Northern NY Agricultural Development Program
2014 Project Report

Winter-Forage Small Grains to Boost Feed Supply: Not Just a Cover Crop Anymore!

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NY On-Farm Research Partnership:
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Cooperating Producers:
Clinton County: Adirondack Farm, B.C.S. Farms, Happy Haven Farm
Jefferson County: Plessis Farm, Reed Haven Farms, Sheland Farm

Lewis County: Grace-Way Farm, Thunder Lane Dairy
St. Lawrence County: Brandy View Farm; Chambers Farms, LLC; Mapleview Dairy, LLC

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Background

Due to the challenging weather conditions of the 2012 growing season, many northern New York State dairies needed to rebuild forage inventory going into 2013.

The data from the fall of 2011 and spring of 2012 show that when properly managed, these winter cereals can supply 2-4 tons of dry matter per acre even with little growth in the fall. However, questions remain related to N management of such a double crop.

This project was based on a main question identified by Northern NY farmers and researchers alike: how much fertilizer N is needed at green-up to grow high yielding and high quality winter cereals for forage, for fields with and fields without a manure application history (fall application). Data from a 2011-2012 study conducted at the Valatie Research Farm in eastern NY suggested the application of N at green-up contributed to higher forage yields for both wheat and triticale. Fields with a manure history and manure applied shortly after the planting of the winter cereal are not expected to need any starter fertilizer, but the data suggest that for optimum yield, the crop might need some additional N when dormancy breaks in the spring. Current farmer practice of applying 50-100 pounds of actual N has seemed to work well, but no data were available to conclude how much N is needed at green-up for either manured or non-manured fields.

We proposed to conduct this research through on-farm trials in the spring of 2013 and to continue in 2014.

Materials and Methods

In spring 2013, we conducted N rate studies on 44 double crop fields including eight cereal rye fields, 33 triticale fields and four wheat fields. Of the 44 trials, eight were located in Northern New York. In 2014, 11 cereal rye and three triticale fields were added to the study, for a total of 58 trials. The selection of sites was determined by collaborators and interest of the producers. Sites were 65 by 80 feet with 4 replications of 5 different N fertilizer rates (0, 30, 60, 90, and 120 lbs of N/acre) applied at time of green-up. Soil samples were taken prior to fertilizer application. The soil samples were then dried, ground, and analyzed for general fertility. In May, above ground biomass was sampled by taking 3 frames (8 by 38.5 inch) at a height of 4 inches from each plot. Above ground biomass was dried and weighed to determine biomass yields (tons/acre) before being ground and analyzed for C, N, and forage quality. Optimum N rates, based on achieving optimum economic yield, were then determined for each of the sites.

Results

Yields and optimum N rate:

Optimum N rates ranged from 0 to 127 lbs N/acre (Figure 1). The average yield across all 58 sites was 1.89 tons DM/acre. Overall, 31% of all sites showed no yield benefits to N addition (where the optimum N rate was zero) and 45% of all sites had an optimum N rate between 75 and 100 lbs N/acre (Figure 1). The optimal N rates for Northern NY sites ranged from 0 to 83 lbs N/acre while yields at optimum N rates ranged from 1.10 to 2.73 tons DM/acre, averaging 1.66 tons DM/acre across the sites (Table 1).

