Proc. Fla. State Hort. Soc. 112:313-315. 1999.

OUTDOOR FLOATING HYDROPONIC SYSTEMS FOR LEAFY SALAD CROP AND HERB PRODUCTION

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Additional index words. *Lactuca sativa*, *Cichorium endiva*, passive, low-tech, non-circulating hydroponics.

Abstract. **An outdoor year-round hydroponic demonstration garden has been maintained at the Seminole County Extension office in Sanford, FL, for the past 3 years. Vegetables, herbs, and flowers were grown in passive, low-tech, non-circulating water culture systems. Most in-season leafy salad crops as well as some herbs and flowers performed well in this floating hydroponic system. Larger plants, such as tomato and pepper were better suited to non-floating, passive hydroponic systems. Successes and failures are described. Replicated lettuce trials were also conducted at the Seminole Community College Horticultural Unit. Five of seven commercial leafy salad crop varieties grown in outdoor passive floating hydroponic growth frames were evaluated to be acceptable to the wholesale produce trade. Because of their simple, low cost design and maintenance, these systems have potential for use by small farmers, u-pick operations, and market gardeners.**

Commercial production of leafy salad crops in a floating raft system has been used in Florida since the early 1980's (Resh, 1998). Ten to twelve crops annually of mostly bibb lettuce are produced in sealed, pad and fan type greenhouses. The high planting density allows production of over 1 million marketable lettuce plants per acre per year; successful marketing can generate between $250,000 to $450,000 per acre in gross revenues.

The main disadvantage of the current commercial system is its high capital cost and the technical expertise necessary to operate. Startup costs of approximately $300,000 per acre can be expected. The system uses concrete or plastic raceways where water is circulated and aerated. Nutrient levels and pH are frequently monitored and adjusted. The startup cost and/or technical expertise can be prohibitive for many entry level farmers.

Passive, low-tech, non-circulating hydroponic systems have been studied at the Asian Vegetable Research Center in Taiwan (Anon., xxxx) and at the University of Hawaii (Kratky et al., 1988; Kratky, 1993, 1996). Additional work with greenhouse vegetable production in Florida showed positive results (Fedunak and Tyson, 1997; Tyson et al., 1998). Since one of the major costs of production is the greenhouse itself, passive hydroponic systems were moved outside and research/demonstrations conducted to determine the feasibility of year-round production in unprotected culture. The objectives of this study were to demonstrate reduction of startup costs, simplify the technical expertise necessary to operate, identify specific crops adapted to this system, and provide a viable option for small farmers, u-pick operations, and market gardeners.

Materials and Methods

At the Seminole County Extension Hydroponic Demonstration Garden growth frames slightly larger than 4 × 8 feet were constructed of 2 × 4, 2 × 6, 2 × 8, and 2 × 10 inch PT (pressure treated) wood. Six mil polyethylene plastic sheets were laid in the growth frames and water was added to a depth of 3, 5, 7, and 9 inches, respectively. The plastic sheets were then stapled to the frame and 1 × 2 inch furring strips were nailed to the frame to secure the plastic.

Additions of nutrients varied but were mostly derived from Masterblend® hydroponic mix, calcium nitrate, and magnesium sulfate added to the growth frames in a ratio of 2-1-1, respectively until the soluble salts measured 2,000 µS/cm. Phosphoric acid was then added until the pH was 5.5. Soluble salts were allowed to fluctuate between 1,000 and 3,000 µS/cm and pH between 5.0 and 7.0 during the growing period.

A 2-inch by 4-foot × 8-foot Styrofoam insulation panel was drilled with a key hole saw making 2 inch holes. Hole spacing varied, but were mostly 12 × 12 inch on the square. Polystyrene panels were used for floats. These panels were ¾ inch thick and were used singly or double layered with holes drilled in a similar fashion as previously described. In addition, perlite filled 4 inch cell size Speedling trays were used in the demonstrations. These three materials were floated in the water filled growth frames. Vegetable and herb transplants were started from seed in oasis cubes and peat pellets and placed in 2 inch net pots or transplanted into perlite filled 3-oz plastic cups and placed in the holes drilled in the panels. Six slits were cut down the side and through the bottom of the plastic cups with a razor knife to allow air and water to enter. Plants for the Speedling trays were grown in a similar fashion as described or purchased from local garden centers and transplanted into the trays with perlite placed around the root ball. Trays were then placed into the float systems.

Randomized trials with 4 replications were conducted in the 2 × 6 inch growth frame comparing lettuce head weight in 2 inch net pots verses perlite filled 3 oz cups (Expt. 1) and 2 inch net pots verses 3 oz cups without perlite (Expt. 2). 'Green Ice' leaf lettuce was transplanted on 2 Sept. 1997 and harvested 30 days later. 'Valmaine' romaine lettuce was transplanted on 15 Apr. 1998 and harvested 35 days later.

