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Foreword

These Proceedings summarize three days of meetings and educational seminars at the 60th Lower Mainland Horticultural Improvement Association Short Course held in conjunction with the 20th Annual Pacific Agriculture Show from January 25-27, 2018 in Abbotsford, BC. There were 867 registered for the Short Course and 85 presenters, along with over 300 exhibitors and over 7,500 general attendees at the Pacific Agriculture Show. The Short Course provides an opportunity for participants to learn about the recent progress in research and development, sustainability and innovation, marketing, agricultural programs and policies, and the ever-changing face of the horticulture industry in BC. This event is organized by the LMHIA Board of Directors, which includes growers, agribusinesses, government and university personnel – all of whom deserve credit for its delivery. Short Course evaluations this year indicated a very high rating for both the choice of speakers and the topics presented. Our social media presence is at the following sites year-round:

Twitter: www.twitter.com/pacagshow
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This volume contains summaries written by the speakers themselves. The LMHIA Board, and all others involved in the Short Course acknowledge and appreciate the widespread participation of the speakers, and in their drafting of summaries of their presentations to be included in these Proceedings. The Proceedings stand as a resource of information for the horticulture industry as a whole, and a record of the state of development of agriculture in BC. Revenue generated by the Short Course enables the LMHIA to award research projects in support of agriculture in BC, indicated at the end of this document.

We look forward to seeing you at next year's Short Course from January 24-26, 2019.

The Editing Committee - Todd Kabaluk and Lisa Frey

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Evaluating the Use of UAVs or Drones in the BC Agriculture Sector

Organics

Tools for Evaluating Nutrient Status of Management Zones for Small-Scale Vegetable Operations

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Several tools for evaluating and managing nutrient status on small-scale farms are discussed. Nitrogen planning can be especially difficult. Following a brief overview of soil nitrogen cycling, results of a multi-year on-farm study of nitrogen fertility on 5 organic farms is provided. Mid-season fertility testing and side dress fertilizer applications are additional tools for nitrogen management. Finally, the management zone approach to soil testing is helpful for nutrient management and directing lime applications, especially on diversified vegetable farms.

Overview of Nitrogen Cycling and Challenges for Organic Farmers

Organic farmers face a difficult problem in managing nitrogen: the magnitude and timing of nitrogen mineralization from organic matter cannot be easily predicted. Many direct-market farmers rely on organic nitrogen fertilizers that cost $5 to $9 per pound of plant available nitrogen. This can cost $1,000 to $1,800 per acre for heavy-feeding crops. Soil building practices such as incorporating leguminous cover crops and amendment with composts and manures can reduce fertilizer need. Disturbed soils and soils low in organic matter can experience dramatic increases in productivity following organic matter addition. Also, judicious use of organic amendments can maintain or enhance yields in soils with relatively high native productivity (Evanylo et al., 2008). When determining how much nitrogen to apply, producers should take into account the plant N requirement as well as contribution from any recently applied amendments or cover crops, and the nitrogen contribution from organic matter (**Figure 1**).

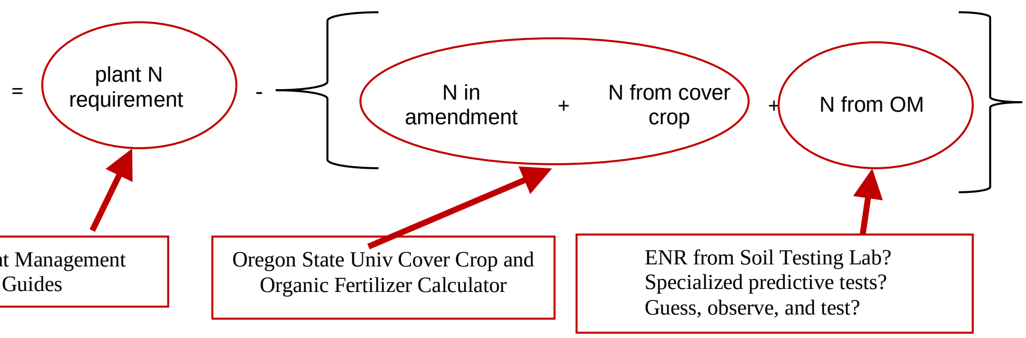


Figure 1. Requirements and credits for making a nitrogen application and potential sources for gathering information. ENR= Estimated nitrogen release.