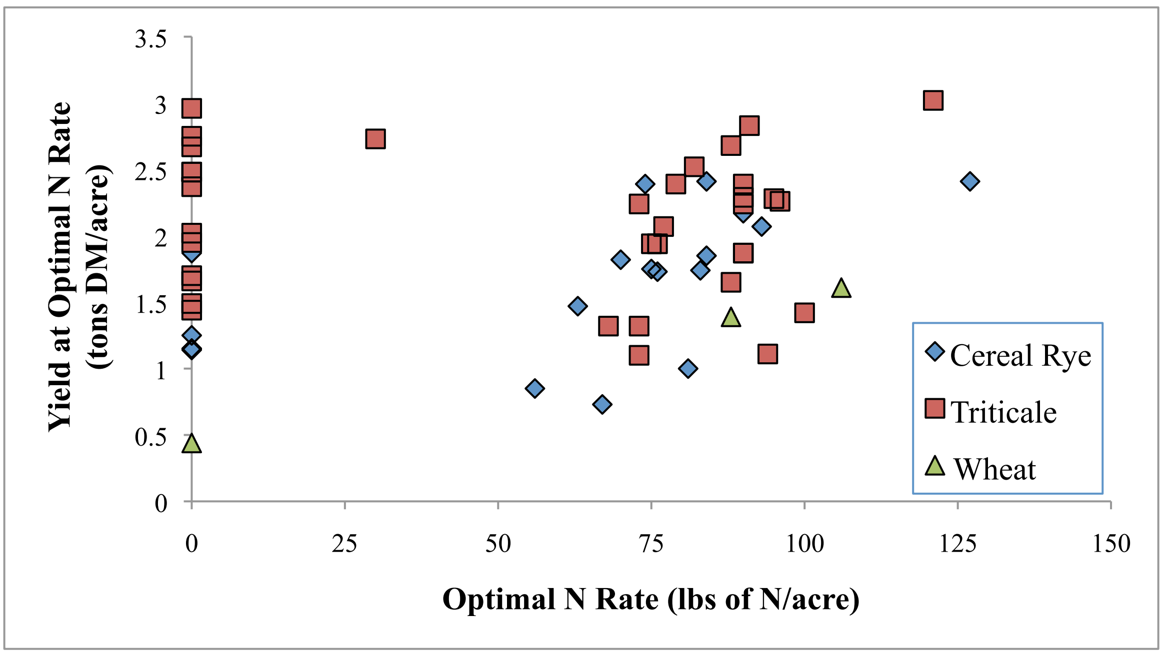

Figure 1: Forage yield (tons DM/acre) at optimal N by optimum economic N rate (lbs of N/acre) for cereal rye, wheat, and triticale sites across NY in the 2013 and 2014 double crop trials. Yield at optimum N rate was determined at a price of $0.60 per lb of N and $250 per ton of forage.

Table 1: Yields at each N rate, optimal N rate, and yield at optimal N rate for each Northern NY site in the 2013 and 2014 double crop trials.

County	Site	Crop	Yield					Optimum N rate	Yield at optimum N rate
			N application rate						
			0	30	60	90	120		
2013			Tons dry matter/acre					Lbs/acre	Tons/acre
St. Lawrence	1	Triticale	1.47	1.76	1.61	1.77	1.70	0	1.66
St. Lawrence	2	Triticale	2.09	2.65	2.79	2.57	2.89	30	2.73
Clinton	3	Cereal rye	1.25	1.47	1.67	1.75	1.77	83	1.74
Clinton	4	Cereal rye	1.17	1.04	1.22	1.13	1.16	0	1.14
Jefferson	5	Triticale	1.59	1.92	2.40	2.16	2.19	73	2.24
Jefferson	6	Triticale	0.53	0.85	1.05	1.14	1.04	73	1.10
Lewis	7	Triticale	1.52	1.66	1.73	1.92	1.71	0	1.70
2014									
St. Lawrence	8	Cereal rye	1.24	1.15	1.27	1.26	1.33	0	1.25
St. Lawrence	9	Cereal rye	1.03	1.43	1.39	1.47	1.42	63	1.47
Clinton	10	Cereal rye	1.43	1.71	1.75	1.87	1.84	70	1.82
Clinton	11	Cereal rye	1.19	0.98	1.12	1.36	1.09	0	1.15
Jefferson	12	Cereal rye	1.74	1.64	1.96	1.85	2.16	0	1.87

**Yield at optimum N rate was determined at a price of $0.60 per lb of N and $250 per ton of forage.*

These results show that both low and high yields can be obtained under Northern NY growing conditions. Of the 12 sites, six had an optimal N rate of 0 lbs N/acre (i.e. did not respond to N fertilizer addition), while another five needed 75–100 lbs N/acre for optimum economic yield. For the highest yielding triticale site the optimum N rate was 30 lbs N/acre. Various field characteristics such as soil fertility, planting date, and manure history could possibly explain the variation in yields and optimal N rates.

