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"Investigating best practices for timing and amount of organic soluble nitrate fertigation of hops in the Northeast"

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Investigating best practices for timing and amount of organic soluble nitrate fertigation of hops in the Northeast

Summary

There has been a resurgence of hop growing in the Northeast, with particular interest in organic hops. The majority of hops in the US are grown commerically in the Pacific Northwest, using conventional fertigation methods, with amount of weekly injections based on N levels from petiole tissue samples. The methods used in the Pacific Northwest are not easily translated to our Northeast region, mainly due to differences in soil type, precipitation, and scale. Little is known about either using petiole analysis to adaptively manage hop nutrient levels in the Northeast, or soluble organic fertigation.

During the 2014 growing season, we conducted an experiment to address best practices for organic fertigation in different ages and varieties of hops by comparing: (1) fertigation delivery in either a "set" approach (timing and amount predetermined) or (2) an "adaptive" approach (timing adjusted weekly based on petiole N analysis) and compared these to the current "standard" recommendations of (3) plants side-dressed with granular fertilizer delivered in both a full and (4) a split application.

Due to different planting years for each variety, different age groups were compared for each variety; generally "young" or "mature" plants. Specifically, we compared (1) Cascade: 2-year old, (2) Cascade 5-year old, (3), Centennial: 2-year old, (4) Centennial 5-year old, (5) Mount Hood: 2-year old, and (6) Nugget: 5-6 year old. Finally, in order to compare whether fertigating is advantageous for 1-year old plants, we delivered a "set"

schedule to fertigate 1-year old Cascade plants, and compared with single and split delivery of granular fertilizer.

Hop wet mass yield and whole plant tissue N for both whole plants and hop cones were compared between groups. Petiole tissue N was correlated to whole plant tissue N to investigate how well petiole sampling reflects actual crop uptake.

Fertigation resulted in significant increases in hop yield. Pooling across all varieties and ages, fertigation-set produced the highest mass of hops, 75% higher than the yield of granular split or single; fertigation-adaptive yielded 57% higher than granular treatments. Generally, the two fertigation treatments did not produce significantly different results from each other; nor did the two granular treatments differ from each other. There was a strong positive relationship between percent nitrogen in whole bines and hop cone wet mass for mature plants, but not for two-year old plants. Petiole nitrates were not correlated with hops cone wet mass with all varieties pooled, but when analyzed by variety separately there was a significant positive relationship for only two varieties: Cascade and Centennial.

Outreach consisted of a combination of the full .pdf version of the final report made available for download from the Aroostook Hops website, a short experiment summary with photos posted on the Research page of our website, a public field day that was held in September 2014, a Maine Agricultural Trades Show talk that was given in January 2015, and continued email and phone call communication with interested growers.

This experiment provides guidelines for Northeast hop farmers interested in increasing yields and revenue using targeted fertilizer delivery. Future recommendations involve a mixed approach of late spring side-dressing 75#N/acre, followed by delivering 150#N/acre/season via fertigation, possibly with a couple of petiole nitrate tests per season to monitor levels.

Introduction

Commercial hop production in the US has long been concentrated in the more arid Pacific Northwest, with over 93% grown in Washington and Oregon (USDA, 2010), almost all using conventional non-organic methods. Mature hops require a large input of nitrogen (100-150 lbs/acre), and the standard method of fertilization on these large-scale farms is injecting into irrigation lines ("fertigating") using conventional soluble fertilizer (largely N) products. Farmers most often inject 5-20lbs/acre weekly, and use petiole tissue analysis to adjust their fertilizer needs throughout the growing season until cone maturity is reached.

A resurgence of hop growing in the Northeast has occurred in the last few years, with a particular interest in organic hops. Due to the differences in scale, soil type, precipitation, and disease pressure between here and the Pacific Northwest, common large-scale agronomic practices may not translate or may need significant adjustment to be effective in the Northeast. Petiole analysis is just beginning to be adapted to hops in the Northeast, with guidelines based on Pacific Northwest ranges. However, most of the petiole-based nitrogen management recommendations from the Pacific Northwest are proprietary and either not shared at all, or only shared through consultation fees.

The benefits of fertigation are clear, and include ease of nutrient application, providing more constantly available levels of fertilizer to crops when they need them, and greatly reducing fertilizer inputs due to their targeted delivery. Additionally, only the crop root zone is irrigated and there is less potential for nitrogen leaching (Shock, 2013). Overall, fertigation offers the opportunity for a much more economically and environmentally sustainable agricultural approach to organic hop growing.

Different ages and varieties of hops have different nutrient needs, as well. First-year plantings require only 75lbs/acre of N, and fully mature plants (5-6 years old) will require more nitrogen than younger plants. Data from the Pacific Northwest shows that different hop varieties have different "typical" standards, with Casade, for example, requiring more nitrogen than other varieties (G. Ollard, personal communication, 2013). Since the nutrient requirements and yield potential of young versus mature plants and within different varieties vary greatly, recommendations should take age and variety into consideration.

Despite the fact that large-scale, conventional hop growers in the Pacific Northwest routinely use fertigation in combination with petiole analysis, very little is known about implementing these practices in organic systems and especially in the Northeast. Some Northeast growers have begun to use petiole analysis to manage nitrogen requirements (Darby, 2011) but much remains to be learned about how nitrate levels in petiole tissue samples relate to nitrogen needs/uptake, and ultimately, plant yield. There are currently "no University recommendations for interpreting petiole N", with advice to "compare to previous years' testing results and hop yields" (Darby, 2011). The general guide for nitrate-N levels consist of ranges in "low" at 0-6000 ppm, "normal" at 6000-10000 ppm, and "plenty" at 10,000 ppm, with cautions that they are based on the Pacific Northwest under very "different growing conditions" (Darby, 2011).

Thus, we conducted an experiment to investigate the best practices for timing and amount of soluble organic nitrogen fertigation of hops in the Northeast. This experiment considered different ages and varieties, and used an adaptive approach that was based on petiole analysis (versus a predetermined recommendation). The usefulness of petiole analysis was further investigated by comparing petiole nitrate results to whole hop plant tissue percent nitrogen levels.

