ADAPTING THE OREGON STATE UNIVERSITY COVER CROP CALCULATOR FOR IDAHO CONDITIONS

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INTRODUCTION

Many Idaho growers grow cover crops as a source of nitrogen for other crops in their rotation. However, estimating the amount of nitrogen (N) released from a cover crop can be challenging. Tools such as the Oregon State University (OSU) Cover Crop Calculator can predict plant available nitrogen (N) from a recently tilled-under cover crop, based on the N concentration in the tissue. The OSU calculator was developed with controlled incubation studies, following N mineralization patterns for Oregon soils and plant tissue from plants grown in Oregon. A major concern with using the OSU calculator for Idaho and other regions is variations in soil type and in plant species between the two regions. The goals of this project were to 1) adjust the OSU Cover Crop calculator to reflect Idaho conditions through N mineralization incubation studies with Idaho soils and plants and 2) create and post a UI cover crop calculator online for quick and easy access to Idaho growers.

CALIBRATION INCUBATION STUDY

The goal of the calibration incubation study was to evaluate ammonium and nitrate concentrations over a 70 day period for a typical Idaho soil mixed with Idaho cover crops containing various concentrations of N. This was the method used to develop the OSU cover crop calculator, and is a standard method for evaluating mineralization of organic N from soil amendments. We selected a Portneuf silt loam for the incubation study (mesic Durinodic Xeric Haplocalcid), the most common agricultural soil in Southcentral Idaho. Plants included in the incubation study 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 (Table 1).

Table 1. Tissue N concentrations for plants used in the Idaho cover crop calculator calibration study.

Cover crop	Tissue %N
Triticale	1.3 – 1.7
25% Pea, 75% Triticale	2.3
25% Vetch, 75% Triticale	2.4
50% Pea, 50% Triticale	2.9
Red Clover	3.0
50% Vetch, 50% Triticale	3.1
Daikon Radish	3.3
75% Pea, 25% Triticale	3.4
75% Vetch, 25% Triticale	3.8
Austrian Pea	4.0
Wheat, early stage	4.3
Hairy Vetch	4.3 – 4.5

Plant tissue was collected from existing cover crop fields in Kimberly and Aberdeen, Idaho. The plant tissue was clipped at soil level from four 1 ft. X 1 ft. square frames that were placed randomly throughout existing cover crop fields. Plant tissue samples were analyzed for tissue N concentration and dry matter content. Approximately 500 g of Portneuf silt loam (dry basis) was mixed with 2 grams of chopped dry plant tissue and incubated for 70 days at 22^{o}C in plastic bags. Drinking straws were inserted in bags and bags were opened and massaged weekly to insure optimum gas exchange for N mineralizing bacteria. Soil moisture was maintained at 80% field capacity. Bags were placed in an incubator in a randomized complete block design with four replications. To reduce variability in moisture content between plant tissue samples, we chose to use dried plant tissue instead of frozen tissue (frozen tissue was used for the OSU incubation studies).

After 70 days of incubation, a quadratic model was fitted to the tissue N vs. Plant Available Nitrogen (PAN) relationship, as was done in Vigil and Kissel (1991). The model fitted to the data is: $PAN\% = -64.3 + 43.9 * \sqrt{Tissue\ N\ \%}$, r^2 = 0.90 (Figure 1). For tissue N concentrations ranging from 1.3 to 4.5%, our PAN results were much lower (-10 to 27% PAN) than the OSU incubation study PAN results (10 to 60% PAN, comparison not shown?). A second incubation was conducted to determine if PAN differences between the two studies were true differences in soil and plant tissue origin, as opposed to a reflection of differences in the experimental methodology.

