PROJECT REPORT

This is a final project report submitted
to the Organic Farming Research Foundation.

Project Title:

Adapting organic apple practices for Great Lakes Region organic hops production

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Organic Hops Production for the Great Lakes Region Using Organic Apple Growing Practices

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1. *Project Summary*

The high value of organic hops (up to $10,000/acre gross) makes them an especially attractive crop for small to midsize organic farms. Organic apple farmers may be especially well suited to hops production given the similarities between modern, high-density apple orchards and hops production. These similarities include: perennial production, the need for trellising or other structural support, as well as comparable harvest dates (August-October). However, potential hops production in the upper Midwest also presents significant challenges such as: selection of varieties well adapted to microclimatic conditions and local markets, development of realistic expectations for the cost of production and assessment of potential pest management issues. We established an experimental hopyard at AlMar orchards in Spring 2009 to answer some of these questions. Sixteen certified organic hop varieties were planted in a single trellised row. Hop varieties had representatives from both bittering and aromatic hops. Data collected in our first year of growing hops was limited by unusually cool summer conditions (the 10th coolest summer in MI recorded history) resulting in slower than expected hops vine development. Our efforts were focused on collecting data on the weekly growth of the 16 hops varieties and the relative abundance of pests. First year establishment of a hopyard using materials adapted from high density tree fruit cost approximately $7,317. The two-spotted spider mite was our most serious pest with mite damage first observed in mid July and continuing until final harvest. Chinook, Pride of Ringwood, and Galena appeared to be less frequently attacked by two-spotted spider mite compared to the other hops varieties. The first harvest of cones was on August 27, 2009, and the final harvest performed on September 24. Bittering hops proved more vigorous than aromatic hops with Cascade, Chinook, Pride of Ringwood, Brewer's Gold, and Galena varieties producing a limited number of cones in their first year (a total of 1.7 oz of dry cones from 53 vines across all five varieties). Magnum, Sterling, Northern Brewer, Golding, Fuggle, Centennial and Kent Golding varieties performed rather poorly with less than 24" average peak vine length. This project proved to be a very popular one with multiple requests for information at our lab website, a well-attended field day in June 2009, and an award winning poster presentation in March 2010.

2. *Introduction to the Topic*

Several SARE farmer grants have been funded in the past decade that have addressed organic and/or small scale hops production in the Northeast with the conclusion that it is feasible (SARE 1998, 2006). The 1998 SARE project concluded that German and "Fuggles" varieties were slow developing in upstate New York, while varieties typical of Northwestern production (*e.g.* Cascade, Golding, Brewers Gold) were faster growing. Neither of the SARE projects reported significant problems with insects or disease. However, there is an almost complete lack of research or extension publications that deal with the economic and horticultural aspects of growing hops under Great Lakes regional conditions.

Hops were introduced to the United States in 1629 and grown initially in Massachusetts (Bamka, 2002). By the mid 1800s, hops were being grown throughout the Eastern U.S., with production reaching 1.5 million lbs/year (Kuepper, 2005). However, during the 1920s a combination of disease pressure from powdery mildew, labor unrest, and prohibition forced the production of hops to the Pacific Northwest (Hilchey, 2003; Kuepper, 2005). Hops production in the Pacific Northwest successfully escaped powdery mildew for three quarters of a century, until 1997, when the disease was discovered and is once again a major concern (Mahaffee et al., 2003a, Hengel and Shibamoto, 2002). Today, Washington, Oregon, and Idaho produce almost all of the commercial hops in the United States with Washington accounting for 77% of U.S. hops production in 2007 (Hop Growers of America, 2008).

Currently there is a shortage of hops due to increased demand and reduced commercial acreage. Beer production has risen internationally over the past five years (19.11% in Asia, 10.59% in Europe, and 9.53% in the Americas) and demand for locally produced hops is also on the rise with a 7.5% increase in U.S. microbreweries in the last decade (Brewers Association, 2008). During this same decade, worldwide hops acreage decreased by over 18% (Hop Growers of America, 2008). The resulting shortage of hops has caused prices to increase by as much as a factor of 10 for conventionally produced hops (USDA, 2007). Organic hops typically sell for two to four times as much as conventionally produced hops and most of the U.S. supply is currently imported from New Zealand (Kuepper, 2005; De Keukeleire et al., 2007; O'Brien, 2007).

