Cover Crops for Emergency Forage

(Thames Valley and Eastern Valley Paired Partner Grant – Interim Report)

Purpose:

There is a great opportunity following winter wheat to grow cover crops, which can also be used as additional forage. As producers needed and considered this forage opportunity, it became obvious that virtually no data existed on the best crop to fill this void. Even once the cover crop species was chosen, management for optimum forage yield was unknown. Optimum seeding and nitrogen rates were major areas were data was minimal or even non-existent.

This project was initiated to determine agronomic recommendations for cereal crops grown as forage following a winter wheat crop.

Methods:

Small plot, 4 replicate trials were established at 16 sites from 2012 - 2014. Three different crops (Oat, Barley, Oat/Pea mix) were planted at 4 different seeding rates (targeting 2, 3, 4, and 5 bushels per acre). Wheat and forage oats were also included at 2 of the sites in 2012. In 2014 triticale and a rust resistant variety of oats was added to the plots. In 2012, sites were planted between July 31st and August 4th. In 2013 and 2014 planting was delayed until mid to late August. The planting dates ranged from August 15th through August 27th. The seed was no-tilled into wheat stubble using a 1560 John Deere Drill. In 2013 and 2014 half the sites were seeded using a Vaderstaad Rapid seed drill. Four different nitrogen rates (0, 30, 60, and 90 lbs of actual N) were applied across these strips. In 2013 and 2014 a 120 N rate was also included. Urea fertilizer was broadcast once the crop emerged using a Valmar air delivery system. Yields were measured using a Carter forage plot harvester that cut and weighed a 1.5 X 3 metre (5’ X 10’) foot strip through each plot. The plants were cut at or near ground level. A sub sample was collected and chopped to determine moisture, phosphorus and potash tissue levels, along with several factors to calculate relative feed value across the treatments (ADF, NDF, protein, Mg, Ca, etc). To reduce analysis costs only one seeding rate from each site was analyzed for feed quality, with the same relative seeding rate used for each species at any location. Every nitrogen rate was sub sampled and analyzed for quality at that seeding rate. It was assumed that seeding rate would not have a significant impact on forage quality. To further reduce the risk from making this assumption, the seeding rate used for sampling was alternated across locations.

Results:

The 3 year yield data is summarized in Table 1. Seeding rates had a slight impact on yields based on the average data but results were variable between years. All yields are reported on a 100% dry matter basis (0% moisture).

Table 1: Yield Results 2012-2014 12 Sites (t/acre 0%DM)

Treatment	0 N	30 N	60 N	90 N
70 lbs Oats	1.02	1.42	1.58	1.77
105 lbs Oats	0.98	1.45	1.60	1.80
140 lbs Oats	1.16	1.54	1.69	1.78
175 lbs Oats	1.20	1.66	1.81	1.97
70 lbs O+P	0.96	1.22	1.34	1.46
105 lbs O+P	1.24	1.46	1.62	1.72
140 lbs O+P	1.25	1.55	1.68	1.78
175 lbs O+P	1.29	1.56	1.70	1.79
90 lbs Barley	0.88	1.17	1.33	1.42
130 lbs Barley	0.96	1.27	1.42	1.54
170 lbs Barley	0.94	1.27	1.40	1.59
205 lbs Barley	0.97	1.35	1.45	1.65

Table 2 contains the seeding rate data broken down by year. In 2012 Oats and Peas (O+P) was the only crop that showed any response to higher seeding rates. Oats alone and barley showed no response to increasing seeding rates above 2 bushels/acre (70 and 90 lbs respectively). In 2013 and 2014 all 3 crops had some yield response to higher seeding rates. However, yield response was variable across locations. The lower yields in 2013 and 2014 are due to later planting dates (early Aug in 2012 and mid to late Aug in 2013 and 2014). While there is some response to seeding rate in 2 of the 3 years, it is generally not an economic response.

Table 2: Seeding Rate Impacts by Year (t/ac 0%DM)

seeding rate (bu/ac)	Oats			O+P			Barley		
	2012	2013	2014	2012	2013	2014	2012	2013	2014
2	1.90	1.43	1.17	1.69	1.23	0.94	1.68	0.74	1.25
3	1.80	1.46	1.31	1.84	1.56	1.27	1.61	1.04	1.34
4	1.83	1.63	1.31	2.03	1.60	1.19	1.72	1.00	1.30
5	1.97	1.80	1.35	1.94	1.67	1.27	1.67	1.13	1.38

Nitrogen (N) rates had a major impact on yields. Yield response to N is summarized in Table 3. In 2012 oats and O+P had relatively strong yields with no nitrogen but yields still increased dramatically with the addition of 30lbs N and continued to increase up to 60 N. There was no additional yield response to 90N with the oats or O+P combination. Barley showed the strongest response to N. Barley yields almost doubled from the addition of 90 N over the 0N check.

