Adapting Oregon State University Cover Crop Calculator for Idaho Conditions

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Mid Season Winter Wheat
1.7 %N, 25.6:1 C:N
Lincoln County, South Central Idaho

Austrian Pea and Winter Wheat
2.8 %N, 15.9:1 C:N
Twin Falls County, South Central Idaho

Rye
2.9 %N, 15.6:1 C:N
Ada County, South Western Idaho

Red Clover
3.0 %N, 15.3:1 C:N
Twin Falls County, South Central Idaho

Daikon Radish
3.3 %N, 13.3:1 C:N
Power County, South Central Idaho

Austrian Peas
4.0 %N, 11.4:1 C:N
Canyon County, South Western Idaho

Early Season Winter Wheat
4.3 %N, 10.4:1 C:N
Canyon County, South Western Idaho

Hairy Vetch
4.5 %N, 10.9:1 C:N
Canyon County, South Western Idaho

Background

- **Oregon State University (OSU) Cover Crop Calculator**
  - Predicts plant available N, based on %N in tissue
  - Strongly supported by Oregon research studies (figure 1)
  - Concerns with using OSU calculator for Idaho
    - Variations in soil type
      - Acid vs. alkaline
      - High organic matter vs. low organic matter
      - Clay/silt vs. sand/silt
    - Variations in cover crops
      - Winter hardy Idaho crops-Austrian peas, hairy vetch, red clover, brassicas, barley, wheat, oat
      - Oregon cover crops-Common vetch, phacelia, oat, rye, crimson clover

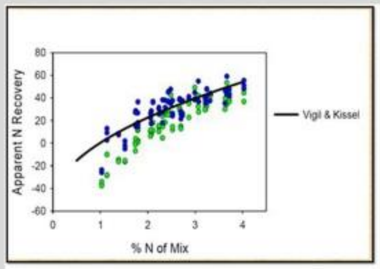

Figure 1. Equation supporting the OSU calculator, with data points from the OSU incubation studies. Graph courtesy of Dan Sullivan and Nick Andrews.

- **Project Goals:**
  - Use % N data collected from plant tissue and PAN data collected from incubation studies to adjust the OSU Cover Crop calculator to reflect Idaho conditions
  - Create and post UI cover crop calculator online for quick and easy access

Calibrating OSU Cover Crop Model for Idaho Conditions

- **Goal of Calibration Incubation Study**
  - Evaluate ammonium and nitrate concentrations over a 70 day period for a typical Idaho soil mixed with Idaho cover crops containing various concentrations of nitrogen
    - Common method for evaluating mineralization of organic nitrogen from soil amendments
- **Experimental Design**
  - Selected soil - Portneuf silt loam (mesic Durinodic Xeric Haplocalcid), common agricultural soil in Southern Idaho (figure 2)
  - Plants included in incubation were Triticale, Hairy Vetch, Austrian Pea, Daikon Radish, and Red Clover
    - We also varied ratios of Triticale and Vetch or Pea plant mixtures, to account for moderate tissue N concentrations
    - Tissue N concentrations ranged from 1.3 to 4.4 %N
    - More information on plant tissue is listed with photos below the title of this poster

Figure 2. Distribution of Portneuf silt loam in Southern Idaho. Portneuf silt loam was used for the cover crop calibration incubation trials. Map courtesy of NRCS Web Soil Survey.

Figure 3. Example of a cover crop that will be weighed and analyzed for dry matter content and total N concentration. This information is required for the calculator.

- **Incubation Procedure**
  - Followed similar protocol as was used for OSU cover crop calculator incubation studies
    - Collected plant tissue from existing cover crop fields in Kimberly and Aberdeen, Idaho
      - Tissue clipped at soil level from four 1 ft. X 1 ft. square frames, placed randomly throughout the crop field (figure 3)
      - Subsamples analyzed for tissue N concentration and dry matter content
    - Incubated 500 g of soil with 2 grams of dry plant tissue for 70 days at 22 °C in plastic bags (straw inserted in bags and bag opened an massaged weekly to insure optimum gas exchange for N mineralizing bacteria) (figure 4)
    - Soil moisture maintained at 80% field capacity
    - RCBD with three replications
    - Used dried plant material instead of frozen plant material
      - During preliminary incubations, we had issues with consistency in tissue moisture content for frozen tissue sample
      - To reduce variability, we used dried plant tissue instead of frozen tissue

Figure 4. Plastic bag containing soil, water, and plant tissue for incubation. A plastic straw was inserted into the bag to insure optimum air flow into the bag.

