2019

Hop Crowning Trial

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THE UNIVERSITY OF VERMONT
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2019 HOP CROWNING TRIAL

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Downy mildew has been identified as the primary pathogen plaguing our northeastern hop yards. This disease causes reduced yield, poor hop quality, and can even cause the plant to die in severe cases. Control measures that reduce disease infection and spread while minimizing the impact on the environment, are desperately needed for the region. Mechanical control is one means to reduce downy mildew pressure in hop yards. Scratching, pruning, or crowning is a practice initiated in the early spring prior to or when new growth has just emerged from the soil.

The first shoots have an irregular growth rate and are not the most desirable for producing hop cones later in the season. Removal of this first new growth through mechanical means also helps to remove downy mildew inoculum that has overwintered in the crown. The top of the crown itself can be removed to further eliminate overwintering downy mildew. When the top of the crown is removed, the practice is typically referred to as "Crowning." Crowning also reduces the amount of plant material that is above ground and susceptible to downy mildew spores during wet spring conditions that are ideal for infection. To achieve this effect, cutting is performed 0.50 to 1.0 inch below the soil surface. Setting the plant back like this is an advantage for managing disease, but also reduces the time the plant has to grow vegetatively to the top of the trellis, potentially affecting yield. While crowning is standard practice in other regions, we are still learning about the effects of crowning in the Northeast. So far, our studies have indicated that crowning does result in better hop yields under the right conditions, and that earlier crowning (mid to late April) is more effective for this region.

Over the course of crowning study trials, multiple crowning dates, methods, and practices were tested in an attempt to develop best practices in the Northeast for hop production. Throughout the six year span, early crowning dates were maintained, while each year other variations on crowning dates and methods occurred. Trials included early crowning, late crowning, uncovering, and flaming as methods to reduce likelihood of downy mildew infection and incidence within the hop yard as well as to improve overall yields as a result.

MATERIALS AND METHODS

In 2019, the experimental design was a randomized complete block with split plots and 3 replicates. The main plots were crowning treatments and the split plots were hop varieties Cascade and Nugget. Mechanical crowning took place on 22-Apr and flaming took place on 10-May after shoot emergence. Plots were 10 x 35' containing seven hills per plot. Plots received 100 lbs N ac^{-1} on 10-May and 50 lbs N ac^{-1} on 30-May in the form of calcium ammonium nitrate (CAN) broadcast across each plot individually.

Hop plants were trained from 24-May through 30-May. Beginning on 24-May, the entire hop yard was sprayed with Champ WG (Alsip, IL) at a rate of 1 lb ac^{-1} and was sprayed on a weekly basis through 28-Jun. During this period, plots were scouted weekly for downy mildew basal spikes and aerial spikes. Plants were also scouted on a weekly basis starting 17-Jun for pest and beneficial insects through 19-Aug. Two plants and three random leaves per plant within each plot (variety) were visually inspected. The number of potato leaf hoppers (PLH), hop aphids (HA), two-spotted spider mites (TSSM), and mite destroyers (MD) present on each leaf was recorded.

Hop harvest was targeted for when cones were at 21-27% dry matter. At harvest, hop bines were cut in the field and brought to a secondary location to be run through our mobile harvester. Cascade plants were harvested on 9-Sep and Nugget plants were harvested on 17-Sep. Plants were harvested using a Hopster 5P hop harvester (HopsHarvester LLC, Honeoye, NY). The number of individual plants harvested and total cone yield was recorded for each treatment. Cone samples were weighed and dried to determine dry matter content. Cones were also rated in browning severity on a 1-10 scale where 1 indicates low browning and 10 indicates severe browning. All hop cones were dried to 8% moisture, baled, vacuum sealed, and then placed in a freezer. Hop samples from each plot were sent to the University of Vermont's testing laboratory to be analyzed for alpha acids, beta acids and Hop Storage Index (HSI). Yields are presented at 8% moisture on a per acre basis. Per acre calculations were performed using the spacing in the UVM Extension hop yard of 872 hills (1744 strings) ac^{-1}.

