Nitrogen Credits from Cover Crops in Organic Vegetable Production

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INTRODUCTION

Using cover crops to provide N for subsequent vegetable crops can reduce the cost of fertilizer for organic farmers, but better tools are needed to predict N credits or debits. We are testing a Cover Crop N Availability Calculator for on-farm use that was adapted from the N subroutine of the CERES family of models. It uses cover crop and soil characteristics along with local weather station data to predict N mineralization from cover crops. Cover crop N, carbohydrates, cellulose, lignin are measured by NIRS and used with soils data, cover crop biomass, and date of termination to predict available N and rate of release. The calculator has been used with sunnhemp and cowpea cover crops for fall broccoli production.

METHODS

On the Durham Horticulture Farm in Watkinsville, GA (Piedmont), organic 'Packman' broccoli *(brassica oleracea var. italica)* yields following 'Iron Clay' cowpeas (*vigna unguiculata)* were measured in cover-cropped and no-cover crop plots with four rates (0, 0.5, 1, 1.5 the recommended rate) of N fertilizer to develop yield curves. The no cover treatments received the full N fertilizer recommendation (168 kg ha^{-1}) from feathermeal. The cover crop treatments received the recommended N fertilizer minus the predicted N credit. Yields from no cover and cover crop treatments were also compared on-farm. Crystal Organics, a certified organic farm, used 'AU Golden' sunn hemp (*Crotalaria juncea)* cover crop followed by broccoli 'Gypsy' and feathermeal as the N source. Wide Bottom Farms, a sustainable farm, used cowpeas followed by broccoli 'Packman' and urea (34-0-0) as the N source.

Production Practices Summary
All cover crops were hand broadcasted and raked in after seed bed preparation. At 3 row sites broccoli rows offset.

Site/Year	Seeding Rate (kg/ha)	Transplant Start Date	Transplant Date	Bed Size (m), # of Rows	Plant Spacing (cm)	N Rate (kg/ha)	P and K (kg/ha)	Harvest Date
Hort Farm 2014	90	7/30/14	9/8/14	1.83m 3 rows	46x46	0, 84, 168, 252	Biolink 0-5-5	11/05/14
Hort Farm 2015	90	7/25/15	8/26/15	1.83m 3 rows	46x46	0, 84, 168, 252	None	10/16/15
Crystal Organics 2014	67		9/04/15	1.52m 2 Rows	46x76	0, 84, 168, 252	Biolink 0-5-5	12/04/14
Wide Bottom 2015	90	7/23/15	8/24/15	1.83m 3 rows	46x46	0, 84, 168, 252	256 TSP 252 K_2SO_4	10/15/15

Soil Analysis

Soil organic C and potentially mineralizable N (PMN) were measured using NIRS. Inorganic N was measured by KCl extraction and analyzed colorimetrically. (USEPA 353.2 and 350.1).

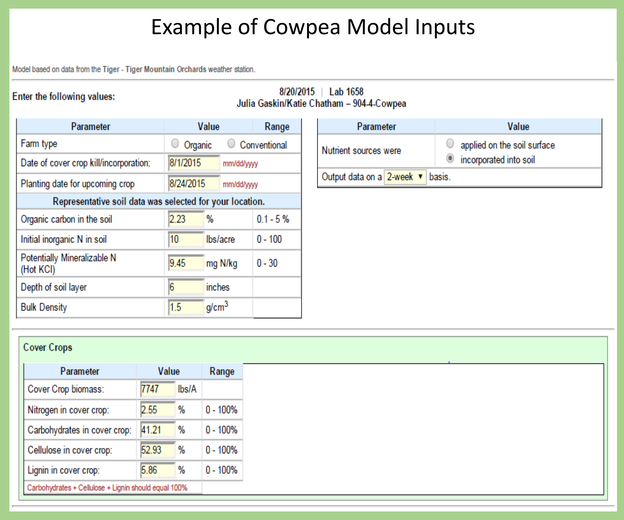
Cover Crop Analysis

Three 0.09 m^2 quadrats in each plot to determine biomass. Crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), lignin and ash analysis by NIRS. Sunn hemp and cowpeas were analyzed using the "Mixed Hay" equation developed by the NIRS Forage and Feed Testing Consortium. The carbohydrate, cellulose lignin used in the N Calculator were calculated as follows:
%Carbohydrate = %CP +%Fat + %Non-fibrous carbohydrates [100-(%CP+%NDF+%Fat+%Ash)]
%Cellulose = %Cellulose [%ADF – (%Lignin + %Ash)] + %Hemicellulose [%NDF - %ADF].
%Lignin = %Lignin
These variables are normalized to equal 100%.