PAN Findings from Calibration Study

- **What we found:**
  - After 70 days of incubation, we fitted a quadratic model to the PAN tissue N vs. PAN relationship, as was done in Vigil and Kissel (1991)
  - $PAN\% = -64.3 + 43.9 * \sqrt{Tissue\ N\ \%}$, $r^2 = 0.90$ (figure 6)
  - Compared to OSU incubation findings, our PAN results were much lower at all tissue N concentrations
    - -10 to 27% PAN for our study, compared to 10 to 60% PAN for Oregon study at same tissue N % range
  - Wanted to confirm that these differences were valid, and not just difference in experimental design. A second incubation was conducted
- **Supplemental Incubation Study**
  - In the second incubation study, we compared:
    - Oregon soil to Idaho soil
    - Oregon plant tissue to Idaho plant tissue
    - Fresh tissue to dried tissue
  - Soil and plant tissue origin effects were not statistically significant (data not shown)
  - Tissue moisture effects were significant
    - Fresh tissue samples released approximately 15.7 ppm more PAN than dried tissue samples, regardless of tissue N concentration (figure 5)

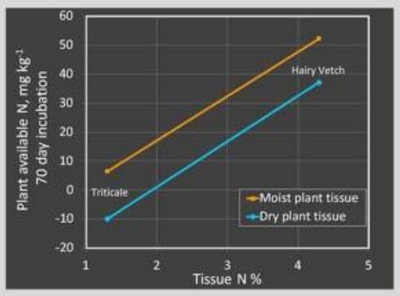

Figure 5. Comparing PAN (mg kg^{-1}) between dried and fresh plant tissue

- **Adjustments to model**
  - Added 15.7 ppm to PAN values from dried plant tissue calibration study PAN values
  - Use this adjusted model for prediction of PAN from fresh tissue (aka green manures) and original model for prediction of PAN from dried tissue (aka crop residues)
  - $PAN\% = -8.5 + 20.7 * \sqrt{Tissue\ N\ \%}$, $r^2 = 0.73$ (figure 6)

University of Idaho Cover Crop Calculator Models)

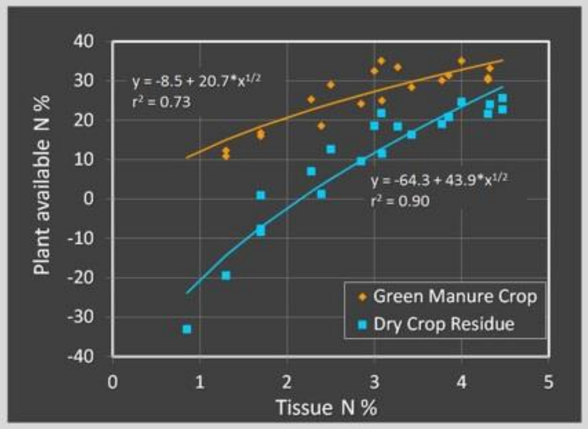

Figure 6. Equations and calibration data supporting the University of Idaho Cover Crop Calculator, which estimates plant available nitrogen (PAN) in the soil over a growing season for spring-tilled green manure crops or crop residues on irrigated cropland in Southern Idaho. Many of the plant tissues included in this analysis are listed below the title of this poster.