Optimizing Nitrogen Management on Organic Farms: On Farm Research Trial

It is difficult to quantify the extent to which fertilizers can be reduced based on past practices. Fast, simple, and cheap methods to predict N mineralization are desirable for farmers, especially those that rely on soil building practices such as cover cropping and manure for soil fertility. Certified organic farmers are encouraged to use these methods to build soil, and are required to use only organic sources of nitrogen for fertility. Depending on N content of organic fertilizers and amendments, only small amounts of N may be made available in the year of application while the bulk is likely to contribute to the organic matter pool (Gale et al., 2006).

Sullivan et al. (2008) described a site-specific method for growers to estimate N mineralization potential by plant uptake over the course of a growing season using a "zero-N" plot. A more rapid method with the potential to predict N mineralization before the growing season is the Solvita™ colorimetric test for soils (Solvita Inc., Woods End, MA). This method has been correlated with other methods of determining carbon dioxide concentration (Haney et al., 2008). In addition to correlating 24-hour respiration with a 24-day incubation, Haney et al. (2001) also found strong correlation with forage uptake in fine sandy loam soil. The efficacy of these tests for predicting nitrogen mineralization has not been widely tested in field conditions, especially in western Washington.

The goals of the current study were to estimate optimum soil nitrogen fertilizer rates in organic broccoli production and to evaluate how well nitrogen mineralization predictive tests estimate available nitrogen across five organic farms.

Methods

Field Trials: An experiment to assess nitrogen contribution from organic matter and the economic benefit of five different rates of fertilizer application was performed with 5 organic farms. Two farm sites were located near Royal City in central Washington (Sites 1–2) with a semi-arid climate. Three farm sites were located in western Washington (Sites 3–5) with a maritime climate.

Fertilizer rates were determined through interviews with cooperating farmers and by consulting broccoli production guides. In 2016, organic feather meal fertilizer (11%N, 0%P, 0%K) was applied at 0, 60, 120, 180, and 240 lbs N/acre in a randomized complete block design with 3 replications at each farm. In 2017, 2 additional N rates were added: 360 and 480 lbs N/acre.

Certified organic broccoli transplants were prepared at a central location and transplanted following ground preparation and fertilizer application. Transplanting occurred mid-April in central WA and mid-May in western WA in 2016 and 2017. Plant spacing was determined by individual farmers and was similar at sites 1, 2, 3, and 5. Site 4, the smallest farm planted broccoli more densely in 2016. Weather stations were set up at each site to record air temperature for calculation of growing degree days.

Soil Analyses: Soils were sampled before planting broccoli and analyzed for bulk density (BD), water-holding capacity, organic matter (OM), total C, mineral-associated C, particulate organic C, nitrate-N, P, K, and pH. Soil nitrate-N was more intensively sampled by sampling at 0 and 28 days after transplant (DAT) and at harvest (between 71 and 91 DAT). In addition to laboratory analysis, soil nitrate was also analyzed with a field nitrate testing kit (EM Quant™). Nitrogen mineralization predictive tests were done for soils collected in spring before planting. Predictive tests included the Haney test (performed at Ward Labs, Kearney, WA) which includes both 24-hr CO_2 respiration (Solvita™ test) and predicted available nitrogen calculated from Solvita™ and weak acid extraction of mineral nitrogen. Other predictive tests were 42-day aerobic nitrate (NO_3) mineralization at 22 and 35 °C (incubated soils sampled at 0, 7, 21, and 42 days), and 7-day anaerobic ammonium (NH_4) mineralization at 40°C.

Crop Yield and N uptake: Marketable broccoli yield was taken from each plot. Additionally, three adjacent broccoli plants from each replication of each treatment were destructively harvested and combined into a single sample and analyzed for biomass, total N and total C.

