2011 HOPS SCOUTING REPORT

The UVM Extension hops program is working to develop agronomic recommendations for hops production in the Northeast. Since 2010, UVM Extension has been evaluating 19 publicly available varieties at Borderview Farm in Alburgh, VT. The goal is to determine suitable varieties for this region. One aspect of determining suitability is to assess pest susceptibly. Weekly scouting of the research hopyard has helped identify pertinent pest and pest predators in the Northeast. Scouting is an essential aspect of Integrated Pest Management (IPM). Varieties that are more resistant to pests could be a good strategy for minimizing costs of production by reducing pesticide volumes and application frequencies. Ultimately improving crop yield and quality and profitability. The results and observations presented below are a summary of pest and predator incidence in the first year of hop production at the research site.

MATERIALS AND METHODS

The replicated research plots were located at Borderview Farm in Alburgh, VT on a Benson rocky silt loam. The experimental design was a randomized complete block with three replicates; treatments were the 19 varieties. The hopyard was constructed in the spring of 2010 using 20' x 6" larch, tamarack and cedar posts, with a finished height of 16 feet. Aircraft cable (5/16") was used for trellis wires. A complete list of materials and videos on the construction of the UVM Extension hopyard can be found at www.uvm.edu/extension/cropsoil/hops

Hop beds were prepared with a moldboard plow and rototiller, resulting in a bed with a width of 4'. The tillage was implemented prior to construction of the hopyard. The prior crop was an alfalfa/grass crop. Hills were distanced 7' apart, and rows were spaced at 10'. This left a strip of grass/alfalfa between the rows of hops. Each plot consisted of five consecutive hills. Hills were planted with two vegetative hop cuttings per hill on 4-August, 2010. Varieties were evaluated for survival on 12-April and 27-June 2011. In-row rototilling was the primary weed control method, and as the weeds were brought under control, rows were trained with two strings of coir (coconut fiber) per hill, fertilized, and mulched with hardwood mulch. Pro-Gro ® 5-3-4 and Probooster® 10-0-0 were applied to provide 30 lbs plant available N, 40 lbs P, and 80 lbs K ac^{-1}. Boron was also applied at a rate of 10 lbs ac^{-1}. On 7-June, Chilean nitrate (16-0-0) was sidedressed at a rate of 50 lbs N ac^{-1}. All fertilizers were OMRI-approved for use in organic systems, and were applied at rates recommended in the Pacific Northwest (Gingrich et al., 2000).

Table 1. 2011 Spray schedule in the organic hop variety trial, Alburgh, VT.

Date	Downy mildew control		Potato leafhopper control	TSSM[β] control
	Regalia	Sonata	Pyganic	Aza-Direct
17-Jun	*All*			
30-Jun	*All*		*All*	*All*
14-Jul		*All*	*Select plots*[ǂ†]	*Select plots*
20-Jul		*All*		*All*
2-Aug	*Select plots*			*Select plots*
12-Aug		*Select plots*		*Select plots*

ǂ, select plots; plots with leafhopper TSSM that met or exceeded threshold levels.
β, TSSM, two spotted spider mites

In late June, three leaves per hill and two hills per plot were scouted for insects and diseases. The hopyard was scouted weekly in July and August, and pesticides were applied as needed (Table 1). Potato leafhoppers (Empoasca fabae) (Figure 1; 2) and two-spotted spider mites (*Tetranychus urticae* Koch) were identified in the hopyard and determined to be above economic threshold. Economic thresholds for potato leafhoppers in hops has not been documented, but with an in-depth literature review, it was determined that two leafhoppers per leaf could be economically damaging to the hops. In the Pacific Northwest the economic thresholds for two-spotted spider mites is 1-2 spider mites per leaf in June, or 5-10 per leaf in July. Downy mildew (*Pseudoperonospora humuli*) was identified on var. Cluster in mid-June (Figure 3). Powdery mildew (*Podosphaera macularis*) was not identified in the hopyard.

Figure 1. Potato leafhoppers.

Figure 2. Leafhopper damage, called "hopper burn."

