Northern New York Agricultural Development Program
2016 Project Report

Late Summer-Planted Oats for Forage: A Viable Option for NNY? Year 2

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Background:

In the 6-county region of Northern New York (Jefferson, St. Lawrence, Lewis, Franklin, Clinton and Essex), a majority of the dairy and livestock farms rely on grass-based forages as a primary source of animal feed. Grass hay is the largest acreage of any crop grown, followed by corn.

Shortages of forage crops have occurred when weather conditions negatively impact productivity and/or when planting or harvesting operations are impeded. Cold, wet spring weather can delay hay and pasture seedings and corn planting while hot, dry summer weather can cause hay and pasture yields to be inadequate. In these cases, late-planted summer annual crops such as sorghum-sudangrass, teff, pearl millet and oats can be used as emergency annual forage crops.

BMR sorghum sudangrass and teff have been shown to yield well in Northern NY. Sorghum sudangrass requires high nitrogen (N) fertility for maximum yields of 3-5 tons DM/acre, can be difficult to harvest due to its high moisture content at harvest, and must be managed to avoid prussic acid toxicity.

Teff yields about 2 tons DM/acre and requires much less N, but its very small seeds can present planting and establishment difficulties.

Oats grown for forage can also fit into a late-planting window with fewer seeding, fertility, harvest and toxicity concerns. Common oat (*Avena sativa*) is an annual spring grain typically grown for both livestock and human consumption. Oats grow well in cooler temperatures and are more tolerant of wet weather than other cereals, so can be particularly adapted to cool, wet summers.

Preliminary on-farm oat research conducted in 2013 and 2014 at one Jefferson County location suggested that late summer-planted oats are capable of producing high quality, high yielding forage (Tables 1 and 2).

Oats yielded an average of 1.62 tons DM/acre in 2013 and 2.39 tons DM/acre in 2014. However, it is not clear if a grain-type or forage-type oat variety should be used, or what the ideal N rate is, for this late-summer crop.

Oat cultivars selected specifically for forage production are generally slower to mature than grain-type cultivars, however this distinction is based on normal spring establishment. Development of all cultivars is generally much slower in the fall, and differences between cultivars of different maturity classes are not well understood. It is possible that a grain oat variety may be better suited for a late summer forage crop due to its earlier maturity compared to a forage type variety. 2015 results of this comparison yielded inconclusive results. Oats yielded poorly and were not responsive to fertilizer N across locations due to unusually dry weather.

Of 3 experimental sites comparing grain and forage oats at 3 N fertility rates in 2015, the Alexandria plots failed to establish due to dry conditions, the Canton site was very dry, low-yielding and unresponsive to N while the Chazy site yielded poorly but did provide some meaningful results. See Table 3. At Chazy, the grain variety outyielded the forage variety of oats, 1.3 vs .7 tons per acre. At Canton, despite no yield due to N fertilizer, 50 and 100 lbs of N increased crude protein content relative to the 0 N treatment.

Table 1. Summary of a preliminary on-farm forage oats trial conducted in 2013 in the Town of Alexandria, Jefferson County, NY.

Planted July 31, 2013 with grain drill at 120 lbs / acre
N Fertility: 55 lbs/acre at planting or 55 lbs at planting + 55 lbs 3 weeks later
Harvested September 20, 51 days later

Yield:	Forage yield averaged 1.62 tons DM / acre, no N effect								
Forage Quality:	CP	ADF	NDF	NeL	NFC	NSC	Ca	P	K
	19.45	27.3	46.1	0.7	23.55	14.58	0.35	0.6	5.21

Table 2. Summary of a preliminary on-farm forage oats trial conducted in 2014 in the Town of Alexandria, Jefferson County, NY.

Planted August 1, 2014 with forage and grain-type oats at 120 lbs / acre with or without a red clover underseeding.
N Fertility: 55 lbs/acre at planting or a Red Clover underseeding
Harvested October 5, 65 days later

	Tons DM/acre
Grain Oats	2.47 b
Forage Oats	2.53 b
Grain Oats + Red Clover	2.19 a
Forage Oats + Red Clover	2.37 ab

a,b Values followed by the same letter are not significantly different (P ≤ 0.05).

