Evaluation of hop cultivation feasibility in Connecticut©

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INTRODUCTION

Hop (*Humulus lupulus*) cultivation and brewing has a long tradition that started with the first settlers in the Northeastern of the United States. Disease pressure and the enactment of Prohibition moved production to the Pacific Northwest starting in the 1800s, which currently constitutes the largest production area worldwide (FAOSTAT, 2013). However, interest in hop cultivation in the Northeast has increased in the last few years led by New York State and Vermont. The increasing popularity of the microbrew culture, local brewpubs, home brewing, and the growing demand for regional products have created a new niche for hops in New England. Brewing beer in Connecticut is on the rise as well, because of the high water quality (Paul Dockter and Lamott, personal communication). The commercial production of hops in Connecticut has just started.

Location, climate, and cultivation practices, e.g. fertilization and irrigation, influence the characteristics and quality of hops. To initiate hop production, proper research, a well-prepared work plan, and a good source of start-up capital for the trellis system, and equipment such as a hop harvester, and a drying oven are required. Hop plants will typically produce their full yield after the third year. Once the trellis system is ready, the rootstocks are crowned, 2 to 3 bines are trained on twines, and additional shoots are pruned in the spring. During the summer, the work tasks include fertilizing, irrigating, scouting and controlling diseases and pests. The harvest of the cones is usually from mid-August to mid-September depending on the cultivar (Figure 1). Processing after harvest includes drying in kilns or a drying oven and pelletizing the cones. Not only proper cultivation, but also a well-planned disease and pest management program is important to achieve high hop quality. The best method to control diseases and pests is through integrated pest management, which requires knowledge of diseases and pests and includes chemical applications as well as biocontrol methods, planting resistant or tolerant healthy varieties, phytosanitary measures (such as crowning, pruning, removing diseased leaves or plants and removing lower leaves), weed, irrigation and fertilization management. For decisions regarding appropriate measures, weekly scouting for symptoms and insects as well as observation of the weather conditions and weather forecast are required.

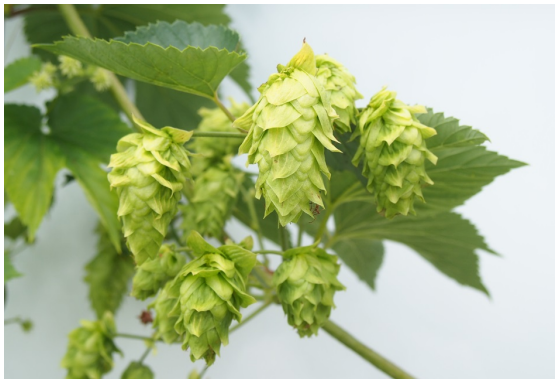

Figure 1. Hop cones of the cultivar ‘Cascade’.

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Downy mildew, caused by *Pseudoperonospora humuli*, is a major disease worldwide and the most damaging disease in the Northeast U.S. Disease outbreaks occur during wet weather, high humidity, and temperatures from 8 to 23°C, which are very common weather conditions for New England. Downy mildew can infect all parts of the plant. Stunted and chlorotic hop shoots, called spikes, often with grey to black sporulation underneath the leaves in the spring, are the first symptoms and are signs of a systemic infection (Figure 2). Further, the leaves show angular lesions delimited by veins and sporulation may form on the underside of the leaf (Figure 3). Infection of inflorescences and cones may lead to 100% yield losses. Lesser amounts of infection can reduce the quality and marketability of the cones due to discoloration and reduction of the acid content.

Figure 2. Basal spikes resulting from downy mildew and black sporulation on the underside of the leaves.

