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Evaluation of Cool Season Cover Crops in Southern Montana

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ABSTRACT

Cool season, annuals provide multiple benefits to production agriculture when planted as a cover crop such as suppressing weeds, controlling soil erosion, adding nitrogen, increasing soil organic matter and other soil health improvement, and pollinator habitat enhancement. However, success of cover crop plantings depends on selection of the best adapted cultivar or variety meeting the planting objective. The purpose of this study was to evaluate fifty-eight commercially available cultivars and varieties of eight common annual, cool season species for their adaptation to the Montana and Wyoming climate. Austrian winter pea (*Pisum sativum* L.), balansa clover (*Trifolium michelianum* Savi), black oats (*Avena sativa* L. and *A. strigosa* Schreb.), cereal rye (*Secale cereal* L.), crimson clover (*Trifolium incarnatum* L.), daikon radish (*Raphanus sativus* L.), hairy vetch (*Vicia villosa* Roth), and red clover (*Trifolium pretense* L.) were evaluated for field emergence, plant height, days after planting to 50% bloom, disease and insect damage, and aboveground biomass production at the Montana Plant Materials Center, Bridger, Montana in 2017 and 2018. Austrian winter pea cultivars had good to excellent emergence, averaged 30 ± 9 inches height, and had good quality forage. 'Arvica 4010', 'Dunn', and 'Maxum' exhibited the greatest height and aboveground biomass values making them effective cover crop choices. Balansa and crimson clovers did not perform well in this study and are not recommended as cover crops for Montana or Wyoming. 'Cosaque', black oats and 'Soil Saver', black seeded oats were relatively slow to establish but had consistent overall growth averaging 53 inches in height and produced high amounts of aboveground biomass with relatively consistent forage quality regardless of cultivar. Cereal rye cultivars had good to excellent emergence, a mean plant height that varied among cultivars but produced consistently high aboveground biomass across cultivars. Percent field emergence of daikon radish cultivars were consistently good to excellent, except for 'Graza' which performed poorly throughout the study. Daikon radish averaged 42 ± 12 inches in height and produced an average of 4010 ± 1864 lb/ac of good forage quality making it a good choice for use when forage production and soil stability are a resource concern. Hairy vetch cultivars were slow to establish and varied in plant height but produced large amounts of high-quality aboveground biomass averaging 3890 ± 2424 lb/ac. 'TNT' and 'Villana' hairy vetch had the greatest aboveground biomass production with over 6000 and 7000 lb/ac, respectively. Red clover cultivars were slow to emerge, had a mean plant height of 16 ± 4 inches for both years, and produced an average of 1339 ± 211 lb/ac of high-quality aboveground biomass. Any of the red clover cultivars are recommended in Montana or Wyoming except 'Mammoth' or 'Starfire II'.

INTRODUCTION

Utilizing annual, cool season grasses and legumes as cover crops improves soil health, conserves energy, builds resilience, and manages climate risk (Lal, 2004; Reicosky and Forcella, 1998; Hargrove, 1986; Reeves, 1994). Cool season, annual legumes such as hairy vetch and crimson clover reduce nitrogen inputs of subsequent commodity crops (Singh et al., 2004; Smith et al., 1987), while non-leguminous cover crops, such as small grains, effectively limit nitrate leaching and soil erosion (Meisinger et al., 1991). However, multiple benefits are not achieved unless the best adapted cultivar(s) are planted that meet the planting objectives (i.e. weed suppression, nitrogen scavenging, reduce soil erosion) and the

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end-user's expectations. The purpose of this study is to evaluate growth characteristics of annual, cool season grass, legume, and forb cultivars to determine their adaptation for cover cropping in Montana and Wyoming.

MATERIALS AND METHODS

The study was conducted at the USDA-Natural Resources Conservation Service, Bridger Plant Materials Center, Bridger, MT in 2017 and 2018. Bridger is at 3,670 feet elevation and has Heldt silty clay loam soil and average annual precipitation is 11.5 inches. Annual, cool seasons were planted on a pure live seed (PLS) basis (Table 1). Legumes were inoculated with appropriate rhizobia before seeding. Plots were seeded on May 9, 2017, and May 8, 2018, using a single-row, push-type, cone-seeder with a furrow opener and a packer wheel on 12-inch row spacing. Each cultivar was planted in a 20-foot row. Spring pea (*Pisum sativum* L.) was planted around the perimeter of the plots and a 3-wire electric fence was used to control deer browsing of the planted cover crops (Figure 1). No irrigation was applied. Monthly rainfall and air temperature were recorded in 2017 and 2018 (Table 2).

Figure 1. Cover Crop test trial layout, Bridger Plant Materials Center, June 2017.

Approximately every seven days in both years, field emergence was estimated in each plot for four weeks after planting using the following rating scale: 0 = poor (<25% germination), 1 = moderate (30 to 60%), 2 = good (65 to 85%), 3 = excellent 90 to 100%). Average plant height was measured at three random location in each plot. Bloom period was monitored by noting the date of beginning bloom and 50% bloom. Entries were evaluated for disease and insect damage (rated from 0 to 5, where 0 = no damage and 5 = severe damage) at 50% bloom (date varied by species and cultivar). Aboveground biomass samples were collected for each cultivar at 50% bloom by cutting the aboveground plant material from three randomly selected 1-foot frames in the row. Prior to weighing, all samples were dried in a forage drier at 50°C for 48 hours. Cultivars producing at least 0.5 pounds of sample dry matter in 2017 were analyzed for forage quality estimates of crude protein, acid detergent fiber, neutral detergent fiber, total digestible nutrients, relative feed value, and nitrate.

The experimental design was a randomized complete block with four replications. To determine variation among cultivars within a species, mean and standard deviation were reported for field emergence, plant height, days after planting (DAP) to 50% bloom, disease and insect damage, and aboveground biomass using Statistix 10 (Analytical Software, Tallahassee, FL). ANOVA models were constructed to determine cultivar, year, and cultivar*year interaction effects on plant height. Specific cultivar comparisons were reported using Tukey Honest Significant Difference (HSD) procedure with differences considered significant at $p \leq 0.05$.

