Monday April 26 – Black Sheep Creamery, Chehalis, Sheep Dairy, Farm Emergency Plans and Agencies - 12:30pm-4pm, www.blacksheepcreamery.com, Paid pre-registration required

Monday, May 10th – Hedlin Family Farm, La Conner, Row Crop Production, High Tunnel and Greenhouse Cropping, Succession Planning - 12:30pm-4pm, www.sustainablenorthwest.org/stories/hedlin-family-farm


Monday, June 7 – Tonnemaker Hill Farm, Royal City, Orchard Diversification and Organic Transition, Fresh Market Vegetables - 12:30pm-4pm, http://tonnemaker.com

Wednesday, June 16 – WSU Field Day and Organic Farm, Pullman Wheat Variety Trials & Organic Diversified CSA Farm - 9am-3pm, www.css.wsu.edu/organicfarm, farm Walk is free, pre-registration required for lunch

Monday, July 26 – WSU Field Day and Organic Farm, Puyallup, On-Farm Mock GAP Certification Process - 12:30pm - 4pm, www.puyallup.wsu.edu/soilmgmt

Monday, September 6 – Manuel Mendoza Orchard, Quincy, Apple and Cherry Orchard, Latino Landowner Challenges and Opportunities - 12:30-4:00pm, http://www.tilthproducers.org/ManuelMendozaOrchard.pdf

Monday, September 27 – Filaree Farm, Omak, Biodiversity, Cooperative Marketing Model, Seed Saving - 12:30pm-4pm, www.filareefarm.com

Monday, October 11 – Boistfort Valley Farm, Curtis, Low Input Season Extension, Organic Row Crop Production - 12:30pm-4pm, www.boistfortvalleyfarm.com, paid pre-registration required

Thursday, November 11 – Pre-Conference Farm Walk – Stay tuned for details.
Tilth Producers Annual Conference, Fort Worden, Port Townsend, November 12-14, 2010
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Photos: Burk, Slow Food Skagit River Salish Sea
Dave Hedlin’s grandfather moved from Denmark to the fertile Skagit Valley about 100 years ago and settled close to where the North Fork of the Skagit River lets out into Skagit Bay. His grandfather helped build the dikes next to the town of La Conner and bought land from the Conner family as he could afford it. Dave explains, “There are actually 17 tax statements on the 65-acre farm. Each time my granddad would make money on a seed crop or something, he would buy some land.”

The dikes built by men like Dave’s grandfather have kept this naturally moist land in production. Dave explains, “This is all subtidal agriculture. If this dike wasn’t here, at high tide we would have about six feet of water.” The wetness of the valley attracts all sorts of wildlife. Dave remarks, “Virtually everything on the Washington Department of Ecology wetland poster swims or flies across here every day.” The area offers prime chinook salmon rearing habitat. It’s fresh river water, but has a bit of salt water that comes up under the fresh. “With the shading over the water,” Dave says, “it’s a nice place for salmon to equilibrate – spend a little time in that interface between fresh and salt water – it truly is a magic spot.”

Dave Hedlin and Serena Campbell now owns 150 acres, and farm a total of 400 acres of prime delta farmland. They have produced vegetable seed there for over 100 years — primarily cabbage seed, beet seed, and spinach seed. “If you have sauerkraut in Germany or kim chee in Korea,” Dave explains, “there is a really good chance that the seed that grew that cabbage came from within 10 miles of here.” Pickling cucumbers, peas, wheat, bees, greenhouse tomatoes, and a farm stand are other key pieces of the operation.

Half of Hedlin Farms acreage is farmed organically, and about half is farmed conventionally. Conventionally, they grow beet, spinach, and cabbage seed, wheat, and pumpkins.

Organic crops include a broadly diversified fresh market garden including vegetables from
artichokes to zucchini, small fruit, cut flowers, and high tunnel production of heirloom tomatoes, peppers, cucumbers, and lettuce. This produce is marketed through a variety of venues – a La Conner roadside stand, three farmers markets, a 150 member CSA, and sales to restaurants, hospitals, grocery stores, and some larger wholesale customers if they’re long on a crop. As Dave puts it, “The nice thing about the fruit stand and the fresh market operation is that you build a clientele of a couple hundred customers, you have a business. If you have one customer, they own you.”

Hedlin Farms also grows organic haylage, silage corn, and barley and is currently partnering with Dr. Stephen Jones of WSU to trial wheat varieties suitable for bread production that can be grown in predictably damp Western Washington. In addition to their Organic Certification, Hedlin Farms maintains a Salmon Safe certification on their entire farm.

Many years ago, the Dave and Serena set out to diversify their operation for two reasons: to help with cash flow, because cash flow on a Northwestern vegetable operation is very seasonal, and to provide more year-round employment for their people. To diversify, Dave drew on the past. He explains, “We had third generation connections with a seed company. My mother was a field rep for Lilly Seed Company when women were not field reps. She was a remarkable woman.” Hedlin Family Farms built on this link and began growing conventional and organic cauliflower and cabbage plants and providing transplanting services for the seed industry. Dave explains, “We’re differentiated in the marketplace by providing these services; the seed companies don’t have to own their own transplanters and they don’t have to hire crews to run that equipment.”

Farmers in the Skagit Valley have joined together to address the preservation of farmland, and they cooperate on more immediate farming needs as well. The Hedlins swap land with their neighbors to maintain a five-year rotation on their fields. “As the valley has tended to specialize, we have not sacrificed our rotation, but we have started trading ground more,” comments Dave. “I grow a lot of pickling cucumbers, my neighbor grows a lot of potatoes. In a given year I might give him 30 acres for potatoes and take 30 acres of his for cucumbers. So you basically achieve rotation by trading ground.”

Farming the same land as his ancestors has provided Dave with a unique long-term perspective. “When somebody tells me they are going to run for political office, I say, ‘Try and be a hero in 30 years – not tomorrow – because you’re not going to make it on tomorrow. There will always be somebody upset, but if you do the right thing with a good vision, you can be a hero in 30 years.’ That’s the kind of thing we need to encourage,” he says, “that long-range vision."
“Organic is an emerging part of our business,” explains Dave. “It makes up about 10 to 15 percent of our total acreage. We are Food Alliance certified. On virtually all of our fresh market operation we just don’t use any pesticides, we use some beneficial insects and that’s about it.”

A small whitewashed on-farm fresh market stand offers berries, peppers, fresh bundles of flowers, tomatoes, basil, and greens, all grown on the surrounding 25 acres. Dave remarks, “We started about 25 years ago growing strawberries here and evolved to this. We try to diversify our operation: I characterize it as trying to be profitable without losing track of who you are.”

They hit a couple farmers’ markets a week and sell the rest on the farm. It has not been incredibly profitable, but Dave thinks that this sort of diversification is really important for them as a farm.

Dave is downright cheerful when talking about the challenging economics of farming: “There are lots of different crops, like winter wheat, that are not particularly profitable, but they are important in our rotation to help us build up this heavy clay soil, get more organic matter, and break up disease cycles.” Other pieces of Hedlin Farms’ business have emerged in what Dave calls “natural fits and progressions.” For instance when the Jensen ladies of Golden Glen Creamery began making farmstead cheeses, Dave was quick to see how their mozzarella might pair with Hedlin’s tomatoes and greenhouse basil.

Then there is the issue of encroaching residential development. “Any place this nice, people see it and want to live here,” Dave says. “We need lots of help to keep land in production and open space; it’s an incredibly difficult job.” At the Hedlins’ greenhouse next to La Conner, land is worth $4000 an acre; if you walk ten more feet into La Conner, it’s worth $5 to $10 a square foot. “Those are huge differentials,” Dave explains, “and that puts on lots of pressure. It begs the fundamental question of why land for commercial use is worth so much more than land that produces food, open space and wildlife habitat.”
Preserving the Magic in Skagit Valley: Diversified Sustainable Production on Hedlin Farms

By
Rural Roots and University of Idaho Research Team:

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November 2005
The Northwest Direct farm case studies were developed to provide in-depth information about the direct and semi-direct marketing opportunities that exist for farmers within their regional food system and how these opportunities are captured by a diverse set of successful producers in Idaho, Oregon and Washington. Direct marketing strategies employed by the farmers featured in this series include farmers’ markets, community supported agriculture (CSAs), u-pick, farm stand and on-farm sales. Semi-direct marketing strategies include sales to restaurants, caterers, retailers (grocery stores, butchers, etc.) and processors, arranged and completed by the farmer him/herself without the use of brokers or wholesalers.

In 2002 and 2003, members of the case study research team performed in-depth on-farm interviews with each of the 12 farm families in this study. Interviews were transcribed, financial information was collected, reviewed and interpreted and outlines for the case study content were developed. Professionals were hired to write the case studies. Each case study went through a series of reviews by the case study farmers, university faculty and research team members with final permission for publishing and distribution given by the farmers themselves.

The nature of profitable small acreage farming demands flexibility and the willingness to change. These case studies, therefore, reflect a “snapshot in time” of each farm. Readers should be aware that these farms have undoubtedly evolved since the initial interviews. They should also be aware that the unique nature of each farm necessitates an individualized treatment of the analysis of farm profitability and the criteria by which that is measured. The case studies contain financial information to the extent that farmers were willing to share, and reflect our intention to educate the reader, while at the same time protecting the farmers’ need for confidentiality.

It is our intent that the case studies will be of use to:

• Current farmers who want access to a greater share of the revenue that comes from the foods they grow and raise and are interested in exploring one or more marketing options.

• New farmers who are designing their production and marketing systems, who are interested in employing one or more marketing strategies, and are establishing a business plan for their farm.

• Educators and other agricultural professionals who work with producers and others interested in direct and semi-direct marketing.

• Policy-makers who are interested in enhancing the financial stability of family farms in the region through innovative policy and government funding.

A total of 12 case studies were produced by Rural Roots, Inc. and the University of Idaho as part of the Northwest Direct project. A list of the other case studies in the series is included at the end of this document. These case studies are one component of a larger USDA Initiative for Future Agriculture and Food Systems project called *Northwest Direct: Improving Markets for Small Farms*. For more information on this project and its outcomes, visit the project website at [http://www.nwdirect.wsu.edu/](http://www.nwdirect.wsu.edu/).

Colette DePhelps, NW Direct Case Study Research Team Leader
Dave Hedlin knows he is a lucky man. “Being able to farm here on this land with Serena as a partner is a privilege,” he says. Dave Hedlin and Serena Campbell are the third generation on the Hedlin family farm, raising crops on approximately 400 acres of fertile land in the Skagit Valley of northwestern Washington outside of La Conner.

“The Magic Skagit,” as it is called by locals, is home to some 90,000 acres of farmland. The people here value the beautiful scenery, the rich soils, the diversity of wildlife sustained by slough habitats, and the cultural heritage of their unique valley. Hedlin and Campbell are active members of the organization, Skagitonians to Preserve Farmland, dedicated to preserving farmland and wildlife habitats, promoting farming as an economically viable livelihood, providing educational opportunities for farmers to improve their marketing and management skills, and educating the community in the process.

Hedlin and Campbell’s devotion to this cause is fed by their desire to stay true to their ideals while remaining financially stable. Hedlin says, “Serena and I are trying to…figure out how to make a living without losing track of who we are. We like being farmers. We like producing food for people that is good for (them).”

Through the years, they have continued to evolve as farmers, diversifying their business plan and their production methods to fill the niches available to them in the area. They grow a variety of crops on 400 acres. Everything they grow is Food Alliance and Salmon Safe Certified, and some crops are Certified Organic. They have a half acre greenhouse operation, where they grow 6000 square feet of tomatoes, including heirlooms for high-end markets. Here, they also provide services to vegetable seed companies and tissue culture labs. They grow field crops in large quantities, such as pickling cucumbers, plus they grow a diverse selection of vegetables and fruits in their 25 acre market garden. They have a fresh and mail order dahlia service, and sell Christmas trees and poinsettias in the winter, in an effort to have income from sales year-round.

Preserving the Magic in Skagit Valley: Diversified Sustainable Production on Hedlin Farms

Farm Overview and History

Dave Hedlin knows he is a lucky man. “Being able to farm here on this land with Serena as a partner is a privilege,” he says. Dave Hedlin and Serena Campbell are the third generation on the Hedlin family farm, raising crops on approximately 400 acres of fertile land in the Skagit Valley of northwestern Washington outside of La Conner.