Aroostook Hops (www.aroostookhops.com) is a small family farm, run by a husband (Jason Johnston) and wife (Krista Delahunty) team and located in Westfield, northern Maine. We began growing hops commercially in 2009, and now have 4-acres of five varieties of hops. In 2015, our farm became USDA certified organic (by Maine Organic Farmers and Growers, MOFGA). In addition to over 6 years of experience growing hops for commercial production, we both have extensive experience in research and backgrounds in Biology (Jason Johnston, PhD in Biological Sciences, Krista Delahunty, MSc in Cognitive and Behavioural Ecology). We have conducted two previous on-farm SARE experiments: FNE 11-711 which showed hop yields increased significantly with irrigation during 2011, and FNE 12-742 which investigated cover cropping and non-herbicide weed management in hops.

Our technical advisor is Marcus Flewelling, a crop specialist with Crop Production Services. Marcus continues to provide support to our farm with recommendations on organic products, IPM, and other growing advice. We also benefit from continuing technical support from Dr. Heather Darby, an Agronomic and Soils Specialist with the UVM Extension and leader of the UVM Hops Project.

Methods

Hops were strung (2-3 bines/string x two strings/plant) from mid-May to early June using coir twine on 18' trellising. We tilled around plants in the spring, and used a combination of plastic and straw mulch to suppress weeds within rows. Between rows we planted a cover crop of white clover underseeded with oats, which was then mowed after establishment. We amended our soil in the spring with lime, based on previous fall soil tests. We surveyed all plants weekly for insects. When plants were tall enough, we stripped the bottom 5' of leaves by hand to reduce downy mildew infection. We also have a schedule of spraying Champ WG (copper hydroxide) mixed with Regalia (a biofungicide) to control for downy mildew.

One granular fertilizer group ("single") was irrigated and received a full side-dressing of organic granular Oasis 11-0.7-1.0 fertilizer (Lancaster Agriculture Products, Ronks, PA) once in early June, which serves as a control. A second granular group ("split") split the granular side-dress delivery between early and late June. It is of interest to note that one week after the second granular delivery for the split group, tropical storm Arthur delivered 4.7" of rain in one day (July 5th), which likely had consequences for granular fertilizer loss in both granular groups.

When considering which product to use for fertigation in this experiment, we sought an organic, soluble product that was high in nitrogen content, cost effective, and low in particulate matter. This combination proved to be far more challenging than anticipated. Initially, we had proposed to use a liquid fish fertilizer product, which we selected from a published table of organically approved fertigation products (Miles et al., 2012). However, we consulted with our irrigation technician, and there was considerable concern about the fact that the product was published to pass through an 80-mesh screen, while the conventional standard for drip tape is for a product to pass through at least a 200-mesh screen. When we revisited the Miles et al. (2012) table, we discovered that many products or companies listed no longer existed at all, or at least, not in their listed form, and some that were still available were only regionally available (i.e. California).

Though we eventually settled on a product, the challenge remains – a single commercial product that is OMRI-approved, relatively high in nitrogen, widely available, and affordable fertilizer for use in drip tape fertigation is currently an unlikely combination.

We eventually decided to use Ferti-Nitro Plus (13.62-0-0), an OMRI-approved soluble soybean-based fertilizer produced by Ferti Organics (Brownsville, TX). However, it is important to note here that due to a miscommunication with the supplier, we received a soybean-based product also made by Ferti-Organics called Solu-Nitrogen (15-0-0), which is not OMRI-approved. The non-organic Solu-Nitrogen cost $3.10/lb. (with shipping), and the OMRI-approved Ferti-Nitro Plus would have cost $4.15/lb. (with shipping), which may be cost-prohibitive for commercial hop crop production. All calculations in this report are based on the $4.15/lb. price for the organic product, as planned.

The fertigation system was a Venturi bypass system utilizing a 25 gph Mazzei injector, with backflow prevention. Header hose was 1" oval hose with a 48 PSI capacity, and this was divided into 5 zones of roughly 0.8 acres per zone. Drip tape was 5/8" 8 mil, 16" TSX 'T-Tape' which was connected to the header with barbed valves, and also had a valve at the terminal end for line cleanout.

Photo 1: Fertigation injection station.

Beginning in June, we started weekly fertigation toward the end of an irrigation event, to retain more fertilizer around the root zone. When the fertilizer injection was complete, the system was flushed for at least 30-minutes to prevent line clogging. Plants in the "set" fertigation group received 18.75 #/acre of Solu-Nitrogen (15-0-0, Ferti Organics, TX), with the goal of providing the recommended 150 #/acre over the eight weeks. By the end of the season, we delivered just under our goal, with 131.4#N/acre/season delivered to the fertigation-set group.

Petiole sampling started on June 24th, and was done roughly every second week (July 2, July 18, July 27), ending with the fifth sampling event on August 7th. This consisted of taking 30 petioles at ~5' high from plants within each age/variety treatment group (n=6). These were mailed to the U. Maine Soil Testing Laboratory (Orono, ME) for nitrate tissue analysis, and results were emailed back to us, usually within 48-72 hours.

When we received the results of the test, we adjusted the next injection of fertilizer to plants in the "adaptive" groups in an attempt to achieve a "normal" range. Since the petiole results showed lower than optimal nitrate levels, the "adaptive" plants received more fertilizer during these weeks. The total amount delivered to the fertigated-adaptive group was 150#/acre/season.

After our first petiole test results were received, we consulted with an agronomist experienced in routine hops fertigation management using tissue sampling (Agrimanagement Inc., Yakima, WA), and again consulted towards the end of the growing season.

Harvest began when cones were mature and at target dry matter levels, beginning in late August with Mount Hood, followed by Centennial and Cascade, and finished in the second week of September with Nugget. For each experimental group, we selected every third plant in a row for a total of ten. Each plant was run through our mechanical hop harvester separately, and wet mass of hop cones was recorded. For three of these ten plants, we also collected 20-30 petioles to measure nitrate levels, a subset of the whole plant (bine+leaves) to measure total nitrogen levels, and a subset of hop cones to measure total nitrogen levels. The U. Maine Soil Testing Laboratory (Orono, ME) ground the tissue samples and conducted all analyses.