In 2013 a 120 N treatment was added to the trial. Similar to 2012 O+P had relatively strong yields with no nitrogen. Yield response to 30 N was not as significant in 2012 but yields continued to respond to added N up to the 120 N treatment. Oat yields lagged without any N but quickly rose as N was added. In 2013 something went wrong with the barley strips at several locations. The plants were short and were behind in maturity resulting in very poor yields overall. Despite this barley continued to show a strong response to increased N.

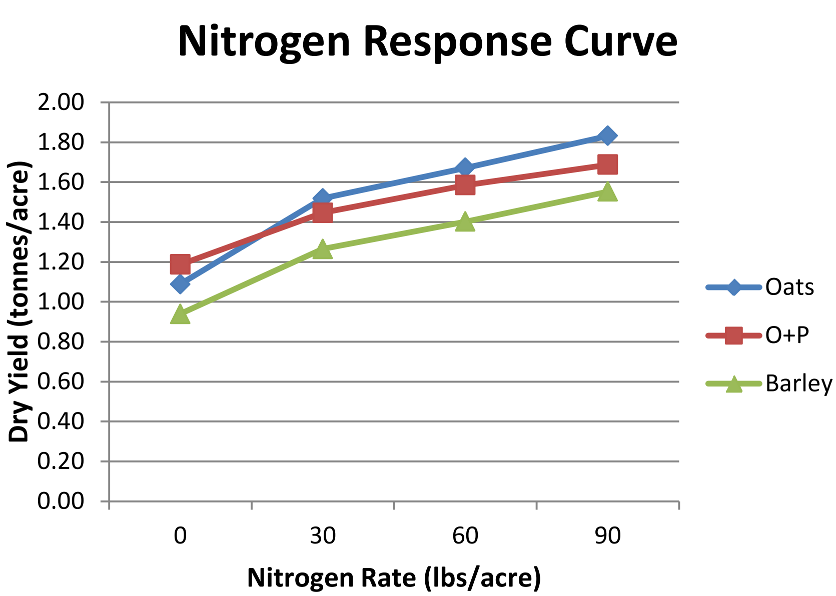
In 2014 all 3 crops had a lower response to increased N. Oats once again had a strong response to the first 30 pounds of N but yield gains were smaller as additional N was added. Similar to 2013 O+P showed a slow but consistent response to N. Barley yields were back up to normal in 2014 but similar to oats response to added N was much lower than previous years. Both oats and barley began to reach maximum yields with 90 N.

Table 3: Yield Response to N by Year

N Rate	Oats			O+P			Barley		
	2012	2013	2014	2012	2013	2014	2012	2013	2014
0	1.39	0.93	0.95	1.49	1.15	0.92	1.14	0.68	1.00
30	1.95	1.36	1.24	1.91	1.36	1.07	1.63	0.87	1.30
60	2.10	1.56	1.36	2.05	1.50	1.21	1.86	0.99	1.35
90	2.07	1.96	1.47	2.05	1.74	1.28	2.05	1.14	1.47
120	-	2.08	1.41	-	1.83	1.36	-	1.21	1.46

To better show how each crop responds to N, the 3 year yield response curve is graphed in Figure 1.

Figure 1: Yield Response Curve 2012/2013/2014 average



Yield is not the only factor that determines which cover crop will be the best fit for all producers. Protein is a very important aspect of an animal's diet. The crude protein values are summarized in Table 4. Forage quality analysis from the 2014 sites is still pending so only the 2012 and 2013 data is shown. There was variation in protein response between sites but as expected protein increased with the addition of nitrogen. Across all locations and nitrogen rates O+P clearly had higher protein values than barley or oats alone. The protein values are relatively low in 2012 because the crops were at the heading stage when harvested compared to the flag leaf stage in 2013.

Table 4: Crude protein values

N Rate	Oats		O+P		Barley	
	2012	2013	2012	2013	2012	2013
0	7.8	11.6	10.4	15.4	8.9	13.1
30	8.7	12.2	12.6	15.1	9.7	14.3
60	9.1	13.2	12.8	16.6	10.5	15.3
90	10.7	14.0	14.0	16.1	10.9	15.8
120	-	16.2	-	17.9	-	16.4

The relative feed value (RFV) determined from the quality analysis across locations is summarized in Table 5. RFV incorporates potential intake along with digestibility to produce one value to represent forage quality. In 2012 RFV for barley and oat decreased slightly but consistently as nitrogen rates increased. The exact reason for this decrease has not been determined. Whether higher nitrogen rates caused increased stem elongation and increased lignin content, or some other factor, this result remains to be explained or verified. 2013 results showed almost no difference in RFV across treatments. Increasing nitrogen rates had little impact on the quality of the O+P mix in both years, where the addition of peas helped maintain forage quality across N rates.