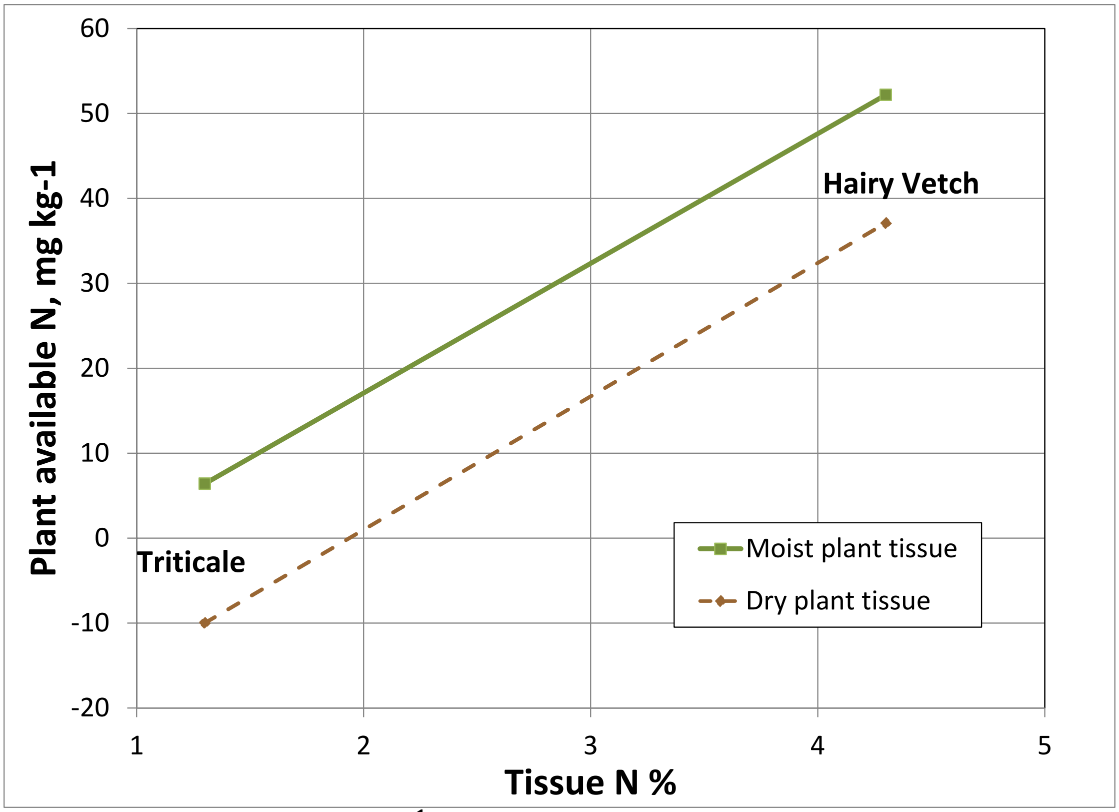

Figure 1. Comparing PAN (mg kg^{-1}) between dried and frozen fresh plant tissue from first incubation study.

In the second incubation study, we compared a Canderly sandy loam from Oregon to a Portneuf silt loam from Idaho, adding dried hairy vetch, dried triticale, and a 50/50 mixture of dried vetch and triticale to both soils as the plant tissue source. We also compared dried plant tissue collected from Idaho (vetch and triticale) to plant tissue collected in Oregon (plant species unknown), applying the tissues to a Portneuf silt loam for comparison. Soil and plant tissue origin effects did not have a statistically significant effect on PAN after 70 days of incubation (data not shown).

In addition to soil and plant origin effects, we also wanted to see how much the plant-drying was affecting PAN. To address this question, fresh and dried samples of hairy vetch and triticale were added to a Portneuf silt loam at a rate of 2 g of plant tissue (on a dry basis) to 500 g of soil. Water additions were adjusted for plant moisture contents to insure that each bag had the same moisture content. Tissue moisture had a significant effect on PAN after 70 days of incubation. Fresh tissue samples released approximately 15.7 ppm more PAN than dried tissue samples, regardless of tissue N concentration (Figure 2). As a result of this finding, we added 15.7 ppm to PAN values from the dried plant tissue calibration study PAN values to more accurately predict PAN from living moist plant tissue. We used this adjusted model for prediction of PAN from fresh tissue (aka green manures) and used our original Idaho calibration for prediction of PAN from dried tissue (aka crop residues) both models are shown in Figure 2.

