EFAO 2022: Research Protocol

Measuring Plant-Available Nitrogen Release From Cover Crops

Farmer-researcher: Jesse Way, Milky Way Farm - West

Project type: Research trial

Research priorities: Cover crops, Soil health

EFAO Contact: Sarah Larsen

Background

Milky Way Farm is an ecologically focused, 4 season mixed vegetable farm, owned and operated by Meghan Brandenburg and Jesse Way.

Growing on 1.5 acres just south of Woodstock, they follow organic production practices but are not certified, and sell their vegetables through a 100+ member CSA and a year-round online retail store. They utilize a variety of ecologically focused growing practices including cover cropping and diverse crop rotations, low and no-till soil preparation, and the incorporation of perennial fruit trees, berry bushes, and flowers throughout the farm.

This trial stems from on-farm observations of cover crops, comparing different amounts of nitrogen fertilizer rates, with at times no noticeable difference in yields between higher and lower nitrogen fertilizer rates.

Objective

To quantify how different cover crop blends contribute to plant available nitrogen (PAN), therefore enabling better incorporation of cover crop PAN into fertility planning.

Research Questions

1. *How much plant available nitrogen (PAN) do our spring cover crops provide to the following summer vegetable crop; and is soil nitrate sufficient at midseason to meet crop demand?*

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2. *How does the contribution of PAN change over time?*
3. *Are field based estimates reliable as an indicator of PAN?*
    a. *Cover crop wet biomass X literature provided %Dry matter and %N*
    b. *Field nitrate strips*

Notes from Reference 1:

- Nitrogen percentage in a cover crop is strongly related to PAN release following cover crop incorporation.
- For legumes (e.g., common vetch) that are high in N, about half of cover crop N is released as PAN because the cover crop has more N than needed to "build" soil organic matter.
- To maximize PAN, kill cereal cover crops early, but wait until bud stage to kill legumes.
- In cereal/legume mixtures, the best crop growth stage for maximum PAN benefit depends on the percentage of legume in the stand.
    - When the cover crop has mostly legume (75 percent legume), it behaves much the same as does a pure legume cover crop. However, the PAN from crop residue increases until cereal boot stage (Feekes stage 10; Zadoks stage 45). After cereals reach boot stage, PAN declines.
    - When a cover crop has more cereal than legume (25 percent legume), it follows a similar PAN curve as a solo cereal crop, but negative PAN is usually not seen until the cereal reaches boot stage (around mid-May). A cover crop with at least 25 percent legume can be allowed to grow until early May (boot stage for cereal) without danger of N immobilization (negative PAN).
- Seeding legume/cereal mixes instead of a solo cereal crop allows greater flexibility in timing of cover crop kill without consequences of negative PAN.

Notes from Reference 2:

- The most important time to determine soil nitrate levels is during the **first 3 to 6 weeks after seeding or transplanting**, prior to the crop's rapid vegetative growth. When sidedressing N at midseason is feasible, these midseason soil test results can be used to guide sidedress N application rates.
- The predictive value of the midseason nitrate test has two components:
    a. The test measures nitrate-N already in the soil at the time of sampling.
    b. It also gives an indication of the likely N mineralization amount for the remainder of the growing season.

- In summer, typical rates of nitrate accumulation from mineralization of SOM (0- to 12-inch depth) are 1 to 2 lb N/acre/day. **So, in the 30 days following a midseason nitrate test, an additional 30 to 60 lb/acre of nitrate-N is typically produced.**
- A single midseason test is useful, but sampling a**t 2- or 3-week intervals after seeding** can be even more informative.

Experimental Design

Management history has been uniform except for in fall 2020 1/3 of the field block was cover cropped to fall rye/vetch while remaining 2/3 was cover cropped in spring 2021 to oats/peas

Jesse will compare different cover crop mixes and their potential effect on PAN in four replicate plots of the following three treatments:

1. No cover crop control
2. High legume mix (75% legume/ 25% cereal);
   75 day spring cover crop mix of oats, peas, phacelia, vetch mix: 90lb/ac peas/ 23lbs/ac vetch/ 30lb/ac oats/ 7lbs/ac phacelia = 150 lbs/ac (120g/bed peas/ 30g/bed vetch/ 40g/bed oats/ 10g/bed phacelia).
3. Low legume mix (25% legume/ 75% cereal);
   75 day spring cover crop mix of oats, peas, phacelia, vetch mix: 105lbs/ac oats/ 8 lbs/ac phacelia/ 30lbs/ac peas/ 7 lb/ac vetch = 150 lbs/ac (140g/bed oats/10g/bed phacelia/ 40g/bed peas/ 10g/bed vetch).