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Dave Hedlin’s grandfather, Rasmus Koudal emigrated from Denmark in 1904 and slowly bought the Skagit Valley property they now farm. Hedlin’s parents were graduates of Cornell University in crop and weed sciences. Dave Hedlin was raised on the farm.

Of his own background, Hedlin says, “I was very mechanically inclined. When I was seven years old my grandfather gave me a Chevrolet car, and my dad gave me a bucket of tools, and I took it all apart. It took four years. Anytime they needed to find me, that was where I was…. It was a good life. I was never pushed to farm, ever. My father died when I was eleven and I helped my grandfather for a number of years. When I was fifteen, I was too young to start farming and he was old enough that he had to retire. He was in his eighties. So the family farm was rented out for a number of years. I graduated from high school and took two years of industrial mechanics at Skagit Valley College. I worked…as a mechanic for pea harvesters…. Then I went to work full time for a food processor and started accumulating equipment so I could rent the family farm back. I did that in 1974. (I was) never pushed to farm. I came to that on my own. Like most kids I was pretty sure that I didn’t want to farm when I was my son’s age. (I was) pretty sure that I did four years later.”

Serena Campbell was raised in Bellingham, Washington. Her family was affiliated with the timber industry. She received degrees in biology and oceanography, and worked for the University of Washington for ten years. She and Dave Hedlin were introduced by Hedlin’s sister. Although Campbell’s family was somewhat skeptical about the farming industry, Hedlin says, “I told (Serena) that there was big money in farming and that we should get married. Fortunately we were safely married before she found out that there was only big money in farming if you put it there.” Campbell says that the science of farming and the science of oceanography are very similar. She has been able to use her biological knowledge to their advantage and apply it to their farming endeavors.

Hedlin and Campbell have two grown children, Lauren and Arne. Lauren attends an equestrian college in West Virginia. Arne is going into mechanical engineering, though he helps at the farmers’ markets and with some of the production. Dave Hedlin says that regardless of whether his children pursue farming, he wants more than anything that they be good stewards of the family land.

The family property is divided in half by Sullivan Slough, which connects to the Skagit River. Hedlin and Campbell own water rights for drainage and irrigation. Hedlin owns a second farm in Dodge Valley on the Skagit River, with a private dike. The Skagit has both riverine and tidal influences at that location. Occasional floods deposit silt and nutrients into the farm’s soil, making the ground extremely fertile. “It’s wonderful land,” says Campbell. The locals like to joke that they spend more money on pumping excess water out than on bringing water in for crop irrigation. Only about 15% of Hedlin’s Dodge Valley property has to be irrigated.

The R.C. Koudal Land Company, a partnership in stewardship shared by Hedlin and his two siblings, owns much of the farm property. Hedlin Farms and its produce stand operate as a separate business entity from the family partnership, and rents the land.

“Serena and I are trying to figure out how to make a living without losing track of who we are. We like being farmers. We like producing food for people that is good for (them).”
on which the stand sits. The farm rents 130 acres from the family trust, owns about 50 acres, and rents another 220 acres from other sources.

Hedlin Farms employs seven full-time employees, and hires up to 40 workers in the summers, plus some local kids. As the farm diversifies, Hedlin and Campbell are challenged by the management aspects, including allocating the right amount of labor to the right task at the right time.

**Marketing**

When asked about his strategy for direct marketing Hedlin Farms products, Dave Hedlin jokes, “I would call it stumbling around.” Hedlin and Campbell actually do a rather successful job at marketing their produce through their produce stand, which they consider to be their primary marketing focus, as well as through farmers’ markets and restaurants.

**Hedlin Farms’ Produce Stand**

The farmers went into business 25 years ago with a small strawberry stand. The stand was a “tiny shed”- a six by eight foot structure on the side of the road. For the first ten years the farm sold only strawberries. They then added tomatoes. In 1996, Hedlin and Campbell bought a dahlia business and began selling and advertising the flowers at the stand. In 1998, they offered a full line of fresh market fruits and vegetables at their stand, plus they began selling produce at wholesale price to other fruit stands. In 2001, a new structure was built by altering a tractor garage which they bought and hauled from the owner’s property. Their current stand is twelve feet by twenty and has two metal kiosks for shade. More produce is displayed outside, and they have purchased additional amenities, such as a cash register, a cooler for storage, scales, and electricity. Dave Hedlin says that the operating hours of the produce stand are “from 10:00 to 6:00, or pretty much from when we open, until we close.”

In addition to their standard fare of fresh fruits and vegetables from their market garden, the farmers provide hothouse tomatoes, peppers and basil to people desperate for fresh produce from May to the end of November. They also sell pumpkins in the fall, and for several years they have sold Christmas trees and poinsettias to boost winter sales. The start-up cost for this sales venue was very minimal, Serena Campbell says, “We’ve done this on a shoestring from the beginning.”

**Farmers’ Markets**

Hedlin and Campbell have been selling at farmers’ markets for over 15 years. When their daughter was six, they began selling strawberries at the Mt Vernon and Snohomish markets. Over the years, they added more products and stayed at market more weeks of the season. They have sold at the Mt. Vernon market since its inception, and have tried the Fairfield market as well. At the time of the interview, the farmers were looking into another farmers’ market to supplement their Mt. Vernon sales.

The farmers’ markets started as a way to involve their children in their business. Campbell says, “It has been as much a kid project as a business strategy.” But Hedlin and Campbell see the markets as an advertising venue as well. They say that customers that come to their stand often find them first through the farmers’ markets. Campbell says, “We depend on the markets to keep us in people’s thoughts.”

Campbell describes some of the ways that farmers’ markets provide free advertising for the farm. She says that when selling their heirloom tomatoes, “these older ladies would show up and be first in line. Then, they would sit there and visit. When other people would show up who weren’t familiar with what we were producing, they would look at the tomatoes and (complain about the prices.) This group of older ladies would stand there and …explain to them for us why they were worth that much. They would tell them that the worst thing that could happen is that you end up being hooked on these tomatoes and you’d have to come back every week and buy more. This went on for several summers. It was really good advertising.”
Also, a local chef who sold at the market would include Hedlin Farms’ products in the dishes she was cooking on site, and then send people over to buy the fresh product. These avenues of relationship marketing, afforded by simply being present at the farmers’ markets, have served Hedlin and Campbell well.

**Restaurant Sales**

Hedlin Farms began selling to restaurants because chefs began purchasing their produce at their produce stand. Now they deliver to La Conner restaurants, such as at the Wild Iris Bed and Breakfast and Kerstin’s. Dave Hedlin explains, “Kerstin’s, one of the up-scale restaurants uptown, features our tomatoes and basil. It is listed on their menu, and people talk about them, and customers say they are the best that they have ever had….The waitress tells them that they can stop by the produce stand and pick up a flat to take to their friends.”

**Advertising**

Hedlin and Campbell don’t pay much to advertise. They keep brochures for the farm at their produce stand. They have some signage and are developing a website. They occasionally advertise in the local newspaper. Campbell explains, “The problem is that we don’t have a lot of time and it is difficult to allocate time to advertising. Currently we are discussing the hiring of a market manager—someone that could do advertising, website development… (and) professional signage.” They pay attention to trends in the market, however, and adjust their production and sales accordingly. They have increased their range into organic markets over the years, and are reaching people who are interested in having a high-quality, locally produced product. Hedlin says, “Our slogan is, ‘Grown while you watch, by people you know.’”

They also get their name out by being “really involved.” Their voice in the community is well-known as they support local schools, speak out on development and conservation issues, and sell products that stand out for their freshness and quality. Campbell explains, “We are willing to be involved in community groups (and) talk about who we are.”

**Production Methods**

By following the market trends, and in order to remain diverse and economically viable, Hedlin Farms has been in transition for a number of years. Hedlin explains, “It is a big transition for a production type farm to transition into a fresh market produce stand. It is a different kettle of fish.” He continues, “My heart of hearts is in produc-
tion. I like to grow 30 acre blocks of cucumbers.” But by obtaining organic and Food Alliance certifications, by adding a 25 acre fresh market garden, and by growing fresh food and products that can be sold year round and through a variety of sales venues, Hedlin and Campbell ensure their longevity as family farmers.

The farmers have transitioned a portion of their land into Certified Organic production. In order to do this, they grew hay without pesticides for three years, bartering the hay for manure with a neighbor who owns a dairy. Some of their pickling cucumbers are being grown on organically certified land, as is some of the cabbage being grown for the local sauerkraut plant. Much of their greenhouse production takes place without pesticides, but sometimes with conventional seeds or fertilizers, so certification doesn’t apply there.

Hedlin uses a five year rotation on all crops except spinach, which requires a ten year rotation. He grows cabbage, beet and spinach for seed. Green peas have been grown on Hedlin Farms since the forties, but recently profit margins have been too low to justify it. He grows cucumbers, pumpkins and winter wheat as cash crops, plus the wheat serves as a rotation crop to break down clay soils and add organic matter.

Hedlin does custom planting and transplanting, and provides services to seed companies through custom greenhouse contracts. He also keeps bees for pollination of crops, and rents his 250 hives to other farms and to seed companies for extra income. The hives are kept on trailers, which are moved to other properties and rented according to the time used and the crop being pollinated.

Hedlin and Campbell do not raise livestock for profit. Hedlin says, “I am a vegetable farmer. You put a vegetable on the truck, it stays on the truck.” Hedlin explains that their horses, chickens, dogs and cats are merely remnants of the children’s 4-H projects. He qualifies this by saying, though, “We do run about two million head of bees.”

Management Issues

Campbell says, “One of the really big challenges in a farm like ours is figuring out how to allocate management, because inevitably, you are thin on management.” There are a lot of management issues Hedlin and Campbell face in their transition into direct marketing their products. The first is management of time. The farmers struggle to appropriately divide their time, and the time of their employees, between tasks related to the different enterprises. The control of weeds, for example, especially in the certified organic fields, is a time-consuming endeavor. When labor is allocated to different areas, like greenhouse work, it is difficult not to fall behind. Mistakes in the allocation of resources results in higher costs, either in labor or in lost opportunities. Hedlin states that he might drive by the market garden and see something should have been done earlier. As a result, he has to pull the crew out of the greenhouses and “put 400 or 500 hundred dollars worth of labor into a crop that will probably only gross 400 to 500 dollars.”

Campbell states, “We only have a certain number of people we can hire and not enough (profit) margin to hire all of the people we would really like to have around.” Hedlin spends a lot of his time on production, and Campbell manages the office, paperwork, payroll and administrative tasks associated with the greenhouse operation. As a result, the produce stand and other direct marketing endeavors are unable to get their full attention. Campbell says, “I know that if Dave and I could get down to that produce stand, we could double the sales if we were there full time. But I can’t do it when we are shipping out a lot of greenhouse transplants.”

To be effective in supplying the direct markets, the farmers have to be able to forecast production for the upcoming season, including being able to predict the volume of crops needed for particular markets. Then their planting schedule must be derived from those estimates. This process can be very complex, especially when growing many different crops.
**Equipment**

Hedlin says, “We have bought one new piece of equipment.” The farmers own a six row Monosem seeder that they purchased new. Because Hedlin studied industrial mechanics, his ability to repair equipment has made expensive purchases unnecessary in many cases. They tend to buy used equipment at auctions, and then make any necessary repairs. Hedlin has hand built some equipment as well, such as a swather that cuts hybrid cabbage. Increasingly, they are leasing more equipment. As their production has diversified, he no longer has time to repair things like he used to, and the costs have gone up. Hedlin says, “We have a 4640 (tractor) with a gazillion hours on it, a John Deere. We bought it for $25,000. It doesn’t really owe us anything. The trick is that if the transmission goes out of it, you have to be willing to walk away from it. It will be $15,000 to fix it, and what you have is an incredibly old tractor with a new transmission. In the old days, I would fix anything if it broke. I (still) have the ability to fix things, but a lot of the time, it just doesn’t make sense.” The complexity of the new machinery, the expense of parts and testing equipment needed to fix new machinery, and the time involved, are all factors prohibiting Hedlin from using his skills and resources in this way.