Data was analyzed using SAS Version 9.4. For the hop quality data, we conducted a linear mixed model analysis with repeated measures (PROC MIXED). Fixed effects included collection date, replicate, year, and collection date by year. All statistics will be run at the 0.10 level of significance and generated using SAS Version 9.4 (Copyright 2014, SAS Institute Inc., Cary, NC, USA). Variations in yield and quality can occur because of variations in genetics, soil, 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. At the bottom of each table, a LSD value is presented for each variable (i.e. yield). Least Significant Differences (LSD's) at the 10% level of probability are shown. Where the difference between two treatments within a column is equal to or greater than the LSD value at the bottom of the column, you can be sure in 9 out of 10 chances that there is a real difference between the two varieties.

Treatment	Yield
A	**2100a**
B	1900ab
C	1700c
LSD	300

Treatments that were not significantly lower in performance than the highest value in a particular column are indicated with an asterisk. In this example, A is significantly different from C but not from B. The difference between A and B is equal to 1.5, which is less than the LSD value of 2.0. This means that these varieties did not differ in yield. The difference between A and C is equal to 3.0, which is greater than the LSD value of 2.0. This means that the yields of these varieties were significantly different from one another. The letter indicates that B was not significantly lower than the top yielding variety. Within the trial there were no significant variety x treatment interactions so data was pooled across varieties and is presented based on manure treatment impacts.

RESULTS

Table 1 shows a summary of the temperature, precipitation and growing degree-day (GDD) summary. In the 2019 growing season, there were an accumulated 2322 GDDs, 157 less than the historical 30-year average with greatest deviations from the norm occurring in April and July. The 2019, growing season experienced a wet spring followed by a dry summer with well below average precipitation occurring during the month of July. Supplemental irrigation was applied to plants at a rate of 4500 gal ac^{-1}, however drier summer months and limited well capacity resulted limited the ability to provide adequate water to the crop.

Cooler temperatures in the spring and early summer also severely slowed vegetative growth and likely limited overall yield.

Table 1. Temperature, precipitation and growing degree day summary, Alburgh, VT, 2019.

Alburgh, VT	March	April	May	June	July	August	Sept
Average temperature (°F)	28.3	42.7	53.3	64.3	73.5	68.3	60.0
Departure from normal	-2.79	-2.11	-3.11	-1.46	2.87	-0.51	-0.62
Precipitation (inches)	1.36	3.65	4.90	3.06	2.34	3.50	3.87
Departure from normal	-0.85	0.83	1.45	-0.63	-1.81	-0.41	0.23
Growing Degree Days (Base 50)	9	59	189	446	716	568	335
Departure from normal	-13	-52	-103	-36	86	-14	-25

Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger. Historical averages are for 30 years of NOAA data (1981-2010) from Burlington, VT. (http://www.nrcc.cornell.edu/page_nowdata.html).

Each season, we calculate the number of days that had ideal downy mildew conditions using a Pacific Northwest forecasting model based on temperature and humidity (Gent et al. 2010) (Figure 1). The model was calculated using data from a nearby weather station in Chazy, NY. We determined the number of days out of the 183 days between 1-Apr and 30-Sep that exhibited conditions considered likely for downy mildew infection based on variable weather conditions.

