United States Department of Agriculture

Planting in a High Tunnel

Natural Resources Conservation Service

What is a Seasonal High Tunnel System?

A high tunnel (Seasonal Tunnel System for Crops) is a polyethylene (plastic) covered structure that allows growers to increase production of certain crops, grow some crops that could not otherwise be grown in their area, and extend the length of time in the year (growing season) that the crops may be grown.

High tunnels often look similar to greenhouses, but are usually only single walled and are typically not temperature controlled. The plastic covering traps sunlight to raise temperatures inside the structure for the plants growing inside. The growing season can be extended by up to four weeks by protecting crops from potentially damaging weather conditions. Crops grown inside high tunnels tend to be of higher quality and produce higher yields.

Because crops within a high tunnel are sheltered from the elements, the grower is able to control the environment, reducing disease incidence, improving crop quality, and potentially increasing cost benefit per square foot of growing space. However, growing multiple plant types in a semi environment can be challenging since every plant must be kept happy under similar growing conditions.

High tunnel styles: Gothic style above, Quonset style below

Alaska Crops

In Alaska four crops immediately come to mind as benefitting from extended seasons, warmer temperatures and high market return. These are tomatoes, cucumbers, corn, and peppers. They are currently the most popular, as well as profitable, crops for high tunnel production. Of course, this does not rule out other plants, nor does it rule out starting earlier in the season with cooler tolerant plants (i.e. quick maturing baby greens), harvesting them and planting a second crop that matures later in the season. High tunnel efficiency is increased by getting two or more crops a growing season. This strategy also works if you have some plants that are incompatible because one plant shades another. You can however, overcome shading by spacing and/or by where you physically locate plants within the high tunnel. Some Alaska high tunnel veterans plant their taller plants in the back of the high tunnel (north side) and shorter plants on the south side. Plants are immobile so they must adapt to an environment or alter it in order to thrive.

A third factor to consider when intercropping or companion planting in a high tunnel is that some plant species produce chemicals sent into the air or soil that can help or hinder another plant species. For example, the mustard (Cabbage) family produces a chemical (mustard oil) that defends the plant against microorganisms, animals and even encroachment by some other plants.

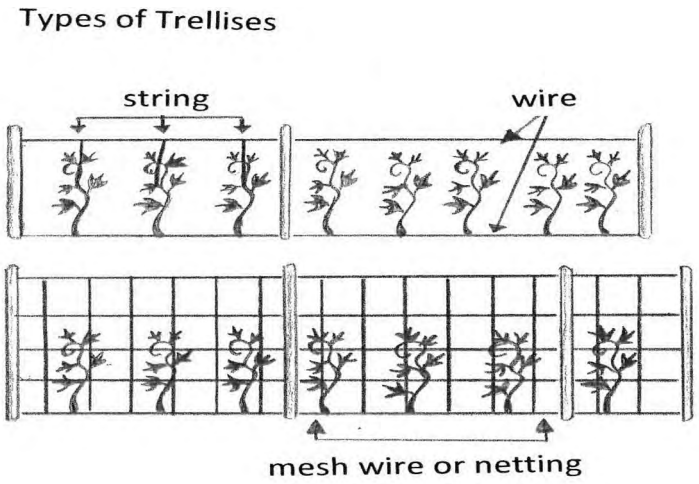
Companion Cropping

Some plants benefit from being around certain plants and do not like being around others. The table below lists the five most common plants that benefit from a high tunnel and their preferences for neighbors.

	Compatible	Incompatible
Tomatoes	Chives, Onions Garlic, Parsley	Cabbage family, Potato, Fennel
Corn	Beans, Legumes Sunflower, Potato Parsley	Tomato Celery
Peppers	Tomato, Geranium Petunia	Beans, Kale, Cabbage Brussels sprouts
Cucumber	Beans, Lettuce Radish, Sunflower Peas, Beets, Carrots	Potato Aromatic herbs
Baby Greens	Onion, Garlic Beets, Cucumber	Spinach Sunflower

Trellis

By definition, a trellis is a simple framework of vertical supports and horizontal crosspieces that is flat and usually trains plants like shrubs, small or young trees or vines to grow up and against an object. In a high tunnel where space can be at a premium, trellises allow the grower to maximize ground space by increasing production vertically. For some plants it allows them to do what they naturally want to do and for others it serves as a structure where the grower can guide the plants. Trellises can be as elaborate or as simple as you wish to make them.