Establishment of a new hop yard presents a number of challenges to grower including: initial cost, seasonal labor needs, as well as pest and disease pressure. Building a trellis system for hops to grow on is often the biggest investment. Established hop yards require a level of maintenance comparable to tree fruit production. In the beginning of the growing season, young vines must be trained onto string or twine leading up to the top wires of the trellis system (SARE, 1998; Kneen 2003; Kuepper 2005). Hops continuously put out new vines, so there is the added labor of having to trim off unwanted vines weekly amounting to 15 minutes of labor per plant per season (SARE, 1998; Kneen 2003; Kuepper 2005). At the end of a season, small-scale hop producers must hand pick the hops, since purchasing mechanized equipment would not be economical (Bamka, 2002). Several harvesting dates may be necessary, since hops mature at the end of the vine before hops at the base of the vine (Bamka, 2002).

The three major diseases affecting hops are powdery mildew, downy mildew, and verticillium wilt. Powdery mildew plagues hop growers worldwide, can become a problem at any point in the season, and can have a significant impact on yield due to direct damage to flowers and cones as well as reducing the growth rate of the hop plants (Mahaffee et al., 2003a,b). Downy mildew most often strikes early in the growing season and verticillium wilt tends to occur late in the season (Kneen, 2003). Cultural methods of disease management include the use of drip irrigation and rotational sheep grazing or hand pruning of lower leaves to ensure low moisture levels at the base of the plant (Kuepper, 2005, Kneen, 2003). If emergency measures are required, OMRI approved sulfur, copper, bicarbonate, and oil based fungicides are available to help manage these diseases (Kuepper, 2005, Kneen, 2003, Mahaffee et al., 2003b).

The two most important pests of hops encountered worldwide are the damson-hop aphid and the two-spotted spider mite (Losel and Lindemann 1996, Hengel and Shibamoto 2002). Aphids can vector Hop mosaic virus (HpMV), Hop latent virus (HpLV), and American hop latent virus (AHLV) (Pethybridge et al., 2008). Pests of hops that have recently been

encountered in New Jersey are aphids, spider mites, leafhoppers, Japanese beetles, and European corn borer (Bamka, 2002). Spider mites can also do a great deal of damage, but tend to be more of a concern in areas that are hot and dry (Kuepper, 2005). Aphid and spider mite infestations can be controlled by natural predators or those introduced as part of a biological control program. OMRI approved insecticidal soaps, oils, and Neem formulations can be used to control outbreaks in emergency situations (Kuepper, 2005).

3. *Project Objectives:*

Objective #1: To determine the economic feasibility of adapting high-density orchard technology (e.g. trellis and drip irrigation systems) and practices (i.e. floor management, pest management tactics) for Michigan/Upper Midwest production of organic hops.

Significant Revisions: None.

Objective #2: To determine the relative suitability/productivity of sixteen varieties of Hops for Michigan/upper Midwest climatic conditions.

Significant Revisions: None.

Objective #3: To determine initial pest management challenges for organic hops produced under Michigan conditions

Significant Revisions: None.

4. Materials and Methods

Plot and Vine Establishment and Management:

