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High Tunnel Lettuce in Utah

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Introduction

The demand for fresh locally produced lettuce is on the increase. A high tunnel makes it possible to grow lettuce 6-8 weeks before and after the outside production season. In addition, year-round production may be possible in some situations. High tunnels increase marketing opportunities, improve early and late season cash flow, and yields are often higher than outdoor-grown lettuce. High tunnels are relatively inexpensive to build, are not heated, and allow planting as early as February in many locations in Utah.

High tunnels are temporary structures covered with a single layer of greenhouse grade plastic which is supported by a galvanized steel or PVC frame. Frequent sunny days make growing in high tunnels logical in Utah because tunnels are passively heated using solar radiation. High tunnels can help protect plants from cold injury at night and maintain optimal growing temperatures during the day (Figure 1). Daily ventilation may be necessary to prevent temperatures from exceeding the optimal growth range. A full list of

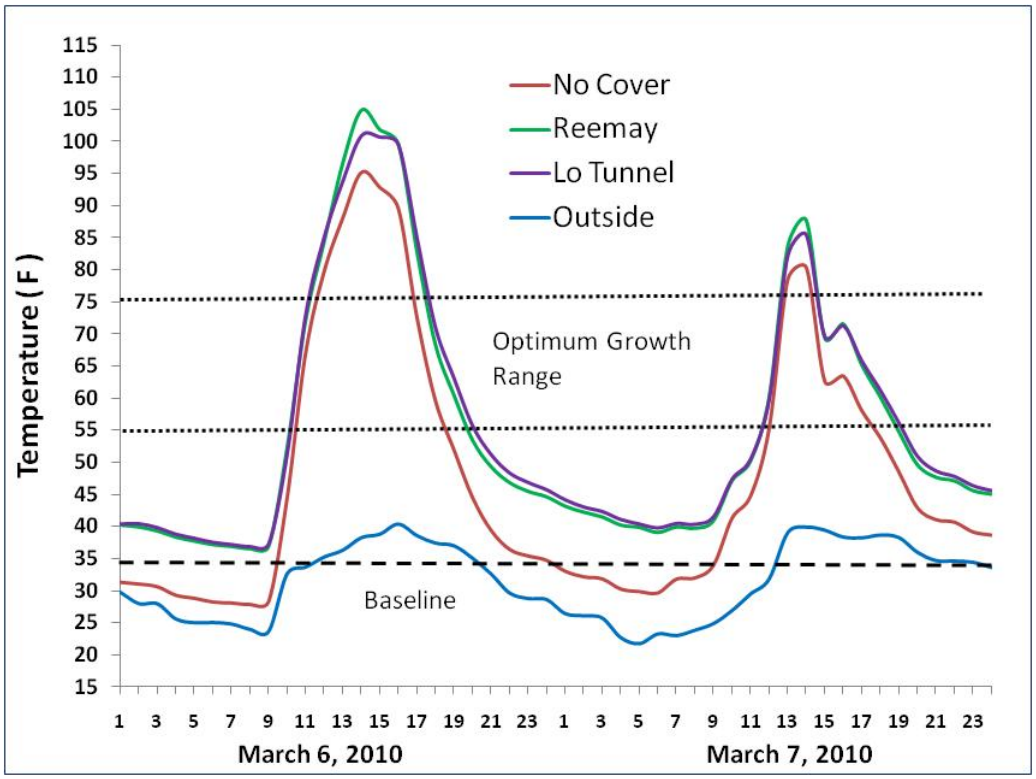


Figure 1. The change in hourly mean air temperature outside and under various row covers (Reemay, Lo Tunnel) in a high tunnel over 2 days in early March 2010.

construction details and photographs for a low-cost PVC-frame high tunnel can be found on the Utah State University Extension website (Black et al., 2008).