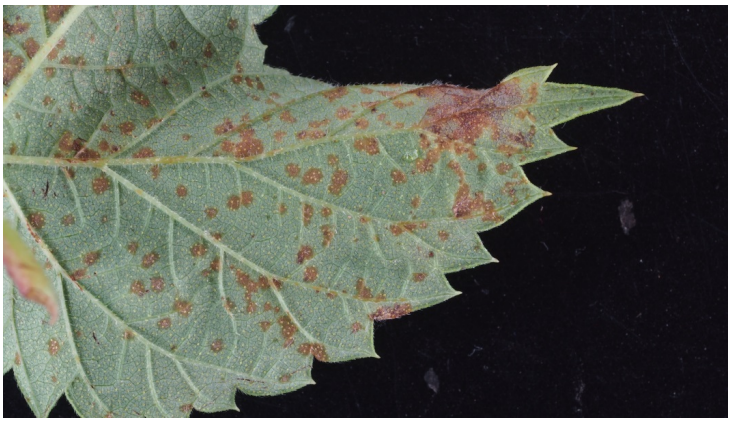

Figure 3. Lesions and sporulation on the leaf undersurface caused by downy mildew.

Disease management is based on timely fungicide application depending on the weather and prediction as well as planting resistant or tolerant varieties, sanitation practices (e.g., planting healthy rhizomes, crowning in the spring, and removing infected spikes) and harvest time (Mahaffee et al., 2009; Gent et al., 2010a, b). Other important diseases for hops are powdery mildew, which was recently observed in New York State (Miller, 2016), and verticillium wilt, which occurs in the Pacific Northwest, but hasn't yet been observed in the Northeast.

Several pests such as two-spotted spider mites, Damson-hop aphids, potato leafhoppers, Japanese beetles, and hop flea beetle may infest hops. Spider mites are very common in hops as well as other crops and ornamental plants. They feed on leaves, cause yellow spots, silver and bronze discoloration and produce a web on the underside of the leaves. If the mites infest the cones a total yield loss may occur. The population can increase

very rapidly in hot and dry conditions. Beneficial insects and predatory mites may control small populations, but above the economic threshold insecticides with a low effect on these predators should be used (Mahaffee et al., 2009; Gent et al., 2010a).

A novel pest, which has had a big impact on hops in the Northeast, is the potato leafhopper. The symptoms are necrosis of leaves, and browning of the outer edges and tips forming a distinctive "V", called hopper burn, yellowing of leaves at the tip followed by necrosis and leaf curling (Figure 4). Further symptoms are shortening of internodes, stunted growth, fewer flowers and reduced cone production. Until recently, there has been no economic threshold level, but the University of Vermont currently recommends control at two leafhoppers per leaf. Leafhoppers can be controlled by organic or conventional chemical insecticides, but also by predators (Kittell-Mitchell and Darby, 2011). Trap crops, plants which are preferred by the pest, seem to be a promising alternative choice.

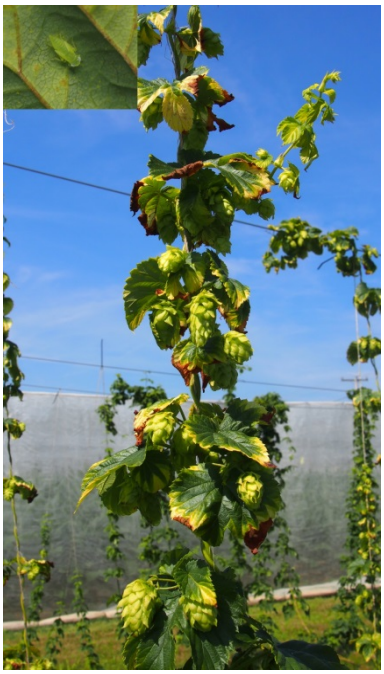

Figure 4. A young potato leafhopper and necrosis of the leaves "hopper burn", where the outer edges and tip turn brown and forming a distinctive "V".

The main objective of this study was to evaluate the feasibility of growing hops in Connecticut. Therefore, the growing characteristics, yield, and susceptibility to diseases and pests of five hops cultivars—AlphAroma, Cascade, Newport, Perle, and Summit—at high and low trellis systems in two locations (Figure 5) were analyzed over 3 years.

