Evaluation of Multiple Species for use as Cover Crops in Dryland Production in Montana

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Oat | Foxtail Millet | Flax | Buckwheat | Pearl millet | Sunflower | Cowpeas | Proso millet | Fababean | Sunnhemp | Flax | Pea | Diversity Mix | Cool Season Mix | Warm Season Mix

Introduction

Cover crops are commonly used in regions of excess rainfall for soil conservation, to reduce nutrient leaching, and to build soil carbon. Winter wheat -- fallow is the dominant rainfed rotation in Montana where annual precipitation is less than 360 mm (14 in). This limited amount of precipitation either precludes the use of a cover crop, or requires management to terminate that cover crop to save water and reduce the potential for a negative impact to the following cash crop. Reducing fallow is a priority to sustain or improve soil quality. Management strategies to do this include using cover crops but terminating early or using rotational crops which need less total water like dry pea or lentil in the traditional fallow period. Pulse crop acreage has expanded greatly here in the past 10 years which indicates some grower acceptance of alternative practices. Another option for cover crops is to graze or feed them for animal production. Some revenue from a gain in meat or dairy production can offset expected reductions in grain crop revenue. Research questions are how and where to add cover crops to the system (see Box at right), and what species or species mixture might provide the best fit for use of cover crops in Montana.

Materials & Methods

A statewide investigation (see Map) of several cover crop species was conducted to determine biomass production and associated feed quality. Design was a replicated (3 or 4X) randomized complete block for each planting date. Seeding varied by location but plot size was typically 1.5 x 7 m. Biomass production was estimated by harvesting a known area (varied by location, but typically 2-m row) and weighed after drying at 60 °C until stable. Harvest date was triggered once the grass species within the planting date began to flower. The specie types and mixtures (Table 1) used are listed within the data tables, some varied by planting date. Subsamples of dried forage were mixed, ground to pass a 2-mm sieve and analyzed for the profiles listed in Table 4. Nutrient analysis was performed on samples combined across reps by location.

Table 1. Composition of the multi-species cover crop mixtures used in both early and late plantings. Dollar amounts are estimated seed cost.

Cool Season Mix	Warm Season Mix	Alternative Mix	Diversity Mix
Radish	Radish	Radish	Radish
Turnip	Turnip	Turnip	Turnip
Spring pea	Chickpea	Faba Bean	Spring pea
Canola	Faba Bean	Black Bean	Faba Bean
Safflower	Sunflower	Teff	Chickpea
Oat	Sorghum	Indian corn	Canola
		Sorghum	Safflower
			Sunflower
			Oat
			Sorghum
$19.55	$39.95	$37.71	$29.27