**Profitability by Enterprise**

Hedlin and Campbell’s farm profitability goals all relate to risk reduction, and by extension, their efforts to preserve the farming industry in the valley. They are working towards achieving these goals through three primary means: entering into non-speculative growing contracts, establishing year round sales to provide cash flow, and selling directly to consumers. Hedlin explains, “If you have a business with 200 customers, you have a business. If you have a business with one customer, they own you.” Growing contracts that are non-spectulative in nature, a “service for a fee” approach, gives the farm consistent income to carry the more speculative ventures. The farmers calculate their costs for growing the product and tack on the desired margin. A contract is signed with the seed companies, and Hedlin and Campbell plant the crops with a better idea of what they will be receiving for that production.

Providing year round cash flow through various direct market sales also reduces financial risks to the farm. The market garden, dahlia
as, and seasonal sales of Christmas trees and poinsettias help provide the farm with income throughout the year, reducing the feast or famine dynamic inherent in seasonal enterprises. This makes the financial burden of meeting payroll and paying bills easier.

Finally, selling through direct markets increases their return on the crops that they grow. While there are additional costs to selling locally on a smaller scale, they still end up capturing larger portions of the revenue stream by selling them directly to consumers at premium prices.

Hedlin Farms is a complex operation with many production methods and sales avenues being utilized at all times. Sales from row crops sold through conventional markets were the largest source of gross receipts, accounting for 45% of sales in 2003. Greenhouse sales through contracts with other operations, and other greenhouse produce, like the heirloom tomatoes and basil accounted for 37% of gross receipts. While direct marketing sales were
Figure 2: Breakdown of Revenue from Direct Marketing Sources
2002-2003

Figure 3: Income from Produce Stand Sales, 2002-2003
small relative to the size of the other sales, they are important to the overall operation. They are financially stable and they provide steady cash flow and higher margins than other sales avenues do. In total, they accounted for 9% of gross receipts in 2003 (See Figure 1).

Another interesting source of income for Hedlin Farms isn’t a crop or produce item, its bee hives. Bees are essential part of the farm ecosystem, pollinating crops. Originally the bee hives were brought on farm to pollinate their own seed crops and pickling cucumbers. After Hedlin Farms started engaging in greenhouse contracts they diversified into custom transplanting their greenhouse starts for other farmers in the seed industry. Offering the bees as a pollinating service was a natural extension of the greenhouse business operation. In 2003, the bee hives contributed 1% of total receipts.

**Produce Stand**

There is a striking contrast between the breakdown of receipts through the direct markets between 2002 and 2003. In 2002, the produce stand provided 76% of direct marketing receipts, while farmers’ markets only accounted for 9%. In 2003, however, the produce stand business dropped substantially, and contributed only 56% of direct marketing receipts, followed by farmers’ market sales at 18% (See Figure 2.) The sales figures in 2002, the first year of operation for the new produce stand, were great. Coming out of that year, Campbell was very optimistic about what the produce stand could accomplish financially. But that optimism was quickly stifled by road construction that took place in 2003 directly in front of their stand. Campbell says that her goal for that season was simply to, “maintain a presence and not lose money.” The impact of the construction was tremendous. “It halved the income from the stand,” says Campbell (See Figure 3.) “People couldn’t get there, it was dirty, it was noisy- it was total chaos. A lot of days you couldn’t get to the driveway, and if you could, it was covered with equipment. They destroyed our driveway, tearing it up I don’t know how many times. It was a big mess.”

Despite the construction, the produce stand still managed to break even. “We knew that it was going to be hard and that we had to get through the summer anyway that we could.… The easiest thing to have done would have been to sit the year out, but we have a customer base,” explains Campbell.

**Farmers’ Markets**

Hedlin Farms sold a large selection of products at farmers’ markets in 2003. Most of the produce (63%) came from crops raised in the Greenhouses (refer to Figure 4.) These sales were primarily of heirloom tomatoes, but also include basil and a variety of peppers. Produce from the market garden also played a significant role, representing 23% of total sales. Cut flowers, field crops, and small fruits rounded out the remaining percentage of sales, each accounting for approximately 5%.

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**Figure 4: Product Origin for Farmers Market Sales, 2003**

- **Market Garden**, 23%
- **Greenhouse Produce**, 63%
- **Cut Flowers**, 6%
- **Field Crops**, 4%
- **Small Fruit**, 4%
While Hedlin enjoys selling at farmers’ markets, Campbell isn’t sure that they necessarily pay for themselves. “I’m not sure that I’m as positive about the farmers’ markets as Dave is,” she says. “I think that it is great advertising for us (though), as long as we aren’t losing any money. I do feel like there are some intangibles that carry through.” Those intangibles include generating cash flow during the cash poor months in the early summer, developing a customer base to support additional produce stand sales, and introducing their products to area chefs, which sometimes results in restaurant sales.

Hedlin and Campbell agree that farmers must know their production costs, and charge accordingly, in order to make a profit at the market. “Farmers’ markets are a sustainable sales avenue only when the prices charged at market are an accurate reflection of what it actually costs to grow the food,” says Hedlin.

**Greenhouse Operation**

The greenhouse operation provides products for sale to both the seed industry and to Hedlin Farms’ direct marketing avenues. The majority of that production is plugs grown for the seed industry. These include crops such as cabbage, cauliflower, broccoli, brussel sprouts, radishes, beets, and chard. The farmers also grow a number of vegetables in the greenhouses for sales through the produce stand, farmers’ markets, and restaurants.

There are several benefits that the greenhouse operation provides to the farm profitability. First, growing in the greenhouses lowers risk of crop failure. Second, the seed and tissue contracts pay well, and provide consistent cash flow at a dependable profit margin. Finally, the greenhouse operation gives Hedlin and Campbell the opportunity to offer consistent, year round employment to their workers, which keeps employee satisfaction and productivity high.

Ten years ago, they started growing tomatoes in the greenhouse in the hopes of “figuring out how to grow a good tasting greenhouse tomato–” something Hedlin had noticed was lacking in the market. Since that time they have expanded their tomato production three-fold and have incorporated other produce into the mix, including basil and a wide variety of peppers. Despite their success, however, Hedlin says, “We are what we like to call ‘militantly small’ on that. We can’t compete with the ‘faster, cheaper, bigger’ paradigm of food production, so we would only expand if the sales are there on the highest tier.”

By using the contracts from the greenhouse operation as a means to stabilize their income, and keeping their tomato production to a manageable size, Hedlin and Campbell are able to remain diversified in both their production methods and their marketing avenues. Diversification and appropriate pricing are keys to keeping the farm profitable. The instability of markets, as well as the risks associated with any given production method, cautions against the reliance on any one strategy.
Philosophy, Goals, and Future of the Farm

Hedlin and Campbell are committed to preserving the lifestyle and livelihood of farmers in the Skagit Valley. In order to do this, they spend a significant amount of resources and energy being involved in organizations that further this goal. Some of the organizations that work to support farms and farmers in the region include the Northwest Agricultural Research Foundation, the Puget Sounds Seed Growers Association, and the Skagitonians to Preserve Farmland.

The Skagit Valley is a very complex farming landscape. Currently, over 80 crops of commercial significance are grown in the Valley. Research is an essential component of balancing the economic, cultural, and ecological needs in the area. In reference to the production techniques that are unique to their area, Dave Hedlin says, “It is difficult to transpose rules and knowledge based off of slope agriculture onto sub-tidal lands…” To fund agricultural research in the Skagit Valley, most of the area’s farms make a donation or assess themselves a certain percentage of their income. In 2004, over 90% of the farms in the region made a contribution.

The future of Hedlin Farms lies in the farmers’ willingness to diversify, strategically market their products, and remain flexible. Hedlin explains, “Fifty years ago you could ride a good idea for a lifetime. Now it is good for about two years. I think change is inevitable, as is the evolution of this farm. Being flexible and ready to change is critical.” Dave Hedlin and Serena Campbell see a lot of potential for themselves in the future of farming in the region. Hedlin says, “I think that there is a real opportunity for people in small businesses to reinvent themselves on a regional scale…. I think that the slow food movement and the organic movement are indicators that people want quality and are willing to pay for it. People are starting to realize that there are better alternatives to the way that they are currently eating.”

Hedlin and Campbell enjoy living on their farm. They say they have the best ground for growing things and are surrounded by wonderful people. They look forward to growing old together in a community with a multigenerational sensibility. Hedlin concludes, “It may be tough to make a living, but who else gets to raise their kids on a dead end road on Sullivan Slough at the mouth of the Skagit River with eagles up in the trees? Every (creature) on the (Department of Ecology) wetlands poster swims, flies, hops, or crawls by our office everyday.”

“(Plus) a few things that aren’t,” adds Serena Campbell.

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Find Hedlin’s Farm Fresh Products

Hedlin Family Produce: 12275 Valley Road Mount Vernon, WA
Snow Goose Produce: 15170 Fir Island Road Mt. Vernon, WA
Bellevue Farmers Market: 1717 Bellevue Way NE Bellevue, WA
    Thursdays 3 pm - 7 pm (May 19 - October 21)
Mount Vernon Farmers Market: Gates & Main Mount Vernon, WA
    Saturdays 9 am - 1 pm (May 28 - October 8)
Coppa Mediterranean Bistro: 1224 Harris Avenue Bellingham, WA
Manino’s Italian Restaurant: 1007 Harris Avenue Bellingham, WA
Porterhouse: 416 West Gates Mount Vernon, WA
Rexville Grocery Store: 19271 Best Road Mount Vernon, WA
Rose’s Bakery Café: 382 Prune Alley Eastsound, WA
Seeds Bistro and Bar: 623 Morris Street La Conner, WA

“I think that the slow food movement and the organic movement are indicators that people want quality and are willing to pay for it.”
Northwest Direct is a four-year research project involving the five partners listed below. Our goal is to increase profitability of small farms in the Pacific Northwest through research and extension. We have documented locally based food systems, developed case studies of direct marketing farmers, fostered expansion of farmers markets, and addressed regulatory and infrastructure barriers to direct sales. Northwest Direct is coordinated by Washington State University’s Small Farms Program. More information is available at www.nwdirect.wsu.edu.

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Portable Field Hoophouse
Portable Field Hoophouse

By

Carol A. Miles, Ph.D., Washington State University Department of Horticulture and Landscape Architecture, Mount Vernon Northwestern Washington Research and Extension Center

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When constructing a greenhouse would be unwieldy and too expensive, a plastic-enclosed house—the hoophouse—fulfills most of a small farmer's or home gardener's needs. So named because of the arched or “hoop” structure that supports the plastic “skin,” hoophouses are available in many lengths.

If you have a small farm business and are looking for ways to increase crop diversity or earliness, this portable field hoophouse may help. Some crops that are well suited to this type of hoophouse include tomatoes, peppers, eggplants, and melons—crops that need to be planted after danger of frost and that generally mature late in the season west of the Cascade Mountains. The hoophouse effectively allows a grower to produce early yields of crops that require more heat units than the environment may otherwise provide.

The hoophouse rests directly over the soil in the field, using no benches or special growing media. Two people can easily dismantle and reassemble the lightweight structure in a different section of the field each year or within a growing season. An advantage to moving the hoophouse around the field is crop rotation, which avoids pest buildup. Another is the low cost, approximately $350 for a 10’ X 42’ hoophouse.

The following hoophouse design will result in a structure approximately 10’ wide at the base, 6 1/2’ high at the center, and 42’ long (Figure 1). Growers can easily adjust the length by adding or taking away support hoops and altering the length of the polyethylene plastic appropriately. The maximum length of polyethylene plastic available on the market is 100’, which governs the maximum length for constructing a hoophouse. While initial construction of the hoophouse will take a day, two people can later put it up and take it down in only 2 hours. Storing the hoophouse out of the field during the winter months spares it from some of the worst weather and makes it last many years. Using wood treated with water-based preservatives also increases the longevity of the structure.

Selecting Materials

Polyethylene plastic is available in many grades. A 6 mil weight is recommended for greenhouses. Selecting a lighter weight (4 mil) is not recommended. Untreated polyethylene will cost less initially; however, the lifespan of the material is significantly less, and the material will likely degrade after one year of use. When treated with a UV inhibitor, 6 mil plastic generally is guaranteed for 3 years.