The project was carried out at AlMar Orchards, located outside of Flushing, Michigan. A single row of hops was planted in an area measuring approximately 50’ x 800’ (~1 acre) (Fig. 1). Sixteen varieties of certified organic hops rhizomes (Cascade, Centenial, Chinook, Willamette, Fuggle, Magnum, Mt. Hood, Nugget, Northern Brewer, Perle, Pride of Ringwood, Sterling, Kent Golding, Brewer’s Gold, Galena, and Golding [The Thyme Garden Herb Company, Alsea Oregon]) were planted in March 2009 (Table 1). Hop vine spacing was approximately four feet with support posts for trellis wire spaced every 30’. The posts used for the trellis were 5” in diameter and 20’ tall with 4’ set into concrete. Trellis wires were set at 16’ (the top of the posts) and 3’ with trellis wire and a pair of earth anchors placed for every eighth post. Twelve gauge steel wire was used for trellising. A drip irrigation system was established in April 2009, utilizing the 3’ wire for support. Irrigation emitters were placed in between rhizomes to minimize moisture deposition on the vines. To simplify management and harvest, as well as to preclude the chance of confusing varieties, hop varieties were planted in continuous separate sections of the trellis (10-11 rhizomes per section). This decision was made during the planting process and after consulting with the rhizome suppliers and several “backyard” hops growers. Beginning in

Figure 1: Hops trellis in April

April 2009 a single vine from each rhizome was trained to the trellis system using orchard twine, and additional shoots pruned off at the crown.

Hops development and pest management practices

Throughout the initial year of the study we recorded the amount of (non-scientific) labor and inputs used to establish and maintain the hops planting. Each hop vine was measured weekly and the presence of diseased or mite infested leaves or developing cones recorded. A final assessment of mite damage was assessed on September 18 using a 5 level scale assessing the percentage leaves with apparent mite damage: 0 = 0% damage, 1= 1-10% damage, 2 = 11-25% damage, 3, 26-75% damage, and 4 = 76-100% damage. Cones that completed development were collected on a weekly basis and wet weights taken after which they were dried in a food dehydrator for 12 hours and dry weights collected. Hops were weeded as needed and a handheld weed trimmer used to manage plants growing more than 1' away from the vines.

Table 1: Hops Variety General Characteristics

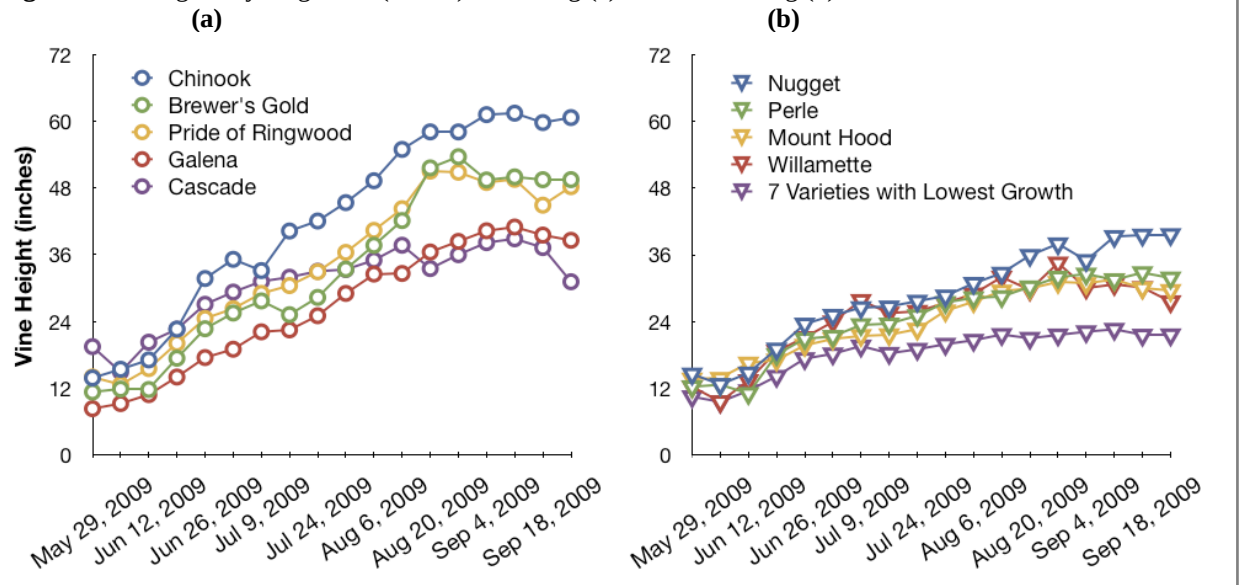
Hops Variety	Origin	Brewing Use	Alpha Acid
Cascade	*USA: WA*	Dual Purpose	*4-7.5%*
Centennial	*USA: WA*	Dual Purpose	*10%*
Chinook	*USA: WA*	Bittering	*12-14%*
Willamette	*USA:OR*	Aroma	*4-6%*
Fuggle	*England*	Aroma	*4-5.5%*
Magnum	*Germany*	Dual Purpose	*10-12.6%*
Mt. Hood	*USA*	Aroma	*5-8%*
Nugget	*USA:WA*	Bittering	*12.5-14%*
Northern Brewer	*England*	Dual Purpose	*6.6-8%*
Perle	*Germany*	Aroma	*7-9.5%*
Pride of Ringwood	*Australia*	Bittering	*8.5-10%*
Sterling	*USA*	Aroma	*6-9%*
Kent Golding	*England*	Aroma	*4-5.5%*
Brewer's Gold	*Germany*	Bittering	*5.5-6.5%*
Galena	*USA: ID*	Bittering	*12-14%*
Golding	*England*	Aroma	*4-5%*