Regalia was sprayed as a preventative measure against downy mildew, and was tank-mixed with Pyganic (McLaughlin Gormley King Company, EPA Reg. No. 1021-1771) and Aza-Direct (Gowan, EPA Reg. No. 71908-1-10163). Pyganic is derived from chrysanthemums and is a botanical insecticide that is labeled for use against leafhoppers in hops. Aza-Direct is a botanical insecticide derived from neem (Azadirachta indica) seeds and is labeled for mites and hops. Regalia (Marrone Bio Innovations, EPA Reg. No. 84059-3), an extract of *Reynoutria sachalinensis*, is labeled for use on hops against powdery and downy mildew. Regalia is used to help bolster a plant's natural defense mechanisms. Sonata was used in rotation with Regalia (AgraQuest, EPA Reg. No. 69592-13) against downy mildew. Sonata is a biofungicide that uses *Bacillus pumilis* strain QST 2808. It is a preventative product that is used to control and suppress powdery and downy mildew in hops. All pesticides applied were OMRI-

Figure 3. Downy mildew on var. Cluster. Note short internodes and down curled leaves.

approved for use in organic systems and were applied at rates specified by their labels.

The data presented is of three replications. Differences in pest incidence can occur because of variations in surrounding habitat, weather, and other growing conditions. Statistical analysis makes it possible to determine whether a difference among varieties is real, or whether it might have occurred due to other variations in the field. Insect incidence was analyzed using the PROC MIXED procedure in SAS using the Tukey-Kramer adjustment, which means that each variety was analyzed with a pairwise comparison (i.e. 'Cluster' statistically outperformed 'Cascade', Cascade statistically outperformed 'Mt. Hood', etc.) In all tables, the top performing variety can be found in bold. Varieties that were not significantly lower in performance than the highest variety in a particular column are indicated with an asterisk.

RESULTS

October 2010 was a very wet month with above average rainfall, saturating the newly planted hop vegetative cuttings. The 2010-2011 winter in Alburgh provided adequate snow cover, which helped protect the young rhizomes. April and May brought excessive rainfall and floods throughout Vermont. Dry and even drought like conditions was observed in the hopyard during July and most of August. In August, Tropical Storm Irene hit the Northeast, and Alburgh was subject to 70 mph winds and 4" of rain in the middle of harvesting (Table 2).

Table 2. Temperature, precipitation*, and Growing Degree Day summary, Alburgh, VT.

	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11	Jul-11	Aug-11	Sep-11
Average Temperature (°F)	70.4	64.0	50.6	39.9	27.7	22.8	20.8	32.9	46.6	58.7	67.1	74.4	70.4	63.8
Departure from Normal	1.4	3.6	1.8	2.2	2.3	4.6	0.5	2.1	3.1	2.1	1.3	3.3	1.6	5.8
Precipitation (inches)	5.48	4.32	6.73	2.93	3.39	0.90	3.12	3.39	7.88	8.67	3.52	3.68	10.23	5.56
Departure from Normal	1.63	0.86	3.75	0.00	1.52	-1.05	1.71	1.07	5.00	5.35	0.09	-0.29	6.38	2.10
Growing Degree Days (base 32°F)	1192.0	990.5	578.2	243.4	17.1	0.0	0.0	144.2	465.0	826.2	1088.1	1314.4	1120.7	962.6
Departure from Normal	45.0	138.5	57.4	63.4	12.4	0.0	0.0	27.9	120.0	63.6	74.1	103.9	-26.3	110.6

Based on National Weather Service data from cooperative observer stations in South Hero, VT, which is in close proximity to the variety trial.
*Due to missing data from the South Hero station, precipitation from March to July 2011, and average temperature for August and September 2011 are taken from an observer station in Burlington, VT.
Historical averages are for 30 years of data (1971-2000).

Variety by scouting date interaction for two-spotted spider mite incidence

The interaction between variety and scouting date were found to be significant for levels of two-spotted spider mite (TSSM) (Figure 4). This indicates TSSM populations by variety responded differently across scouting date. Economic threshold levels used in the Pacific Northwest (PNW) are 1-2 TSSM leaf^{-1} in June, and 5-10 TSSM leaf^{-1} in mid-July. Miticides were applied as needed by plot, usually between scouting dates, however no pesticides were applied between the 8-July and 13-July scouting dates (Table 1). There was no difference in TSSM populations by variety on 8-July. Some varieties were a few varieties with TSSM above economic thresholds but the hops were not sprayed with insecticides. On 13-July, TSSM populations did differ by variety. The TSSM populations were reduced despite no chemical control intervention in all varieties except 'Liberty', 'Chinook', 'Perle' and 'Galena' (Figure 4; Figure 5). This may indicate that these varieties are especially susceptible to TSSM or it may indicate that predatory insects do not prefer these varieties. If predatory insects cannot colonize variety this may lead to explosive outbreaks of pests if spraying is not continuous.