Statistical Analysis and Interpretation: The average of 3 field replications was calculated for bulk density, basic soil analyses, Haney tests, 7-day anaerobic NH_4 incubation, and seasonal soil NO_3. The aerobic NO_3 mineralization rate (lbs NO_3 day^{-1}) was calculated by attempting to fit a linear to plateau model with nitrate mineralization versus days of incubation and averaging the rate across replications.

Results and Discussion

Soil physical properties, days to first harvest, and plants per acre are shown in **Table 1**. Site 5 was a silt loam while the other sites were sandy loam, fine sandy loam, or very fine sandy loam. Soil organic matter ranged from 2.0% to 11.3% and pH ranged from 5.8 to 7.8 (**Table 2**). Organic matter was higher and pH was lower in the soils from the western Washington maritime climate than in the soils from the semi-arid climate in central Washington.

Table 1. Climate, soil properties, and plant density at organic farm sites in Washington State, 2016.

Site	Climate	$GDD_{7.2}$ to first harvest	Days to first harvest	Soil Type	BD g cm^{-3}	Plants $acre^{-1}$
16.1	Semi-arid	701	71	Royal very fine sandy loam	1.10	14,520
16.2	Semi-arid	~700[1]	71	Taunton fine sandy loam	1.24	14,520
16.3	Maritime	652	71	Yelm fine sandy loam	0.93	16,228
16.4	Maritime	679	72	Alderwood gravelly sandy loam	0.89	23,522
16.5	Maritime	802	79	Nooksack silt loam	1.06	16,228
17.1	Semi-arid		91	Royal very fine sandy loam	1.10	14,520
17.2	Semi-arid		91	Taunton fine sandy loam	1.24	14,520
17.4	Maritime		81	Alderwood gravelly sandy loam	0.89	15,125

[1]The weather station at Site 2 was compromised, but GDD were likely similar to Site 1. $GDD_{7.2}$=Growing Degree Days with base temperature of 7.2 C. There was no harvest from sites 17.3 or 17.5 in 2017.

Table 2. Basic soil analyses from each site prior to planting.

Site	pH	NO3-N mg/kg	P mg/kg	OM %	Total Org C %	Organic C (Mg ha-1)	POM-C (Mg ha-1)	C:N POM
16-1	7.7	3.2	86.9a	2.8	1.32	25.7	11.7	8.4
17-1	7.8	3.1	140	2.7	1.53	22.1	9.3	8.2
16-2	7.8	1.1	18.9a	2.0	1.18	21.9	7.5	7.4
17-2	7.7	4.7	41	2.2	1.16	22.2	6.5	8.0
16-3	6.0	3.0	206.0b	7.5	5.51	78.0	24.1	13.3
17-3	6.2	4.4	216	11.3	5.62	79.7	44.2	11.4
16-4	7.1	6.2	102.9b	7.7	4.89	66.3	22.3	14.6
17-4	6.2	7.7	143	10.1	5.28	71.6	36.3	12.5
16-5	5.8	3.0	25.2b	3.5	1.80	30.2	6.2	10.1
17-5	7.5	2.3	51	3.5	1.87	29.1	5.2	10.7

[a]Olsen P test, [b]Bray P test, [c]Olsen K test, [d]NH_4OAC K test

Tests to predict N mineralization varied slightly in their ranking of the soil sites. The Haney test, Solvita test, and 7-day anaerobic tests all predicted greater N mineralization from sites three and four in both years (16.3, 16.4, 17.4, 17.3). The ranking of sites with 45 d aerobic tests were similar, but site 1 was also identified as having potentially high N mineralization (**Table 3**).

In 2016, broccoli transplants in several plots at Site 1 were completely lost to rodent damage, so Site 1 data was not included in above ground biomass or marketable yield analyses. Similarly, harvests at sites 3 and 5 were lost in 2017. Fertilizer rate had a significant effect ($p<0.05$) on above ground biomass at Sites 2 and 4, but not Site 3 or 5 (**Figure 1**). Fertilizer rate significantly affected marketable weight at Sites 2-5 ($p<0.05$; **Figure 2**).

