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College of Agriculture, Food and Environment
Cooperative Extension Service

Center for Crop Diversification Crop Profile
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Hydroponic Lettuce

Cheryl Kaiser[1] and Matt Ernst[2]

Introduction

Lettuce (*Lactuca sativa*) is one of the most commonly grown hydroponic vegetables. Hydroponics is a method of growing plants without soil. Plants may be grown in a nutrient solution only (liquid culture) or they may be supported by an inert medium (aggregate culture). In both systems, all of the plants' nutritional needs are supplied through the irrigation water.

Hydroponics is a highly exacting and demanding system that requires a greater amount of production knowledge, experience, technical skill and financial investment than many other greenhouse systems. A grower must be committed to meeting the daily demands of production to be successful.

While there are a number of different hydroponic systems that have been commercially successful for lettuce production, this profile will focus on the nutrient film technique and the floating raft method. Prospective growers should obtain as much information as they can about hydroponic production before entering into this type of enterprise.

Marketing

Hydroponics production costs require growers to either identify consistent markets willing to pay a premium price, or produce at a great enough scale to realize cost economies while shipping large amounts of produce. Such market niches may take some time to develop to maximize returns. Growers with superior crops and off-season or year-round availability will have a marketing edge. Potential hydroponic growers should talk to local grocers or specialty food retailers interested in locally grown crops. Schools, restaurant chefs and caterers are other potential markets. Wholesalers, such as produce brokers selling to restaurants, may also be potential markets for hydroponically grown lettuce and greens.

Market Outlook

The quantity and variety of leafy greens and herbs demanded by Americans has increased as consumers desire more health and diversity in their diets. Consumption based on per capita disappearance of leaf lettuces increased through 2014. Greens and herbs may be grown and marketed on a variety of scales for different markets, from farmers markets to large-scale commercial wholesale accounts. Wholesale lettuce production is dominated by western production regions. While Kentucky producers could investigate smaller-scale wholesale production, opportunities for hydroponic greens will most likely come from direct marketing to consumers. Proper handling practices and other food safety considerations are crucial components for successfully

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www.uky.edu/CCD

[1]Cheryl Kaiser is a former Extension Associate with the Center for Crop Diversification.
[2]Matt Ernst is an independent contractor with the Center for Crop Diversification.

marketing lettuce and other greens and herbs.

Production Considerations

Facility requirements and location

Hydroponics production requires greenhouses with the ability to provide adequate heat in winter months and either shading or chilling for water in the summer months. Well or county water is almost always used for hydroponic lettuce production as surface water may increase risk for diseases. Overly chlorinated city water can cause problems in lettuce production. It is recommended that growers submit their start water to an analytical laboratory for analysis. It will help them to better develop a nutrient management plan for their crop.

The facility should include a germination area for seedling production. This may be a section of the greenhouse or an environmentally controlled room with benches and artificial lighting (cool white fluorescent or high pressure sodium lamps).

Cultivar and plant selection

The most common types of lettuce grown hydroponically are looseleaf, butterhead and romaine (cos). Leafy greens, sometimes used to complement a lettuce selection, include bok choy, spinach and Swiss chard.

What do we select for?

- Varieties specifically developed for greenhouse hydroponics
- Disease resistance
- High degree of coloration
- Varieties can be selected for cool and low light winter conditions or warmer season cropping
- Resistance to physiological disorders, bolting and tipburn in spring and summer
- Varieties bred to maintain growth rates during fall and winter

Because of the capital-intensive nature of hydroponics, growers should grow only those crops with a high economic value and the qualities in demand for the intended market.

Germination

Plants are propagated by placing seeds into a germination medium. Seeds can be placed into a soilless mix (such as peat and perlite) in seeding or plug trays. An inert medium (such as rockwool or oasis cubes) can also be used to produce transplants. Hydrate and stabilize the rockwool cubes before seeding (pH 5.5-5.8). Optimum germination temperature is 64-68°F. Most lettuce requires light at low radiation levels to germinate. Pelleted seed will split open when moisture is added, allowing light to fall on the seed. Otherwise, cover the seed lightly with vermiculite. Germinating seeds are sub-irrigated using an ebb and flow bench. Overhead watering may retard germination. When sub-irrigating, the irrigation water plus fertilizer is periodically pumped on to the ebb and flow bench and then drained away after a specified period. Along with irrigation and high humidity, providing a light source and temperature control helps promote the rapid germination of strong, healthy transplants. Excessive temperatures often encountered in summer can reduce germination of some lettuce varieties. After germination and for the duration of the propagation period, light levels and temperature (77°F) may be increased.

Ebb and flow benches used for seedling propagation.

Seedlings are usually allowed to grow for two to three weeks prior to transplanting.

Production systems

A discussion of hydroponic production systems is complicated by the number of different techniques that can be used and whether they are open or closed; continuous flow (active) or static (passive); liquid or aggregate. Production of plants in artificial soil or soilless mixes commonly used in greenhouse or nursery production, including the tobacco float system, is technically not hydroponics since the potting medium provides some nutrition.

Hydroponic lettuce is commonly produced using either the nutrient film technique (NFT) or the floating raft method, both as closed systems. A closed system is one in which the surplus nutrient solution is recovered after use and then recycled through the system. This requires monitoring and adjusting the solution so that depleted nutrients can be replenished and the solution sterilized prior to circulating through the system again. In contrast, the nutrient solution in an open system is not recovered and recycled.

Floating Raft

Seedlings are inserted into holes in a platform or raft that is generally made of Styrofoam. Rafts may be small enough to support an individual plant or large enough for multiple plants. Roots from the plants grow into the nutrient solution as the raft floats directly on top of it. Air is pumped into the solution to provide the necessary oxygen for healthy root development.

Nutrient Film Technique (NFT)

Plants are placed through holes along a plastic pipe (e.g. PVC pipe), tube, or closed trough (channel) so that only the roots extend inside. Standard channel length does not exceed 12 feet. A shallow stream of nutrient solution constantly flows over the bare roots within the pipes. The recommended flow rate is between 0.26 and 0.53 gallons per minute. The pipes are placed on a slight decline (1-3%), generally at bench height. The nutrient solution is introduced to the head of the pipes where it flows by gravity to the lower end, is collected, and recirculated.

Nutrient solutions

There are numerous nutrient solution recipes available for hydroponic systems. Nutrients can be purchased as a ready-to-mix product or growers can prepare their own solutions based on a standard or modified formula. In most systems, two nutrient tanks are required: one to supply the calcium nitrate and the other for the remaining nutrients. These two solutions mix as they are injected into the irrigation line. Hydroponic nutrient solutions lack the buffering capacity of soil, so the solution pH can change during production. The pH, along with oxygen levels, soluble salts and temperature, need to be closely monitored.

Pest management

Sanitation is the key to maintaining a disease-free system. The most devastating disease problems occur in hydroponics when a water mold (e.g. Pythium or Phytophthora) or other water-borne pathogen is introduced into the system. Water molds have motile spores that can quickly spread to all the plants within a recirculating system. Since there are no fungicides registered for controlling these pathogens on greenhouse lettuce, this type of disease outbreak can result in complete loss of the crop. The solution tanks will have to be drained and all equipment must be cleaned with a bleach solution or other disinfectant before planting subsequent crops. If the infection originated in the germination area, those benches and systems will also have to be thoroughly disinfected.

Other diseases that can occur on greenhouse lettuce include Botrytis gray mold, powdery mildew and downy mildew.

Greenhouse pests of particular concern are aphids, thrips, whiteflies and mites. Taking steps to prevent insects and mites from entering the greenhouse is the first step to controlling infestations. The use of insect screening on the sidewalls (if sidewall ventilation is used) and other entry points can help in this regard.

Plants should be inspected daily for signs of disease, insects and mites. There are very few pesticides labeled for greenhouse production of these crops, so preventative management and early detection of pest and disease problems will be crucial.

The nutrient solution provides an ideal location for algal growth. Since algae thrive in wet, well-lit sites, shading solution tanks can inhibit their growth.

Harvest and storage

Hydroponic lettuce is generally harvested with the roots attached. Excessively long roots may be trimmed or wrapped around the lower stem prior to packing. Leaving the roots intact provides a longer post-harvest storage life; plants can stay fresh for two to four weeks under the proper storage conditions (near freezing temperatures and high humidity). Because there is no soil involved, the plants remain clean and do not require washing. Plants can be packaged individually or in bulk, depending on the market demand.

Labor requirements

Labor needs per 3,000-square foot greenhouse with eight turns (harvests) may average about 1,500 hours per year, or slightly more than 180 hours per turn.

Economic Considerations

Greenhouse production requires a significant start-up cost, as well as demanding labor and management. Initial investments include greenhouse construction, production system costs and equipment. The cost of a production-ready greenhouse, excluding land costs, can exceed $10 per square foot. A well-run hydroponics operation can have gross returns of $10 to $25 per square foot of production space for the season, depending on crop quality and market.

Initial investments include greenhouse construction and equipment purchases as well as purchase of seed and other inputs. Higher marketing and packaging costs may be expected for producing hydroponic herbs and greens for premium markets.

Hydroponic lettuce production budgets from The Ohio State University were modified in 2016 to reflect Kentucky production scenarios. Breakeven costs for a 3,000-square foot greenhouse with eight turns (harvests) per year and 5,900 marketable heads per turn were estimated at $0.74 per head for variable costs and $0.19 per head for fixed costs. This equals a breakeven price above all costs, including operator labor time, of about $0.93 per head.

Hydroponics production can vary considerably by operation and market. Because of variations in greenhouse size and construction materials, as well as packaging and marketing used, producers should develop budgets specific to their situation.

Selected Resources

- Aquaponics – Integration of Hydroponics with Aquaculture (ATTRA, 2010) https://attra.ncat.org/attra-pub/summaries/summary.php?pub=56
- Opportunities in Hydroponics (Purdue University, 2016) https://vegcropshotline.org/article/opportunities-in-hydroponics-3/
- Controlled Environment Agriculture (Cornell University) http://www.cornellcea.com/
- Floating Hydroponics Greenhouse (Cornell University) http://horteng.envsci.rutgers.edu
- Hydroponic Crop Program: Economic Budgets (Ohio State University) http://u.osu.edu/greenhouse/hydroponic-crop-program-economic-budgets/
- Hydroponic Systems (Kansas State University, 1997) https://www.ksre.k-state.edu/historicpublications/pubs/MF1169.pdf
- Hydroponics (Oklahoma State University) http://osufacts.okstate.edu/docushare/dsweb/Get/Document-6839/HLA-6442web.pdf
- Hydroponic Vegetable Production (Texas A & M, 2005) http://aggie-horticulture.tamu.edu/greenhouse/hydroponics/index.html
- Market Analysis of Hydroponic Lettuce in the Nashville Region (University of Tennessee, 2002) http://www.hort.vt.edu/ghvegetables/documents/Economics/Reference%20Other/TN%20lettuce%20study.pdf

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Reviewed by Petrus Langenhoven, Horticulture and Hydroponic Crop Specialist, Purdue University
Photos courtesy of Petrus Langenhoven **September 2016**