Variety Selection

Many types of lettuce grow well in high tunnels including: romaine, bibb, oakleaf, butterhead, batavia, and baby lettuce mixtures. Heading lettuce such as Iceberg is not suited for high tunnel production. Select varieties based on market demand, cold or heat tolerance, and disease resistance. Lettuce takes 35-65 days to mature depending on the variety and climate conditions (Jackson et al., 1996). Baby lettuces may be ready to harvest 20-30 days after seeding. Customers expect a variety of greens in a salad mix with varying colors, textures, and leaf sizes. Herbs and other specialty greens add pleasant flavors and textures to a salad. Arugula, radicchio, and mustards are specialty greens common to a mesclun mix. Some customers like the specialty greens with a spicy or strong flavor while others prefer mild, sweet flavors. Consult with your seed salesman or any seed catalog for detailed information on lettuce growth characteristics. All leaf lettuce varieties tend to have a better performance and higher quality when grown in a high tunnel. Although Utah State University has not conducted any variety trials for lettuce grown in high tunnels, a list of suggested varieties and desirable characteristics can be found at the Washington State Extension website in the publication "Winter Lettuce" (WSU, 2010).

Site Selection

Lettuce grows best in sandy loam to light clay soils with a pH of 6.5 to 7.5. Utah soils are good for lettuce production as long as the soil is well drained and there is not a buildup of salts, as measured by the soil electrical conductivity (EC). The high tunnel should be located near a year-round water source in order to facilitate irrigation in the early spring and late fall when seasonal irrigation water is not available. Shifting sun angle can cause buildings and trees that do not shade a high tunnel in the summer to shade a tunnel in the winter months. Be sure to position the high tunnel so it is not shaded for early season production.

Site Preparation and Fertility Management

Prior to planting, have the soil tested to determine nutrient deficiencies and soil electrical conductivity. A conventional fertilizer that includes nitrogen, phosphorous, and potassium should be incorporated before planting. Phosphorous is essential for early growth, particularly when plants are grown in cold or cool environments. For crops grown for approximately 60 days in spring and fall, apply a total of 10-15 lbs/acre of nitrogen (Example: 10 lbs of 5-3-3 fertilizer per 14 x 96' high tunnel). Apply 20-30 lbs/acre for summer crops. Nitrogen should be added two or three times throughout the growing cycle starting about 2 weeks after planting. Spreading out the nitrogen applications allows for less leaching and improves plant growth and yield. Injecting soluble fertilizer in the irrigation system is an efficient and effective application method.

Lettuce can be grown with organic fertilizers which can promote soil quality. Organically grown lettuce may have a higher market value. Incorporate well composted organic matter before planting to sustain soil fertility. An initial application of 5 tons per acre of high quality compost of known nutrient analysis is recommended. This is equal to 300 lbs per 14' by 96' high tunnel. Repeat this process between crop cycles to build up soil fertility. Be sure to test soil regularly as nutrient and salt levels can build up quickly when compost is constantly added to the high tunnel. More information about organic lettuce production can be found on the Sustainable Agriculture Information Service website (Kuepper et al, 2002).

Incorporate the compost or fertilizers to a depth of 4-6 inches with a tractor-mounted or hand-operated tiller. High tunnels can be designed to accommodate small machinery for soil tillage and other operations. Plant residue from previous plantings should be removed completely before re-planting to create a clean seed bed and avoid disease carryover.

Irrigation Management

Lettuce plants require a constant supply of moisture. Drip irrigation is well suited for lettuce production in high tunnels. Drip tape should have emitters every 4 inches to water closely spaced lettuce plants, and should be located 1 to 2 inches away from the plants. Watering should be frequent enough to prevent the leaves from wilting. Soil water monitoring is easily done with a resistance block such as the Irrometer® Watermark sensor. Place one sensor 6 inches deep and another sensor 1 foot deep. The meter will give a reading in centibars, which reflects the force required for a plant to extract water from the soil, so a higher reading means drier soil. Soil texture (clay, loam, sand) influences the soils ability to hold on to water. An example of threshold readings for different soil textures are listed in Table 1. Irrigation should occur when 20-25% of the available water is depleted. A reading of less than 5 centibars indicates excessive water. A comparison of other low cost tools and methods to monitor soil water can be found at: attra.ncat.org/attracub/soil_moisture.html.

Table 1. Soil Tension Values for Different Soil Textures for Use in Scheduling Trickle Irrigation as Listed by the Midwest Vegetable Production Guide for Commercial Growers (Creswell et al., 2010).

