Economic analysis of cover crops: Impact of interseeding red clover in wheat on corn production economics

Interseeding (frost seeding) red clover in winter wheat has proven a successful and mostly consistent way of establishing a legume cover crop before corn. This relay cropping system mitigates the risk of stand failure associated with post-harvest establishment frequently attributed to dry summer conditions. Additionally, it captures one-half of season-long growing degree day accumulation, provides nearly complete soil cover and contributes nitrogen (N) to the following corn crop. In no-till systems, the growing cover crop and subsequent residue protects the soil from wheat canopy closure through corn harvest. Recommendations for clover establishment and management can be found in several University Extension publications including “Frost seeding red clover in winter wheat” cited below.

The nitrogen credit to corn is frequently cited as the major economic benefit of the practice, however, there is growing evidence that properly managed cover crops can cause a yield increase in the following crop. This positive “rotational effect” has been attributed to several factors including improved soil health among other things, but the bottom line is that it can contribute to the bottom line. Figure 1 demonstrates both the rotational effect and N credits attributable to red clover.

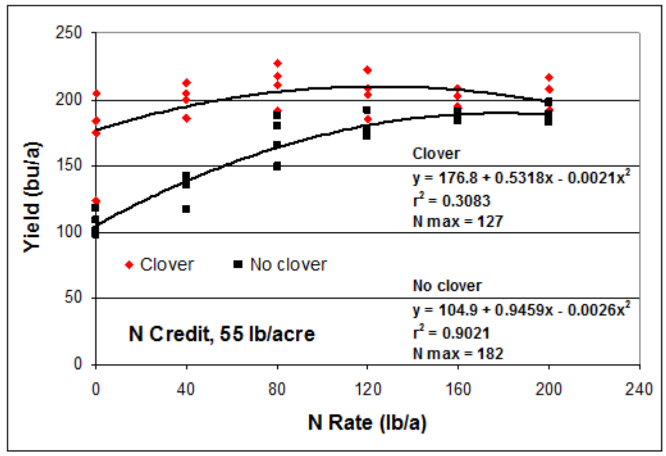

Figure 1. Corn response to previous cover crop and N application demonstrating both rotation and N effects.

A recently completed study, funded by the National Wildlife Federation examined the economic performance of the system in the upper mid-west. This publication discusses important findings of the study.

Study Methods

This study had two objectives. The first was to determine the size and variability of the rotational effect and the second, to conduct an economic analysis factoring in all additional costs and returns under current market conditions to estimate the net return ($/acre) for cover crop use.

Rotational effect was determined by a meta-analysis of data from all reported studies (31 site-years of data, all replicated 4 times) where corn followed wheat with and without (+/-) red clover and where N fertilizer was applied at rates which met or exceeded University Extension recommendations, insuring N was not a limiting factor. Response ratio: corn yield following wheat + clover/corn yield following wheat alone was used to estimate the rotational effect. The average value of this dataset is a 12.1% yield increase. To determine variability as an estimate of risk, standard deviation was used which covers approximately 70% of the probability a yield response will fall in the range from low to high. For the sake of this analysis, values were rounded to the nearest whole percentage; the average yield response is 12%; low, 2% and high, 22%. Calculations vary by corn yield level. This “base yield” is assumed to be a long-term average as used in crop insurance.

Partial budget analysis, which accounts for cost and return differences between the systems was used to calculate a net return per acre. The analysis included additional costs for clover establishment, management and termination (constant costs) and costs associated with additional corn yield including drying, hauling and nutrient removal (yield-dependent costs). Interest was charged at 5% for all constant costs from the time of material application to corn harvest. Three-year (2014-2016) average prices based on published market surveys were used (Table 1).

Returns include additional corn yield valued at several market prices and the value of the N credit. A 50 lb/acre N credit, the minimum based on University of Wisconsin- Extension recommendations was assumed to make the analysis conservative. Returns are variable based on market prices so sensitivity analysis was used to demonstrate the relationship between changing market prices and net return.