On 15 May 1999, thirty six basil plants were transplanted into 2 inch net pots on styrofoam in a 4 foot by 8 foot demon-

Florida Agricultural Experiment Station Journal Series No. R-07216.

stration growth frame and test harvested for commercial potential. Harvest of 4-6 inch terminals began 3 weeks later with a total of 4 harvests conducted at 14 day intervals.

Experiment 3 was conducted at the Seminole Community College Horticultural Unit in Sanford using a growth frame slightly larger than 4 feet by 50 feet constructed of 2 × 6 inch PT wood and prepared similar to the growth frames previously described. The 4 × 8 feet Styrofoam panels with 2 inch holes were used as the floats. Transplants were obtained from commercial varieties grown in the greenhouses of Zellwin Farms, Zellwood, Florida. They were transplanted into 2 inch net pots in the panels in a completely randomized design with 3 replications on 5 Feb. 1998 (Expt. 3). Replication one was harvested on 18 Mar., replication two on 24 Mar., and replication three on 3 Apr. 1998. Marketability ratings were made by seven employees of Zellwin Farms. Three were salesmen, three were farm managers, and one was a former USDA vegetable market inspector.

Results and Discussion

General observations: There were differences in crop response among the three floating panels used. Leafy salad crops and basil performed better in the 2 inch deep styrofoam panels.

The ¾ inch deep polystyrene panels had to be doubled to provide more depth before crops would perform well. The 4 inch deep, perlite filled speedling flats had the most success with a diversity of small rooted crops. These flats were the largest (4-inch cell size) available and provided the most space for root development above the water compared to the other floats. However, leafy salad crop quality was better in the styrofoam panels compared to the speedling flats. Speedling flats are much more expensive than the panels but will last longer. The useful life of the styrofoam, polystyrene, and speedling floats are estimated at 2, 4, and 8 years respectively.

Growth frames of various depths were used to determine maintenance of various water depths (3, 5, 7, and 9 inches) for continued achievement of good results. Crops in the 3 inch deep water performed less consistently whereas no difference in performance was seen between the 5, 7, and 9-inch water depths. As a result, a minimum of 6 inch high frames could be made to reduce startup materials cost compared to taller frames without compromising productivity.

When water, nutrients, and light occur together algae will grow. It is important to exclude light from the growth frames to reduce algal buildup which will compete for nutrients with the crop and sour the water. After growth frames are filled with water and nutrients, additional water and nutrients should be added between multiple crops; however, where algae were successfully excluded, complete water changes were required only every 3 to 6 months.

It is important to follow the recommended vegetable crop planting dates for Florida (Maynard and Hochmuth, 1999) when growing outdoors hydroponically in unprotected culture. Vegetables can be classified as cool season and warm season crops and will respond well or poorly to outside temperatures (Lorenz and Maynard, 1988). For herbs and flowers, temperature, as well as optimum light conditions, will affect growth. Follow seed company recommendations for optimum planting times and growing conditions.

Herbs: Many herbs that benefit from moist growing conditions did well in at least one of the floating panels. Herbs that need dryer growing conditions performed poorly. Four cuttings averaging one pound of marketable basil per harvest were made from a 4 foot by 8 foot styrofoam demonstration panel. Additional trials of mint, rosemary, lavender, chives, cuban oregano, and nasturtium showed potential for good production in speedling flats but not in styrofoam or polystyrene floats.

Experiment 1 and 2: Results of replicated trials comparing 2 inch net pots verses 3 ounce plastic cups in styrofoam float systems showed net pots significantly increased leaf and romaine lettuce head weights (Table 1), irrespective of plastic cups being filled with perlite (Expt. 1) or left empty (Expt. 2).

Experiment 3: Lettuce seed that is marketed for hydroponic production can be expensive; therefore a 3rd experiment was conducted to test the production and marketing qualities of recommended field grown Florida lettuce varieties in outdoor float hydroponics. Results indicated 3 of the 7 varieties (Escarole, Boston, Bibb) were completely acceptable and could have been marketed with Zellwin Farms lettuce (Table 2). Four varieties were partially unacceptable due to being undersized; however, the third replication, harvested 10 days after the ratings were made on the second harvest, indicated that the romaine

Table 1. Lettuce head weight in net pots verses plastic cups.

	Average head wt. (oz)	
	Exp. 1 Leaf lettuce	Exp. 2 Romaine lettuce
Net pots	10.0a[z]	10.2a
Plastic cups	7.0b	8.4b

[z]Mean separation in columns by Duncan's Multiple Range Test, 0.05 level.

Table 2. Outdoor float hydroponics leafy salad crop yields.