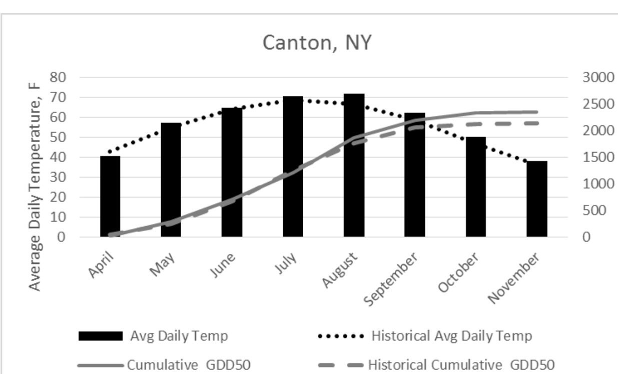
Table 3. Effect of oat type and N fertility on DM yield and crude protein content of oat forage grown in 2015 in Canton and Chazy, NY.

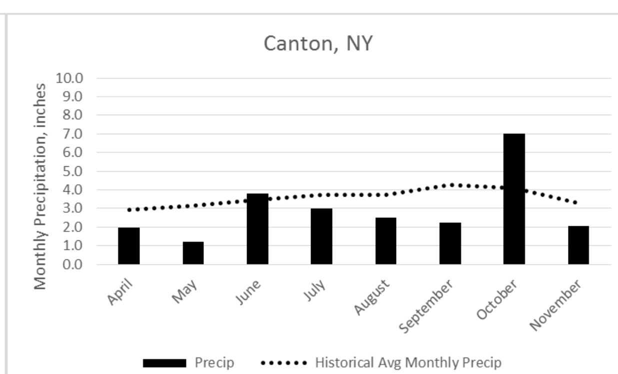
	DM Yield, tons / acre			Crude Protein, % of DM		
	Canton	Chazy		Canton		Chazy
Grain	0.768	1.328	a	23.2		20.1
Forage	0.795	0.681	b	21.9		21.7
0N	0.695	0.895	b	18.6	b	20.9
50N	0.783	1.043	ab	24.6	a	21.2
100N	0.865	1.077	a	24.6	a	20.6

a,b Values followed by the same letter are not significantly different (P ≤ 0.05).

Methods:

An oat variety and N fertility field study was conducted at 3 locations in Northern New York in 2015 and was repeated in 2016. The 3 sites are described in Table 4. The sites are silty, loamy soil types commonly used for production of forages for dairy and livestock in Northern NY. Average monthly temperature and precipitation totals for the closest available weather station from April through November 2016 are summarized in Figure 1 for the 3 trial locations. Watertown is the closest weather station to the Alexandria trial location. Figure 1 also includes a summary of cumulative growing degree-days (GDD) for 2016 compared with historical averages. GDD were calculated using a base temperature of 50 ºF.





