Cereal Intercrop Systems for Silage and Pasture: Farm Scale Trials
1: Cereal Silage Results

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Introduction

Intercropping is a system where two or more crops are grown in the same field at the same time. An intercrop can often produce a higher yield or better yield stability than a monocrop, especially under low-input situations. In the present study, an intercrop was used to extend the portion of the growing season when an annual forage crop was actively growing, and in turn, producing a higher yield of forage over the season.

Spring cereals have been used as a forage crop for many years, usually when seeding down a new stand of alfalfa. Work from New Liskeard has shown that cereal crops can produce moderate yields of high quality silage, however, the economics of cereals for forage are not attractive when used as a monocrop without seeding down. Yields of cereal silage are limited since they utilize only a portion of the growing season. In the present study, three crops (annual ryegrass, fall (cereal) rye, and winter triticale) were evaluated in mixtures with spring grains. The objective was to harvest the initial growth as silage composed mostly of spring grain, and then allow the aftermath of the intercrop species to grow and harvest it as pasture in late summer. This trial was conducted on a farm scale at three sites: the New Liskeard Research Station, Glen Osprey Farm (David and Nancy Pease) in the Shelburne area, and Quarry Hill Farm (Gerald and Louise Rollins) in the Cobden area. The New Liskeard site was set up as a replicated, randomized trial covering 11 ha in total, the Shelburne and Cobden sites consisted of one strip of each treatment covering approximately 4 ha and 8 ha, respectively. Details of the treatments are shown in Table 1.

Table 1. Details of intercrop treatments and locations.

Mixture	Oats *plus*	i) Annual Ryegrass *or*	ii) Fall (cereal) rye *or*	iii) Winter triticale
Variety	Rigodon	Aubade (Westerwold)	common	Pika
Seeding Rate	55 kg/ha	20 kg/ha	55 kg/ha	60 kg/ha
Locations	New Liskeard (clay)	Shelburne (sandy-loam)	Cobden (clay loam)	
Seeding Date	May 15/00	April 28/00	May 30/00	
Silage Cut	July 25/00	July 12/00	Aug. 03/00	
Start Grazing	Sept. 20/00	Sept. 05/00	Oct. 13/00	

Silage Harvest Yield and Quality

The first growth was cut for whole plant silage at about 65 to 75 days after seeding. Average silage dry matter yields ranged from 3.2 to 5.3 t/ha. The Shelburne site suffered from very heavy rainfall during May, which likely resulted in some loss of nitrogen on the sandy-loam soil. Seeding at the Cobden site was delayed by heavy rain in May and this later seeding likely reduced yield somewhat. The New Liskeard site had adequate rainfall and overall yields met

expectations for whole plant cereal silage cut at the milk stage.

Table 1. Silage yield and quality from initial growth of intercrop mixtures at three sites.

	NLARS (New Liskeard)	Glen Osprey Farm (Shelburne)	Quarry Hill Farm (Cobden)
DM Yield (kg/ha)			
Oats-Annual Ryegrass	4867	3140	3778 (78% oats)
Oats-Fall Rye	5322 (81 % oats)	3393	3104 (71 % oats)
Oats-Winter Triticale	5754 (87 % oats)	3222	4030 (68 % oats)
Average	5314	3252	3637
Significance[a]	ns (cv[b]=9.5%)	-	-
Crude Protein			
Oats-Annual Ryegrass	13.5	9.9	14.4
Oats-Fall Rye	13.4	10.5	16.2
Oats-Winter Triticale	11.6	9.3	15.5
Average	12.8	9.9	15.4
Significance	ns (cv=11.9)	-	-
Acid Detergent Fibre			
Oats-Annual Ryegrass	37.2	31.7	36.2
Oats-Fall Rye	35.1	31.5	33.8
Oats-Winter Triticale	39.0	32.0	31.3
Average	37.1	31.7	33.8
Significance	* (cv=2.8%)	-	-
Neutral Detergent Fibre			
Oats-Annual Ryegrass	57.3	53.1	57.6
Oats-Fall Rye	55.7	53.3	55.6
Oats-Winter Triticale	54.6	54.2	54.0
Average	55.9	53.5	55.7
Significance	ns (cv=3.1)	-	-

a: ns = not significant; * = significant at the 5% level of probability b: cv = coefficient of variation