Forage quality:

Crude protein (CP) content of the double crop forage increased with increasing fertilizer N addition (Table 2). Crude protein content at the optimum N rate ranged from 8.6% to 19.4% for Northern NY sites (Table 3), comparable to an average of 13% CP without N addition and 18% to 20% CP at the highest two N rates across all sites in Northern NY over the two year study. However, CP levels without N addition showed a wide range among sites, from a low of 7.5% to a high of 19% CP (statewide), showing that fertilizer N is not necessarily needed to increase CP to desirable levels. At three quarters of the sites, neutral detergent fiber (NDF) levels decreased with increasing fertilizer N addition (Table 3). Across all sites, NDF content at the highest two N rates was 2.1% to 3.1% lower than NDF forage content with no N addition. All other forage parameters were not significantly altered with N application, but did vary among sites as indicated below in the Northern NY subset (Table 4).

Table 2: Crude protein (CP) content (% dry matter) of the double crop forage as impacted by five rates of fertilizer N addition (0, 30, 60, 90, and 120 lbs/acre) in trials at Northern NY sites in the 2013 and 2014 double crop trials.

Crude protein (CP) as %DM							
Site		N Rate (lb/ac)					
	Species	0	30	60	90	120	P value
1	Triticale	8.6 c	10.1 bc	12.3 a	12.9 a	13.8 a	0.0001
2	Triticale	9.4 d	11.8 c	12.6 c	14.8 b	16.1 a	<0.0001
3	Cereal rye	14.6 d	15.5 cd	17.7 b	20.4 a	21.9 a	<0.0001
4	Cereal rye	16.0 d	17.1 cd	18.1 bc	18.9 b	20.4 a	0.0004
5	Triticale	12.0 d	13.9 c	18.3 b	19.1 ab	20.5 a	<0.0001
6	Triticale	10.8 d	12.0 cd	15.2 b	15.9 b	18.4 a	<0.0001
7	Triticale	15.8 d	17.5 c	19.2 ab	19.2 a	20.8 a	<0.0001
2013	Average	12.5	14.0	16.2	17.3	18.8	
8	Cereal rye	15.3 d	16.8 cd	18.6 bc	19.9 b	23.6 a	<0.0001
9	Cereal rye	13.3 c	15.4 bc	17.6 b	20.1 a	21.0 a	<0.0001
10	Cereal rye	14.1 c	15.1 bc	16.8 b	18.6 a	19.4 a	<0.0001
11	Cereal rye	13.5 d	15.9 cd	16.8 c	18.8 ab	20.9 a	<0.0001
12	Cereal rye	12.8 c	14.5 c	19.3 b	19.1 b	21.6 a	<0.0001
2014	Average	13.8	15.6	17.8	19.3	21.3	
2-yr	Average	13.0	14.6	16.8	18.1	19.9	

Table 3: Neutral detergent fiber (NDF) content (% dry matter) of the double crop forage as impacted by five rates of fertilizer N addition (0, 30, 60, 90, and 120 lbs/acre) in trials at Northern NY sites in the 2013 and 2014 double crop trials.

Neutral detergent fiber (NDF) as %DM							
Site		N Rate (lb/ac)					
	Species	0	30	60	90	120	P value
1	Triticale	56.1 a	56.6 a	55.2 a	56.2 a	56.0 a	0.6591
2	Triticale	57.7 ab	58.1 a	56.4 abc	55.8 bc	55.4 c	0.0420
3	Cereal rye	53.0 ab	54.1 a	53.2 ab	51.8 bc	50.4 c	0.0283
4	Cereal rye	51.1 a	49.6 b	49.2 b	49.3 b	48.8 b	0.0105
5	Triticale	49.4 a	49.8 a	49.7 a	49.0 a	48.4 a	0.2470
6	Triticale	48.7 a	48.1 a	48.3 a	48.1 a	47.8 a	0.6511
7	Triticale	48.2 a	46.8 b	45.7 bc	45.9 bc	44.9 c	0.0016
2013 average		52.0	51.9	51.1	50.8	50.2	
8	Cereal rye	55.6 a	54.3 b	52.1 b	51.9 b	49.2 c	<0.0001
9	Cereal rye	59.1 a	56.0 ab	56.0 ab	52.1 b	53.1 b	0.0019
10	Cereal rye	55.5 ab	55.9 a	53.9 bc	53.2 c	52.9 c	0.0002
11	Cereal rye	53.8 a	51.1 ab	51.0 ab	51.0 ab	48.9 b	0.0093
12	Cereal rye	50.1 a	48.5 a	46.5 a	46.6 a	45.7 a	0.1041
2014 average		54.8	53.2	51.9	50.9	49.9	
2013–2014 average		53.2	52.4	51.4	50.9	50.1	