Soil and High Tunnel Temperatures

In addition to the previous compatibility chart, crops have different soil temperatures that favor seed germination and different air temperatures that favor growth and quality. These temperatures greatly influence when you plant or transplant into the high tunnel. Below are two tables for reference.

Soil Temperature Conditions for Vegetable Seed Germination[1]

Vegetable	Minimum (°F)	Ideal Range (°F)	Maximum (°F)
Corn	50	60 to 95	95
Cucumber	60	60 to 95	95
Lettuce	35	40 to 80	75
Pepper	60	65 to 95	85
Tomato	50	60 to 85	85

Compiled by J. F. Harrington, Department of Vegetable Crops, University of California Davis.

Approximate Air Temperatures for Best Growth and Quality of Vegetable Crops

Temperature (°F)			
Minimum	Optimum	Maximum	Vegetable
45	60 to 65	75	Artichoke, cardoon, carrot, cauliflower, celeriac, celery, Chinese cabbage, endive, Florence fennel, lettuce, mustard, parsley, pea, potato
50	60 to 75	95	Sweet corn, southern pea, New Zealand spinach
60	65 to 75	90	Cucumber, cantaloupe
65	70 to 75	80	Sweet pepper, tomato
65	70 to 85	95	Eggplant, hot pepper, okra, sweet potato, watermelon

Tomatoes

Questions to ask yourself when choosing the "right tomato" variety. First is growth form.

- **Continuous ripening season long harvest** (indeterminate or vining) varieties continue to grow and produce until frost. They require trellising (*see break out box on the previous page*).

- **Ripen all at once** (determinate or bush-type) varieties grow to a certain height, produce all their tomatoes at once ,and then die. They allow 1 or 2 harvests a season. They may be less rampant in high tunnels.

- Do not start indoor tomatoes too early because root bound transplants may remain stunted all season.

- Do you want to grow beefsteak, cherry, or roma tomatoes? Heirloom varieties sell well at farmers markets but are more susceptible to diseases.

Growth	Varieties
Indeterminate	Black Plum, Tropic, Vendor
Determinate	Bush Early Girl, Ultra Girl

Site Selection

- Tomatoes like well drained sandy to loamy soil with a pH between 6.0 and 7.5.
- Be aware of the organic matter (OM) in your soil. OM breaks down during the season and releases nitrogen to plants.

Preparation

- Have your soil tested by a soil testing laboratory. It is hard to fix something if you do not know what needs fixing.
- After having your soil tested you can amend if the test results indicate you need added nutrients.
- Any nutrients material should be tilled into top 4 to 6 inches of your tomato bed before transplanting.

Tomatoes growing in a Homer, Alaska high tunnel. The tomatoes have been trellised against string mesh

Starting Transplants

- In Alaska, tomatoes should be transplanted into high tunnels or green houses for optimal production.
- Seed 6 to 8 weeks before transplanting into high tunnel.
- Transplants should have well developed root systems and 5 to 7 mature leaves.
- Going from your warm house to the outdoors (even in a high tunnel) can be a shock for tomatoes. You need to gradually get them used to the outdoors. Set them in the high tunnel, gradually increasing the time each day (by an hour or so) for a week before transplanting them. Bring them inside at night.

Spacing

- Depending on the variety, tomatoes in a high tunnel should be spaced 18 to 24 inches apart within a row and rows should be spaced 36 to 48 inches apart.

Pruning

Tomatoes produce axillary shoots (suckers) just above the axis of a leaf branch and the main stem (crotch). To grow the strongest tomato plant possible, prune side stems below the first fruit cluster. These should be pruned to promote early tomato production and improve air circulation (see figure above).

Sweet Corn

Sweet corn in Alaska can fetch a grower from $1.50 to $2.00 an ear, so it is not surprising to see growers putting at least part of their high tunnels into corn production.

Maturity	Varieties
Early	Yukon Chief
Mid to late season	Earlivee, Seneca Horizon

Corn growing in a high tunnel in Homer, Alaska

Site Selection

- Corn needs full sun and well drained soil.
- Soil should have a pH of 5.8 to 6.6 so you may wish to add limestone to bring it to that level.