Unfortunately, due to a late change in the working field map not being updated electronically, we missed the opportunity to collect samples on the 2 year old Mount Hood plants that received the single granular delivery.

Separately, a group of one-year old Cascade plants were fertigated with the "set" approach (since immature plants do not produce enough bine for repeated petiole analysis), and were compared to single and a split application of granular fertilizer to assess whether fertigation of first-year plantings is worthwhile.

Outcomes and impacts

Petiole nitrate levels (Figure 1) declined significantly from mid-July to early-August, during the time of flower and cone development. They were also lower than the general "normal" recommended level of 6000-10,000 ppm.

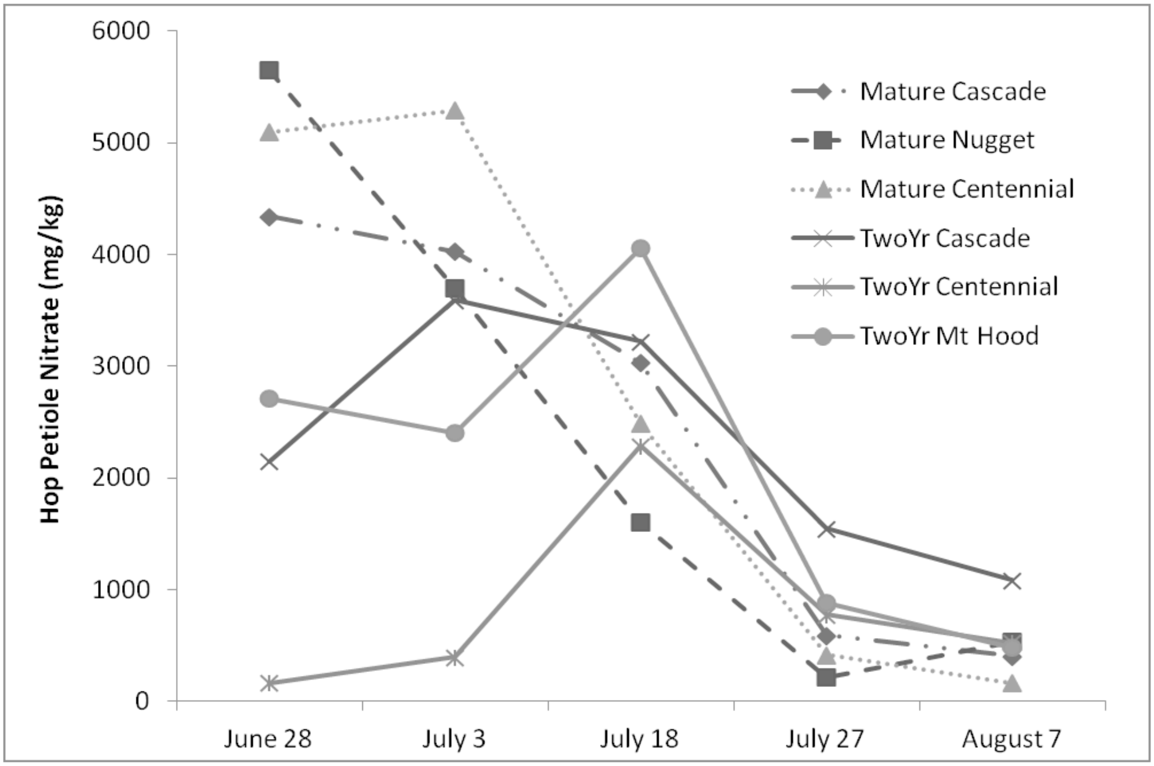

Figure 1: Petiole nitrate levels (mg/kg) for plants in the fertigation-adaptive group by age and variety sampled throughout the 2015 growing season at Aroostook Hops, Westfield, ME.

After we received the first couple of petiole nitrate results, we increased delivery of nitrogen to the fertigation-adaptive group, as planned. The fertigated-adaptive group received 18.6#/acre more than the fertigation-set group in late July, which may have been later than optimal. Despite this increase in fertilizer delivery, our petiole nitrate levels remained below the standard target and continued to decline seasonally, indicating that we were still not meeting the hop plants' nitrogen demands. We consulted with Scott Stephen of Agrimanagement (Yakima, WA), who provided some helpful insights for our management plan. First, hops may actually utilize 250+ lb. N/acre/season, so we plan to address this increased target during this coming 2015 growing season. Second, it is typical for petiole nitrate levels to decline after the time that cones set (though our levels were too low throughout the season overall). Third, it is expected that organic hopyards will have lower petiole nitrate levels due to proportionally more uptake of NH_2 (protein) and NH_4 (ammonium) than NO_3 (nitrate).

Agrimanagement also provided some useful hop petiole nitrate reference ranges specific to each variety (though for conventional hop production and in eastern Washington):
Cascade: 9,000-20,000 ppm
Nugget: 8,000-16,000 ppm
Centennial: 5,000-13,000 ppm
Mount Hood: 6,000-16,000 ppm

They estimated the total nitrogen supplied to our fertigated-adaptive hop plants as 15 lb/acre from the soil residual, 50 lb/acre from organic matter release, and 150lb N/acre from fertigation, equaling 215 lb N/acre for the season. Based on our low petiole nitrate levels, this was insufficient in amount and/or timing. Agrimanagement recommended for us a plan that begins with late spring side-cast of 75 lbs N/acre at the time of training, followed by weekly fertigation when plants are halfway up the strings, delivering 100 #N/acre/season through this method. In our northern Maine climate, plants are usually halfway up the string by mid-June, and the burr stage begins around the end of July, so this approximately 7-week window would necessitate a 14.3 #N/acre/week fertigation delivery. This scenario would result in a seasonal total of 240 lbs. N/acre/season.

By the end of the season, when percent nitrogen was sampled in plant tissues, there was no significant difference by experimental treatment (all $p > 0.05$) in nitrogen levels in cones, whole bines, or petioles in either two-year old or mature hops (Table 1).

