THE OHIO STATE UNIVERSITY
COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

NORTH CENTRAL SARE
Sustainable Agriculture Research & Education

Dear Farmer Cooperator:

Enclosed is the summarized data you collected in 2019 for the Ohio State Hop Soil Fertility Project. Nicole Hoekstra, the technician that was helping coordinate much of this work, has unfortunately left our lab to take another position and this has delayed us getting the results to you. (Now you know who did the real work on this project!) We appreciate your patience through this process!

This letter contains:

- The 2019 data collected from your hopyard(s)
- 2019 Preliminary Overview of Research Results – 3-page summary of data collected over all hopyards. This is provided for you to compare your results to other hopyards in the region
- Soil Health and Active Organic Matter Handout
- Soil Test Results Interpretation

We want to caution that everything we've provided is a preliminary analysis. More work is needed to fully understand these results and a 2nd growing season will add a great deal of confidence to what we've found already.

We are starting to gear up for the 2020 field season. **We need to know if you're interested in participating in this study for a 2nd (and final) year? Please email Bethany Herman herman.271@osu.edu or Steve Culman culman.2@osu.edu and to let them know if you are or are not interested in participating in 2020**.

We really appreciate your participation in this project! Don't hesitate to reach out with any questions.

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Overview of Hop Research Results – 2019 Preliminary Take Aways

Soil Results

- Soils sampled: 33 farmers and 87 hopyards.
- Spring-sampled soils for nutrient analysis (Table 1) and soil health measurements (Table 2).

Table 1. Distribution of Soil Nutrient Analysis

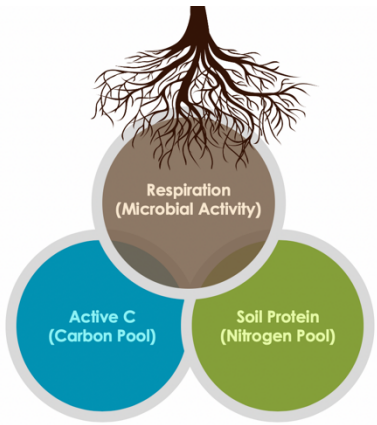
	Soil pH	Organic Matter (%)	CEC (meq/100g)	Phosphorus (M3, ppm)	Potassium (M3, ppm)
Minimum	4.9	0.8	3.2	8	48
25th percentile	5.8	1.8	8.7	28	93
50th percentile	6.3	2.3	11.8	61	140
75th percentile	6.8	2.8	15.2	116	190
Maximum	7.7	9.1	27.5	397	578

Soil nutrient analysis take home messages:

- Hops grow best in soils with pH between 6.0 – 7.0. Many of the hopyards we sampled had low pH values, suggesting low pH might be limiting nutrient availability in many hopyards. Nitrogen fertilizers further acidify soil and so it is crucial that soil pH be monitored and managed. It is easiest to manage pH before hopyard establishment, but lime applications can still be made in established hopyards.
- Most hopyard soils have sufficient P fertility (>25-40 ppm), but K fertility may be lacking. The Michigan State University hop management guide recommends >300 ppm soil test K, but only 2% of our hopyards were over 300 ppm. We believe trying to keep soils above 300 ppm will be very difficult in many soils, so a more reasonable goal might be 150-200 ppm soil test K.

Table 2. Distribution of Soil Biological Health Values

	Active C (mg/kg)	Respiration (mg/kg)	Protein (g/kg)
Minimum	224	8.5	2.1
25th percentile	400	47.1	4.1
50th percentile	550	70.7	5.1
75th percentile	663	102.5	6.0
Max	1423	265.4	25.7



Soil health take home messages:

- We've analyzed over 1000 soils across a diversity of Ohio farms over the past 5 years
- Across all of these samples, the average values were:
  - Active C: 490 mg/kg
  - Respiration: 41 mg/kg
  - Protein: 5 g/kg

- Hopyards sampled in this project have better than average soil health values.
- Only weak relationships between soil values and hop cone quality (data not shown).
- See accompanying handouts in this letter for more information on soil test results.

Petiole Nitrate Analysis

- Hops use a large amount of nitrogen – up to 150 lbs N/acre per year. Most of this uptake occurs in late spring/early summer and so N nutrition is really important this time of year.
- Petioles were sampled ~every 2 weeks: June 15, July 1, July 15, August 1 in 53 total hopyards
- Petiole nitrate was measured with hand-held meters (Figure 1).

