Great Lakes Fruit, Vegetable & Farm Market EXPO

Michigan Greenhouse Growers EXPO

December 9 - 11, 2014

DeVos Place Convention Center, Grand Rapids, MI

Greenhouse Vegetable Production

Tuesday afternoon 2:00 pm

Where: Gallery Overlook (upper level) Room A & B

MI Recertification credits: 1 (1B, COMM CORE, PRIV CORE)
CCA Credits: NM(0.5) CM(1.5)

Moderator: Paul Gross, Extension Educator, MSU Extenson, Mt. Pleasant, MI

2:00 pm	Trends in Specialty Greenhouse Vegetable Crops
	• Bob Hochmuth, Suwannee Valley Agricultural Extension Center, Univ. of Florida
2:45 pm	Greenhouse Production Systems
	• Bob Hochmuth, Suwannee Valley Agricultural Extension Center, Univ. of Florida
3:15 pm	Fertilization of Greenhouse Vegetables
	• Shubin Saha, Horticulture Dept., Univ. of Kentucky
4:00 pm	Session Ends

Trends in Specialty Greenhouse Vegetable Crops

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Introduction

A significant greenhouse vegetable industry has flourished in Florida for almost 25 years. During the decade from 1991 to 2001, the fresh fruit and vegetable protected agriculture industry was nearly exclusively greenhouse-grown vegetables and herbs. Results on acreage reported in the University of Florida surveys indicated greenhouse vegetable and herb acreage was 66, 58, and 95 acres in 1991, 1996, and 2001 respectively. Greenhouse vegetable acreage grown during the decade between 1991 and 2001 began to show crop diversification: while tomato, cucumber, and lettuce were more popular in the early part of the decade, acreage of alternative crops such as pepper, fresh herbs, and strawberry began to become much more important by 2001.The most recent survey was conducted in 2013 and compiled with the data from 240 grower operations in Florida. The results of the 2013 survey documented a significant expansion of the industry in terms of both size and scope. The scope of the entire protected agriculture industry in 2013 was documented to be at least 386 acres of all types of protected agriculture structures and systems. The 2013 survey documents the high level of crop diversification that has evolved in protected agriculture in Florida since 2001. Crops that were popular in protected agriculture in the decade from 1991 to 2001 are still popular today. Those crops include tomato, pepper, lettuce, cucumber, and basil. However, the survey results show significantly higher acreage of blueberry, strawberry, microgreens, specialty leafy greens, herbs other than basil, and specialty root crops (beets, radish, and carrot). Much of the recent expansion of the greenhouse hydroponic industry in Florida is a result of small farmers seeking to enter the marketplace with locally grown fresh produce. The marketing strategy for local sales generally means a small grower needs to produce a variety of crops, rather than one or two for a larger wholesale market. Direct sales to consumers are generally higher when the grower has a mix of crops to sell at the market. Several crops other than the "big three" (tomato, cucumber, and lettuce) are being successfully grown and marketed now, and the University of Florida is continuously evaluating others. This paper discusses some of the alternative or specialty crops being grown and marketed, other than traditional greenhouse tomato, cucumber, and pepper. The discussion will, however, include nontraditional or specialty types of the "big three."

Mini Cucumber

Mini cucumber, also known as Beit Alpha or Persian type are smaller than the standard European seedless cucumber and have become a popular new crop (http://edis.ifas.ufl.edu/cv277). The Beit Alpha cucumber is relatively new to the United States and is the main cucumber type grown in Israel and Spain and exported to Europe. There is also extensive production in Mexico and Canada. The Beit Alpha cucumber originated in Israel but is now being sold throughout the world. Beit Alpha cucumbers are gynoecious (all female), parthenocarpic (develop fruit without pollination) hybrids, and they have a gene for flower clustering, which means many fruit set at each internode. The fruit is seedless and has a thin skin like the traditional longer European cultivars. It does not require plastic shrink wrapping to prevent dehydration after harvest. Many consider the flavor as tops among all fresh cucumber types. Fruit are harvested at a very immature stage for highest quality. This is a major advantage in the cost of postharvest handling and marketing. Fruit production is prolific for Beit Alpha cultivars; many of the small fruits are set on each node and on the laterals. Beit Alpha cultivars grow well under extreme environmental conditions,