Table 1: Percent nitrogen for the whole bine, cones, and petioles, by experimental treatment in mature and two-year old bines taken at harvest in September. ANOVA (summarized in the text) was conducted by age but with varieties pooled, due to a sample size of 3 for each age/variety combination.

	Mature %N Bines	SE	Two-year %N Bines	SE
F-adaptive	1.75	0.07	1.75	0.05
F-set	1.82	0.09	1.71	0.05
G-single	1.70	0.09	1.73	0.15
G-split	1.82	0.09	2.04	0.13

	Mature %N Cones	SE	Two-year %N Cones	SE
F-adaptive	1.75	0.07	1.75	0.05
F-set	2.08	0.03	1.96	0.09
G-single	1.97	0.06	1.99	0.18
G-split	1.90	0.09	2.06	0.12

	Mature Petiole Nitrate	SE	Two-year Petiole Nitrate	SE
F-adaptive	71.0	34.2	39.3	14.8
F-set	62.7	10.8	56.3	26.1
G-single	56.2	20.4	51.2	27.8
G-split	71.0	10.1	95.1	54.6

Table 2: Average percent nitrogen for the whole bine, cones, and petioles, by experimental treatment, age, and variety (n=3 per cell) taken at harvest in September.

Age	Variety	Treatment	Bines % total N	Cones % total N	Petiole Nitrate (mg/kg)
Year Two	Cascade	F-adaptive	1.69	1.69	16.7
Year Two	Centennial	F-adaptive	1.74	2.21	60.9
Year Two	Mount Hood	F-adaptive	1.81	2.12	40.3
Year Two	Cascade	F-set	1.79	1.64	9.9
Year Two	Centennial	F-set	1.58	2.10	23.2
Year Two	Mount Hood	F-set	1.77	2.12	135.9
Year Two	Cascade	G-single	1.66	1.62	14.5
Year Two	Centennial	G-single	1.80	2.35	87.8
Year Two	Cascade	G-split	1.96	1.68	30.9
Year Two	Centennial	G-split	1.69	2.12	30.0
Year Two	Mount Hood	G-split	2.46	2.39	224.4
Mature	Cascade	F-adaptive	1.96	1.97	14.6
Mature	Centennial	F-adaptive	1.79	2.26	175.3
Mature	Nugget	F-adaptive	1.51	1.85	23.0
Mature	Cascade	F-set	2.11	2.07	83.9
Mature	Centennial	F-set	1.67	2.15	68.3
Mature	Nugget	F-set	1.67	2.01	35.8
Mature	Cascade	G-single	1.96	1.97	24.5
Mature	Centennial	G-single	1.48	2.01	19.8
Mature	Nugget	G-single	1.66	1.91	124.2
Mature	Cascade	G-split	2.11	2.10	64.8
Mature	Centennial	G-split	1.81	2.04	93.0
Mature	Nugget	G-split	1.54	1.56	55.1

While there were no differences in percent nitrogen level by treatment, there was a significant positive correlation between percent nitrogen in whole bines and petiole nitrate levels (Figure 3; p=0.0005; $R^2 = 0.17$). Pooling across all varieties and ages, there was no relationship between percent nitrogen in whole bines and hop cone wet mass (Figure 2; p=0.074; $R^2 = 0.047$), but, when analyzed separately by age (still pooling all varieties), there was a strong positive relationship between percent nitrogen in whole bines and hop cone wet mass (p=0.0002; $R^2 = 0.33$) for mature plants, but, not for two-year old plants (p=0.75; $R^2 = 0.0034$). Finally, petiole nitrates were not correlated with hops cone wet mass with all varieties pooled (Figure 3; p=0.57); however, there was a significant positive relationship between petiole nitrates and hops cone wet mass for two varieties: Cascade (p=0.048) and Centennial (p=0.0016).

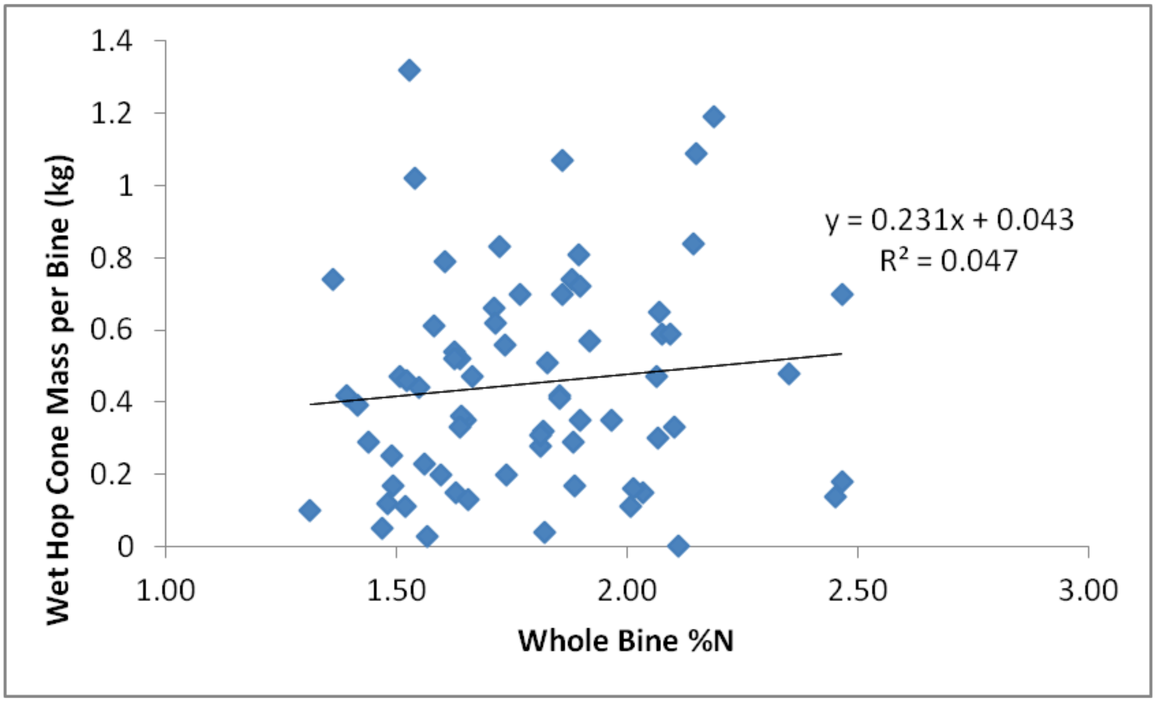

Figure 2: There was no correlation between whole bine percent nitrogen and wet hop cone mass per bine (p=0.074) with all varieties and ages pooled, but when analyzed separately by age (still pooling all varieties), there was a strong positive relationship between percent nitrogen in whole bines and hop cone wet mass (p=0.0002; R^2 = 0.33) for mature plants, but, not for two-year old plants (p=0.75; R^2 = 0.0034).