Table 1. Species, cultivars, and seeding rates of annual cool season cover crops planted in 2017 and 2018 at the USDA-NRCS Bridger Plant Materials Center, Bridger, MT.

Common name	Species	Cultivar	PLS lb/acre	% PLS	Seeding Rate lb/acre
Austrian winter pea	*Pisum sativum*	Arvica 4010	10	99	10
Austrian winter pea	*Pisum sativum*	Dunn	10	98	10
Austrian winter pea	*Pisum sativum*	Frost Master	10	95	11
Austrian winter pea	*Pisum sativum*	Lynx	10	94	11
Austrian winter pea	*Pisum sativum*	Maxum	10	97	10
Austrian winter pea	*Pisum sativum*	Whistler	10	95	11
Austrian winter pea	*Pisum sativum*	Windham	10	95	11
Balansa clover	*Trifolium michelianum*	Fixation	20	43	47
Balansa clover	*Trifolium michelianum*	Frontier	20	51	39
Black seeded oats	*Avena sativa*	Cosaque	20	88	23
Black oats	*Avena strigosa*	Soil Saver	20	99	20
Cereal Rye	*Secale cereale*	Aroostook	20	94	21
Cereal Rye	*Secale cereale*	Bates	20	93	22
Cereal Rye	*Secale cereale*	Brasetto	20	87	23
Cereal Rye	*Secale cereale*	Elbon	20	89	22
Cereal Rye	*Secale cereale*	FL 401	20	90	25
Cereal Rye	*Secale cereale*	Guardian	20	92	22
Cereal Rye	*Secale cereale*	Hazlet	20	95	21
Cereal Rye	*Secale cereale*	Maton	20	90	22
Cereal Rye	*Secale cereale*	Maton II	20	88	23
Cereal Rye	*Secale cereale*	Merced	20	98	20
Cereal Rye	*Secale cereale*	Oklon	20	92	22
Cereal Rye	*Secale cereale*	Rymin	20	95	21
Cereal Rye	*Secale cereale*	Wheeler	20	91	22
Cereal Rye	*Secale cereale*	WinterGrazer 70	20	73	27
Cereal Rye	*Secale cereale*	Wren's Abruzzi	20	89	22
Crimson clover	*Trifolium incarnatum*	AU Robin	20	50	40
Crimson clover	*Trifolium incarnatum*	AU Sunrise	20	46	43
Crimson clover	*Trifolium incarnatum*	AU Sunup	20	30	67
Crimson clover	*Trifolium incarnatum*	Contea	20	60	33
Crimson clover	*Trifolium incarnatum*	Dixie	20	53	38
Crimson clover	*Trifolium incarnatum*	KY Pride	20	56	36
Daikon radish	*Raphanus sativus*	Big Dog	10	98	10
Daikon radish	*Raphanus sativus*	Concorde	10	92	10
Daikon radish	*Raphanus sativus*	Control	10	93	10
Daikon radish	*Raphanus sativus*	Defender	10	97	9
Daikon radish	*Raphanus sativus*	Driller	10	98	9
Daikon radish	*Raphanus sativus*	Eco-till	10	94	10
Daikon radish	*Raphanus sativus*	Graza	10	93	10
Daikon radish	*Raphanus sativus*	Groundhog	10	97	11
Daikon radish	*Raphanus sativus*	Lunch	10	98	10

Common name	Species	Cultivar	PLS lb/acre	% PLS	Seeding Rate lb/acre
Daikon radish	*Raphanus sativus*	Nitro	10	98	9
Daikon radish	*Raphanus sativus*	Sodbuster Blend	10	97	10
Daikon radish	*Raphanus sativus*	Tillage	10	96	10
Hairy vetch	*Vicia villosa*	Groff	10	90	11
Hairy vetch	*Vicia villosa*	Lana	10	98	10
Hairy vetch	*Vicia villosa*	Purple Bounty	10	78	13
Hairy vetch	*Vicia villosa*	Purple Prosperity	10	90	11
Hairy vetch	*Vicia villosa*	TNT	10	75	13
Hairy vetch	*Vicia villosa*	Villana	10	100	10
Red clover	*Trifolium pratense*	Cinnamon Plus	20	61	33
Red clover	*Trifolium pratense*	Cyclone II	20	49	41
Red clover	*Trifolium pratense*	Dynamite	20	55	36
Red clover	*Trifolium pratense*	Freedom	20	57	35
Red clover	*Trifolium pratense*	Kenland	20	81	25
Red clover	*Trifolium pratense*	Mammoth	20	87	23
Red clover	*Trifolium pratense*	Starfire	20	48	34
Red clover	*Trifolium pratense*	Wildcat	20	77	26

RESULTS AND DISCUSSION

Total precipitation from May 1 through September 30 was 5.3 inches in 2017 and 5.1 inches in 2018, compared to the long-term average precipitation for the same time period of 6.9 inches (Table 2). The average air temperature in all months, except September 2018, was greater than the long-term average for the same time period. Overall, climate conditions during the study were drier and warmer than the long-term averages.

Table 2. The 2017, 2018, and long-term average monthly precipitation and air temperature for the cover crop growing season, USDA-NRCS Bridger Plant Materials Center, Bridger, MT.

Month	2017 Total Monthly Precipitation	2018 Total Monthly Precipitation	Long-term Monthly Precipitation	2017 Average Air Temperature	2018 Average Air Temperature	Long-term Average Air Temperature
	----------inches----------			-------degrees Fahrenheit--------		
May	0.9	1.1	2.2	56.5	57.8	53.4
June	0.5	2.4	1.9	66.2	63.4	62.1
July	0.3	0.3	0.8	76.1	71.3	69.9
August	0.3	1.3	0.8	69.5	68.0	67.6
September	3.3	0.0	1.2	58.0	57.8	57.9
Total	5.3	5.1	6.9	-	-	-

Austrian Winter Pea

Austrian winter pea is a cool-season crop grown for its edible seed or seed pods, which can be consumed by humans or animals. Peas are a nutritious legume that contain a high percent protein and produce large amounts of biomass. Peas can be grazed while in the field and will regrow multiple times after being grazed. Peas are a desirable cover crop species because they interrupt disease and pest cycles, provide nitrogen, improve soil microbe diversity and activity, improve soil aggregation, conserve soil water, and provide economic diversity (Pavek, 2012).