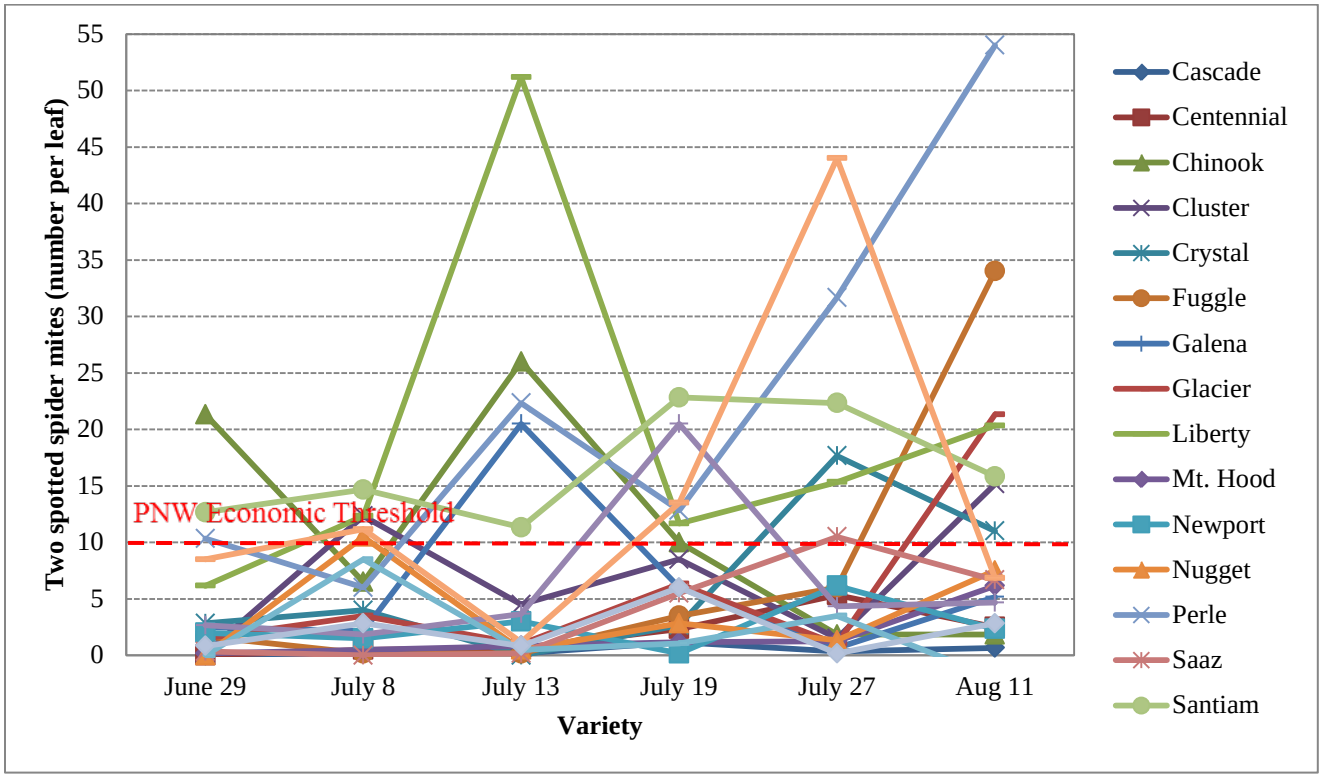

Figure 4. Two spotted spider mite incidence according to scouting date by varieties.