There were no significant differences in silage yield among treatments at New Liskeard, similarly, yields at the on-farm sites were similar, although they cannot be compared using statistical analysis. Estimates of the composition of the silage at the Cobden site indicated that between 68% and 78% of the forage harvested was oats, with the balance being the other intercrop species. At New Liskeard, the oat-winter cereal mixtures ranged from 81% to 87% oats. Composition data is not available from the annual ryegrass mixture at New Liskeard or from the Shelburne site.

Silage crude protein levels ranged from 10% to 15% across locations (Table 2). Protein levels were somewhat lower at the Shelburne site, possibly reflecting the loss of soil nitrogen due to heavy rainfall in May and June. Acid detergent fibre (ADF) levels ranged from 32% to 37% across locations. In general, treatments with more oats in the mixture would be expected to have higher ADF (higher fibre = lower digestibility) than treatments with less oats. This shows in the New Liskeard results where the oat-triticale mixture had significantly higher ADF than the oat-fall rye mixture. ADF levels were quite low at the Shelburne site, indicating high digestibility of the forage. Neutral detergent fibre (NDF) levels ranged from 53% to 56%, which is not unusual for cereal silage crops. There were no differences in NDF among treatments. Comments from the cooperators indicated that the intercrop silage preserved well and was not noticeably different from other cereal silage crops.

While we did not include a pure oat control treatment, work done in small plots at New Liskeard has shown no difference in first cut yield between pure oats and oat intercrops. Our quality data above suggests that oat intercrops should have somewhat better quality as compared to pure oat silage. Thus, from first cut results, we can conclude that the intercrop is at least equal to a pure oat crop.

Interpretation:

There appears to be little difference between the three intercrop treatments based on the silage harvest alone. In the first growth, none of the intercrop species was able to dominate the mixture to the point of causing a significant difference in yield or quality of the mixtures. This is to be expected since the rapid emergence and rapid growth of the spring cereal makes it much more competitive in the early stages of growth than either winter cereals or annual ryegrass. Further results on the aftermath yield and quality, animal performance on pasture, and economics are found in following articles.

Cereal Intercrop Systems for Silage and Pasture: Farm Scale Trials
2: Pasture Yield and Quality
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Introduction:

Background information on the cereal intercrop trial was presented in the first report of this series, please refer to it for details of treatments and seeding rates. This update describes the yield of quality of the aftermath (pasture) growth of the intercrop mixtures at 3 locations.

Pasture Harvest Yield and Quality

At all sites, the aftermath growth of the mixtures was harvested as pasture. Weaned calves were used at New Liskeard, while cow-calf pairs were used at the other two sites. The interval between cutting for silage and beginning to graze was about 55 days at New Liskeard and Shelburne, and about 70 days at the Cobden site. The date when grazing commenced at the on-farm sites was partially controlled by the availability of other pasture sources.

Overall, pasture yield ranged from 2.9 to 4.0 t/ha across sites (Table 2). Pasture yield was highest for the annual ryegrass treatment at all three sites, with the difference at New Liskeard being significant. At New Liskeard, two replicates of stockpiled pasture were also measured for yield and quality. The stockpiled pasture consisted of mainly bluegrass, quackgrass, and white clover. It was rested from July 30 until grazing started in mid-September. It had a dry matter yield of 3.9 t/ha, which is excellent growth for this type of pasture at this location.

Forage crude protein levels ranged from 13.5% to 15.8% across locations (Table 2). Annual ryegrass had the lowest protein at all sites, however, there was no statistical difference in protein levels at New Liskeard. The type of ryegrass used (Westerwold) produces stems and seed heads frequently and this likely resulted in lower protein levels than the very leafy growth of the winter cereals. Stockpiled pasture at New Liskeard had a protein level equal to the best intercrop treatments.