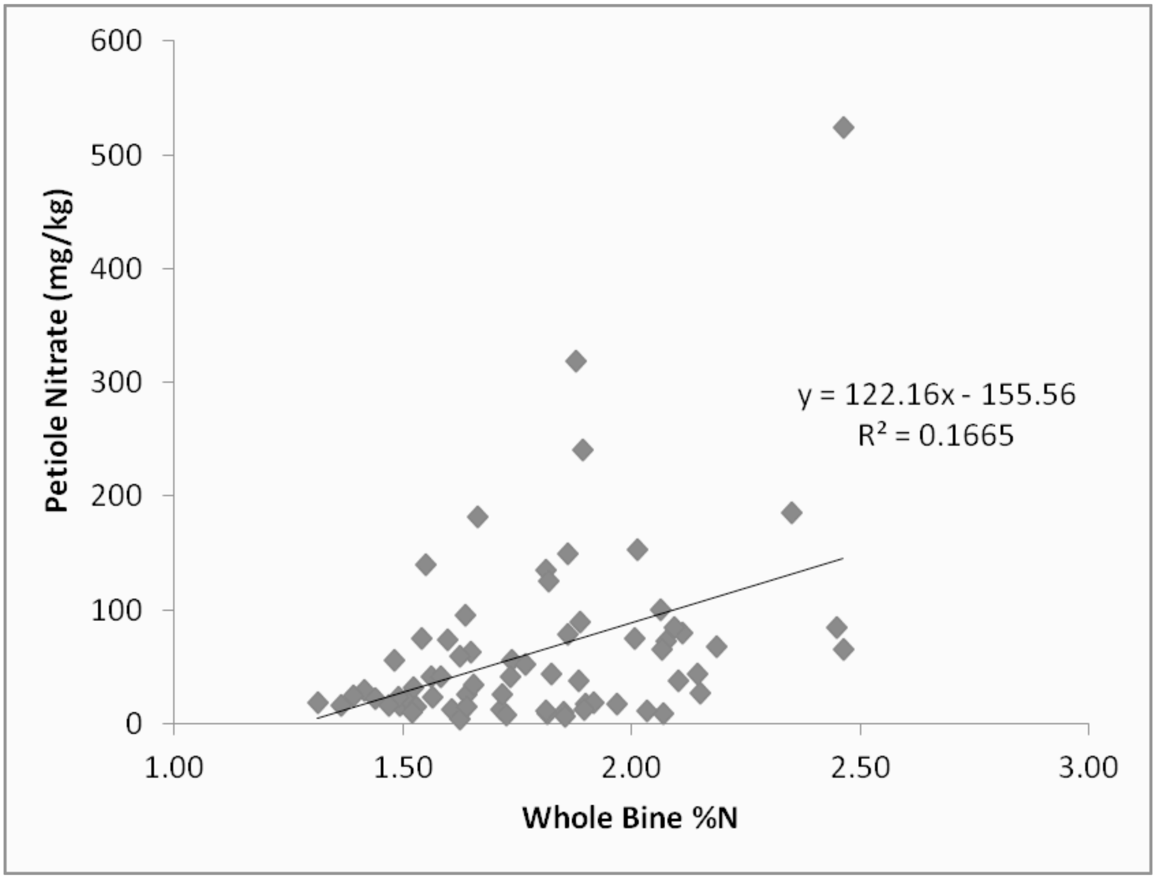

Figure 3: Correlation between whole bine percent nitrogen and petiole nitrates taken at harvest in September 2015 was not significant (p=0.57). However, there was a significant positive relationship between petiole nitrates and hop cone wet mass for two varieties: Cascade (p=0.048) and Centennial (p=0.0016).