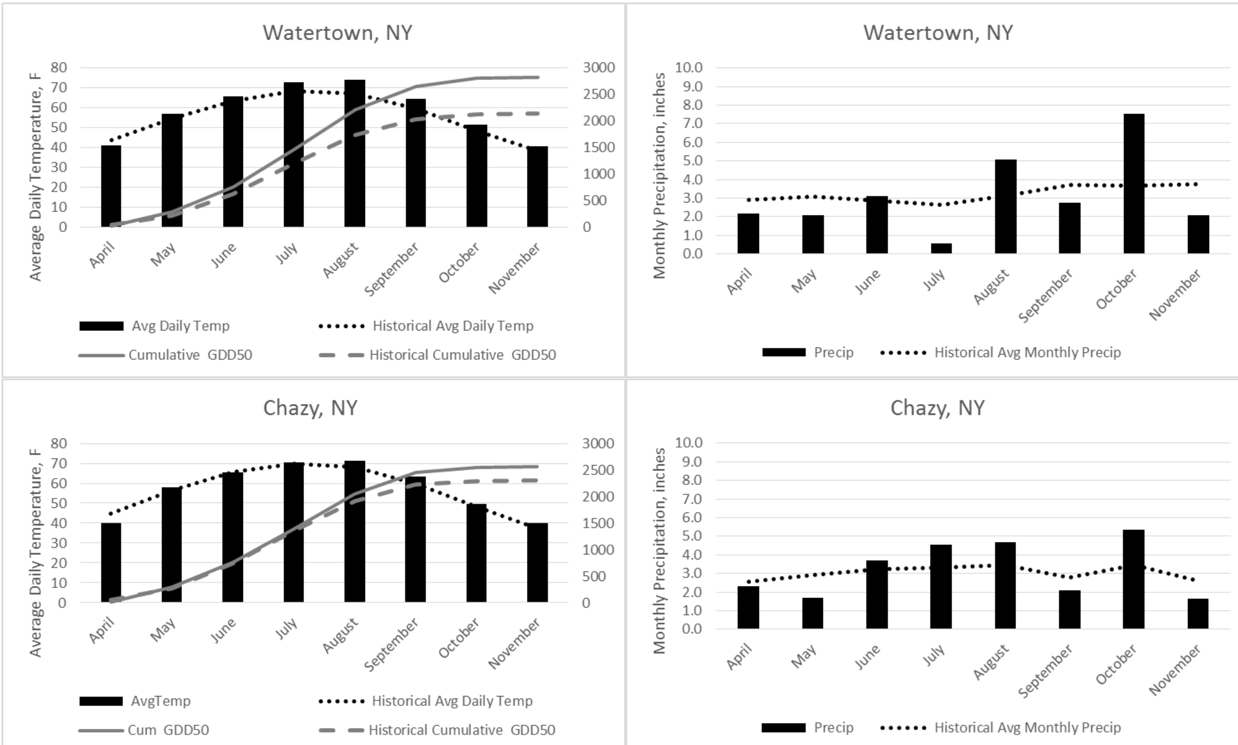


Figure 1. **Graphs in the left column depict average monthly temperature in 2016 (dark bars), historical average monthly temperature (dark dotted line) and GDD accumulation for 2016 (solid gray line) and historical GDD accumulation (dashed gray line) for 3 experimental sites. Graphs in the right column depict monthly precipitation totals for 2016 (dark bars) and historical average monthly precipitation totals (dotted line) for all 3 experimental sites. Arrows indicate the approximate planting date at each site.**

Table 4. Description of 3 field sites selected for a comparison of oat variety and N fertility on yield and quality of oat forage in 2016.

County	Town	Soil Type	2016 Planting	2016 Harvest
Jefferson	Alexandria, NY	Kingsbury silty clay	29 July	12 October
St. Lawrence	Canton, NY	Hailesboro silt loam	15 August	20 October
Clinton	Chazy, NY	Roundabout silt loam	8 August	6 and 17 October

The field study at Alexandria, Canton and Chazy locations was designed as a randomized complete block with 4 field replications. The main experimental factor was oat variety or type with N fertility managed as a split plot. Oat varieties planted in all 3 trial locations were the same as in 2015:

“Corral” variety oats (Seedway LLC, Hall, NY), a medium-maturity grain type, and
“Foragemaker 50” variety (King’s AgriSeeds, Inc., Ronks, PA), a later maturing forage type.

Oats were seeded at 3 locations from July 29 to August 15 at 120 lbs per acre, at a depth of 1” with a grain drill at 7” row spacing. Plots at all sites were conventionally tilled (tandem disk) and managed with field-scale machinery throughout the experiment. P and K fertility needs were managed at each site prior to planting according to standard recommended practices.

Just after planting, N was manually surface-applied to split plots in the form of urea (46-0-0) treated with 1.6 ounces of Agrotain urease inhibitor (Koch Agronomic Services, LLC, Wichita, KS) per 50 lbs to reduce risk of ammonia volatilization. Rain fell on each site within 5 days of urea application. Nitrogen treatments were no N applied (0), 50 or 100 lbs /acre of total N. No herbicides or pesticides were applied to oat plots during the experiment.