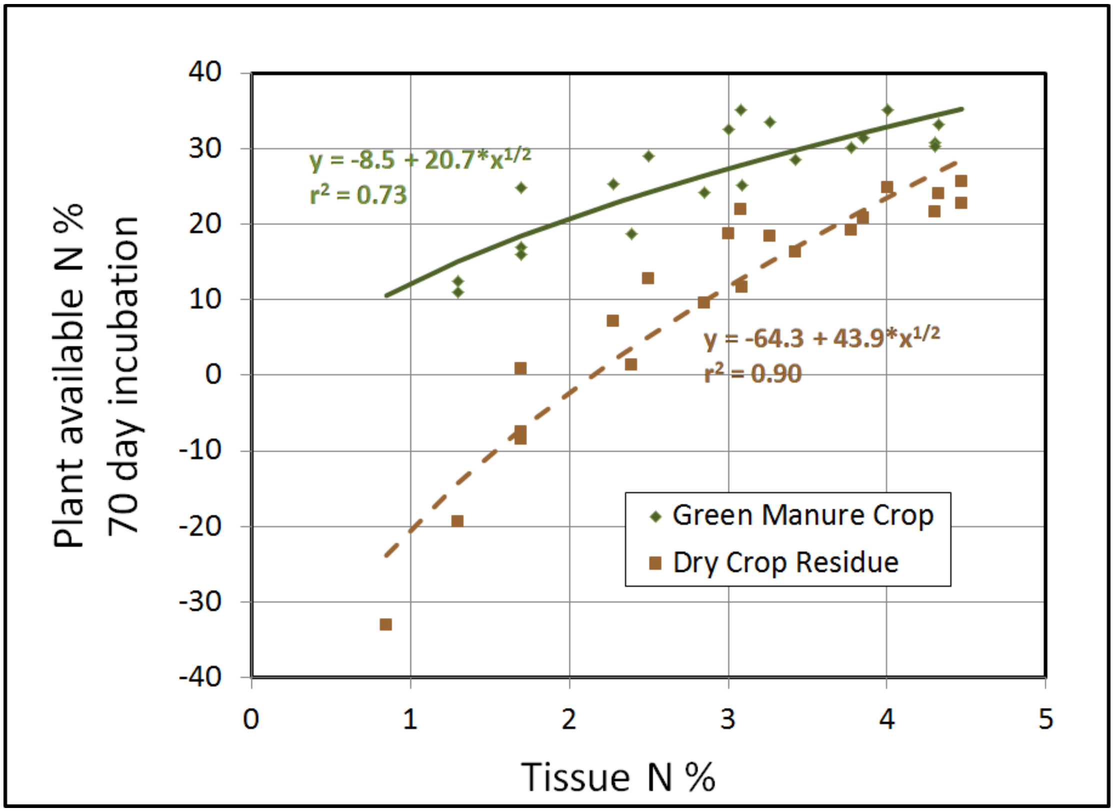

Figure 2. Equations and calibration data supporting the University of Idaho Cover Crop Calculator, which estimates PAN in the soil over 70 days of incubation for fresh and dried cover crop residues on an irrigated Portneuf soil in Southern Idaho. Green manure data points were extrapolated from dry residue data points, increasing PAN by 15.7 ppm.

INTERFACE FOR THE UNIVERSITY OF IDAHO COVER CROP CALCULATOR

Our goal was to create a simple and efficient interface for the calculator, as online calculators can often overwhelm users with too many inputs, outputs, and extraneous information (Figure 3). Additional pages include: Calculator User's Guide, Plant Tissue Sampling Guide, and Calculator Development Information. An additional calculator designed with altered units for small acreage farms and gardens is also included on the website.

