Northern NY Agricultural Development Program
2012 Project Report

Cover Crops in Corn Silage Systems in Northern New York

Can Farms Conserve Nitrogen Fertilizer and Safe Money by Using Cover Crops?

Project Leader:
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Collaborators:
Cornell University: Greg Godwin, NMSP Research Support Specialist, Sheryl Swink, NMSP Research Aide, Shona Ort and Emmaline Long (undergraduate honors students), Karl Czymmek, PRODAIRY, and Mike Davis, Willsboro Research Farm.
Cornell Cooperative Extension: Mike Hunter (CCE of Jefferson County), Joe Lawrence (CCE of Lewis County), Kevin Ganoe (CCE of Central NY).
Consultants: Pete Barney, Barney Agronomic Services, and Tom Kilcer, Advanced Ag Systems.

Cooperating Producers:
Lewis County: Joe Kanealy and Cortney Markham
Jefferson County: Burger Farm, Eastman Farm, Porterdale Farm, Reedhaven Farm, Sheland Farm, and Windsong Farm
St. Lawrence County: Maple View Dairy, LLC and McKnight's River Breeze Farm, LLC
Essex County: Willsboro Research Farm
Other non-NNY producers funded with Federal Formula Funds: Wyoming County: Meeder Farms, LLC, Table Rock Dairy Farm, LLC, and Van Slyke's Dairy Farm, LLC. Cayuga Country: Aurora Ridge Dairy. Chenango County: Kemmeren Farm.

Background
Cover crops have received increasing interest from farmers in Northern New York and elsewhere. The reasons for using cover crops vary from erosion control and conserving nutrients to improving soil quality and field trafficability. As fertilizer prices continue to increase and producers aim to improve nitrogen (N) management, questions arise about N uptake by cover crops and the possible impact on corn the following year.

In addition, a growing number of producers are interested in improving the direct return on cover crops by seeding winter cereals that can be harvested for forage (double crop: a second crop of forage in between corn seasons).

The three main questions are: (1) amount of N uptake by a cover/double crop seeded after corn silage harvest; (2) what amount of N can be credited to the following crop after the cover is terminated in the spring; and (3) if we do not terminate as a cover crop but harvest as a double crop, what yield and forage quality can be expected? With funding from NNYADP, USDA-CIG, and CUAES, work was done in 2011/2012 to answer these questions.

Materials and Methods

In the fall of 2011, we sampled 49 cover crop fields seeded to oats (4 fields), cereal rye (18 fields), triticale (9 fields), and winter wheat (18 fields) to evaluate N uptake. This included 15 fields in Northern New York. Site selection was determined by collaborator and producer interest. Cover crop biomass was determined at four spots in each field (8 by 38.5 inch sampling area); cover crops were uprooted to determine both above and below ground biomass. Samples were washed to remove soil. Root and shoot portions were separated, dried, ground, and analyzed for carbon (C) and N content to determine biomass, total C and N pools, and C:N ratios of the shoots and roots.

In spring 2012, overwintering cover crops (46 fields) were sampled again either at the time of cover-crop termination early spring (32 fields), or as a double crop harvested in May (14 fields).

Results

Fall N uptake: The average total N accumulation in the fall ranged from 18 to 29 lbs N/acre across all four species in the statewide project (Table 1). Total C pools ranged from 174 to 369 lbs C/acre. These averages were very consistent with the 20-30 lbs of total N/acre and 250-450 lbs of total C/acre reported for cover crops seeded after corn silage the previous fall (2010) but Table 1 also shows that the variability among fields was large.

Table 1: Fall biomass, total C and total N accumulation of four cereals seeded after corn silage harvest in New York (roots and shoots combined).

Species (# of fields)		Biomass	Total C	Total N
		ton/acre	lbs/acre	lbs/acre
Oats (4)	Average	0.20	174	18
	Min	0.02	18	1
	Max	0.32	280	28
Triticale (9)	Average	0.42	369	24
	Min	0.08	68	5
	Max	0.91	813	47
Wheat (18)	Average	0.38	331	24
	Min	0.05	44	3
	Max	0.81	707	52
Rye (18)	Average	0.42	365	29
	Min	0.02	21	2
	Max	0.89	779	64

Variability reflected field management histories (especially manure applications), planting dates, soil types, and local growing conditions. Oat fields were planted between 9/16 and 9/25/2011 and all received fall-applied manure. The field with the lowest N uptake received 2,300 gallons/acre of manure versus 4,800 gallons/acre for the field that had the largest total N accumulation.

