Greenhouse Protected Agriculture of Vegetable Crops at the University of Florida: An Overview

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Abstract: The Florida vegetable industry relies heavily on plasticulture technologies from the transplant nursery through the packing house and market chain. The value of the Florida vegetable industry has consistently risen while the acreage has declined for many commodities. The use of greenhouse technologies for high-valued crops is an alternative method of crop production that would compliment the current industry while answering several of the many challenges that have caused acreage to decline. Greenhouse protected agriculture technology allows production in less desirable locations using sustainable irrigation methods and low use of chemicals via integrated pest management methods. The University of Florida Protected Agriculture Project researches the process of greenhouse vegetable production with key focus for Florida growers.

Keywords: polyethylene, soilless culture, biological control, sustainability, fertigation

Introduction

Florida accounts for the second largest U.S. state for annual cash receipts of fresh market vegetables, following only California. In 2005-2006, vegetable crops, including potato, melon, and strawberry, were produced on 218,000 acres and valued at $1.9 Billion (FDACS, 2007). The annual Florida Agricultural Statistical Directory (FDACS, 2007) does not include greenhouse vegetable crops. In 2003-2004, there were approximately 30 ha of vegetable greenhouses operating in Florida (Tyson et al., 2004). There may be less than 20 ha in operation today after the hurricanes of 2004 (Charley, Francis, Ivan, and Jeanne) (Mitchell and Cantliffe, 2005) and 2005 (Wilma) that caused catastrophic damage to several locations. Nevertheless, protected agriculture of vegetable crops, using plasticulture systems, including greenhouses, is a viable alternative for traditional crop production.

The Florida vegetable industry involves intensive production practices that are now faced with several major challenges including 1) the loss of the soil fumigant, methyl bromide; 2) increased regulation of water, fertilizer, and pesticide inputs; 3) increased urbanization and loss of warm production land in southern/coastal Florida; 4) continued challenges from weather, including freezes, winds, and rain; and 5) the broad focus of regional and global market competition (Cantliffe et al., 2001). New cultural technologies are needed for Florida growers to remain competitive.

Plasticulture with soilless cultural systems could address several of the serious challenges facing the vegetable industry in Florida and could provide a new foundation for Florida producers. Some plasticulture technologies currently exist but need to be evaluated and refined for use in Florida. Already, this technology is in use in several places around the world, including Israel and other Mediterranean countries, several Far East countries (China, Korea, Japan), Canada, and Mexico. These countries face some of the same challenges as does the Florida vegetable industry. The University of Florida Protected Agriculture Project (UFPAP) initiated hydroponic, vegetable research in a high-roof passively-ventilated greenhouse in spring 1999 (Gainesville, FL). The UFPAP focuses on research that targets the challenges faced by Florida producers and provides the initiative to adopt this exciting new
agricultural business endeavor. This paper will briefly review the research conducted at the UFPAP (see website for complete publications and current reports: http://www.hos.ufl.edu/protectedag).

**Methods and Materials**

Research during 1999-2003 was conducted at the Horticultural Unit, Gainesville, FL. The 0.20 ha greenhouse was a passively-ventilated design with 3.6 m high sidewalls and a 1.2-m roof vent at 6 m for a total floor to roof peak of 7.2 m (Top Greenhouses, Ltd, Barkan, Israel). From Oct. 2003 until the present, experiments were conducted in similar structures located at the UF Plant Science Research and Education Center in Citra, FL. The 0.41 ha greenhouse had sidewalls 4.2 m high and a 1.5-m roof vent located at 4.2 m for a total roof to floor peak of 5.7 m (Top Greenhouses, Ltd). Both structures were covered with anti-condensate polyethylene plastic (Ginegar Plastic Products, Ltd., Kibbutz Ginegar, Israel), however, the first structure was covered with a double layer while the latter was a single layer. All sidewalls and roof vent openings were covered with 0.6-mm anti-virus insect screen (Klaymen Meteor Ltd., Petah-Tikva, Israel) to prevent the movement of insects (pests and beneficials) into or out of the greenhouse.

Experiments have included: cultivar trials of tomato (Rodriguez et al., 2001), pepper (Shaw and Cantliffe, 2002), melon (Mitchell et al., 2007; Shaw et al., 2001), cucumber (Shaw et al., 2007c; Shaw and Cantliffe, 2003; Shaw et al., 2000), squash (Shaw and Cantliffe, 2005), strawberry (Paranjpe et al., 2003b), datil pepper (Shaw et al., 2007a), and blueberry; media trials have compared perlite, peat-mix, and/or pine bark for strawberry (Cantliffe et al., 2007a; Paranjpe et al., 2003a), pepper (Jovicich and Cantliffe, 2001), melon (Rodriguez et al., 2006; Shaw et al., 2007b) and cucumber (Shaw et al., 2004b); water and fertilizer use has been compared for strawberry (Cantliffe et al., 2007a), pepper (Jovicich and Cantliffe, 2001; Jovicich et al., 1999), melon (Rodriguez et al., 2005), and cucumber (Jovicich et al., 2007b); plant densities were compared for strawberry (Paranjpe et al., 2003c), pepper (Jovicich et al., 2004b), and melon (Rodriguez et al., 2007); cooling studies with fog and aluminized shade were reported in pepper (Cantliffe et al., 2007b); recycling/sanitization of irrigation water in pepper; (Saha and Cantliffe, 2007); several species of biological control insects have been researched on various crops (Jovicich, 2007a; Jovicich et al., 2004a; Rondon et al., 2004a,b,c); and economic feasibility of pepper (Jovicich et al., 2005), melon (Shaw et al., 2007b; Shaw et al., 2004a), cucumber (Webb, 2007), and strawberry (Paranjpe et al., 2004) when grown in a passively-ventilated greenhouse.