Pea flower. Photo by USDA-ARS.

Austrian winter pea cultivars were relatively slow to establish with "poor" to "moderate" early field emergence in 2017 and 2018, but "good" to "excellent" emergence thereafter (Table 3). All Austrian winter pea cultivars had relatively consistent number of days to 50% bloom within a year, and all cultivars had low insect and disease damage ratings (Table 4). Cultivars differed significantly in height when years were averaged (P<0.05) and averaged of 30 ± 9 inches height. 'Arvica 4010', 'Dunn' and 'Maxum' exhibited the greatest height and aboveground biomass production making them effective cover crop choices for conservation practices addressing forage production, weed suppression, preventing soil erosion, and more (Table 5). Austrian winter pea cultivars had high and relatively consistent relative feed values.

Table 3. Mean and standard deviation of emergence ratings of Austrian winter pea cultivars at 7, 14, 21 and 28 days after planting in 2017 and 2018 at USDA-NRCS Bridger Plant Materials Center, Bridger, MT.

Austrian Winter Pea Cultivar	Emergence Ratings for Days After Planting[1]							
	7 days		14 days		21 days		28 days	
	2017	2018	2017	2018	2017	2018	2017	2018
Arvica 4010	0.0	0.0	0.3	3.0	2.8	3.0	2.8	3.0
Dunn	0.0	0.0	0.3	2.8	2.5	3.0	2.5	3.0
Frost Master	0.0	0.0	0.0	2.0	1.3	2.5	1.5	2.5
Lynx	0.0	0.0	0.0	1.8	1.8	2.5	2.0	2.8
Maxum	0.0	0.0	0.3	2.5	2.5	3.0	2.5	3.0
Survivor 15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Whistler	0.0	0.0	0.0	2.4	2.5	3.0	2.3	3.0
Windham	0.0	0.0	0.0	2.0	2.5	3.0	2.3	3.0
Mean	0.0	0.0	1.6	2.4	2.2	2.9	2.3	2.9
SD[2]	0.0	0.0	1.2	0.6	0.7	0.4	0.7	0.3

[1] 0 = poor (<25% emergence); 1 = moderate (30-60% emergence); 2 = good (65-85% emergence); 3 = excellent (90-100% emergence)

[2] SD - standard deviation

Table 4. Mean and standard deviation for plant height, days after planting to 50% bloom, and insect and disease ratings for Austrian winter pea cultivars in 2017 and 2018 at USDA-NRCS Bridger Plant Materials Center, Bridger, MT.

Austrian Winter Pea Cultivar	Plant Height (in.)			DAP to 50% Bloom		Insect[1] Damage	Disease[1] Damage
	2017	2018	Average[2]	2017	2018	Average	Average
Arvica 4010	50	33	41 a	68	57	0.5	0.3
Dunn	39	34	37 ab	66	57	0.5	0.4
Frost Master	34	30	32 bc	67	58	0.5	0.5
Lynx	21	16	19 d	68	57	0.3	0.3
Maxum	40	32	36 ab	68	56	0.5	0.1
Survivor 15	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Whistler	30	21	25 cd	68	58	0.4	0.4
Windham	23	17	20 d	60	56	0.1	0.4
Mean	34	26	30	66	57	0.4	0.3
SD[3]	11	8	9	3	1	0.0	0.1

[1] 0= no damage and 5 = severe damage

[2] Means followed by different letters are significantly different for cultivar*year interaction according to Tukey's HSD at $P<0.05$.

[3] SD - Standard deviation

Table 5. Average aboveground biomass and forage quality of Austrian winter pea at 50% bloom stage, USDA-NRCS Bridger Plant Materials Center, Bridger, MT.

Austrian Winter Pea Cultivar	Biomass	Protein (crude)	Fiber (acid detergent)	Fiber (neutral detergent)	Total Digestible Nutrients	Relative Forage Value	Nitrate (NO_3)
	lb/ac	%	%	%	%		%
Arvica 4010	3328	30	22	27	77	246	0.2
Dunn	3042	21	19	27	80	253	0.5
Frost Master	2283	32	21	22	78	301	0.1
Lynx	911	-	-	-	-	-	-
Maxum	3690	23	23	28	77	241	0.2
Whistler	2019	34	24	27	75	238	0.7
Windham	1413	-	-	-	-	-	-
Mean	2384	28	22	26	77	256	0.3
SD[1]	1024	6	2	2	2	26	0.3

[1] SD - Standard deviation

Balansa Clover

Balansa clover is an annual, cold- and drought-tolerant clover that can improve soil drainage, improve water infiltration, and decrease soil compaction due to its deep tap root. It can tolerate a variety of soil types and short periods of inundation. It is often used as a cover crop species for nitrogen fixation, high forage production, non-bloating forage, excellent forage quality, improved pollinator habitat, and weed control (OSU, 2018).

Balansa clover cultivars emerged slowly after planting in both years and only achieved a mean "moderate" emergence at 14, 21, and 28 days after planting (Table 6). The two balansa cultivars had relatively consistent number of days to 50% bloom within a test year, with 'Fixation' reaching bloom stage approximately 20 days earlier than 'Frontier' (Table 7). Both cultivars had low insect and disease damage ratings. 'Fixation' had a significantly greater height than 'Frontier' though both were small-statured plants with only 10 and 4 inches of total height, respectively (P=0.0197). 'Fixation' produced nearly four times more aboveground biomass than 'Frontier' but neither cultivar produced adequate biomass for forage quality testing.

Table 6. Mean and standard deviation of emergence groups of balansa clover at 7, 14, 21 and 28 days after planting in 2017 and 2018 at USDA-NRCS Bridger Plant Materials Center, Bridger, MT.

