WHY PLANT WINTER RYE AFTER CORN SILAGE?
NUTRIENT MANAGEMENT IMPLICATIONS

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Introduction

Planting a winter rye cover crop after corn silage is an easily implementable conservation practice. Harvest as forage the following spring can generate income which should make the practice even more appealing for producers. Forage best management practices can be found in an NPM Program publication: Planting Winter Rye after Corn Silage, Managing for Forage (http://ipcm.wisc.edu/Publications/tabid/54/Default.aspx). Managing rye for optimum forage yield and quality will maximize conservation benefits including nutrient management. In this paper we will discuss nutrient management implications and opportunities.

Rye Nutrient Removal

Estimated nutrient removal by rye harvested in boot stage is shown in table 1. The Wisconsin information represents trial data from three locations in Southern Wisconsin (Arlington, Janesville and Lancaster, 11 site-years) and is comparable to values published by the National Research Council (NRC, 2001).

Table 1. Estimated nutrient removal by rye forage harvest, Wisconsin data compared to values published by the National Research Council.

	Wisconsin	NRC*
	lb/ton	
N	52	52
P_2O_5	18	19
K_2O	80	81
n	212	1155

* Source: NRC, 2001 (values rounded). All values on a dry matter basis.

Rye nutrient removal values reported here exceed those published in University of Wisconsin-Extension (UWEX) publication A2809 “Nutrient application guidelines for field, vegetable, and fruit crops in Wisconsin”. This new data will be incorporated into the next revisions of UWEX A2809 and SNAP Plus for use in nutrient management planning. Both of these resources are revised periodically as new information becomes available.

Under the NRCS 590 (9/05) standard (V.A.1.a), use of plant tissue analysis is permissible for nutrient application decisions if plant sampling and testing are done following University of Wisconsin recommendations. Documentation of rye dry matter (DM) yield with approved tissue testing to establish removal rates could serve nutrient management planning purposes until revisions are made. This is also recommended based on the discussion of nutrient variability below, especially on high test soils. Nutrient management planners may want to contact county plan reviewers (NRCS or Land Conservation departments) to determine what’s permissible for plans submitted in that jurisdiction.

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Nutrient Removal Variability

Wisconsin data indicate that rye tissue levels of phosphorus (P) and potassium (K) are variable and significantly related to soil test levels of these nutrients. Figure 1 shows the relationship when trial data are controlled to remove the effect of all other variables. The correlation is stronger for P than K, although soil test K levels had less of a uniform distribution across experimental sites compared to soil test P.

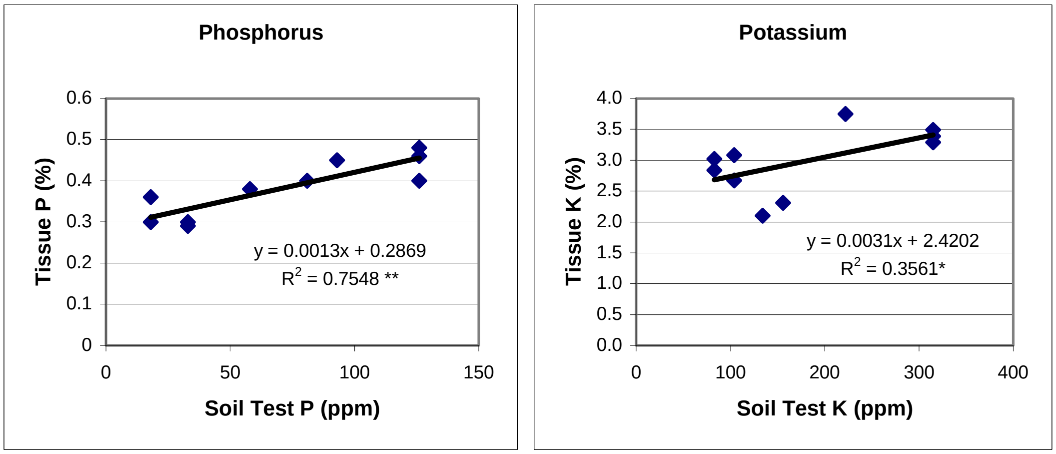

Figure 1. The relationship between soil test level and rye tissue nutrient concentration. Data points represent trial means, n=184.