*Seeding rates are adapted from Johnny's Selected Seeds Recommendations (Johnny's Cover Crop Comparison Chart).

Each of the 12 plot areas will be one 50' bed (30" wide). The beds will vary slightly in terms of crop planting date with Blocks 1 and 2 being planted on the same date, and Blocks 3 and 4 being planted ~1 week later, but otherwise they are all going into the same variety of storage carrots (variety: Bolero) and all have the same management history.

Jesse will also plant unreplicated beds to compare different seeding rates of 100lbs and 200 lbs/ac in side-by-side demonstration.

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Field Layout

Replicated trial

The beds will be divided into 4 blocks, and each of the three treatments will be randomly assigned to a bed within each block in a complete randomized block design with four replicates.

Block 1			Block 2			Block 3			Block 4		
H	L	C	C	H	L	C	L	H	L	C	H

H - high legume CC mix

L - low legume CC mix

C - no cover crop control

Seeding Rate Demonstration

4 plots, with 2 seeding rates per cover crop mix

- Biomass measurements

Statistical model

We will use an analysis of variance (ANOVA) to assess differences among treatments. (Can use discrete treatments: control, high, low; or % legume: 0, X, X.)

Measurements

Quantitative

Plant available nitrogen

1. ***How much plant available nitrogen (PAN) do our spring cover crops provide to the following summer vegetable crop; and is soil nitrate sufficient at midseason to meet crop demand?***

- Lab soil inorganic N, 0-12 inches
    - Pre-planting/cover crop termination (week 0) x 12 lab tests
    - Early season @ 4 weeks post cover crop termination x 12 lab tests
    - Midseason 1 @ 7 weeks post cover crop termination x 12 lab tests
    - Midseason 2 @ 10 weeks post cover crop termination x 12 lab tests

- Post-harvest @ ~15 weeks post cover crop termination x 12 lab tests

2. How does the contribution of PAN change over time?

- Lab soil inorganic NO3N, 0-12 inches (**same samples as for 1**.)
  - 0 week (above) x 12 lab tests
  - 4 weeks post cover crop termination x 12 lab tests
  - 7 weeks post cover crop termination x 12 lab tests
  - 10 weeks post cover crop termination x12 lab tests
  - Post-harvest @ ~15 weeks post cover crop termination x 12 lab tests
- In field sampling with test strips
  - 0 weeks x 12 tests
  - 2 weeks post CC termination x 12 tests
  - 4 weeks post CC termination x 12 tests
  - 7 weeks post cc termination x 12 tests
  - 10 weeks post cc termination x 12 tests
  - post-Harvest ~ 15 week post cc termination x 12 tests

3. Are field based estimates (wet biomass and nitrate strips) reliable as an indicator of PAN?

- Biomass method
  - Compare %DM and %N estimates using cover crop wet biomass measured on the farm from Sullivan et al. 2020 (i.e. 'field method') to site specific cover crop biomass %DM and %N measured by lab (i.e. 'lab method').
    - Compare cover crop biomass, % dry matter and % N to the predicted 4 and 10 week PAN reference numbers provided in Sullivan et. al. 2020
  - Also compare biomass from demonstration plots of seeding comparison
- In field nitrate test strips
  - Compare the field nitrate strips to the lab NO3-N to calibrate and confirm the field strips method as legitimate.

Baseline measurements

- 1 composite soil sample test for the study area = 1 sample (management history has been consistent across all beds/plots so 1 composition sample should be representative for all beds/plots)
- Soil sample in early April before cover crop planting for all macro and micronutrients, SOM and a baseline soil NO3-N with fertility recommendations.

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- All beds would be amended based on soil test the same before cover crops so their fertility management is consistent, other than cover crop contribution of PAN.