Soil Texture	0% Depletion of Available Water (Field Capacity)[1]	20-25% Depletion of Available Water[2]
	Soil Tension Values (in centibars)	
Sand, loamy sand	5-10	17-22
Sandy loam	10-20	22-27
Loam, silt loam	15-25	25-30
Clay loam, clay	20-40	35-45

[1]At field capacity the soil contains 100% of available water holding capacity; any excel water in the root zone has drained away.
[2]Start trickle irrigation for shallow-rooted crops at this point.
Information adapted from New Jersey Commercial Vegetable Production Guide, New Jersey Ag. Expt. Station, Rutgers; and "Water Management in Drip-irrigated Vegetable Production" by T.K. Hartz, UC-Davis, Calif., Vegetable research and Information Center.

Direct Seeding vs. Transplanting

Lettuce plants can be direct seeded or transplanted into the high tunnel. Transplanting is recommended when temperatures outside are not favorable for germination. Lettuce seeds germinate best when soil temperatures are between 60 and 65 °F. Lettuce seeds can germinate when soil temperatures are near 40 °F, but emergence is slow. Seeds become dormant at soil temperatures above 75 °F, so germination is poor when soils are too warm. Lettuce leaves that are cut and sold as baby greens are generally direct seeded while lettuce sold as a head is typically transplanted. Seeding tools are available to spread seed uniformly into rows along the soil. Pelleted (coated) seed that is uniform in size and shape must be used with seeders. Some thinning may be required after seeding.

For transplants, sow seed into 128 cell flats and grow for 3 to 4 weeks before transplanting. Plant seeds ¼ inch deep and water gently so seeds do not wash to the surface. Use sterile flats and media to avoid transmitting root diseases. Seeds can also carry root diseases and may be treated before purchasing. Root disease may appear as poor germination and stunted growth of seedlings (Figure 2). Water and feed daily with a soluble complete fertilizer diluted to 100 ppm N after emergence. Condition or "harden off" transplants by exposing them to cool temperatures one week before transplanting to prepare the plants for the colder temperatures they may experience in the tunnel.

Figure 2. Variable transplant size can occur when sowing depth is not uniform or when plants get over-watered and root rot occurs.

Planting Dates and Spacing

High tunnels make it possible to plant 6-8 weeks earlier in the spring compared to planting outside. The lettuce trials at Utah State University used Parris Island Cos for all of their studies and found that it did well when transplanted and grown in a high tunnel from mid February through early June. Since temperatures during the day can be very warm inside a high tunnel even during the winter months, Parris Island Cos was selected because the variety is slow to bolt when subjected to warm temperatures. Hot temperatures in July and August did cause the lettuce to bolt, even when grown under a 40% shade cloth cover. Parris Island Cos also performed well when transplanted from late August through early October in a high tunnel. The trials took place in Logan, Utah, which is a zone 4-5 on the USDA cold hardiness scale. The number of days from planting to harvest is increased when temperatures are cool and sun angle is low. Lettuce takes about 15 days longer to mature when planted at the end of February than it does when planted at the end of March (Coleman, 2009). Seeds can be sown once per week to ensure a continual harvest.

Plant spacing depends on variety and growing period. Seed rows of baby leaf lettuces 2-3 inches apart with a seeder (Coleman, 2009). This equates to 6-9 rows on an 18 inch bed. Within-row spacing can be as close as 1 inch. Transplant lettuce 4-6 inches apart (4-9 plants/ft^2) in beds 2-3 foot wide to give the plant adequate space to mature. Harvesting smaller plants is beneficial in several ways. A smaller plant requires less space, so plants can be sown closer together to increase yield in a given area. The longer a plant is in the ground, the more opportunities there are for pests to invade the plant. More frequent seeding and harvesting will be required to keep up with plant production. When leaves are cut just above the base of the plant, new leaves may grow from the same plant. The quality of re-growth varies by variety.

