Project Title: Spring barley-winter wheat relay cropping for forage production in western Montana

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Objectives:

i. Compare the forage yield and quality of a spring barley-winter wheat relay intercropping system with spring barley and winter wheat monocrop systems.

ii. Investigate the effect of N fertilizer source (ESN® vs. conventional urea), N rate, and their interactions on forage productivity in intercropping and monocrop systems.

Materials and Methods:

Field experiments were planted in the spring of 2010 at two locations in western Montana: Northwestern Agricultural Research Center (NWARC) near Kalispell, MT and Western Agricultural Research Center (WARC) in Corvallis, MT. The trial at NWARC was not irrigated, while the trial at WARC received irrigation throughout the growing season. Soil testing was done prior to planting at each site.

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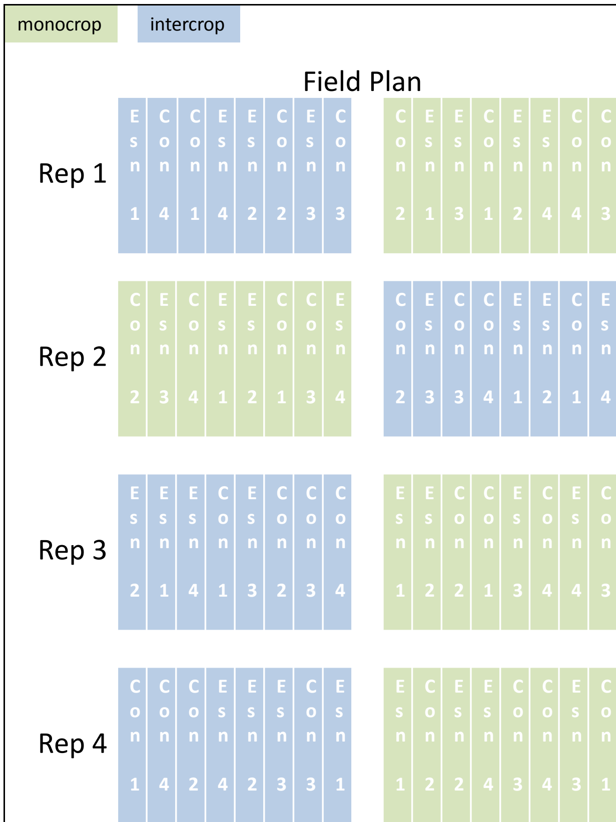
Two Montana-released cereal forage varieties ('Haybet' barley and 'Willow Creek' winter wheat) were grown separately as monocrops and together as an intercrop. In the monocrop system, spring barley was seeded on May 10, 2010 at a rate of 76 lb/ac and was harvested for estimates of forage yield and quality at the late dough stage (July 27, 2010). Fields were cultivated and winter wheat was planted in late fall (Sept. 29, 2010), at a rate of 52 lb/ac. In 2011, winter wheat will be harvested for hay and tested for forage yield and quality at early dough.

In the intercrop system, spring barley and winter wheat were planted perpendicular to one another in the spring of 2010 (May 10, 2010) at rates of 76 and 52 lb/ac, respectively. The intercrop was harvested for estimates of forage biomass and quality on the same dates as the monocrop was harvested. The remaining winter wheat crop was left in the field to resume growth. There was a chance that the winter wheat would put on enough late season growth to take a second cutting of hay in 2010, but in late September, it was decided that re-growth was not sufficient to justify a second cutting and the winter wheat was left to overwinter. In 2011, the winter wheat will be harvested at the early dough stage and tested for forage yield and quality.

The second objective of this trial was to investigate the effect of N fertilizer source and N rate on the productivity of winter wheat grown in either a monocrop or intercropped situation. On Oct. 1, 2010, half of the winter wheat plots were fertilized with a polymer-coated urea product (ESN® 44-0-0) at four different N levels (0, 75, 150 and 225 lb N/ac total applied N). In the spring of 2011, winter wheat plots that did not receive fall ESN will receive treatments of conventional urea (46-0-0) at the same N levels.

The experimental design is a split-plot with 4 replications, where cropping system (monocrop vs. intercrop) is the main plot factor and N source x N rate are the subplot factors. Data has been subjected to analysis of variance to assess the effect of cropping system on forage productivity. Yield and forage quality parameters will be regressed against N rate to establish fertilizer guidelines for each system.