Forages were sampled at approximately late boot stage by manually clipping plants at 4” above the soil surface. At Canton and Alexandria, all plots were harvested on the same day. At the Chazy location, forage variety plots were harvested 11 days after the grain variety, though both were approximately at boot stage.

Plant samples were weighed, dried in a 65 ºC forced air oven for 24 hours and weighed again to determine moisture content and DM yield. Dried samples were analyzed with wet chemical methods for standard nutritional components including dry matter, crude protein, acid- and neutral-detergent fiber, non-fiber carbohydrate, relative feed value, total digestible nutrients net energy, metabolizable energy and digestible energy content (DairyOne Lab, Ithaca, NY). Thirty-hour *in vitro* true digestibility (IVTD) and neutral-detergent fiber digestibility (NDFD) were also measured to feed value for dairy cattle and livestock.

Results:

The 2016 growing season was defined by average and slightly above-average temperatures across the North Country with persistent drought classifications by the National Oceanic and Atmospheric Administration. April and May brought below average precipitation to all 3 locations, just 37 to 89% of normal rainfall. June brought average or slightly above average precipitation to each trial site. July marked a return of dry weather for Canton and Watertown where just 80 and 22% of typical rain was received. Chazy fared better, receiving 138% of normal rainfall during July.

Subsequently, in Canton and Alexandria, the oat trials were planted into very dry soils, while in Chazy soils were slightly moister. The months of August and September were below normal precipitation at Canton, with 67% and 52% of typical precipitation for those months. Watertown and Chazy weather stations recorded 161% and 136% of normal rainfall in August and 74% and 76% during September.

The Canton site remained dry and oats stunted for the duration of the trial, but the dry soil conditions of early summer were relieved with adequate August rainfall at Alexandria and Chazy.to prevent failure of oat crops. Temperatures were slightly below average during August and September at all 3 trial sites. Oats grown at the Canton site accumulated approximately 803 growing degree-days (base 50) while those grown at Alexandria and Chazy accumulated 1025 and 939, respectively.

Forage dry matter (DM) yields at all 3 locations were lower than expected for both varieties and all N treatments (Table 5 and Figure 1.). Chazy and Alexandria yields averaged 1.36 and 1.34 tons DM per acre while Canton plots yield only an average of 0.74 tons per acre.

Oat yield was unaffected by variety or N fertilization at all 3 locations. Drought conditions were severe enough that forage plants were unable to respond to N fertilization. Additionally, these oat crops were exposed to fewer GDD than is expected for August and September. The 800

GDD at Canton was 19% less than normal. Watertown and Chazy also saw lower than normal accumulations of GDD during the growth period for this oat crop by 13% and 11% respectively.

Despite the lack of DM yield response, N removal was significantly increased with N fertilization at Canton and Alexandria. Crude protein content of forages at these 2 locations were significantly increased with N fertilization, compared with no fertilization, resulting in an overall positive impact on N removal. See Tables 5 and 8 and Figure 2. Non-fiber carbohydrate content was significantly depressed by N fertility at these 2 locations also (Table 6).

Similar to 2015, crown rust infections were noted in forage oat variety plots though the severity was much less than in 2015. Crown rust (*Puccinia* species) is a common and damaging fungal disease of wild and cultivated oats, grasses and buckthorn.

Forages harvested at all 3 locations were of high nutritional quality, which is expected at late boot growth stage (Tables 7 and 8). Crude protein averaged 20.6 to 21.6% of DM across 3 trial sites. Crude protein content did increase with greater N supply at Canton and Alexandria and, in Chazy, with oat variety. The apparent effect of variety at Chazy, however, is more likely to have been caused by the delayed harvest of the forage variety plots, which occurred 11 days after the grain variety. At Canton and Alexandria, where all plots were harvested on the same day, this effect was not observed.