Cover Crop Biomass

1. **Select the cover crop sampling areas in the field/beds**. It is better to sample a number of representative small quadrats from different parts of the field/bed than to sample one large area. For most fields, four quadrats will give an adequate estimate of cover crop field weight and species mix. Choose sample areas that represent the species mixture and plant biomass in your field. Record the quadrat area sampled (ft2).
    a. **Sample 2 quadrats per cover cropped bed = 2 x 8 = 16 samples**
    b. The no cover crop control beds/plots will not be sampled, if weeds are present they will be mowed to prevent weed seeds so no measurable biomass is anticipated.
2. **Harvest the cover crop**. Cut the cover crop, leaving about an inch of stem above ground. Do not harvest small, low-growing weeds, because they typically have adhering soil. Getting soil into a cover crop sample alters its analysis, inflating DM and reducing N percentage.

- The best method for harvesting quadrats depends on the type of cover crop stand. Three methods are described below. Any harvest method can be used that gives you a clean plant sample with a known harvest area.

    Harvest method A. Short, upright cover crops can be harvested using a quadrat frame. Work the frame through the canopy to ground level. Sample plants that root within the quadrat.

    Harvest method B. For tall or trailing cover crops, push down the canopy in one direction and cut through the cover crop lying on the ground.

    Harvest method C. Use a sickle-bar mower or similar harvesting equipment to cut a cover crop strip from the field.

- Regardless of the harvest method used, **combine all of the field/bed cover crop samples in a large bag or container**. Clean plastic tubs or bags (at least 10 gal) work well. Avoid crushing or smashing the cover crop into slime. Protect samples from wilting in the sun or getting soaked by rain.

3. **Weigh quadrat samples**. Weighing can be done in the field with a tarp, tripod, and hanging scale. When it is not convenient to weigh in the field, you may want to weigh samples under a roof on a platform scale. **An accuracy of about 0.1 lb is sufficient.**
4. **Prepare subsample for laboratory analysis**. Place the combined field samples on a tarp or clean, flat surface and vigorously mix the sample. Chop or tear apart large plants. When the sample is thoroughly mixed, collect a large handful that fits loosely in a paper bag (half full) and weighs about a pound. This is your lab sample.

- It might take a couple of rounds of subsampling to reduce the field sample volume to a 1-gal lab sample volume. If you are not satisfied that you are getting a good mix of species, leaves, and stems, slice the plants into 4- to 6-inch pieces before doing the final subsampling.

Yield

For this experiment, yield measurements aren't critical to answering the questions but could provide additional insights into N availability for the carrots.

In the past Jesse and Meghan have stored their storage carrots unwashed and wash them as needed through the winter, which prohibits practical measurements of yield until after all storage carrots are sold in late winter of the following year (2023). They are considering building a root washer and pre-washing their storage carrots before putting away for winter storage, in which case they could get yield measurements from each treatment at the time of harvest.

Photos

Jesse will take the following photos and upload them to this folder on the Drive:

1) Once cover crops are established to show treatments.
2) At cover crop maturity before biomass measurements/cover crop termination.
3) During cover crop biomass measurements/field weighing of wet biomass to show method of harvesting and weighing cover crops.
4) At cover crop termination/week 0 soil sampling to show termination and sampling methods.
5) During midseason in-field nitrate sampling after cash crop planting to show use of in-field nitrate sampling strips.
6) At harvest to potentially show comparison of treatment yields.

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Research Plan

Please note that if data is submitted after the submission deadline, EFAO staff cannot guarantee that your data will be analyzed and written up before the Research Symposium and/or the next growing season.