especially under the high temperatures (90°F–95° F) common much of the year in Florida greenhouses. These cucumbers are sensitive to low temperatures, especially in the seedling stage.
The University of Florida has conducted several production and postharvest trials in Gainesville, Citra, and Live Oak. Several cultivars have produced very high marketable yields, equivalent to and occasionally higher than standard European cucumber types. Most Beit Alpha types produce fruits 5–8 inches in length. The specific fruit size is important in certain ethnic markets. Management of powdery mildew was a primary production challenge in the past. Most early released cultivars were very susceptible to the disease; however, newer releases have excellent tolerance. Several cultivars have been evaluated at the Suwannee Valley Agricultural Extension Center near Live Oak, and Horticultural Sciences faculty members in Gainesville have evaluated a dozen others. Cultivars such as 'Manar' and 'Jawell' have consistently performed well.

Lettuces and Other Leafy Green Vegetables

The traditional greenhouse lettuce crop in Florida and elsewhere is a bibb-heading type normally grown in NFT channels or in a floating system. The product is usually sold as a "living plant" with the roots still attached and packaged in a bag or special plastic clam shell. Lettuce is also produced for baby greens and salad types. Lettuce is a fast-growing crop, typically taking 30–35 days from seeding to harvest. Growing lettuce in the warm season in Florida makes the disorder known as leaf tip burn more difficult to manage. Environmental controls for temperature, light, cultivar selection, and good calcium nutrition are all critical to properly managing leaf tip burn. Even though demand for bibb lettuce is still very high, there are new opportunities for greenhouse and outdoor hydroponic growers to see other specialty leafy green vegetable crops, especially at local upscale markets. Recent educational programs in Florida have connected growers with restaurant chefs. These programs revealed great interest among chefs to purchase specialty salad greens and fresh herbs. Developing production systems and timing production schedules for these markets can be very challenging. Many small hydroponic growers whose crops grow inside greenhouses, high tunnels, under shaded structures, and even outdoors in Florida are producing several specialty lettuces and other leafy greens to be sold directly to consumers on the farm and at local farmers markets. In these cases, a wide variety of colors and lettuce types have become popular, including loose leaf, romaine, and summer types. In addition to lettuce, many growers report great demand locally for other leafy greens, such as Swiss chard, spinach, kale, and mustard.

Culinary Herbs

In the last two decades, there has been a dramatic increase in greenhouse herb production in Florida, from virtually none in 1991 to nearly 17 acres in 2013. The most popular herb now grown in Florida greenhouses is basil; however, dozens of other herbs are also being grown, including chives. Herbs have a long history of human use. In ancient times, as well as today, herbs were used for medicinal, cosmetic, and culinary purposes. The demand for fresh-cut herbs is expected to continue to increase, in part because of health-conscious consumers and increasing consumption of ethnic cuisine. Greenhouse production of herbs offers several production and market advantages, including more rapid plant growth, the ability to provide specific cultural and nutritional requirements, wintertime production when market prices are highest, and a clean product. The clean hydroponic product may not require washing prior to shipment, which contributes to a longer shelf-life and a high-quality appearance. Quality was rated as the most important factor in selecting herb suppliers by 78% of herb buyers responding to a national survey.

Baby Squash and Squash Flowers

Mini or "baby" vegetables have become increasingly popular items for restaurant chefs and retail sales. Squash (*Cucurbita pepo*) are generally cultivated in open fields where climate, insect, and disease pressures create challenging conditions for growers and shippers who produce and market this delicate, immature fruit. Squash cultivars, including zucchini, yellow summer, patty pan/scallop, and cousa, can be

grown hydroponically in a greenhouse. Squash are graded as "baby" when they are less than 4 inches in length for zucchini, yellow summer, and cousa and less than 1.5 inches in diameter for round and patty pan/scallop. The use of commercially available bumble bees is important for good pollination and uniform shape. Zucchini produce between 16 and 25 baby-sized fruit per plant. Yellow summer squash have produced more than 45 baby fruit per plant in University of Florida trials. Patty pan/scallop squash production ranged from 50 to 67 baby-sized fruit, and cousa produced approximately 30 baby-sized fruit per plant. Squash plants can produce numerous high-quality baby-sized fruit when grown hydroponically in a reduced pesticide greenhouse environment where they can be harvested, packaged, and distributed to buyers daily.