Drought conditions at Canton and Alexandria were not severe enough to impair N uptake by oat plants, but the limited water availability did appear to limit stem elongation and biomass accumulation. Neutral detergent fiber (NDF) content was unaffected by variety or N fertilization and ranged from 43 to 57% of DM across location and treatment.

In vitro true digestibility (30-hour) was highest for the Canton and Alexandria sites and lower for Chazy forages. At Chazy, grain variety oats had a significantly higher IVTD30 than forage variety, 79.8% vs. 76.3% of DM, though this effect may be due to the delayed harvest of the forage variety plots. The 50N treatment significantly depressed IVTD30 compared with 0N forages at Alexandria only. Digestibility of NDF was also quite high for oat forages grown at Canton and Alexandria (80 to 86% of DM) while slightly lower at Chazy (61% average).

Conclusions/Outcomes/Impacts:

Results of this study were complicated by drought conditions, but just enough rain fell in August to prevent loss of the crop. Forage variety oats were again observed to have presence of crown rust, though the infection was not nearly as severe as in 2015. Both drought and rust fungus are possible in any given year in Northern NY, which may affect the feasibility of late summer oats as an emergency forage option.

Productivity of both grain and forage oat varieties was poor across locations and seasons in this 2-year trial, regardless of location and N fertility treatment. Forage quality was very good, despite poor yields. Where dry conditions were slightly less severe, yields reached about 1.4 tons per acre, though yield did not improve with N fertilization. Nitrogen fertilization did improve crude protein content and N removal at 2 locations of 3 in 2016.

As a late summer emergency forage, spring oats did not perform as well as warm-season crop options such as pearl millet, BMR corn or BMR sorghum-sudangrass have in NNY and NYS trials. See Figure 3. Oats would be expected to perform better during a cool, wet August and September. Nitrogen fertility recommendations for optimal yield cannot be determined from this

2-year study, though 50 and 100 lbs of N were equivalent in increasing crude protein above no N fertilizer.

Outreach:

We plan to develop a practical guide for growing and fertilizing summer-planted crops for forage production for high-quality livestock feed. An agronomy factsheet will be written summarizing best management practices for forage oats, together with other late summer forage options. Research will be summarized for presentation at Crop Congresses and for distribution across the 6-county region in CCE Field Crops News and local county newsletters. The research summarized here builds on experience with summer annual forage options appropriate for Northern NY.

Next Steps: Nitrogen fertility recommendation for optimal yield cannot be determined from this 2-year study. The project could be repeated in the future to better determine this important management parameter.

For More Information:

- Kitty O'Neil, Cornell University Cooperative Extension, NNY Regional Ag Team, 2043B State Highway 68, Canton, NY 13617; 315-379-9192
- Mike Hunter, Cornell University Cooperative Extension, NNY Regional Ag Team, 203 N Hamilton St, Watertown, NY 13601; 315-788-8450
- Quirine Ketterings, Cornell Nutrient Management Spear Program, 323 Morrison Hall, Department of Animal Sciences, Cornell University; 607-255-3061
- Mike Davis, Farm Manager, Cornell University Willsboro Research Farm, 48 Sayward Lane, Willsboro, NY 12996; 518-963-7492.

Table 5. Effect of oat type and N fertility on DM yield and nitrogen removal of oat forage grown in 2016 in Canton, Chazy and Alexandria, NY.

	DM Yield, tons / acre			Crude Protein, % of DM					
	Canton	Chazy	Alexandria	Canton		Chazy		Alexandria	
Forage	0.675	1.441	1.339	21.5		19.2	b	21.3	
Grain	0.805	1.279	1.331	19.9		22.5	a	22.1	
0N	0.741	1.360	1.335	20.7	c	20.8		21.7	c
50N	0.720	1.391	1.560	24.8	b	21.1		27.0	b
100N	0.754	1.470	1.514	27.6	a	22.1		28.9	a
Forage+0N	0.676	1.441	1.339	21.5		19.2		21.3	
Forage+50N	0.734	1.347	1.525	24.7		20.3		26.8	
Forage+100N	0.770	1.404	1.567	26.6		21.3		28.9	
Grain+0N	0.806	1.279	1.331	19.9		22.5		22.1	
Grain+50N	0.706	1.435	1.595	24.9		22.0		27.2	
Grain+100N	0.739	1.535	1.462	28.5		22.8		29.0	
ANOVA F-test, p-value									
Oat Type	0.339	0.446	0.967	0.319		**0.026**		0.516	
N Trtmt	0.911	0.677	0.181	**<.0001**		0.420		**<.0001**	
Type*N Trtmt	0.531	0.474	0.770	0.152		0.629		0.869	