Balansa Clover Cultivar	Emergence Ratings for Days After Planting[1]							
	7 days		14 days		21 days		28 days	
	2017	2018	2017	2018	2017	2018	2017	2018
Fixation	0.0	0.0	0.0	0.0	1.0	0.5	1.1	0.8
Frontier	0.0	0.0	0.3	0.0	0.3	0.8	0.3	0.3
Mean	0.0	0.0	0.1	0.0	0.6	0.6	0.9	0.5
SD[2]	0.0	0.0	0.4	0.0	1.0	1.2	1.0	0.5

[1] 0 = poor (<25% emergence); 1 = moderate (30-60% emergence); 2 = good (65-85% emergence); 3 = excellent (90-100% emergence)

[2] SD - standard deviation

Table 7. Mean plant height, days after planting to 50% bloom, and insect and disease ratings, and aboveground biomass for balansa clover cultivars in 2017 and 2018 at USDA-NRCS Bridger Plant Materials Center, Bridger, MT.

Balansa Clover Cultivar	Plant Height (in.)			DAP to 50% Bloom		Insect[1] Damage	Disease[1] Damage	Biomass (lb/ac)
	2017	2018	Average[2]	2017	2018	Average	Average	Average
Fixation	16	4	10 a	75	72	0.4	0.5	717
Frontier	7	2	4 b	52	56	0.0	0.0	181
Mean	11	3	7	63	64	0.2	0.3	449
SD[3]	7	2	4	12	8	0.3	0.4	181

[1] 0= no damage and 5 = severe damage

[2] Means followed by different letters are significantly different for cultivar*year interaction according to Tukey's HSD at $P<0.05$.

[3] SD - Standard deviation

Black Oats / Black Seeded Oats

Black oat is an upright, winter annual grass used as a cool season, rotational cover crop either alone or seeded into a cover crop mixture. It does best on sandy or loamy soils but can also grow in heavy clay and soils with low nutrient value. It is not frost tolerant. It produces large amounts of aboveground biomass for weed control, erosion prevention, green manure, and forage production. Black oat is considered an excellent feed due to its high nutritional value and good digestibility (Dial, 2014).

Black oat seeds, Photo by USDA-AMS.

'Soil Saver,' black seeded oats, reached a "good" to "excellent" field emergence rating faster than 'Cosaque,' black oats (Table 8). However, both cultivars were relatively slow to establish, requiring 14 to 21 days to reach "good" emergence, which may be explained by cool spring temperatures. Warmer temperatures when planting may help accelerate emergence. Cultivars had statistically consistent overall growth between the two years averaging 53 inches ($P>0.05$; Table 9). Both cultivars had moderate insect damage and low disease damage ratings. Biomass production was similar among cultivars and had relatively consistent forage quality regardless of cultivar (Table 10). Both cultivars would make a good cover crop selection in Montana and Wyoming for conservation practices targeting forage production, soil stabilization, and weed suppression.

Table 8. Mean and standard deviation of emergence groups of black oats at 7, 14, 21 and 28 days after planting in 2017 and 2018 at USDA-NRCS Bridger Plant Materials Center, Bridger, MT.

Black Oat Cultivar	Emergence Ratings for Days After Planting[1]							
	7 days		14 days		21 days		28 days	
	2017	2018	2017	2018	2017	2018	2017	2018
Cosaque	0.0	0.0	0.3	1.8	1.8	2.0	2.0	3.0
Soil Saver	0.0	0.0	0.8	2.5	2.8	3.0	3.0	3.0
Mean	0.0	0.0	0.5	2.1	2.3	2.5	2.5	3.0
SD[2]	0.0	0.0	0.8	0.6	0.7	0.5	0.5	0.0

[1] 0 = poor (<25% emergence); 1 = moderate (30-60% emergence); 2 = good (65-85% emergence); 3 = excellent (90-100% emergence).

[2] SD - standard deviation

Table 9. Mean plant height, days after planting to 50% bloom, and insect and disease ratings for black oat cultivars in 2017 and 2018 at USDA-NRCS Bridger Plant Materials Center, Bridger, MT.

Black Oat Cultivar	Plant Height (in.)		DAP to 50% Bloom		Insect[1] Damage	Disease[1] Damage
	2017	2018	2017	2018	Average	Average
Cosaque	54	30	84	107	1.3	0.5
Soil saver	66	60	94	65	1.0	0.5
Mean	60 a	45 a	89	86	1.2	0.5
SD[2]	7	34	30	22	0.2	0.0

[1] 0= no damage and 5 = severe damage

[2] SD - Standard deviation

Table 10. Average aboveground biomass and forage quality of black oats at 50% bloom stage, USDA-NRCS Bridger Plant Materials Center, Bridger, MT.

Black Oat Cultivar	Biomass	Protein (crude)	Fiber (acid detergent)	Fiber (neutral detergent)	Total Digestible Nutrients	Relative Forage Value	Nitrate (NO_3)
	lb/ac	%	%	%	%		%
Cosaque	7071	22	30	53	68	116	2.1
Soil Saver	6543	22	32	56	66	107	2.0
Mean	6807	22	31	55	67	112	2.1
SD[1]	373	0	1	2	1	6	0.1

[1] SD - Standard deviation

Cereal Rye

Cereal rye is an upright, cool season, annual grass that is drought tolerant. As a cover crop, cereal rye can build soil, reduce compaction, prevent erosion, provide soil organic matter, and provide good quality forage. It absorbs unused soil nitrogen remaining from previously grown crops. It overwinters and creates a physical barrier to weeds by producing large amounts of biomass. Cereal rye has the potential to become a weed if it produces mature seed (Casey, 2012).

Flowering cereal rye in a cover crop plot, Photo by USDA-MOPMC.