5. *Project Results*

First year hops growth and yield

Hops did not develop evenly or quickly during 2009, with striking differences observed among the 16 varieties. Bittering hops consistently grew better than aromatic hops. Weekly growth and development of hops is presented in Figure 2. Chinook, Brewer's Gold, Pride of Ringwood, and

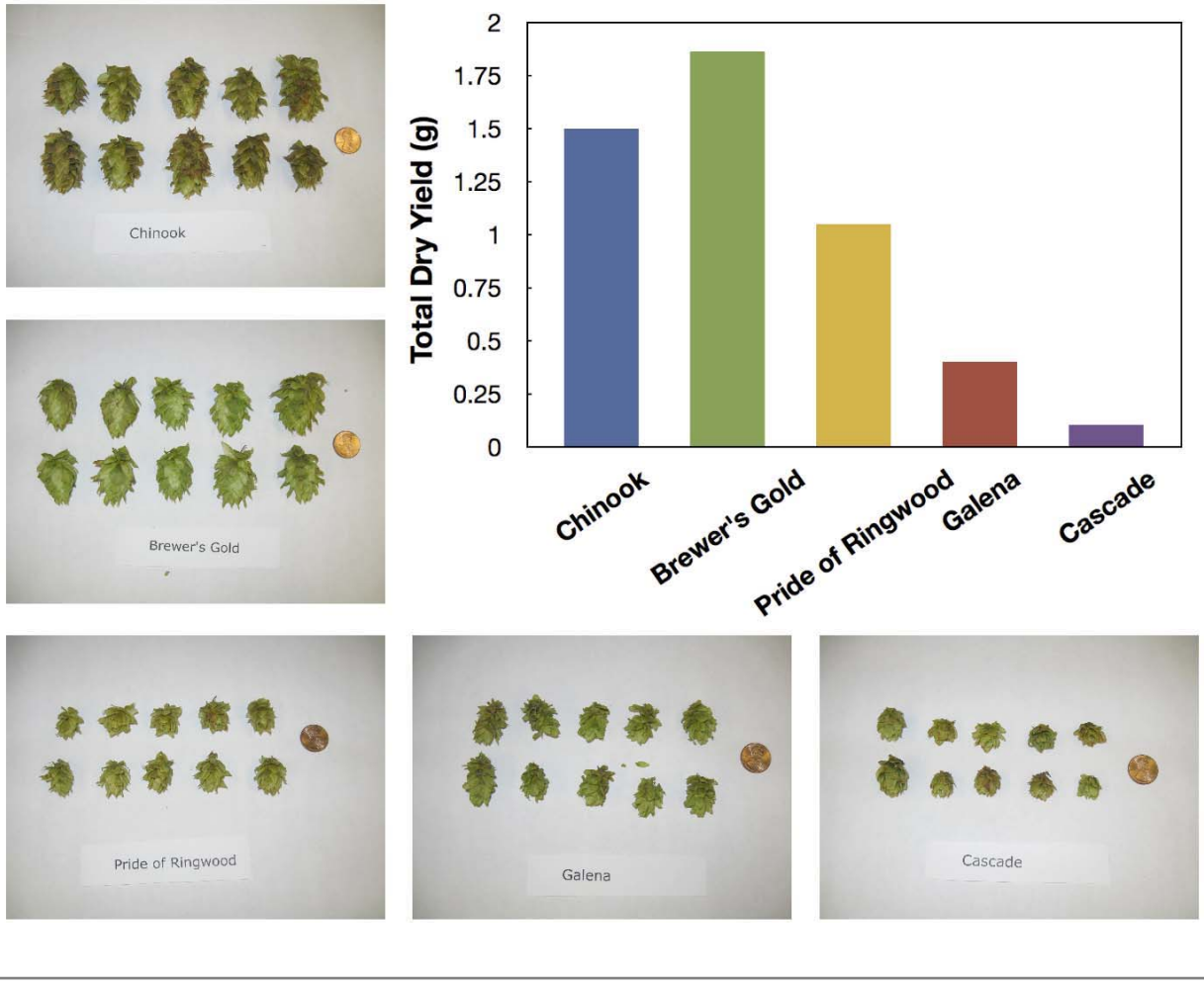
Figure 2: Average 1st year growth (inches) of bearing (a) and non-bearing (b) varieties