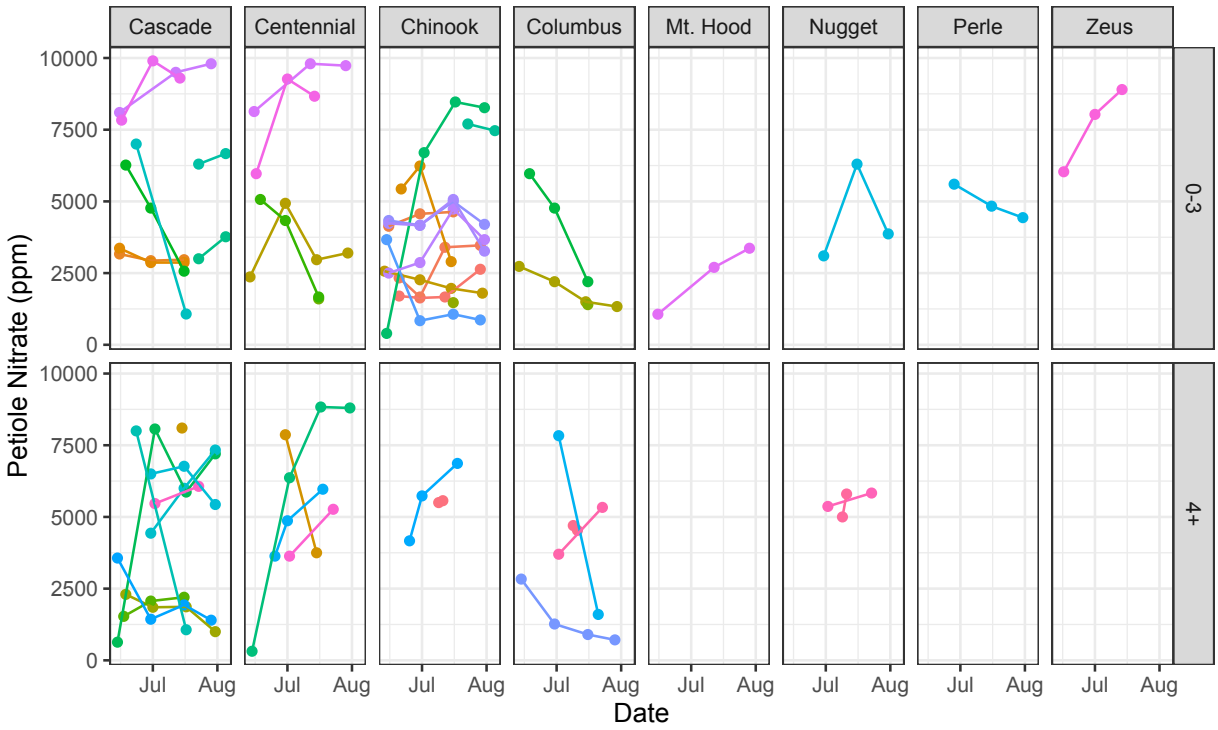


Figure 1. Trends in Petiole Nitrate over 4 Time Points (June 15 – Aug 1) in 2019, classified by Variety (columns) and stand age (rows).

Petiole nitrate take home messages:

- Petiole nitrate levels varied greatly across all hopyards and ranged from ~ 500 – 10,000 ppm.
- Trends in petiole nitrate varied greatly – some hopyards started with low nitrate levels and increased dramatically, while others started high and dropped rapidly. These trends reflect the differences in N management likely due to the lack of robust nitrogen fertilization guidelines. As an industry, we would like to see more consistency in N levels and trends over time between hopyards.
- Recommended petiole nitrate levels vary from 4,000 to 12,000 ppm depending on the time of year, variety and the source of information.
- Next steps are to link farm N management with petiole nitrate values and hop cone yields and quality.

Leaf Nutrient Concentrations

Table 3. Distribution of Hop Leaf Nutrient Content.

	N	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Zn
	----------% ----------						---------- ppm ----------				
Minimum	3.12	0.12	0.98	0.55	0.28	0.14	10	3	62	18	18
25th percentile	3.84	0.27	1.36	2.14	0.60	0.29	57	6	93	59	26
50th percentile	4.46	0.35	1.64	3.11	0.83	0.33	75	7	103	120	29
75th percentile	4.37	0.37	1.76	2.98	0.83	0.32	92	31	109	193	34
Maximum	4.85	0.45	2.20	3.80	1.00	0.36	106	19	122	192	35

Leaf nutrient take home messages:

- There was a wide range of leaf nutrient values across hopyards. Established values of what are 'sufficient'
- We are still trying to determine values for each nutrient that would be 'sufficient' for production

Preliminary Conclusions

- After 1 (abnormally wet) year, our results suggest hop growers could be managing soil fertility better.
- Timing of N management is really important and likely key for profitable N management.
- A second year of data and additional analysis will provide greater confidence in these results.
- We hope you'll continue to work with us in 2020!

Soil Test Results Interpretation

So what do these values mean and what do I do with them?

The optimal ranges in Table 1 are provided by numerous sources to help you better understand what they mean. Major sources include:

- Michigan State University Hop Production Guide: https://www.canr.msu.edu/resources/michigan-hop-management-guide
- Vegetable Crops: https://ag.purdue.edu/btny/midwest-vegetable-guide/Pages/default.aspx
- Ohio Soil Fertility Resources: https://agcrops.osu.edu/fertilityresources

Paper copies of these guides (and others) can be provided upon request.

The soil health test results in Table 2 are less understood. However, we are making strides in how these three tests relate to soil organic matter and how your specific results compare to soils that are similar to yours. In general, the greater the value, the better the soil health, but note that increasing your values over time is largely based on your soil type and where you soils 'started from'. All soils are different and have a history of management that can carry over for years to decades.

If your values are in the low range of the soils in this study, we recommend implementing soil conserving management practices that will increase your soil health. Examples include, using manure or compost, and cover cropping when possible. If your values are in the high range, then you've likely already been practicing one or more of these.

We want to stress that all soils are unique and rather than rating your soils against others, it might be more fruitful to think of this test result as a baseline sampling. This is the start of you monitoring your soils over time. You can now see how your management practices (whether you are starting something new this year, or continuing practices) are influencing the health of your soil. These 3 tests are sensitive to management, so changes (for good or bad) should be detectable within a few years. We would recommend testing soils every 3-4 years. It's important that you sample in the same field and at the same time of the year that you took this sample.

An excellent reference for more on soil health and soil testing is the Cornell Soil Health Manual: https://soilhealth.cals.cornell.edu/training-manual/