Acid detergent fibre (ADF) levels ranged from 28% to 32% across locations and neutral detergent fibre (NDF) levels ranged from 49% to 55% across locations. There was no statistical difference in fibre levels at New Liskeard, although at all sites there was a tendency for annual ryegrass to have higher levels of fibre. Fibre levels in stockpiled pasture were similar to the intercrop treatments for ADF, but were lower than the intercrop treatments for NDF. This is likely due to the legume content of the stockpiled pasture. At similar stages of maturity, legumes consistently have lower NDF levels than grasses.

Table 2. Pasture yield and quality from second growth of intercrop mixtures at three sites.

	NLARS (NewLiskeard)	Glen Osprey Farm (Shelburne)	Quarry Hill Farm (Cobden)
DM Yield (kg/ha)			
Oats-Annual Ryegrass	4486	3456	5059
Oats-Fall Rye	2307	2655	3393
Oats-Winter Triticale	2085	2544	3647
Stockpiled Pasture[a]	*3966*	-	-
Average	2959	2885	4033
Significance[b]	* (cv = 19.6)[c]	-	-
Crude Protein			
Oats-Annual Ryegrass	11.7	9.1	13.0
Oats-Fall Rye	15.8	16.3	18.5
Oats-Winter Triticale	15.2	15.2	15.9
Stockpiled Pasture	*16.2*	-	-
Average	14.2	13.5	15.8
Significance	ns (cv = 13.3)	-	-
Acid Detergent Fibre			
Oats-Annual Ryegrass	29.7	35.0	31.5
Oats-Fall Rye	27.9	30.1	24.4
Oats-Winter Triticale	28.0	32.0	27.8
Stockpiled Pasture	*30.0*	-	-
Average	28.5	32.4	27.9
Significance	ns (cv = 7.6)	-	-
Neutral Detergent Fibre			
Oats-Annual Ryegrass	49.6	57.5	56.2
Oats-Fall Rye	49.8	51.0	48.5
Oats-Winter Triticale	47.9	56.0	53.0
Stockpiled Pasture	*43.5*	-	-
Average	49.1	54.8	52.6
Significance	ns (cv = 7.2)	-	-

a: Values for stockpiled pasture represent a grass-clover stand rested from July 30. The values for stockpiled pasture are not included in the statistical analysis.
b: ns = not significant; * = significant at the 5% level of probability c: cv = coefficient of variation

Interpretation: Following the silage harvest in July, the regrowth of the winter cereals (fall rye and winter triticale) was disappointing. At the Shelburne and Cobden sites, leaf disease pressure was moderate to heavy on these treatments and likely suppressed yield. At New Liskeard, winter triticale showed very sparse regrowth and much of what regrew was actually oats. The fall rye treatment filled in reasonably well, but tillers remained small and hence yields remained low. Annual ryegrass was much higher yielding at all sites. At all three sites, the annual ryegrass

treatment had little or no oat regrowth during the grazing period, indicating that the annual ryegrass was fairly competitive once the silage had been removed. There was sufficient regrowth of annual ryegrass at New Liskeard that a second cut of silage would have been justified, but this may have been too late to allow a grazing pass later in the fall. At the Shelburne site, the annual ryegrass was unusually coarse, with little leaf present on the plants. It is suspected that low soil nitrogen levels may have been responsible for this, although moisture and temperature conditions can affect leafiness as well.

Overall, it is clear that the annual ryegrass was more productive during the second (pasture) growth than either of the winter cereals. Although the quality data indicated that annual ryegrass had somewhat lower crude protein and higher fibre levels, it still had good quality for September grazing. The tendency of the Westerwold ryegrass to head out repeatedly is a problem for grazing the second growth. Ideally, this type of annual ryegrass should be cut for silage in the second growth (after the oats are cut for silage) and then could be grazed in the third growth. Another option is to intercrop oats with Italian ryegrass, which does not produce stems in the year of seeding. This should provide a much leafier second growth for grazing, but still produce a high yield necessary to justify the intercropping technique. Given our experience in 2000, we are recommending that producers wishing to try this intercropping strategy use a spring grain-annual ryegrass mixture. As an alternative, we are planning to include an intercrop of spring grain with Italian ryegrass for evaluation in 2001.