N Availability Calculator

The Calculator predicts N mineralization/ immobilization from cover crop residue based on decomposition (first-order kinetics) of the carbohydrate, cellulose, lignin pools (Quemada and Cabrera 1995). The decomposition rate is modified daily based on C:N ratio of residue and soil, water and temperature data from the Georgia Automated Environmental Monitoring Network.

Example of Cowpea Model Inputs



Model based on data from the Tiger - Tiger Mountain Orchards weather station.

Enter the following values: 8/20/2015 | Lab 1658
Julia Gaskin/Katie Chatham – 904-4-Cowpea

Parameter	Value	Range
Farm type	Organic / Conventional	
Date of cover crop kill/incorporation:	8/1/2015 mm/dd/yyyy	
Planting date for upcoming crop	8/24/2015 mm/dd/yyyy	
Representative soil data was selected for your location.		
Organic carbon in the soil	2.23 %	0.1 - 5 %
Initial inorganic N in soil	10 lbs/acre	0 - 100
Potentially Mineralizable N (Hot KCl)	9.45 mg N/kg	0 - 30
Depth of soil layer	6 inches	
Bulk Density	1.5 g/cm³	

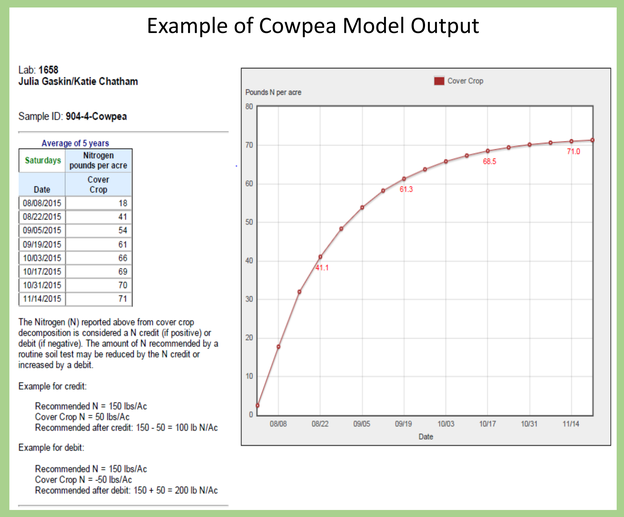
Parameter	Value
Nutrient sources were	applied on the soil surface / incorporated into soil
Output data on a 2-week basis.	

Cover Crops

Parameter	Value	Range
Cover Crop biomass:	7747 lbs/A	
Nitrogen in cover crop:	2.55 %	0 - 100%
Carbohydrates in cover crop:	41.21 %	0 - 100%
Cellulose in cover crop:	52.93 %	0 - 100%
Lignin in cover crop:	5.86 %	0 - 100%

Carbohydrates + Cellulose + Lignin should equal 100%

Example of Cowpea Model Output



Lab: **1658**
Julia Gaskin/Katie Chatham

Sample ID: **904-4-Cowpea**

Average of 5 years

Saturdays	Nitrogen pounds per acre
Date	Cover Crop
08/08/2015	18
08/22/2015	41
09/05/2015	54
09/19/2015	61
10/03/2015	66
10/17/2015	69
10/31/2015	70
11/14/2015	71

The Nitrogen (N) reported above from cover crop decomposition is considered a N credit (if positive) or debit (if negative). The amount of N recommended by a routine soil test may be reduced by the N credit or increased by a debit.

Example for credit:

Recommended N = 150 lbs/Ac
Cover Crop N = 50 lbs/Ac
Recommended after credit: 150 - 50 = 100 lb N/Ac

Example for debit:

Recommended N = 150 lbs/Ac
Cover Crop N = -50 lbs/Ac
Recommended after debit: 150 + 50 = 200 lb N/Ac

