photo by D. Rohrer).

You can grow subtropical and tropical perennial fruits year-round under a covered high tunnel. During the summer, you can use shade cloth or whitewash, or remove the plastic completely once frost is not a possibility. As temperatures drop, you must cover the tunnel according to specific crop protection requirements. Unheated high tunnels effectively protect plants or fruit against frost that may not kill plants but can cause significant economic damage. To protect vulnerable fruit crops from winter freezes, growers may need to increase heat retention with a secondary plastic layer or low secondary tunnel over the plants (Figure 11). Another low cost heating strategy is to collect water in drums or vinyl water walls, which are sold by greenhouse companies. The cooling water releases heat in the tunnel during freezes. Microsprinklers on the floor around or near plants are effective at raising interior temperature. This process is called latent heat of fusion—each gallon of water that freezes generates 1200 BTUs. You can use other heat sources such as lights or propane heaters to increase the interior temperature when needed and produce nontraditional fruit crops in Texas.

To produce perennial fruits successfully you must manage tree or bush size within the high tunnel frame (Figure 12). Currently there are no spacing/design recommendations in Texas, because tunnel dimensions vary and cultural practices cause plants to be different sizes. Plant and row spacing will affect how easy the crop is to prune and harvest, and the yield per square foot. Pests such as spider mites can be a bigger problem when plants are overcrowded in a high tunnel. Training trees with methods such as the vertical Y (Figure 13) for peaches and stone fruits allows closer spacing and shorter overall tree height. Dwarfing rootstocks and suitable soil can help you manage fruit trees long term. For information on fruit varieties and rootstocks see: http://aggie-horticulture.tamu.edu.

Ornamentals

Many specialty cut flowers are suitable for high tunnel production (Figure 14). High tunnel production of cut flowers allows growers to extend the growing season, work during inclement weather, and produce a higher quality product with longer stems. Most cut flower producers in the US are growing flowers other than roses, carnations, and chrysanthemums. The long vase life of these flowers makes low-cost offshore production a strong competitor.

Soil preparation, irrigation, and fertilization for cut flowers are similar to that for annual vegetable production. Keeping nitrogen and potassium levels relatively low can help cut flower production because too much nitrogen encourages excessive vegetative growth. Irrigation water should be delivered directly to the plant's roots, preferably through a drip irrigation system. Keeping water off the leaves reduces leaf spotting and diseases. A tensiometer will help you schedule irrigation more accurately than visual estimates or feeling the soil by hand.

High tunnels protect delicate flower petals by keeping rainwater from splashing onto the plants. Keeping the foliage dry can significantly reduce fungal and bacterial diseases. Reducing wind

FIGURE 14. Flowering snapdragons grown in a high tunnel in Lubbock, Texas on May 4 (photo by R. Wallace).

FIGURE 15. High quality long-stem Benary Giant Mix zinnias produced in high tunnels in Starkville, MS (photo by M. Gu).

and sun stress with tunnels can also increase flower stem size, which improves market quality (Figure 15).

In much of Texas, open field cut flowers are harvested between April and October. In high tunnels, cut flowers can be harvested throughout the year. Not only can warm-season flowers be harvested earlier in the spring and later in the fall, but cool-season flowers can be harvested during the winter months.

There are cultivars of almost every cut flower species that will be more productive in high tunnels. However, before deciding what to grow, ask yourself how much you can earn per square foot per day. For example, most irises only flower once per year. Although there are benefits of growing iris in high tunnels, their long production cycle and potential revenue do not justify the tunnel space it takes to grow them. Sunflowers are also grown for a single harvest. Most cultivars flower around 60 days in the field and a little less in high tunnels. Returns for growing sunflower and other single-harvest flowers in high tunnels are not likely to justify the space required.