Table 4: Crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), in vitro digestion (IVTD), and neutral detergent fiber digestibility (NDFD) content of double crop forage (harvested at flag leaf stage) at optimal N rate for Northern NY sites in 2013 and 2014 double crop trials.

County	Site	Species	CP	NDF	ADF	IVTD	NDFD
2013			% DM	% DM	% DM	% DM	% NDF
St. Lawrence	1	Triticale	8.6	56.1	30.6	85.0	73.3
St. Lawrence	2	Triticale	11.8	58.1	34.6	80.8	66.9
Clinton	3	Cereal rye	19.4	52.5	28.9	86.6	74.5
Clinton	4	Cereal rye	16.0	51.1	25.5	90.9	81.5
Jefferson	5	Triticale	18.1	49.3	25.8	89.0	77.8
Jefferson	6	Triticale	15.3	48.2	24.6	90.5	80.2
Lewis	7	Triticale	15.8	48.2	26.3	90.5	80.2
2014							
St. Lawrence	8	Cereal rye	14.9	55.7	30.3	89.1	79.2
St. Lawrence	9	Cereal rye	17.7	55.1	30.6	86.4	75.4
Clinton	10	Cereal rye	17.3	54.0	29.4	89.3	80.2
Clinton	11	Cereal rye	13.6	53.1	27.7	89.8	80.2
Jefferson	12	Cereal rye	13.0	49.6	25.9	87.1	75.9

<u>Soil fertility:</u> Soil fertility did not differ among plots within a site, but fertility did vary greatly among sites across the state. Northern NY sites had similar soil pH, but there was large variation in the other soil fertility parameters (Tables 5 and 6). Initial analyses suggest that soils that have optimal soil fertility, high organic matter and optimum pH support higher yields than low fertility soils.

Table 5: Soil type, soil pH, phosphorus (P), potassium (K), and organic matter (OM) for the Northern NY sites in the 2013-2014 double crop study. Sampling depth was 8 inches.

County	Site	Soil Type	Soil pH	Cornell Morgan P		Cornell Morgan K		OM
				lbs/acre		lbs/acre		%
St. Lawrence	1	Swanton	6.2	5	Medium	196	Very high	3.8
St. Lawrence	2	Hogansburg	6.5	53	Very high	212	Very high	4.1
Clinton	3	Shaker	6.3	8	Medium	83	Medium	2.1
Clinton	4	Hailesboro	6.9	45	Very high	343	Very high	5.8
Jefferson	5	Kingsbury	6.6	129	Very high	860	Very high	5.5
Jefferson	6	Hinckley	6.8	4	Medium	135	High	3.7
Lewis	7	Nellis	6.6	12	High	169	Very high	6.3
St. Lawrence	8	Swanton	6.9	29	High	286	Very high	3.2
St. Lawrence	9	Grenville	7.1	52	Very high	357	Very high	3.3
Clinton	10	Malone	6.5	8	Medium	225	High	2.3
Clinton	11	Bombay	6.3	3	Low	49	Very low	3.4
Jefferson	12	Collamer	6.6	17	High	245	Very high	3.9

Table 6: Illinois soil nitrogen test (ISNT), critical ISNT, soil nitrate- and nitrite-N (NO_3-N and NO_2-N) and ammonium-N (NH_4-N) contents for Northern NY sites in the 2013–2014 double crop study. Sampling depth was 8 inches.