Cereal rye cultivars had “good” to “excellent” emergence ratings within 14 days after planting in both years (Table 11). Cover crops that quickly emerge and accumulate fall growth are important attributes for protecting the soil from sheet

and rill erosion, suppressing problematic weeds, and scavenging residual soil nitrate nitrogen after crops have matured (Matias et al., 2004; Roberts, 2015). The mean plant height varied considerably among cultivars and was 43 ± 18 inches in 2017 and 30 ± 15 inches in 2018 (Table 12). Even though cereal rye cultivars varied in height, the aboveground biomass production at 50% bloom was relatively consistent and averaged 5218 ± 588 lb/ac (Table 13). Mean days after planting to 50% bloom was 78 ± 19 days in 2017 and 58 ± 5 days in 2018. If seed production is a concern, select a cultivar with greater number of days to 50% bloom; however, these cultivars often also have lower heights. Cereal rye cultivars had low to moderate insect damage ratings and low disease ratings. Cereal rye averaged 121 relative forage value and 25% protein at 50% bloom stage. Nitrate ranged from 0.9 to 4.7% and averaged 2.7% which was higher than the forbs and other grass in the study and may reflect cereal rye's ability to absorb soil nitrogen. Cereal rye is a good cover crop selection in Montana and Wyoming for conservation practices targeting fast emergence, soil stabilization, improving soil organic matter, and forage production. However, care should be taken to minimize potential nitrate impacts to livestock.

Table 11. Mean and standard deviation of emergence groups of cereal rye cultivars at 7, 14, 21 and 28 days after planting in 2017 and 2018 at USDA-NRCS Bridger Plant Materials Center, Bridger, MT.

Cereal Rye Cultivar	Emergence Ratings for Days After Planting[1]							
	7 days		14 days		21 days		28 days	
	2017	2018	2017	2018	2017	2018	2017	2018
Aroostock	0.0	1.3	2.8	3.0	3.0	3.0	3.0	3.0
Bates	0.0	1.8	2.8	3.0	3.0	3.0	3.0	3.0
Brasetto	0.0	1.5	2.0	3.0	2.3	3.0	2.3	3.0
Elbon	0.0	1.0	3.0	3.0	3.0	3.0	3.0	3.0
FL 101	0.0	1.8	3.0	3.0	3.0	3.0	3.0	3.0
Guardian	0.0	1.0	2.5	2.5	3.0	3.0	3,0	3.0
Hazlet	0.0	1.3	2.8	3.0	2.8	3.0	2.8	3.0
Maton	0.0	1.3	2.5	3.0	2.8	3.0	2.8	3.0
Maton II	0.0	0.5	2.0	2.5	2.5	3.0	2.5	3.0
Merced	0.0	1.5	2.8	3.0	3.0	3.0	3.0	3.0
Oklon	0.0	1.0	2.3	2.8	3.0	3.0	3.0	3.0
Rymin	0.0	1.5	3.0	3.0	3.0	3.0	3.0	3.0
Wheeler	0.0	1.0	2.0	2.3	2.5	3.0	2.5	3.0
Wintergrazer 70	0.0	1.0	2.8	3.0	2.8	3.0	2.8	3.0
Wren Abruzzi	0.0	1.3	3.0	3.0	3.0	3.0	3.0	3.0
Mean	0.0	1.2	2.6	2.9	2.8	3.0	2.8	3.0
SD[2]	0.0	0.6	0.5	0.2	0.4	0.0	0.4	0.0

[1] 0 = poor (<25% emergence); 1 = moderate (30-60% emergence); 2 = good (65-85% emergence); 3 = excellent (90-100% emergence)

[2] SD - standard deviation

Table 12. Mean plant height, days after planting to 50% bloom, and insect and disease ratings for cereal rye cultivars in 2017 and 2018 at USDA-NRCS Bridger Plant Materials Center, Bridger, MT.

Cereal Rye Cultivar	Plant Height (in.)[2]		DAP to 50% Bloom		Insect[1] Damage	Disease[1] Damage
	2017	2018	2017	2018	Average	Average
Aroostock	31 ef	15 d	79	66	0.7	0.6
Bates	59 abc	47 ab	67	57	0.5	0.1
Brasetto	21 f	14 d	105	56	1.1	0.6
Elbon	40 de	28 c	71	64	0.9	0.3
FL 401	70 a	56 a	60	55	0.4	0.3
Guardian	21 f	14 d	107	65	1.3	0.6
Hazlet	20 f	15 d	105	49	1.5	0.8
Maton	47 cd	30 c	69	62	0.4	0.5
Maton II	56 bc	35 bc	68	57	0.5	0.1
Merced	62 ab	40 abc	56	49	0.0	0.0
Oklon	42 de	28 c	70	59	0.6	0.4
Rymin	21 f	14 d	105	N/A	1.0	0.6
Wheeler	35 de	17 c	81	62	1.0	0.5
Wintergrazer 70	58 abc	45 ab	65	55	0.5	0.3
Wren Abruzzi	59 abc	48 ab	63	56	0.4	0.3
Mean	43	30	78	58	0.7	0.4
SD[3]	18	15	19	5	0.4	0.2

[1] 0= no damage and 5 = severe damage

[2] Means in columns followed by different letters are significantly different for cultivar according to Tukey's HSD at $P<0.05$.

[3] SD - Standard deviation

Table 13. Average aboveground biomass and forage quality of cereal rye at 50% bloom stage, USDA-NRCS Bridger Plant Materials Center, Bridger, MT.