Bulb crops such as anemone, ranunculus, tulips, hyacinth, calla lily and lilies are excellent for high tunnel winter production. Depending on weather and tunnel conditions, these may need supplemental heat during extreme cold. Except for anemone and ranunculus, the other bulb crops can be forced by leaving them in cold storage in crates with a moist soilless mixture for about 8 weeks before bringing them out to flower. You can grow all the bulbs mentioned in the ground or in crates. Growing them in crates reduces weed or soil-borne disease problems and requires less cleanup once the crop is complete. Other winter cut flowers may include greenhouse-type snapdragon, dianthus, statice, stocks, trachelium, bells of Ireland, and sweet pea (Figure 16).

FIGURE 16. Overwintering (November 6) cut flower varieties growing on the Texas High Plains (photo by R. Wallace)

FIGURE 17. Staggered transplanting of lily in bulb crates and raised beds inside a high tunnel in Dennis, Mississippi (photo by M. Gu).

FIGURE 18. Trellises and netting used for cut flower production in Stillwater, Oklahoma (photo by M. Gu).

FIGURE 19. Netting used for supporting lisianthus cut flower production in high tunnels in Dennis, Mississippi (photo by M. Gu).

FIGURE 20. High tunnel strawberries grown in Lubbock, TX on black plastic and drip irrigation (photo by R. Wallace).

You can start warm-season production as early as February, or whenever winter crops are finished. Harvesting can be extended to the following early winter. Lisianthus, zinnia, and celosia can tolerate the summer heat in high tunnels. Except for bulb forcing, most cut flowers plants are grown in ground from transplants (Figure 17).

Plant spacing is generally 4 to 6 inches by 6 inches except in cases like large sunflowers. Except for sweet pea, most cut flowers do not need vertical support. However, using 6-inch by 6-inch netting for horizontal support ensures straighter stems (Figure 18). Plants with longer stems such as delphinium may benefit from more than one layer of horizontal netting.

You should support the netting with stakes at the ends of the planting beds. You may need additional stakes in longer beds. Adjust the netting as the plants grow taller. Where more than one net is used, place all layers at transplanting. As the plants grow taller, raise all layers, and then leave one layer in place and lift the others to support to additional growth (Figure 19). Planting flowers closer together may reduce the need for support netting. However, closer spacing reduces ventilation and can increase disease problems.

Strawberries

Though they require more hand labor than other crops, strawberries are one of the most popular and profitable crops for high tunnel production (Figure 20). Strawberries are perennial plants, though they are grown as annuals in many areas. They prefer sunny locations with sandy to sandy loam soils. Most cultivars are very sensitive to high winds and blowing dust, which damage their leaves and stems and reduce flower production. In areas similar to the Texas High Plains, open field production yields only one third as much as crops grown in high tunnels. Strawberries grow best in drip-irrigated raised beds with soil that drains well and has a pH 6.5 to 7.0. Plastic mulch helps optimize soil moisture retention and reduces weed competition.

Strawberries grow better as transplanted rooted plugs than as bare-root plants. Though more expensive, rooted plugs will increase growth and yields. Punch holes

FIGURE 21. Root plugs transplanted at 12 inch spacing with two staggered rows per bed (photo by R. Wallace).

FIGURE 22. Cold temperatures may inhibit pollination and fruit growth resulting in misshapen fruit (photo by P. Porter).

into the plastic mulch in two staggered rows at 12 inches apart (Figure 21). Cutting the runners and pulling flowers for the first few months will delay harvests, but can increase yields during peak harvest periods. In Texas, you can get the highest yields by transplanting strawberries in September or October.

Strawberry cultivars are generally classified as June-bearing, ever-bearing or day-neutral types. June-bearers develop flowers in the early spring from buds formed during the previous fall, or under short-day conditions. Ever-bearing types usually produce fruit under long-day conditions, while day-neutrals produce yields under any day length if temperatures are below 70°F. Research in Texas shows that June-bearing cultivars had 43 percent higher yields than ever-bearing strawberries (Table 2).