Figure 1. Portable field hoophouse, 10’ wide by 42’ long, resting directly on soil surface in the field.
Gases that escape from the PVC (polyvinyl chloride) pipes contribute to the deterioration of the polyethylene plastic. To prevent “off-gasing,” paint the PVC pipes with white latex paint. Use wood treated with water-based preservatives for the base of the door frame, where the wood comes into contact with the soil. Untreated wood used for the remainder of the frame will not severely affect its longevity. Choose a mid-weight (4 oz to 5 oz) corrugated plastic for the ends. A clear plastic generally will darken over the years, whereas a colored plastic will lighten with time. The color of the plastic will not affect the usability of the hoophouse. Most light will enter through the polyethylene sides.

The choice of nylon twine for tying the hoops in place is broad. Twisted twine is susceptible to unraveling, while braided twine is more durable. Natural fiber twine (jute or cotton) is not recommended due to the stretching these materials experience. Baling twine is inexpensive and durable.

**MATERIALS**

- 9 ea. 2”x 4”x 12’ boards, treated with water-based preservatives
- 4 ea. 2’x 8’ sheets of 4 oz greenhouse-grade corrugated plastic
- 30 ea. 1/2”x 18” lengths of reinforcing rod (rebar)
- 17 ea. 18’ lengths of 3/4” rigid white schedule 40 PVC (20’ lengths cut down)
- 430’ good quality nylon twine (minimum tensile strength 210 lbs.)
- 1 piece of 6mil polyethylene plastic sheeting, 50’ long x 20’ wide
- 38 ea. 3” galvanized self-tapping screws with rubber washers
- 30 ea. 1” galvanized self-tapping screws with rubber washers
- 10 ea. 1/4”x 4” bolts and matching wing nuts
- battery powered drill

**Building the Ends**

Two of the two-by-four boards will become the bottoms of the door frames. Construct both door ends in the same fashion. For each door frame, place an 11-foot length of two-by-four down with a 4-inch side facing up. Mark the center of the 11-foot board, then mark 14 1/2” on each side of the center. These marks frame a 29” length in the middle of the board, which will become the bottom of the doorway. At each end of the framing board, measure 6” and drill two 1-inch holes next to each other into the bottom piece, placing the holes as close together as possible (Figure 2).

Turn the bottom piece on its side and insert a PVC length into holes at opposite ends, to form a hoop. This will be the outermost hoop. The corrugated plastic and door frame will attach to it. Cut two 6-foot lengths of two-by-four for the door uprights, along with one 32-inch piece for the top (header) of the door. Screw the header into the uprights, using the 3-inch self-tapping screws, so that the door frame is 2” wide and 4” deep. The door frame is then screwed to the bottom piece at the marked position using 3-inch self-tapping screws. Brace each side of the doorway with a two-by-four cut 60” long with the ends cut at a 45° angle. Screw braces in place with 3-inch self-tapping screws.

Cut the corrugated plastic, lining up the ridges horizontally, to fit the ends of the hoophouse. Fitting the corrugated plastic horizontally gives added strength to the ends. Overlap the top piece of corrugated plastic a few inches over the bottom piece to keep the ends weatherproof. Use 1-inch self-tapping screws with rubber washers to attach the corrugated plastic to the door frame and the hoop. The rubber washer is helpful to keep the corrugated plastic from cracking.

Attaching the ends to the hoop structure with bolts makes the hoophouse quite easy to take apart and reassemble.

**Forming the Hoop Structure**

In the field, mark an area 10’ wide by 42’ long for the hoophouse site. At each of the four corners, hammer an 18-inch piece of reinforcing bar (rebar) 12” into the ground, leaving 6” above the surface. The aboveground portion of the rebar will hold the PVC hoops of the hoophouse in place. Place a door frame upright at one end, inserting the PVC hoop onto the rebar. In what will be the inside of the hoophouse, attach a support leg to each door upright (Figure 3).

Using 3-inch self-tapping screws, attach the support legs to the side of each door frame.
Figure 2. Top view of bottom piece with two holes drilled 6” from each end and door uprights marked, and front view of the hoophouse end frame.

Figure 3. Support leg and “foot,” attached to the side of door upright which will face the polyethylene plastic, on what will be the inside of the hoophouse.
that will face the polyethylene plastic. Attach a support “foot” to the end of each leg and pound them into the ground. The support legs will keep the hoophouse frame from shifting, losing its shape, or straining the plastic. Place the second door frame at the opposite end of the area marked for the hoophouse. Insert the PVC hoop over the rebar and secure with support legs in the same fashion.

At 3-foot intervals along each of the 42-foot sides, hammer rebar into the ground, always leaving 6” above the surface. Gently bend an 18-foot length of PVC, positioning each end directly above the rebar, and carefully slide the PVC ends onto the rebar to form an arch (Figure 4). Repeat this procedure until you have formed 13 PVC hoops. It is not necessary to insert rebar into the two remaining holes in the bottom of each of the door frames. Simply insert the PVC into the holes, forming a double hoop at each end. When the polyethylene plastic is in place, bolt the double hoops together.

Starting at one end of the hoophouse, attach one end of the twine to the top center of the second hoop—the hoop immediately next to the door frame end. Pass the twine over to the next hoop, pulling it tight and looping it around the hoop. Continue on to each successive hoop until all hoops are attached together. When you reach the last hoop, reverse the process until you are back where you started. Connecting the hoops with twine helps to stabilize the hoop frame and will support the polyethylene plastic that will lie on top of it. It is important to keep the twine tight to prevent the plastic from sagging and collecting water when it rains. This would cause stress on the plastic and on the PVC framework.

Measure and cut a 5-foot strip off the 50-foot length of polyethylene plastic. This will leave a piece 45’ long by 20’ wide to be used for the hoophouse body. Use the piece 5’ long by 20’ wide for the doors. Spread the 45-foot length of polyethylene plastic across the hoop structure, pulling it tight, and insert the ends of the plastic between the double-hoops at each end. Bolt the corrugated plastic to the double-hoop ends, keeping the polyethylene plastic sandwiched between. To bolt the ends together, drill five holes through the corrugated plastic, the double-hoop ends, and the polyethylene plastic. Space the bolts so that one is at the top center, and two are on each side spaced 2’ apart (Figure 2). Place a rubber washer over the hole on the corrugated plastic side, insert the bolt, and secure the wing nut on the inside of the hoophouse.

Secure the polyethylene plastic in place with twine tied over every hoop except the double hoop ends. To attach the twine to the hoops, lift

Figure 4. View of the PVC hoops outlining the sides of the hoophouse.
the PVC hoop up slightly, tie a 20-foot length of twine to the rebar, and slip the PVC hoop back in place. Throw the twine over the hoophouse to the other side and tie it in the same fashion to the rebar supporting the other end of the PVC hoop. The twine should be just loose enough to allow slipping the polyethylene plastic up when raising the sides of the hoophouse for ventilation. Tying the plastic down at each hoop prevents the plastic from blowing out due to wind pressure.

**Finishing Touches**

The doors are simply polyethylene plastic sheeting, weighted on the bottom and hung on hooks at the top of the doorways. Cut the remaining piece of 5’ X 20’ polyethylene plastic to form two pieces 5’ wide and 6’ long. Attach a narrow piece of scrap wood at each end of the 6-foot length of polyethylene plastic. You can roll the plastic doors up on warm days to allow a breeze through the hoophouse, lowering the temperature. The polyethylene plastic along the 42-foot sides of the hoophouse also can be rolled up and attached with twine to the hoops (Figure 5). This additional ventilation is necessary during the hot summer months in most climates. To use the hoophouse, form two soil beds, one running down each side of the hoophouse, and install drip tape in each bed for easy watering (Figure 6). Transplant or direct seed crops into the soil.

Figure 5. View of the side of the hoophouse, showing polyethylene plastic secured by twine. A side of the hoophouse has been raised for ventilation and tied in place with twine.

Figure 6. Transplant crops into the soil inside the hoophouse. Lay drip tape down the center of each bed.
Abstract: This publication offers an overview of organic greenhouse tomato production. To be successful, the small-scale producer needs to do thorough production and marketing research, find or create a niche market, and produce a consistently healthy crop. Maintaining optimum fertilization and moisture levels, practicing rigorous pest management, and ensuring good pollination can increase crop yields. Information in this publication includes organic management methods for major diseases and insect pests; organic fertilization recommendations; a list of organic fertilizer suppliers; and a directory of further resources available on the Internet.

By Mardi Dodson, Janet Bachmann, and Paul Williams
March 2002

Special thanks to Dr. Elizabeth M. Lamb, Vegetable Extension Specialist, University of Florida Institute of Food and Agricultural Sciences, for reviewing this publication.

INTRODUCTION

Tomatoes are the leading greenhouse vegetable crop in the United States and Canada. In the U.S., the total acreage in greenhouse tomato production increased by 40 percent between 1996 and 1999. Statistics for 1999 show that the U.S. had about 800 acres in greenhouse vegetable production, with tomatoes accounting for 750 of those acres (1). The leading states in greenhouse vegetable production are California, Florida, Colorado, Arizona, Ohio, Texas, and Pennsylvania—each with more than one million square feet in production (2). The vast majority of greenhouse tomatoes are produced in greenhouses using conventional production systems. Conventional and organic greenhouse production differ in the types of potting media, fertilization practices, and pest control methods they use.

EDUCATION IS KEY

Education is the first step toward a successful greenhouse tomato crop, and there is a lot of...
information available on growing greenhouse tomatoes. Your local extension agent is an excellent source of information for your area. Extension publications from all U.S. states are available on the Internet. Most publications can be downloaded and printed at no charge. California, Colorado, Florida, North Carolina, Georgia, and Mississippi all have excellent information on growing greenhouse tomatoes. Dr. Mary Peet’s Greenhouse Vegetable Production Website is an especially good resource with links to many related websites (see the Web Resources section for the website address). This website offers valuable information on sustainable production and integrated pest management, with specific information on individual crops. Mississippi State Extension Service has many publications and articles on greenhouse tomato production written by Dr. Rick Snyder (see the Web Resources section for the website addresses). This website focuses mainly on conventional greenhouse production; however, much of the information is valuable to both organic and conventional growers.

**MARKETING**

Sell your tomato crop before you plant it. It is important for small growers to explore niche markets such as selling directly to the public via roadside stands or at farmers’ markets. Marketing your products as “locally grown” is a possible strategy to explore. It may also be feasible to wholesale your product directly to local and regional retailers that sell organic produce.

Direct market sales are affected by competition among local greenhouses and by cut-rate wholesale organic produce. The market can change rapidly, and greenhouse producers must be adaptable to change. The popular press and advertising can have a powerful influence on consumers. Niche markets can fade overnight with the arrival of large wholesale operations or simply by a change in consumer demand (3). For more information, request the ATTRA publications Direct Marketing and Organic Marketing Resources.

**SCHEDULING THE CROP**

Greenhouse tomatoes bring the highest price from December through April, when it is too cool for local field-grown tomatoes. Winter growers may choose between a one- or two-crop system. With the one-crop system, plants are set in September and grow through the winter and spring until late June. This system works best in the cooler and less humid northern regions and is also used by most Florida growers. In a two-crop system, the fall crop is succeeded by a spring crop. Tomato plants that have been growing since September do not have the same vigor as the younger transplants. The older plants tend to have a denser growth by winter, which reduces airflow and aggravates problems with humidity. Plants held over winter are more likely to be infected with diseases that thrive on high humidity and cooler temperatures, such as Gray Mold (caused by *Botrytis cinerea*) and Leaf Mold (caused by *Cladosporium fulvum*).

In a two-crop system, the fall crop is seeded between July and September. Check with your local extension agent for planting times in your area. If the crop is planted too early, high summer heat can stunt the young plants and delay harvest. For premium prices, try to schedule the first harvest to coincide with the first frost in your area. In some southern states, first frost may come as late as mid-November to early December.