For triticale, the large range in C and N uptake reflected differences in planting dates (between 9/13 and 9/23/2012) and manure application histories. The field with the highest C and N accumulation (813 lbs C/acre and 47 lbs N/acre) had received 5,000 gallons/acre surface applied manure. The lowest N accumulation occurred in a field that did not receive manure or fertilizer.

Wheat fields were planted 9/16/2011 to 10/12/2011. Total N uptake ranged from 3 to 52 lbs N/acre, most likely primarily reflecting the planting date. The range in C and N accumulation by the 18 cereal rye fields also reflected a one month spread in planting date; the lowest uptake of 2 lbs N/acre occurred in the field seeded on 10/12/2011 while the largest accumulation of 64 lbs N/acre was for a field seeded on 9/12/2011.

These ranges indicate that independent of species, planting date and manure history can greatly impact fall growth. However, fields were randomly chosen. To properly evaluate and quantify the impact of planting date and manure history on N uptake, replicated trials are needed.

For the fields sampled in fall 2011, the roots contained 7-13% of the total N (Table 2) similar to the 10-15% determined in the fall of 2010 (Ketterings et al., 2011). Total C in the roots varied from 16 to 22%, also consistent with fall 2010 data, where 10-24% of total C was present in the roots. Thus, only a small percentage of the total N pool is in the roots and this percentage is fairly constant across species and seasons. The results suggest that total N pool may be determined from measurements of above ground biomass only. We will continue to evaluate this issue.

Table 2: Average fall biomass, carbon (C) and nitrogen (N) content, C:N ratio, and total C and N accumulation for shoots versus roots of various cover crop species seeded after corn silage harvest in New York.

Species (# of fields)		Biomass		C	N	C:N	Total C		Total N	
		ton/acre	%	%	%		lbs/acre	%	lbs/acre	%
Oats (4)	Shoots	0.17	85	43.25	4.84	9	147	85	16	89
Triticale (9)	Shoots	0.32	83	43.93	3.34	13	287	84	21	90
Wheat (18)	Shoots	0.31	76	44.08	3.80	12	272	78	22	88
Rye (18)	Shoots	0.35	82	44.30	4.21	11	306	82	26	92
Oats (4)	Roots	0.03	15	39.85	2.41	17	27	16	2	11
Triticale (9)	Roots	0.10	17	42.64	1.46	30	82	16	3	7
Wheat (18)	Roots	0.07	24	41.58	1.82	25	60	22	2	13
Rye (18)	Roots	0.07	18	41.30	1.85	24	60	18	2	8

Spring N pool:
Of the 49 fields seeded after corn silage, 32 were sampled in spring 2012 (8 in Northern New York). At the time of spring sampling, these cover crops had accumulated 37 to 45 lbs N/acre, 1.5-2 times their fall N accumulation (Table 3).

Table 3: Spring 2012 total biomass, carbon (C) and nitrogen (N) content, C:N ratio and total C, and N pools for various cover crop species following corn silage in New York.

Species (# of fields)		DM	Total C	Total N
		tons/acre	lbs/acre	lbs/acre
Rye (13)	Average	0.75	632	45
	Min	0.08	71	7
	Max	1.61	1295	94
Wheat (15)	Average	0.64	529	37
	Min	0.07	62	6
	Max	1.32	1088	83
Oats (4)	Average	0.12	93	9
	Min	0.01	8	1
	Max	0.24	183	17

The fairly low C:N ratios indicate the N in the cover crops could become available to the following corn crop after termination of the stand (Table 4). In warm, moist conditions, materials with a C:N ratio of 25:1 or less are typically expected to decompose rapidly and result in a net contribution of N.

Table 4: Average spring 2012 biomass, carbon (C) and nitrogen (N) content, C:N ratio and total C, and N pools for shoots versus roots of various cover crop species planted after corn silage in New York.