A linear to plateau model described the effect of fertilizer increase on market head weight in 2 of 4 sites analyzed in 2016. The other 2 sites did not plateau and only a linear model could be fit. In 2017, when 2 additional fertilizer rates were included, a linear to plateau model fit the 3 sites where there was a measureable harvest. Plateau N levels ranged from 152 to 457 lbs N / acre.

Fall soil nitrate levels are another indication of appropriate nitrogen application rate; leaving excess nitrate in the soil after harvest can degrade water quality. Soil nitrate at 30 ppm or greater is considered high and equates to about 105 lbs NO_3-N a^{-1}. Only one site had fall soil nitrate levels above this level and this occurred at the highest rate of N application (480 lbs N/acre).

Table 3. Results of nitrogen mineralization predictive tests.

Site	Haney Tests		45-day aerobic incubation, 0-6 inches		7-day anaerobic incubation, 0-6 inches
	Solvita CO_2-C day^{-1}	Predicted N min lbs $acre^{-1}$	NO3 lbs a^{-1} day^{-1}		NH4 mg kg $soil^{-1}$
			22C	35C	40 C
16.1	15.3	13.2	1.0	2.2	39.2
16.2	22.5	10.8	1.2	2.2	53.6
16.3	153.3	71	1.7	4.9	108.0
16.4	70.9	54.2	1.1	2.2	97.3
16.5	39.9	18.6	0.5	1.6	7.5
17.1	19.4	16.4	1.6	2.7	54.4
17.2	24.2	21.9	1.6	2.3	57.6
17.3	114.4	48.2	1.6	4.2	86.1
17.4	148.7	51.0	1.9	3.8	105.2
17.5	49.9	16.8	1.2	2.3	36.9

Timing of Nitrogen Availability and Pre-Side dress Nitrate Tests

Nitrogen availability is dynamic throughout the season and this further complicates management. As nitrogen is mineralized, nitrate may pool in the soil or be lost via leaching, incorporation into organic form (immobilization), or as a gas (volatilization). Most vegetables experience a period of rapid nitrogen uptake between 20 and 50 days after seeding. Organic fertilizers are generally best applied as preplant broadcast applications, but some formulations can be surface banded beside the row. Evaluation of the EMQuant field nitrate testing kit revealed it was well correlated with a traditional laboratory test, but overestimated nitrate by about 1.75 times. Mid-season testing and side dress applications are potential methods to increase nitrogen use efficiency in vegetable crops.

Management Zone Approach

Soil samples provide useful information to farmers about the nutrient status, pH, cation exchange capacity, and organic matter content of their soils. To effectively direct application of soil amendments and fertilizers based on these data, soil samples should be taken from distinct management zones. Management zones are contiguous areas that are planted to the same crop at about the same time and have the same amendments applied to them. A management zone can be as narrow as the equipment used to apply amendments, such as a tractor width.

The mix of plantings on diverse vegetable farms poses a challenge for linking farm management to soil sample results (Collins, 2012). To combat pests and meet market requirements farmers may plant a single field to a dozen or more different crops which have a range of nutrient needs. Because of the high spatial variation in plantings on typical small organic vegetable farms, it quickly becomes apparent that sampling each management zone each year is not economically realistic. We tested a method of sampling representative zones from each field with the goal of describing on-farm variation in soil parameters and linking soil management practices to soil nutrient values.

Sampling on a field scale—across different crops—will generalize management practices and crop effects on soil properties. If samples are taken on a management zone basis then growers can link soil test results to their management and make appropriate changes to improve profitability and environmental stewardship. Several of the management zones sampled had excessive fall nitrate levels—a water quality hazard and economic loss (**Figure 2**). Excess soil nitrate can be washed from the soil profile and contaminate ground and surface water. Where late-season fertilizer applications were made, average soil nitrate levels were the highest (**Figure 3**). A mid-season nitrate test can be an effective tool to guide mid-and late-season fertilizer applications.