Galena and Cascade were the most vigorous varieties and were the only varieties to produce cones in their first year (Figs 2a). Hops growth for varieties that did not produce cones is presented in Figure 2b. Seven of the hops varieties had an average vine growth of less than 24" in 2009. These included: Magnum, Sterling, Northern Brewer, Golding, Fuggle, Centennial, and Kent Golding.

Hops were harvested twice towards the end of the growing season, once on August 27 and again on September 24. Hops yields and representative images of cones of the yielding varieties are presented in Figure 3. Chinook yielded the highest dry weight of cones, followed by Brewer's Gold, Pride of Ringwood, Galena, and Cascade. However, so few cones were produced we were unable to provide samples to brewers or assess hops quality. A much better harvest is expected in 2010 now that the rhizomes have had a chance to establish a root system.

Figure 3: First year hops dry yields (oz) and representative images of the five yielding varieties' cones.



First year costs and potential profit

Estimated cost of first-year hops establishment in our one-acre test plot was approximately $8,317 with $2,415 spent on materials and $5,902 spent on labor and machinery. These costs do not include research labor. A detailed breakdown of estimated cost is presented in *Table 2*. Labor costs associated with weeding, especially in the first two months, were higher than initially anticipated. In part this was because we were unable to utilize sheep as initially proposed due to the hops vines' slow growth. Unfortunately first year yield was so low as to not warrant calculation. A total of 1.7 oz. of dried cones was collected from the entire experimental plot (165 rhizomes planted across all varieties). This was over two orders of magnitude lower than the 1+ oz. per vine we had hoped for. Second year harvest is expected to be much higher. Representative pictures of cones from the five varieties is presented in figure 5.

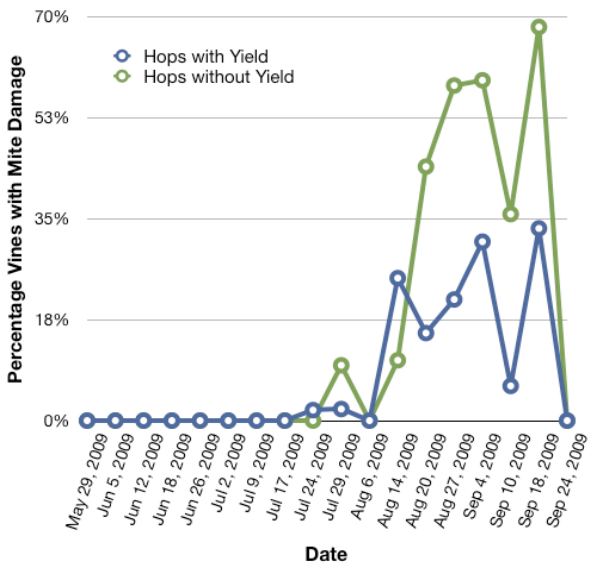
Table 2: 1st year Hopyard costs for 1 acre

