



# High Tunnel Green Bean Production

*Daniel Drost*, Vegetable Extension Specialist, and *Reagan Wytalucy*, Undergraduate Student

## Introduction

Beans are a warm season plant requiring fertile, well-drained soils. Traditionally, beans are field planted from late April to early June (depending on location), but with high tunnels, they can be planted 4 to 6 weeks earlier. The use of high tunnels for green bean production can result in an early growing season, increase fruit set, and provide a product for early markets. Planting date trials with bush beans have been conducted to test what time of year is best for early plantings for an early bean market.

## Variety Selection

Many of the different types of beans and varieties available will grow in high tunnels. Varieties should be selected to meet production goals and market demands. Some factors to consider when choosing varieties are: growing environment, available space, market requirements, and desired use. There are two common types of beans: bush and pole. Bush varieties do not require trellis systems and normally mature 50 to 60 days after planting. Pole varieties require trellises to support their growth and extended production over many weeks.

For Utah's climate, no bean variety evaluations have been conducted in Utah State University high tunnels. However, Iowa State University has successfully grown different bean varieties in high tunnels.

<http://www.ag.iastate.edu/farms/09reports/Armstrong/HighTunnel.pdf>.



Photo 1.

Consult your seed provider or other reputable source to help identify bean varieties that meet your production criteria and suitability for high tunnel production.

Recommended bean varieties are:

- Green Bush Beans: Provider, 16G Jade, E-Z Pick, Blue Lake 247, Prevail
- Yellow Bush Beans: Rocdor, Carson, Gold Rush
- Green Pole Beans: Fortex, Northeaster, Kentucky Wonder, Blue Lake
- Yellow Pole Beans: Marvel of Venice, Kentucky Wonder Wax

## Site Selection

Beans require well-drained, sandy loam soils, which warm rapidly in the spring. Heavier soils can be productive, provided they have good drainage and proper irrigation management. A list of the most important factors to consider when selecting a site for beans is below:

1. Soil test for drainage and fertility
2. Year-round irrigation
3. Full sunlight
4. Micro climates
5. Previous crops and diseases
6. Bed arrangements and configurations

## Site Preparation and Fertility Management

In Utah, high tunnels should be constructed with an east to west orientation in order to maximize low-angle light of early spring and late fall (Nelson, 2003). In areas prone to heavy wind however, there may be benefits to orienting the tunnel parallel to wind direction with well-reinforced end walls.

Detailed information on constructing a low-cost high tunnel can be found at <https://tunnel.usu.edu>.

Test the soil if the selected site has not been recently farmed (or cultivated) or if past yields have been low. Utah State University Analytical Laboratories (USUAL) perform soil testing and provide information on sampling procedures, cost structures, and previous tests. Information for USUAL can be found at <http://www.usual.usu.edu>. Adding organic matter to intensely managed high tunnel soils before planting will help improve nutrient levels, increase soil water holding capacity, reduce soil crusting issues, and mitigate drainage problems. Apply 200-300 lbs/1000 ft<sup>2</sup> of high quality compost to enrich the soil. Planting into unfavorable soil conditions can result in poor plant health.

Beans have high fertility needs, but over fertilizing may affect fruit quality and early production. Aside from N, P, and K, beans are very sensitive to Mn, Zn, and Fe deficiencies (Davis, 1997). To prevent deficiencies, fertilizers should be added to the soil before planting. Soil potassium (K) and phosphorus (P) applications should be based on soil test results. Higher rates of P may be needed for early plantings when soils are cold or if soil pH is 7.5 or above. Applications of N may not be necessary for beans

because they fix their own N with root nodules. The seed should be inoculated with rhizobium as soils in high tunnels may have low natural levels of bacteria needed to colonize bean roots. Nitrogen should only be applied at low levels to boost early bean seedling growth when they have not yet developed nodules. Adding 1.15 lbs N/1000ft<sup>2</sup> helps improve plant growth. If growth is slow, additional N can be applied with the irrigation. A good fertilization program will ensure plants keep growing for the whole season. Soil amendments (compost and fertilizer) should be uniformly applied and incorporated into the top 6 inches of soil.

## Irrigation

Beans require regular watering to prevent poor early vigor, inadequate leaf cover, and flower drop. Because beans are subject to soil crusting, pre-irrigate the high tunnel before planting. As temperatures increase and plants grow, irrigation rates should be increased to meet plant needs. Drip irrigation in the high tunnel is ideal to conserve and put water where it is needed. Overhead irrigation is not recommended as an increase in pathogens may result.