Cereal Intercrop Systems for Silage and Pasture: Farm Scale Trials
3: Grazing Results at New Liskeard
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Background information on the cereal intercrop trial was presented in an earlier report in this series, please refer to it for details of treatments and seeding rates. This update describes calf performance while grazing on the intercrop mixtures at New Liskeard.

Methods

At the New Liskeard site, weaned calves were used to graze the intercrop treatment as well as adjacent stockpiled pasture. There were three replications of each intercrop treatment, as well as two replications of stockpiled pasture for a total of 11 groups of calves. The area that each group of calves grazed was referred to as a cell. The grazing period lasted 28 days starting on September 20, 2000. The number of calves on each cell was determined based on an estimate of the forage available, the desired length of the grazing period, and the total number of calves available. Based on these estimates, each cell of fall rye and winter triticale carried 4 calves, each cell of annual ryegrass carried 8 calves, and each cell of stockpiled pasture carried 8 calves. Thus, the entire trial had 64 calves grazing. They were February -born, cross-bred with both exotic and British genetics, mixed sex (steers and heifers), and had an average starting weight of 563 pounds. The calves had been weaned around September 01 and had been grazing perennial grass pastures prior to the start of the grazing trial.

Calf Performance

Over the 28 days of grazing, the calves on each of the 3 intercrop treatments averaged 0.68 kg (1.5 pounds) of gain per day (Table 1). The calves on the stockpiled perennial pasture gained an average of 1.18 kg (2.6 pounds) per day. On a per hectare basis, the fall rye and winter triticale pastures produced about 75 kg/ha of liveweight gain, while the annual ryegrass treatment produced 157 kg/ha of liveweight gain and the stockpiled pasture produced 276 kg/ha of liveweight gain. Carrying capacity averaged 232 calf-days per hectare on the annual ryegrass and the stockpile pasture, and only 108 calf-days per hectare on the fall cereal treatments.

Table 1. Performance of calves grazing intercrop pastures or stockpiled pasture.

Performance Measure	Annual Ryegrass	Fall Rye	Winter Triticale	Stockpiled Pasture
Calf Gain (kg/hd/day)	0.68	0.68	0.68	1.18
Calf Gain (kg/ha)	157	73	76	276
Carrying Capacity (calf days/ha)	232	108	108	232

Forage Consumption:

Residual forage yields (ie: the yield left after grazing) were about 1000 kg/ha for the fall rye and

the winter triticale treatment, and about 1500 to 1800 kg/ha for the annual ryegrass and stockpiled pasture treatments. The apparent consumption of forage by the calves ranged from 1060 kg/ha for the winter triticale treatment to almost 3000 kg/ha for the annual ryegrass treatment. When apparent consumption by the calves is corrected for calf weight and grazing days, it was estimated that the calves on the intercrop treatments consumed between 3.7 and 4.9% of their own bodyweight in forage each day. On the stockpiled pasture, intake was estimated to be 3.4% of calf liveweight. Forage utilization, (ie: removal by animals) was estimated at 67% for ryegrass, and from 50 to 56% for the other treatments.

Table 2. Forage residual yields, disappearance, and utilization under calf grazing.

	Annual Ryegrass	Fall Rye	Winter Triticale	Stockpiled Pasture
Residual Forage Yield (kg/ha)	1496	990	1025	1829
Apparent Forage Consumption (kg/ha)	2990	1317	1060	2137
Apparent Intake (% of calf liveweight)	4.9	4.6	3.7	3.4
Forage Utilization (%)	67	56	50	52.1

Interpretation:

Calf weight gain was quite acceptable at 0.68 kg/head/day (1.5 pounds per day) on the intercrop treatments. Calf performance on the stockpiled pasture was outstanding at 1.18 kg/head/day (2.6 pounds per day). Previous examination of the pasture yield and quality information indicated little difference between the stockpiled pasture and the intercrop pastures. It is likely that the superior calf performance on the stockpiled pasture was related to it being a similar diet to the calves previous pasture (no change in diet) as well as less stress during wet weather since the thick sod of the stockpile kept the calves and the forage free of mud. Other aspects of calf performance appeared similar across treatments. For example, no health problems were evident within any group of calves.