Species (# of fields)		DM		%C	%N	C:N	Total C		Total N	
		tons/acre	%	%	%		lbs/acre	%	lbs/acre	%
Rye (13)	Shoots	0.62	83	42.88	3.69	13	526	83	41	91
Wheat (15)	Shoots	0.55	86	41.86	3.47	13	452	85	34	92
Oats (4)	Shoots	0.07	56	41.64	5.12	9	57	61	7	78
Rye (13)	Roots	0.13	17	40.36	1.75	25	106	17	4	9
Wheat (15)	Roots	0.10	16	40.60	1.73	26	77	15	3	8
Oats (4)	Roots	0.05	42	40.70	2.77	15	36	39	2	2

Forage harvest:
The winter cereals that were harvested as a forage (double crop) in May 2012 (14 fields) ranged in yield from 2.0 to 3.8 tons of DM/acre (a corn silage equivalent at 35% DM of 5.7 to 11.4 tons/acre!!). Fall growth was not a good predictor for spring growth, indicating that even with limited fall growth spring biomass accumulation can be large. The highest yields were obtained in St Lawrence County (see photos). Crude protein exceeded 15% and forage digestibility was high, reflecting high quality forage (and high N uptake/removal). At harvest, the C:N ratio of the roots ranged from 17:1 to 37:1.

Though at some locations the C:N ratio of roots was greater than 25:1 C:N ratio, we do not expect net N immobilization because only a small portion of the total biomass was in the roots. Thus, double crop harvesting is likely to be neutral in terms of N credits for the following crop.

Table 5: Biomass of winter cereals seeded in fall 2011 after corn silage harvest at locations across New York State. Since these are not side by side comparisons in the same field, the averages illustrate ranges and should not be compared directly.

Species (# fields)	Planting date	Fall biomass	Harvest date	Yield
		ton/acre		Ton DM/acre
Rye (3)	9/23 to 10/8/'11	0.10	5/16+17/'12	2.14
Triticale (8)	9/12 to 9/23/'11	0.33	5/4+7/'12	2.03
Wheat (3)	10/12/'11	0.32	5/17+ 6/2/'12	3.78

Conclusions/Outcomes/Impacts:

Research in New York in 2010 and 2011 support an estimate of 20-30 lbs N/acre fall accumulation for cover crop seeded after corn silage in NY.

Fall N uptake: This work supports previous research and allows us to conclude that fall N uptake by winter cereals seeded as cover crops after corn silage harvest typically ranges from 20-30 lbs N/acre, independent of species. Early planting is essential for the greatest N uptake. ***Thus, a cover crop seeded after corn silage can prevent 20-30 lbs N/acre from being lost to the environment***.

Spring accumulation of 35-45 lbs N/acre can be expected. This suggests a 20-30 lbs N/acre credits can be applied for cover crops terminated in spring.

Spring N pool: In the spring, an accumulation of 35-45 lbs N/acre can be expected, 1.5-2 times the fall N accumulation. The C:N ratio of the shoots and roots at cover crop termination suggest this N could become plant available to the following corn crop. Assuming an uptake efficiency of 60-75%, such N pools suggest ***a 20-30 lbs N/acre credit can be applied to cover crops when terminated as a cover crop, early spring***.

Winter cereals grown as double crop increased season yields by 2 tons DM/acre or more. Additional research is needed to determine N rates for the double crops.

Winter cereals as double crops: We conclude there is ***great potential for double crops to increase season productivity with yields consistently exceeding 2 ton DM/acre***. Additional research is needed to determine optimum N rates for double crops and to evaluate their impact on following corn crops. Such studies are scheduled for spring 2013.

Outreach: A website was established, as part of the NY On-Farm Research Partnership: http://nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/CoverCrops.html. Several extension articles were generated summarizing the studies, and numerous talks were delivered as well (see lists below; joint funding statewide project).

1. Ketterings, Q.M. (2013). Cover Crops Performance in Research Trials. 2013 Winter Crop Meeting. Cornell Cooperative Extension South Central NY Dairy and Field Crops Program. Ithaca, NY. January 23, 2013. 45 min. ~ 75 people. Invited.
2. Ketterings Q.M. (2012). NY On-Farm Research Partnership: Working together on research for greater impact at farm and state levels. Capital District Agriculture and Horticulture Program (CCE); Improve Your Business with On-Farm Research (Winter Meeting). Latham, NY, December 18, 2013. 45 min. ~25 people.
3. Ketterings, Q.M. (2012). Winter-Forage Small Grains to Boost Feed Supply: From Cover Crop to Double Crop. Big Flats Plant Material Center 4th Annual Cover Crop Workshop. Big Flats, NY, November 15, 2012. ~100 people.
4. Ketterings, Q.M. (2012). Cover crops in corn rotations; quick update on current status of research projects and plans for next spring. Tillage and cover crop field day in Steuben County. Wayland, NY. September 27, 2012. 10 min. ~40 people.
5. Ketterings, Q.M. (2012). Cover crops in corn rotations. Valatie Research Farm field day. June 29, 2012. Valatie, NY. 30 min. ~50 people.
6. Ketterings, Q.M. (2012). Nutrient management research update. Northern New York Agriculture Development Program (NNYADP). Plattsburgh, NY, March 1, 2012. 30 min, ~20 people.
7. Ketterings, Q.M. (2012). Nutrient management research update. Northern New York Agriculture Development Program (NNYADP). Watertown, NY, January 27, 2012. 30 min, ~30 people.
8. Ketterings, Q.M. (2012). Cover crop carbon and nitrogen content: Fall N uptake and credits for the next year. Corn congress. January 18 and 19, 2012. 30 min. Batavia and Waterloo, NY. 632 people (393 in Batavia, 239 in Waterloo).