Figure 2. Box plot distributions of selected soil parameters across four farm sites in 2010. N=29

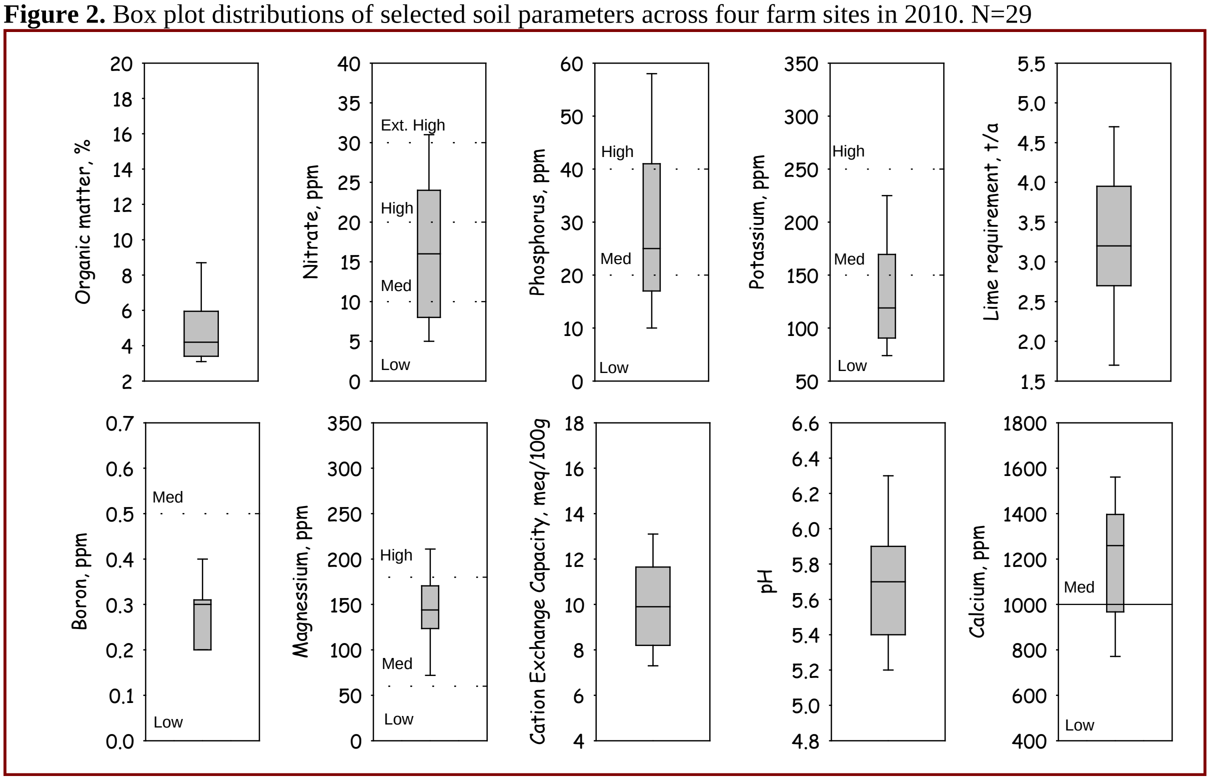
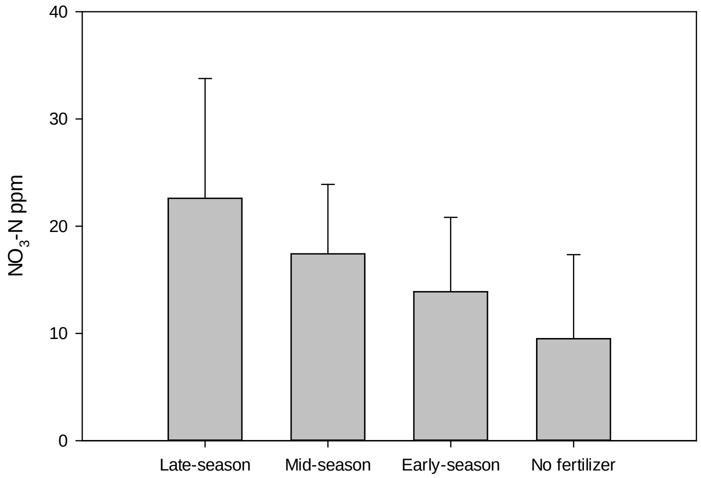