Table 2. Comparison of strawberry cultivar yields when grown in high tunnels in Lubbock

Cultivar	Fruiting type	Yield/plant
Chandler	June-bearing	1.55
Strawberry Festival		1.50
Florida Radiance		2.36
San Andreas	Day-neutral	1.33
Seascape		0.87
Albion		0.87

Source: Wallace, R.W. and C.J. Webb. 2012. Strawberry High Tunnel Trials at the Texas A&M AgriLife Research & Extension Center, Lubbock.

Weather permitting, you can begin harvesting strawberries as early as late November, though yields will be low. Peak harvest is usually during March, April, and May. Extreme cold temperatures (less than 32°F) can inhibit pollination and reduce marketable yields (Figure 22). Many growers purchase bees to improve pollination and yields. During the peak months, you may have to harvest 3 to 4 times a week or more. For additional information on growing strawberries in Texas, visit http://aggie-horticulture.tamu.edu.

Pest management

Integrated pest management (IPM) for high tunnels and greenhouses is similar, but tunnels are more open so it is harder to exclude pests and control the environment inside them.

IPM stresses:

- Preventing pest problems where possible
- Detecting problems through continuous monitoring
- Controlling pests quickly and effectively

Pest exclusion begins with the design and construction of the tunnel. You can't seal a tunnel against the outside environment completely, but openings should be as small as possible and the covering kept in good repair. Many pests are nocturnal and tunnel lighting will attract flying insects at night. Inspect all plants for insects before taking them into the tunnel, and buy seeds from reputable sources to ensure they are free of plant pathogens.

FIGURE 23. Weeds along the inside and on tunnel edges can harbor insects and diseases if not controlled (photo by R. Wallace).

FIGURE 24. Scouting for pests is critical inside high tunnels (photo by P. Porter).

FIGURE 25. Evaluating a yellow sticky trap for flying insect pests in blackeyed peas (photo by R. Wallace).

Sanitation is critical for preventing pest and disease problems. Weeds often host insects and diseases, so eliminate them in or near tunnels (Figure 23). Remove culled plant material from tunnels immediately because insects will move from culls to live plants.

Market forces influence what you plant, but pest resistance is another important consideration. Varietal descriptions often mention disease resistance but seldom mention insect resistance. Experience will teach you to drop susceptible varieties in favor of more resistant ones. The alternative is to spend more time and money on a control program.

Detecting pests early reduces loss and gives you more control options. Train your workers regarding common insects and diseases and have them look for signs of infestation whenever they are in the tunnels (Figure 24).

Monitoring tools can also help detect insects that are too few or small to see easily. You can buy yellow sticky cards that attract and capture pests (Figure 25). These cards are an economical and effective way to monitor pests such as aphids, thrips, whiteflies, etc.

Open-field crops and greenhouse crops have different EPA-approved pesticides. Though they share some pesticides, the active ingredients may have different rates, preharvest intervals and worker protection standards. High tunnels fall into the greenhouse category and nongreenhouse category depending on whether the doors, windows, and sides are open or closed and for how long. The status of the tunnel will determine if any application you are considering is an approved use under the Federal pesticide label. These differences are defined in Sections

4.17–4.19 on the EPA Worker Protection Standard document at http://www.epa.gov/oppfead1/safety/workers/wpsinterpolicy.htm#4.1%20Definitions.

High tunnels fall under greenhouse rules when their sides are down, whether the windows and doors are open or closed. When the sides are up and will stay up from application to reentry time for the pesticide, they are not considered greenhouses (Figure 26). TDA required pesticide application records must state whether the tunnel application was made under greenhouse or nongreenhouse status.

One criterion for choosing an insecticide is that it act on the pest, but as little as possible on beneficial species and their food sources. Preserving biological control agents like ladybugs or lacewings is critical to reducing pests and their damage long term.

For example, spider mites are a common pest in high tunnel production (Figure 27). If you use a broad-spectrum insecticide to control spider mites, it will also kill predatory insects that eat spider mites. Without biological control agents to keep them in check after a pyrethroid application, surviving spider mites almost always rebound worse than before.