County	Site	ISNT	Critical ISNT	ISNT Interpretation	NO_3-N and NO_2-N	NH_4-N
		ppm			ppm	ppm
St. Lawrence	1	314	306	Marginal	3.7	31.2
St. Lawrence	2	381	308	Optimal	4.9	27.6
Clinton	3	205	246	Low	3.5	23.3
Clinton	4	394	332	Optimal	9.1	23.3
Jefferson	5	429	331	Optimal	6.3	27.3
Jefferson	6	289	297	Marginal	2.4	25.2
Lewis	7	532	335	Optimal	8.0	22.6
St. Lawrence	8	281	293	Marginal	4.4	27.4
St. Lawrence	9	287	294	Marginal	8.9	30.9
Clinton	10	199	257	Low	5.2	18.8
Clinton	11	285	293	Marginal	5.2	18.7
Jefferson	12	319	310	Marginal	4.4	24.6

Economic Assessment:

The economic assessment centered around two main questions:

(1) what are the expected changes in profit associated with incorporating double crops into cropping systems? and

(2) what expected yield levels ensure that adoption of double crops will be a profitable change for New York State and Northern NY?

Winter cereal seed and planting costs, fertilizer use, tillage practices, machinery availability, value of a winter cereal as a forage, yield levels, possible yield reduction for a shorter season corn variety after winter cereals and other factors all impact profit associated with incorporation of double crops into corn cropping systems.

While the statewide database indicated that 45% of all fields in the study needed about 75 lbs N/acre for optimal yield, 50% of the fields in Northern NY did not respond to any N applied at green-up. Thus, the economic assessment is done for both 0 and 75 lbs N/acre scenarios. Table 7 shows both the changes in profit, averaged across three farm sizes (100, 500 and 1000 cows), and the results of the analysis used to identify yield levels that increase the likelihood of winter cereal forages adoption. The analyses reflect N cost fixed at $0.57 per lb of N, and a value for winter forage of $180 per ton of DM.

Table 7. (A) Expected change in annual profit ($ per acre) by tillage/harvest system, by expected change in corn silage yield (ton DM per acre), by spring N application; and (B) Minimum winter forage production (ton DM per acre) that results in an expected change in profit greater than or equal to zero by tillage/harvest system, expected change in corn silage yield (ton DM/acre), and spring N addition (lbs of N/acre).*

	Conventional tillage		Reduced tillage, wide swath & merge harvest		No-till	
	Triticale		Triticale		Cereal Rye	
	No change in corn yield	1 ton/acre DM less for corn	No change in corn yield	1 ton/acre DM less for corn	No change in corn yield	1 ton/acre DM less for corn
A	Expected change in annual profit ($ per acre)					
No N needed for winter cereal	175	10	219	54	229	64
75 lbs N/acre at green -up for winter cereal	121	-44	165	0	175	10
B	Minimum winter forage level of production (ton DM per acre)					
No N needed for winter cereal	1.0	1.9	0.7	1.7	0.7	1.6
75 lbs N/acre at green -up for winter cereal	1.3	2.3	1.0	2.0	1.0	1.9

**Table values represent averages across three farm sizes (100, 500 and 1000 cows), winter cereal forage yield fixed at 2.0 ton DM per acre (Section A of Table 7 only), N cost fixed at $0.57 per lb of N, and value of winter cereal as a forage fixed at $180 per ton DM. Triticale is the winter cereal for the conventional and reduced tillage scenarios, while rye is the winter cereal for the no-till scenario.*

Conclusions/Outcomes/Impacts:

The average double crop forage yield at optimum N rate across all 2013 and 2014 sites was 1.89 tons DM/acre for the statewide study and 1.66 tons DM/acre for the Northern NY portion of the study.

Optimal N rates across all sites ranged from 0 to 127 lbs of N/acre and from 0 to 83 lbs of N/acre in Northern NY.

Six out of 12 locations in Northern NY did not show a yield response to N addition while another five locations needed 75 to 100 lbs N/acre to reach optimum yield.

Crude protein levels increased and neutral detergent fiber levels decreased with increasing N fertilizer rates with no or inconsistent impact of N rate on all other forage quality parameters that were measured in the study.