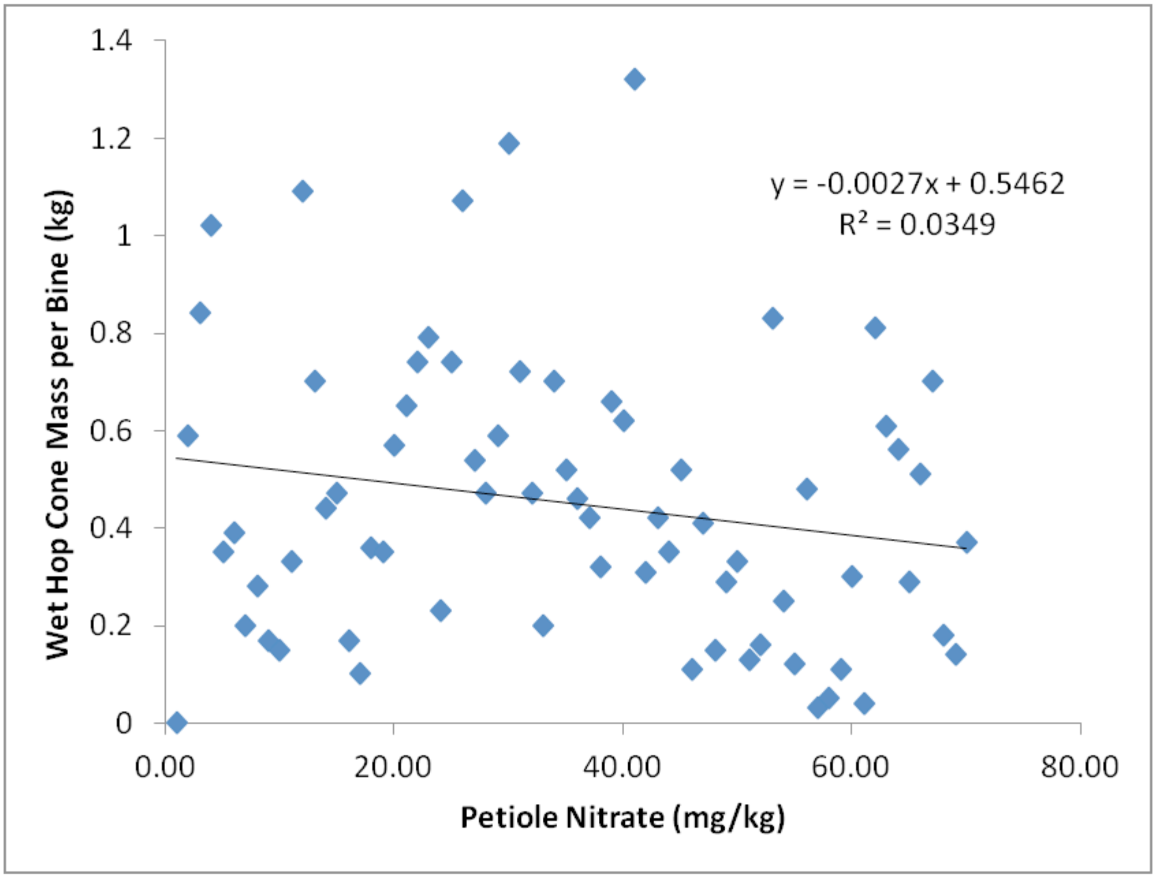

Figure 4: There was no correlation (p>0.05) between whole bine total percent nitrogen and petiole nitrate concentrations taken at harvest in September 2015.

Statistical analysis of percent nitrogen levels of bines, cones, and bines and cones together were conducted. However, neither of these showed many clear patterns, overall. The analysis of hop wet mass did show a clear pattern of differences, and so hop wet mass only are presented here for brevity and simplicity.

Hops wet mass was, in general, significantly improved by fertigation versus granular application of nitrogen. Pooling across all varieties and ages, fertigation-set produced the highest mass of hops (0.51 kg/bine), which was 75% higher than the yield of granular split or single (both at 0.292 kg/bine); fertigation-adaptive yielded 0.46 kg/bine which was 57% higher than granular treatments; however, there was no significant difference between the fertigation treatments, and both fertigation treatments were higher than both granular treatment (ANOVA, p<.0001 and Tukey's posthoc LSD). Hops mass by age (pooling across varieties) produced similar results: both two year old plants (p=0.0002) and mature plants (p=0.0021) were significantly affected by treatment. For two-year old plants, fertigation-set (0.61 kg/bine) was not significantly different from fertigation-adaptive (0.49 kg/bine), but was higher than granular-single and granular-split (both 0.37 kg/bine). Finally, examining by both age and variety, there were significant overall treatment effects for 5 of the 6 age/variety combinations; only two-year old Mt. Hood wet mass did not differ by treatment (and data were missing for granular-single). Means, variance, and summary of comparisons of means are illustrated in Figure 5 for two-year old plants, and Figure 6 for mature plants. In general, fertigation treatments were higher than granular treatments.

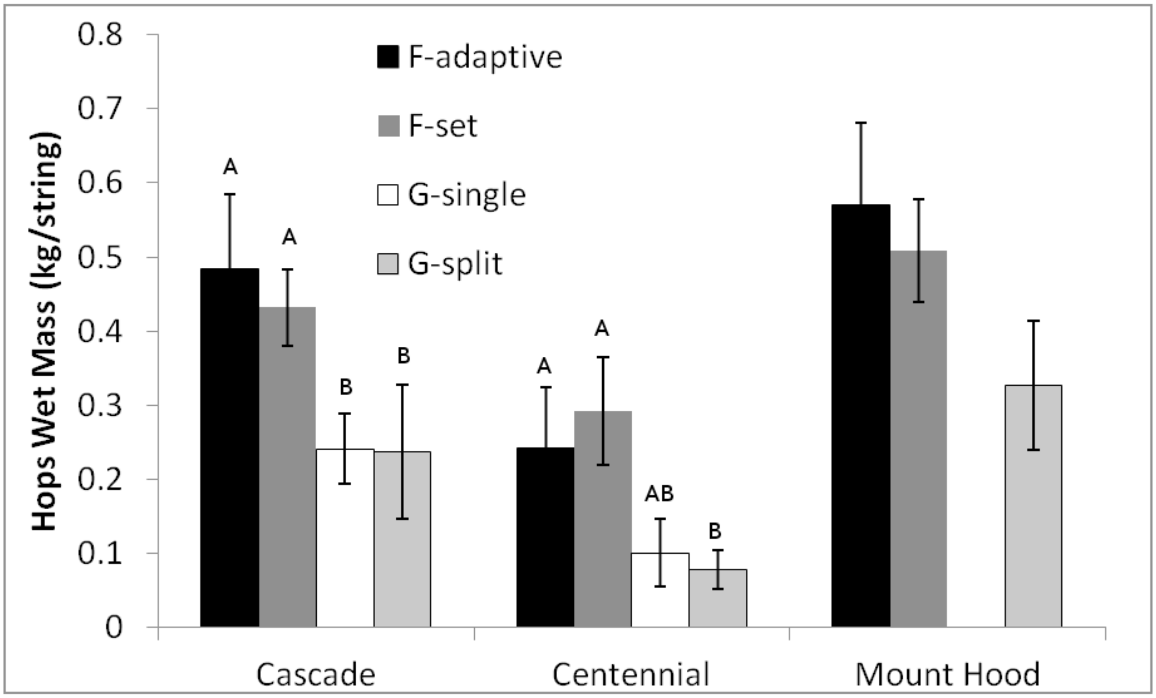

Figure 5: Hops average wet mass (bars show standard error) for two-year old hops by variety and treatment. Data missing for Mount Hood granular-single. Bars with different letters are significantly different (Tukey's LSD posthoc test).

