Growing fresh vegetables:

Midnight sunlight & the Earth's warmth

Welcome to Chena Hot Springs Resort "Chena Fresh" greenhouses.

Here you'll find:

- a year-round production greenhouse entirely run on geothermal energy
- a collaboration that integrates business innovation with the most up-to-date scientific findings
- cutting-edge horticulture research focusing on hydroponics and production management
- public education and outreach about Alaska agriculture

and of course, fresh, tasty vegetables!

The round-the-clock daylight that interior Alaska experiences in the summer can be advantageous or challenging for farmers, researchers, and horticulturists. On the other hand, there are times in the winter when the sun barely peeks over the horizon, making greenhouse growing particularly difficult. As Alaska strives to become more sustainable we must accept these challenges and take advantage of the opportunities.

This endeavor is a collaboration involving **Chena Hot Springs Resort** (CHSR) and the **University of Alaska Fairbanks School of Natural Resources and Agricultural Sciences** (SNRAS). CHSR is working toward becoming a self-sustaining community, and an important part of making this vision a reality is to strive for greater independence in food production. The crops grown in the greenhouse along with other Alaska Grown produce are featured in the on-site restaurant. In an effort to ensure continuous future supplies of Alaska Grown produce, CHSR offers on-the-job training opportunities for high school students in **Alaska FFA** chapters and students in post-secondary degree programs at UAF. A small test greenhouse, built in 2004, has been operating year round and is heated entirely with water from a nearby geothermal source. In January 2009, the greenhouse maintained temperatures of 85°F while ambient temperatures dropped to -45°F, which is typical for interior Alaska winters. This 130°F temperature differential is the largest recorded for any greenhouse production facility in the U.S. The resort added a 4,320-square-foot greenhouse in 2006 to provide the restaurant with a greater variety of fresh produce twelve months out of the year.

With guidance from **Dr. Meriam Karlsson**, UAF professor of horticulture, and **Jeff Werner**, research professional, the project incorporates many avenues of research. At this and other sites, Dr. Karlsson is working to make locally-grown produce in remote Alaska regions a reality. In high tunnels, greenhouses, or high-tech facilities, researchers are focusing on plant requirements, varieties, and treatments to maximize productivity for growers. Objectives are to develop cultural management techniques and reliable protocols to efficiently produce suitable vegetables, culinary herbs, small fruit, flowers, and hanging basket crops in various environments.

Dr. Karlsson's work determines the best materials for high tunnels and greenhouses so that crop productivity is optimized and expanded. She studies specific crops, including tomatoes, lettuce, green beans, culinary herbs, and strawberries, so that optimum conditions for best output can be shared with agricultural producers across the state. Specific lighting tests, including LED (light-emitting diode) lights, are also included in her research. Partnerships with commercial enterprises such as CHSR and Pike's Waterfront Lodge in Fairbanks not only provide scientific expertise to the businesses but showcase innovative agricultural methods (such as hydroponic techniques) to the public. The Chena Hot Springs greenhouses offer an excellent research site for UAF undergraduate and graduate students.

The resort

CHSR is located off the grid in a semi-remote location 60 miles northeast of Fairbanks. The available 165°F geothermal water is sufficiently hot to heat the buildings at the resort throughout the year. When the resort accomplished converting geothermal energy to electricity along with the geothermal heating, year-round greenhouse production became a reality.

Hydroponics

Originally, growing plants with the roots immersed in a water solution of nutrients was called hydroponic culture or hydroponics. Hydroponic systems refer to a range of soilless production techniques. In these systems, the required nutrients are dissolved in water and provided to the roots held directly in the solution or in a prepared growing medium. The growing medium can be organic or inorganic and may consist of a single or several mixed materials such as peat moss, gravel, or perlite (siliceous rock).

Jeff Werner and a variety of lettuce types in a Chena Hot Springs greenhouse.

Tomatoes and lettuce are grown hydroponically in the Chena Hot Springs greenhouse built in 2006. Hydroponic production systems are popular because of benefits such as rapid growth, no soil-borne pests, easier harvest, uniform head size, lower labor costs, and year-round production. Nutrient film technique (NFT) is the most common hydroponic system used in commercial greenhouses. In a closed NFT system, the plants rest in a growing channel and nutrient solution is circulated with the roots bathed by a constant flow of nutrients, ensuring sufficient aeration for plants. The remaining solution is returned to a stock tank and required nutrients, pH, electrical conductivity, and water levels are adjusted before re-circulation.

Salad anyone?

The NFT system works well at CHSR for producing lettuce. Most cultivars are mature and ready to harvest after 28 to 30 growing days from seeding during summer conditions. The production time is extended to 32 to 35 days when light is primarily supplied from metal halide lamps. Even during times of above-optimal temperatures, the hydroponic system supports high productivity. For instance, the lettuce Nevada grown during a summer heat wave and harvested after 28 days produced heads of 4.8 oz. with more than 30 leaves for consumption.

Many types of loose-leaf lettuce with a range of leaf forms are available for greenhouse production. The leaves develop without forming a head and the window of optimal harvest is wider than for head-forming lettuce. Multi-leaf lettuce is a relatively new type and as the name suggests produces an abundance of leaves. To be a multi-leaf lettuce, the cultivar should preferably produce 200 leaves or at least twice as many leaves as a comparable leafy cultivar. Lollo lettuce originated in Italy and comes with red leaves as Lollo Rosso (Rossa) or green leaves as Lollo Bianco (Bionda). The extensively frilly Lollo lettuce forms a tight rosette that may be mistaken for a head. Resembling the leaves of oak, the oak-leaf lettuce is tender with green or red leaves. Curly lettuce has brilliant green wavy-edged leaves of good flavor and texture.