Seed the spring crop in mid-to late November. If possible, the seedlings should be started in a separate house, in case there is a disease or insect problem with the fall crop. The seedlings will be ready to transplant about six weeks after seeding. Expect to see the first harvest in late March or early April. The spring crop is usually grown until the summer crop of field tomatoes is ready to harvest.
SOIL AND SOILLESS MEDIA

Greenhouse tomatoes can be grown in soil or in soilless media. In soil culture, crops are grown at ground level or in raised beds. The soil is usually amended with approved compost and other approved organic additives. The potential for disease and nematode build-up in organic soil-based greenhouses is quite high in many areas. Tomatoes, in particular, are vulnerable to many soil-borne diseases, including Verticillium and Fusarium wilts. Nematodes that can cause root knot galling can also be a problem in some soils. Many growers go to the added expense of grafting onto disease and nematode resistant rootstock. (Additional information about grafting is available at http://www.agnet.org/library/article/eb480.html#1.) Steam pasteurization and solarization in the summer are approved pest control methods for nematodes, Verticillium, Fusarium, and other soilborne pathogens.

Soilless cultivation methods—sometimes collectively (and loosely) known as hydroponics—are covered in the ATTRA publications Greenhouse and Hydroponic Vegetable Resources on the Internet and Aquaponics: Integration of Hydroponics with Aquaculture.

PEST MANAGEMENT

One key to a successful organic greenhouse operation is maintaining rigorous pest management. A pesticide-free greenhouse means that growers must practice good sanitation and pest management methods from the beginning. Pathogens or insects can become epidemic in a greenhouse environment in a very short time. Once a pest problem has set in, there are few options available to organic greenhouse producers. For detailed information on specific greenhouse tomato pests and controls, see Appendix One. Integrated Pest Management (IPM) is a strategy that can be used in organic production as well as in conventional production systems.

IPM promotes a variety of tactics, including the use of pest resistant varieties and biological, cultural, and physical controls. Pesticides are a control tactic used in IPM, but they are used only when needed. Pesticide use is thus minimized without jeopardizing crop quality or yield. Organic production systems use all of these, with the exception of chemical pesticides. Other pesticides, such as insecticidal soaps, biopesticides, botanicals, and mineral-based pesticides, are allowed. For more detailed information on greenhouse IPM, refer to the ATTRA publication, Integrated Pest Management for Greenhouse Crops.

Cultural Control Methods

In a closed environment, some diseases can literally spread overnight. Pathogens come in contact with the plants in many ways. Infested soil or plant debris, air movement, water, and contaminated hands, tools, or clothing can all spread disease. Good ventilation and air circulation, rigorous sanitation practices, and maintaining optimum temperatures and humidity levels are effective methods of disease control in the greenhouse.

Sanitation

Rigorous sanitation practices are essential for healthy and productive crops. Before a crop is planted, it is important to thoroughly inspect the greenhouse. Screens, doors, and walls should be checked periodically for any tears or other openings. Mulching around the plants and using landscape fabric on walkways helps to reduce weeds and soilborne pathogens. It is not advisable to store houseplants in vegetable production greenhouses. A seemingly healthy

For general information about greenhouse organics, see the ATTRA publication Organic Greenhouse Vegetable Production.
houseplant can be a vector for many diseases that attack vegetable crops (4).

During tomato production, debris and cull piles are a prime source of many plant diseases. Promptly remove all plant debris from the greenhouse areas before an infection can take place. Work surfaces should be made of non-porous material, such as stainless steel, and sterilized after each use. Laundry bleach is an acceptable disinfectant, providing the residual chlorine levels in the bleach-water do not exceed those set by the Safe Drinking Water Act (4 ppm).

Proper sterilization of hands, feet, and clothing when moving from house to house greatly reduces cross-contamination. Before entering the greenhouse, hands should be washed in hot soapy water. For tobacco users (both smokers and chewers), a rinse of 1–3% trisodium phosphate prior to washing in hot soapy water is recommended to avoid the introduction of Tobacco Mosaic Virus (TMV) into the greenhouse. Because TMV can survive on clothing for long periods of time (up to 3 years in a darkened closet), it is important that clothing and overalls be changed daily and washed and dried at high temperatures. A shoe wash with a disinfectant-soaked mat at the entrance to the greenhouse will help eliminate pathogens brought in on shoes. Adding a small enclosed entry porch to the greenhouse provides a place to decontaminate shoes, tools, and equipment, and also helps keep out pests. In situations where there is a contagious disease such as bacterial canker, all tools, machinery, and electromechanical pollinators should be sterilized at the end of every row with ethanol or 0.5% sodium hypochlorite (5).

Good (Green)housekeeping

- Keep doors closed and make sure all screens are in good working order.
- Make sure all plant debris and cull piles are removed promptly.
- Sanitize hands, tools, and machinery when moving from house to house.
- Have a shoe wash at each entrance.
- Wash clothing regularly in hot water.
- Do not store houseplants in production greenhouses.

Ventilation, temperature control, and humidity reduction

Temperature control and humidity reduction play a major role in maintaining greenhouse crop health. During the fall, winter, and spring, when the majority of greenhouse tomatoes are grown, high humidity and limited air circulation give many diseases an ideal growing environment. Moisture condensation creates humid conditions within the foliage, encouraging fungal and bacterial infection (6).

Good ventilation and proper temperature control are critical for reducing humidity and controlling airborne fungal diseases. To ensure good ventilation, allow several feet of airspace above the plants and use proper spacing between them. Pruning the suckers just below the first fruit set also helps to maintain good air circulation within the canopy. To increase ventilation, Mike Collins of Old Athens Farm in Westminster, Vermont, culls the bottom leaves once his plants are four feet tall. Collins cuts the leaves off an inch away from the stem and snaps off the stubs at the next pruning to minimize Botrytis infection sites (7). Some greenhouse producers also “lower” their crop—move the plants on their supports, so the sections ready for harvest are always at the same level, enjoying the same temperature.
Temperature control can be maintained in several ways. Polyethylene tubing works best for maintaining even temperatures throughout the greenhouse. With this system, fresh air from the outside can be warmed with fan-type heaters to maintain optimum temperatures. Fans inside the greenhouse, mounted above the crop, help keep temperature uniform. With a pad and fan system, the air can be too cool at the cooling-pad end and too warm at the fan end. Temperature differences of 10–15°F can occur within the same greenhouse, which can cause catfacing, uneven growth, failures in fruit set, and devastating foliage disease (6). And the higher the humidity, the less efficient evaporative systems are. For even heating from the ground up, heating pipes can be placed between alternating rows. The heated air rises and pushes the cooler air to the floor, helping to maintain good airflow. In hot climates, greenhouses need higher roofs to keep hot air away from the plants.

**Resistant Varieties**

Using disease-resistant seeds and transplants whenever possible is one of the organic greenhouse producer’s best lines of defense. For best results, use good-quality seed from a reputable source. Organic growers must use organically grown seed if it is commercially available, or untreated seed from a conventional source if it is not. For a list of organic and untreated seed and transplant suppliers, see ATTRA’s *Suppliers of Organic and/or Non-GE Seeds and Plants*.

### Optimum Air Temperature for Sustained Tomato Growth

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### Table 1. Common Disease Abbreviations*

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<th>Disease Abbreviation</th>
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<td>Early Blight (Alternaria)</td>
<td>EB</td>
</tr>
<tr>
<td>Fusarium Crown &amp; Root Rot</td>
<td>FCRR or FrWi</td>
</tr>
<tr>
<td>Verticilium Wilt Race 1</td>
<td>V</td>
</tr>
<tr>
<td>Fusarium Wilt Race 1</td>
<td>F1</td>
</tr>
<tr>
<td>Race 2</td>
<td>F2</td>
</tr>
<tr>
<td>Race 3</td>
<td>F3</td>
</tr>
<tr>
<td>Leaf Mold (Cladosporium)</td>
<td>C2, C5, C7</td>
</tr>
<tr>
<td>Nematode</td>
<td>N</td>
</tr>
<tr>
<td>Powdery Mildew (Oidium)</td>
<td>Oi</td>
</tr>
<tr>
<td>Gray Leaf Spot (Stemphylium)</td>
<td>St</td>
</tr>
<tr>
<td>Tobacco Mosaic Virus</td>
<td>TMV</td>
</tr>
<tr>
<td>Tomato Spotted Wilt</td>
<td>TSW or TmSw</td>
</tr>
<tr>
<td>Tomato Mosaic Virus</td>
<td>ToMV</td>
</tr>
</tbody>
</table>

*These are examples of common abbreviations. Suppliers may differ in abbreviation styles.

To indicate disease resistance, a series of abbreviations is usually listed with the description of the cultivar. Each abbreviation stands for a specific pathogen. For instance, Tobacco Mosaic Virus is TMV; Fusarium Wilt race 1 is F1, etc. (8). Fusarium Crown and Root Rot may be printed as FCRR or FrWi depending on the distributor. See Table 1 for examples of major greenhouse tomato diseases and their abbreviations. See Table 2 for a list of resistant greenhouse tomato varieties.

Once a variety of tomato has been selected, the next task is to decide whether to grow transplants from seed or to purchase plugs. Either way, all transplants must be grown using approved organic methods and inputs. The advantages of producing plugs in-house include an efficient use of greenhouse space and rapid production. The disadvantages include extra labor cost for seeding and transplant production and increased heating costs in winter (plugs...
are very sensitive to temperature fluctuations). There are many issues to consider when deciding whether to use seed or transplants. The size of the operation, available labor, and cost of production are just a few considerations. According to Kessler and Behe (9):

The decision should be based partially on market considerations, labor availability and expertise, the number of plants to be produced, the cost per plug, and the specialized equipment and facilities required. This investment is often not economically practical unless production is large or plugs are marketed to other growers. For most small to medium sized growers, especially [beginners], it is often more economical to purchase...plugs from specialized growers and concentrate on producing finished containers. The issue of grow versus purchase should be reviewed periodically as the needs and facilities of the grower change.

For more-detailed information on plug production, see the ATTRA publication Organic Plug and Transplant Production.

**NUTRITION**

A well-fed plant is a healthy plant. Maintaining optimum nutrient, light, and moisture levels will result in healthier plants that are better able to fend off diseases and insect pests. Tomatoes are heavy feeders because of their rapid growth and long production season. Tomatoes need 75 to 100 pounds of nitrogen (N) per acre and moderate to high levels of phosphorus (P) and potassium (K) for maximum yields. Soil tests can establish what nutrients soil needs. Some growers add a mixture of animal meal by-products, rock phosphate, and kelp meal to provide needed nutrients. Fertilizer efficiency is highest at a pH of 6.0 to 6.8. To help maintain proper nutrition and pH levels, a pH meter is a handy tool. For more information on organic fertilizers and the nutritional needs of tomatoes, see the ATTRA publication, Organic Tomato Production.

According to the National Organic Standards, it appears that organic greenhouse crops may be grown either in soil or in soilless media. Build-
ing nutrient-rich soil in a greenhouse environment takes extra time and effort, but the results are well worth it. Compost is the main nutrient ingredient used in soil beds. One grower in Canada applies compost at a rate of one or two cubic meters per 100 square meters of bed space (1.2 to 2.4 cubic yards per 1,000 square feet). The beds are then covered with straw mulch. Five to six applications were added to the beds at five- to six-week intervals in the first year. The compost was applied in smaller amounts and less frequently through the fourth year. A rich, healthy soil was the result. Soil organic matter usually ranges from 10 to 12% and can even reach a remarkable 25 to 30% after several years. For more information on large-scale composting, see ATTRA’s Farm-Scale Composting Resource List.

Soilless technology shows promise for increasing yields and reducing economic losses to soil-borne diseases. Dr. Mary Peet and Janet Miles of North Carolina State University have recently concluded a study to develop organic fertilization regimes specifically for greenhouse tomatoes using soilless media. See Appendix Two for a copy of the article, “Recommended Fertilization Practices for Producing Organic Green-

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**Grower Profile**

Six years ago, Mike Duda, a market gardener from Victor, Montana, was just sick about his tomatoes: The high winds and cool nights around Victor were costing him two-thirds of his crop. That was when he decided to try greenhouse production. He bought a 30’ x 90’ metal-frame greenhouse kit, erected it himself, and installed an inflatable poly cover. A second-hand oil-fired furnace supplied the heat. An old attic fan furnished ventilation exhaust, and some used house fans moved air around inside the greenhouse. And not much has changed since then, except that Mike’s tomato harvest has tripled.