Costs for field operations are based on published custom rate guides. Field operations are based on best management practices (BMPs) detailed in the afore mentioned publication which seek to capture efficiencies by piggy-backing clover management on existing operations representing no net additional cost in most cases including:

- Clover seed is co-applied with urea to wheat using air-flow equipment during spring N application
- Volunteer wheat is terminated in fall with herbicide. Additional herbicide (2,4-D ester) is added to increase efficacy of clover termination.

Table 1. Three-year average costs.

Additional constant costs	**($/a)**
Red clover seed, 12 lb/a	32.16
Clipping	13.10
2,4-D (ester), 1 qt/a	6.27
Interest (5%APR)*	3.77
*from time of application to corn harvest	
Total:	55.30

Additional yield-dependent costs	**($/unit)**
Drying (bu)*	0.45
Hauling (bu)**	0.17
P and K removal (bu)	0.22
*25% to 15%, $0.045/pt.	
** to market, within 25 miles	

Unit prices	**($lb)**
N	0.49
P_2O_5	0.36
K_2O	0.27
Red clover seed	2.68
* as 28% UAN, DAP, potash	

2014-2016

Findings and Analysis

A positive rotational effect is necessary under current market conditions to produce a net return. Total costs for clover establishment, management and termination exceed $55/acre which are only partially offset by the value of the N credit ($24.50/acre).

Net return per acre varies based on crop price, base corn yield and level of yield response (Table 2). Net returns with an average yield response of 12% are positive regardless of base yield or corn price. Returns increase substantially with high yield response regardless of base corn yield. Under conditions of low yield response, returns are negative but are reduced as base yield increases.

Table 2. Net return ($/acre) to corn following red clover based on base corn yield, level of yield response and corn price.

Base yield (bu/a):*	**125**			**150**			**175**			**200**		
Yield response level:**	**Low**	**Ave.**	**High**	**Low**	**Ave.**	**High**	**Low**	**Ave.**	**High**	**Low**	**Ave.**	**High**
Corn yield (bu/a):	**127.4**	**140.1**	**152.8**	**152.9**	**168.1**	**183.3**	**178.4**	**196.1**	**213.9**	**203.8**	**224.1**	**244.4**
Corn Price ($/bu):												
3.50	-17.12	15.51	48.14	-15.81	23.34	62.49	-14.51	31.17	76.85	-13.20	39.00	91.20
3.75	-16.49	19.26	55.01	-15.06	27.84	70.74	-13.63	36.42	86.47	-12.20	45.00	102.20
4.00	-15.87	23.01	61.89	-14.31	32.34	78.99	-12.76	41.67	96.10	-11.20	51.00	113.20

** Represents 10-year average corn yield*
*** Yield response: low; 2%; ave. 12%; high, 22%*

The relationship between the level of yield increase and corn price is shown in Table 3. The table covers a range of yield response from 2 to 12%, the range in which break-even occurs and the practice becomes profitable. In general, as average base corn yield increases, less yield response to cover crop is required for a positive net return. Conversely, greater yield responses are required where base yield and yield potential are lower.

Table 3. Net return ($/acre) based on yield response and corn price by base yield level.

