FISH AND WORMS

DEVELOPING FOOD PRODUCTION SYSTEMS IN POPULATION CENTERS

Greenhouses integrate hydroponics and vermiculture for year-round fruit and vegetable production, such as tomato plants (left).

Project at Saginaw Valley State University in Michigan experiments with aquaponics and vermicomposting to increase food security.

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ACROSS the U.S., as small, local groceries close in the face of competition from large, distant supercenters, more and more impoverished inner city and rural residents live in "food deserts," without access to fresh, affordable food. In 2007, USDA reported that 7 percent of U.S. households suffer from low food security while 4.1 percent of U.S. households suffer from very low food security. A project at Saginaw Valley State University (SVSU) in Saginaw, Michigan, set out to meet these challenges through aquaponics (a combination of hydroponics and aquaculture) and vermicomposting.

In 2003, a pair of experimental greenhouses was developed at SVSU by a multidisciplinary team of faculty, staff and students. Funded by a grant from the Allen Foundation, a Midland, Michigan-based group, the project seeks to identify a cost-effective, year-round means to produce fruits and vegetables locally and organically. The SVSU system incorporates three basic features: An economically designed aquaponics system to efficiently grow fruits and vegetables with minimal horizontal space, fertilizer and water; Vermiculture to efficiently convert campus food waste and paper waste into organic fertilizer for use in the system; and, Renewable energy, such as passive solar heat, to cut the costs of operating both the vermiculture and hydroponic units.

Four criteria drove the project: *Cost* of components and operations must not exceed what the global market can currently bear; *Scale* of the project must be local, with dimensions such that losses do not exceed gains; *Resource availability*, with local construction materials and alternative energy sources used whenever possible; and *Ease of Implementation*, with installation and operation managed by the local labor force.

The aim was to develop a system that could be widely replicated in economically blighted regions, used as a cost-effective vehicle to teach the public the importance of growing the right fruits and vegetables to ensure a healthy diet. The grand vision was to ultimately establish regional production systems in population centers worldwide.

STARTING WITH HYDROPONICS

Hydroponics is gaining widespread attention because it can outperform soil-based cropping, due to more efficient uptake of nutrients, with faster plant growth and higher yields per square foot of horizontal area. In the first production year at SVSU, three hundred pounds of tomatoes were produced on a tiered hydroponic unit.

The high cost for turnkey hydroponic systems can be prohibitive, so the SVSU team used a relatively primitive, do-it-yourself system, with cheap and readily available materials from the local hardware store: two-by-four lumber, plastic water pipe and an ordinary fountain pump. A provisional patent application has been filed on this system.

Other cost-intensive aspects of hydroponics are electricity to operate pumps and artificial lighting, and heat for year-round growing. Although alternative energy sources like wind turbines, solar panels, geothermal heat pumps and biomass furnaces have high capital costs, once operational these investments provide cheap, clean energy.

One low-cost energy solution used at SVSU is passive solar heating of the benches that support potted plants. Benches were constructed from recycled pickle barrels filled with water and topped with durable, recycled fencing material. The water barrels provide a significant thermal buffering capacity that allows solar heat, absorbed during the day, to be released at night.

INTRODUCING FISH AND WORMS

Specialty chemicals that serve as plant nutrients and herbicides pose another costly problem with hydroponics, as they are usually produced from nonsustainable petroleum or natural gas. At SVSU, a combination of vermicompost tea and the development of aquaponics have replaced these chemicals.

Aquaponics is essentially the same as hydroponics, except that plant nutrients are provided by fish excrement instead of synthetic chemicals. Also, plants filter the water before it returns to the fish tanks. Using simple plumbing and hardware, water in a fish tank is circulated through a hydroponic system where naturally occurring bacteria produce powerful organic fertilizer. The only chemical input is fish food.

At SVSU, a 150-gallon water tank contains 12 Koi fish. A fountain aerates the water for the Koi, and a pump circulates fish tank water into two 50-gallon plastic tanks that serve as hydroponic grow beds. The water in each grow bed recirculates back into the fish tank using a so-called "ebb and flow" system, where an electric timer controls a pump that intermittently floods and drains each grow bed. The grow beds are filled with Hydroton clay aggregate, a gravel-like material that is manufactured in high-tech kilns in Germany, and supports the roots of the growing plants. By simply circulating fish tank water through each grow bed, two types of bacteria, *Nitrosomonas* and *Nitrobacter*, naturally begin to grow on aggregate surfaces. In turn, these bacteria convert ammonia, which is excreted by the fish and dissolved in water, to nitrate, a powerful organic fertilizer (similar to the fertilizer used in large-scale American agriculture, conventionally produced from natural gas).