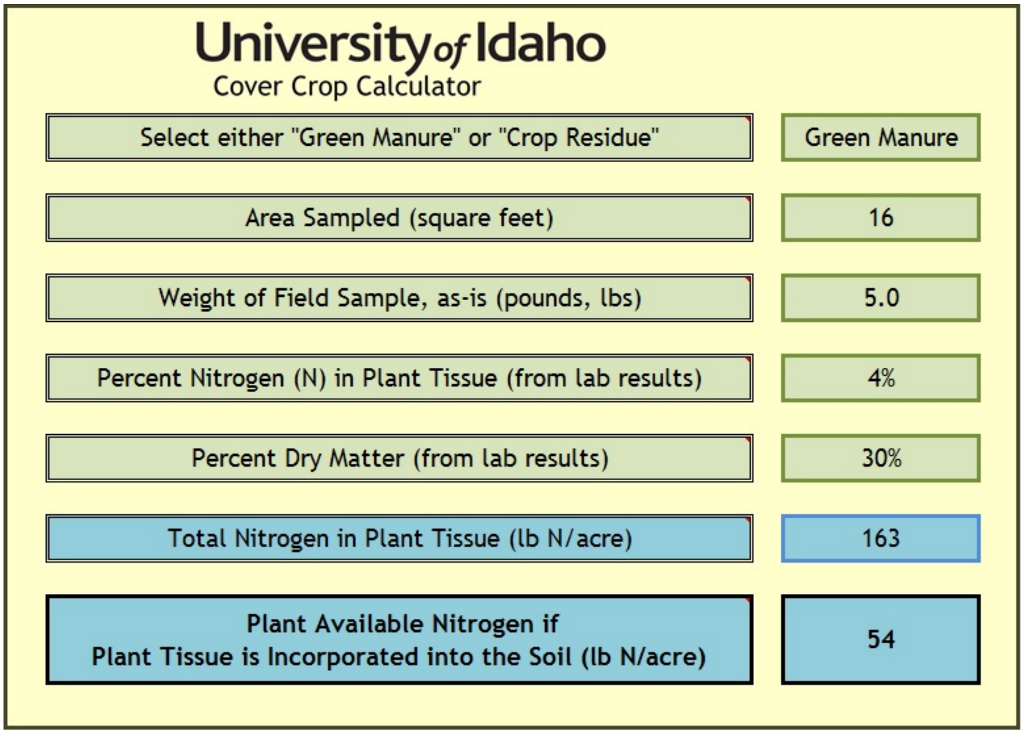

Figure 3. Online interface for the University of Idaho Cover Crop Calculator. The website and supporting materials are located at http://www.extension.uidaho.edu/nutrient/CC_Calculator/Cover_Crop_Main_page.htm. Online calculator and website were developed by University of Idaho graduate student, David Graybill.

COMPARISON TO OREGON COVER CROP CALCULATOR

In Figure 4, we compared the University of Idaho Cover Crop Calculator equations to theVigil and Kissel (VK) equation used to support the OSU cover crop calculator and the calibration equation used to justify use of the VK equation for the OSU cover crop calculator. The goal of this comparison is to help us understand how and maybe even why the Idaho tissue N-PAN equations differ from the Oregon tissue N-PAN equations.

The Idaho calculator predicted less PAN than the Oregon calculator at tissue N above 2.0%. This difference may be due to the alkaline nature of Idaho soils, which could limit N mineralization activity in the soil. While the comparison between Oregon and Idaho soil did not show a significant effect on PAN, more soils were needed in this comparison to adequately state that there is not a soil effect between the two regions.

The VK and UI dry tissue models predicted immobilization below 1 and 2% tissue N, respectively, while the fresh and frozen tissue models do not predict immobilization at any tissue N concentration. This finding reiterates the importance of not relying on incubation studies using dried plant tissue for prediction of PAN from fresh tissue.