Specialty Cut and Edible Flowers

As consumers demand highly specialized crops, greenhouse producers should consider meeting these needs. Often the local market demands crops in a condition or at a time that can only be met by using the protection of a greenhouse. Among these specialty crops being grown on small commercial acreage in Florida, primarily for local sales, are fresh-cut flowers and edible flowers. University of Florida efforts near Live Oak have been successful in refining a production system for cut flowers similar to that used for vegetables. This project evolved out of greenhouse vegetable growers wanting to produce other profitable greenhouse crops and diversify their offerings at local markets. The crops that have the most potential are those specialty cut flowers that are difficult to ship from other larger, distant production areas. These include flowers such as zinnia, snapdragon, sunflower, delphinium, stock, dianthus, and lisianthus. Small growers in Florida have been successful in producing top-quality flowers targeting local sales at both farmers markets and florists.Edible flowers can be good companion crops for local greenhouse growers, especially herb producers. Although the demand is small, the value is high and the opportunity to provide high-quality edible flowers to chefs in urban Florida restaurants is great. Postharvest handling and packaging are very important in successfully adding edible flowers to a grower's list of specialty crops. Vertical production (Verti-Gro®) of these has been highly successful in trials at the Suwannee Valley Agricultural Extension Center near Live Oak. Edible varieties of nasturtium, viola, stock, and marigold have all been successfully produced in trials at Live Oak.

Microgreens and Baby Greens

Frequently called "vegetable confetti," microgreens (http://edis.ifas.ufl.edu/hs1164) are young, tender greens that are used to enhance the color, texture, or flavor of salads, or to garnish a wide variety of main dishes. Harvested at the first true leaf stage and sold with the stem, cotyledons (seed leaves), and first true leaves attached, they are among a variety of novel salad greens available on the market that are typically distinguished categorically by their size and age. Sprouts, microgreens, and baby greens are simply those greens harvested and consumed in an immature state. Based on size or age of salad crop categories, sprouts are the youngest and smallest, microgreens are slightly larger and older (usually 2 inches tall), and baby greens are the oldest and largest (usually 3–4 inches tall). The crops used for microgreens usually do not include lettuces because they are too delicate and wilt easily. The kinds of crops that are selected for production and sale as microgreens have value in terms of color (like red or purple), unique textures, or distinct flavors. In fact, microgreens are often marketed as specialty mixes, such as "sweet," "mild," "colorful," or "spicy." Certain crops of microgreens germinate easily and grow quickly. These include cabbage, beet, kale, kohlrabi, mizuna, mustard, radish, Swiss chard, and amaranth. At least 80–100 crops and crop varieties have reportedly been used for growing microgreens. Others that have been used include carrot, cress, arugula, basil, onion, chive, broccoli, fennel, lemongrass, popcorn, buckwheat, spinach, sweet pea, and celery. The commercial marketing of microgreens is mainly targeted toward restaurant chefs or upscale grocery stores. Microgreens are ready for harvest when they reach the first true leaf stage, usually at about 2 inches tall. Time from seeding to harvest can vary greatly by crop from 7 to 21 days.

Specialty Cultivars of Solonaceous Crops (Pepper, Tomato, and Eggplant)

Colored peppers and beefsteak or cluster tomatoes are considered traditional greenhouse vegetable crops. These crops, along with their relative, eggplant, can also provide alternative crop opportunities for small greenhouse growers if nontraditional cultivars are used. Such examples being produced in Florida include heirloom tomatoes, hot or other specialty peppers, and unusual types of eggplants. In some cases, producing specialized varieties of many vegetable crops in the field can be very difficult because of diseases, insects, or weather problems. The controlled greenhouse environment may create opportunities to produce specialty crops, like heirloom tomatoes, off-season specialty pepper, or tender eggplant varieties. These are typically opportunities for small and more specialized greenhouse operations. Heirloom tomatoes are in very high demand among upscale restaurants and local direct-to-consumer markets. These highly perishable fruit command high prices of $3–$6 per pound in certain markets. However, heirloom tomatoes are very challenging to grow because they have limited or no disease tolerance, are very susceptible to cracking, have relatively low yields, do not set fruit in very high temperatures, have highly variable fruit quality, and are difficult to prune and train to a production system. These production challenges create an advantage to the excellent growers who can better manage these difficulties. Other specialty tomato types being grown include grape, cocktail, cherry, and cultivars with varying colors of all types.