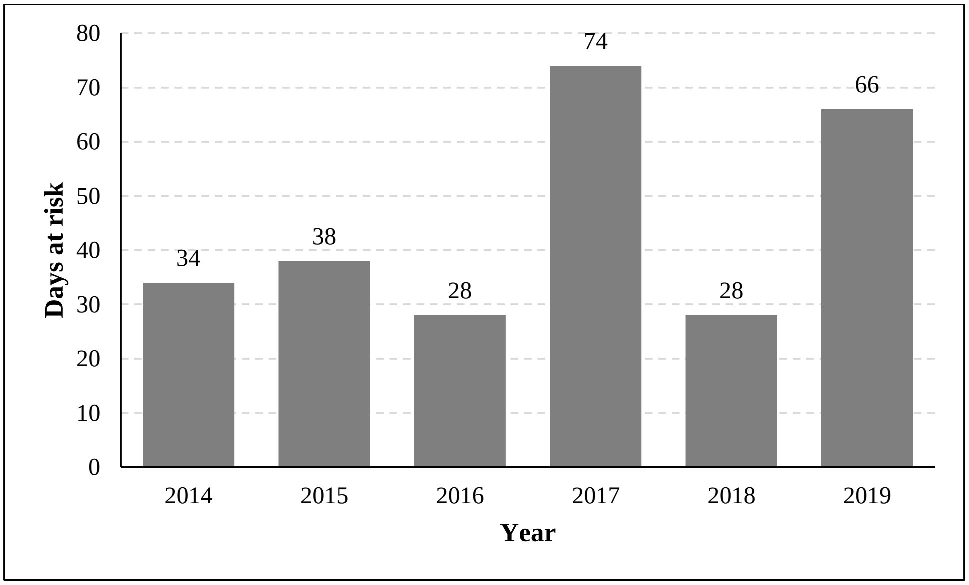

Figure 1. Yearly comparison of days at risk for disease infection.

The abnormally dry weather during 2016 and 2018 kept disease pressure low throughout the season whereas slightly higher amounts of precipitation during 2014 and 2015 resulted in higher disease incidence and greater severity throughout the trial. In both 2017 and 2019, the region experienced extreme wet weather conditions, especially during the early months of the growing season. This of course resulted in heavy disease pressure as plants emerged and developed throughout their vegetative stage.

Within the trial, crowning treatments appeared to have no impact on aerial spikes or basal spikes and did not have an impact on observed insect pests (Table 2). Each treatment experienced similar populations of aerial spikes with a trial average of 5.41 spikes plot^{-1} and basal spikes with a trial average of 2.49 spikes plot^{-1}. Hop aphids, potato leaf hoppers, and two spotted spider mites were also present across all treatments in similar populations with a trial average of 1.44, 1.45, and 0.228 pests leaf^{-1} respectively.

Table 2. Average insect pest and disease scouting incidence for manure application rates, Alburgh, VT, 2019.

Treatment	Aerial spikes	Basal spikes	HA†	PLH	TSSM
	plot^{-1}	plot^{-1}	leaf^{-1}	leaf^{-1}	leaf^{-1}
Control	5.92	2.47	1.19	1.23	0.130
Crown	4.33	2.57	1.58	1.77	0.407
Flame	5.97	2.43	1.53	1.35	0.148
LSD (0.10) ‡	NS ¥	NS	NS	NS	NS
Trial mean	5.41	2.49	1.44	1.45	0.228

† HA= hop aphid. PLH = Potato leaf hopper. TSSM = two-spotted spider mites.
‡LSD –Least significant difference at p=0.10.
¥NS –No significant difference between treatments.

In 2019, we experienced below average temperatures and higher than normal precipitation which led to increased disease incidence and severity across all samples (Table 3). Crowning treatment did not significantly impact dry matter, 100 cone weight, or cone disease incidence, but it did impact yield at 8% moisture and cone disease severity. The average dry matter for this year's trial was 28.2%. Yield at 8% moisture was the highest in the control treatment (572 lbs ac^{-1}), and was significantly higher than the crowned and flamed treatments (Figure 2). The 100 cone weight averaged 43.9 grams and cone disease incidence averaged 79.7% for the trial. Cone disease severity was the highest in the crowned treatment (6.67) and that was statistically higher than in the control and the flamed treatments.

Table 3. Harvest cone quality and yields, Alburgh, VT, 2019.

Treatment	100 cone weight	Diseased cones	Disease severity	Harvest dry matter	Yield at 8% moisture
	g	%	1-10 €	%	lbs ac^{-1}
Control	47.7	80.5	**5.17 a**†	28.2	**572 a**
Crown	41.5	80.5	6.67 b	28.4	414 b
Flame	42.5	78.2	5.33 a	28.1	378 b
LSD (0.10) ‡	NS¥	NS	1.24	NS	129
Trial mean	43.9	79.7	5.72	28.2	455

†Within a column treatments marked with the same letter were statistically similar (p=0.10). Top performers are in **bold.**
‡LSD –Least significant difference at p=0.10.
¥NS –No significant difference between treatments.
€Cones were rated in browning severity on a 1-10 scale where 1 indicates low browning and 10 indicates severe browning.