Table 5: Relative Feed Value

N Rate	Oats		O+P		Barley	
	2012	2013	2012	2013	2012	2013
0	121	118	115	116	121	136
30	119	113	118	112	114	131
60	111	109	114	114	110	129
90	108	108	113	119	106	135
120	-	115	-	118	-	134

RFV is one indicator of forage quality but does not consider all factors affecting forage value**.** TDN (Total Digestible Nutrients) and milk/ton are summarized in Table 6. Milk/ton is a more comprehensive analysis to predict milk production from each treatment, and is a better tool to assess value in the dairy industry. It is based on NDF (Neutral Detergent Fibre), crude protein, ash, and ether extract. TDN is widely used in the beef industry to determine forage quality and is based on digestible energy. Barley consistently had the highest feed value while there was little difference between Oats and O+P. Nitrogen had little impact on milk/ton or TDN.

Table 6: TDN and Milk/Ton

Crop	Asses.	0 N	30 N	60 N	90 N	120 N
Oats	Milk/ton	3141	3103	3064	3052	3068
	TDN	63.3	61.3	61.4	60.4	62.5
O+P	Milk/ton	3104	3056	2989	3057	3049
	TDN	62.5	61.8	62.1	62.1	61.6
Barley	Milk/ton	3164	3176	3135	3144	3111
	TDN	64.7	63.68	63.7	64.58	64.1

Table 7 contains the estimated production per acre accounting for both yield and forage quality. Since there was little difference in milk/ton or TDN between N rates, production per acre closely follows the same trend as yield per acre. The high forage quality of barley was not able to compensate for the lower yield.

Table 7: Pounds of Beef/milk per acre

Crop	Asses.	0	30	60	90	120
Oats	Beef/acre	219	293	329	381	401
	Milk/acre	3257	4455	4932	5774	5911
O+P	Beef/acre	237	276	309	344	361
	Milk/acre	3536	4093	4463	5078	5364
Barley	Beef/acre	200	253	274	309	315
	Milk/acre	2935	3791	4051	4520	4587

Another consideration when growing any forage is nutrient removal. Phosphorus and potash removal is summarized in tables 8 and 9. The removal values are summarized as the amount of fertilizer needed to replace crop removal. Phosphorus removal is P2O5 and potash is K2O, the equivalent form that commercial fertilizer is based on. Removal per acre is based on the nutrient concentration in the plant and the average yield across all seeding rates at each location: eg: oats with 60 lbs N applied removed 30.6 lbs of P2O5 and 136.3 lbs of K2O per acre (on average) in 2012. The 2014 forage analysis is still pending.

These removal rates are extremely high**.** In high yield situations, over $100/acre can easily be removed in P and K fertilizer values alone. The difference in phosphorus and potash removal between 2012 and 2013 is explained by the higher yields in 2012.

Table 8: P2O5 Removal (pounds/acre)

N Rate	Oats		O+P		Barley	
	2012	2013	2012	2013	2012	2013
0	19.2	10.4	22.8	12.8	17.6	9.3
30	28.6	18.3	31.3	17.3	26.8	12.5
60	30.6	19.6	32.5	20.4	32.5	15.8
90	31.8	23.4	35	20.6	36.5	17.6
120	-	25.9	-	22.9	-	20.0

Table 9: K2O Removal (pounds/acre)

N Rate	Oats		O+P		Barley	
	2012	2013	2012	2013	2012	2013
0	70.2	54.6	91.6	65.2	59.0	42.8
30	120.8	98.0	136.1	91.8	93.0	57.7
60	136.3	112.8	151.7	112.6	119.4	74.3
90	150.2	121.4	167.9	106.9	138.1	84.0
120	-	140.9	-	122.0	-	100.7

Potash concentrations in all crops increased dramatically as nitrogen rates increased (Figure 2). This finding was a surprise, and has not been fully explained. It may have to do with ion balance in the plant, with higher N rates (negative charge) requiring higher potash uptake (positive charge) to maintain proper ion balance, but this hypothesis has yet to be verified. However, the consistency of this outcome, and the huge impact on nutrient removal, means it must be considered when harvesting the crop.