High Tunnel Temperature Management

Lettuce grows best at temperatures between 55 and 75°F (Figure 1). The best growing seasons for high tunnel lettuce in Utah are spring and fall. Hot temperatures in the summer cause lettuce to bolt, or flower prematurely, though some varieties are less prone to bolting. Shading with a 40-50% shade cloth can help cool the plants and extend the growing season a week or two in periods of hot temperatures. Lettuce plants are susceptible to chilling injury when temperatures are near freezing. Plants may not show immediate signs of injury, but growth may not be as vigorous. The cold protection of a high tunnel is limited to 2 to 3 °F when outside temperatures are near freezing. Row cover cloth or Reemay® (a thin spun bonded polyester fabric) can be laid directly on the plants to protect them from chilling injury (Figure 3). The row cover fabric helps limit heat loss around the plants during cold clear nights and keeps night temperatures 2 to 4 °F warmer than the surrounding high tunnel temperature. Low tunnels made with greenhouse-grade plastic suspended over hoops that are 2-3 feet high at their peak (Figure 2) will keep night temperatures slightly warmer, but plastic must be removed during the day to avoid excessive heat. Low tunnels should be used in the very early spring and late fall when outside temperatures are below or near freezing.

Daily ventilation of the high tunnel is needed to ensure temperatures inside do not exceed 75°F. Ventilation may entail opening a single end door in March, or both sides and ends in April when day temperatures are warm. The plastic on the tunnel is generally removed when outdoor temperatures stay above 50ºF.

Figure 3. Low tunnel (left) and row cover cloth (right) covering spinach growing in high tunnels in late winter.

Pest and Disease Management

Pests can reduce yield and threaten plant quality. Lettuce is expected to be free of pests before it is sold at the market. Healthy plants grown in a clean environment are less likely to have pest outbreaks that require management. Application of chemicals in tunnels is more hazardous than in the open field due to the closed environment. If using chemicals in tunnels, determine if the material is registered for greenhouse use, and if so follow the directions on the label closely and always wear appropriate personal protective equipment. If you are having trouble diagnosing a pest problem, contact your county Extension agent or other knowledgeable individual. Some of the common insects found in high tunnels include aphids, slugs, and grasshoppers. A brief summary of each pest is provided here, and for specific pesticide recommendations see the Utah State University Integrated Pest Management website (http://utahpests.usu.edu/ipm/).

Aphids: Aphids are tiny insects that feed on plants by sucking sap out of stems and leaves. Aphids can also transmit plant viruses and diseases. Symptoms include stunting and distortion of plant growth and sticky sap on the leaves. Prevent aphids from becoming a problem by making sure transplants are free of aphids before planting and controlling weeds in and around the tunnels. Insecticidal soaps and horticultural oils are effective at controlling aphids and often come in organic formulations. Natural predators can also help suppress aphids. Natural predators of aphids include green lacewings, parasitic wasps, aphid midges, and lady beetles. More information about aphid control can be found at http://attra.ncat.org/attra-pub/gh-aphid.html.

Slugs: Slugs are a common lettuce pest. Diatomaceous earth is a naturally occurring fine rock powder that slugs will not crawl over because it dries them out. The efficacy of diatomaceous earth in tunnels may be marginal when humidity is high. Copper stripping is an effective barrier because it causes a chemical reaction that repels slugs. Place a 2-6 inch wide (depending on how big your slugs are) strip of copper around the outer edge of the high tunnel. Many home gardeners find success using a shallow dish of beer to attract and drown slugs. Chemical slug baits are also very effective, but can be toxic to wildlife and animals. Chemical slug baits must not come in contact with the plants, so it is recommended to apply it outside the high tunnel only. Some of the organic (natural) slug baits can be used safely in the tunnels and around plants.

Grasshoppers: Grasshoppers emerge in spring with an appetite for foliage and fruit that lasts all summer. Eliminating weeds near the high tunnel will deter grasshoppers from feeding there and finding a way into the tunnel. It is a good idea to scout regularly for

grasshoppers before they become a problem. Removing plants promptly after the harvest and controlling weeds in the fall will discourage female grasshoppers from laying eggs near the tunnels. Biological baits are available for grasshopper control as well as baits containing chemical insecticide for fast control in severe infestations.