Materials	***$2,415***
20' 5" diameter	**17 posts @ $53.82/post = $915**
Trellis Wire	**1 roll of 12 gauge trellis wire = $65**
Hops Rhizomes	**160 @ $6/rhizome = $960**
Drip Sprinkler Line	**Approximately $150**
Concrete	**45 80-lb bags at $5/bag = $225**
Fish, copper, sulfur	**5 applications @ $20/application = $100**
Labor/Machinery	***$5,902***
Plot Value	**1 acre @ $1000/acre/year**
Machinery costs	**40 hours at $72.55/hour = $2,902**
Post Setting	**48 hours @ $10/hour = $480**
Trellising	**16 hours @ $10/hour = $160**
Planting	**16 hours @ $10/hour = $160**
Hops Training	**15 hours @ $10/hour = $150**
Pest Scouting	**52 hours @ $10/hour = $520**
Weeding	**53 hours @ $10/hour = $530**
Total 1st Year Costs	**$8,317**

First year pest pressure

Two-spotted spider mites were the primary pest observed in 2009 with the incidence of damage increasing towards the end of the season (Fig. 4). Because hops growth was so much slower than expected we decided not to take weekly leaf samples as originally proposed, but rather recorded the presence of mite damage on a per week/vine basis and performed a mite damage evaluation during the harvest period (Fig. 5). Mite presence and damage were observed on all but the Chinook variety hops, with Willamette and Centennial vines appearing to be most susceptible to mites. Magnum, Pride of Ringwood, Galena, and Kent Golding appeared to have minimal impacts from mites. Low harvests prevented us from accurately assessing the economic impact of mites. However, varieties with high levels of mite damage

Figure 4: Average vines with mite damage over the 2009 growing season



typically did not yield and had low vigor (Figs. 4 and 5). Chinook, the one variety that never showed signs of mite damage, had both the most vigorous growth (Fig. 2) and highest yield (Figs. 3 and 5).

Japanese beetle, aphids, and an unidentified Arctiid moth (Fig. 6) were all observed feeding on hops over the course of the season. However, none of these insects were consistently present or appeared to cause significant plant stress. However, deer did browse on some of the hops varieties and several vines were lost to "mower blight". The only pest management inputs (other than weeding) applied to the vines consisted of 5 applications of fish emulsion, sulfur, and copper, which were applied in May and June just prior to or after rainfall events.

Figure 5: Percentage vines with mites, mean mite damage severity, and relative yield of the 16 hops varieties