Miticides that control spider mites but have little or no effect on the beneficial species usually provide excellent control, but leave the beneficials to keep remaining mites at acceptable levels. A dedicated miticide may cost more and take a few days longer than a broad-spectrum insecticide, but it allows beneficials to keep spider mites down and protect your economic return.

FIGURE 26. Spraying crop for insects or diseases inside a high tunnel in Lubbock (photo by P. Porter).

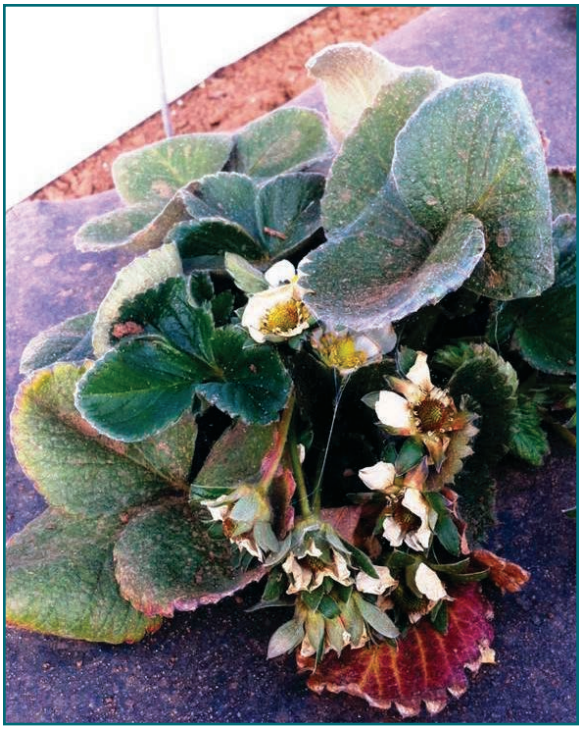

FIGURE 27. Severe spider mite damage to strawberries inside a high tunnel on February 28 (photo by R. Wallace).

Ten high tunnel production tips

1. Maintain good soil quality inside the tunnels to ensure top yields. This is critical with four-season tunnels or when natural rainfall does not reach the soil inside. Add clean, high quality compost to the soil yearly to promote beneficial microorganisms, suppress disease, and increase crop growth. How much compost you need will depend on yearly soil tests. Compost will add nutrients, improve water holding capacity, and increase health and root growth.
2. Equipment and foot travel between rows inside high tunnels will compact the soil. Compaction reduces root growth and drainage. If there is enough room, till between the beds to improve soil texture and control weeds. Avoid tilling any plastic mulch used on the beds. Plow deeply between crops to break up the hardpan.
3. Unless you move the tunnel structures between seasons, you must rotate crops within them. Do not plant crops from the same vegetable families in the same soil in successive years. Rotating crops will help reduce plant damage by breaking disease and insect life cycles. If you have multiple tunnels, plant similar crops in each tunnel and rotate crops between tunnels. Plan and keep accurate records so you can rotate vegetable crops successfully.
4. Lay drip tape under black plastic or biodegradable mulch in high tunnels when growing transplanted or seeded vegetables. You will also need drip irrigation when seeding vegetables without mulches. Drip irrigation and plastic mulch improve water use efficiency by

directing water to the roots and reducing soil water evaporation. Uniform irrigation improves fruit set and quality, especially in tomatoes. The drip system can accurately apply soluble fertilizers to the roots as needed throughout the growth cycle leading to higher yield and quality. The drip system can also apply fungicides and insecticides labeled for root application.