It is important to prevent moisture stress during flowering, pod set, and pod growth (Davis, 1997). Water stress is known to influence pod shape and quality (Photo 2). With dramatic temperature changes in the high tunnel on sunny days, monitoring temperatures closely will limit possible water stress to plants. Soil type greatly affects water holding capacity and will influence how often watering is required.



Photo 2.

Soil moisture content can be determined by the use of soil moisture sensors. For more information on soil moisture monitoring visit:

[https://attra.ncat.org/water\\_quality.html](https://attra.ncat.org/water_quality.html).

## Planting

Space inside the high tunnel is valuable and plants should be arranged to utilize all available space. As in-row spacing increases, yield per plant and fruit size increases. However, total high tunnel yield decreases due to decreased plant numbers. With bush beans, planting rows can be arranged 12 to 15 inches apart with 2 to 3 inches between seeds. Beans seeds should be planted 1-1½ inches deep into soil. Place the irrigation lines between every other row.

## High Tunnel Temperature Management

Local freeze-free dates can be found at the Utah Climate Center website under climate reports (<http://climate.usurf.usu.edu/reports/freezeDates.php>). Use the website to find the earliest, average, and latest recorded spring freeze dates for your production area. With this information, beans can be planted from 4-6 weeks earlier, which allows for earlier flowering and fruiting. Some frost protection is still needed when planting in high tunnels.

To germinate, beans require air temperatures of 60° to 70°F with soil temperatures of 86°F (Black & Drost, 2010). High tunnels can mitigate these temperature variations thus resulting in early germination, higher yields, and more #1 quality fruits. Early, uniform germination is key to producing higher yields and quality fruit. Establishing low tunnels inside the high tunnel, when outside temperatures are between 20° and 35°F in early spring, will increase temperatures in the soil by 3° to 10°F, promoting early germination. Using root zone heating will also offset the negative effects of low air temperatures and ensure early germination.

Air temperatures above 86°F can damage bean blossoms causing flower drop or misshapen fruit (Photos 1 & 2). Daily ventilation may be required to ensure temperatures inside the tunnels do not exceed 85°F. Ventilation may entail opening a single door in April, or both sides and doors in May when day temperatures are warm. Low tunnels

should also be ventilated during sunny days early in the season to prevent excessive heat, and removed during frost-free days. When night temperatures reach 50°F, the plastic on the high tunnel should be replaced with 30% shade cloth to avoid excessive heat buildup. Bush beans may be completely harvested by then and may not require shade cloth. However, pole bean harvest may extend later into June or July and require shading from shade cloth.

## Pest Management

Early season crops grown using high tunnels are less likely to have pest problems unless favorable conditions arise. Healthy plants grown in a clean environment are less likely to have pest outbreaks that require chemical treatments. Application of chemicals in tunnels is more hazardous than in the open field due to the closed environment. Chemicals used inside a closed high tunnel should be labeled for greenhouse use and directions for use should be followed closely. If you are having trouble diagnosing a pest problem, contact your county Extension agent or other knowledgeable individual. Some of the common insects seen in high tunnels include aphids, cutworms, beetles and hopping insects.

## Insects

### Aphids

Aphids are pale-green, soft-bodied sucking insects that cluster on the underside of leaves. Stunted plant growth and reduced fruit are common symptoms. Viruses can also be transferred to healthy plants by the aphids. The best method of control is to use chemicals.

### Cutworms

These green, reddish, or black caterpillars grow up to 2 inches long. They are a common pest of vegetable crops planted in early spring. They hide in the soil during the day and come out to feed at the base of the stem at night (Hahn & Wold-Burkness, 2008). Bait for cutworms is the best method of control.

### Mexican Beetle

These beetles are round and tan with black spots on their wings and look like a lady beetle. Larvae feed on roots, underside of leaves, and pods doing the most damage when plants are small. Skeletal or lacy

leaves indicate a problem (Decoteau, 2000). Chemical control is most effective when applied during the larvae stage, when they are most vulnerable.

### **Bean Leaf Beetle**

This small, dark yellow to tan beetle has six black dots and eats large holes into bean leaves. Adult damage is similar to Mexican Beetle damage. Their yellow eggs can be found at the base of the plant. The larvae will hatch and live within the soil feeding on the roots.

### **Leafhoppers**

Leafhoppers are small green wedge-shaped sucking insects that feed on leaf juices. Leaves tend to curl, dry out, and stipple follow feeding. Plants severely damaged turn yellow and have stunted growth. Control with insecticides can be difficult because of insect mobility (Swiader & Ware, 2002). Regular applications of insecticide should be sufficient enough to control the pest, if identified.

