Hops: An Aromatic Addition to Farms in the Northeast

Megan Muehlbauer, Michelle Infante-Casella, William Bamka, Edwin Dager, and James Simon
Rutgers University

Background on Hop Production

Hops are herbaceous, perennial bines (the flexible, wrapping stem of the hop plant) that grow from underground rhizomes. Once established, they are prolific yielders with bines that will grow to reach the top of 20 foot trellises each growing season. Hops are cultivated and harvested for their female flowers (cones). These cones produce resins and essential oils that impart the flavor, acids, and aromatic compounds to beer through the brewing process.

As is the case for many crops (i.e. wine grapes and cider apples), hops must be processed to create the final product. It is critical to accurately measure the biochemical components of the crop/ingredients to ensure a quality final product. For hops, aromatic profiles and alpha and beta acids are measured. These values provide brewers information to help them tweak brew recipes and better utilize each local hop shipment. In addition, these quality metrics can be leveraged as marketing tools for growers to garner increased profits for their hop crop.

Hop demonstration plot after one year of growth at the Snyder Research Farm in Pittstown, NJ.

Hop Research at Rutgers New Jersey Agricultural Experiment Station, Cooperative Extension

Rutgers NJAES CE has conducted research to develop guidelines for establishing hop varieties adapted for New Jersey (produce the highest yields and consistently meet high biochemical quality). This work took place between 1994 and 1999 by William Bamka (Agricultural Agent in Burlington) and Edwin Dager (Farm Supervisor at the Rutgers NJAES Snyder Research Farm in Pittstown, NJ). Ed and Bill established a hop yard on two low trellising systems (6 and 10 foot). Five varieties were grown in each trellising system and their yields ranged from 60-1306 lbs. per acre in dry weight. The highest yielders at the time were found to be the varieties 'Cascade' and 'Chinook'. Alpha and beta acids were analyzed and found to be variable throughout the study. Unfortunately, alpha acids did not meet the required range desired by growers in the Pacific North West (the primary hop production region in the United States) in the 5 varieties tested.

Although the project at Rutgers halted, research resumed in 2015,

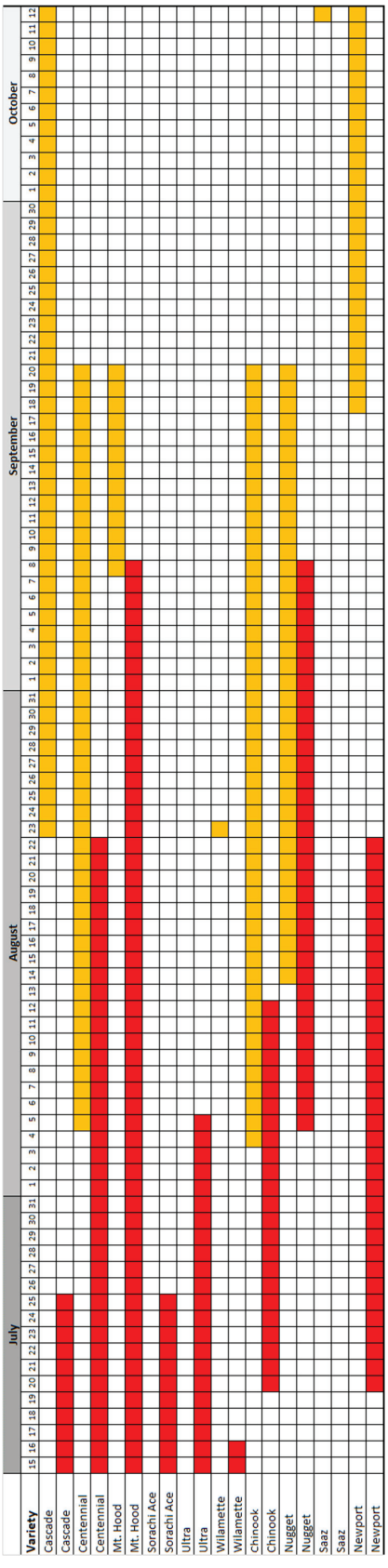

Figure 1. The chart depicts the start date, end date, of harvest in both 2015 (orange) and 2016 (red) for each of the hop cultivars grown at the Rutgers University Snyder Research and Extension Farm in Pittstown, NJ.