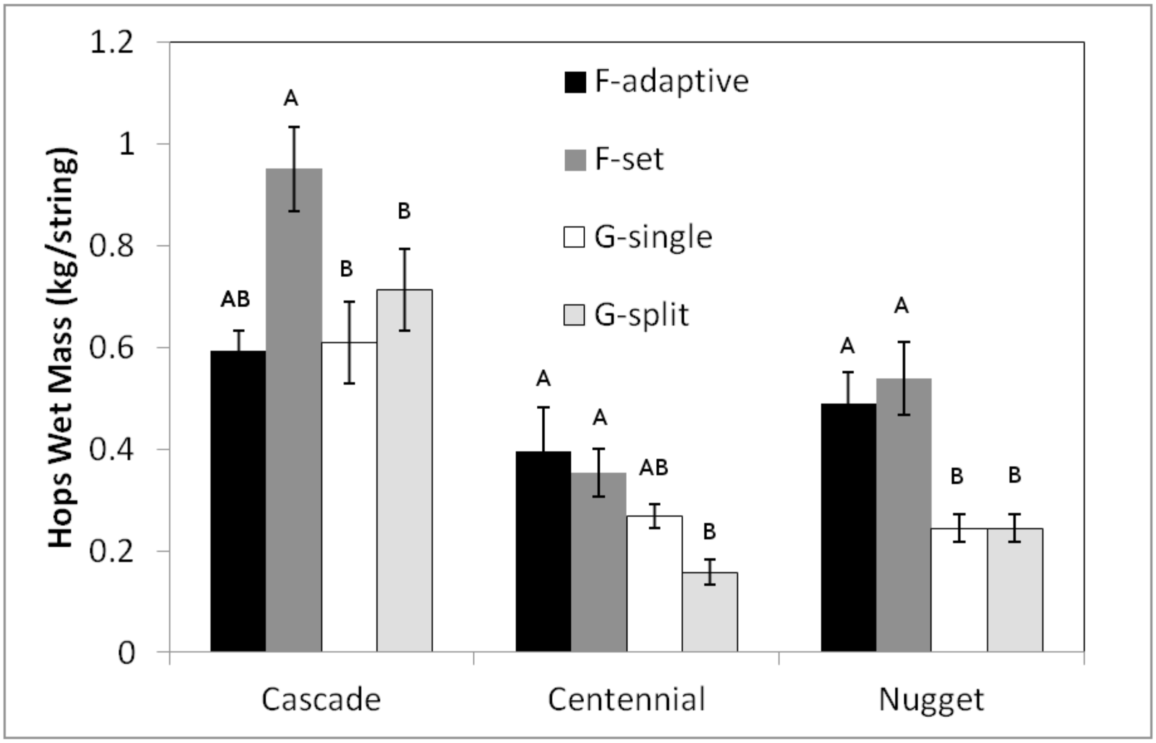

Figure 6: Hops average wet mass (bars show standard error) for mature (5-6 year old) hops by variety and treatment. Bars with different letters are significantly different (Tukey's LSD posthoc test).

First year Cascade plants did not differ in height by fertilizer treatment (p=0.78; Figure 7). The fertigation-adaptive group did have higher percent nitrogen in first-year Cascade bines (Figure 8), but this was not able to be statistically tested due to insufficient sample size (3 bines per treatment).

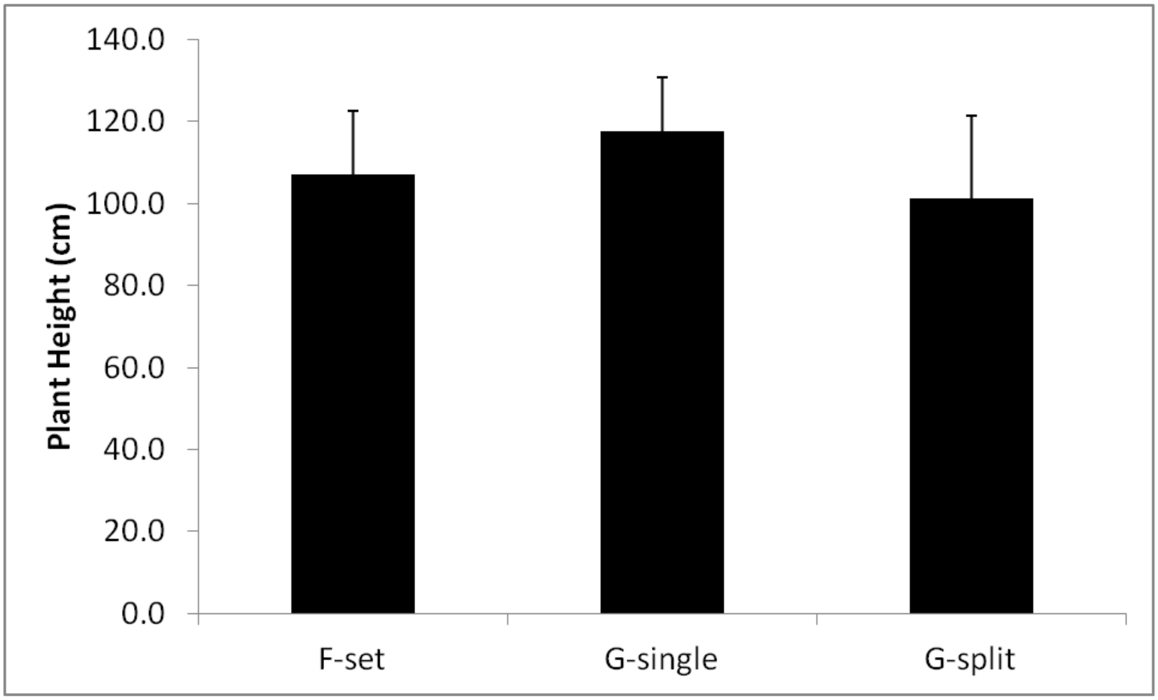

Figure 7: Average height (with standard error) of first year Cascade bines by treatment.