### **Grasshoppers**

These mobile insects are one of the most damaging pests for high tunnel grown crops in Utah. Grasshoppers usually eat leaves, but they will also damage fruit. Chemicals for grasshoppers are not recommended since they can damage most crops grown in Utah. Bait and cultural control are the best methods to manage grasshopper populations.

## **Disease & Viruses**

### **Grey Mold**

Grey mold, also known as Botrytis blight, is more likely to occur in early spring. It likes cool, moist, and poorly ventilated conditions, similar to greenhouses. Sprinkler irrigation will favor the disease and is not recommended. Venting the high tunnel to reduce moisture levels is key to preventing grey mold during wet conditions from early spring.

### **Root Rot**

Seed and root rots are common in cool, wet conditions in the spring. The seedling darkens, wilts, and dies. Crop rotation of 4 to 5 years is necessary to control the fungi. Crops that are susceptible to root rot should not be grown in the same location. Using well-drained soil and treated seed will also help prevent root rot from occurring (Miller, et al., 1995).

### **Bacterial Blight**

Small water soaked spots or light green patches are the first signs of the bacteria. They will enlarge and form large lesions on stems, leaves, and pods. Pods may shrivel and die, depending on the strength of the infection (Decoteau, 2000). Buying a variety that is resistant to bacterial blight is the best method of control.

### **Weed Control**

Weeds promote pests and compete with beans for water, nutrients, and light, especially when bean plants are small. Insects are likely to harbor on weeds, making pest control harder to manage. Clearing weeds in and around the tunnel will reduce pest problems. Hand or hoe weeding should be shallow near the plants to avoid damage to roots. Chemical weed control should be avoided at all costs. Herbicides labeled for field beans may not be appropriate for use in tunnels due to the risk of accumulating fumes in the closed environment.

## **Harvesting and Handling**

Green beans can be picked when they have reached physiological maturity (15 to 18 days after full bloom). Beans should be 4 to 6 inches long and slender for harvest. Harvesting should take place frequently (two to three times per week). Depending on the type of bean, the length of harvest will vary. With bush types, the concentration of production takes place in three to five harvests. Pole types concentrate their production over a 3-week period. Planting crops on different dates will extend the season and produce a steady income.

Before marketing, beans may be graded into U.S. size and grade categories. Specific bean grading guidelines can be found at <http://www.ams.usda.gov/AMSV1.0/getfile?dDocName=STELPRDC5050250>. Beans should be refrigerated after harvest at 40° to 45° F with high humidity to remove field heat and keep fresh for marketing (Decoteau, 2000). With these storage conditions, beans can be kept 7 to 10 days before dehydration issues occur.

## USU High Tunnel Bean Trials

Green beans (cultivar Provider) were used for all trials at Utah State University. Beans were seeded in high tunnels on three dates during the springs of 2012 and 2013. The trials evaluated planting date and plant cover effects on seed emergence and bean yield. Prior to planting, soil was irrigated, deep tilled and plots were marked. Planting dates were 30 March, 9 April and 20 April, 2012, and on 26 March, 5 April and 15 April, 2013. Seeds were planted in rows that were 5 feet long and spaced 12 inches apart. Each plot consisted of four rows and 25 seeds were planted in each row. Low tunnels (12 inches high) were constructed over half of the plots with the remaining plots left open or uncovered. Drip irrigation was used for watering and fertilizer applications. Seedling emergence was counted two or three times per week until no further seedlings emerged. Soil and air temperatures were monitored and flowering dates and yield recorded each year.

### Planting Date and Row Cover Study: 2012 & 2013

Final seedling emergence was not influenced by planting date in 2012 or 2013 (Table 1). In addition, low tunnels used in the high tunnels did not affect final emergence when compared to the open treatment. While final percent emergence was lower in the open treatment (65%) compared to the low

tunnel (78%) covered treatment, these values were not significantly different.

Time to 50% emergence (T50) gives some indication of how quickly the bean seedlings emerged (Table 1). Values are measured in days and describe the number of days needed for half of the seedlings to emerge. Lower numbers indicate that seedlings emerged faster (took fewer days). In 2012, T50s were not significantly different between the open and covered treatments, but planting beans under low tunnels did result in earlier (fewer days) emergence compared to open planting. In 2013, seeding beans under low tunnels resulted in significantly earlier emergence than seeding in the open. In both 2012 and 2013, early planting dates (late March) took longer to emerge than later planting dates (early or mid-April).

Bean seedling emergence patterns (Fig. 1) show that early planting (late March) tends to have lower final percent emergence and a larger difference between seeds that were covered compared to open. Beans planted under low tunnel covers (2013) emerged much more rapidly than those left uncovered. As planting dates got later into the spring, differences between open and covered are not that different. This indicates that covering early plantings can help speed up emergence which may benefit plants later in the production cycle.