Disease Control: High tunnels trap warm humid air which can promote disease. Disease resistant varieties, proper irrigation and soil drainage, good ventilation, and crop rotation aid in disease prevention. Plants in the cabbage family (kale, radish), beet family (chard, spinach), or carrot family are examples of plants that could be rotated with lettuce in high tunnels. Limit opportunities for disease growth by removing dead plant residue, and managing weeds and insects in the tunnel and surrounding area. Diseased plant materials should be destroyed and kept out of compost used for future plantings. Remove plants carefully to avoid distributing spores. The most common diseases found in high tunnels are leaf drop, damping-off, and downy mildew. Controlling disease with fungicides must be done at the proper life stage of the disease to be effective. Guidelines for use can be found on the label.

Leaf Drop: Leaf drop (*Sclerotinia minor*) infects the stem and leaves that come into contact with the soil. A soft brown decay can be seen on the base of the plant which eventually kills the crown tissue and causes all the leaves to drop. The fungus thrives in cool wet conditions, and can live in the soil for 2 -3 years. Apply irrigations carefully to avoid excessively wet soils. Fungicide can be used to protect the crop and must be directed toward the base of the plant to be effective.

Damping off: The damping off (*Rhizoctonia solani*) organism lives in the soil and attacks young seedlings. Seedlings may be infected before they emerge from the soil surface resulting in uneven stands. Infected seedlings have decayed roots and brown lesions on the stem. Several fungicides are effective at controlling *Rhizoctonia*.

Downy Mildew: Downy mildew (*Bremia lactucae*) appears as light green to yellow spots on the upper leaf surface with white fluffy growth on the underside of the spots. Older leaves are attacked first. Downy mildew can also kill seedlings if the cotyledons are infected, but many varieties are resistant to *Bremia*. Apply fungicides before the development of the disease, if the disease has been a problem in the past.

Weed Control: Weeds harbor insect and disease pests and compete with lettuce for water, nutrients, and light, especially when plants are small. Plants spaced close together prevent weeds from growing and becoming a problem. Collinear, diamond, and stirrup shaped hoes are easy to use and small enough to drag in-between rows of plants. They do a good job of severing small weed seedlings at the soil surface. Weeds taller than 2 inches are harder to remove without digging up the soil, which may damage the roots of the lettuce. Hand weeding is required for larger weeds.

Harvesting and Marketing

Harvest whole lettuce plants by cutting the stem with a sharp knife at the soil surface or for repeated harvests cut individual leaves at their base. After cutting, place lettuce in cool water to keep it hydrated. Lettuce greens must be washed thoroughly and dried before packaging. Commercial salad spinners are available for drying, but many growers build their own. A mixer is helpful in combining lettuce varieties to make a salad mix. Washing and mixing must be done carefully to avoid bruising or breaking the leaves.

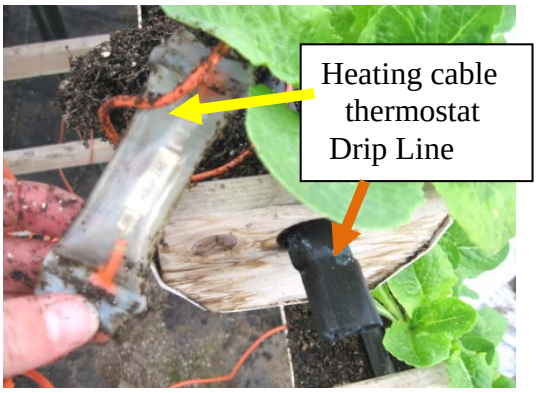
Growing high tunnel lettuce is a good idea for farmers that already have a customer base that wish to add salad greens to their product offering. During the winter months when direct marketing through farmers markets may not be available, local restaurants, caterers, or small food service providers may be new markets for lettuce. For existing community supported agriculture (CSA) farms, off season production can allow for extended subscriptions when few local produce options are available.