Loose-leaf lettuce held aloft, showing the roots.

The romaine, butterhead, and summer crisp lettuce form a head of leaves, in contrast to the leafy lettuce types. Romaine or cos lettuce grows upright with long, narrow outer leaves forming an oval head around a tender flavorsome center. Warm temperatures tend to predispose romaine lettuce to bolting and turn the lettuce bitter. Bolting, the failure to properly form a head due to excessively rapid stem elongation or leaf twisting, may be especially problematic under naturally extended high-latitude

Lettuce grown at Chena Hot Springs Resort using the nutrient film technique.

day lengths independent of temperature. Butterhead, Boston, or bibb lettuce forms a loose head of leaves. The leaves are soft and "buttery" to the touch with a sweet taste. Butterhead lettuce grows quickly and rarely turns bitter. Summer crisp lettuce is also known as French crisp or Batavian lettuce. The outer leaves can be harvested as loose-leaf lettuce while the head is forming. The leaves are tasty and sweet. Although quite demanding for fertilizer nutrients, summer crisp is resistant to bolting.

Producing greenhouse lettuce and other crops in high-latitude locations is challenging. Outside temperatures may vary up to 145 degrees, from - 50°F during the winter to +95°F in the summer. Large seasonal variations in natural day length from 3 hours and 33 minutes between sunrise and sunset at winter solstice to 22 hours and 6 minutes at summer solstice (latitude 65°N) require attention to the photoperiodic response in choosing cultivars and selections. The choice of cultivars is critical for successful northern greenhouse lettuce production. A range of lettuce selections has therefore been evaluated at CHSR to identify the ones most suitable for year-round production.

Continuous year-round adjustments managing the greenhouse environment are necessary. Commercially available lettuce types and cultivars suitable for long or short days are rotated throughout the year in the nutrient film production system. Long-day lettuce selections are usually developed in areas with several hours of definite darkness each day. Growth and development may be acceptable for these long-day lettuce types under prolonged twilight and continuous summer light, but not optimal. Short days and limited natural light during the winter demand supplemental lighting. Metal halide lamps are used to supplement irradiance and extend the day. Various combinations of lighting protocols, timing, and qualities are under evaluation to establish the most advantageous and cost-effective growing environment supporting high-latitude hydroponic lettuce production.

Tomatoes anyone?

Research and production advancements have resulted in highly efficient techniques and systems for growing greenhouse tomatoes. New indeterminate cultivars with a continuously growing terminal bud work specifically well in these systems. They can be prompted to produce fruits on a stem several feet long, which makes trellising possible to maximize production in a limited space. This is the kind of tomato grown here in the Chena Hot Springs geothermal greenhouse. In contrast, determinate or bush-type tomatoes used in field production and gardening have a main stem ending in a flower cluster with tomatoes developing on many side branches.

Although several cultivars such as Clarence, Tricia, and Trust have been tested, most plants at Chena Hot Springs today are of the cultivar Trust producing 7-7.5 oz. tomatoes along with the cherry tomatoes Conchita and Picolino (fruit size 0.75 oz). The tomatoes are transplanted and grown in Dutch Bato buckets filled with a mixture of perlite and a peat based growing medium. The containers drain into a collection pipe for recirculation with minimal loss of water and nutrients. The plants are supported with twine connected to an overhead wire. Lower leaves and developing lateral shoots (suckers) in the leaf axils are removed to leave one single stem. As the growing plant reaches the wire, it is lowered, letting the stem lay horizontally while keeping the growing shoot upright into the light.

For good growth and optimal fruit development, 68 to 72°F during the day and 60 to 65°F at night are recommended for tomato production. The large variation in outside temperature and light conditions over the year makes greenhouse production challenging this far north. The plants are entirely dependent on supplemental artificial lighting during the exceptionally short winter days. The geothermal generator produces the power for running the lights and other greenhouse equipment. A combination of metal halide and high pressure sodium lamps is used to provide supplemental lighting to the tomatoes.

Summary

Karlsson and her team are looking at various research questions in support of optimal management and productivity. For instance, the arrangement and daily scheduling of lighting throughout the year in relation to temperature need to be better understood. Most crop cultivars available today are not fully adapted to continuous light without a natural dark period. Still, many of these selections produce high yields in interior Alaska. How do plants adapt to a twenty-four hour cycle of continuous light in respect to photosynthesis and growth? To manage crops under excessively long natural days as well as growing conditions requiring combinations of artificial and natural light, the importance and relationship of daily dark and light periods need to be evaluated for implementation in production. Ongoing UAF research using specific light qualities of LED lamps to complement existing lighting technologies suggests improved crop performance in high-latitude greenhouse production.

The greenhouse technology and management procedures developed and demonstrated at CHSR are suitable for dissemination to regions of similar infrastructures and climatic conditions. Although CHSR is able to take advantage of geothermal energy, the opportunity to operate greenhouses year round affordably is not limited to locations with geothermal hot springs. A variety of alternative, renewable, and waste energy resources in addition to geothermal energy can be used to run the CHSR system of heating and electric power generation.

Thank you for visiting!

For further information please see www.uaf.edu/snras/.

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