Cereal Rye Cultivar	Biomass	Protein (crude)	Fiber (acid detergent)	Fiber (neutral detergent)	Total Digestible Nutrients	Relative Forage Value	Nitrate (NO_3)
	lb/ac	%	%	%	%		%
Aroostock	5418	28	27	53	72	119	3.5
Bates	5520	21	27	49	72	128	1.6
Brasetto	5371	23	29	52	70	118	2.5
Elbon	5333	34	25	46	74	142	3.0
FL 101	5662	16	34	56	64	104	0.9
Guardian	5528	22	32	55	66	108	1.7
Hazlet	5767	18	28	54	71	115	0.7
Maton	5225	24	28	49	70	126	2.0
Maton II	4483	26	27	49	71	129	3.3
Merced	3487	18	35	58	63	99	1.7
Oklon	5003	28	26	51	7	124	4.3
Rymin	5756	23	30	54	69	112	2.2
Wheeler	4928	29	28	49	71	128	4.5
WinterGrazer 70	5222	29	27	50	72	127	4.6
Wren's Abruzzi	5571	32	28	48	70	129	4.7
Mean	5218	25	29	52	66	121	2.7
SD[1]	588	5	3	3	17	11	1.4

[1] SD - Standard deviation

Crimson Clover

Crimson clover is commonly used as a winter or summer annual cover crop. Crimson clover makes an excellent weed-suppressing green manure crop adding nitrogen to the soil. It is a widely planted as a nutritious forage legume, particularly in the southern U.S., and can produce high yields of good quality hay when harvested at or before the mid-bloom stage. The flowers produce abundant nectar and pollen for bees, and it is an important wildlife forage species (Young-Mathews, 2013).

Flowering crimson clover, Photo by USDA.

Mean percent field emergence was slow for crimson clover cultivars with only three cultivars reaching "good" emergence in 2017 at 28 days after planting (Table 14). In 2018, none of the cultivars reached a "good" emergence rating. There were statistically significant differences among cultivars for height (years combined; *P*<0.05; Table 15). Heights ranged from 9 to 13 inches with a mean plant height of 11 ± 3 inches). Crimson clover reached the 50% bloom stage 74 and 72 days after planting in 2017 and 2018, respectively. All cultivars had low to moderate insect damage and low disease damage ratings. The low aboveground biomass production of most cultivars reflected the short stature of this species in the trial. In fact, most cultivars did not have enough sample aboveground biomass for forage quality analysis (Table 16). Crimson clover is known as a high yielding, high quality forage in the southern United States but did not perform well in this Montana field trial. If crimson clover is desired for use in Montana or Wyoming to add diversity or forage quality to cover crop mixes, then 'Kentucky Pride' and 'Dixie' cultivars should be selected.

Table 14. Mean and standard deviation of emergence groups of crimson clover cultivars at 7, 14, 21 and 28 days after planting in 2017 and 2018 at USDA-NRCS Bridger Plant Materials Center, Bridger, MT.

Crimson Clover Cultivar	Emergence Ratings for Days After Planting[1]							
	7 days		14 days		21 days		28 days	
	2017	2018	2017	2018	2017	2018	2017	2018
AU Robin	0.0	0.0	0.8	1.0	1.8	1.3	2.0	1.8
AU Sunrise	0.0	0.0	0.5	1.0	1.8	1.0	2.0	1.5
AU Sunup	0.0	0.0	0.0	0.3	0.3	0.5	0.3	1.3
Contea	0.0	0.0	0.0	0.5	0.0	1.0	0.0	1.3
Dixie	0.0	0.0	0.0	1.0	1.0	1.0	1.5	1.3
Kentucky Pride	0.0	0.0	1.0	1.0	1.5	1.0	2.0	1.5
Mean	0.0	0.0	0.4	0.8	1.0	1.0	1.3	1.4
SD[2]	0.0	0.0	0.7	0.4	0.8	0.4	1.0	0.5

[1] 0 = poor (<25% emergence); 1 = moderate (30-60% emergence); 2 = good (65-85% emergence); 3 = excellent (90-100% emergence)

[2] SD - standard deviation

Table 15. Mean plant height, days after planting to 50% bloom, and insect and disease ratings for crimson clover cultivars in 2017 and 2018 at USDA-NRCS Bridger Plant Materials Center, Bridger, MT.

Crimson Clover Cultivar	Plant Height (in.)			DAP to 50% Bloom		Insect[1] Damage	Disease[1] Damage
	2017	2018	Average[2]	2017	2018	Average	Average
AU Robin	19	7	13 a	76	76	0.5	0.4
AU Sunrise	19	6	12 a	65	63	0.8	0.5
AU Sunup	9	5	7 b	65	60	0.8	0.4
Contea	14	4	9 ab	84	79	1.0	0.4
Dixie	21	5	13 a	75	70	1.0	0.4
Kentucky Pride	20	6	13 a	80	83	1.0	0.4
Mean	17	6	11	74	72	0.9	0.4
SD[3]	7	2	3	8	10	0.2	0.2

[1] 0= no damage and 5 = severe damage

[2] Means followed by different letters are significantly different for cultivar*year interaction according to Tukey's HSD at $P<0.05$.

[3] SD - Standard deviation

Table 16. Average aboveground biomass and forage quality of crimson clover at 50% bloom stage, USDA-NRCS Bridger Plant Materials Center, Bridger, MT.

Crimson Clover Cultivar	Biomass	Protein (crude)	Fiber (acid detergent)	Fiber (neutral detergent)	Total Digestible Nutrients	Relative Forage Value	Nitrate (NO_3)
	lb/ac	%	%	%	%		%
AU Robin	1078	-	-	-	-	-	-
AU Sunrise	863	-	-	-	-	-	-
SU Sunup	409	-	-	-	-	-	-
Contea	746	-	-	-	-	-	-
Dixie	1350	26	21	31	79	221	1.4
KY Pride	1641	27	21	31	79	220	1.5
Mean	1015	27	21	31	79	221	1.5
SD[1]	440	0.7	0	0	0	1	0.1

[1]SD - Standard deviation

Daikon Radish

Daikon radish is used as a cover crop to maintain soil quality, fertility, and productivity. Daikon radish is usually planted in late summer to early fall or after harvest of the primary crop. Radish develops a deep taproot that allows it to penetrate soil layers, thereby reducing soil compaction in the upper soil profile while scavenging nitrogen from lower soil depths. Daikon radish is also used for weed and pest management, and forage production (Jacobs, 2012).

Cultivars of daikon radish growing at MTPMC, Photo USDA-NRCS.