Table 1. Influence of planting date and low tunnels (covers) on final percent emergence in 2012 and 2013. Low tunnel covers were constructed of Reemay (2012) or clear plastic (2013). Time to 50% emergence is a measure of how fast the seedlings emerge.

	2012			2013		
	30 Mar	9 Apr	20 Apr	26 Mar	5 Apr	15 Apr
	Final Percent Emergence					
Open	62.7	63.3	68.3	58.3	71.3	73.3
Covers	84.0	76.3	72.7	68.0	75.7	76.7
sign. 0.05	ns	ns	ns	ns	ns	ns
	Time to 50% Emergence (days)					
Open	16	14	13	30	22	19
Covers	14	12	11	22	18	16
sign. 0.05	ns	ns	ns	*	*	*

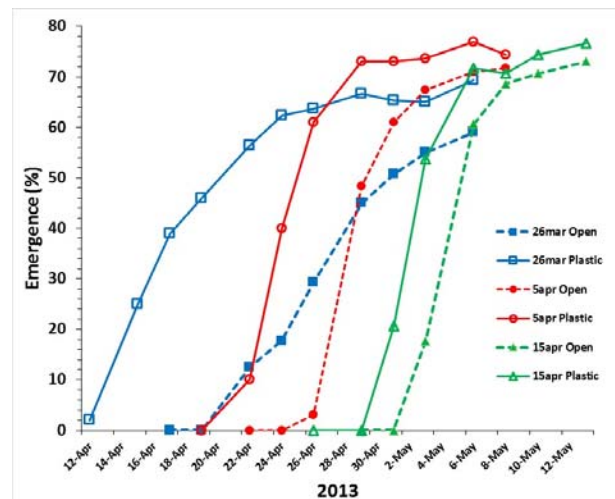
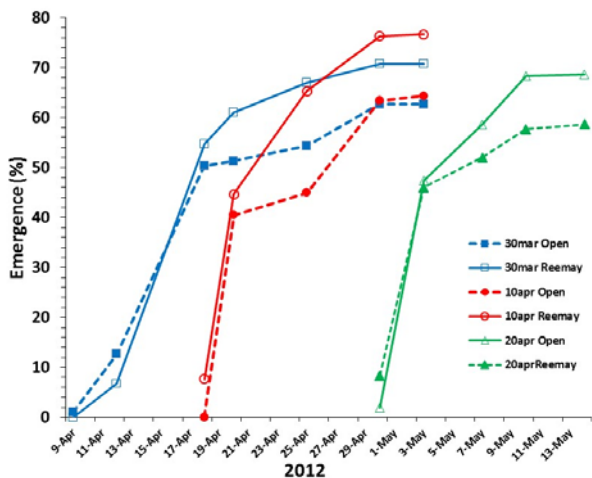


Figure 1. Emergence patterns of beans planted on three dates and for two treatments in 2012 and 2013. Planting dates and treatments are listed in Table 1.

### High Tunnel Bean Yields, 2012 & 2013

Beans were harvested over a 10-14 day period in both 2012 and 2013. Our goal was to achieve marketable yield of about 0.25 lbs/ft<sup>2</sup> and to have the productivity spread out over about 1 month. Ideally, there would be some overlap in production between the planting dates to ensure continuity of production. The targeted first harvest would be around June 10-15, approximately 1 month earlier than outdoor bean production. Figure 2 illustrates that planting at 10 day intervals results in a steady supply of beans at the 0.25 lbs/ft<sup>2</sup> or greater

productivity level in both 2012 and 2013. Use of plastic low tunnels in 2013 resulted in earlier production when compared to Reemay covers used in 2012. At this level of production in a 14 ft x 96 ft (1100 ft<sup>2</sup> of production area) high tunnel would generate roughly 220-330 lbs of beans at each harvest. Spreading out the planting dates to every 2 weeks may shift the windows of production sufficiently to ensure a more uniform level of supply at the 0.25 lbs/ft<sup>2</sup> production target. Results demonstrate that early bean production ahead of outdoor competition is possible and could be quite profitable.