Duda grows in soil, on raised beds. As he describes it: “We live in cattle country, so manure is easy to find. I use aged (three years) cow manure about two inches deep, dolomite lime, rock phosphate, and a little homemade wood ash. I use a soil test to gauge the amounts and hand-dig the beds. . . . I also fertilize with seabird guano every couple of weeks. I use drip tape for irrigation and tie the tomatoes to twine attached to the greenhouse for support.

“I start the tomatoes from seed on December 26. . . . Harvest starts the last week in May and continues through October. It peaks mid-June to mid-August, when we get 250 pounds a week.

“I use garden variety tomatoes, not greenhouse varieties. They’re bred for shipping, not taste. I use Brandywine with good results, Oregon Spring with excellent results (they don’t need pollination), and Sungold with excellent results (they produce until Thanksgiving).

“I spray with kelp weekly until the fruit set. It works well. You eventually get some disease, but it’s near the end of the crop, so you tolerate it as long as you can, then remove [the diseased plants]. We do see a few aphids. I use soap spray when they get too bad. This year I’m going to try some beneficial insects; it’s hard to spray effectively when the plants are big.

“We sell all of our tomatoes at the farmers’ market, all at retail prices. It’s good for us, and the customers love fresh tomatoes. This will be our sixth year for greenhouse tomatoes, and I can’t imagine not having them. It’s fun to be able to start gardening in the middle of winter, and tomatoes always sell well.”
house Tomatoes” by Janet Miles. This article includes detailed recipes for each stage of maturity.

**Pollination**

Tomato plants have both male and female reproductive organs on the same flower, so with a little help, each flower can self-pollinate. In the natural environment, wind and insects pollinate tomatoes. In a greenhouse environment, more attention must be paid to the pollination process to ensure maximum fruit set. Today, tomatoes are pollinated in greenhouses either by bumblebees or by mechanical pollinators.

Mechanical pollination is done with a battery-powered, hand-held pollinator or by electric vibrating benches. The hand-held pollinators are labor-intensive. Workers have to hand pollinate each plant two or three days each week during flowering. Vibration benches work on an automatic timer and do not require much labor after installation, but they are expensive and not cost-effective for small- to medium-scale growers.

Mechanical pollination of tomatoes was predominant in U.S. and Canadian greenhouses until the mid-90s, when the use of bumblebees was adopted from European growers. Today, most greenhouse tomato growers in North America are using bumblebees, which work every day of the week, selecting only the flowers that are ready to pollinate. Bumblebees can pollinate up to 30 flowers a minute. It is not unusual to have 100% pollination, which results in higher yields than are achieved with mechanical methods (10).

Bumblebees are mild-mannered and easy to work with; they rarely sting without provocation. They start a new colony each year, with only a single queen hibernating over the winter. This queen then starts a new colony in the spring. By mid-summer the colony can number in the hundreds. At the end of the summer the bees begin to die out and the process starts over again. However, due to breakthroughs in bumblebee breeding, full-strength colonies of bumblebees are now available year round.

For commercial production, the bees are shipped by airfreight and placed in the greenhouse as the first flowers begin to open. Stocking rate varies from one hive for a small greenhouse to two to four hives per acre for larger facilities. The hives are usually replaced every 8 to 12 weeks as the colony begins to die out. There are two primary species of bees produced in Canada and the United States: Bombus occidentalis for the west and B. impatiens for the east. According to the USDA and AgCanada, the dividing line is at the 100th meridian, which runs through the middle of Texas, Oklahoma, Kansas, Nebraska, and the Dakotas. To avoid confusion, the USDA has classified these states as “eastern” states in the case of bees. Bees West, Inc., supplies western species, and Koppert Biological Systems, Inc., supplies eastern species (10).

**Summary**

A successful organic greenhouse tomato operation will require research into all aspects of the business. Before planting the first seed, it is important to locate a niche market in your area and schedule harvests to coincide with times of high market value. Soil systems have many advantages compared to soilless systems; however, they can be sources for soil-borne diseases such as Verticillium and Fusarium wilts. Maintaining rigorous pest control is key to maintaining a healthy, productive greenhouse operation. Successful pest control includes incorporating Integrated Pest Management practices, including cultural control methods, and the planting of disease resistant varieties. Organically grown seed must be used if available. If not, commercially available untreated seed may be used. All transplants, whether purchased or grown on the farm, must be grown using approved organic methods and inputs. Maintaining proper
pH and fertilization levels improves disease resistance and increases yields. Using bumblebees for pollination can also increase yields and reduce labor costs.

REFERENCES


4) Dr. Craig Anderson, Horticulture Extension Specialist, University of Arkansas, Personal communication, June 2001.


RESOURCES

Organic Fertilizer Distributors

Agri-Growth International, Inc.
http://www.agriorganics.com
Agri-Growth International, Inc. is a manufacturer of organic plant nutrients and stimulators. This website offers information on their products. Send e-mail to herb@agriorganics.com, or contact them at 1-780-484-0102 for a distributor listing in your area.

Alternative Garden Supply
Alternative Garden Supply offers a complete online store and a listing of retailers in your area. They carry a variety of liquid organic fertilizers such as Earth Juice, Fox Farm, Pure Blend, Maxicrop, and Age Old Organics.

Atlantis Hydroponics
1035 Baxter Street
Athens, GA 30603
(706) 543-9980
Toll Free: (888) 305-4450
Fax: (706) 543-9919
info@atlantishydroponics.com
http://www.atlantishydroponics.com
Atlantis Hydroponics offers a wide range of organic fertilizers and stimulants: Alaska Startup, Earth Juice, Fox Farm, Neptune’s Harvest, Pure Blend, and others.

Greenfire
347 Nord Ave. #1
Chico, CA 95926
(916) 895-8301
Fax: (916) 895-8317
http://www.greenfire.net/
Greenfire offers a wide range of organic fertilizers for both soil and soilless media. Greenfire is an Earth Juice distributor.

Tradewinds Wholesale Garden Supply
http://www.tradewindsgarden.com/index.html/
   Online catalog with a distributor list for retailers in your area. Organic products include B’Cuzz Growth, Root, and Bloom Stimulators; Nitrozime; and Age Old Organics Liquid Grow, Bloom, and Kelp.

Harvest Moon Hydroponics
http://www.hmoonhydro.com/
   Harvest Moon Hydroponics offers a complete online store with a wide range of organic fertilizers and stimulants: including B’Cuzz, Earth Juice, Pure Blend, Superthrive, Nitron A-35, Grow Big, and Big Bloom. The website includes a list of Harvest Moon retailers in your area.

Home Harvest® Garden Supply, Inc.
3807 Bank Street
Baltimore, Maryland 21224
1-800-348-4769
Voice: (410) 327-8403
Fax: (410) 327-8411
ugrow@homeharvest.com
http://homeharvest.com/storeinfo.htm
   Earth Juice, Fox Farm, and others.

HydroMall™
http://www.hydromall.com/web/index.php
   HydroMall™ offers organic fertilizers from Agri-Growth International, Inc., such as: Myco-Net Biological Inoculum, Nutri-Max, and others. Order online from HydroMall™ or see their Stores Directory for a retail store near you.

Information on the Web

Budget for Greenhouse Tomatoes
Mississippi State University, Cooperative Extension Service
http://msucares.com/pubs/p2257.html

Commercial Greenhouse Tomato Production
Colorado State University; Cooperative Extension Service
http://www.ext.colostate.edu/pubs/garden/07606.pdf

Dr. Mary Peet’s Greenhouse Vegetable Production Website
North Carolina State University
http://www.ces.ncsu.edu/depts/hort/greenhouse_veg/resources/
   Resource page with links to conversion tools, print information, and related Websites.

Environmental Control for Greenhouse Tomatoes
Mississippi State University, Cooperative Extension Service
http://msucares.com/pubs/pub1879.htm

Florida Greenhouse Design
University of Florida, Cooperative Extension Service
http://edis.ifas.ufl.edu/ae016

Grafting, De Ruiter Seeds Inc.
http://www.deruiterusa.com/guide.html (Guidelines for Grafting)
http://www.deruiterusa.com/root.html (Rootstock Germination)

Greenhouse Tomato Handbook
Mississippi State University, Cooperative Extension Service

Greenhouse Tomato Production
Oregon State University, College of Agricultural Sciences
http://nwrec.hort.oregonstate.edu/tomatogh.html

Growing Hydroponic Tomatoes
The University of Arizona, College of Agriculture
http://ag.arizona.edu/hydroponictomatoes/index.htm
Insect and Disease Problems of Tomato
Texas A&M University, Aggie Horticulture
http://aggie-horticulture.tamu.edu/imagemap/mgmaps/mgprob.html

North Carolina State’s Greenhouse Food Production Website
North Carolina State University
http://www.ces.ncsu.edu/depts/hort/greenhouse_veg/index.htm
Topics include cultural control, biological control, and organic production.

Single Truss Tomato Production System
Bioresource Engineering Department
Rutgers University - Cook College, New Jersey
http://nj-nscort.rutgers.edu/visitor/tps/index.html

Starting A Greenhouse Business
Mississippi State University, Cooperative Extension Service

Starting Vegetable Transplants
Mississippi State University, Cooperative Extension Service

Texas Greenhouse Management Handbook
Texas A&M University, Aggie Horticulture
http://aggie-horticulture.tamu.edu/greenhouse/guides/green/green.html

Tomato Plant Problems FAQ, by Kay Klier
http://home.earthlink.net/~shelly.johnson/tomato.html An overview of tomato plant problems and organic cures.

The electronic version of Organic Greenhouse Tomato Production is located at:
HTML
http://www.attra.org/attra-pub/ghtomato.html
PDF

By Mardi Dodson, Janet Bachmann, and Paul Williams
NCAT Agriculture Specialists

Edited by Richard Earles
Formatted by Cynthia Arnold

March 2002

IP 190
# Appendix One

## Problems in the Greenhouse

<table>
<thead>
<tr>
<th>Name</th>
<th>Damage</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Early blight</strong> <em>Alternaria solani</em></td>
<td>Leaves have brown spots with concentric rings and yellow &quot;halos&quot;; Increases in warm, humid weather.</td>
<td>Use resistant cultivar; Sanitation at season end; Mulching; Air circulation; Avoid water on leaves; Rotation; Copper spray.</td>
</tr>
<tr>
<td><strong>Fusarium Crown &amp; Root Rot</strong> <em>Fusarium oxysporum</em> sp. <em>radicis-lycopersici</em></td>
<td>Tops of plants wilt; Dark brown colored root rot at soil level; Stems may have red-brown vascular discoloration; Symptoms appear just before first pick.</td>
<td>Use resistant varieties; Transplant when soil or media is 68°F or above; Remove first fruit to allow plant to recover.</td>
</tr>
<tr>
<td><strong>Fusarium Wilt</strong> <em>Fusarium oxysporum</em> sp. <em>lycopersici</em></td>
<td>Clearing of veins and chlorosis of lower leaves; Wilting leaves and stems; Marginal necrosis of leaves and eventual defoliation; Roots may be stunted; Stems may have borwn discoloration; Prefers warm greenhouses.</td>
<td>Use resistant varieties; Sterilize seed; Use of soilless media or hydroponics reduces incidence of disease; Use good sanitation practices; Avoid excessive warming of cultivation beds (keep below 82°F).</td>
</tr>
<tr>
<td><strong>Gray Leaf Spot</strong> <em>Stemphylium solani</em></td>
<td>Older leaves affected first. Small brown to black spots on leaves, enlarging to gray centers that drop out to make several tiny holes in leaf.</td>
<td>Use resistant varieties; Reduce humidity and increase air circulation; Keep canopy dry; Avoid water on leaves; Destroy infected plant material.</td>
</tr>
<tr>
<td><strong>Gray Mold</strong> <em>Botrytis cinerea</em></td>
<td>Gray, velvety coating of spores on fruit, stems, and petioles. Thrives at temperatures below 65°F. Begins on flowers and spreads to fruit.</td>
<td>Keep canopy dry; Avoid water on leaves; Reduce humidity (below 85%); Increase temperature and air circulation; Ventilate at night if possible.</td>
</tr>
<tr>
<td><strong>Leaf Mold</strong> <em>Fulvia fulva</em> (syn. <em>Chakosporium fulvum</em>)</td>
<td>Chlorotic (yellow-green) spots on upper surface of older leaves; Undersurface may have olive green spores; Spots merge to affect entire leaf; Prefers poorly ventilated, cool, humid conditions; Spreads by air, water, workers and insects; Affects soil or hydroponics.</td>
<td>Good sanitation practices; Use resistant varieties; Proper row and plant spacing; Avoid excessive Nitrogen; Reduce humidity (below 85%) and increase air circulation (heated air); Avoid water on leaves; Burn or bury infected plant material; At season’s end, remove and destroy all crop residue and sanitize greenhouse.</td>
</tr>
<tr>
<td><strong>Powdery Mildew</strong> <em>Oidium lycopersici</em></td>
<td>Leaves develop irregular, bright yellow blottches; Severe infections can kill leaves; Sunscald from leaf loss.</td>
<td>Avoid water on leaves; Humidity control; Sulfur sprays; Biofungicide AQ10 (<em>Ampelomyces quisqualis</em>); Baking Soda (see ATTRA’s Greenhouse IPM: Sustainable Aphid Control); Use of Baking Soda as a Fungicide; Copper sprays.</td>
</tr>
<tr>
<td><strong>Septoria Leaf Spot</strong> <em>Septoria lycopersici</em></td>
<td>Numerous small brown water-soaked spots on leaves, petioles &amp; stems with gray or black centers; Leaves turn yellow and drop; Sunscald may occur; Spreads by wind, water, hands, tools &amp; aphids; Favors warm, dry days and damp nights (85%-100% relative humidity).</td>
<td>Rotation; Avoid water on leaves; Burn or bury infected plant material; Maintain optimum temperatures and humidity control; Aphid control (see ATTRA’s Greenhouse IPM: Sustainable Aphid Control); Copper sprays.</td>
</tr>
</tbody>
</table>
2. **Major Bacterial Diseases of Greenhouse Tomatoes**