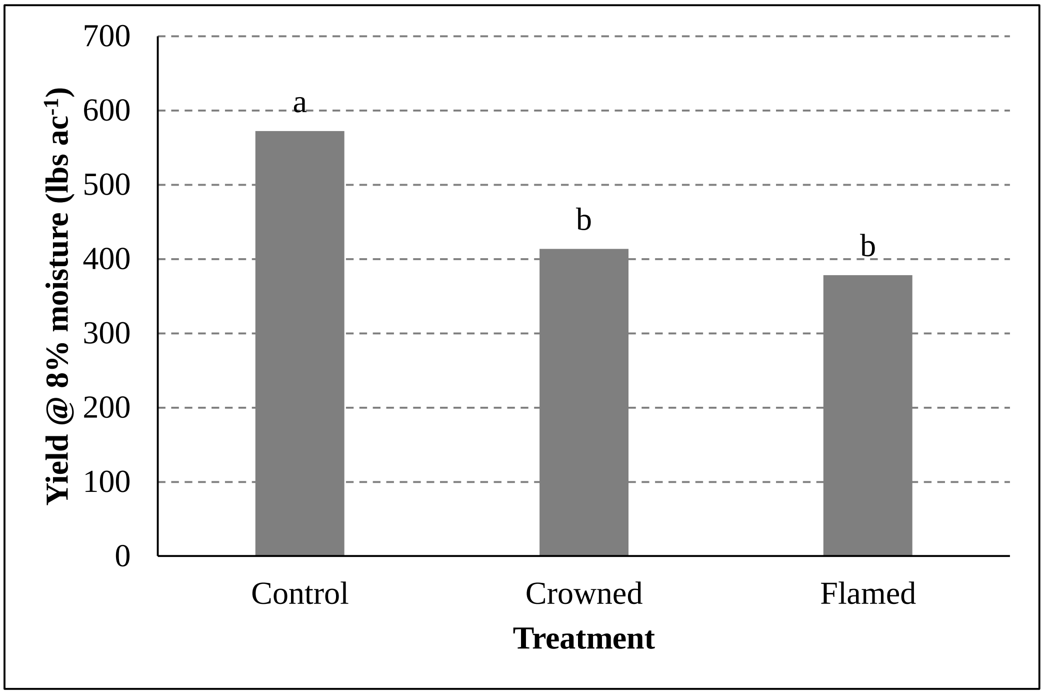

Figure 2. 2019 Yields for control, crowned, and flamed treatments.
Treatments with the same letter are not significantly different from each other.

Hop brewing quality was also not impacted by crowning treatments this past year (Table 4). Alpha and beta acids were highest in the control but were not significantly different from crowning and flaming treatments. Trial averages for alpha acids were 9.56%, 5.8% for beta acids and 0.272 for HSI.

Table 4. Hop brew quality, Alburgh, VT, 2019.

Treatment	Alpha acids %	Beta acids %	HSI
Control	10.2	6.04	0.271
Crown	9.65	5.50	0.272
Flame	8.85	5.87	0.274
LSD (0.10) †	NS‡	NS	NS
Trial mean	9.56	5.80	0.272

† LSD –Least significant difference at p=0.10.
‡NS –No significant difference between treatments.

DISCUSSION

This season, we observed higher yields in the control treatment compared to the crowned and the flamed treatments, and the highest disease severity in the crowned treatments. Cone disease incidence did not differ significantly between treatments, nor did cone weight. Low yields across the entire trial were likely a result of extremely cold conditions throughout much of the hop vegetative growth stage. Overall, this season we experienced a high number of days at risk for disease infection which was similar to conditions in 2017. While increased pressure from downy mildew in this region gives us more to gain by crowning to remove overwintering downy mildew, our much shorter growing season makes the timing of this practice tricky. This year a cool wet spring followed by a dry summer created challenging conditions that postponed emergence and growth after crowning took place. Additionally, if we crown too late, we risk leaving too short a window for plants to reach the top of the trellis by late June. Our research from the past five seasons indicates that there are benefits to crowning, and that it is important to implement this practice as early as possible in the spring. Crowning can help to remove overwintering inoculum and to aid in warming the crown for plant growth under the right conditions. Early crowning in past trials helped to improve yields, whereas late crowning or uncovering appeared to have negative or marginal impact on our hops.

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