Economic analyses showed minimum double crop yields of 0.7 to 1.0 tons DM/acre are needed for a positive return on investment if the yield of corn following the double crop is not impacted and winter cereals can be grown without N input. When N applications of 75 lbs N/acre are needed to reach optimum yield and corn silage yield is reduced by 1 ton DM/acre, minimum yield ranged from 1.0 to 2.3 tons DM/acre.

Outreach (in grey are NNY specific articles/activities):

Website (part of the NY On-Farm Research Partnership):

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

Impact Statements, written by Lisa Fields:

1. NMSP's Double Crop N Rate Study at Joleanna Holsteins Has Local Impact. Nutrient Management Spear Program, Animal Science, Cornell. http://nmsp.cals.cornell.edu/publications/impactstatements/PaulCerosalettiDoubleCrops.pdf.
2. Crop advisor's collaboration with NMSP promotes double cropping in Northern New York. Nutrient Management Spear Program, Animal Science, Cornell. http://nmsp.cals.cornell.edu/publications/impactstatements/EricBeaverDoubleCrops.pdf.
3. Grazing specialist teams up with NMSP for double crop study at Schumacher Dairy-Ops. Nutrient Management Spear Program, Animal Science, Cornell. http://nmsp.cals.cornell.edu/publications/impactstatements/JonathanBarterDoubleCrops.pdf
4. Crop advisor explores double crop concept with NMSP nitrogen rate study at AA Dairy. Nutrient Management Spear Program, Animal Science, Cornell. http://nmsp.cals.cornell.edu/publications/impactstatements/JeffWilliardDoubleCrops.pdf
5. Northern NY crop advisor and NMSP initiate double crop field research. Nutrient Management Spear Program. Animal Science, Cornell. http://nmsp.cals.cornell.edu/publications/impactstatements/PeterBarneyDoubleCrops.pdf
6. Oneida county extension specialist explores double-cropping with NMSP field study. Nutrient Management Spear Program, Animal Science, Cornell. http://nmsp.cals.cornell.edu/publications/impactstatements/JeffMillerDoubleCrops.pdf
7. New field crops specialist dives into collaborative double-cropping research with NMSP. Nutrient Management Spear Program, Animal Science, Cornell. http://nmsp.cals.cornell.edu/publications/impactstatements/BillVerbetenDoubleCrops.pdf

Extension articles:

1. Ort, S.B., Q.M. Ketterings, S.N. Swink, G. Godwin, S. Gami, and K. Czymmek (2014). Spring carbon and nitrogen pools of wheat and cereal rye following corn silage. What's Cropping Up? 23(3): 3-4.
2. Ort, S., Q.M. Ketterings and K.J. Czymmek (2014). Nitrogen rate studies of winter cereals. Eastern DairyBusiness. The Manager. 6(2): 19.

3. Ort, S.B., M. Stanyard, S.N. Swink, Q.M. Ketterings, G. Godwin, S. Gami, K. Ganoe, and K. Czymmek (2013). Fall carbon and nitrogen uptake of various cover crop mixtures following small grains; fall 2010 and 2011 data. What's Cropping Up? 23(2): 7-9.
4. Ort, S.B., Q.M. Ketterings, K.J. Czymmek, G.S. Godwin, S.N. Swink and S.K. Gami (2013). Carbon and nitrogen uptake of cereal cover crops following corn silage. What's Cropping Up? 23(2): 5-6.
5. 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.
6. Long, E., K. Van Slyke, Q. M. Ketterings, G. Godwin, and K.J. Czymmek (2013). Triticale as a cover and double crop on a New York dairy. What's Cropping Up? 23(1): 3-5.

Journal article:

1. Ketterings, Q.M., S. Ort, S.N. Swink, G. Godwin, T. Kilcer, J. Miller, W. Verbeten, and K.J. Czymmek (2014). Winter Cereals as Double Crops in Corn Rotations on New York Dairy Farms. Journal of Agricultural Science (*in press*).