Yield (bu/a)	Corn Price ($/bu)	Yield Increase	Yield Response (%)/ Yield Increase (bu/a) 2%	3%	4%	5%	6%	7%	8%	9%	10%	11%	12%
125		bu/a:	2.50	3.75	5.00	6.25	7.50	8.75	10.00	11.25	12.50	13.75	15.00
	3.00		(18.37)	(15.73)	(13.09)	(10.45)	(7.82)	(5.18)	(2.54)	0.10	2.74	5.37	8.01
	3.10		(18.12)	(15.35)	(12.59)	(9.83)	(7.07)	(4.30)	(1.54)	1.22	3.99	6.75	9.51
	3.20		(17.87)	(14.98)	(12.09)	(9.20)	(6.32)	(3.43)	(0.54)	2.35	5.24	8.12	11.01
	3.30		(17.62)	(14.60)	(11.59)	(8.58)	(5.57)	(2.55)	0.46	3.47	6.49	9.50	12.51
	3.40		(17.37)	(14.23)	(11.09)	(7.95)	(4.82)	(1.68)	1.46	4.60	7.74	10.87	14.01
	3.50		(17.12)	(13.85)	(10.59)	(7.33)	(4.07)	(0.80)	2.46	5.72	8.99	12.25	15.51
	3.60		(16.87)	(13.48)	(10.09)	(6.70)	(3.32)	0.07	3.46	6.85	10.24	13.62	17.01
	3.70		(16.62)	(13.10)	(9.59)	(6.08)	(2.57)	0.95	4.46	7.97	11.49	15.00	18.51
	3.80		(16.37)	(12.73)	(9.09)	(5.45)	(1.82)	1.82	5.46	9.10	12.74	16.37	20.01
	3.90		(16.12)	(12.35)	(8.59)	(4.83)	(1.07)	2.70	6.46	10.22	13.99	17.75	21.51
	4.00		(15.87)	(11.98)	(8.09)	(4.20)	(0.32)	3.57	7.46	11.35	15.24	19.12	23.01
150		bu/a:	3.00	4.50	6.00	7.50	9.00	10.50	12.00	13.50	15.00	16.50	18.00
	3.00		(17.31)	(14.15)	(10.98)	(7.82)	(4.65)	(1.49)	1.68	4.85	8.01	11.18	14.34
	3.10		(17.01)	(13.70)	(10.38)	(7.07)	(3.75)	(0.43)	2.88	6.19	9.51	12.83	16.14
	3.20		(16.71)	(13.25)	(9.78)	(6.32)	(2.85)	0.62	4.08	7.55	11.01	14.48	17.94
	3.30		(16.41)	(12.80)	(9.18)	(5.57)	(1.95)	1.67	5.28	8.90	12.51	16.13	19.74
	3.40		(16.11)	(12.35)	(8.58)	(4.82)	(1.05)	2.71	6.48	10.25	14.01	17.78	21.54
	3.50		(15.81)	(11.90)	(7.98)	(4.07)	(0.15)	3.77	7.68	11.60	15.51	19.43	23.34
	3.60		(15.51)	(11.45)	(7.38)	(3.32)	0.75	4.82	8.88	12.95	17.01	21.08	25.14
	3.70		(15.21)	(11.00)	(6.78)	(2.57)	1.65	5.86	10.08	14.30	18.51	22.73	26.94
	3.80		(14.91)	(10.55)	(6.18)	(1.82)	2.55	6.92	11.28	15.65	20.01	24.38	28.74
	3.90		(14.61)	(10.10)	(5.58)	(1.07)	3.45	7.96	12.48	17.00	21.51	26.03	30.54
	4.00		(14.31)	(9.65)	(4.98)	(0.32)	4.35	9.02	13.68	18.35	23.01	27.68	32.34
175		bu/a:	3.50	5.25	7.00	8.75	10.50	12.25	14.00	15.75	17.50	19.25	21.00
	3.00		(16.26)	(12.56)	(8.87)	(5.18)	(1.49)	2.21	5.90	9.59	13.29	16.98	20.67
	3.10		(15.91)	(12.04)	(8.17)	(4.30)	(0.43)	3.43	7.30	11.17	15.04	18.90	22.77
	3.20		(15.56)	(11.51)	(7.47)	(3.43)	0.62	4.66	8.70	12.74	16.79	20.83	24.87
	3.30		(15.21)	(10.99)	(6.77)	(2.55)	1.67	5.88	10.10	14.32	18.54	22.75	26.97
	3.40		(14.86)	(10.46)	(6.07)	(1.68)	2.71	7.11	11.50	15.89	20.29	24.68	29.07
	3.50		(14.51)	(9.94)	(5.37)	(0.80)	3.77	8.33	12.90	17.47	22.04	26.60	31.17
	3.60		(14.16)	(9.41)	(4.67)	0.07	4.82	9.56	14.30	19.04	23.79	28.53	33.27
	3.70		(13.81)	(8.89)	(3.97)	0.95	5.86	10.78	15.70	20.62	25.54	30.45	35.37
	3.80		(13.46)	(8.36)	(3.27)	1.82	6.92	12.01	17.10	22.19	27.29	32.38	37.47
	3.90		(13.11)	(7.84)	(2.57)	2.70	7.96	13.23	18.50	23.77	29.04	34.30	39.57
	4.00		(12.76)	(7.31)	(1.87)	3.57	9.02	14.46	19.90	25.34	30.79	36.23	41.67
200		bu/a:	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00
	3.00		(15.20)	(10.98)	(6.76)	(2.54)	1.68	5.90	10.12	14.34	18.56	22.78	27.00
	3.10		(14.80)	(10.38)	(5.96)	(1.54)	2.88	7.30	11.72	16.14	20.56	24.98	29.40
	3.20		(14.40)	(9.78)	(5.16)	(0.54)	4.08	8.70	13.32	17.94	22.56	27.18	31.80
	3.30		(14.00)	(9.18)	(4.36)	0.46	5.28	10.10	14.92	19.74	24.56	29.38	34.20
	3.40		(13.60)	(8.58)	(3.56)	1.46	6.48	11.50	16.52	21.54	26.56	31.58	36.60
	3.50		(13.20)	(7.98)	(2.76)	2.46	7.68	12.90	18.12	23.34	28.56	33.78	39.00
	3.60		(12.80)	(7.38)	(1.96)	3.46	8.88	14.30	19.72	25.14	30.56	35.98	41.40
	3.70		(12.40)	(6.78)	(1.16)	4.46	10.08	15.70	21.32	26.94	32.56	38.18	43.80
	3.80		(12.00)	(6.18)	(0.36)	5.46	11.28	17.10	22.92	28.74	34.56	40.38	46.20
	3.90		(11.60)	(5.58)	0.44	6.46	12.48	18.50	24.52	30.54	36.56	42.58	48.60
	4.00		(11.20)	(4.98)	1.24	7.46	13.68	19.90	26.12	32.34	38.56	44.78	51.00