5. Unless you remove the plastic covering, rainfall will generally not reach the soil inside the tunnel. However, most crops respond positively to rainwater and you can use a gutter system on the tunnels or nearby buildings to apply rainwater through the drip system. Filter sediment or particles from the rainwater before it enters the irrigation system.
6. Follow soil temperature recommendations when planting crops inside high tunnels. Soil in high tunnels will warm significantly earlier than in open fields—especially when using black plastic. As a result, you can transplant crops up to six weeks earlier than in the open field. Use a soil thermometer set at least 6 inches deep to confirm that the soil temperature is correct for planting.
7. You must control diseases, insects, and weeds in high tunnels. Diseases and insects can infest tunnel crops earlier and more intensely than they do in open field crops. This is because tunnel crops are planted earlier, or are grown year-around. For example, spider mites and aphids can attack high tunnel strawberries in January and February on the High Plains. High tunnels improve the environment for crops as well as the pests that attack them. You must inspect crops in high tunnels weekly. You must also immediately remove weeds and trash, which can harbor insects and diseases. A hand-pumped-backpack sprayer is useful for applying chemicals—always follows pesticide label instructions.
8. When air and soil temperatures are correct for planting, wind will be likely and stress new plants. When wind exceeds 25 mph, close the tunnel's sides, doors, and windows. Even when hot, it's best to close the tunnel against stiff wind. In the short run, wind damage to leaves and stems can be more harmful than high temperatures. Avoiding wind damage in high tunnel crops during high temperatures is a delicate balance. You will have to visit the site regularly during heat and wind. Opening the downwind side vents can allow some heat to dissipate without exposing the plants.
9. Ventilation is critical when it is hot. High temperatures can slow plant growth and lower yields by causing flowers to abort. Heat can wilt plants even when moisture is plentiful. Opening the side vents partly or completely—depending on wind speed and direction—will help dissipate heat. Some tunnel ventilation systems roll up, others have sides that roll down. Systems that roll down may be best for windy areas because you can vent heat while protecting small crops from wind damage. Depending on the construction of the end panels, opening the doors and windows can also help cool the tunnel. If nighttime temperatures are too cold for crops, close all doors, windows and sides several hours before sunset to capture heat for the night.
10. You must maintain high tunnels to keep their frames and coverings in good condition. High winds can tear the plastic and shift the frame. It is important to inspect all bolts, clamps, wigglewire, boards and u-channel—inside and out. Tunnel frames can shift during winds over 55 mph. Retighten all bolts, screws and clamps at least every six months. Finally, inspect the plastic covering for tears and holes, which can grow following high winds. Many manufacturers sell repair tape for small tears and holes, though the tape may need to be replaced often.

Economics of high tunnel production

Although this guide can help you decide whether or not to grow crops using high tunnels, you should review your farm plans with high tunnel construction and crops with your local county agent or Extension risk management specialist before proceeding. Questions include: Do I have enough funds for construction and the increased labor to produce high tunnel crops? Is there a market for the crops when produced earlier or off-season? Which crops will give me the best and quickest return on my investment?

Below is an example of high tunnel construction and associated production costs for starting a strawberry crop. For additional information on high tunnel construction, refer to the guide 'High Tunnels for Crop Production in Texas' HT-106.

High tunnel production is an effective and efficient method for producing high quality, early-season fruits and vegetables. Detailed information on high tunnel production can be found at www.hightunnels.org/, http://extension.psu.edu/plants/plasticulture/technologies/high-tunnels, and http://mtvernon.wsu.edu/hightunnels/Content/cropTunnels.html.

Table 3. Example of production costs when growing strawberries in a 30 ft x 96 ft high tunnel