Time	Task	Methods & Measurements or Action Item
Week of - April 4th	Baseline measurements S1B+S7+NO3N	Composite soil sample from research beds using soil probe. - **Bring soil sample to the lab.**
Week of April 11th - 15th	Amend according to baseline results	Calculate plot amendment requirements based on soil sample results and amend accordingly.
Week of April 11th - 15th	Plant cover crop	Broadcast cover crop seeds according to plot requirements and lightly incorporate along with amendments using BCS rototiller with Precision Depth Roller (PDR).
Between June 20th and 30th, depending on CC growth stage	Biomass measurements Chain of Custody_Biomass (2 pages)	**Field measurement**: Use quadrat sampling at cereal boot stage to measure cover crop biomass. Measure wet weight on farm, subsample for lab analysis - **Bring in samples for lab analysis of %DM and %N x 12 samples** (8 CC treatments + 4 side by side demonstration plot samples)
Between June 20th and 30th, depending on CC growth stage	Terminate CC + Week 0 soil nitrate testing. Chain of Custody_Nitrate (2 pages)	- Immediately following cover crop biomass sampling, terminate cover crop using BCS with flail mower. - Sample soil from all plots - Use an in-field soil nitrate sensor to measure soil NO3-N of all 12 plots. - **Send in soil samples for lab analysis of soil NO3-N x 12 samples** (1 per plot) - Incorporate flailed cover crop using BCS rototiller with PDR, cover with

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		silage tarps to create stale seed bed for cash crop planting.
Weeks of July 11 -15 and July 18 - 22.	Seed carrots	Use Jang seeder, xy-24 roller, sprockets 11-10 to seed carrots, 5 rows/bed; blocks 1 and 2 week of July 11-15, blocks 3 and 4 week of July 18-22. Cover with silage tarps until germination.
2 weeks post cc termination	Week 2 in-field nitrate samples	**Field measurement:** Use in-field soil nitrate test strips to measure soil NO3-N of all 12 plots. MISSED
4 weeks post cc termination	Week 4 in-field and lab based soil nitrate sampling Chain of Custody_Nitrate (2 pages)	**Sample soil** from all plots + **field measurement:** - Use in-field soil nitrate test strips to measure soil NO3-N of all 12 plots. - **Send in soil samples for lab analysis of soil NO3-N x 12 samples** (1 per plot)
After week 4 soil nitrate testing depending on results.	Fertilizing as needed after early season soil nitrate test	Depending on week 4 soil nitrate levels, potentiality side dress all beds with feather meal to ensure adequate nitrogen for crop growth.
7 weeks post cc termination	Week 7 in-field and lab soil nitrate sampling Chain of Custody_Nitrate (2 pages)	**Sample soil** from all plots + f**ield measurement:** - Use in field soil nitrate sensor to measure soil NO3-N of all 12 plots - **Send in soil samples for lab analysis of soil NO3-N x 12 samples** (1 per plot)
10 weeks post cover crop termination	Week 10 in-field and lab soil nitrate sampling. Chain of	**Sample soil** from all plots + f**ield measurement:** - Use in-field soil nitrate sensor to measure soil NO3-N of all 12 plots.

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	Custody_Nitrate (2 pages)	- **Send in soil samples for lab analysis of soil NO3-N x 12 samples**, 1 per plot).
October	Harvest	Yield measurements - depending on whether root washer is available, among other factors.
Late October	Post-harvest in-field and lab soil nitrate sampling Chain of Custody_Nitrate (2 pages)	**Sample soil** from all plots + f**ield measurement:** - Use in field soil nitrate sensor to measure soil NO3-N of all 12 plots - **Send in soil samples for lab analysis of soil NO3-N x 12 samples**, 1 per plot).
December 31, 2022	Farmer-fee and research expense invoice with receipts for expenses	Submit invoices at this site: https://efao.ca/data/
January/February 2023	Finalize and publish research report	Work with EFAO staff to review polished research report for publication.

Staff check-ins

Beginning of May

- General check-in via email

Mid June

- **Field visit** in anticipation of cover crop biomass measurements, week 0 nitrate measurements

Late July

- At the 4 week sampling date once we have a second round of lab and field nitrate samples to compare to see how well correlated they are.

October

- Check in about whether they will take yield measurements

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Materials

Please list all materials, supplies and equipment that will be reimbursed for this project. If possible, please also indicate a short-list of any in-kind materials, supplies and equipment that you will use.