Leachate is collected from the vermicompost bins, and aerated to produce compost tea.

SVSU is now incorporating a vermiculture system into the university greenhouses. After attending a short course from Will Allen at Growing Power, Inc. (see "Composting And Local Food Merge At Urban Garden," *Biocycle* November 2008), the following waste recycling process was implemented, with cooperation from Aramark Corporation, the manager of SVSU Dining Services.

Cooks in the university kitchen place fruit and vegetable scraps into five-gallon plastic buckets. A Starbucks café located on campus provides spent coffee grounds. On any given school day, 10 to 15 buckets of combined food scraps and coffee grounds are hauled to the university greenhouses. The weight and contents of each bucket are recorded to monitor consumption rate. During the fall 2008 semester, 15,175 pounds of combined food scraps and coffee grounds were collected.

The school's aquaponics system has a 150-gallon tank with 12 Koi fish.

At the greenhouse, red wiggler worms are cultivated in a series of eight vermiculture beds, 4 feet wide by 8 feet long by 8 inches high, built from ordinary construction lumber. Worms are fed a mixture of 50 percent food scraps, including coffee grounds, and 50 percent shredded office photocopier paper donated by Veteran's Affairs Medical Center of Saginaw, Michigan.

Vermicompost is slowly generated and periodically separated from the worm bin using a simple sieve consisting of a galvanized wire screen (1/4 to 3/8-inch square mesh). The screen is laid on top of a worm bin, and raw material (worms plus compost) is gently spread onto the screen's surface. Fleeing from the overhead light, the worms quickly migrate through the screen, falling below into the bed.

Each bed is monitored by an inexpensive handheld probe that simultaneously measures soil moisture and pH. Moisture concentration must be maintained between 50 and 60 percent, while pH must be maintained between 6 and 8. By carefully controlling what the worms eat, pH can be maintained without addition of chemicals. To aerate the mixture, the solid material in each worm bed is occasionally turned by pitchfork, as needed.

To maintain the correct moisture concentration, water mist is briefly sprayed on the surface of each worm bed daily, using a garden sprayer controlled by an electronic timer. Excess water leaches through the vermicompost and drains through a series of 1/2-inch diameter holes drilled into the plywood bottom of each worm bed. The aqueous leachate drips into a series of gutters fabricated from recycled plastic drain pipe, and is collected in a series of 5-gallon plastic buckets.

Leachate collected in each bucket is periodically poured into 55-gallon recycled plastic barrels. These barrels are aerated with a simple fish tank aerator, which reduces odor and also keeps bacteria active, turning the leachate into a valuable vermicompost tea. The tea is then used in the university greenhouse to fertilize plants grown hydroponically or in topsoil, providing an economic alternative to commercial nutrient solutions. The solid compost that remains is used as a soil amendment in potted plants in the greenhouse.

COMMUNITY OUTREACH

In 2007, the Green Cardinal Initiative (GCI) was formed, a consortium of students, faculty and staff interested in defining SVSU's role in the green movement, both within and outside the university. Initiated by sociologist Brian Thomas, GCI originated around activities in the greenhouse including developing methods for local food production and distribution in urban settings, engaging student artists in publicizing GCI and food production activities, and developing affordable energy and fertilizer options for both urban and rural settings in the U.S.

The Greenhouse Project and GCI have coordinated with three local nonprofits located in an economically depressed part of Saginaw — Houghton Jones Neighborhood Center, the Good Neighbors Mission and the Mustard Seed — to develop the Saginaw Urban Food Initiative. The aim is to increase the availability of fresh produce to the community through the development of urban agriculture. Funding was obtained from the Saginaw Community Foundation to install hydroponics units in the Houghton-Jones Neighborhood Center and the Good Neighbors Mission to explore the potential of year-round food production. The project's goal is to take systems that have been tested at SVSU and examine their effectiveness in real-world circumstances.

With technical support and training by SVSU faculty and staff, members of these two organizations recently began operating hydroponics systems, monitoring productivity and labor and energy requirements. Similar to the setup at SVSU, vermiculture systems have been established at each site to supplement the hydroponics systems. Staff members at each site bring food waste and scrap paper from home to feed the worms.

Using experimental data from the university greenhouses, a financial model is currently being built to calculate the anticipated benefits that these community centers and other prospective organizations can anticipate. Input data includes labor requirements, installation and operating costs, rates of worm reproduction and the rates of food waste and paper waste delivered. Output data includes rates of waste reduction and the yields of produce, worm tea and vermicompost.

Additional information on this and other projects underway at the SVSU greenhouses can be found at www.greencardinal.org. ■

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