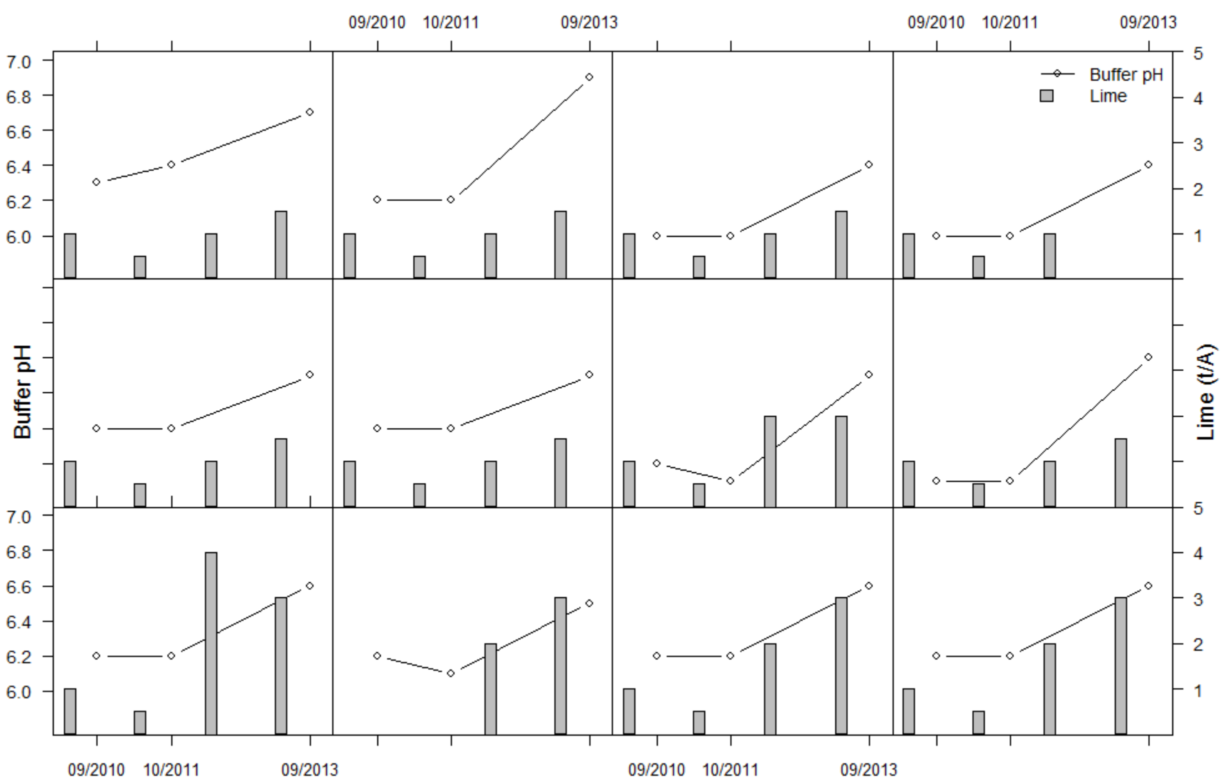
Figure 3. Fall soil nitrate levels by timing of fertilizer application across 4 farm sites in 2010. Mid-season = May–June; Early-season = March–April. Bars are SD.



	Late-season	Mid-season	Early-season	No fertilizer
Number of samples	10	7	8	4
Average total N application (lbs/a)	100	91	41	0

Many western WA soils are excessively acidic and soil tests indicated a median lime requirement exceeding 3 t/A (**Figure 2**). Lime applications at Oxbow farm between spring 2012 and spring 2013 effectively raised soil pH and reduced lime requirement in all management zones tested (**Figure 4**). Future applications can be tailored by specific needs indicated by soil test results.

Figure 4. Buffer pH and lime applications by management zone at Oxbow Farm, Carnation, WA between 2010 and 2013.



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