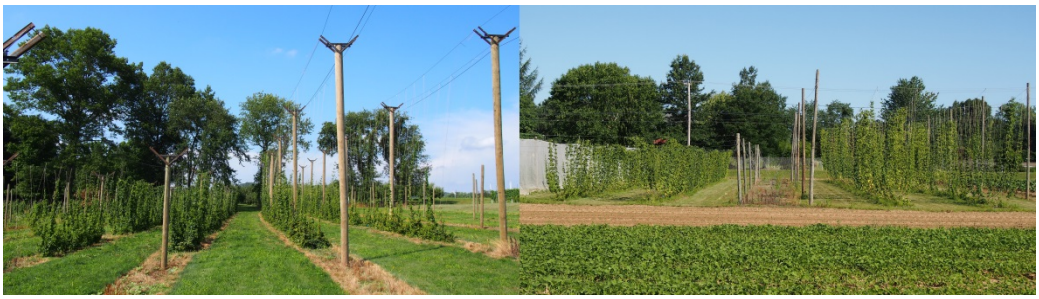

Figure 5. Hopyard systems at the Lockwood farm in Hamden (left) and at the Valley Laboratory in Windsor (right), Connecticut.

MATERIALS AND METHODS

High and low trellis systems were installed in 2013 at the Valley Laboratory in Windsor and at the Lockwood farm in Hamden, CT (Figure 5). Five cultivars—AlphAroma, Cascade, Newport, Perle, and Summit—were planted at both locations. In the spring the first shoots of the hops plant were pruned and in May trained to the trellis set up. Additional shoots were pruned frequently. Lower leaves were removed to reduce disease pressure. The plants were inspected on a routine basis to identify and record pests and diseases. In August and September, depending on the cultivar, the cones were harvested by hand and the yield and quality were determined.

RESULTS AND DISCUSSION

To evaluate the feasibility of growing hops in Connecticut, we analyzed growing characteristics, yield, diseases and pests of five different cultivars. Yields from 2014 and 2015 showed that the cultivars Cascade and Summit had the most well-adapted growth (Table 1). The harvest and yield evaluation for 2016 is still in progress at this time and cannot be included in this paper. The high trellis set up was more reliable for 'Cascade', 'Newport', 'AlphAroma', and 'Perle', whereas, 'Summit', a semi-dwarf cultivar, had higher yield on the low trellis system. 'Perle', a German breeding line, had weak development and growth and poor yield.

Table 1. Yields (cones) per vine (g) in the years 2014 and 2015 at the Valley Laboratory, Windsor Connecticut.

Cultivar	High trellis		Low trellis	
	2014	2015	2014	2015
AlphAroma	132.7	64.2	34.4	40.8
Cascade	341	97.5	258.5	93.5
Newport	174.4	44.4	120.2	39.1
Perle	72.5	19.8	72.8	9.3
Summit	256.3	65.0	312	127.8

Furthermore, diseases and pests were scouted and evaluated over the season. Downy mildew, spider mites, and potato leafhoppers were observed every year, but were controlled with rigorous pest management. Downy mildew appeared in the first planting year and every year since (Table 2). A significant outbreak was observed at Lockwood Farm in Spring 2016 (Table 3), but after downy mildew disease evaluations were recorded, disease was controlled with appropriate measures such as spraying fungicides and removing infected shoots. 'AlphAroma', which is described as tolerant to downy mildew, had by far the most symptoms. Spraying fungicides, removing weeds and redundant sprouts as well as stripping the upper leaves helped to reduce the spread of disease. Forecasting in association with a management program, which is utilized in the Pacific Northwest might be required in the Northeast as well (Gent et al., 2010b). Spider mites were observed but were controlled by predatory mites (*Amblyseius andersoni*) and by horticultural oil as well as insecticides. Potato leafhoppers appeared unexpectedly in 2015 and caused greatly reduced yields compared to the year before. In general, the yields in 2015 were lower because of the leafhopper damage and drought stress due to reduced irrigation. The data showed that intensive scouting for diseases and pests as well as a proper irrigation management are necessary to produce optimal yields. In New England, growers will face difficulties with diseases and pests, but should be able to achieve maximum yields using improved management techniques. Hop trials in Vermont showed consistently lower than standard yields compared to the Pacific Northwest (Darby et al., 2015). However, the hops had good quality characteristics, as defined by Alpha and Beta acids and hop storage index (data not shown). Growing hops in the humid Northeast might be a challenge, but with good start-up capital, a well-prepared work plan, and a rigorous integrated pest management program, hops seem to be a promising crop for Connecticut.