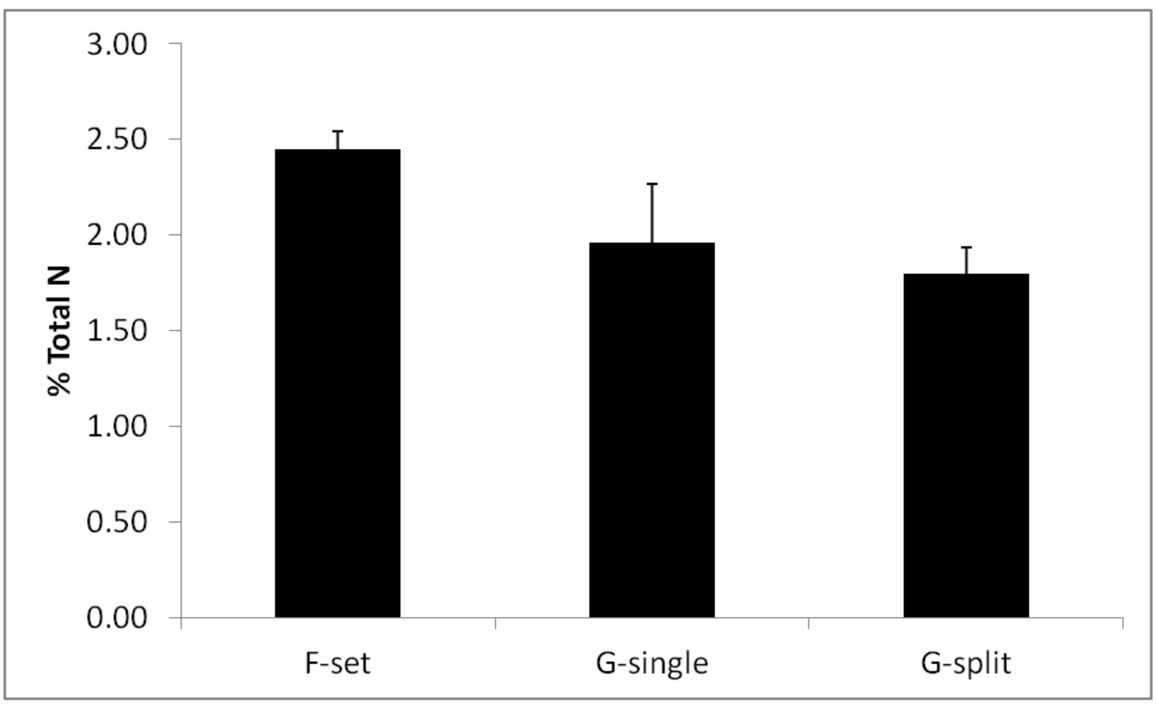

Figure 8: Average percent total N (with standard error) of first year Cascade bines by treatment.

Table 3: Cost for a 1-acre hopyard of the four experimental fertilizer treatment and the recommended future approach.

	Granular-single	Granular-split	Fertigated-set	Fertigated-adaptive	Recommended Plan
fertilizer $/lb. N	$12.36	$12.36	$30.47	$30.47	both types
fertilizer $/lb.	$1.36	$1.36	$4.15	$4.15	both types
fertilizer total/acre	$597.16	$597.16	$644.60	$735.85	$1,034.43
fertigation hardware	$0.00	$0.00	$807.79	$807.79	$807.79
fertilizing labor - fertigating	$0.00	$0.00	$307.50	$330.00	$307.50
fertilizing labor - granular	$52.50	$105.00	$0.00	$0.00	$52.50
petiole testing labor	$0.00	$0.00	$0.00	$37.50	$15.00
petiole testing	$0.00	$0.00	$0.00	$77.45	$30.98
TOTAL cost for one acre	$649.66	$702.16	$1,759.89	$1,988.59	$2,248.20

The fertilizer costs associated with each of our experimental groups, as well as the best recommended future approach, are summarized in Table 3. Cost is estimated for a one-acre hopyard, and includes shipping on materials. Field labor is based on $10/hr., with $15/hr. for petiole testing. The recommended approach includes two petiole testing events. Fertigation hardware, obviously, is a one-time cost that can be removed from the equation after the first year when calculating cost of materials and labor alone. Clearly, there are higher costs associated with fertigating, and analyzing whether the increased hop yield provided by fertigating is economically worthwhile will be up to an individual grower.

Potential Contributions

Providing best fertility levels at the appropriate time to nitrogen-hungry hop plants is an important component of successful hop growing and increasing hop yields. Northeast growers, and especially those using organic management practices, have not been able to match the hop yield per acre of the established Pacific Northwest large-scale farms. This experiment provides valuable insight into optimal fertility practices specific to our Northeast soils and growing season, and has the potential to benefit the growth in yield and acreage of many farms and the Northeast hop industry as a whole.

Publications & Outreach

We held our annual hop harvest field day on Labor Day, September 1, 2014, and hosted interested members from the general public and the local agricultural community. We gave hopyard tours (including of our fertigation equipment) and discussed hop nutrient needs with respect to this experiment. On January 13, 2015 we spoke about hop growing for Maine Organic Farmers and Growers Association (MOFGA) at the Maine Agriculture Trade Show in Augusta, ME, where we again discussed hop fertigation. To make the results of our experiment as widely available as possible, we have made a .pdf version of this report available for download from our website, and added a short summary of text and pictures to our existing “research” tab of our webpage. Additionally, we continue to answer emails and phone calls from growers across the state and beyond about hop growing.

Future Recommendations

The results of our experiment clearly show that fertigating hops at key times in the growing season before burr development is very beneficial in terms of increasing hop yields. We recommend a fertilizer plan involving spring nitrogen addition at a rate of 75 lbs. N/acre, followed by fertigating from the time plants reach halfway up the strings to burr (flower) development at a rate of 100 lbs. N/acre/season, or 14-15 lbs. N/week for ~7 weeks. When choosing an organic fertilizer, high solubility and low particulate size are important factors in successful delivery through a drip tape irrigation system. Petiole testing should be conducted a couple of times in a growing season to monitor nitrate levels and adjust, if needed.

References

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