Percent field emergence of daikon radish cultivars were consistently "good" to "excellent" emergence within 14 to 21 day for both years, except for 'Graza' which performed poorly throughout the study (Table 17). The spring planting resulted in an average of approximately 60 days until 50% bloom in both years (Table 18). Daikon radish had insect damage in the majority of its leaves but exhibited low disease damage for all cultivars. There were significant differences among Daikon radish cultivars for height in 2017 and 2018 (cultivar by year interaction $P<0.05$). Overall, Daikon radish averaged 42 ± 12 inches height and produced an average of 4010 ± 1864 lb/ac (Table 19). All Daikon radish cultivars provided good forage quality with an average of 30% crude protein and 190% relative feed value. Nitrate averaged 5.3 ± 1.0% which was the highest of any species tested in this trial. Based on these results, Daikon radish would be a fast-establishing cover crop species for a mix in Montana or Wyoming if soil quality, soil stability, forage production, and forage quality are resource concerns. However, care should be taken to minimize potential nitrate impacts to livestock.

Table 17. Mean values and standard deviations of emergence groups of daikon radish at 7, 14, 21 and 28 days after planting in 2017 and 2018 at USDA-NRCS Bridger Plant Materials Center, Bridger, MT.

Daikon Radish Cultivar	Emergence Ratings for Days After Planting[1]							
	7 days		14 days		21 days		28 days	
	2017	2018	2017	2018	2017	2018	2017	2018
Big Dog	0.0	0.0	2.5	2.5	3.0	3.0	2.8	3.0
Concorde	0.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0
Control	0.0	0.0	3.0	3.0	3.0	3.0	3.0	3.0
Defender	0.0	0.0	2.5	2.8	3.0	3.0	3.0	3.0
Driller	0.0	0.0	2.5	3.0	2.8	2.3	2.8	3.0
EcoTill	0.0	0.0	2.8	2.8	3.0	3.0	3.0	3.0
Graza	0.0	0.0	0.0	0.8	0.3	1.5	0.5	2.0
Groundhog	0.0	0.0	2.5	3.0	2.8	2.3	2.8	3.0
Lunch	0.0	0.0	2.0	3.0	2.5	3.0	2.3	3.0
Nitro	0.0	0.0	2.5	2.8	3.0	3.0	2.8	3.0
Sodbuster	0.0	0.0	2.0	2.3	3.0	3.0	2.8	3.0
Tillage	0.0	0.0	2.2	2.8	2.3	2.8	2.5	2.8
Mean	0.0	0.0	2.3	2.6	2.6	2.7	2.6	3.0
SD[2]	0.0	0.0	0.8	0.7	0.8	0.7	0.8	0.8

[1] 0 = poor (<25% emergence); 1 = moderate (30-60% emergence); 2 = good (65-85% emergence); 3 = excellent (90-100% emergence).

[2] SD - standard deviation

Table 18. Mean values for plant height, days after planting to 50% bloom, and insect and disease ratings for daikon radish cultivars in 2017 and 2018 at USDA-NRCS Bridger Plant Materials Center, Bridger, MT.

Daikon Radish Cultivar	Plant Height (in.)			DAP to 50% Bloom		Insect[1] Damage	Disease[1] Damage
	2017	2018	Average[2]	2017	2018	Average	Average
Big Dog	53	37	45 ab	58	57	2.0	0.5
Concorde	52	44	48 a	60	56	2.0	0.5
Control	53	42	48 a	63	60	2.0	0.5
Defender	54	43	48 a	61	55	2.0	0.5
Driller	47	36	42 ab	56	56	2.0	0.5
EcoTill	50	39	45 ab	56	61	2.0	0.5
Graza	0	9	5 c	96	N/A	3.8	0.5
Groundhog	52	37	44 ab	56	58	2.0	0.5
Lunch	47	36	42 ab	56	59	2.0	0.5
Nitro	48	38	43 ab	56	59	2.0	0.5
Sodbuster	42	38	41 b	56	58	2.0	0.5
Tillage	43	37	40 b	56	57	2.0	0.5
Mean	45	36	42	61	58	2.2	0.5
SD[3]	15	9	12	11	3	0.5	0.0

[1] 0= no damage and 5 = severe damage

[2] Means followed by different letters are significantly different for cultivar*year interaction according to Tukey's HSD at *P*<0.05.

[3] SD - Standard deviation

Table 19. Average aboveground biomass and forage quality of Daikon radish at 50% bloom stage, USDA-NRCS Bridger Plant Materials Center, Bridger, MT.

Daikon Radish Cultivar	Biomass	Protein (crude)	Fiber (acid detergent)	Fiber (neutral detergent)	Total Digestible Nutrients	Relative Forage Value	Nitrate (NO_3)
	lb/ac	%	%	%	%		%
Big Dog	4013	32	31	36	67	170	5.1
Concorde	5748	30	29	29	70	215	6.0
Control	7246	29	30	32	69	189	5.3
Defender	7398	26	35	35	63	166	4.0
Driller	3220	33	27	27	71	234	5.6
Eco-till	3558	32	34	37	64	159	5.3
Graza	1226	-	-	-	-	-	-
Groundhog	3545	31	30	33	68	185	5.2
Lunch	2539	33	30	29	68	211	7.5
Nitro	3174	33	29	30	70	205	6.2
Sodbuster	2810	26	33	35	66	169	4.5
Tillage	3646	28	29	32	70	192	3.8
Mean	4010	30	31	32	69	190	5.3
SD[1]	1864	3	2	3	3	24	1.0

[1] SD - Standard deviation

Hairy Vetch

Hairy vetch is a vining, annual or biennial legume suited for a wide range of soils. It is used as a cover crop in no-till rotations, especially in regions that are less favorable for clover and pea cultivation, and in orchards and vineyards USDA-NRCS, 2002). Hairy vetch is noted for its ability to fix large quantities of nitrogen, provide heavy mulch/biomass for soil and water conservation, and provide good quality forage for livestock. This species may become weedy in some habitats and may displace desirable species (USDA-NRCS, 2002).