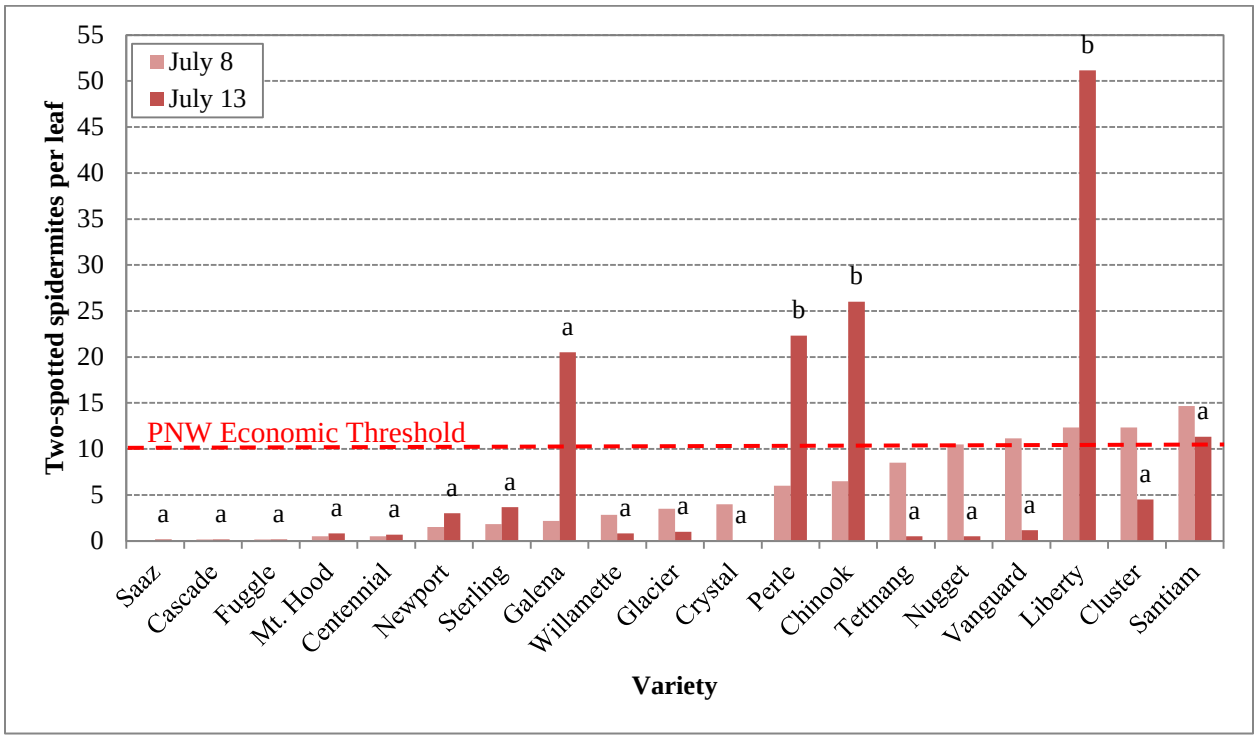

Figure 5. Two spotted spider mite populations on July 8 & 13th of 2011. ***For the 13-July scouting date varieties with a different letter are statistically different.***

Pest and predatory insect incidence by variety

In 2011, leafhoppers were identified as a potentially damaging pest of hops. Varieties differed significantly in incidence of potato leafhoppers, TSSM, and spider mite destroyer lady beetles (*Stethorus picipes*) (Table 3). The variety Newport and Saaz had the greatest number of potato leafhoppers (Table 3). There were several varieties including Willamette and Centennial that was not severely impacted by leafhoppers (Table 3; Figure 8). Interestingly, Newport remained healthy and vigorous despite high leafhopper populations. Spider mite destroyers are a predator of the TSSM (Figure 6; Figure 7). Varieties such as Mt. Hood, Centennial, Willamette, and Tettnang, which showed lower levels of TSSM, had higher populations of mite destroyers (Table 3; Figure 9). Varieties with high populations of TSSM often had high levels of destroyers. It is clear that TSSM and leafhopper populations are impacted by the hop variety. However, it is less clear if the mite destroyers have affinity for particular varieties or if populations are driven by the populations of TSSM.

Table 3. Incidence of pests and predatory insects in an organic hopyard by variety across dates, Alburgh, VT.