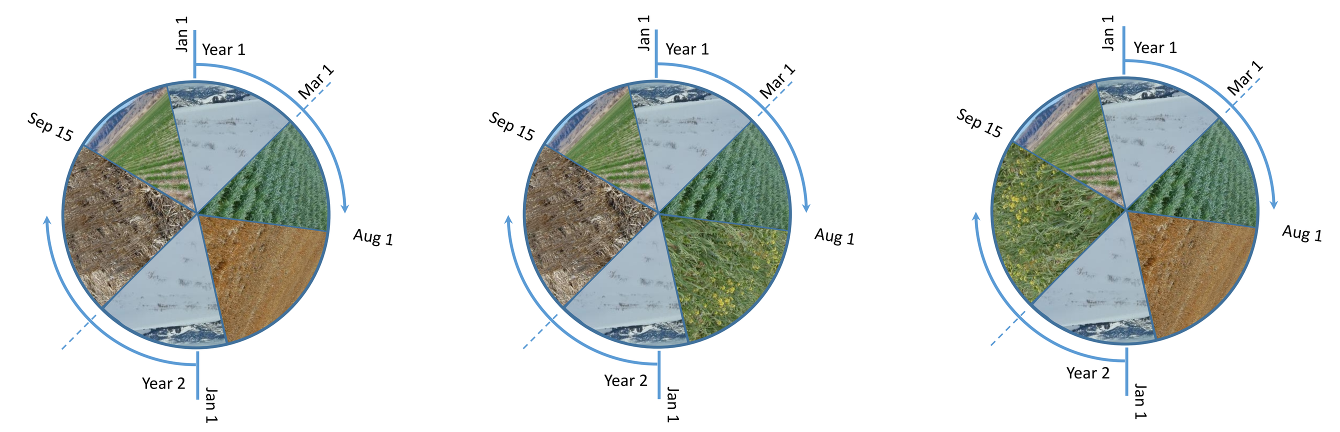
Discussion

A wide array of biomass production was measured across the region. In general grasses like oat, millet, and sorghum provided the highest yields, while cool season crops like alsike clover, turnip, and radish typically yielded less. Mixtures like the cool season mix and Diversity had greater yield stability than yields of many single species across locations. The warm season and alternative mix were more productive in the late planting because of the inclusion of C4 grasses like sorghum and corn which respond to greater heat units. Late plantings generally provided greater yield although the design of this study doesn't allow a direct comparison for all treatments. The treatments common to both early and late plantings included the four mixtures which are compared in Figure 2. Later plantings produced greater biomass than planting early for all these treatments.

Feed values of the cover crops are presented in Table 4. Treatments included species that can be used as feed and all would provide significant sources of protein and fiber. Grasses tend to have lower relative feed value (RFV) as expected. The differences in biomass production is likely as important as the differences in feed value.

Single specie cover crops like peas have been used for years across the state of Montana; using cover crop mixtures here is a fairly new idea. Mixtures show promise in providing yield stability and could be used as a source of forage for animal production. This study provides information on individual species performance across the region, which can be used to help assemble mixtures of species that fit the environments within the state.

Adding Cover Crops to the Winter Wheat / Fallow Cycle.



wheat/fallow timeline | Option A | Option B

Figure 1. Each graphic represents a two year cycle. There are 2 places for cover crops (if the rotation doesn't change), both of which are challenging in a semi-arid environment. Option A establishing a cover crop directly following wheat harvest is tough as usually there is little moisture available to germinate and sustain plant growth. Option B planting in spring, is an easier time to establish a cover crop, but in a semi-arid environment decreased soil moisture storage usually compromises yield of the following cash crop. Terminating the cover crop early (at the end of June) can help save soil moisture and provide a mulch to harvest additional late summer rain. Late termination typically allows greater biomass accumulation, but depletes soil moisture directly ahead of winter wheat planting which can impact growth and yield potential.

Table 2. **Early planted** above ground biomass yield (kg ha^{-1}).

Cover Crop	State Avg		CARC		EARC		NARC		NWARC		SARC		WARC	
Radish	668	g	668	efgh	548	e	331	cdef	281	f	1632	de	549	bcd
Turnip	815	fg	701	efgh	663	de	98	gh	16	f	3043	bc	368	ef
Spring Pea	1271	e	882	defg	1702	ab	961	bcde	2130	de	1014	ef	941	a
Oat	2539	a	1445	bc	1869	a	1911	a	5559	a	3688	ab	762	ab
Canola	1781	c	677	efgh	1124	cd	1431	ab	3822	bc	2968	c	661	bc
Safflower	988	f	1875	a	670	de	769	cdef	1743	e	580	fg	292	ef
Hairy Vetch	702	g	1567	ab	820	cde	697	cdef	514	f	0	g	612	bc
Alsike Clover	246	h	666	efgh	347	e	0	h	54	f	204	fg	201	f
Triticale	2217	b	1209	bcd	1228	bc	1839	a	4651	ab	3757	a	622	bc
Flax	983	f	578	fgh	543	e	321	fgh	2899	cd	1130	ef	426	cdef
Cool Season Mix	1524	de	1051	cde	1734	ab	1351	abc	2973	cd	1277	ef	757	ab
Warm Season Mix	593	g	460	h	500	e	209	fgh	560	f	1345	e	482	cde
Diversity Mix	1427	de	966	def	1355	abc	1065	bcd	2477	de	2127	d	572	bcd
Alternative Mix	689	g	561	gh	642	de	207	fgh	625	f	1631	de	469	cde
average	1174		951		982		799		2022		1743		551	
CV (%)	56		45		52		81		89		70		36	

*Means separation by Fisher's protected LSD at 5% confidence level.

Table 3. **Late planted** above ground biomass yield (kg ha^{-1}).