Table 2. Downy mildew infected plants 2013, 2014, and 2015 at the Valley Laboratory; high trellis: 'AlphAroma', 'Cascade', and 'Perle' each with 25 plants; 'Newport' with 20 plants; 'Summit' with 5 plants; low trellis: each 20 plants.

Cultivar	High trellis			Low trellis		
	2013	2014	2015	2013	2014	2015
AlphAroma	0	0	11	6	6	13
Cascade	0	0	1	0	0	6
Newport	0	0	4	0	0	6
Perle	0	0	0	0	1	1
Summit	0	0	0	0	6	0

Table 3. Downy mildew infected plants Spring 2016 at the Valley Laboratory; high trellis: each 25 plants; low trellis: 'AlphAroma' with 19 plants; 'Cascade', 'Perle', and 'Summit' each with 20 plants; 'Newport' with 18 plants.

Cultivar	High trellis		Low trellis	
	Infected plants	Number of spikes	Infected plants	Number of spikes
AlphAroma	18	7	14	9
Cascade	6	0	5	0
Newport	5	0	9	0
Perle	11	0	4	0
Summit	-	-	15	7

Growers and people interested in hop production recently formed and incorporated the Connecticut Hop Growers Association and commercial farming of hops took full swing in 2015 with approximately sixteen acres planted among farms consisting of an acre of hops or larger. Connecticut has now seen 2 years of harvest involving at least 10 different cultivars. Over the course of the next five years farmers and investors have begun to plan and diversify their farms into hop acreage, with the potential for planting another 100 acres. Having a new pelletizing facility constructed centrally in the state has encouraged farmers into investing land and time into planting the perennial crop.

SUMMARY

Interest in hop cultivation in the Northeast of the USA has risen in recent years because of the popularity of microbrew culture, local brewpubs, home brewing, and the demand for regional products. This study examined the feasibility of hop cultivation regarding yield, growing characteristics, and susceptibility to diseases and pests in Connecticut. Five cultivars: AlphAroma, Cascade, Newport, Summit, and Perle were evaluated in low and high trellis systems at two locations over 3 years. 'Cascade' and 'Summit' were identified as well suited for Connecticut and the high trellis system resulted in better growth and yield with the exception of the semi-dwarf cultivar Summit. 'Perle', a German breeding line, had the weakest growth and lowest yield. Downy mildew, the most damaging disease in the Northeast, spider mites, and potato leafhoppers were observed, but could be well controlled by intensive scouting and IPM measures. This study demonstrated the feasibility of hop production in Connecticut by using proper varieties, cultural practices, and a well-established integrated pest and disease management program.

CONCLUSION

The general feasibility of growing hops in Connecticut can be proven with this presented study. Data evaluating growth, yield and disease/pest development demonstrated that 'Cascade', a very popular cultivar in the USA, and 'Summit' seemed to be promising cultivars for hop cultivation in Connecticut. 'AlphAroma' is not recommended for cultivation in New England because of high susceptibility to downy mildew, or 'Perle' because of weak

performance. Further cultivar evaluation will be conducted with ten additional cultivar planted in 2016 at both locations.

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