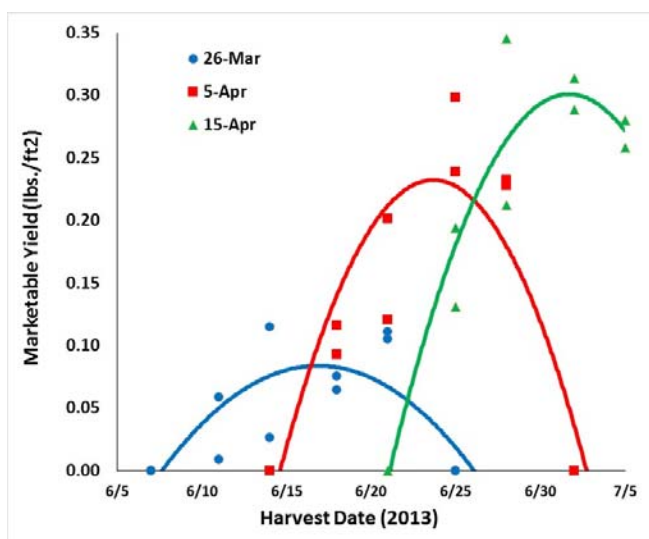
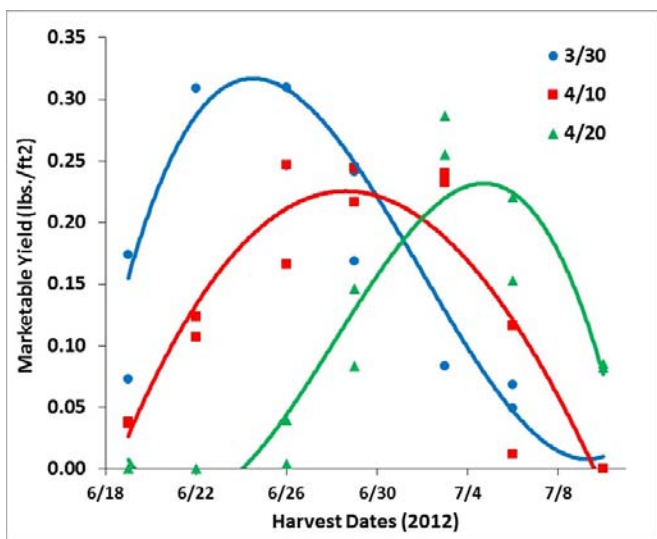


Figure 2. Seasonal change in marketable yield (lbs/ft<sup>2</sup>) for beans planted on three different dates and grown in high tunnels during 2012 and 2013.

## Summary

High tunnels can provide fresh beans 4 to 6 weeks before field bean production. Plastic low tunnels inside the high tunnel have proven to be effective in promoting early germination and production. With interval planting dates, fresh beans can be provided to local markets for a longer period of time and be sold for a premium price. High tunnel bean production helps expand marketing opportunities for growers already raising field grown beans.

## Citations

- Black, B., and D. Drost. 2010. Temperature Management in High Tunnels. Utah State University, Logan, UT.  
[http://extension.usu.edu/files/publications/publication/Horticulture\\_HighTunnels\\_2010-04.pdf](http://extension.usu.edu/files/publications/publication/Horticulture_HighTunnels_2010-04.pdf)
- Davis, J.H.C. 1997. Phaseolus Beans. In: H. Wien (ed.), The Physiology of Vegetable Crops. CAB International, New York, NY.
- Decoteau, D. 2000. Vegetable Crops. Prentice Hall. Upper Saddle River, NJ. p. 464.
- Hahn, J., and S. Wold-Burkness. 2008. Cutworms in Home Gardens. University of Minnesota, Minneapolis, MN.  
<http://www.extension.umn.edu/garden/insects/find/cutworms-in-home-gardens/>
- Miller, S., R. Riedel, and R. Rowe. 1995. Damping-off and Root Rot of Beans. Ohio State University, Columbus, OH.  
<http://ohioline.osu.edu/hyg-fact/3000/3110.html>
- Nelson, P. 2003. Greenhouse Operation & Management (6<sup>th</sup> ed.). Prentice Hall, Upper Saddle River, NJ. p. 690.
- Swiader, J., and G. Ware. 2002. Producing Vegetable Crops (5<sup>th</sup> ed.). Interstate Publishers, Inc., Danville, IL. p. 658.

Utah State University is committed to providing an environment free from harassment and other forms of illegal discrimination based on race, color, religion, sex, national origin, age (40 and older), disability, and veteran's status. USU's policy also prohibits discrimination on the basis of sexual orientation in employment and academic related practices and decisions.

Utah State University employees and students cannot, because of race, color, religion, sex, national origin, age, disability, or veteran's status, refuse to hire; discharge; promote; demote; terminate; discriminate in compensation; or discriminate regarding terms, privileges, or conditions of employment, against any person otherwise qualified. Employees and students also cannot discriminate in the classroom, residence halls, or in on/off campus, USU-sponsored events and activities.

This publication is issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Kenneth L. White, Vice President for Extension and Agriculture, Utah State University.