A field day was held in Lewis County at Thunder Lane Dairy, Castorland, on October 24th where three crops had been planted (cereal rye, oats, and tillage radishes). Focus of the field day was benefits and challenges to growing cover crops and their adaptability to Northern New York. In addition, one of the Northern New York farmers in the project (Dave Fisher) was quoted in the February issue of Eastern DairyBusiness (2013).

Next steps if results suggest continued work is needed in the areas of research, demonstration and/or education.

For winter cereals grown as forage, if yields of 2-3 tons of DM/acre can be obtained with manure and/or lower N fertilizer application rates than currently recommended (50-100 lbs N/acre) the savings can be substantial. This is in addition to the estimated 20-30% increase in season yield as a result of double cropping, substantially reducing the need for imported feed or extra land. On-farm assessments are needed to quantify N needs of the double crop system. In 2013, we aim to work with two farms in each of the Northern New York counties to determine wheat, rye or triticale yield as impacted by N application rate at spring green-up. Additional sites will be included from other parts of the state (USDA Conservation Innovation Grant and CUAES funding).

Acknowledgments:

We received additional funding from USDA (Conservation Innovation Grant for the Upper Susquehanna Watershed) and Federal Formula Funds, allowing us to develop a

statewide research program and compare results from various regions of the state. We thank all our collaborators on the project

Reports and/or articles in which the results of this project have already been published.

Project website (includes protocols)

1. http://nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/CoverCrops.html.

"What's Cropping Up?" articles:

1. Kilcer, T., Ort, S., Q.M. Ketterings, and K.J. Czymmek (2012). Winter-Forage Small Grains to Boost Feed Supply: Not Just a Cover Crop Anymore! What's Cropping Up? 22(4): 1-2.
2. Ketterings, Q.M., J. Kingston, S. McIlvennie, E. Long, G. Godwin, S. Gami, M. Stanyard, and K. J. Czymmek (2011). Cover crop carbon and nitrogen content: Fall of 2010 sampling. What's Cropping Up? 21(3): 1-4.

Popular press article:

1. Ketterings, Q.M., T. Kilcer, S. Ort and K.J. Czymmek (2013). Double cropping winter cereals yields triple bottom line. Eastern DairyBusiness; The Manager. 5(2): 15-16.

Two Cornell University seniors gained experience in applied research and extension within the cover/double crop project. Both students graduated with distinction in research, completing their honors theses:

- Shona Ort, Animal Science (Fall 2012)
  - nmsp.cals.cornell.edu/publications/impactstatements/ShonaOrt.pdf
- Emma Long, Agricultural Sciences (Spring 2012)
  - nmsp.cals.cornell.edu/publications/impactstatements/EmmaLong.pdf

Person(s) to contact for more information (including farmers who have participated: Quirine M. Ketterings, Associate Professor, Cornell Nutrient Management Spear Program (NMSP), Department of Animal Science, Cornell University. Email: Qmk2@cornell.edu. Phone: 607-255-3061. Project website: http://nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/CoverCrops.html.

Triticale harvest at Dave Fisher's farm in Canton, NY, spring 2012 (photo: Q. Ketterings).

Triticale harvest at Dave Fisher's farm in Canton, NY, spring 2012 (photo: Q. Ketterings).

Oats seeded (September 17th, 2012) after corn silage at Thunder Lane Dairy in Castorland, NY. Picture taken November 11th, 2012 (photo: Joe Lawrence).

Cereal rye seeded after corn silage (September 17th, 2012) at Thunder Lane Dairy in Castorland, NY. Picture taken November 11th, 2012 (photo: Joe Lawrence).

Tillage radishes seeded after corn silage (September 17th, 2012) at Thunder Lane Dairy in Castorland, NY. Picture taken November 11th, 2012 (photo: Joe Lawrence). # # #