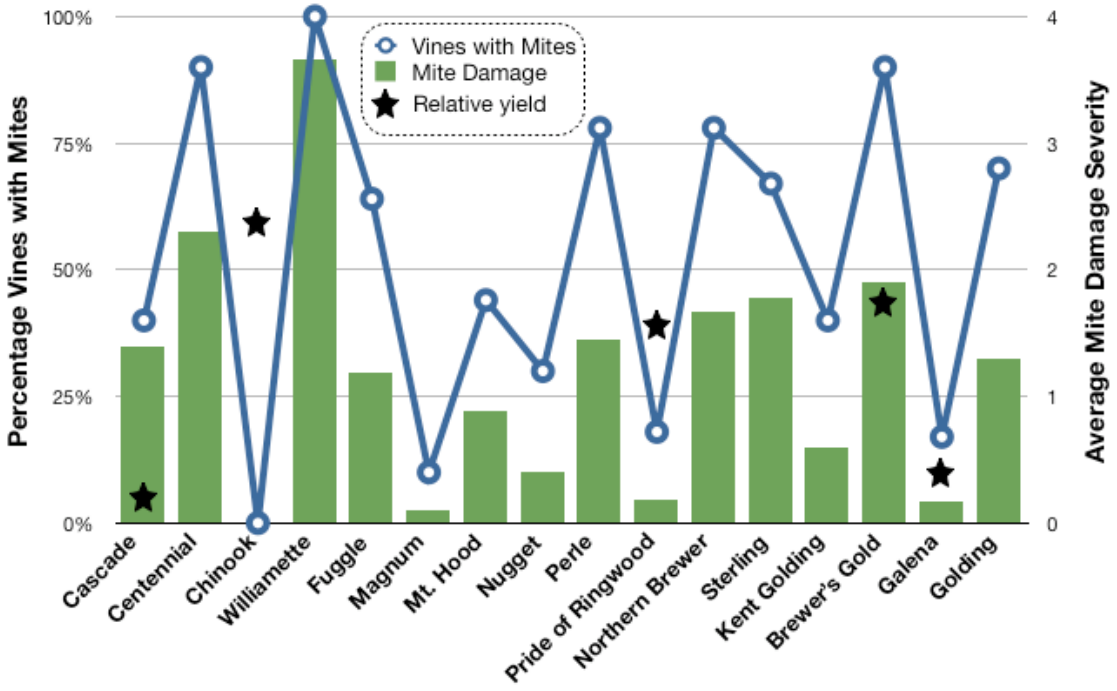


Figure 6. Insects observed on hops vines

Japanese Beetle

Arctiid Adult

Arctiid Larva

6. *Project Conclusions*

We feel that our first attempt at growing organic hops using high-density tree fruit techniques was largely successful. While we had negligible yield in our first year, all but a few vines overwintered and are expected to provide increased yields in subsequent years. Based on our first year results it appears that bittering hops are better suited to growth under Michigan conditions (Figs. 2,3). In particular, Chinook, Brewer's Gold, Pride of Ringwood, Galena, and Cascade showed good vigor and produced at least a few cones (Figs. 2a and 3). Magnum, Sterling, Northern Brewer, Golding, Fuggle, Centennial and Kent Golding performed the worst of the 16 varieties tested with average maximum vine heights of 26" or less (Fig. 2b). However, both the exceptionally cool summer as well as the perennial nature of hops need to be taken into consideration when interpreting these results.

The cost of establishing a hopyard ($8,317/acre in our study [Table 2]) may represent a considerable barrier for some organic growers especially considering the fact that first year yields appear likely to be negligible. However, costs were similar to those associated with planting tree fruit and anecdotal observations made during the early summer of 2010 suggest that a measurable yield can be obtained in the second year of growth while, in comparison, even the smallest dwarf apple trees do not typically yield until year 3 or 4. Labor costs were especially high immediately following planting as once rhizomes were planted they needed to be aggressively weeded on a regular basis and hops trained to the trellis system. We expect that these costs will need to be borne on a yearly basis as each years' growth represents a new vine which will need to be trained and weeded.

Two-spotted spider mites present the most serious initial pest management issues for organic hops in Michigan. Just prior to harvest mites were present on 25% or more of hop leaves for more than 50% of the varieties and may have reduced already low yields. Bittering hops such as Chinook, Pride of Ringwood, and Galena appeared to suffer the least from mite damage but Cascade yielded a fair number of cones despite extensive damage by mites (Fig. 5.). It is possible that sulfur applications early in the season exacerbated two-spotted spider mite populations. A potiential research topic for future organic hops research should be the efficacy of alternative fungicides such as potassium bicarbonate, compost teas, and milk solids. Likewise, efficacy trials of OMRI approved acaricides (such as horticultural oils) would be likely useful for organic growers considering hops production.

7. *Outreach*

Preliminary results and concept were shared at an organic tree fruit field held at AlMar orchard in June 2009. In addition two posters were prepared and presented at grower meetings: the first at the 2009 Great Lakes Fruit and Vegetable Expo (December 2009) and the second at the Michigan State University organic research reporting session (March 2010). The latter poster was prepared and presented by the undergraduate intern (Ben Phillips) who performed most of the sampling and was awarded a second place prize in a student research competition.

8. *References Cited*

Bamka, W. 2002. *Fact sheet-Growing hops in the backyard*. New Jersey Agricultural Experiment Station, Rutgers Cooperative Research and Extension, FS992.