<table>
<thead>
<tr>
<th>Name</th>
<th>Damage</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bacterial Canker</strong> C. michiganensis pv. michiganensis</td>
<td>Very contagious; Wilting lower leaflets; Older leaflets curl upwards and die from margin inward; Cankers may form on stems; Brown, dry, mealy pith in later stages; Small, raised white &quot;bird's eye spots&quot; on fruit; Spreads from infected seed (systemic) or tools, hands, insects, or splashing water (local); Infection is favored by warm, wet conditions.</td>
<td>Use disease-free seed or sterilize seed in 130°F water for 25 minutes; Use drip irrigation to reduce splash; Reduce humidity and increase air circulation; Maintain optimum temperatures; Use sterilized soil or potting mixes; Disinfect benches, hoses, tools, etc. between crops; Sterilize or discard wooden stakes; Destroy infected plant material; Copper sprays.</td>
</tr>
<tr>
<td><strong>Bacterial Speck</strong> P. syringae pv. tomato</td>
<td>Most severe in 3-5 leaf stage; Small, dark lesions with yellow rings on leaves; Superficial, brown, rough spots on fruit; Retards growth and delays fruit maturity; Spread by sprinkler irrigation; Infection is favored by cool, wet conditions.</td>
<td>Use resistant cultivar; Use disease-free seed or sterilize seed in 130°F water for 25 minutes; Reduce humidity and increase air circulation; Maintain optimum temperatures (Bacterial Speck disappears with warmer temperatures); Use drip irrigation or mulch to reduce splash; Remove and destroy infested plants if severe; Copper sprays.</td>
</tr>
</tbody>
</table>

3. **Major Insect Pests of Greenhouse Tomatoes**

<table>
<thead>
<tr>
<th>Name</th>
<th>Damage</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aphid</strong></td>
<td>Sucks sap; Vectors disease; Creates honeydew which attracts sooty mold; Missshapen foliage, flowers, and fruit</td>
<td>Insecticidal soap; Beneficial insects (ladybugs, lacewings, etc.) Beauveria bassiana; Pyrethrum; Rotenone</td>
</tr>
<tr>
<td><strong>Fruitworm</strong></td>
<td>Feeds on foliage, flower, fruit</td>
<td>Destroy infested fruit; Bt; Row covers; Neem; Ryania</td>
</tr>
<tr>
<td><strong>Pinworm</strong></td>
<td>Fruit has narrow black tunnels</td>
<td>Destroy infested fruit; Till at season end to prevent overwintering; Sabadilla</td>
</tr>
<tr>
<td><strong>Whitefly</strong></td>
<td>Distorted, yellow leaves; Honeydew which attracts sooty mold</td>
<td>Insecticidal soap; Yellow sticky traps; Beneficial insects; Garlic oil; Pyrethrum; Rotenone; Beauveria bassiana</td>
</tr>
</tbody>
</table>

*Affects mostly field tomato crops but has also been known to infest greenhouse crops*
APPENDIX TWO

RECOMMENDED FERTILIZATION PRACTICES FOR PRODUCING ORGANIC GREENHOUSE TOMATOES

BY JANET MILES

Janet Miles developed these recommendations as part of an M.S. thesis under the supervision of Dr. Mary Peet. The thesis is entitled: Organic, Biorational and Conventional Growing Systems for Greenhouse Tomatoes, 2000, North Carolina State University, Raleigh, NC.

For more information on this study and on organic production, visit the North Carolina Greenhouse Food Production website: <http://www.ces.ncsu.edu/greenhouse_veg/>.

These recommendations were devised from studies performed on ‘Grace’ tomatoes—a variety bred specifically for greenhouse production, grown in 5 gallon upright plastic bags with soilless substrates in polyethylene greenhouses.


A list of suppliers of organic fertilizers and horticultural substrates is available from ATTRA <http://www.attra.org/>.

This study was begun in 1998, before the initiation of national standards and with few potentially certifiable materials available. It can be used as a guideline for selecting and using organic fertilizers for greenhouse tomato production, but growers are advised to check the ATTRA and OMRI sites for new materials and with their certifying agency to see if particular materials are allowable.

Transplant Production:

1) Seeds: 4-7 days until first true leaves appear
   a) sow in sterile seedling mix
   b) Place seed trays in a mist bed with bottom heat
      i) Temperature: 75-80°F
      ii) 16 hours fluorescent light

2) Transplant Seedlings: 4-6 weeks depending on Fall or Spring crop
   a) 4” pots with peat or coir-based substrate
      *note: We used a special mix provided by Faford which is equivalent to their commercial 4-P, but without the starter nutrient charge or wetting agent, which would not be acceptable for organic certification. (See Substrate Recipe in the Greenhouse Production section).

   b) Nutrients:
      i) Constant feed of fertilizer/water solution
      ii) Earth Juice™ brand: This product is comprised of three different formulations. They also have a source of K2O and a source of micronutrients.


         Bloom: analysis 0-3-1. Ingredients: bat guano, Chilean sea bird guano, Norwegian Sea Kelp, natural sulfate of potash, steamed bone meal, oat bran, and rock phosphate.

         Catalyst: analysis 0.03-0.01-0.10. Ingredients: oat bran, kelp, wheat malt, molasses, and yeast.

Earth Juice Recipe

Mixed in 2 gal. water for direct fertilization:
(Not concentrated for injectors) 3 tbsp. Bloom
3 tbsp. Catalyst
5 tbsp. Grow
2 tbsp. K₂O
* To provide 90 ppm N, 45 ppm P, and 195 ppm K.

iii) Magna Gro™ brand:
Hydroponic Base Mix analysis 2-3-6. Ingredients: poultry compost tea, pasteurized blood meal, calcium phosphate, and seaweed. This also contains trace minerals with fermented molasses in the form of Zn SO₄, Mg SO₄, and Fe SO₄. 19% N from poultry compost tea and pasteurized blood meal. K-9: 9% K₂O from seaweed. Organic forms of trace minerals supplied as 6% B, 6% Fe, 6% Mg, and 6% Ca.

Magna Gro Recipe
Mixed in 2 gal. water for direct fertilization:
(Not concentrated for injectors)
2 tbsp. Hydroponic Base Mix
1/8 tsp. 19% N
1/3 tsp. 9% K
*To provide 90 ppm N, 45 ppm P, and 195 ppm K.

Greenhouse Production:

1) Transplant when seedlings have 5-7 true leaves—BEFORE any flowers have opened.

2) 5 gal. plastic “grow bags” filled with peat or coir-based substrate that has not been amended with a starter nutrient charge or wetting agent, as these products are most likely from inorganic sources and not acceptable for use in organic production. We blended our own mix from commercial blend specially formulated to omit the wetting agent and starter charge.

3) Nutrition:

*Note—Stage 1 = From transplant to the first fruit set
Stage 2 = From first fruit set to “topping” the plants—when they are about 6’ tall
Stage 3 = From topping to the end of the crop

a) Fertigation using ½ gph emitters is ideal:
   Stage 1: 6 minutes/cycle, 4 cycles/day, to supply 0.89 liters/plant/day
   Stage 2: 8 minutes/cycle, 4 cycles/day, to supply 1.20 liters/plant/day
   Stage 3: 13 minutes/cycle, 4 cycles/day to supply 1.77 liters/plant/day

b) Commercial fertilizers should be for-

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1Fafard’s Special Organic Mixture: Contact Hugh Poole, Fafard, 6406 Carmel Road, Suite 30, Charlotte, NC 28226, SC 29622 Phone: 1-800-845-1664 or 1-800-722-7645 email: sales@fafard.com; http://www.Fafard.com/
2Wetting agent: Harold Uradomo, 805-650-8942, J.H. Biotech, Inc., 4951 Olivas Park Drive, Ventura, California 93003
mulated to provide the following N-P-K concentrations:

<table>
<thead>
<tr>
<th>Stage 1</th>
<th>Stage 2</th>
<th>Stage 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>90 ppm N</td>
<td>125 ppm N</td>
<td>165 ppm N</td>
</tr>
<tr>
<td>45 ppm P</td>
<td>45 ppm P</td>
<td>45 ppm P</td>
</tr>
<tr>
<td>195 ppm K</td>
<td>195 ppm K</td>
<td>310 ppm K</td>
</tr>
</tbody>
</table>

i) **Earth Juice™.** In addition to products listed under the Organic Transplant Production section, they also have a product called: 

"Microburst Three"—derived from sulfates of Magnesium, Cupric, Ferrous Manganese, Zinc, Borate, and Kelp to provide micronutrients. K₂O is a 10% K source.

**Recipe—Earth Juice™: Stage 1**

To make 1 gal. of stock to be injected at a rate of 50:1

- 1 qt. Grow
- 1 qt. Catalyst
- 2 c. Bloom
- 1½ c. 10% K₂O

**Recipe—Earth Juice™: Stage 2**

To make 1 gal. of stock to be injected at a rate of 50:1

- 1 qt. + 1¼ c. Grow
- 1 qt. + 1¼ c. Catalyst
- 1¼ c. Bloom
- 1¼ c. 10% K₂O
- ½ c. Microburst Three

**Recipe—Earth Juice™: Stage 3**

To make 1 gal. of stock to be injected at a rate of 50:1

- 1 qt. + 3 c. Grow
- 1 qt. + 3 c. Catalyst
- ¾ c. Bloom
- 2¼ c. 10% K₂O
- ½ c. Microburst Three

ii) **Magna Gro™**

**Recipe for Magna Gro™: Stage 1**

To make 1 gal. of stock to be injected at a rate of 50:1

- 1 qt. + ¼ c. Hydroponic Base Mix (HBM)
- 1/3 c. 19% N
- ¼ c. 9% K

**Recipe for Magna Gro™: Stage 2**

To make 1 gal. of stock to be injected at a rate of 50:1

- 1 qt. + ¼ c. Hydroponic Base Mix (HBM)
- 1 c. 19% N
- 2 c. 9% K

**Recipe for Magna Gro™: Stage 3**

To make 1 gal. of stock to be injected at a rate of 50:1

- 1 qt. + ¼ c. Hydroponic Base Mix (HBM)
- 1/3 c. 19% N
- ¼ c. 9% K

**Recipe for Magna Gro™: Stage 3**

To make 1 gal. of stock to be injected at a rate of 50:1

- 1 qt. + ¼ c. Hydroponic Base Mix (HBM)
- 1 c. 19% N
- 2 c. 9% K

**Recipe for Magna Gro™: Stage 3**

To make 1 gal. of stock to be injected at a rate of 50:1

- 1 qt. + ¼ c. Hydroponic Base Mix (HBM)
- 1 c. 19% N
- 2 c. 9% K

**c)** The start-up nutrient charge that was added to the growing medium will provide enough nutrients to last 2-3 weeks after transplanting. At this time, plants will probably have progressed to Stage 2 of development.
Do you need a way to reduce the time you spend seeding for transplants? How much time do you waste thinning hand-seeded trays of tiny transplants because it's so hard to drop just one tiny seed in each cell of a 200-cell tray? Consider a vacuum seeder; it could be a time and body saver.