partially due to the burgeoning craft brewery industry throughout the United States. This influx, coupled with the enthusiasm and demand for locally grown beer ingredients, spurred interest in re-establishing a demonstration hop yard at the Snyder Research Farm. This re-establishment was in collaboration with James Simon, Professor with the Rutgers SEBS Plant Biology and Pathology Department. Dr. Simon's laboratory assessed the quality of the hops cones (alpha and beta acids and aromatic compound profile) grown at farms throughout New Jersey. The demonstration plot at the Snyder Research Farm served as a control where the plants were grown to closely mimic Pacific North west (PNW) horticultural maintenance methods.

Findings from Chemical Analysis of Hops Grown Throughout New Jersey

A total of 10 hop varieties were grown at the demonstration plot in Pittstown, New Jersey. (Figure 1) Harvest dates of the varieties grown at the demonstration plot were recorded in an effort to develop hop harvest/post-harvest guidelines. (Figure 1) Harvest dates are variable from year to year, although by 2017 (data not shown), the optimal timing of hop harvest was improved as seen from quality metrics of hop acids and aromatic compounds.

The yields of each variety grown at the demonstration plot were also recorded and displayed for 2015-2016. (Figure 2) Initial data showed that 'Chinook' and 'Nugget' were exceptionally heavy yielders in comparison to the other varieties (~45 and ~25 pounds fresh weight per 20 plants respectively), although preliminary data from 2017 showed 'Cascade' may be a promising high yielding variety as well.

Throughout 2015 and 2016, hop samples were sent to Dr. Simon's lab from 6 commercial farms alongside samples from the demonstration plot. Locations are noted in Figure 3. Aromatic oil profiles were analyzed for several samples in 2015 (2016 and 2017 data has not yet been recorded). These results were shown alongside samples purchased from the Pacific North West (YCH HOPS, LLC) Figure 3. The essential oil profiles of all varieties tested were found to be comparable to those of hops grown and purchased from the PNW. Additional testing of samples obtained in 2016 and 2017 will serve to assist in corroborating these findings, and may show that hop aromatic oil profiles could remain similar despite different growing conditions.