Preparation

- Prepare the garden bed by using a garden fork or tiller to loosen the soil to a depth of 8 to 15 inches.
- Have your soil tested by a soil testing laboratory. Follow any nutrient level changes the laboratory suggests. You do not want to under or over fertilize.
- Mix suggested nutrient source into the top 6 inches of soil as per laboratory suggestions.
- You can also start sweet corn in small biodegradable pots indoors and transplant them when the soil temperature in the high tunnel is adequate for growth.

Planting and Spacing

- You can lay down plastic mulch and plant into it when soil temperature is above 60°F (*see Table 2*).
- Space rows 24 to 30 inches apart and plant 9 to 12 inches apart within the row.
- Plant corn in rows or blocks in the center of the high tunnel (the highest point in the high tunnel).
- When corn tassels, gently shake plants to aid pollination.

Corn planted into plastic mulch in the center of this high tunnel

Fertilization

- Fertilize according to the results of your soil test. You do not want to skimp or over fertilize.
- You can fertilize through drip irrigation. (Monitor your drip emitters as they can become clogged).
- Also, monitor your water as corn is known to be a heavy water user and you cannot depend on rains in a high tunnel.

Sweet corn harvested from a high tunnel in the Mat Su Valley

Peppers

"If the Holy Grail of gardening is the perfect tomato, the perfect pepper cannot be too far away." (*Jeff Lowenfels, gardening columnist for the Anchorage Daily News, March 21, 2013.*)

Peppers Sweet	Peppers Hot
Blushing Beauty, Carmen	Hungarian Yellow Wax
Giant Marconi, Gypsy	Thai Hot
Italian Sweet, Mohawk	Senorita
New Ace, Park's Early Thickset	Super Chili
Redskin	Super Cayenne

Site Selection

- Peppers prefer a well drained soil in the 5.8 to 6.5 pH range.

Preparation

- Make sure you have the soil into which you plant tested for any lime and nutrient deficiencies you will need to address.
- Apply any Nutrient source as per the results of your soil test.
- Incorporate these nutrients into the top 6 inches of soil.
- Peppers often require a preplant application of nitrogen, but only if your soil test suggests it may help.

Starting Transplants in Your Home

- Start peppers indoors 8 to 10 weeks before transplanting into the high tunnel
- The seed germinates best at 85°F so you may need a heat mat to germinate the seed.
- You will also want to keep temperatures between 75° F in day and 65°F at night.
- Apply a complete soluble fertilizer (20 to 20 to 20) diluted 1 ounces to 3 gallons of water once or twice a week.
- You will want to harden them off for a week by decreasing their day temperatures to 60 to 65°F before transplanting them into the high tunnel. You can do this by moving them into the high tunnel each day, like with tomatoes.

Pepper transplant spacing on left and trellised tomatoes on right

Planting and Spacing

- When you transplant be aware that plant space is valuable and spacing will depend on the pepper variety.
- In general, transplants are spaced 12 to 18 inches apart within a row and 15 inches between rows.

Fertilization

- Your soil test recommendations may require additional nutrients be added after planting. They may even suggest splitting your nutrient additions into two applications. Follow their recommendations.

Where to Send your Soil Samples

Soil and Plant Analysis Laboratory
Palmer Center for Sustainable Living
Matanuska Experiment Farm
University of Alaska Fairbanks
1509 S Georgeson Dr.
Palmer, AK 99645
(907) 746-9450

Soil Test Farm Consultants
2925 Driggs Dr.
Moses Lake, WA 98837
1-800-764-1622 www.soiltestlab.com

A & L Eastern Agricultural Laboratories
76221 Whitepine Rd.
Richmond, VA 23231
1-804-743-9401 www.al-labs-eastern.com

Brookside Laboratories Inc.
200 White Mountain Dr.
New Bremen, OH 45860
(419) 977-2766 www.blinc.com

When sending an Alaskan soil sample, remember fertilizer recommendations are compiled by the University of Alaska Fairbanks and are based on a set of standard tests with specific extraction techniques for Alaskan soils. Above are commonly used labs. Other labs are available. NRCS does not recommend any specific vendor.

Cucumbers

What can be said about cucumbers except that people love them, they are high yielding if treated right, but are extremely sensitive to cold temperatures? They will grow well in a high tunnel and allow you to maximize vertical production.