Utah State High Tunnel Lettuce Trials

Parris Island Cos lettuce has been used for lettuce trials at Utah State University since spring 2008. Transplants were raised in a heated greenhouse for 4 weeks before being transplanted into the high tunnel. The trials evaluated a vertical growing technique to utilize space inside a high tunnel as well as root zone heating in 2009. Plants were grown in ground beds for comparison. In the vertical growing system, plants were grown in PVC gutters attached to wood frames and positioned at south, east, and west orientations (Figure 4). Plants were grown in potting soil (soilless media)

Figure 4. Lettuce growing in PVC gutters.

consisting of equal parts peat moss, vermiculite, and perlite. All plants were spaced 6 inches apart. Drip irrigation was used for watering and all fertilizer application. A cloth row cover was placed over the plants when temperatures were below freezing. In mid June 2008, the plastic covering the tunnel was removed and replaced with a 40% shade cloth to maintain more favorable temperatures for growth. In 2009, soil heating cables (Figure 5) were installed in half of the gutters to



prevent the soil media from freezing and to promote

Figure 5. Soil heating cable used in PVC gutter.

plant growth. The cables included an automatic thermostat set at 70°F.

Vertical vs. Ground Production Case Study

The vertical growing system allowed for six plants per square foot compared to four plants per square foot in the ground. New plants were transplanted approximately once per month and harvested at 10 day intervals with the final harvest occurring after 40 days. The vertical system had higher fresh weight yield after 40 days compared to the ground system in the spring and fall only (Figure 6). Lower production in gutters during the summer months (June-August) was due to excessively hot root zone temperatures which were unfavorable for growth (Table 2). Table 2 also shows the media in the gutters froze during the early spring,while the ground soil did not.

Gutter orientation (E, W, or S facing) did not influence lettuce production.

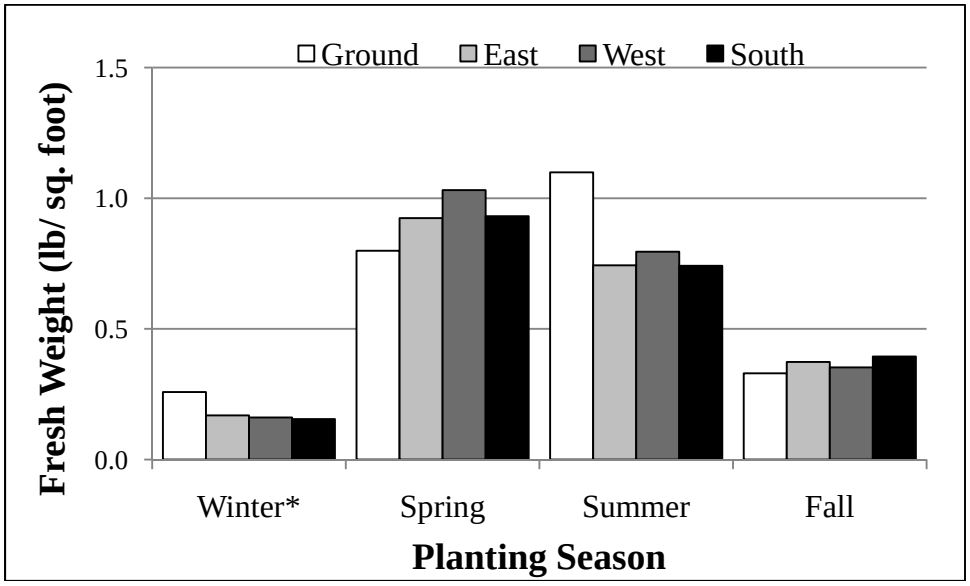


Figure 6. Vertical production of several orientations compared to ground production based on fresh weight per square foot after 40 days in 2008. *Winter (November – February), spring (March - May), summer (June – August), fall (September – October).

Table 2. Monthly Soil and Air Temperature Extremes in the High Tunnel in 2008.

	Minimum Temperatures (ºF)			Maximum Temperatures (ºF)		
	Soil	Gutter Soil	Air	Soil	Gutter Soil	Air
February	32	23	14	50	80	95
March	41	31	16	55	82	104
April	45	31	20	61	94	100
May	50	32	28	68	88	95

Root Zone Heating Case Study

Inserting heating cables into the gutters prevented the soil media from freezing and allowed for continued growth when temperatures in the tunnel were below freezing. Figure 7 shows root zone heating increased productivity (lb/ft^2) in the gutter system enough to exceed production in the ground during the October and November planting periods. Freezing root zone temperatures restricted productivity in the unheated gutters by limiting water and nutrient uptake (Table 2). Each cable covered 20 feet of gutter and had an output of 80 watts. The cost of electricity for the soil heating would be approximately $4.00 per day per 1350 sq ft of growing area when temperatures are below freezing.