Entry	Source	Avg. wt./plant (oz.) by harvest date 3/18	3/24	4/3	Average wt./plant (oz.)
		Days from transplant 41 days	47 days	57 days	
Romaine 'Valmaine'	Orsetti	9.0	15.2	16.5	13.6
Chicory 'Salad King'	Pybas	5.3	10.9	16.0	10.7
Escarole 'NR65'	Pybas	8.0	14.9	16.8	13.2
Boston 'Esmarelda'	Peto	9.1	13.3	12.0	11.5
Green leaf 'Crisp & Green'	C. Valley	5.6	6.4	6.9	6.3
Red leaf 'New Red Fire'	Takii	5.0	6.9	6.9	6.3
Bibb 'Florabibb'	Pybas	8.8	10.9	13.6	11.1

Table 3. Outdoor float hydroponics leafy salad crop marketability ratings.

Entry	Commercially[z]		Color			Size		
	Accept.	Unaccept.	Light	Good	Dark	Under	Good	Over
Romaine 'Valmaine'	4	3		5	2	5	2	
Chicory 'Salad King'	4	3	1	4	2	6	1	
Escarole 'NR65'	7			7		3	4	
Boston 'Esmarelda'	7		2	5			6	1
Green leaf 'Crisp & Green'	4	3	2	4	1	6	1	
Red leaf 'New Red Fire'	4	3	1	4	2	6	1	
Bibb 'Florabibb'	7			3	4		3	4

[z]No. of responses from 7 individual ratings at Zellwin Farms from harvest on 3/24/98.

and the chicory probably increased in size sufficiently to be marketable. The green and red leaf lettuces did not increase in size enough for Zellwin standards. However, for market garden and u-pick operations they would be satisfactory.

Results indicate the potential for commercial production of cool season leafy salad crops and warm season basil in 2 inch styrofoam floating panels. Four inch cell size perlite filled floating speedling flats showed potential for production of short season small rooted herbs and flowers. Additional work needs to be done to fine tune suitable crops and system dynamics to maximize production and minimize costs.

Literature Cited

Anonymous. Xxxx. ATTRA—Appropriate Technology Transfer for Rural Areas. Hydroponic vegetable production: Information package. Fayetteville, AR.

Fedunak C. A. and R. V. Tyson. 1997. Lettuce cultivars for low-tech non-circulating hydroponics. Proc. Fla. State Hort. Soc. 110:384-385.

Kratky, B. A., J. E. Brown and H. Imai. 1998. Observations on a noncirculating hydroponic system for tomato production. HortScience 23(5):906-907.

Kratky, B. A. 1996. Non-circulating hydroponic methods. DPL Hawaii, Hilo, HI.

Kratky, B. A. 1993. A capillary, non-circulating hydroponic method for leaf and semi-head lettuce. HortTechnology 3(2):206-207.

Lorenz, O. A. and D. N. Maynard. 1988. Knott's handbook for vegetable growers, 3rd ed. John Wiley & Sons, New York, NY.

Maynard, D. N. and G. J. Hochmuth. 1999. Vegetable production guide for Florida, SP 170. University of Florida/IFAS Publications, Gainesville, FL.

Resh, H. M. 1998. Hydroponic Food Production, 5th ed. Woodbridge Press Publishing Company, Santa Barbara, CA.

Tyson, R. V., K. W. King, J. M. White and J. A. Gargiulo. 1998. Greenhouse tomatoes in low-tech non-circulating water culture. Proc. Fla. State Hort. Soc. 111:224-226.

Proc. Fla. State Hort. Soc. 112:315-319. 1999.

TOMATO FERTILIZATION, GROUND COVER, AND SOIL NITRATE NITROGEN MOVEMENT

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Additional index words. Ammonium nitrate, sorghum-sudangrass, ryegrass.

Florida Agricultural Experiment Station Journal Series No. N-01766. This project was supported in part by the Florida Department of Agriculture and Consumer Services.

Abstract. **Residual soil nitrate-nitrogen (N) can leach into groundwater in fallow soil, following removal of polyethylene mulch after harvest of fresh market tomatoes, during fall and winter (spring crop) and winter and spring (fall crop). The influence of N rates and ground cover following tomato (*Lycopersicon esculentum* Mill) on soil nitrate-N movement was monitored in spring and fall crops during 1998. Nitrogen rates varied from 0 to 360 lb/acre in the spring crop and from 0 to 600 lb/acre in fall tomato. Ground cover treatments were polyethylene mulch, fallow, and a cover crop. Cover crops were sorghum-sudangrass [*Sorghum bicolor* (L.) Moench] following spring tomato and ryegrass (*Lolium multiflorum* Lem.) following fall tomato. The soil type was an Orangeburg loamy fine sand (Typic Kandiudults, Fine- loamy, Siliceous, Thermic). Yield ranged from 1900 to 2600 boxes/acre in spring tomato, and from 1300 to 2700 boxes/acre in fall tomato. Fertilizer N rates above 180 lb/acre were excessive as shown by yield and residual soil nitrate-N levels. Residual soil nitrate-N was proportional to N application rate. Soil nitrate-N concentration following harvest was highest in the 1 to 3 ft depth range for spring tomato and 2 to 4 ft depth range for fall tomato. Polyeth-**