Field Operations

Season	Monocrop	Intercrop
Spring 2010	• Preplant fert • Plant barley	• Preplant fert • Plant wheat and barley together
Summer 2010 Fall 2010	• Cut barley • Plant winter wheat • Broadcast ESN (at rate 1,2,3 or 4) in subplots marked 'esn'	• Cut barley • Allow established winter wheat to continue growing • Broadcast ESN (at rate 1,2,3 or 4) in subplots marked 'esn'
Spring 2011	• Broadcast conventional urea (at rate 1,2,3 or 4) in subplots marked 'con'	• Broadcast conventional urea (at rate 1,2,3 or 4) in subplots marked 'con'
Summer 2011	• Harvest wheat hay	• Harvest wheat hay

Legend
ESN=environmentally smart N (44-0-0)
CON=conventional urea (46-0-0)
Numbers 1,2,3,4 denote fertilizer levels (0, 75, 150 and 225 lb N/ac total applied N)

Figure 1. Experimental design and protocol for the Forage Relay Trial.

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As at NWARC, two Montana-released cereal forage varieties ('Haybet' barley and 'Willow Creek' winter wheat) were grown separately as monocrops and together as an intercrop. In the monocrop system, spring barley was sown in May 4, 2010 at a rate of 76 lb/ac and was harvested for estimates of forage yield and quality at the late dough stage (July 23, 2010). Fields were cultivated and winter wheat was planted in early fall at a rate of 52 lb/ac. In 2011, winter wheat will be harvested for hay and tested for forage yield and quality at early dough.

In the intercrop system, spring barley and winter wheat were planted perpendicular to one another on May 4, 2010, at rates of 76 and 52 lb/ac, respectively. The intercrop was harvested for estimates of forage biomass and quality on the same dates as the monocrop was harvested. The remaining winter wheat crop was left in the field to resume growth. As was the case at NWARC, winter wheat re-growth was not sufficient to justify a second cutting and the winter wheat was left to overwinter.

An error was made at WARC with respect to the fertilizer treatments. Rather than applying the conventional urea fertilizer treatments in the spring of *2011*, urea treatments were applied immediately after planting in the spring of *2010* (May 18, 2010). The four urea treatments (0, 75, 150 and 225 lb N/ac) were applied to plots at rates corresponding to the intended fall fertilizer treatment (Figure 1). For example, all boxes in Figure 1 labelled with a ‘2’ received urea fertilizer in the spring of 2010 at a rate of 75 lb N/ac. In the fall, ESN fertilizer treatments were applied as planned. That experiment has yielded some valuable information and will continue, but cannot be used in conjunction with the data from the current evaluation. The trial will be conducted again at this site in 2011-12.

Results:

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The site was non-irrigated and received 8” rainfall during the growing season (May-September). At the start of the season, soil N levels measured 72 lb N/ac in the top 24”, and an additional 100 lb of 6-30-40 was broadcast and incorporated prior to planting.

Although barley plants in the monocrop and intercrop systems were seeded at the same rate, mid-season barley density was higher in the monocrop system compared to barley density in the intercrop system, indicating strong competitive pressure from the winter wheat (Table 1). In the intercrop system barley averaged 4.8 plants/ft^2 while winter wheat averaged 16.4 plants/ft^2, for a total of 21.2 plants/ ft^2. This overall plant density was similar to that found in the monocrop system, where barley plants averaged 21.6 plants/ ft^2 (Table 1). This indicates that each system had a similar capacity but that winter wheat competed with barley in such a manner that significantly reduced the barley population. However, the vigorous spring habit of the barley outcompeted the winter wheat during the growing season, resulting in comparatively little winter wheat growth (<5” tall).

Competition in the intercrop system resulted in decreased forage yields. Monocropped forage barley yielded 7,243 lb DM/ac, which was significantly more than the 3,328 lb DM/ac harvested from the intercropped forage barley and winter wheat (Table 2). Most quality parameters, however, indicated higher quality in the intercropped forage compared to the monocropped barley. Crude protein was 1% higher in the intercropping arrangement, at 9.7% compared to 8.7% in the monocrop. Acid detergent fiber (ADF) and neutral detergent fiber (NDF) were significantly higher in the monocropped barley (Table 2). Correspondingly, total dietary fiber (TDF) and relative feed value (RFV) were higher when the barley forage was augmented with winter wheat forage (Table 2).

Relatively mild incidences of barley scald and net blotch were identified on barley plants in both the intercrop and monocrop systems. Diseases will continue to be monitored carefully as the trial continues.