Item	Unit	Price ($)	Quantity	Total cost
Labor	**man-hrs**	**$10.00/hr**		
Preplant soil prep	"	"	1	10
Bed shaping	"	"	2	20
Lay drip tape	"	"	0.33	3.3
Lay black plastic	"	"	14	140
Punch holes in plastic	"	"	1.5	15
Apply soluble fertilizer	"	"	1.5	15
Transplant strawberries	"	"	11	110
Cut runners on strawberries	"	"	5	50
Place hoops on beds	"	"	2	20
Initial place row cover clothes on beds	"	"	2	20
Fertilization				
Preplant compost	"	"	1.5	15
Fertigation	"	"	30	300
Scouting for pests (37 weeks @ 0.25 hrs)	"	"	9.25	92.5
Spray fungicides	"	"	4.5	45
Spray insecticides	"	"	4.5	45
Weed control (by hand)	"	"	4	40
Harvesting berries	"	"	112	1,120
High tunnel maintenance	"	"	37	370
Post-harvest cleanup	"	"	6	60
Miscellaneous labor	"	"	7	70
Total				**2,560.80**

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Table 3 continued

Item	Unit	Price ($)	Quantity	Total cost
Production supplies				
Strawberry transplants (plugs)	plant	0.4053	1100	445.83
Black plastic mulch (48" x 4000')	ft	0.046	600	26.5
#9-Wire for hoops	5.5 ft	1.13	120	135.6
Spun-bond row cover cloth	100 ft	25.99	6	155.94
Fertilizer (soluble form of 20-20-20 all purpose)	lb	1.5	25	37.5
Composted cattle manure	cu ft	1.5	36	54
Fungicides (internet pricing)				
Pristine	lb	55.46		5.62
Radiant	qt	199.95		6.33
Dipel	lb	18.95		3.76
Cabrio	lb	39.19		3.92
Topsin	qt	69		3.24
Insecticides				
Malathion	gal	39.95		1.02
Danitol	gal	180		5.9
Zeal	oz	21.5		3.18
Weed control				
Hoes		14	2	28
Harvest				
Pint-sized basket		0.112	1200	134.63
Preplant soil test		30	1	30
Irrigation				
2" PVC (use from water source)	ft	0.47	250	117.5
Netafim 12" emitter spacing drip tape	ft	5.24 cents	600	31.44
Blue line layflat (2")	ft	0.81	30	24.3
Hose clamps		1.02	6	6.12
Drip tape tee		0.87	6	5.22
2" PVC 90° elbow		1.51	1	1.51
Hydrant		3.71	1	3.71
2" PVC valve		23.97	1	23.97
Irrigation valve box		11.78	1	11.78
Cor. Pipe		9.19	1	9.19
PVC adapters to 2" blue line		2.35	1	2.35
Adapter (blue line to drip tape)		0.84	1	0.84
Drip tape valves		1.89	6	11.34
Bushing/reducers (gauges, hydrants)		1.61	1	1.61
Pressure gauge		2.34	1	2.34
PVC glue		20	1	20
Hole punchers		5	2	10
3-Gallon hand-held sprayer			1	80
Personal protection equipment			1	60
Garden hose and spray nozzle		25	1	25
Rat bait			1	39.72
Duct tape	case		1	180.7
Anchor straps		11.66	6	69.96
Cement bags (80 lbs)	bag	3.55	18	63.9
Gravel rock	1 trailer	43.31	1	43.31
High tunnel maintenance supplies		2-year average		416.15
Total				**2,342.93**

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Table 3 continued

Item	Unit	Price ($)	Quantity	Total cost
High tunnel and construction				
High tunnel (ClearSpan colossal 30′ x 96′)	kit	shipped	1	8,140.56
Wooden framed end panels 2 x 4s	ft	0.49	465	227.85
Drip tape support strapping (used)	ft	0	240	0
Hip boards and baseboards	ft	0.66		253.44
Construction labor	man-hrs	10	60	600
Irrigation setup	man-hrs		10	100
Total				**9,321.85**
Fixed expenses				
Tractor	hrs			
Disk	"	0.5		
Cultivator	"	0.5		
Rototiller (3-point)		1		
Bed shaper	"	1		
Mulch layer	"	3		
Water tank (3-point)	"	3		
Pickup truck (to tunnels and for supplies)	mileage	0.55	2,781	1529.55

Texas A&M AgriLife Extension Service

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