Cover Crop	State Avg		CARC		EARC		NARC		NWARC		WARC	
Radish	781	f	169	gh	808	e	660	g	1362	d	908	abc
Turnip	848	f	219	gh	838	e	762	fg	1863	cd	563	cde
Sorghum	2466	ab	1776	bc	2171	abc	2815	abcd	4630	a	944	abc
German Millet	2082	bc	2059	ab	1930	abcd	2376	abcde	3201	abc	847	bcd
Sunflower	1862	cd	1714	bcd	2525	a	2556	abcde	1660	cd	858	bcd
Soybean	1138	ef	1109	def	1106	de	1482	defg	1262	d	736	bcde
Fababean	1166	ef	704	efg	717	e	1496	defg	1834	cd	1080	ab
Chickpea	1129	ef	545	fgh	1242	cde	1903	bcdef	1554	cd	406	e
Black Bean	1232	ef	1133	def	1042	de	1002	efg	2065	cd	920	abc
Indian Corn	2871	a	2665	a	2445	ab	3775	a	4728	a	745	bcde
Berseem Clover	872	f	253	gh	697	e	1535	cdefg	1375	d	501	de
Teff	1260	ef	0	h	1521	bcde	2944	abcd	1114	d	722	bcde
Cool Season Mix	2414	ab	1668	bcd	1830	abcd	3273	ab	4279	a	1025	ab
Warm Season Mix	1440	de	1199	cde	2095	abc	1306	defg	1845	cd	761	bcde
Diversity Mix	2411	ab	1584	bcd	2171	abc	3149	abc	3853	ab	1302	a
Alternative Mix	1649	cde	1683	bcd	1409	cde	1878	bcdef	2261	bcd	1017	ab
average	1601		1155		1534		2057		2430		833	
CV (%)	42		67		42		46		52		27	

*Means separation by Fisher's protected LSD at 5% confidence level.
SARC location was removed from analysis due to drought and poor emergence.

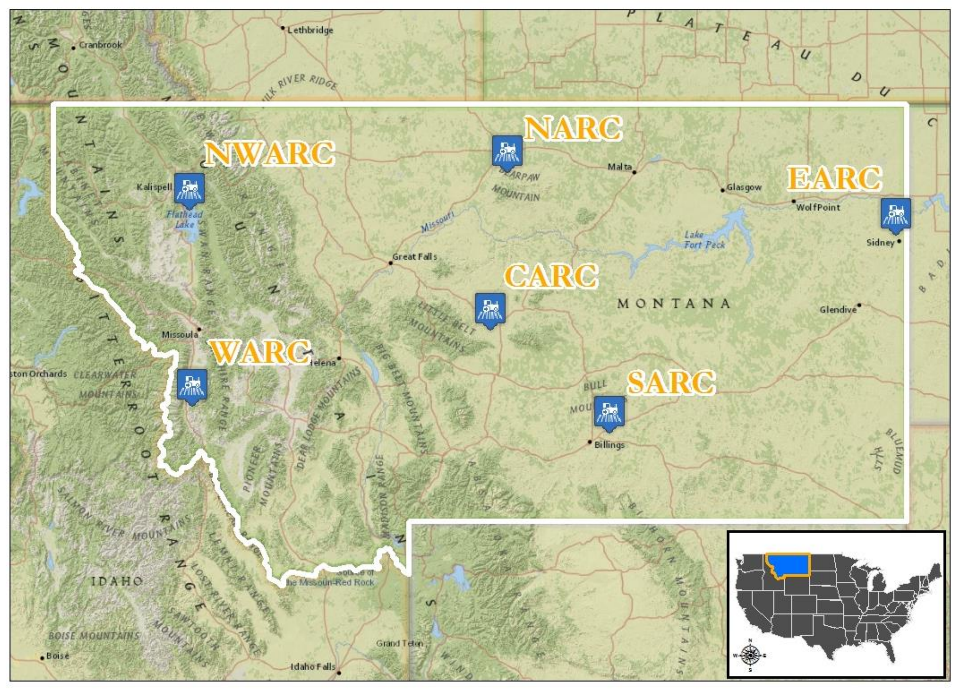
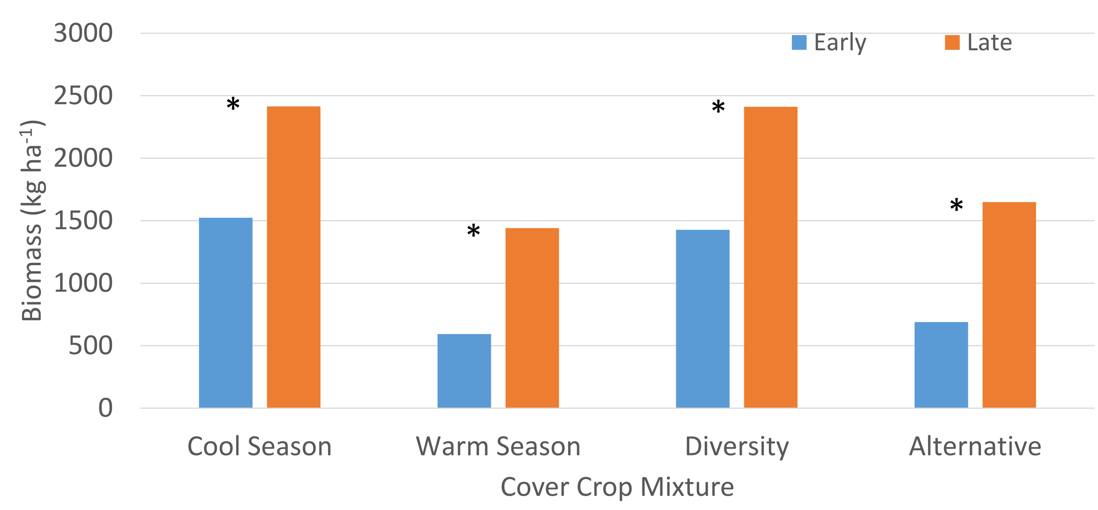