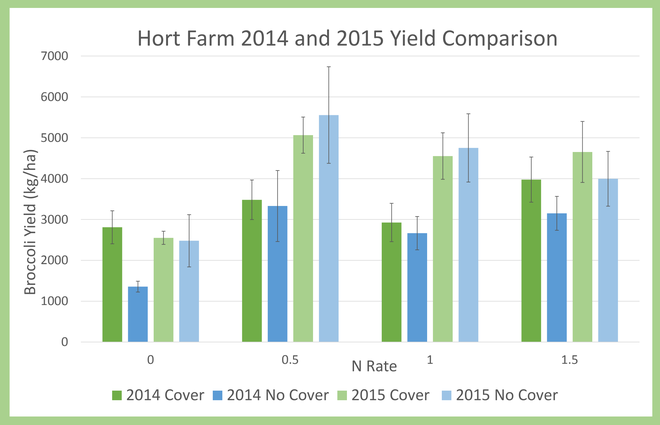
RESULTS

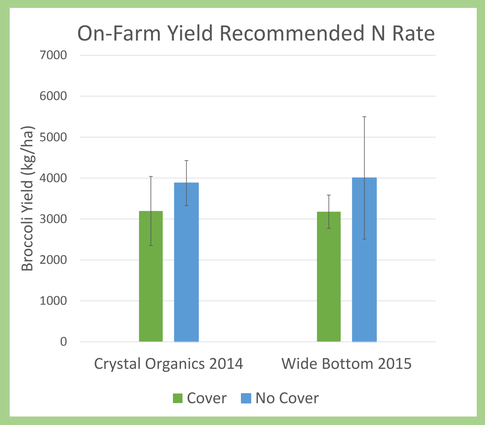
Cover crop biomass was highly variable. This was due to broadcast seeding, weed pressure and grazing pressure from deer. The N% was more consistent with the cowpea averages near 3% and the sunn hemp slightly greater. Weed pressure was higher in 2015 than in 2014. This affected the cover crop quality at the Wide Bottom Farm site (average = 45%). Percent N (r2 = 0.5478) and carbohydrates (r2 = 0.6395) were inversely related to the percentage of weeds in total biomass and cellulose (r2=0.6357) and lignin (r2=0.3595) were positively correlated. The variation in cover crop biomass and quality gave rise to a wide range of cover crop credits at each site.

Cover Crop Analysis Results Summary

Site/Year	Cover Crop Biomass (kg/ha)	Nitrogen (%)	Carbohydrate (%)	Cellulose (%)	Lignin (%)	CC credit (kg/ha)
Hort Farm 2014						
Average	6,573	2.97	47.2	48.8	4.05	70
Max	9,556	3.26	53.1	53.8	4.73	119
Min	4,783	2.62	42.4	42.4	3.50	44
Cv	0.25	0.08	0.09	0.08	0.10	0.37
Hort Farm 2015						
Average	7,841	2.99	50.2	46.6	3.18	95
Max	11,176	3.28	54.6	49.8	3.76	159
Min	5,114	2.68	46.5	42.4	2.53	64
Cv	0.24	0.06	0.05	0.05	0.11	0.39
Crystal Organics 2014						
Average	4,674	3.33	48.1	47.5	4.37	62
Max	6,781	3.57	51.7	51.8	4.59	86
Min	2,689	2.99	43.7	44.1	4.16	34
Cv	0.27	0.05	0.04	0.04	0.03	0.26
Wide Bottom 2015						
Average	7,653	2.51	48.1	47.5	5.75	67
Max	9,834	3.15	51.7	51.8	7.78	120
Min	5,674	1.68	43.7	44.1	4.35	25
Cv	0.17	0.16	0.04	0.04	0.17	0.44

Despite variability, similar yields were seen both at the research farm and on-farm when using the N Calculator. At the recommended rate of 168 kg N ha^{-1}, the cover crop credit ranged from 41 to 57% of the needed N, but yields were similar. The difference in response at the 0 N rate in 2014 and 2015 may be due to soil. The experimental plots in 2014 had only been in organic production for two years. In 2015, the plot were rotated to an area that had been managed organically for eight years.





For cowpeas, based on a seed cost of \$138 ha^{-1}, establishment cost of \$37 ha^{-1}, \$12/sample for cover crop analysis, and \$15/hour to take the cover crop sample, the cover crop would only need to supply 19 kg N ha^{-1} to save the farmer money compared to using feathermeal (\$13.05 kg^{-1}) as the sole N fertilizer. This means as little as 2,242 kg ha^{-1} of biomass would be economically beneficial. Because sunn hemp seed costs are greater \$238 kg^{-1}, the breakeven point was 28 kg N ha^{-1}. The breakeven point 85 kg N ha^{-1} was much higher for Wide Bottom Farms that used urea as an N source. The Wide Bottom Farm would need more than 5,045 kg ha^{-1} of biomass for the cover crop to be economically beneficial solely as an N source.

CONCLUSIONS

The N Calculator can help organic farmers better manage their nitrogen fertilizer application by giving them a conservative estimate of the amount of N supplied by a cover crop. Cover crop N is considerably cheaper than organic N fertilizers such as feathermeal. The missing link is a better assessment of the N supplied by the soil. Further research is focusing on better developing this aspect of the underlying model so we can predict a soil N credit.

REFERENCES

Quemada, M. and M. Cabrera. 1995. CERES-N model predictions of nitrogen mineralized form cover crop residues. Soil Sci. Soc. Am. J. 59:1065-1065

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