Material	Unit	Quantity Required	Total Cost*	Note
CC seed	$58.25/22.5kg bag oats $75.35/22.5kg bag peas	2kg oats 2 kg peas	$6 + $7 =$13	Prorated from farm seed purchase
Complete soil test including micronutrients and nitrate	$54	1	$54	
CC biomass %N, %DM lab test	$39/sample	2 treatments x 4 reps = 8 samples; + 4 samples from side by side demonstration = 12	$468	No control samples needed
Soil nitrate lab tests	$17/sample	3 x 4 = 12 x 5 sampling dates = 60	$17 x 12 x 5 = $1020	
Nitrate test trips	50 packs	100	$60	
Total			$1615	$1700 total

References

1) Estimating Plant-Available Nitrogen Release from Cover Crops. 2020. Sullivan, D.M., Andrews, N., Brewer, L.J. https://catalog.extension.oregonstate.edu/pnw636

2) Soil Nitrate Testing for Willamette Valley Vegetable Production. 2019. Sullivan, D.M., Andrews, N., Heinrich, A., Peachey, E., Brewer, L.J. https://catalog.extension.oregonstate.edu/em9221

Farmer-fee

$500 for 2022

Invoices for Farmer-Fees & Reimbursements

Research expenses

- Submit an **invoice along with copies of receipts** for all qualified expenses using form found at **https://efao.ca/data/**
- **Deadline**: December 31, 2022

Farmer-fee

- Submit an **invoice** for your farmer-fee using form found at **https://efao.ca/data/**
- **Deadline**: December 31, 2022

Memorandum of Understanding

Please fill out the MOU at https://airtable.com/shrlAcZ7bowmTQwvd

EFAO Account Information

As a farmer-researcher, you must maintain current membership with EFAO throughout the duration of your trial.
We use your mailing address to deliver cheques, farmer-led research signs and any trial supplies.
To check the status of your membership, log in here:
https://efao.z2systems.com/np/clients/efao/login.jsp or contact Martina, martina@efao.ca.

Farmer-fees and Reimbursements

I agree with the following:

- The deadline for reimbursements and farmer-fees is December 31, 2022.
- To receive reimbursement for qualified research expenses, I will submit an invoice and copies of receipts at the form found at https://efao.ca/data/.
- To receive my farmer-fee, I will submit an invoice to https://efao.ca/data/ after I have submitted the final data and photos.

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Photo Use

We like to share snippets and stories of farmer-led research through EFAO's print publication, e-newsletter and social media accounts, using photos and updates that you send us. We will credit you when we use any photos.

Choices (Select all that apply on the MOU):

- EFAO has my permission to share photos in EFAO's print publications
- EFAO has my permission to share photos in EFAO's e-newsletters
- EFAO has my permission to share photos in EFAO's social media
- I do not want my photos share in these ways
- Other

Farmer-Led Research Agreement

I agree with the following:

- I will complete my trial to the best of my ability following the written protocol.
- If circumstances change and I am unable to conduct my trial, I will notify EFAO staff as soon as possible.
- I will keep in contact with EFAO staff with updates and questions, or to make changes to my protocol .
- I will submit data to the EFAO by the date specified in the written protocol.
- I acknowledge that if I submit data after the submission deadline outlined in the written protocol, EFAO staff cannot guarantee that my data will be analyzed and written up before the Research Symposium and/or the next growing season.
- I will work with EFAO staff to interpret data and write the research report.
- I will take photos of my project throughout the season(s).

Program Participation

There are several farmer-led research events held throughout the year including webinars, field days, and the Research Symposium. The Research Symposium is held in conjunction with the annual EFAO Conference at the end of November/early December.

When and where possible I will:

- Attend farmer-led research events, including webinars and field days
- Attend and present my research findings at the Research Symposium
- I will complete the feedback survey related to the program

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Data Use

You own all data generated on your farm as part of your farmer-led research trial with EFAO. You can notify EFAO at any time to remove EFAO's privileges to use and share your data, photos and farm information. To opt out of sharing your data, please contact Sarah Larsen via email (sarah@efao.ca) or mobile (226-582-0626).

I agree with the following:

- By participating in the EFAO's FLRP, I agree to share with the EFAO the data collected as part of my trial, along with photos of the project and any farm information (e.g. soil type, previous farm practices, and soil tests) that I deem relevant.
- By sharing my data, photos, and farm information with EFAO, I agree that EFAO can use this information in research reports, posters, and summaries of my trial (e.g. summaries on the EAFO blog and in EFAO's print publication).
- I understand that I can notify EFAO at any time to remove EFAO's privileges to use and share my data, photos, and farm information.

Signature

Please fill out the MOU at https://airtable.com/shrlAcZ7bowmTQwvd