Figure 2. Impact of planting date on above ground biomass accumulation of mixed species plantings averaged across locations.



* Indicates treatments are significantly different at 5% level using pairwise comparison.

Table 4. Nutrient profiles (%) of forage from trial entries averaged across locations. RFV is an index value as compared to alfalfa (100), nitrate values are ppm.

Established	Cover Crop	CP	ADF	NDF	TDN	RFV	NO_3
Early	Hairy Vetch	28	26	28	65	232	719
	Alsike Clover	21	25	31	63	215	195
	Pea	20	25	34	66	193	273
	Warm Season Mix	21	27	34	61	205	1294
	Turnip	19	30	33	57	208	3448
	Safflower	18	28	35	62	181	1086
	Alternative Mix	20	28	36	60	182	1991
	Radish	18	28	37	58	176	2100
	Diversity Mix	17	26	44	66	146	1110
	Cool Season Mix	16	28	45	65	141	955
	Canola	17	32	44	60	142	1778
	Oat	13	30	53	65	115	884
	Flax	14	35	51	61	115	162
	Spring Triticale	13	35	62	62	92	526
	average	18	29	40	62	167	1180
Late	Radish	16	24	30	65	161	165
	Purple Top Turnip	15	26	30	60	221	3350
	Sorghum	16	26	33	65	91	111
	German Millet	16	28	38	58	88	1634
	Sunflower	18	31	38	58	166	366
	Soybean	14	33	41	58	194	2223
	Fababean	14	33	44	59	159	86
	Chickpea	14	31	45	61	137	1957
	Black Bean	14	34	46	57	222	203
	Indian Corn	12	31	50	61	100	725
	Berseem Clover	13	31	51	62	129	985
	Teff	12	32	53	62	89	632
	Cool Season Mix	9	33	59	63	115	75
	Warm Season Mix	8	37	62	60	136	126
	Diversity Mix	10	35	64	61	119	263
	Alternative Mix	8	37	64	60	122	118
	average	13	31	47	61	141	814

*Abbreviations are as follows. CP, crude protein; ADF, acid detergent fiber; NDF, neutral detergent fiber; TDN, total digestible nutrients; RFV, relative feed value = DDM x DMI /1.29 where DDM is Digestible Dry Matter= 88.9 – (0.779 x %ADF), and DMI is Dry Matter Intake = 120/%NDF; NO_3, nitrate concentration. RFV categories : Premium > 140, Good 110 – 139, Fair 90-109, Utility < 90

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