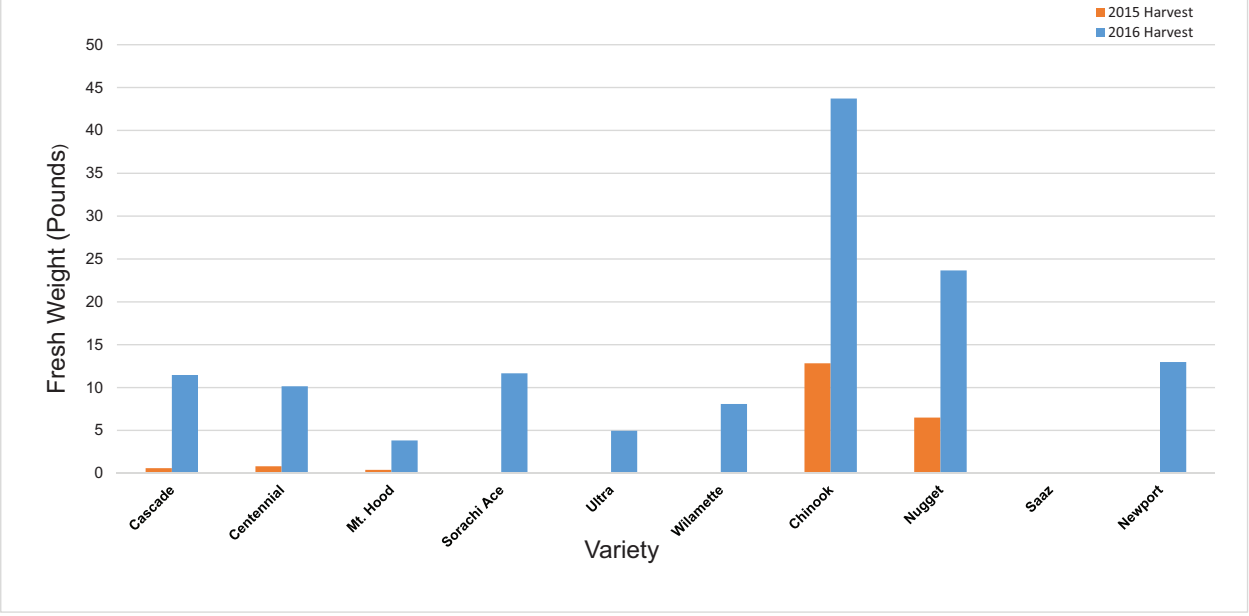

Figure 2. This figure displays the total yields of each variety harvested from the demonstration plot at the Rutgers University Snyder Research and Extension Farm in Pittstown, NJ (20 plants per variety) included in this study for both the 2015 and 2016 harvest seasons.

The most extensive biochemical analysis was done for alpha and beta acids. The results from all NJ farms as compared to hops grown and sold from the PNW are shown in Figure 5. Only one sample of 'Cascade' had acid levels that fell within the optimal quality range. Interestingly, based on background information from the grower, this sample was harvested and handled in close accordance with PNW standards (optimal harvest timing, short harvest interval, brief and hot dry drying time, and pelletized product). This grower's sample illustrated the significance of focusing on post-harvest handling and processing of hop cones to obtain a product that meets optimal quality parameters. Based on preliminary data obtained from the demonstration plot in 2017, it was found that after 3 growing seasons, the quality of hops as

Table 1. This figure displays the major essential oil volatiles found in seven samples harvested in 2015 from throughout New Jersey alongside those of samples purchased from YCF HOPS LLC.

Variety	Location ID	β-myrcene (%)	α-Humulene (%)	β-caryophyllene (%)	% of Total Oil
Cascade	3	61.63	12.30	5.43	79.36
Cascade	**YCH HOPS**	**52.50**	**13.00**	**4.50**	**70.00**
Cascade	4	56.34	15.09	6.56	78.00
Chinook	**YCH HOPS**	**35.50**	**13.00**	**4.50**	**53.00**
Chinook	4	47.09	19.43	7.77	74.28
Chinook	1	39.16	24.10	9.95	73.20
Chinook	5	59.46	13.86	7.49	80.81
Columbus	**YCH HOPS**	**45.00**	**15.00**	**10.00**	**70.00**
Columbus	1	67.41	10.22	6.99	84.62
Nugget	**YCH HOPS**	**51.50**	**17.50**	**8.00**	**77.00**
Nugget	5	51.47	23.71	9.76	84.94

Figure 5: The bittering acids found in samples harvested in 2015 and 2016 alongside samples purchased from YCH HOPS LLC.