Greenhouse peppers are generally sold as a large bell pepper, typically red, yellow, or orange in color (http://edis.ifas.ufl.edu/hs228). However, many other specialty peppers can easily be grown in protected culture (Figure 33). Recently, there has been an increase in pepper production under open-shade systems (http://edis.ifas.ufl.edu/hs368) to extend production well into the heat of Florida's summers. This system has mainly been used to extend the season for green bell peppers. Colored peppers seem to require more environmental controls as provided by the shelter of greenhouses or high tunnels. Local demand for specialty peppers seems highly variable in the state, but examples of specialty peppers that are gaining popularity include poblano, jalapeno, cubanelle, hot Datil, unusual sweet types, and small colored types.

Eggplant is not normally considered a greenhouse crop. However, in diversified operations, eggplants have found a place among the offerings. The types being grown are slender, long, mild fruit types or ones with unusual colors or color patterns. Eggplants have higher light requirements for fruit set but can tolerate high temperatures.

Summary

The eye-appealing combinations of fruit size, color, and shapes among tomato, pepper, and eggplant at local market displays make this group of traditional crops very nontraditional and popular among consumers. Many small operations have been successful with a crop diversification approach when selling directly to consumers at farmers markets or other retail markets. High-quality greenhouse tomato, cucumber, or pepper accompanied by lettuce, cut flowers, baby squash, strawberries, herbs, and specialty leafy greens and other vegetables can make a great crop mix at a local market for a small but talented greenhouse grower. For additional reading on many of the crops being researched and grown in Florida greenhouses, see (http://smallfarms.ifas.ufl.edu/crops/hydroponics/index.html) and (http://www.hos.ufl.edu/protectedag/index.htm).

Greenhouse Production Systems

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Introduction

There are numerous production systems currently being utilized worldwide by commercial greenhouse vegetable producers. Among the more important include lay-flat bag or upright container culture, trough culture, rockwool, vertical culture, nutrient film technique (NFT), aeroponics, and ground (in-soil) culture. Many modifications of these basic production systems are presently being utilized and most are appropriate for vegetables and herbs in Florida, except unamended non-fumigated ground culture in permanently fixed greenhouses due to soil-borne insect, disease, and nematode problems (http://edis.ifas.ufl.edu/cv263).

All greenhouse production systems require the use of similar environmental controls, shade structures, support wires, and general production practices. The major differences would be in the irrigation and nutrient delivery methods and controls. Individual production systems are not necessarily crop specific, but several are often associated with certain crops. All of the major greenhouse vegetable crops can be grown successfully in most systems mentioned above.

During the decade from 1991 to 2001, the fresh fruit and vegetable industry using protected agriculture was almost exclusively involved in greenhouse-grown vegetables and herbs. Acreage reported in the University of Florida surveys indicated greenhouse vegetable and herb acreage was 66, 58, and 95 acres in 1991, 1996, and 2001, respectively. The primary protected agriculture structures used during that period were either fan and pad or passively ventilated greenhouses. Most crops were grown using soilless media such as perlite, rockwool, and peat-based soilless mixes, or other hydroponic systems like nutrient film technique (NFT).

University of Florida Extension faculty, allied industry representatives, and growers identified the need to assess the size and scope of the protected agriculture industry in 2013 by surveying growers in Florida. The task of developing the survey instrument was much more difficult in 2013 than in previous survey years because the industry had greatly diversified in several categories, including crops being grown, types of protected structures being deployed, and the types of soil-based, soilless, and other hydroponic production systems being implemented. The types of structures were determined to fall in one of the following categories: high tunnels, fan and pad ventilated greenhouses, passively ventilated greenhouses, shade houses, retractable roof structures, and those with no permanent structure or with temporary freeze protection covers. Production systems were determined to fall into one of the following categories: native soil, amended native soil, NFT, floating systems, lay-flat bags filled with soilless media, upright containers filled with soilless media, in-ground trench systems filled with composted pine bark, vertical systems filled with soilless media, or other miscellaneous systems.