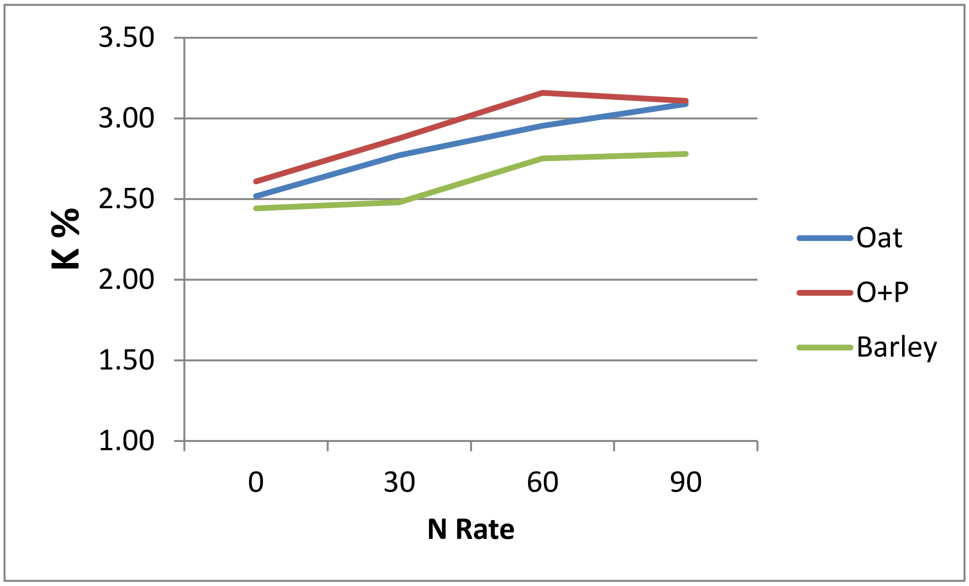
Summary:

Bottom line: recommendations based on the 3 years of this study (to date) support oats as the cover crop of choice, with seeding rates kept reasonably low and additional dollars spent on nitrogen. Weed control is critical to successful cover crop growth. High potash removal rates must be accounted for when removing a cover crop grown after winter wheat as forage.

Seeding rates had little impact on yield while nitrogen dramatically increased forage yields. With no added nitrogen oat-pea blends had the highest yields. With only 30 lbs/ac N applied oat yields began to surpass O+P yields. Additional seed costs associated with the inclusion of peas indicate that oats alone would be more economical, when 30 units of applied N was applied, unless high protein feed is required.

Oat forage yields increased sufficiently to warrant 60 lbs/ac N applied in 2012, 90 lbs N/ac in 2013 and 90 lbs N/ac in 2014. The oat-pea blend responded to 30 N, 90 N, and 60 N, and the barley to 90 N, 90N, and 90 N, respectively.

Figure 2: Nitrogen impacts on Potash Concentration (2012/2013 avg)



When considering both yield and forage quality, oats plus nitrogen still come out on top. Barley had the highest relative feed value but lower barley yields mean less total feed value harvested/acre. Barley required 90 N/ac to match oats or O+P with 30N in TDN or milk/acre. If highest crude protein is required, or no nitrogen will be applied, then an oat-pea blend would be the best choice. Based on milk or TDN production per acre, oats with applied N is the clear winner. Not only do oats with N have the highest production per acre but also the lowest cost.

In 2012 two sites also included spring wheat and forage oats. Spring wheat showed little potential based on yield or feed value. Spring wheat advanced much quicker through its growth stages than expected. Wheat appears most sensitive to photoperiod: as the days get shorter the wheat quickly advances through its growth stages to maturity. This resulted in less crop growth and poor feed quality. Forage oat yields were poor but they had the highest feed value of all the crops. This was likely due to the fact that the forage oats were at the boot stage while the other crops had advanced well into heading.

In 2014 triticale and a rust resistant variety of oats was included. The triticale yields were below oat, O+P, and barley yields. Low yield coupled with high seed costs make triticale a less attractive option. The rust resistant oat had slightly lower yield than the rust susceptible oat even when rust was present. This is likely due to the rust resistant oat not being as far advanced at harvest. It could also be a strict variety response, as this work did not evaluate different varieties for forage yield potential. Spring wheat, forage oat, triticale and rust resistant oat data is not included in the report as it is only based on 1 year of data, but is available upon request.

The yield and quality from one location in 2013 were not included in this report due to large variability in the data. High weed pressure at this location is the probable cause, which illustrates the importance of proper weed control to grow a successful cover crop. Volunteer wheat in strips behind the combine can virtually eliminate any cover crop growth: some form of control of volunteer wheat is essential to achieve highest possible cereal forage yields.

Potash removal rates border on extreme. Phosphorus removal rates are significant. Removal of fertilizer nutrients can easily top $100/acre. These costs must be included when determining the practicality of these crops as forage, and replacement of these nutrients is critical.

Next Steps:

This trial is now complete.

Acknowledgements:

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Location of Project Final Report:

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