Variety	Year	Location ID	cohumulone (%)	n + adhumulone (%)	colupulone (%)	n + colupulone (%)	α-acids (%)	β-acids (%)
Brewers Gold	**Quality Standard**	**YCH HOPS**	***	***	***	***	**8.00 - 11.0**	**4.00 - 6.50**
Brewers Gold	2015	2	1.97±0.01	3.36±0.04	2.31±0.02	1.33±0.04	5.33	3.64
Cascade	**Quality Standard**	**YCH HOPS**	***	***	***	***	**5.50 - 9.00**	**6.00 - 7.50**
Cascade	2015	2	1.30±0.04	2.46±0.12	3.33±0.05	3.36±0	3.76	6.69
Cascade	2015	3	0.73±0.12	1.75±0.29	1.36±0.27	1.50±0.28	2.48	2.86
Cascade	2015	4	1.87±0.11	4.30±0.27	2.25±0.18	2.07±0.18	6.17	4.32
Cascade	2016	5	0.67±0.67	1.63±1.63	1.38±1.38	1.85±1.85	2.3	3.23
Cascade	2016	7	2.15±0.01	4.31±0.02	3.56±0.04	3.40±0.09	6.46	6.95
Cascade (Field 1)	2016	3	1.25±0.07	2.77±0.14	2.50±0.13	2.76±0.11	4.02	5.26
Cascade (Field 2)	2016	3	1.13±0.01	2.49±0.025	2.02±0.03	2.24±0.06	3.61	4.26
Centennial	**Quality Standard**	**YCH HOPS**	***	***	***	***	**7.00 - 12.0**	**3.50 - 5.50**
Centennial	2015	3	0.38±0.07	1.04±0.17	0.31±0.02	0.27±0.03	1.42	0.58
Centennial	2016	5	1.54±0.38	4.56±0.96	1.11±0.25	1.27±0.32	6.1	2.38
Chinook	**Quality Standard**	**YCH HOPS**	***	***	***	***	**11.5 - 15.0**	**3.00 - 4.00**
Chinook	2015	1	3.29±0.1	6.96±0.22	1.48±0.04	0.99±0.04	10.24	2.47
Chinook	2015	2	2.36±0.04	5.12±0.06	1.30±0.02	1.05±0.02	7.48	2.34
Chinook	2015	4	3.02±0.16	7.83±0.21	1.35±0.02	1.18±0.01	10.85	2.53
Chinook	2016	3	2.12±0.07	5.89±0.16	1.17±0.02	1.01±0.01	8.01	2.705
Chinook	2016	5	2.25±0.01	6.39±0.02	1.31	1.28±0.01	8.63	2.58
Chinook	2016	7	2.66±0.08	6.26±0.16	1.39±0.06	1.17±0.05	8.92	2.56
Chinook (Field 1)	2016	6	2.20±0.05	6.90±0.02	0.97±0.01	1.07±0.02	9.1	2.03
Chinook (Field 2)	2016	6	1.98±0.03	6.35±0.24	0.95±0.01	1.17±0.03	8.33	2.12
Columbus	**Quality Standard**	**YCH HOPS**	***	***	***	***	**14.5 - 17.5**	**4.50 - 6.00**
Columbus	2015	1	3.29±0.08	8.61±0.02	2.07±0	1.59±0.02	11.91	3.67
Galena	**Quality Standard**	**YCH HOPS**	***	***	***	***	**13.0 - 15.0**	**7.50 - 8.50**
Galena	2015	2	4.34±0.09	6.60±0.19	4.77±0.16	2.82±0.07	10.94	7.59
Golding	**Quality Standard**	**YCH HOPS**	***	***	***	***	**3.00 - 6.5 0**	**2.00 - 3.50**
Golding	2015	2	4.68±0.06	12.97±0.26	2.51±0.06	2.16±0.06	17.64	4.67
Magnum	**Quality Standard**	**YCH HOPS**	***	***	***	***	**12.0 - 15.5**	**5.50 - 8.00**
Magnum	2016	6	2.56±0.17	8.93±0.5	2.0±0.135	3.53±0.12	11.5	5.53
Mt. Hood	**Quality Standard**	**YCH HOPS**	***	***	***	***	**4.00 - 6.50**	**4.40 - 7.20**
Mt. Hood	2015	3	0.51±0.05	0.90±0.06	1.31±0.06	0.87±0.03	1.41	2.18
Mt. Hood	2016	5	0.36±0.03	0.83±0.05	1.33±0.05	1.77±0.08	1.19	3.09
Newport	**Quality Standard**	**YCH HOPS**	***	***	***	***	**10.0 - 12.5**	**5.50 - 6.50**
Newport	2016	5	1.98±0.06	3.96±0.15	2.82±0.03	2.00±0.04	5.94	4.82
Nugget	**Quality Standard**	**YCH HOPS**	***	***	***	***	**13.5 - 16.0**	**4.40 - 5.58**
Nugget	2015	2	2.06±0.09	8.66±0.37	1.23±0.09	1.66±0.11	10.72	2.89
Nugget	2015	3	1.18±0.19	4.34±0.72	0.72±0.09	0.88±0.12	5.52	1.59
Nugget	2016	2	1.82±0.05	1.66±1.66	1.30±1.30	0.92±0.92	3.48	2.22
Nugget	2016	5	1.30±1.30	4.34±4.34	0.66±0.66	0.84±0.84	5.64	1.5
Nugget	2016	6	2.27±0.05	8.50±0.08	1.04±0.01	1.46±0.02	10.77	2.49
Nugget (Field 1)	2016	3	2.42±0.02	9.34±0.11	1.31±0.03	1.72±0.03	11.76	3.02
Nugget (Field 2)	2016	3	2.05±0.04	8.52±0.11	1.22±0.02	1.69±0.04	10.57	2.9
Perle	**Quality Standard**	**YCH HOPS**	***	***	***	***	**6.00 - 9.00**	**3.00 - 4.50**
Perle	2016	2	0.66±0.06	1.48±0.15	0.62±0.05	0.54±0.04	2.14	1.15
Sorachi Ace	**Quality Standard**	**YCH HOPS**	***	***	***	***	**11.5 - 14.5**	**6.00 - 7.50**
Sorachi Ace	2016	5	2.35±0.09	5.78±0.35	3.41±0.145	4.31±0.22	8.13	7.72
Sterling	**Quality Standard**	**YCH HOPS**	***	***	***	***	**5.50 - 8.50**	**4.50 - 6.00**
Sterling	2015	3	1.08±0.25	2.76±0.67	0.80±0.14	0.72±0.14	3.83	1.51
Sterling	2016	2	2.61±0.13	9.1±0.39	1.8±0.08	2.04±0.07	11.71	3.84
Tettnang	**Quality Standard**	**YCH HOPS**	***	***	***	***	**4.00 - 6.00**	**2.50 - 4.00**
Tettnang	2015	3	0.06±0	0.14±0	0.19±0	0.12±0	0.2	0.31
Ultra	**Quality Standard**	**YCH HOPS**	***	***	***	***	**9.20 - 9.70**	**3.80 - 4.00**
Ultra	2016	5	1.51±.015	3.41±0.08	1.40	1.11±0.02	4.92	2.51
Wilamette	**Quality Standard**	**YCH HOPS**	***	***	***	***	**4.50 - 6.50**	**3.00 - 4.50**
Wilamette	2015	3	0.51±0.02	1.38±0.01	1.10±0.06	1.14±0.03	1.89	2.24
Wilamette	2016	5	0.48±0.48	1.08±1.08	0.85±0.85	0.78±0.78	1.56	1.63