The relationship between N fertilizer price and corn price at several base corn yields using an average yield response of 12% is shown in Table 4. Net return per acre increases as either price increases. This relationship is interesting because in the absence of a cover crop, increasing input prices reduce net income per acre while returns increase with the cover crop as input prices increase because the value of the N credit increases.

Table 4. Net return ($/acre) based on nitrogen fertilizer and corn prices by base yield assuming average yield response.

Corn		N Price ($/lb)															
Yield (bu/a)	**Price ($/bu)**	**0.40**	**0.42**	**0.44**	**0.46**	**0.48**	**0.50**	**0.52**	**0.54**	**0.56**	**0.58**	**0.60**	**0.62**	**0.64**	**0.66**	**0.68**	**0.70**
125	**3.00**	0.70	1.70	2.70	3.70	4.70	5.70	6.70	7.70	8.70	9.70	10.70	11.70	12.70	13.70	14.70	15.70
	3.10	2.21	3.21	4.21	5.21	6.21	7.21	8.21	9.21	10.21	11.21	12.21	13.21	14.21	15.21	16.21	17.21
	3.20	3.72	4.72	5.72	6.72	7.72	8.72	9.72	10.72	11.72	12.72	13.72	14.72	15.72	16.72	17.72	18.72
	3.30	5.23	6.23	7.23	8.23	9.23	10.23	11.23	12.23	13.23	14.23	15.23	16.23	17.23	18.23	19.23	20.23
	3.40	6.74	7.74	8.74	9.74	10.74	11.74	12.74	13.74	14.74	15.74	16.74	17.74	18.74	19.74	20.74	21.74
	3.50	8.25	9.25	10.25	11.25	12.25	13.25	14.25	15.25	16.25	17.25	18.25	19.25	20.25	21.25	22.25	23.25
	3.60	9.75	10.75	11.75	12.75	13.75	14.75	15.75	16.75	17.75	18.75	19.75	20.75	21.75	22.75	23.75	24.75
	3.70	11.26	12.26	13.26	14.26	15.26	16.26	17.26	18.26	19.26	20.26	21.26	22.26	23.26	24.26	25.26	26.26
	3.80	12.77	13.77	14.77	15.77	16.77	17.77	18.77	19.77	20.77	21.77	22.77	23.77	24.77	25.77	26.77	27.77
	3.80	12.77	13.77	14.77	15.77	16.77	17.77	18.77	19.77	20.77	21.77	22.77	23.77	24.77	25.77	26.77	27.77
	4.00	15.79	16.79	17.79	18.79	19.79	20.79	21.79	22.79	23.79	24.79	25.79	26.79	27.79	28.79	29.79	30.79
150	**3.00**	7.08	8.08	9.08	10.08	11.08	12.08	13.08	14.08	15.08	16.08	17.08	18.08	19.08	20.08	21.08	22.08
	3.10	8.89	9.89	10.89	11.89	12.89	13.89	14.89	15.89	16.89	17.89	18.89	19.89	20.89	21.89	22.89	23.89
	3.20	10.70	11.70	12.70	13.70	14.70	15.70	16.70	17.70	18.70	19.70	20.70	21.70	22.70	23.70	24.70	25.70
	3.30	12.51	13.51	14.51	15.51	16.51	17.51	18.51	19.51	20.51	21.51	22.51	23.51	24.51	25.51	26.51	27.51
	3.40	14.32	15.32	16.32	17.32	18.32	19.32	20.32	21.32	22.32	23.32	24.32	25.32	26.32	27.32	28.32	29.32
	3.50	16.14	17.14	18.14	19.14	20.14	21.14	22.14	23.14	24.14	25.14	26.14	27.14	28.14	29.14	30.14	31.14
	3.60	17.95	18.95	19.95	20.95	21.95	22.95	23.95	24.95	25.95	26.95	27.95	28.95	29.95	30.95	31.95	32.95