Variable (and elevated) levels of tissue nutrients will impact total nutrient removal. Table 2 shows the influence of tissue nutrient concentration and forage yield on total nutrient removal across the range of values observed in our trials. The implication of this data is that rye harvested from soils with elevated levels of nutrients will have greater nutrient concentration and following cultural practice which optimize forage yield will enhance nutrient removal. Rye forage should be tested so that true removal can be estimated and accounted for in nutrient management plans. Dairy producers should also monitor forage K levels to avoid related metabolic disorders.

Table 2. Per acre nutrient removal based on tissue nutrient level and dry matter yield.

Tissue	Forage yield (t/a)			
concentration	1	2	3	4
P (%)		P_2O_5 (lb/a)		
0.25	11	23	34	44
0.30	14	27	41	56
0.35	16	32	48	64
0.40	18	36	55	72
0.45	20	41	61	80*
K (%)		K_2O (lb/a)		
2.00	48	96	144	192
2.50	60	120	180	240
3.00	72	144	216	288
3.50	84	168	252	336
4.00	96	192	288	384*

*, values at this level have not been observed in Wisconsin research. All values on a DM basis.

Total Annual Nutrient Removal

Rye harvest as forage contributes significantly to total annual nutrient removal when combined with nutrient removal by the following crop. Table 3 shows the contribution and total removal (2-year) when corn silage is followed by silage again, soybean or alfalfa, three likely cropping sequences, as calculated by SNAP Plus (version 1.121) and using actual removal, calculated from tissue testing results. This example demonstrates the advantage of documenting removal rates with tissue sampling when developing nutrient management plans.

Table 3. Impact of rye on nutrient removal for various crops following corn silage, calculated by SNAP Plus (version 1.121) compared to tissue sampling to estimate removal.

Crop Rotation						Annual increase	
		P_2O_5	K_2O	Impact of rye		(year 2) with rye	
Year 1	Year 2	balance	balance	P_2O_5	K_2O	P_2O_5	K_2O
SNAP Plus		(lb/a)		(lb/a)		%	
Corn silage	Corn silage	-160	-370				
	Rye - Corn silage	-190	-490	-30	-120	38	65
Corn silage	Soybean	-120	-255				
	Rye - Soybean	-150	-375	-30	-120	75	171
Corn silage	Alfalfa seeding	-105	-290				
	Rye - Alfalfa seeding	-135	-410	-30	-120	120	114
Tissue testing							
Corn silage	Corn silage	-160	-370				
	Rye - Corn silage	-210	-590	-50	-220	63	119
Corn silage	Soybean	-120	-255				
	Rye - Soybean	-170	-475	-50	-220	125	314
Corn silage	Alfalfa seeding	-105	-290				
	Rye - Alfalfa seeding	-155	-510	-50	-220	200	209

Yield goals: corn silage, 21-25 t/a; rye, 2-3.5 t/a; soybean, 46-55 bu/a; alfalfa seeding, 1-2.5 t/a.
Tissue sampling example uses means of observed values, Table 1.

Enhanced nutrient removal presents both opportunities and challenges to nutrient management planning. Enhanced phosphorus removal can be used on soils exceeding 50 ppm to maintain nitrogen (N) based manure application rates in absence of prolonged periods of P drawdown (alfalfa). The combination of corn silage and rye will use both first and second year N credits from manure rates supplying the N requirements of corn. Combined P_2O_5 removal exceeds the P contribution from that manure application. On soils requiring P drawdown, the rate will be accelerated with enhanced P removal. Growing a non-forage crop such as soybean after rye will also help with whole-farm nutrient budgeting as a portion of the P will leave the farm as grain. Inclusion of rye as a forage source may make this possible by its contribution to total farm forage inventory, reducing the number of acres devoted exclusively to forage production.

Potassium removal may be more problematic. Although it will be recycled through manure applications, enhanced removal could result in the need for increased K_2O application rates in situations of long drawdown in absence of manure applications, such as rotating to alfalfa. This should be considered when developing nutrient management plans.