The primary focus of the 2013 survey was to document the types of protected agriculture structures, crops, and growing systems being used. In addition, secondary information on location of operations, pest concerns, expected expansion, etc. was collected on many operations. This survey did not include transplant, bedding plant, nursery, or cut flower production.

The survey was compiled with the data from 240 grower operations in Florida (http://edis.ifas.ufl.edu/hs1240). Responses were received from every region of the state, but more operations were reported from south of the Interstate 4 corridor than from north of Interstate 4 (152 versus 88). The scope of the entire protected agriculture industry in 2013 was documented to be at least 386 acres of all types of protected agriculture structures and systems. It is estimated there could easily be an additional 10-20% more protected agriculture acreage, mostly smaller operations, than what was confirmed in the survey due to the difficulty in locating all operations in Florida.

The variety of soil or soilless media choices being used was as diverse as the crop mix in 2013. The largest acreage category was native soil or amended native soil, with 164.18 acres. Large blueberry acreage under high tunnels were typically grown in a pine bark amended native soil or a raised pine bark bed. Much of the field strawberry acreage under tunnel was grown in native soil using the standard plastic mulched bed system. Other crops grown in native soil under high tunnels included tomato, basil and other herbs, and mixed vegetables.

Soilless media choices included single-product materials as well as a variety of product mixes. The most common single soilless media materials were coconut fiber, composted pine bark, and perlite. Soilless mixes were quite varied, with combinations including two or more of the following materials: coconut fiber, peat, perlite, composted pine bark, and vermiculite. Soilless media systems included the following acreage: lay-flat bags (7.81 acres), upright containers (63.96 acres), and open trough (12.28 acres). In some hydroponic systems, only a liquid culture was used. These systems primarily included NFT (5.64 acres) and floating systems (1.75 acres). An additional 16.55 acres of space utilized other types of production systems not in the above categories, including microgreen trays and recirculating systems, ebb and flow, and other miscellaneous or undescribed systems

Bag or Container Culture

Bag culture is a production system where greenhouse vegetables are grown in a soilless mix contained in a polyethylene bag. The bag can be sealed around the mix or it can be an open bag. The closed bags are laid flat on the greenhouse floor with plants growing from planting holes cut along the upper surface of bag after it is laid flat in place. These are called "lay-flat" bags. The nursery container or "upright" bag system involves growing plants in a bag filled with mix. Lay-flat bags contain the media, usually peat-based mixes, perlite, coconut coir or rockwool, in a totally closed bag. Growers can fill their own bags, but most often these bags are purchased filled and prepared. Bags are usually made of 4-mil ultra-violet-light stabilized polyethylene. Bags are typically laid out in double-rows in the greenhouse and the drip irrigation lines are installed. Depending on the size of bag and volume of mix, a few or several tomato plants can be accommodated in each lay-flat bag. Plants are produced in peat/vermiculite mix or rockwool cubes and transplanted into the bags. An alternative is to grow transplants in "bottomless" or mesh-bottom pots filled with media, which are set into the bags. Drainage slits are needed in the bottom edge of the bags so that excess solution can be removed. This is one problem with bag culture because methods are

needed to collect excess fertilizer solution so that it does not leach into the soil under or around the greenhouse.

The use of upright containers, such as upright bags, Bato buckets or nursery pots, has become increasingly popular in Florida. Commonly used media for the containers includes: peat mixes, composted pine bark, coconut coir, perlite, or various mixtures. Recently, composted pine bark and coconut coir have become popular media choices in Florida because they are readily available and economical options. Bags and nursery pots can be purchased at greenhouse supply houses. The containers are filled with the desired media and placed in single or double rows in the house, depending on the crop. Transplants are produced in a soilless mix, such as peat/vermiculite/perlite, rockwool, or foam cubes and then transplanted into the containers.

Trough Culture

Alternatives to native soil or ground culture include methods to grow plants in raised troughs or benches above the soil. The troughs are filled with the same types of soilless mixes as in the bag culture system. Trough culture is less common in Florida greenhouses, however there are a few operators using media-filled troughs for tomato culture. Growers are finding innovative modifications of trough culture to take advantage of the economical media choices. One modification uses a trench formed in the soil, covered with nursery fabric, and filled with media such as composted pine bark (http://edis.ifas.ufl.edu/hs1204).