	3.70	19.76	20.76	21.76	22.76	23.76	24.76	25.76	26.76	27.76	28.76	29.76	30.76	31.76	32.76	33.76	34.76
	3.80	21.57	22.57	23.57	24.57	25.57	26.57	27.57	28.57	29.57	30.57	31.57	32.57	33.57	34.57	35.57	36.57
	3.80	21.57	22.57	23.57	24.57	25.57	26.57	27.57	28.57	29.57	30.57	31.57	32.57	33.57	34.57	35.57	36.57
	4.00	25.19	26.19	27.19	28.19	29.19	30.19	31.19	32.19	33.19	34.19	35.19	36.19	37.19	38.19	39.19	40.19
175	**3.00**	13.42	14.42	15.42	16.42	17.42	18.42	19.42	20.42	21.42	22.42	23.42	24.42	25.42	26.42	27.42	28.42
	3.10	15.53	16.53	17.53	18.53	19.53	20.53	21.53	22.53	23.53	24.53	25.53	26.53	27.53	28.53	29.53	30.53
	3.20	17.64	18.64	19.64	20.64	21.64	22.64	23.64	24.64	25.64	26.64	27.64	28.64	29.64	30.64	31.64	32.64
	3.30	19.76	20.76	21.76	22.76	23.76	24.76	25.76	26.76	27.76	28.76	29.76	30.76	31.76	32.76	33.76	34.76
	3.40	21.87	22.87	23.87	24.87	25.87	26.87	27.87	28.87	29.87	30.87	31.87	32.87	33.87	34.87	35.87	36.87
	3.50	23.98	24.98	25.98	26.98	27.98	28.98	29.98	30.98	31.98	32.98	33.98	34.98	35.98	36.98	37.98	38.98
	3.60	26.09	27.09	28.09	29.09	30.09	31.09	32.09	33.09	34.09	35.09	36.09	37.09	38.09	39.09	40.09	41.09
	3.70	28.20	29.20	30.20	31.20	32.20	33.20	34.20	35.20	36.20	37.20	38.20	39.20	40.20	41.20	42.20	43.20
	3.80	30.32	31.32	32.32	33.32	34.32	35.32	36.32	37.32	38.32	39.32	40.32	41.32	42.32	43.32	44.32	45.32
	3.80	30.32	31.32	32.32	33.32	34.32	35.32	36.32	37.32	38.32	39.32	40.32	41.32	42.32	43.32	44.32	45.32
	4.00	34.54	35.54	36.54	37.54	38.54	39.54	40.54	41.54	42.54	43.54	44.54	45.54	46.54	47.54	48.54	49.54
200	**3.00**	19.80	20.80	21.80	22.80	23.80	24.80	25.80	26.80	27.80	28.80	29.80	30.80	31.80	32.80	33.80	34.80
	3.10	22.21	23.21	24.21	25.21	26.21	27.21	28.21	29.21	30.21	31.21	32.21	33.21	34.21	35.21	36.21	37.21
	3.20	24.63	25.63	26.63	27.63	28.63	29.63	30.63	31.63	32.63	33.63	34.63	35.63	36.63	37.63	38.63	39.63
	3.30	27.04	28.04	29.04	30.04	31.04	32.04	33.04	34.04	35.04	36.04	37.04	38.04	39.04	40.04	41.04	42.04
	3.40	29.46	30.46	31.46	32.46	33.46	34.46	35.46	36.46	37.46	38.46	39.46	40.46	41.46	42.46	43.46	44.46
	3.50	31.87	32.87	33.87	34.87	35.87	36.87	37.87	38.87	39.87	40.87	41.87	42.87	43.87	44.87	45.87	46.87
	3.60	34.28	35.28	36.28	37.28	38.28	39.28	40.28	41.28	42.28	43.28	44.28	45.28	46.28	47.28	48.28	49.28
	3.70	36.70	37.70	38.70	39.70	40.70	41.70	42.70	43.70	44.70	45.70	46.70	47.70	48.70	49.70	50.70	51.70
	3.80	39.11	40.11	41.11	42.11	43.11	44.11	45.11	46.11	47.11	48.11	49.11	50.11	51.11	52.11	53.11	54.11
	3.80	39.11	40.11	41.11	42.11	43.11	44.11	45.11	46.11	47.11	48.11	49.11	50.11	51.11	52.11	53.11	54.11
	4.00	43.94	44.94	45.94	46.94	47.94	48.94	49.94	50.94	51.94	52.94	53.94	54.94	55.94	56.94	57.94	58.94