There are many options, and I would recommend getting exactly what you need – making an investment so the machine fits your scale and, most importantly, works best with the small-to mid-sized seeds you regularly plant.

Shop around, but also talk with growers who have used the seeder you are considering, or who transplant similar crops.

Here are the details on three different types of vacuum seeders, and opinions on them from three very different scale farms. For more information on each product, contact the manufacturer.

**Wand Seeder**

GraMar TM-3 from GraMar, Inc.  
www.gra-mar.com 413.743.2064  
Used by Blue Heron Farm, Rockport, WA

- **Crops seeded:** brassicas, broccoli, cauliflower, cabbage, kohlrabi; also onions, lettuce, fennel, tomatoes
- **Acreage transplanted:** approximately two for direct market sales
- **Type:** Single person seeder. This model runs off an air compressor, although there are vacuum pump models available as well.

**How it works:** Suction is funneled down to seed size-specific needles spaced out along a wand. Each wand has needles spaced to align with the cells of a specific flat.

**Advantages:** If you use a single flat type (72-cell, etc.) for all seeding, one wand is all you need.

**Drawbacks:** You will need a different wand for each flat type and size used.

**How to use a wand seeder:**

1. Select and attach the appropriate needle tips. Use ones that are slightly...
Vacuum Seeders...

A broad variety of needle sizes comes with each seeder smaller than the size of the seed, otherwise they will suck up and waste seed.

2. Attach the wand to the vacuum hose.

3. Fill flat with media. If you want depressions for the seed to sit in, make them now, the seeder cannot push seeds below the surface of the media; it simply places them on the surface.

4. Pour seed into the seed trough and set the packet aside someplace safe and convenient. Shake the trough gently so seed level is uniform. You don’t need to have large quantities of seed, one flat’s worth extra is enough.

5. Turn on the vacuum, pick up the wand, and adjust the pressure with two adjustable knobs.

6. Place your thumb tightly over the air hole (think grade school recorder playing here), and dip the wand into the trough, keeping it level so all the needles just touch down on the seed.

Give it a little tap if many of the needles have picked up two seeds.

7. Position the wand over the first row of cells and lift up your thumb from the air hole. Suction disappears and the seeds drop, one per cell. Follow the seed drop by eye to ensure they all dropped and that each cell has a seed.

8. Put a finger of your other hand on the next row of cells to be seeded—you are going to look away from the flat, and it is easy to lose your place with small, media-colored seeds—put your thumb back over the hole, and go back to the trough for more seed.

You are planting a row of seeds for every motion, and it is certainly faster than by hand, even when comparing a fast seeding hand to a moderately fast wand hand.

Comments: The time wasting occurs when changing out seed varieties for every flat. You have to stop, slide the end off the trough, and pour the leftover seed back into the bag.

If you are doing several flats of the same seed, and you have them all prepped ahead of time, things move right along.

Our seeding time was probably cut by half, and often it was only two flats of the same seed. I still seeded half flats and many large seeds by hand, it feels faster than changing out the seed or the needle tips.

Blue Heron Farm seeds onions in open flats, four lines running lengthwise down the flat. The wand laid down the seed in a line, evenly spaced. The trick was to put four wand-fills in a line, moving the wand small amounts so that the seeds dropped into gaps between the previous dropped seeds.

The stress to the body changes when transferring from hand to wand seeding; shoulders and backs cramp less, but my eyes get tired from scanning up and down the needles and the cells to make sure we were getting a full flat.

It’s intense, but Blue Heron Farm saves on seed and time by avoiding thinning, and the flats are very uniform when the germination rate is good. It

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Vacuum Seeders...

also helps if the seed is clean; lots of chaff clogs the needles. Easy to fix, but you have to watch for it.

GroMoor Wand Seeders are also designed for planting tiny seeds and odd-shaped flower seeds, in addition to providing excellent control for seeding multiple seeds per cell. They also offer a range of other seeding assist devices, from simple dibblers to semi-automated seeding lines.

Plate Seeder

Crops seeded: Tomatoes, peppers, lettuce & greens, onions & leeks, basil & other herbs

Acreage transplanted: Used mostly for production of vegetable transplants for wholesale and direct market sales. Several hundred flats per season.

Type: Single person style. Attaches to a small house vacuum via standard vacuum hose and nozzle.

How it works: Interchangeable, custom-sized and drilled aluminum plates attach to a shallow, Plexiglas box via four screws. A round fitting on the box attaches to the vacuum. A small sliding panel opens and closes the opening, effectively turning the vacuum on and off without reaching for the machine.

Advantages: Goes amazingly fast when doing several trays of the same seed and cell size. Seeding 30 prepped trays of basil six packs takes about 10 minutes with no overseeding. Easy to ensure you have at least one seed per cell in a quick glance. Seeds one entire tray at once. Good way to conserve scarce/expensive seed. Most cost-effective if everything you seed goes into the same size tray (e.g. 10/20s.)

Drawbacks: Changing out plates completely shuts down the process and takes several minutes of fiddling. Plates are expensive, but if you do a wide variety of seed sizes and shapes (tomato, lettuce, petunia, lettuce, cucumbers, etc.), even using the same cell size (e.g. 72s), you should get the ones with holes sized specifically for each seed size and type. You must get entirely separate seeder and plates for trays of a different dimension. Easy to lose a stray seed here and there when pouring off the extra; keep other trays far enough away to prevent variety contamination. It's worth spending more for pelleted seed for odd-shaped varieties (lettuce, etc.) You'll need a dibbler for each different cell count as well.

How to use a plate seeder:

1. Prep all the trays and tags you are going to need ahead of time, including dibbling the surface. Have a good sized container at hand.

2. Attach the correct sized plate and the vacuum; make sure the vacuum shut off on the seeder is wide open.

3. Dump a generous amount (it's faster) of seed onto the plate and turn on the vacuum. The more seed you use, the quicker you fill all the holes.

Homemade dibbler board, plate seeder vacuum shut-off
4. Pick up the seeder and tip it slightly back and forth to spread the seed around until each hole has one or more seeds ‘stuck’ to it. Tip it to one corner over the bowl and gently pour/shake/tap the excess seed into the bowl.

5. Scan the surface to be sure you have one seed per hole. This is where having the right-sized holes for the crop becomes important. Otherwise, you can spend as much time fiddling to get the extras off the plate as you would seeding by hand.

6. When you have one seed per hole, turn the seeder upside down over your tray, gently lower so the edges of the seeder line up with the edges of the tray. Push the vacuum shutoff in, releasing the seedss. Give it a tap and a few seconds to release all the seeds.

7. Remove seeder, turn upright, open the vacuum, and you are ready to dump the contents of the bowl back on the plate and repeat the process for the next tray.

Comments: Even if you are only doing a few trays per variety of several similar seeds, the time saved is worth it. Even for doing a half-flat per variety (Rocky Prairie usually does 40+ tomato and pepper varieties that way) it can still be a time saver. Don’t forget to empty the bowl before seeding the next variety. The time savings from the extensive thinning that usually comes from hand-seeding basil, lettuce, etc. is well worth it.

For half flats, tape (carefully sealing all edges) a piece of paper over one half the holes in the plate. Don’t forget to turn the tray before putting the seeder back on the tray for the second variety.

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Vacuum Seeders...

When used in conjunction with a flat filler, watering tunnel, and soil topper, the seeder line takes between five and six skilled and dedicated people running at full tilt to process 600-800 flats per day.

Advantages:
For large volumes of trays, an automated seeder like this is almost essential.

Drawbacks: Not efficient for small batches. Plenty of moving parts; may be hard to obtain quickly. Very expensive. Needs a permanent location; can't be packed in a box after the season is over.

How it works: The Blackmore Precision Needle Seeder runs off an onboard vacuum pump and air compressor. It comes standard with four needle sets, or manifolds, suited for sizes ranging from very small up to those roughly the size of a cabbage seed. Larger configurations are available. Adjustments for seed size are primarily by choice of needle manifold, the speed at which the seed reservoir vibrates (to "lift" seeds slightly to make them available to the vacuum needles), and the angle at which the reservoir is presented to the needle tips.

Seeds are placed in a reservoir slightly below the needle manifold. When operating, the needle manifold rotates back clockwise and places the needle tips within the vibrating seed reservoir.

At this point, the vacuum pump switches on, and picks up a seed on the end of each needle. The manifold then rotates back around counterclockwise until the needles point down, over the drop tubes, aligned directly above a flat held in place below.

The vacuum releases a brief jet of air to release each seed from the needles, which are then funneled down the drop tubes to fill one cell row of a flat.

On the backstroke, the pump releases another puff of air to clean the needles of any chaff or debris that may have accumulated and the mechanical indexing device advances the flat one row.

Different drop tubes are designed for different sizes of standardized flats. The Blackmore Needle Seeder has double needle row options for seeding two rows at once, which can be used for double seeding of cells if planting lots with very low germination count or if multiple seeds per cell are needed.

The flats can also be run through twice to obtain two seeds per cell. Seed lots down to trial-size packets can be seeded accurately and efficiently, if desired. One of the nice details about this seeder is that it seeds right down to the last of the seed in the reservoir.

Conclusion
There are plenty of models, styles, and manufacturers of these, and other, semi- and fully automated seeding systems.

Check them out, talk with other users, and see if one can help you save time with transplant seeding and thinning on your farm.

For a movie of a needle seeder in action visit www.blackmoreco.com/movies/mv_needle_seeder.html

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More Resources

**Vegetable Production:**

Commercial Vegetable Production Guides: [http://nwrec.hort.oregonstate.edu/vegindex.html](http://nwrec.hort.oregonstate.edu/vegindex.html)

Crops, WSU Vegetable Research and Extension: [http://vegetables.wsu.edu/vegtble.html](http://vegetables.wsu.edu/vegtble.html)

**High Tunnels and other Season Extension Methods:**

Natural Resource Conservation Service High Tunnel Pilot Program:
[http://sustainableagriculture.net/blog/important-update-on-nrcs-high-tunnel-pilot-program/](http://sustainableagriculture.net/blog/important-update-on-nrcs-high-tunnel-pilot-program/)

High tunnel resources: [http://www.hightunnels.org/forgrowers.htm](http://www.hightunnels.org/forgrowers.htm)


Mount Vernon Vegetable Research and Extension: [http://vegetables.wsu.edu/plasticulture.html](http://vegetables.wsu.edu/plasticulture.html)

**Record Keeping and Crop Planning:**


**Direct Marketing Farm Products:**

*Farmers’ Markets:*

[http://attra.org/attra-pub/farmmrkt.html](http://attra.org/attra-pub/farmmrkt.html)


The New Farmers’ Market: Farm-Fresh Ideas to Make Market Sales Sizzle, Vance Corum and Eric Gibson, New World Publishing, 3037 Grass Valley Highway #8185 Auburn, CA 95602, Ph: 916-823-3886


Restaurants
To find out more about the Quillisascut Farm Chef School, visit www.quillisascutcheese.com or call 509-738-2011.

The Chefs Collaborative is a network of chefs, restaurateurs and other culinary professionals who promote sustainable cuisine by teaching children, supporting local farmers, educating each other & inspiring their customers to choose clean, healthy foods. To find out more visit: http://www.chefscollaborative.org/

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