The residual forage yield suggests that intake should not have been limiting to animal performance on the ryegrass or stockpile treatments. This is less certain on the fall cereal treatments, since residual yields were below 1000 kg/ha and a visual assessment of the pasture showed most of the available biomass was very close to ground level. In any case, liveweight gain was not different between treatments, so we must conclude that intake was not severely limited. Apparent consumption and intake by the calves on the annual ryegrass and the fall rye is higher than would be expected. It is likely that some of the ryegrass and fall rye was trampled to the point that it could not be recovered in the post-grazing samples. This would not occur on the thick sod of the stockpiled pasture, and was less likely on the triticale since it was a thin stand with few reproductive tillers. In any case, it seems apparent that generous forage allowances should be made when estimating the carrying capacity of annual grass pastures. While estimated intakes seem high, the proportion of the intercrop mixtures consumed (or otherwise removed) seem low. It is generally considered that 75% to 80% of an annual pasture should be consumed

by the grazing animals, but in this case that target was only reached with the annual ryegrass. The structure of the fall cereals with many tillers close to ground level would make it quite difficult to consume a higher proportion of the forage without lowering animal performance. These types of pastures might better be grazed with stock requiring lower nutrients and better able to graze short plants, such as dry ewes.

In summary, it would appear from this data that weaned calves will perform best on good quality stockpiled grass-legume pasture. Of course, it is sometimes difficult to have sufficient pasture of this type available in late fall. For producers wishing to use intercrops for late summer grazing, they should consider annual ryegrass in their intercrop mixture since it provided similar performance per animal and much higher gains per acre.

Cereal Intercrop Systems for Silage and Pasture: Farm Scale Trials
4:Budget for Intercrop Systems at New Liskeard
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Background information on the cereal intercrop trial was presented in an earlier report in this series, please refer to it for details of treatments and seeding rates. This update discusses the cost of production associated with the intercrop treatments.

Input Costs:

Table 1 lists the various input costs (excluding land cost) to produce intercrops in New Liskeard. The costs represent current costs and/or estimated custom rates. Obviously, actual costs will vary from one part of the province to another, but the costs presented are reasonable. To divide costs between the silage harvest and the pasture harvest, the sum of fall herbicide, tillage, seeding, fertilizer, and seed oats was split in half, with each of silage and pasture being charged equal amounts. The silage also had charged against it all harvesting costs, while the intercrop seed was all charged against the pasture. Differences in harvesting costs reflect different numbers of bales per acre, since many custom fees (baling and wrapping) are charged on a per bale basis.

Table 1. Input costs to produce three intercrop treatments at New Liskeard.

Category	Oat-Annual Ryegrass	Oat-Fall Rye	Oat-Winter Triticale
Fall Herbicide (1.5 l/ac Roundup)	$19.50	$19.50	$19.50
Tillage			
Plough	20.00	20.00	20.00
Cultivate 2x	20.00	20.00	20.00
Seeding (Grain Drill)	10.00	10.00	10.00
Fertilizer			
Nitrogen (108 lb/ac urea)	21.50	21.50	21.50
Phos. (68 lb/ac MAP)	11.95	11.95	11.95
Seed Oats	9.10	9.10	9.10
Intercrop Seed	28.80 (18 lb/ac @ 1.60)	7.50 (50 lb/ac @ 0.15)	9.00 (54 lb/ac @ 0.17)
Silage Harvest			
Cut ($40/hr)	10.00	10.00	10.00
Bale ($5.00/bale)	41.50	36.5	46.00
Haul/Unload ($2.00/bale)	16.60	14.60	18.40
Wrap ($4.00/bale) (all 48" x 54" bales)	33.20	29.20	36.80
Harvest Total	101.30	90.30	111.20
Costs Against Silage	56.03+101.30=157.33	56.03+90.30=146.33	56.03+111.20=167.23
Cost Against Pasture	56.03+28.80=84.83	56.03+7.50=63.53	56.03+9.00=65.03
Total Cost	242.16	209.86	232.26