Table 1. Density of monocrop and intercrop barley and winter wheat grown in 2010 at Kalispell, MT.

	Barley density	Winter wheat density	Total plant density
	#/ft^2	#/ft^2	#/ft^2
Monocrop	21.6	0	21.6
Intercrop	4.8	16.4	21.2
CV (%)	27.0	33.8	18.9
P>F	**	**	ns
LSD (0.05)	1.78	1.38	2.02

*, ** denote significance at α=0.05 and 0.01, respectively; ns indicates P value>0.05

Table 2. Forage yield and quality of monocropped 'Haybet' barley and intercropped 'Haybet' barley and 'Willow Creek' winter wheat grown in 2010 at Kalispell, MT.

	First cut forage yield	Forage crude protein	ADF	NDF	TDF	RFV
	lb DM/ac	%	%	%	%	%
Monocrop	7243	8.7	25.9	46.5	61.8	118.4
Intercrop	3328	9.7	23.1	43.5	64.2	129.5
CV (%)	19.4	9.6	7.2	4.4	3.5	5.9
P>F	**	**	**	**	**	**
LSD (0.05)	513.0	0.44	0.89	0.99	1.10	3.70

*, ** denote significance at α=0.05 and 0.01, respectively; ns indicates P value>0.05

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The site was irrigated and received 17" of water (7" rainfall + 10" irrigation) during the growing season (May-September). At the start of the season, soil N levels measured 23 lb in the top 36" of soil, thus an additional 100 lb of 11-52-40 was broadcast and incorporated prior to planting.

Unlike the Kalispell site, forage yield did not differ between the monocropped (5320 lb DM/ac) and intercropped (5101 lb DM/ac) systems (Table 3). Forage quality was only slightly higher in the intercropped system at Corvallis, with no differences in crude protein or TDF, lower ADF and NDF and higher RFV in the intercrop (Table 3).

Forage yield and protein levels increased with increasing N applications, suggesting that optimal levels of N fertilizer were not supplied to the crop at planting (Table 3). Further, there were no significant N fertilizer x System interaction effects, suggesting that both systems used N fertilizer to a similar degree. This knowledge will allow us to set better fertilizer N guidelines and can be used to improve this study at all sites in subsequent years.

Table 3. Forage yield and quality of monocropped 'Haybet' barley and intercropped 'Haybet' barley and 'Willow Creek' winter wheat grown at four N rates in 2010 at Corvallis, MT.

	First cut forage yield	**Forage crude protein**	**ADF**	**NDF**	**TDF**	**RFV**
	lb DM/ac	%	%	%	%	%
System						
Monocrop	5320	10.4	28.7	49.6	58.4	106.4
Intercrop	5101	10.2	27.8	48.5	59.0	109.5
P>F	ns	ns	*	**	ns	*
LSD (0.05)	342.5	0.54	0.88	0.84	0.92	2.80
N Fertilizer						
0N	3323	7.1	27.1	48.0	60.3	112.4
75N	5533	8.6	28.3	48.9	58.7	108.3
150N	6248	11.7	29.0	49.8	57.4	104.9
225N	5738	13.8	28.7	49.7	58.5	106.3
P>F	**	**	*	**	**	**
LSD (0.05)	484.3	0.78	1.24	1.18	1.31	3.97
CV (%)	19.4	9.6	7.2	4.4	3.5	5.9

*, ** denote significance at α=0.05 and 0.01, respectively; ns indicates P value>0.05

Differences between the two systems were more apparent at the dryland site (NWARC) compared to the irrigated site (WARC), which may be related to interspecific competition for moisture and/or nitrogen. The preliminary results of this trial indicate that the intercropping of spring forage barley and winter forage wheat has the potential to be a suitable cropping system in Montana, but that some adjustments to the system may be beneficial. From the results obtained at WARC, it is probable that our initial N fertilizer levels at both sites were too low to produce optimal forage yields. Thus, we plan to increase initial levels of soil N in subsequent studies. Forage quality in the intercrop system was comparable to or better than forage quality in the monocrop system, increasing the viability of the relay cropping scheme for Montana producers.

Future Plans:

The second phase of this experiment (Conventional urea vs. ESN) is still underway at Northwestern Agricultural Research Center, and we will initiate the study for a second year at that non-irrigated site. We also plan to initiate the originally planned experiment again at WARC under irrigation. Results of this phase will assist Montana forage growers in selecting the most effective and economic fertilizer products.