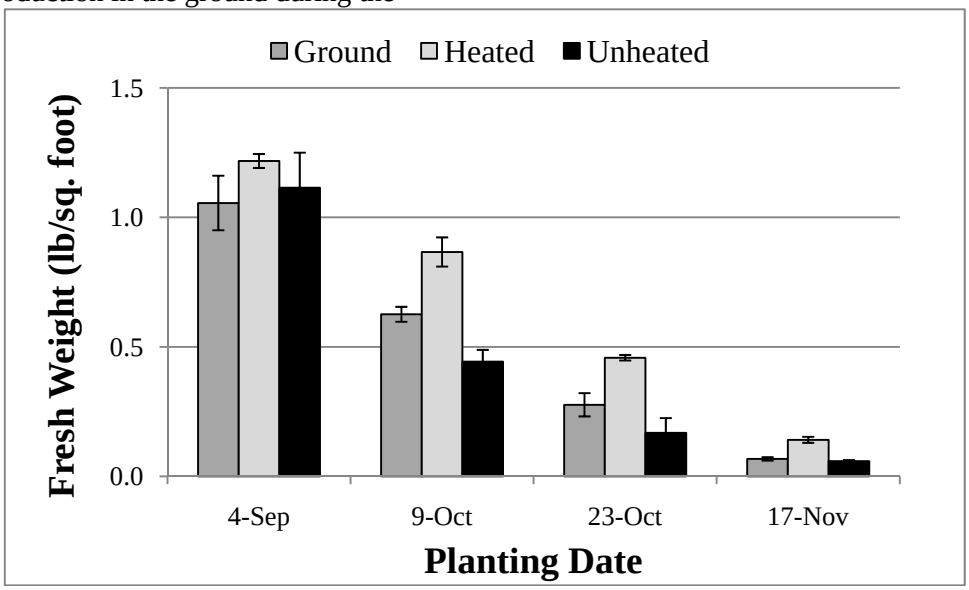


Figure 7. Heated gutter production compared to unheated gutter and ground production based on fresh weight per square foot after 40 days for four fall transplanting dates in 2009. Bars represent the standard error for each category.

Summary

Early and late season lettuce can provide local farmers with produce to sell at farmers' markets and other local retail outlets at a time when outdoor production is not available. High tunnels allow for year round production, high yields, and better quality. High tunnel lettuce should not be thought of as an alternative to outdoor production. Rather high tunnel-grown salad greens are a compliment to other products, thus allowing farmers to supply local produce to the public for a longer period of time.

References

Black, B., D. Drost, D. Rowley and R. Heflebower. 2008. Constructing a Low-cost High Tunnel. http://extension.usu.edu/files/publications/publication/HG_High_Tunnels_2008-01photos.pdf

Coleman, E. (2009). The winter-harvest manual: Farming the back side of the calendar: Commercial greenhouse production of fresh vegetables in cold-winter climates without supplementary heat. Harborside, ME (RR Box 14, Harborside, ME 04642), Four Season Farm.

Egel, D., R. Foster, and E. Maynard. 2010. Midwest Vegetable Production Guide for Commercial Growers 2010. www.btny.purdue.edu/Pubs/ID/ID-56

Jackson, L., K. Mayberry, F. Laemmlen, S. Koike, K. Schulbach and W. Chaney. 1996. Leaf Lettuce Production in California. http://anrcatalog.ucdavis.edu/pdf/7216.pdf

Kuepper, G., J. Bachmann and R. Thomas. 2002. Specialty Lettuce and Greens: Organic Production. http://attra.ncat.org/attra-pub/lettuce.html.

WSU. 2010. Winter Lettuce. Washington State Extension. http://agsyst.wsu.edu/WinterLettuce.html

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