Brewers Association. 2008. *Craft Brewing Statistics*. Retrieved: www.beertown.org/craftbrewing/statistics.html (11/2/08).

De Keukeleire, J., I. Janssens, A. Heyerick, G. Ghekiere, J. Cambie, I. Roldan-Ruiz, E. Van Bockstaele, and D. De Keukeleire. 2007. Relevance of organic farming and effect of climatological conditions on the formation of α-acids, β-acids, desmethylxanthohumol, and xanthohumol in hop (*Humulus lupulus* L.). *Journal of Agricultural and Food Chemistry* 55 (1), 61-66.

Hengel, M.J and T. Shibamoto. 2002. Method development and fate determination of pesticide-treated hops and their subsequent usage in the production of beer. *Journal of Agricultural and Food Chemistry* 50 (12), 3412-3418.

Hop Growers of America. 2008. *USA Hops 2007 Statistical Report*. Retrieved www.usahops.org/graphics/File/2007_Stat_Pack-final.pdf (11/3/08).

Hilchey, D. 2003. CFAP Research update: Northeastern breweries express interest in regionally grown hops. *Community, Food, and Agricultural Program News* 11 (4), 4-5.

Kneen, R. 2003. *Small scale and organic hops production*. Kneen, Left Fields, British Columbia. Available at http://www.crannogales.com/hopsmanual.html (9/15/08)

Kuepper, G. 2005. *Hops: Organic production*. ATTRA-National Sustainable Agriculture Information Service. CT-115

Losel, P.M. and Lindemann, M. 1996. The potential of semiochemicals for control of *Phorodon humuli* (Homoptera: Aphididae). *Pesticide Science* 48 (4), 293-303.

Mahaffee, W.F., W.W. Turechek, C.M. Ocamb, M.E. Nelson, A. Fox, and W.D. Gubler. 2003a. Responding to an introduced pathogen: *Podosphaera macularis* (hop powdery mildew) in the pacific northwest. *Plant Health Progess.*

Mahaffee, W.F., W.W. Turechek, and C.M. Ocamb. 2003b. Effect of variable temperature on infection severity of *Podosphaera macularis* on hops. *Phytopathology* 93 (12), 1587-1592.

O'Brien, C. 2007. The organic hops controversy. *American Brewer Magazine*, Fall Issue. Retrieved http://beeractivist.wordpress.com/2007/11/11/the-organic-hops-controversy/ (10/10/08)

OFRF, 2008. OFRF Grants Awarded, 1990-2008.

Organic Consumers Association. 2007. Anheuser-Busch Pledges to Use Only Organic Hops In Organic Beer. Retrieved:http://www.enn.com/top_stories/article/21757 (11/10/08).

Osorio, C. 2008. Hogs help battle beetle in apple orchard. USA Today (March 5, 2008). Retrieved http://www.usatoday.com/news/nation/2008-03-05-2348980728_x.htm (November 5, 2008)

Pethybridge, S.J., F.S. Hay, D.J. Barabara, K.C. Eastwell, and C.R. Wilson. 2008. Viruses and viroids infecting hop: significance, epidemiology, and management. *Plant Disease* 92 (3), 324-338.

SARE. 1998. Project report: Commercial organic hops production trial. FNE98-195. Available at http://www.sare.org/

SARE. 2006. Project report: Meeting the Needs of the Michigan Craft Brewing Industry: The Potential of Barley and Hops As Alternative Crops. FNC02-418. Available at http://www.sare.org/

United States Department of Agriculture. 2007. *National hop report*. National Agricultural Statistics Service, Agricultural Statistics Board.

Welch, D. 2007. Hops shortage likely to boost price of beer. *Morning Edition, National Public Radio*. Retrieved: www.npr.org/templates/story/story.php?storyid=16245024 (November 2, 2008)

www.almarorchards.com (11/5/08)

www.breworganic.com (11/5/08)

www.ciderguild.org (11/5/08)

www.moffa.org (11/5/08)

www.msuorganicfarm.com (11/5/08)

www.organicskrumpy.com (11/5/08)

www.parisviewfarm.com (11/5/08)