In a high tunnel setting cucumbers are normally grown in raised beds covered with black plastic mulch. This minimizes weed problems, increases heat, and reduces nutrient leaching.

Trellised cucumbers

Site Selection

- As with the other crops we have discussed, cucumbers also like a sunny site with drained soil.
- Soil pH between 6.0 and 6.5.

Preparation

- In our shorter summers make sure you start cucumbers inside where you can control heat.
- Have your soil tested by a soil testing laboratory. Follow any nutrient level changes the laboratory suggests. You do not want to under or over fertilize.
- Cucumbers require low nitrogen and high potassium and phosphorous for good fruit development. The amounts should be determined by your soil test recommendations.

Planting and Spacing

- Cucumbers, as well as other cucurbits, suffer from transplant shock so you must be very careful when you transplant.
- Start seed in pots indoors and pay very close attention to soil and air temperatures. Cucumber seed will not germinate below 60°F and will just rot.
- Cucumbers grow best at air temperatures between 65°F and 95°F.
- You can use black plastic mulch to heat the soil faster and to irrigate (*see below*).

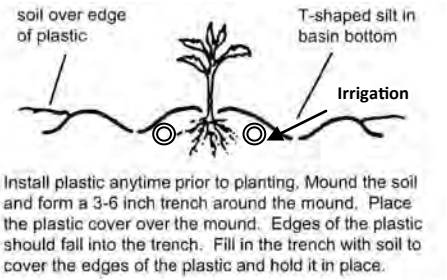


Figure of cucumber planted into black plastic mulch

- As shown, you will transplant into a hill (much the same as potatoes are hilled later in their season).
- Transplant cucumbers at 12 inches spacing within the row with at least 36 inches between rows.

Fertilization

- Assuming you have already added nutrients to your bed you will probably not need to add a whole lot more to your cucumbers.
- If you over fertilize with nitrogen you will get "leggy" vines and slow fruit growth.

Pollination

Since each cucumber flower is open only one day, pollination is a critical aspect of cucumber production. One or more pollen grains are needed per seed, and insufficient seed development may result in fruit abortion, misshapen, curved or short (nubbin) fruit, or poor fruit set.

Male (*left*) and female (*right*) cucumber flowers

Trellising

- Most growers allow cucumbers to "trail" along the ground, but in a high tunnel where space is limited, this is not the most efficient way to grow "cukes."
- Cukes love to climb and trellising your plants conserves space and keeps the fruit off the ground.

Mixed Greens

Examples of greens:

Leafy greens planted in raised beds, but still in contact with the soil

Site Selection

- Salad greens are planted as soon as the soil can be worked. They will germinate in soil temperatures as low as 35°F but the optimum is at least 40°F.
- Sandy loam soil with a pH of 6.5 to 7.5 is best.
- Because greens are shallow rooted, balance drainage with moisture retention in the top 1 inch or so. In other words, have good drainage but not so fast the soil water just runs through that top 1 inch.

Preparation

- Have your soil tested by a soil testing laboratory. Follow any nutrient level changes the laboratory suggests. You do not want to under or over fertilize.
- Plant into a well drained soil that heats up quickly.
- Prepare the bed by mixing in nutrient source (of known nutrient level) in accordance with the results of your soil test**.** Repeat this if you put in a second crop.
- Another option for leafy greens is to plant them into raised beds (*above*). This option warms the soil faster, conserves moisture, and reduces weeds if plants are spaced properly.
- Salad green seeds are very small so the seed bed must be very finely tilled. You can till it with a regular tiller and then come in with an upturned rake and tamp down the larger soil clods.

Planting and Spacing

- Most of the lettuce greens are planted about 60 seeds per feet in a 4 inch to 6 inch wide band.
- Seeds germinate best at 60°F to 65°F (lettuce).
- Plant radicchio 8 inches apart in rows with rows spaced at 12 inches.
- Endive is planted 9 inches apart in rows with rows 20 inches apart.

Fertilization

- Follow your soil test recommendations. If you notice deficiencies talk with your NRCS nutrient manager who may suggest a complete fertilizer can be added to supplement already added nutrient source.

Natural Resources Conservation Service
USDA is an equal opportunity provider and employer