University of Idaho Online Cover Crop Calculator

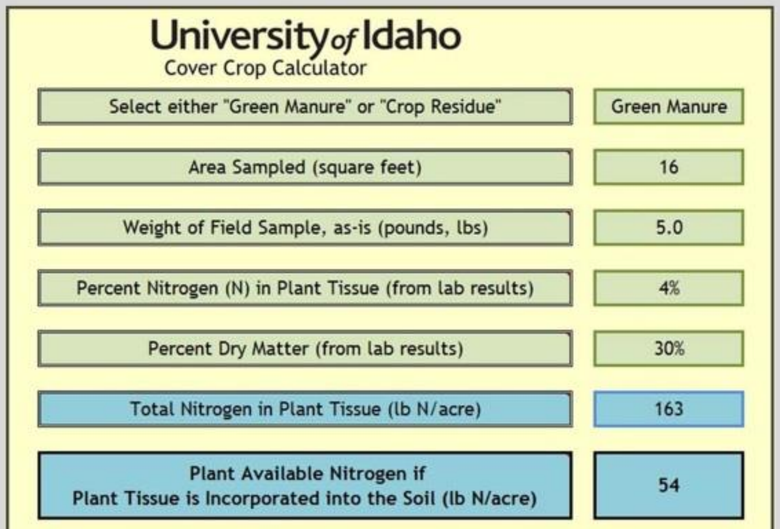

Figure 7. Online interface for the University of Idaho Cover Crop Calculator. The website and supporting materials are located at http://www.extension.uidaho.edu/nutrient/CC_Calculator/Cover_Crop_Main_page.htm. Online calculator and website were developed by University of Idaho graduate student, David Graybill.

- Our goal was to create a simple and efficient interface for the calculator, as online calculators can often overwhelm users with too many input, outputs, and extraneous information. (figure 7)
- Additional pages will include:
  - Calculator User's Guide
  - Tissue sampling and analysis guide
  - Calculator development information
  - An additional calculator designed with altered units for small acreage farms and gardens

Comparing Idaho and Oregon Cover Crop Models

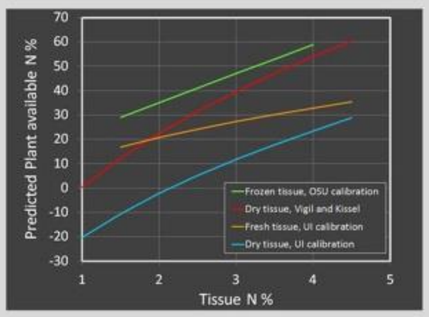

Figure 8. Comparing the University of Idaho Cover Crop Calculator equations (green and brown lines) to Vigil and Kissel equation used to support Oregon State University cover crop calculator (blue line) and the calibration equation used to justify use of the VK equation for the OSU cover crop calculator (purple line).

1. Idaho calculators (blue and orange lines) predict less PAN than Oregon calculator (red line) at tissue N above 3.0 %
- May be due to alkaline nature of Idaho soils, which could limit N mineralization activity in the soil
- Comparison between Oregon and Idaho soil did not show a significant difference
- More soils were needed in this comparison to adequately state that there is not a soil effect between the two regions

2. Both dry tissue models (red and blue lines) predict immobilization below 1% tissue N, while fresh and frozen tissue models (orange and green lines) do not predict immobilization at any tissue N concentration
- Reiterates the importance of not relying on incubation studies using dried plant tissue for prediction of PAN from fresh tissue

Validating the UI Cover Crop Model using Soils and Plant Tissue from Idaho Grower fields

- **Validation Incubation Study**
  - Needed to determine if the cover crop model would be applicable to soils and plant tissue collected from Idaho grower fields
  - To do this, we conducted an incubation of cover crop tissue and soil samples collected from four grower fields in South-Central and South-Western Idaho
  - Sites sampled within a few days of plow-down
  - Because grower plant tissue was dried, we used this incubation study to validate the crop residue equation instead of the green manure equation
  - Information on soil characteristics and plant available nitrogen (predicted and observed) are listed in table 1
  - Observed and predicted PAN were similar
    - Statistical analysis will be conducted to further support this statement
  - This finding suggests that PAN was minimally influenced by soil type among four Southern Idaho agricultural soils, illustrating that this calculator would be appropriate to use for most Southern Idaho soil types

Fred Brossy, cooperator from Shoshone, Idaho, standing in his arvika pea and winter wheat cover crop. Plant tissue and soils collected from his fields were used to validate the UI cover crop calculator.