Variety	Potato leafhoppers		Two-spotted spider mites		Mite destroyers	
	number per leaf					
Cascade	1.39	abc*	**0.42**	a	0.36	B
Centennial	0.47	a	1.89	a	0.69	Ab
Chinook	0.72	ab	11.3	abcd	1.19	Ab
Cluster	0.67	ab	7.03	abc	1.64	Ab
Crystal	2.25	abc	6.32	abc	1.00	Ab
Fuggle	0.78	ab	7.58	abc	0.50	B
Galena	1.22	abc	6.17	abc	0.72	Ab
Glacier	1.22	abc	5.78	abc	0.44	B
Liberty	2.22	abc	19.5	cd	0.97	Ab
Mt. Hood	2.24	abc	1.67	a	0.94	Ab
Newport	2.67	c	2.53	ab	0.33	B
Nugget	1.08	abc	3.78	ab	0.39	B
Perle	0.86	abc	22.9	d	1.17	Ab
Saaz	2.42	bc	3.86	ab	0.72	Ab
Santiam	1.53	abc	16.6	bcd	**2.50**	Ab
Sterling	1.00	abc	6.28	abc	0.61	b
Tettnang	0.83	abc	2.33	ab	0.96	ab
Vanguard	1.69	abc	14.2	abcd	0.94	ab
Willamette	**0.39**	a	2.25	a	0.72	ab
p-value	0.0002		<0.0001		0.0523	

*Varieties with the same letter within a column did not differ significantly.

Figure 6. Two-spotted spider mites, bottom left, adult spider mite destroyer lady beetle, top right.

Figure 7. Two-spotted spider mite damage in hops.

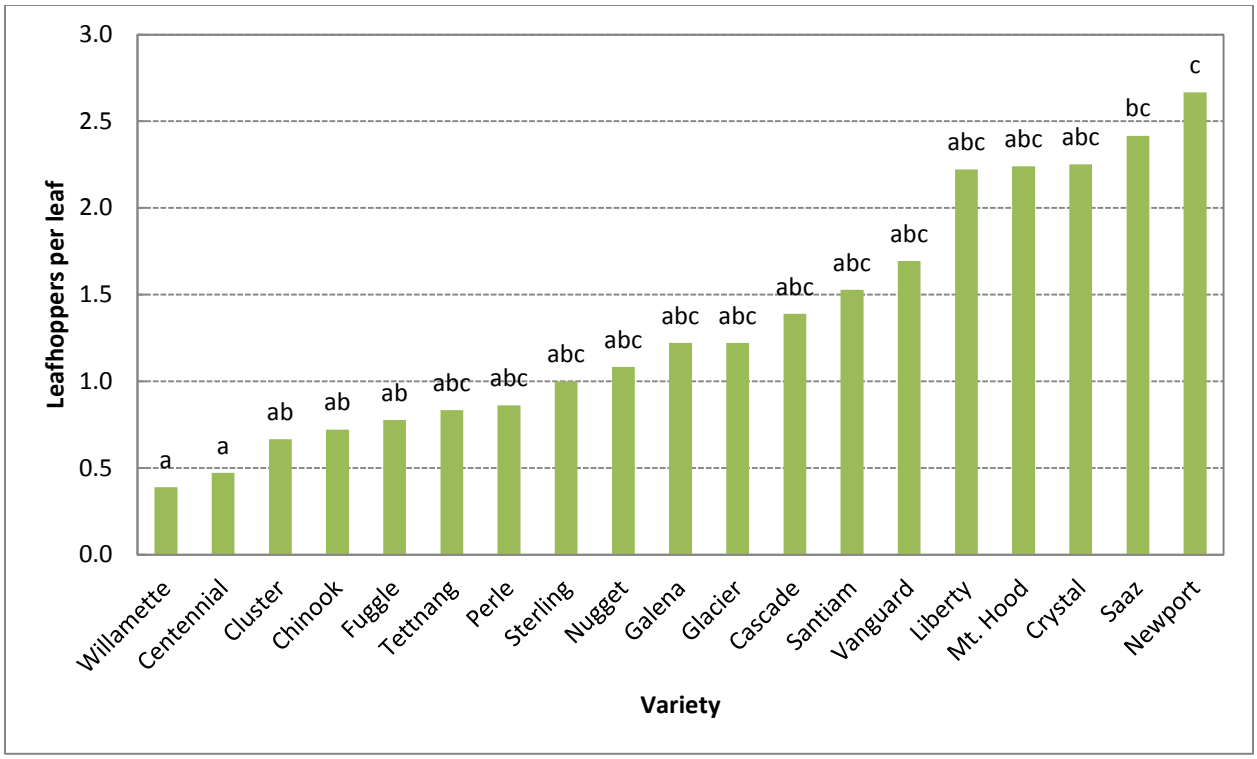

Figure 8. Potato leafhopper incidence by variety across all dates. ***Varieties with the same letter are not statistically different.***