a,b,c Values within a column grouping followed by the same letter are not significantly different ($P \leq 0.05$).

Table 6. Effect of oat type and N fertility on neutral detergent fiber (NDF) and non-fiber carbohydrate (NFC) content of oat forage grown in 2016 in Canton, Chazy and Alexandria, NY.

	NDF, % of DM			NFC, % of DM		
	Canton	Chazy	Alexandria	Canton	Chazy	Alexandria
Forage	44.3 a	56.6	43.0	22.4	12.4	23.8
Grain	46.9 b	57.6	42.9	21.3	8.1	23.2
0N	45.6	57.1	43.0	21.8 a	10.2	23.5 a
50N	45.0	56.7	43.5	18.4 b	10.3	17.6 b
100N	45.3	57.3	42.7	15.3 c	8.7	16.5 b
Forage+0N	44.3	56.6	43.0	22.4	12.4	23.8
Forage+50N	44.0	55.9	42.7	19.5	12.0	18.6
Forage+100N	44.1	55.7	43.2	17.4	11.2	16.1
Grain+0N	46.9	57.6	42.9	21.3	8.1	23.2
Grain+50N	46.1	57.5	44.3	17.3	8.6	16.6
Grain+100N	46.4	59.0	42.3	13.3	6.3	16.9
ANOVA F-test, p-value						
Oat Type	**0.054**	0.594	0.929	0.539	0.086	0.696
N Trtmt	0.569	0.882	0.782	**0.0001**	0.583	**<.0001**
Type*N Trtmt	0.907	0.669	0.550	0.449	0.905	0.536

a,b,c Values within a column grouping followed by the same letter are not significantly different (P ≤ 0.05).

Table 7. Effect of oat type and N fertility on 30-hour In Vitro True Digestibility and NDF Digestibility of oat forage grown in 2016 in Canton, Chazy and Alexandria, NY.

	30h IVTD, % of DM			30h NDFD, % of DM		
	Canton	Chazy	Alexandria	Canton	Chazy	Alexandria
Forage	92.5	76.3 b	94.5	82.8	58.0 b	87.5
Grain	90.0	79.8 a	93.5	78.5	64.8 a	85.3
0N	91.3	78.0	94.0 a	80.6	61.4	86.4 a
50N	92.1	79.1	92.4 b	82.9	63.5	83.0 b
100N	93.1	78.0	93.6 ab	85.3	61.4	85.0 ab
Forage+0N	92.5	76.3	94.5	82.8	58.0	87.5
Forage+50N	92.3	77.8	92.3	82.5	60.5	82.5
Forage+100N	93.5	77.8	93.3	85.8	60.0	84.5
Grain+0N	90.0	79.8	93.5	78.5	64.8	85.3
Grain+50N	92.0	80.5	92.5	83.3	66.5	83.5
Grain+100N	92.8	78.3	94.0	84.8	62.8	85.5
ANOVA F-test, p-value						
Oat Type	0.138	**0.043**	0.157	0.240	**0.002**	0.103
N Trtmt	0.284	0.370	**0.017**	0.203	0.187	**0.007**
Type*N Trtmt	0.588	0.250	0.233	0.600	0.276	0.157

a,b Values within a column grouping followed by the same letter are not significantly different (P ≤ 0.05).

Table 8. Effect of oat type and N fertility on N removal and yield of digestible DM for oat forage grown in 2016 in Canton, Chazy and Alexandria, NY.