Table 1. Soil characteristics, observed PAN from incubation, and predicted PAN from UI cover crop calculator (crop residue equation), using soils and dried plant tissue from four cooperator fields in Southern Idaho.

Grower field ID	Region	% Soil OM	% Clay	Initial soil nitrate (ppm)	Soil pH	Green Manure Crop	% Tissue N	Observed PAN, dried tissue (%)	Predicted PAN, dried tissue (%)
Grower 1	Southwestern Idaho	2.2	6.2	20.0	7.7	Pea/Wheat/ Vetch	3.8	16.9	21.8
Grower 2	South-central Idaho	1.7	7.9	5.2	7.5	Wheat	1.7	-5.7	-6.4
Grower 3	South-central Idaho	2.4	4.5	6.2	7.7	Pea/Wheat	2.8	15.5	9.1
Grower 4	Southwestern Idaho	1.9	16.2	5.4	7.0	Rye	2.9	11.0	9.9

- **Practical Implications**
  - We inserted grower information into the green manure version of the UI cover crop calculator, to determine how much N we would expect to see from these different fields.
  - PAN ranged between 7 and 36 lb N/acre (table 2)
  - In addition to tissue N, the biomass amounts also greatly influence PAN from green manures
    - The rye field was estimated to release twice as much N as the pea/wheat fields, despite having similar tissue N concentrations
  - For Idaho growers to gain significant amount of N from a cover crop, they may need to wait until June before plow-down of cover crops to allow for more biomass growth

Table 2. Predicted quantity of PAN from cooperator green manure crops, based on tissue N concentration and biomass inputs.

Cooperator Green Manure Crop	Tissue N (%)	Biomass (dry ton/acre)	Predicted Total N (lb N/acre)	Predicted PAN (lb N/acre)
Pea/Wheat/Vetch	3.8	1.4	113	36
Wheat	1.7	1.1	39	7
Pea/Wheat	2.8	0.7	41	11
Rye	2.9	1.8	103	27

Discussion

- **Benefits**
  - Allow for Idaho growers to account for N from cover crop, which would help to prevent over- and under-application of N fertilizers
  - Allows Idaho growers to estimate total amount of nitrogen available to plants from a cover crop or from crop residues over a growing season
  - Requires only four inputs
  - Model is easy to access from the internet, and does not require any experience with modeling to use
- **Limitations**
  - Simple models like this one that require minimal inputs can not account for the wide variety of variables that impact nitrogen mineralization, therefore the potential for erroneous predictions are greater in comparison to process-based models, for example
  - As this is an empirical model, it may only be appropriately used for the region that the data was collected from (Southern Idaho, in this case)
  - Collecting and analyzing plant tissue is a key part of this calculator. Growers who prefer the ease of table values may be put off by this step.
  - This calculator is not designed to predict timing of N release over the growing season, but instead provides a single value of predicted N over the entire season.
- **Recommendations for Developing a Cover Crop Calculator for Your Region**
  - Include fresh tissue in incubations, as dried tissue will release significantly less PAN then fresh tissue
  - Include a variety of soils from your region, especially if you have a wide variety of soil types
  - Monitor soil moisture of incubated soil/tissue bags closely. Saturated and dried-out soils will have to be thrown out, as these factors adversely impact N mineralization.
- **Future Research Needed**
  - Release of N from green manures and crop residues that are not incorporated into the soil
  - Timing of nitrogen release over the growing season
  - Further validation of tissue moisture effect on PAN
  - Validation of green manure equation by conducting an incubation with fresh tissue combined with several Idaho soils.

References

- Vigil, M.F. and D.E. Kissel. 1991. Equations for estimating the amount of nitrogen mineralized from crop residues. Soil Sci Soc Am J. 55:757-761.
- Andrews, N., D. Sullivan, J. Julian, and K. Pool. Organic fertilizer and cover crop calculator. http://smallfarms.oregonstate.edu/calculator. Accessed October 2013.
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