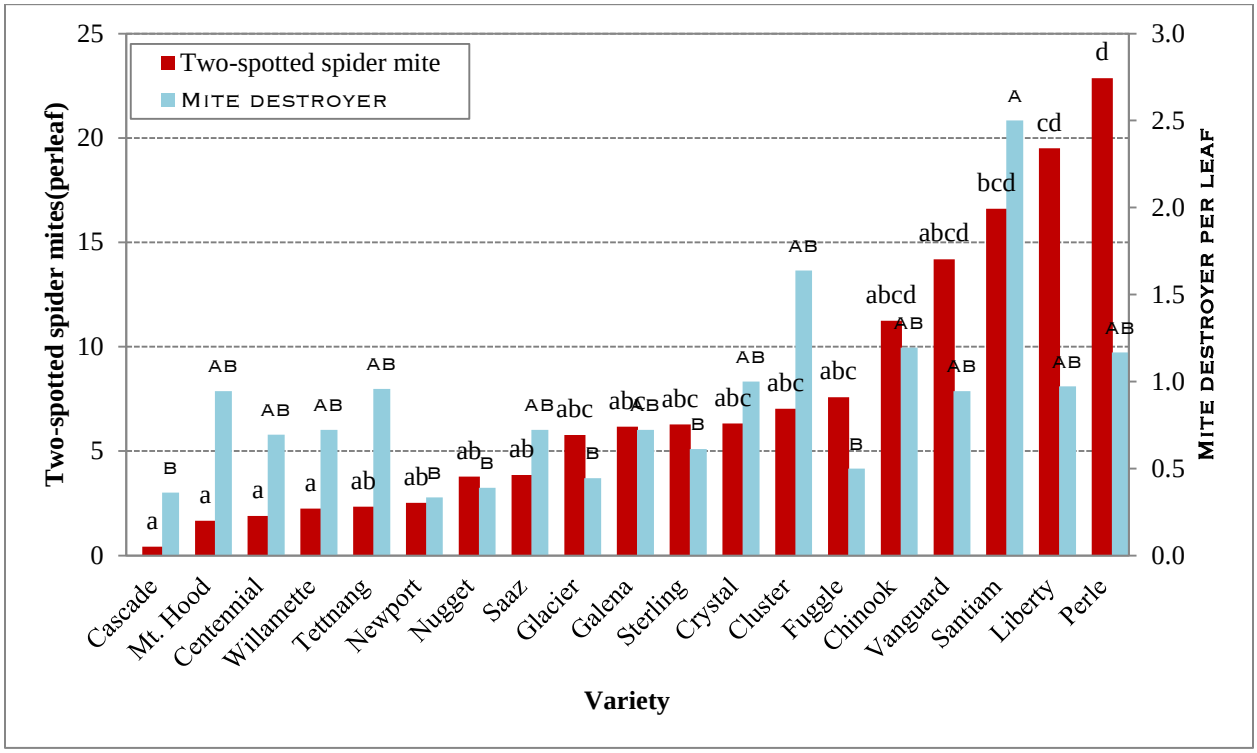

Figure 9. Two spotted spider mite and spider mite destroyer populations by variety across all dates. ***Varieties with the same letter are not statistically different.***

Pest and beneficial insects by date

Potato leafhoppers were most severe on the first scouting date (Table 4). Two spotted spider mite populations continued to get worse as the season progressed, despite chemical intervention in the "hot spots". Mite destroyer populations continued to grow as the season progressed (Table 4). Changes in insect populations over the season can be related to weather and also control strategies.

Table 4. Pest and beneficial insect populations by scouting date in an organic hopyard in Alburgh, VT.

Scouting date	Potato leafhoppers	Two-spotted spider mites	Mite destroyers
		leaf^{-1}	
29-Jun	2.17	**3.88***	0.03
8-Jul	1.46	5.22*	0.34
13-Jul	1.97	7.80*	0.40
19-Jul	0.82*	7.32*	0.31
27-Jul	0.94*	9.20*	1.37
11-Aug	**0.75***	11.52	**2.86***
p-value	<0.0001	0.0063	<0.0001

*Indicates that the treatment did not differ from the top performer (in bold).

DISCUSSION

Disease incidence was low in the hopyard during the 2011growing season. One Cluster hill, which already presented poor vigor due to root rot, was lost to a downy mildew infection that infected the crown. It is presumed that the plant material was infected prior to planting. Other diseases were not prevalent most likely due to an extremely dry July and August.

Weed pressure was combatted by first rototilling the beds, and only when the weeds were under control were the hops trained, resulting in varied training dates among the same variety. As a result of varied training dates, hop plants within the same variety demonstrated different growth characteristics, with earlier trained plants being taller and lusher, which could possibly account for more appealing habitat to some insects.

The UVM Extension hopyard is adjacent to an alfalfa field. After the first cut of alfalfa was harvested, significant damage was noticed in the hopyard. Scouting revealed high levels of the potato leafhopper. Leafhoppers pierce the leaf tissue and suck out water and nutrients. The saliva that is left behind by this action can block the leaf veins, preventing nutrients from reaching the tips of the leaf and in the end causing leaf necrosis. A review of scholarly papers revealed that there are no established economic threshold levels for leafhoppers in hops. Reviews of threshold levels for raspberries, potatoes, and alfalfa, resulted in the establishment of a threshold level of two leafhoppers per leaf. A review article on potato leafhoppers can be found on the UVM Extension Northwest Crops and Soils Team website: www.uvm.edu/extension/cropsoil/hops.

The highest leafhopper incidence was observed between end of June and mid-July. Newport exhibited the highest average of leafhoppers per leaf across the six sample dates while Willamette had the lowest populations. Organic chemical control proved to be fairly affective, and leafhopper incidence did decline over the growing season. At this time it is unknown what draws leafhoppers to certain varieties or perhaps repels them from another. There may be physical differences between hop variety leaves, as is found in leafhopper resistant alfalfa varieties which have dense hair covered in a stick substance that deters nymphs. Other possibilities include hop alpha acid levels or nutrient levels acting as a deterrent or attractant. Further research will be conducted in the following growing season.

Economic threshold levels used in the Pacific Northwest are 1-2 TSSM leaf^{-1} in June and 5-10 TSSM leaf^{-1} in mid-July. Spider mite infestations, if severe enough, can reduce the productivity of the plant, as well as damage the hop cones. July was hotter and drier than usual this year, which will promote TSSM population flare ups. TSSM are also marginally mobile. "Hot spots" in the hopyard where TSSM populations were high quickly spread to neighboring plots as the season progressed. Studies have shown that in many horticultural crops, broad spectrum insecticides that remove natural predators of two-spotted spider mites (*Tetranychus urticae*) are the root cause of mites causing economic damage to a crop (James et al. 2001).

The miticide used in the organic hop variety trial did not seem to demonstrate very good control of TSSM. All plots were sprayed on June 30 and July 20, however, subsequent scouting dates did not show a reduction in average TSSM numbers across all varieties. The miticide successfully reduced TSSM populations in 31.6% of the varieties at the end of June-early July, and 42.1% of the varieties at the end of July. Where it was successful, the miticide seemed to work best on varieties that had average TSSM populations above the threshold. Additional research needs to be conducted to determine efficacy of organic pesticides on pest populations.

Interestingly, many varieties tagged as susceptible to insects by the industry did not suffer as greatly as was originally feared. Chinook, normally considered not excessively sensitive to insects, did have some of the higher TSSM numbers across all scouting dates. This follows what Leonard Perry found in the UVM research trials in the 1990's. However, the vigor of Chinook did not seem to be particularly affected by the pests. Cascade, normally found to be prone to insects, and sited as having mite and aphid problems in the UVM trials in the 1990's, did not suffer too badly from insect predation. Tettnang, considered to be sensitive to TSSM, did not have particularly high levels of TSSM in this year's trial, but did suffer from poor vigor.

Given the complex interactions between variety, environment, pest, and predator populations additional work needs to be done to provide growers with an effective integrated pest management program for hops in the Northeast. This first year of data collection provides some insight on research direction for coming the years.

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