For all crops excluding strawberry, plants were grown in lay-flat polyethylene bags, 3-gal nursery containers, or bato buckets filled with either perlite or pine bark. Strawberry was produced in rigid, plastic hanging troughs (Cantliffe et al., 2007a) using primarily pine bark, but also, peat-mix, perlite or coconut coir. Plants were irrigated with individual pressure-compensating emitters (Netafim USA) or in the case of strawberry, drip-tape (Chapin Watermatics, Inc.). Plants received a complete nutrient solution with every irrigation. Irrigation volume and nutrient concentrations were based on plant need. At the current location in Citra, all leachate is collected, sanitized, filtered for organic particulates, balanced for EC and pH and recycled to the crops. The majority of the irrigation scheduling was performed by time, however, the ability to irrigate based on solar radiation is more efficient and was used during some experiments.

During the first year, insect pests and diseases were managed with chemical applications. However, few chemicals exist that can be applied on greenhouse crops and more so, uniform application is difficult in the dense plant canopy. Integrated pest management strategies were quickly adopted and solely practiced since 2003. Beneficial insect populations can be increased with the use of banker plants (Osborne and Barrett, 2005) and are highly recommended for aphid, whitefly and mite control. Many species of biological control insects are available commercially as well as the occurrence of native populations (Osborne et al., 2004).
Results and Discussion

From the research at the UFPAP, several new crops and production technologies have been introduced to the U.S. The Galia muskmelon and Beit Alpha (BA) cucumber, both crops developed and widely grown in Israel and exported to Europe, can be successfully grown in a passively-ventilated greenhouse in Florida. There is more than one acre of BA cucumber in production in Florida and an unknown amount in Canada and Baja California, Mexico. These sweet, seedless, mini-cucumbers are now found in many supermarkets and are sure to become a consumer staple (Shaw et al., 2007c). Galia muskmelon was developed for dry-land farming and grows poorly under Florida’s usual high humidity and daily rainfall patterns. However, when produced under protected culture, Galia can yield more than 5 fruits per plant and potentially gross $1.5 million per acre annually (Shaw et al., 2007b). Improved Galia muskmelon cultivars have been developed which are better suited for shipping and handling (Mitchell et al., 2007), a factor that has prevented this melon from reaching more consumers.

Peppers can be grown using the Spanish-style pruning method which reduces labor time and costs while increasing yields of short-season crops, especially during warm-summer months (Jovicich, 2004b). Additionally, hot peppers, such as the Datil pepper, can be produced in the same fashion which will provide fresh peppers to hot sauce producers year-round (Shaw et al., 2007a).

Several key factors can be identified to achieve a successful pest management program in a protected structure: 1) predators and parasitoids will not eliminate all pests; 2) pest populations must be below threshold levels for beneficial arthropods to be effective; 3) chemical pesticides must be specifically selected in an IPM program as most chemicals which target pests will also kill natural enemies and bumble bee pollinators; 4) beneficial arthropods should be released at planting or prior to pest infestation; and 5) scouting, record keeping, and proper identification of pests, diseases, and biological agents are key to a successful IPM program. Therefore, knowledge of historical pest events, current record keeping, trained personnel, and good communication with researchers and biological control suppliers are required (Cantliffe et al, 2007c).

Plant disease remains the leading drawback for greenhouse vegetable production. Few chemicals are labeled for greenhouse use and many times, phytotoxicity or use of beneficial insects (such as bumble bees) prevents the use of chemicals allowed. Disease resistant cultivars are recommended when available. Prophylactic measures should be taken to help prevent the onset of disease such as structural maintenance of plastic and insect screens, sanitation between crops, removing and properly disposing of diseased plants and maintaining plant health through proper irrigation and nutrient management, as well as controlling the greenhouse environment (temp., humidity, air movement, light, etc.) (Berlinger et al., 1999).

Conclusion

Consumer demand for high-quality, fresh vegetables has dramatically risen over the past 20 years in the U.S. (Pollack, 2001). In order for Florida vegetable growers to compete in a global market, they must effectively evolve with technology. Greenhouse production of vegetable crops in mild-winter climate locations can be an effective tool used by vegetable growers to secure a future of production in Florida.

Literature Cited:


