DOUBLE CROP ROTATIONS WITH WINTER CEREALS AND CORN SILAGE OR FORAGE SORGHUM

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Winter cereals, such as cereal rye (*Secale cereal* L.) and triticale (x *Triticosecale* Wittm.), grown as double crops in corn (*Zea mays* L.) silage rotations in the Northeast United States, have the potential to increase on-farm forage production as well as provide many environmental, economic and nutritional benefits to dairy farms. The past five years have shown that in some years this double crop rotation can be very successful, while in others late harvesting of the winter cereals in the spring can inhibit timely planting of corn silage while late corn harvest combined with early onset of winter can make planting of the winter cereals impossible. Forage sorghum (*Sorghum bicolor* L.) has shown comparable yields and quality to corn silage but its growing season is shorter and as a result, forage sorghum is now being looking into as a potential fit with winter cereals as well.

In this paper we summarize results of a statewide project that includes 59 on-farm winter cereal and the results of nine sorghum nitrogen (N) rate trials that evaluated (1) yield potential and forage quality of the winter cereals and sorghum, (2) economic viability of double cropping corn silage with winter cereals, and (3) the agronomic performance of forage sorghum as an alternative crop to corn silage in rotation.

WHAT IS DOUBLE CROPPING?

Double cropping is the practice of sequentially growing two harvested crops within one growing season. Double crops serve many of the same purposes as cover crops, such as erosion control, uptake and carryover of end-of-season nutrients, and addition of organic biomass, but in this context double crops are harvested in the spring for forage as well. Forage production on dairy farms in New York primarily consists of 3-4 years of corn silage rotated with 3-4 years of alfalfa (*Medicago sativa* L.) and/or grass hay. The development of high-yielding, short-season forage varieties has lead to increased opportunities for cover cropping, even with short growing seasons found in the Northeast. Cover cropping is a better alternative to leaving the ground bare following corn silage harvest. The latter could result in soil and nutrient loss to the environment. Double cropping (as cover cropping) covers the ground, reducing the risk of erosion and nutrient loss.

Double cropping can also help to reduce crop production risk. If a single crop is produced and production is compromised due to adverse weather or

other constraints, the producer must purchase outsourced forage to make up for the losses. Double crops provide an additional source of nutritious feed and provide environmental benefits to the rotation, in addition to serving as emergency feed in the case of yield deficits. Furthermore, increasing forage production on farmer-owned and operated acreage can reduce whole farm nutrient balances and greatly help farms become more environmentally sustainable.

Cereal rye and triticale are viable options for double crops in the Northeast due to their winter survivability and spring yields. Ideal planting dates for these winter cereals range from mid September and early October, and harvest at flag leaf typically occurs in mid to late May. Because the planting and harvest windows can overlap with the warm-season crop, such as corn silage, studies are ongoing to determine ideal planting and harvest times for optimal yield and quality of the winter cereals and to determine alternative main crops such as forage sorghum.

YIELD EXPECTATIONS FOR WINTER CEREALS

Earlier work in New York showed average yields of 1.6 tons dry matter (DM)/acre for cereal rye and 2.2 tons DM/acre for triticale when harvested at flag leaf stage in the spring (Ketterings et al., 2015). In the N-rate trials conducted in 2013-2016, yields at the most economic rate of N (MERN) averaged 1.5 tons DM/acre for cereal rye and 1.9 tons DM/acre for triticale (Table 1). These studies did not include a direct comparison of species on the same location so we cannot conclude from these data that cereal rye yields less than triticale (Table 1). Most cereal rye trials (70%) yielded between 1.0 and 2.0 tons DM/acre, while most triticale trials (76%) yielded between 1.0 and 2.5 tons DM/acre. According to soil test data, two fields that were very low yielding did not respond to N, likely due to deficiencies in P and K. Soil test data from these sites revealed one site was low in P and the other was low in P and very low in K, emphasizing the importance of soil testing for management of winter cereals.

The MERNs averaged 58 and 52 lb N/acre for cereal rye and triticale, respectively (Table 1). However, 34% of the trials show no yield response to N addition (i.e. MERN = 0 lbs N/acre), indicating that at some locations the soil supplied sufficient N. This is likely due to a variety of soil fertility parameters and management practices. Research is ongoing to determine how to predict yield levels and MERN values for specific sites using soil fertility indicators and field histories.

Table 1. Yield ranges, most economic rate of nitrogen (MERN), and yield at MERN for winter cereals harvested at flag-leaf stage in double cropping rotations.

Species*	Locations	Yield (ton DM/acre)			Avg. MERN	Avg. Yield at MERN
		Min.	Max.	Avg.	(lb N/acre)	(ton DM/acre)
Cereal rye	21	0.25	2.88	1.45	58	1.6
Triticale	38	0.27	5.07	1.86	52	2.0

*Winter cereal species were grown on different farms and different fields and thus should not be directly compared.

QUALITY PARAMETERS OF WINTER CEREALS AS DOUBLE CROPS

Quality parameters at the MERN averaged over all rye and triticale sites and N rates were similar between the species (Table 2). Crude protein ranged from 6.6-28.1% DM depending on N rate. Neutral detergent fiber (NDF) ranged from 40.0-64.3% DM, acid detergent fiber (ADF) from 20.0-38.0% DM, in vitro true digestibility (IVTD) from 77.5-94.0% DM, and neutral detergent fiber digestibility (48 hour fermentation; $NDFD_{48}$) from 61.0-86.2% DM. Crude protein typically increased with N rate while for other quality parameters, N application did not have an impact.

Table 2. Quality parameters at the MERN of winter cereals grown as double crops.

Species*	CP	NDF	ADF	IVTD	$NDFD_{48}$
	% of dry matter				
Cereal rye	16.7	52.3	28.1	87.9	77.1
Triticale	15.5	51.8	27.8	88.0	77.2

*Winter cereal species were grown on different farms and different fields and thus should not be directly compared.

THE ECONOMICS OF DOUBLE CROPPING WITH CORN SILAGE

An economic evaluation of double cropping with winter cereals was documented by Hanshar et al. (2015). For this study, the results of a survey of New York farm managers with double cropping experience (Ketterings et al. 2015) were used to determine costs of production, expected changes in profit, and desirable yields for winter cereals in rotation. Break-even winter cereal yields were calculated based on corn silage yield impact as well as fertilizer costs (Table 3).

Table 3. Break-even yields of winter cereals seeded after corn silage harvest and harvested before corn silage planting under four potential scenarios (Hanchar et al., 2015). Data are averaged across five case studies varying in location, species and tillage practices. These include conventional tillage (triticale in Northern NY and cereal rye in Central NY), reduced tillage with wide swath and merge harvest (triticale in Northern NY), no-till (cereal rye in Northern NY), and no-till with merge harvest (triticale in Western NY).

	No impact on corn silage yields	1 ton/acre reduction in corn silage yield
	ton DM/acre	
No additional N fertilizer needed	0.7	1.7
75 lb N/acre needed at green-up	1.0	2.0

This assessment showed that a minimum of 0.8 ton DM/acre was needed if the winter cereal did not need extra N and corn yield was not impacted. In the worst-case scenario, where 75 lb N/acre was needed and corn silage yields were 1.0 ton DM/acre lower than could have been obtained with a long-season variety, a minimum yield of 2.0 tons DM/acre for the winter cereal was needed. The dataset showed that for 24% of cereal rye sites and 53% of triticale sites yields exceeded 2.0 tons DM/acre. For cereal rye and triticale 95, 90, and 52% (cereal rye) and 97, 97, and 66% (triticale) of sites exceeded 0.8, 1.0 and 1.7 tons DM/acre, respectively.

FORAGE SORGHUM: A VIABLE ALTERNATIVE TO CORN SILAGE?

Sorghum has the potential to fit into double cropping rotations well due to a shorter growing season, resistance to extreme weather such as drought (Rosenow et al., 1983), yields competitive with corn silage, and high nutritional value for livestock (Oliver et al., 2004). The latter is especially true to brown mid-rib (BMR) varieties. Trials were implemented 2013-2016 utilizing a dwarf brachytic (branching) variety of BMR forage sorghum, which has greater resistance to lodging as well as increased forage quality as compared to older varieties. The 2016 trials are being harvested now. A preliminary summary of the previous three years showed yields at the MERN averaged 8.5 tons DM/acre, ranging from 5.8 to 12.6 tons DM/acre, with MERNs ranging from 0 to >300 lbs N/acre depending on the year and location (Table 4). CP at the MERN ranged from 5.5-8.9% DM across all sites. Additional quality parameters were analyzed for the 2013 and 2015 trials. For these years, neutral detergent fiber (NDF) values averaged 48.1-51.8% of DM, while acid detergent fiber (ADF) averaged 28.1-30.6% of DM, and total digestible nutrients (TDN) was 67.9-69.9% of DM. In 2015, $NDFD_{30}$ (30-hour fermentation) averaged 29.1% of DM. Additional trials are currently ongoing.