Troughs are filled to the top with the chosen soilless mix and wetted. Some settling will occur and additional mix should be added. Additional mix will be needed between crops to replace that which oxidized or settled during the previous crop. Reusing the media in the troughs year after year comes with some risk of increasing soil borne diseases and other problems, including weeds if the protected structure is not enclosed. Very few treatments are available to manage certain diseases and other pests. Solarization of the media in the trough between seasons in the summer may be an option in some cases. Irrigation systems, including emitter stakes, and drainage systems will need cleaning and disinfesting between crops as well. The major advantages of the trough system include ease of handling once the system is in place. Trough systems are flexible for various cropping decisions e.g., vegetables, cut flowers, etc. The system is relatively inexpensive to maintain from one crop season to another. The major disadvantage would be in disease control in a particular trough.

Vertical Culture

During the late 1990s and since, hydroponic growers in Florida have greatly increased the use of a wide variety of vertical growing systems. These systems are being used in all types of protected culture structures including greenhouses, high tunnels, shade structures; but are also widely being used in open outdoor systems. For the purposes of this article, we will include vertical systems having pots that stack on top of each other, bags or other containers that are mounted in a vertical arrangement, and various plastic (PVC) systems that are used in an aeroponic culture. The various materials, designs, expense, methods of operation, and risk are widely diverse for vertical systems that are soilless media based or aeroponics based. The most widely used vertical system design uses polystyrene pots manufactured specifically for this use that interlock and stack on top of each other. These pots are filled with a soilless media such as coconut coir, perlite, composted pine bark or coarse vermiculite. Many of these media alone or in mixes have been used successfully. The nutrient solution is delivered into the top pot and

flows from the top pot through each subsequent pot through drainage holes until it has been delivered to all pots in the vertical stack. Managing the delivery of solution is one of the most important management challenges in vertical culture. The system has proven to be very popular among growers for leafy vegetables, fresh cut herbs, edible flowers, and strawberry, in particular. More recently, production techniques for growing tomato and pepper have been developed and are being used successfully. The idea of a vertical production system does allow a grower to increase the plant population of several crops, including leafy vegetables, in a limited space. Increases in plant population vary from crop to crop, however, most configurations allow for an increase of no more than 5-8 times the normal population. Pots are held on a tower rod or pipe in the center of the pots and can often be rotated to provide more uniform exposure to sunlight. Care should be taken to plan proper spacing between towers and not make the stacks too high so there in not excessive shading of the lower pots. Vertical systems make labor tasks generally easier since much of the work can be done without bending over. If these systems are used outdoors, care must be taken for freeze protection. These upright stacks are very susceptible to freezes since they are well above the ground and cannot easily trap the heat stored in the ground. In areas where freezes are of concern during the growing season, a temporary freeze cloth system or the use of a protected structure will be needed. Since much of south Florida has infrequent freezes, outdoor vertical culture is common.

Nutrient Film Technique

NFT is still a very popular, proven, and successful way to grow several crops, such as: lettuce, specialty leafy greens, basil and other herbs. Transplants for NFT are usually started in rockwool or foam cubes and placed in the channels at proper spacing. Lettuce is particularly well adapted to NFT because it is a short-term crop and less subject to the damage from root rot. Different channel widths are used for lettuce and other larger crops.

Summary

As mentioned earlier, there is no single production system that is best for everyone. In comparing the most popular systems (lay-flat bag, upright container, vertical, rockwool, and NFT), one would find that the installation cost of the bag or container system would be roughly comparable but rockwool and bags will need to be replaced periodically in those systems. The initial set up cost for vertical systems and NFT will be higher, but lower annual costs after set up. The total production of the major systems can be extremely high depending on the level of management. This management level is higher for the NFT and vertical systems as opposed to the lay-flat bag or upright container cultures. In selecting a production system, a grower should weigh both the advantages and disadvantages as they relate to the individual's situation, crop selection, and time management concerns.

More Information

For more information on greenhouse crop production, please visit our website at (http://smallfarms.ifas.ufl.edu).