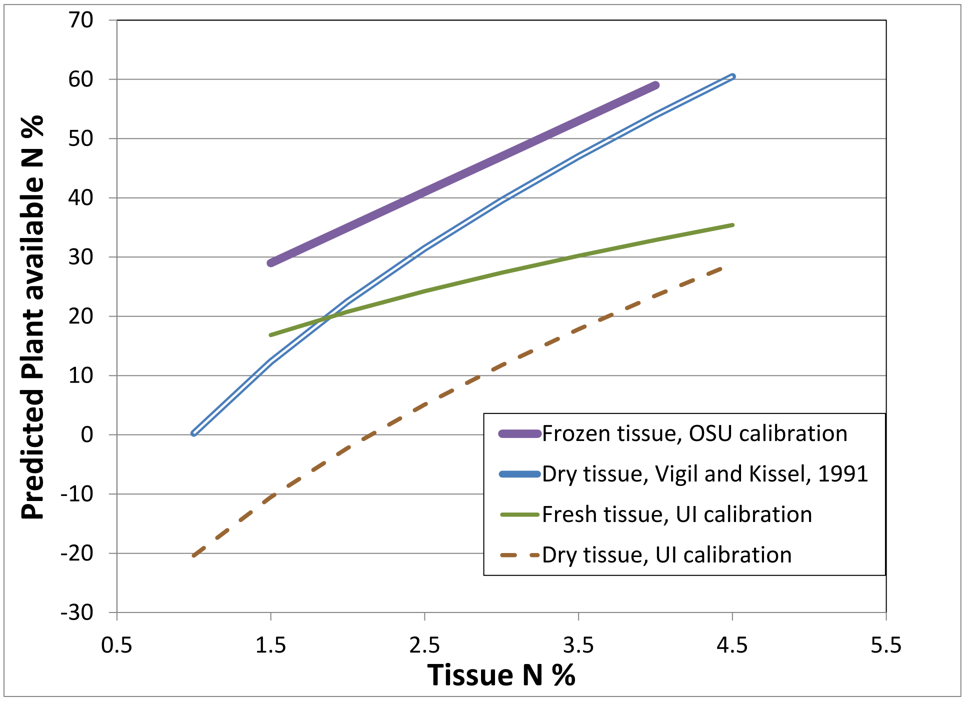

Figure 4. Comparing the University of Idaho Cover Crop Calculator equations (green and brown lines) to VK equation used to support Oregon State University cover crop calculator (blue line) and the calibration equation used to justify use of the VK equation for the OSU cover crop calculator (purple line).

VALIDATION INCUBATION STUDY

We conducted an incubation of cover crop tissue and soil samples collected from four grower fields in South-Central and South-Western Idaho to determine if the cover crop model would be applicable to Idaho soils and plant tissue beyond what was used in the calibration study. Soils and plant tissue were sampled within a few days prior to plow-down. Because grower plant tissue was dried, we used the cooperator validation 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 2. Observed and predicted PAN were similar but have not been evaluated statistically.. This finding suggests that PAN was minimally influenced by soil type among four Southern Idaho agricultural soils, illustrating that the UI cover crop calculator would be appropriate to use for most Southern Idaho soil types.

Table 2. 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

To estimate PAN for each of our growers' fields, we inserted the grower information for biomass into the green manure version of the UI cover crop calculator. The total N release ranged from 7 to 36 lb N/acre (table 3). In addition to tissue N, it is important to note that the biomass amounts also greatly influence the Calculators predicted total N released from green manures. For example, the rye field was estimated to release over twice as much N as the pea/wheat field despite having similar tissue N concentrations, due to differences in biomass. Therefore, conditions allowing for high biomass production (longer growing season, timing of planting, species selection and mixture, etc.) in addition to selecting high N plants (vetches, peas, etc.) will allow for Idaho growers to gain significant amount of N from cover crops.

Table 3. UI Calculator predicted quantity of total N release and the 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** release **(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

The new University of Idaho Cover Crop Calculator developed from this project will allow for Idaho growers to account for N from their cover crop, which will help to prevent over- and under-application of N fertilizers. Also, Idaho growers who have been using the Oregon calculator will now be able to more accurately predict N coming from their crops than they have in the past. Other benefits of the calculator include simplicity (only four inputs), easy to access from the internet, and does not require any experience with modeling to use. Finally, this will provide a calculator specific to Idaho conditions.

As with any model, there are limitations as to what the UI Cover Crop Calculator is able to do. For example, simple models like this one that require minimal inputs cannot account for the wide variety of variables that impact nitrogen mineralization. While N concentration appears to be the driving factor in N mineralization rates, fluctuations in soil temperature and soil moisture content can also have an impact. Also, the Idaho Cover Crop Calculator is only designed to be used for spring-incorporated irrigated cover crops in Southern Idaho. Users from other regions should use the calculator with caution.

Collecting and analyzing plant tissue is a key part of this calculator. Growers who are unable to do this step may guess at these values, which will greatly increase the chance for erroneous results. Also, the calculator provides a single value of predicted N over the entire season instead of N release patterns throughout the growing season, which may be frustrating to growers who want to time in-season fertilizer applications with N release patterns.

While we have learned a lot from this project, we still have a lot of questions about estimating N mineralization from cover crops. For example, with more growers showing interest in no-till systems, we would like to understand more about the release of N from crop residues that are not incorporated into the soil. We would also like to understand more about the N mineralization patterns of fresh tissue instead of dried tissue. Finally, information on the timing of nitrogen release over the growing season would help growers time fertilizer applications with expected N release events from planted cover crops.

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