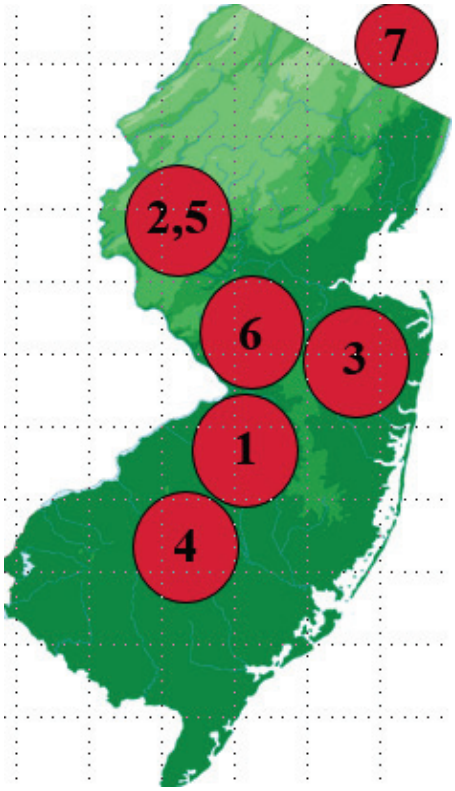

Figure 3. This figure represented the locations of all of the farms from which samples were collected for the study. Each farm is represented by a number, which corresponds to the Location ID in Figures 4 and 5. Note sample 7 was from Connecticut.

A Cascade hop cone nearing maturity at the hop demonstration plot at the Snyder Research Farm in Pittstown, NJ.

measured by alpha and beta acids greatly improves and could consistently meet quality standards.

The preliminary data from this study and that of the hop work done at Rutgers in the 1990s show that 'Cascade', 'Nugget and 'Chinook' are hardy, heavy yielding varieties that may very well adapt to the Northeast's growing conditions. Although, further work must be done to trial the optimal harvest and post-harvest handling methods to ensure the cones harvested from these varieties will meet chemical quality standards.

For more information on hop research being done at Rutgers NJAES CE, and to find out how to submit your hop cones for quality testing by Rutgers University visit the RU BREW website http://sare.rutgers.edu/brew_introduction.html, or contact Megan Muehlbauer at muehlbauer@njaes.rutgers.edu.

Funding for this project was provided through a Northeast SARE Partnership Grant (ONE15-247), the New Jersey Agricultural Experiment Station, and the County of Hunterdon Board of Chosen Freeholders.