Optimizing Nutrient Removal

Nitrogen availability has a significant impact on DM yield and by association nutrient removal because removal is based on yield and tissue nutrient concentration. Rye is moderately responsive to applied N. Multi-year, multi-site N response trials have found that DM yield is maximized at 80 lb/a, and that the slope of the response curve is moderate (Figure 2).

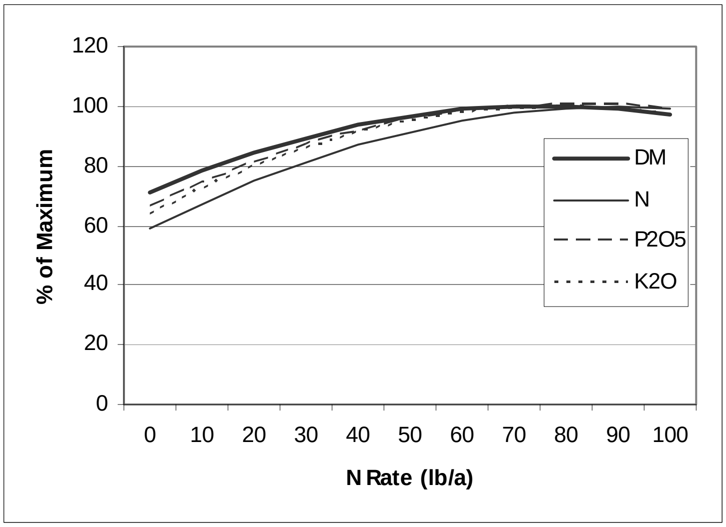

Figure 2. Response of DM yield and nutrient removal to added N, expressed as percentage of maximum yield.

For economically optimum forage production, we've recommended N rates of up to 80 lb/a if legume and/or manure credits are used, and 40 to 60 lb/a if fertilizer sources are used. Fertilizer N rates take into account the moderate slope of the response curve as well as fertilizer price and the value of the forage produced. Economically optimum nitrogen rate for a range of prices and values can be found in Table 4. Rates beyond 80 lb/a are not recommended because of yield reduction from lodging.

Table 4. Economically optimum nitrogen rates (EONR) for fertilizer applications to to winter rye for forage production.

Forage value	Nitrogen price ($/lb N)								
($/ton)	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70
50	49	44	40	35	30	26	21	17	12
60	53	49	46	42	38	34	30	27	23
70	56	53	50	47	43	40	37	34	30
80	59	56	53	50	48	45	42	39	36
90	61	58	56	53	51	48	46	43	41
100	62	60	58	55	53	51	49	46	44

The influence of added N on nutrient removal can also be seen in Figure 2. Although maximum P_2O_5 and K_2O removal occurs at N rates of 80 to 90 lb/a, approximately 90% of total uptake can be achieved at 40 lb/a (one-half the maximum rate, or the low end of the recommended range) because of the slope of the response curve. The likely explanation for this is that rye is an excellent scavenger for residual soil nitrate-N (McCracken et al, 1994; Shipley et al 1992), capturing this nutrient source for crop/livestock use while reducing leaching potential. This has also been demonstrated in Wisconsin (Stute et al., 2007).

It may be possible to manage rye's ability to achieve near maximum removal at one-half maximum rate N fertilization to optimize nutrient removal. This would allow flexibility in nutrient management planning, depending on manure availability and soil test levels. In situations where manure availability is limited, or soil P is to be drawn down, second year credits from manure applications to meet the N demand of previous corn silage will supply sufficient N to achieve 80 to 90% of DM yield and P_2O_5 removal without adding P, accelerating drawdown. In situations where higher manure rates are desired to reduce inventory, rye will accommodate an additional 40 lb N acre (manure equivalent rates: 10 t/a solid, incorporated or 4,000 gal/a liquid, incorporated) and still balance P_2O_5 based on current recommendations (UWEX A2809). Loading N to removal rates is risky because of lodging potential and will over-apply P_2O_5, unless planning for rotation drawdown with long-term alfalfa stands. Long-term nutrient management planning is recommended so manure application strategies can best use the flexibility of rye.

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