Oral presentations:

1. Ketterings Q.M. (2014). Cover/Double Crops. Cornell Cooperative Extension of Delaware County – Crop School. March 18, 2014. 15 min. ~25 people.
2. Ketterings Q.M. (2014). Nutrient Management Update. NNYADP. February 28, 2014. Chazy, NY. 15 min. ~30 people.
3. Ketterings Q.M. (2014). Fall N uptake and spring N credits from cover crops seeded after corn silage. 2014 Otsego County Soil & Water Conservation District Cover Crop and Soil Health Workshop. February 26, 2014. Cooperstown, NY. 30 min. ~35 people.
4. Ketterings Q.M. (2014). Winter cereals as double crops for forage. 2014 Otsego County Soil & Water Conservation District Cover Crop and Soil Health Workshop. February 26, 2014. Cooperstown, NY. 30 min. ~35 people.
5. Ketterings, Q.M. (2014). Reduced risk of forage shortages with double-cropping. Northern New York Crop Congress. February 19, Canton, NY. 60 min. ~50 people.
6. Ketterings, Q.M. (2014). Reduced risk of forage shortages with double-cropping. Northern New York Crop Congress. February 18, Chazy, NY. 45 min. ~50 people.
7. Ketterings Q.M. (2014). Nutrient Management Update. NNYADP. January 31, 2014. Watertown, NY. 15 min. ~40 people.
8. Ketterings, Q.M. (2014). Nitrogen rates and application and timing studies. Winter Crop Meeting, Cornell Cooperative Extension South Central NY (SCNY) Dairy and Field Crops Program. January 17, 2014. Ithaca NY. 30 min. ~100 people.
9. Ketterings, Q.M., S. Ort, and B. Verbeten (2013). Winter cereals as double crops in corn rotations. Experiences from the 2013 growing season. Field Crop Dealer Meetings, December 12, 2013. Syracuse, NY. 40 min. ~60 people.

10. Ketterings, Q.M., S. Ort, and B. Verbeten (2013). Managing nitrogen for winter cereals grown as double crop for forage. Northeast Region Certified Crop Advisor Annual Training. Advanced Training. December 5, 2013. Syracuse, NY. 50 min. 42 people.
11. Ketterings, Q.M. (2013). Winter-Forage Small Grains to Boost Feed Supply: From Cover Crop to Double Crop. Big Flats Plant Material Center 5th Annual Cover Crop Workshop. Big Flats, NY, November 14, 2013. ~130 people. 45 min.
12. Ketterings, Q.M. (2013). Double crops. Discussion group large herd group Oneida County. Oriskany, NY. August 22, 2013. 10 people. 2.5 hours.

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

Project websites (includes protocols)

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

Impact Statements

8. NMSP's Double Crop N Rate Study at Joleanna Holsteins Has Local Impact. Nutrient Management Spear Program, Animal Science, Cornell. http://nmsp.cals.cornell.edu/publications/impactstatements/PaulCerosalettiDoubleCrops.pdf.
9. Crop advisor's collaboration with NMSP promotes double cropping in Northern New York. Nutrient Management Spear Program, Animal Science, Cornell. http://nmsp.cals.cornell.edu/publications/impactstatements/EricBeaverDoubleCrops.pdf.
10. Grazing specialist teams up with NMSP for double crop study at Schumacher Dairy-Ops. Nutrient Management Spear Program, Animal Science, Cornell. http://nmsp.cals.cornell.edu/publications/impactstatements/JonathanBarterDoubleCrops.pdf
11. Crop advisor explores double crop concept with NMSP nitrogen rate study at AA Dairy. Nutrient Management Spear Program, Animal Science, Cornell. http://nmsp.cals.cornell.edu/publications/impactstatements/JeffWilliardDoubleCrops.pdf
12. Northern NY crop advisor and NMSP initiate double crop field research. Nutrient Management Spear Program. Animal Science, Cornell. http://nmsp.cals.cornell.edu/publications/impactstatements/PeterBarneyDoubleCrops.pdf
13. Oneida county extension specialist explores double-cropping with NMSP field study. Nutrient Management Spear Program, Animal Science, Cornell. http://nmsp.cals.cornell.edu/publications/impactstatements/JeffMillerDoubleCrops.pdf

14. New field crops specialist dives into collaborative double-cropping research with NMSP. Nutrient Management Spear Program, Animal Science, Cornell. http://nmsp.cals.cornell.edu/publications/impactstatements/BillVerbetenDoubleCrops.pdf

For More Information:

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