	N Removal, lbs / acre			Digestible DM, lbs / acre		
	Canton	Chazy	Alexandria	Canton	Chazy	Alexandria
Forage	45.5	89.5	90.8	1253	2195	2528
Grain	50.8	91.8	94.5	1450	2037	2493
0N	48.1	90.6	92.6 b	1351	2116	2511
50N	57.1	93.8	134.9 a	1322	2197	2882
100N	65.5	105.4	139.3 a	1400	2291	2836
Forage+0N	45.5	89.5	90.8	1253	2195	2528
Forage+50N	58.3	86.5	131.3	1351	2085	2813
Forage+100N	65.8	96.0	143.5	1440	2183	2925
Grain+0N	50.8	91.8	94.5	1450	2037	2493
Grain+50N	56.0	101.0	138.5	1293	2310	2951
Grain+100N	65.3	114.8	135.0	1359	2399	2747
ANOVA F-test, p-value						
Oat Type	0.588	0.905	0.803	0.410	0.626	0.919
N Trtmt	0.052	0.433	**0.0004**	0.895	0.742	0.272
Type*N Trtmt	0.825	0.766	0.670	0.653	0.631	0.810

a,b Values within a column grouping followed by the same letter are not significantly different (P ≤ 0.05).

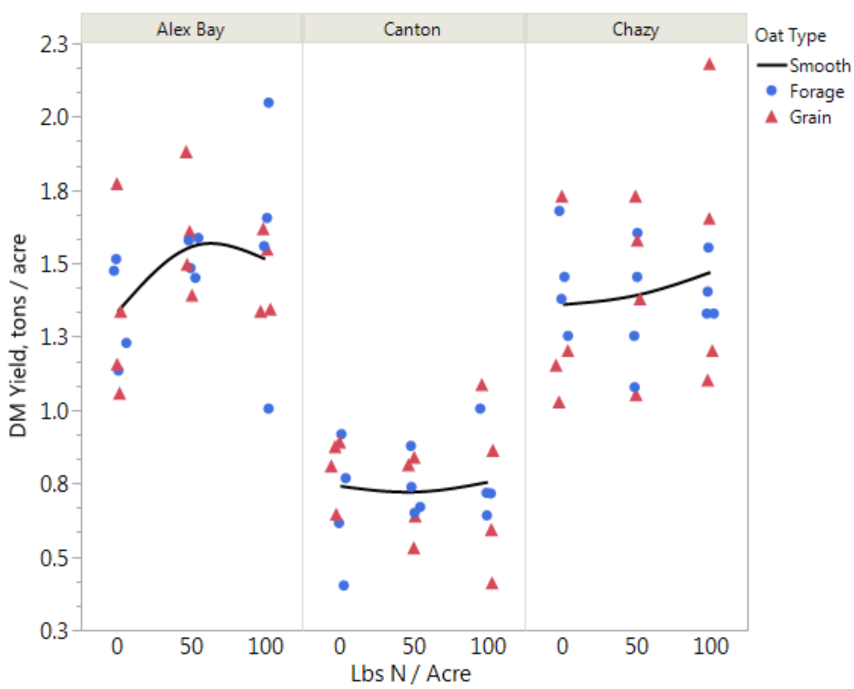


Figure 1. Oat forage dry matter yield (tons per acre) at Alexandria, Canton and Chazy, NY in 2016. Neither oat variety nor nitrogen fertilization significantly affected yield at any location. Forage variety oat yields are shown with blue circles, grain variety yields are depicted with red triangles.