Per unit costs:
As with many economic analysis, costs per unit of output can be calculated in several ways. In this analysis, we have calculated four costs: i) cost per unit of silage dry matter, ii) per unit of pasture dry matter, iii) per pound of calf calf gain, and iv) per unit of total forage dry matter produced (Table 2).

Table 2. Production costs for silage and pasture in intercrop mixtures.

Category	Oat-Annual Ryegrass	Oat-Fall Rye	Oat-Winter Triticale
Silage Yield (bales/ac)	8.3	7.3	9.2
Silage Yield (lb/ac)	4867	5322	5754
Costs Against Silage	56.03+101.30=157.33	56.03+90.30=146.33	56.03+111.20=167.23
Silage Cost (cents/lb DM)	**3.2**	**2.8**	**2.9**
Cost Against Pasture	56.03+28.80=84.83	56.03+7.50=63.53	56.03+9.00=65.03
Pasture Yield (lb/ac)	4037	2076	1876
Pasture Cost (cents/lbDM)	**2.1**	**3.1**	**3.5**
Calf Gain (lb/acre)	157	73	76
Pasture Cost (cents/lb gain)	**54**	**87**	**86**
Carrying Capacity (calf-days/acre)	93	43	43
Pasture Cost ($/head/day)	**0.91**	**1.48**	**1.51**

Interpretation:
Silage costs ranged from 3.2 cents per pound dry matter for oats-annual ryegrass to 2.8 cents per pound dry matter for oats-fall rye. The oat-ryegrass treatments had higher costs due to both lighter bales, hence higher per acre cost for harvesting and to an absolute lower yield. Conversely, the oat-fall rye treatment did not have the highest yield, but it had the lowest cost due to somewhat heavier bales and a very slightly lower seed cost. These costs equate to about $60 to $70 per metric tonne of silage dry matter.

Pasture cost were lowest for the annual ryegrass at 2.1 cents per pound of dry matter, as compared to fall rye at 3.1 cents and winter triticale at 3.5 cents. The annual ryegrass was much lower in pasture cost due to its much higher yield, which more than offset the higher seed costs for the ryegrass.

In terms of calf weight gain, the annual ryegrass had the lowest cost of gain at 54 cents per pound, while fall rye and winter triticale were 87 and 86 cents per pound gain, respectively. These costs are all higher than one would expect to incur grazing yearling cattle on pasture over the summer, where an expected cost of gain would be in the range of 25 to 40 cents. However, the cost of gain in the annual ryegrass treatment would be competitive with costs in confinement, particularly when overhead costs are considered. Costs of gain on the winter cereals treatments would not likely be competitive due to the low yield of forage relative to the cost of production.

When pasture cost is expressed as cost per head per day, ryegrass is lowest at 91 cents per day, while the fall cereal treatments are around $1.50 per day. Considering the rate of gain obtained, the ryegrass treatment would be competitive with a drylot setting, while the other two options would not be economical.

Summary:

If the original goal of the intercropping concept was to obtain both silage and pasture from one set of tillage and seeding costs, then the oat-annual ryegrass option is clearly the best option. This treatment had slightly higher costs per unit of silage produced, but much lower costs per unit of pasture or per unit of calf weight gain. Also, it is likely that this treatment could have produced a second cut of silage and still provided fall grazing for calves. The forage that the calves grazed was quite rank and may have been more suited to grazing for cows or to stored feed. The winter cereal treatments produced high quality pasture but did not have a high enough carrying capacity to make the cost of gain on pasture economical. Therefore, we would not recommend intercrops of oats with winter cereals, but would suggest that oats with annual ryegrass appears to have potential for intercropping.