Conclusions

This analysis demonstrates tremendous potential to increase net farm income by using a red clover cover crop in conjunction with winter wheat. It captures the direct economic effects of yield increase and reduction of fertilizer N use. While the components and contributing factors to yield increase are unknown, clearly the financial incentive exists and spin-off soil and environmental quality benefits are accrued. These have financial value which is difficult to evaluate at the farm-gate level, yet soil quality effects undoubtedly contribute to the positive rotation effect on corn yield.

Under current market conditions, yield response is important for maintaining profitability, indicating producers and their advisors should strive to manage the system to maximize this effect. That said, net losses which occur with low yield response are minimal and well below NRCS cost share levels for this practice.

Variability in yield response demonstrates potential risk and reward for cover crop adoption and should be a factor for anyone considering implementation. That said, a net farm income loss under low yield conditions represents a modest investment in soil conservation and water quality which should be taken into account.

Historical market price analysis (data not shown) indicates this practice currently is at a relatively low potential for profitability. Red clover seed price is high compared to historical levels and increased 30% from 2015 to 2016. As with the growth regulator herbicide (2, 4-D ester), prices have doubled over the past decade. Additionally, the 3-year decline in commodity prices has ultimately reduced nutrient prices, albeit with a lag period, reducing the value of a nitrogen credit. Changes in any of the components of the price structure could drastically change the profitability potential for this practice. Also, experience and input substitution could improve profitability. This is a conservative analysis using the maximum constant costs and assuming a minimum N credit. Experienced producers can probably reduce clover seeding rates, find alternative clover termination methods or products or eliminate clipping, the combination of which would reduce cost to the point that even in low response environments, returns would be positive.

Related publication:

Stute, J. and K. Shelley. 2009. Frost seeding red clover in winter wheat. University of Wisconsin Nutrient and Pest Management Program publication 1-0209-3C.
http://ipcm.wisc.edu/download/pubsNM/RedClover_0109.pdf

Author: James K. Stute, Michael Fields Agricultural Institute
Editing and Layout: Gena McGuigan
Photo credits the author unless specified
The National Wildlife Federation provided funding for this project.
Mention of proprietary products is for reference only and does not constitute an endorsement by the author, the Michael Fields Agricultural Institute or National Wildlife Federation.

For more information or to request the full report:
jstute@michaelfields.org, (262) 642-3303 x112
www.michaelfields.org