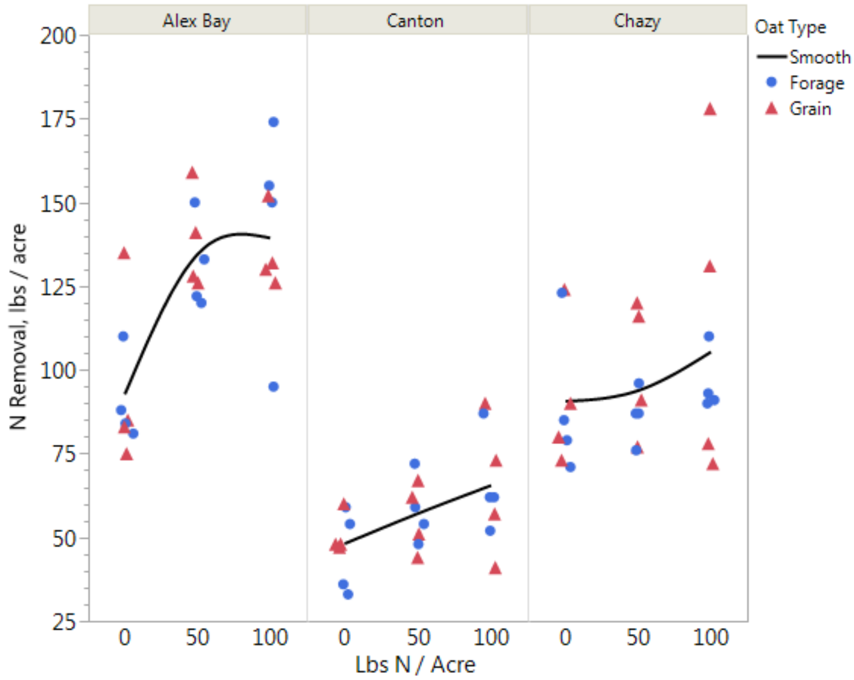


Figure 2. Nitrogen removal (lbs per acre) by oat forages grown at Alexandria, Canton and Chazy, NY in 2016. Nitrogen fertilization significantly affected N removal by oat forages grown at Canton and Alexandria, but not Chazy, NY. Forage variety oat yields are shown with blue circles, grain variety yields are depicted with red triangles.

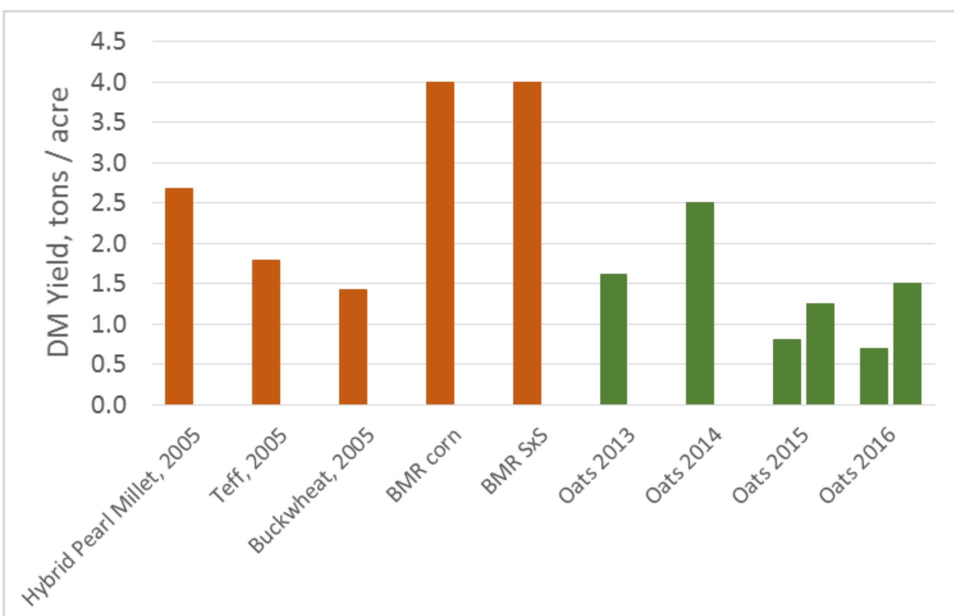


Figure 3. A comparison of late summer forage dry matter yield (tons per acre) grown in New York State. Different forage species were grown in different years, rather than in simultaneous, side-by-side trials. Warm season grasses, millet, teff, corn and sorghum-sudangrass generally produced better than oats and buckwheat.