Table 4. Yield at the MERN and quality for BMR brachytic dwarf forage sorghum harvested at soft dough stage. Quality parameters include crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), total digestible nutrients (TDN), and neutral detergent fiber digestibility (30 hour fermentation, $NDFD_{30}$). CP was found at the MERN due to differences between N rates; all other parameters are averaged across N rates.

Year	Yield at the MERN			DM	CP at MERN	NDF	ADF	TDN	$NDFD_{30}$
	----- ton DM/acre ------			%	---------- % of dry matter ----------				
	Min.	Max.	Avg.	Avg.					
2013	8.3	12.6	10.4	31	7.9	51.8	30.6	67.9	-
2014	6.2	9.3	7.8	27	6.5	-	-	-	-
2015	5.8	9.2	7.5	30	6.6	48.1	28.1	69.9	29.1

Harvesting sorghum silage early in the fall may be necessary to meet the ideal winter cereal planting date of September 15 in the Northeast. In 2015, sorghum was harvested every week for nine weeks to determine the tradeoffs between yield and quality if harvested before or after soft dough, the current harvest time recommendation for sorghum silage. Initial trends reveal that earlier harvest times result in reduced yield but increased CP, NDF, ADF and $NDFD_{30}$ (Figure 1).

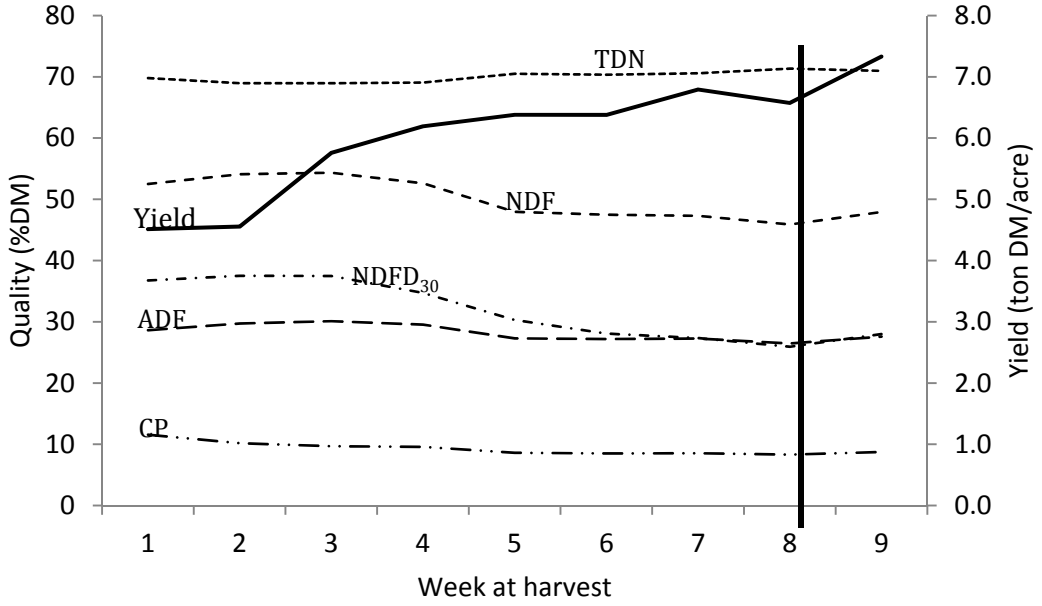

Figure 1. Trends in yield and quality of forage sorghum harvested at different growth stages for one site in 2015. Week 8 is when sorghum was at soft dough stage, and week 9 is following a frost. TDN = total digestible nutrients, NDF = neutral detergent fiber, $NDFD_{30}$ = neutral detergent fiber digestibility at 30 hour fermentation, ADF = acid detergent fiber, and CP = crude protein.

DOUBLE CROPPING POTENTIAL IN THE NORTHEAST

Double cropping in the Northeast has the potential to be an economically and environmentally favorable practice for dairy farmers. Preliminary results show that winter cereals can provide a significant amount of additional, nutritious forage without greatly interfering with corn silage production. However, alternative warm-season crops to corn silage could be viable options. Forage sorghum can be a nutritious silage crop with competitive yields. It fares well in years with extreme weather, such as in 2016 when a severe drought impacted corn silage throughout New York. Work is ongoing to determine specific planting dates, harvest times, and fertilizer recommendations for these crops to ensure successful implementation of these rotations.

CONTACT INFORMATION

To get more information about double cropping and participating in the New York On-Farm Research Partnership including these projects, contact Quirine M. Ketterings, Nutrient Management Spear Program, Cornell University, Department of Animal Science, 323 Morrison Hall, Ithaca NY 14850. Access: http://nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/DoubleCrops.html and http://nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/ForageSorghum.html for protocols and other materials on the projects.

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