Hairy vetch cultivars reached "good" field emergence within 21 days in 2017 and 14 days in 2018 (Table 20). The interaction of cultivar and year had a significant effect on hairy vetch height (Table 21). Plant height varied among cultivars and was greater in 2017 with 27 ± 8 inches, versus 10 ± 3 inches in 2018. Mean DAP to 50% bloom was relatively consistent among cultivars in both years, except for 'TNT' and 'Villana' which reached DAP to 50% bloom approximately 30 days later than other cultivars. Insect and disease damage ratings were low for all cultivars. Hairy vetch produced high amounts of aboveground biomass, averaging 3890 ± 2424 lb/ac. 'TNT' and 'Villana' had the greatest biomass production with over 6000 and 7000 lb/ac, respectively (Table 22). This trial verified hairy vetch as a high-quality forage, averaging 35 ± 5% crude protein and 181 ± 16 relative feed value. 'TNT', 'Villana' and 'Lana' hairy vetch cultivars are good choices for cover crop mixes in Montana and Wyoming when the production of high-quality forage is needed to address resource concerns such as soil stabilization, soil quality, forage production, or forage quality.

Flowering hairy vetch, Photo USDA.

Table 20. Mean and standard deviation of emergence groups of hairy vetch cultivars at 7, 14, 21 and 28 days after planting in 2017 and 2018 at USDA-NRCS Bridger Plant Materials Center, Bridger, MT.

Hairy Vetch Cultivar	Emergence Ratings for Days After Planting[1]							
	7 days		14 days		21 days		28 days	
	2017	2018	2017	2018	2017	2018	2017	2018
CCS Groff	0.0	0.0	0.0	2.0	2.0	3.0	2.0	3.0
Lana	0.0	0.0	0.0	2.0	2.8	3.0	2.8	3.0
Purple Bounty	0.0	0.0	0.0	2.0	1.8	2.5	1.8	2.3
Purple Prosperity	0.0	0.0	0.0	2.0	2.5	3.0	2.5	3.0
TNT	0.0	0.0	0.0	2.0	2.8	3.0	2.8	3.0
Villana	0.0	0.0	0.5	2.0	2.5	3.0	2.3	3.0
Mean	0.0	0.0	0.1	2.0	2.4	2.9	2.3	2.9
SD[2]	0.0	0.0	0.3	0.0	0.6	0.3	0.6	0.3

[1] 0 = poor (<25% emergence); 1 = moderate (30-60% emergence); 2 = good (65-85% emergence); 3 = excellent (90-100% emergence)

[2] SD - standard deviation

Table 21. Mean values for plant height, days after planting to 50% bloom, and insect and disease ratings for hairy vetch cultivars in 2017 and 2018 at USDA-NRCS Bridger Plant Materials Center, Bridger, MT.

Hairy Vetch Cultivar	Plant Height (in.)		DAP to 50% Bloom		Insect[1] Damage	Disease[1] Damage
	2017	2018	2017	2018	Average	Average
CCS Groff	27 ab	9 a	67	64	0.1	0.1
Lana	36 a	10 a	62	67	0.1	0.3
Purple Bounty	29 ab	11 ab	68	62	0.1	0.1
Purple Prosperity	26 ab	9 a	67	62	0.0	0.1
TNT	21 bc	12 ab	98	N/A	0.9	0.0
Villana	22 ab	11 ab	102	62	0.5	0.5
Mean	27	10	77	64	0.3	0.2
SD[2]	8	3	17	5	0.4	0.2

[1] 0= no damage and 5 = severe damage

[2] Means in columns followed by different letters are significantly different for cultivar according to Tukey's HSD at $P<0.05$.

[3] SD - Standard deviation

Table 22. Average aboveground biomass and forage quality of hairy vetch at 50% bloom stage, USDA-NRCS Bridger Plant Materials Center, Bridger, MT.

Hairy Vetch Cultivar	Biomass	Protein (crude)	Fiber (acid detergent)	Fiber (neutral detergent)	Total Digestible Nutrients	Relative Forage Value	Nitrate (NO_3)
	lb/ac	%	%	%	%		%
Groff	1439	43	28	32	71	196	0.5
Lana	4760	37	28	38	71	164	1.2
Purple Bounty	1851	34	27	37	72	170	0.8
Purple Prosperity	2071	36	29	33	69	189	0.4
TNT	6180	35	26	32	72	200	0.5
Villana	7038	27	29	38	69	164	0.3
Mean	3890	35	28	35	71	181	0.6
SD[1]	2424	5	1	3	1	16	0.3

[1] SD - Standard deviation

Red Clover

Red clover a quick growing biennial or short-lived perennial that is easily established and produces high quality forage. It is commonly used for forage production, soil improvement, nitrogen fixation, green manure, and pollinator habitat. It is also used for preventing erosion, competing with weeds, and reducing soil compaction (OSU, 2018).

Red clover flower, Photo by USDA Plants.

Red clover cultivars were slow to emerge in both years. In fact, only three cultivars, 'Cyclone II', 'Freedom', and 'Wildcat', reached a "good" emergence rating within 28 days in 2017 (Table 23). The main effect of cultivar (years combined) had significant effect on the height of red clover. Mean plant height was 16 ± 4 inches for both years (Table 24). Mean DAP to 50% bloom was 90 ± 8 days in 2017 and 85 ± 12 days in 2018. Both insect and disease ratings were low to moderate for all cultivars. Red clover cultivars produced an average of 1339 ± 211 lb/ac aboveground biomass, measured 24 ± 1% crude protein, and had a relative feed value of 214 ± 23% (Table 25). These results support a recommendation to use any of the tested red clover cultivars in Montana or Wyoming except 'Mammoth' or 'Starfire II'. Red clover will be slow to establish but provides moderate forage production of good quality forage. It is suitable to use for addressing soil improvement, forage diversity and quality, and pollinator habitat.

Table 23. Mean and standard deviation of emergence groups of red clover cultivars at 7, 14, 21 and 28 days after planting in 2017 and 2018 at USDA-NRCS Bridger Plant Materials Center, Bridger, MT.

Red Clover Cultivar	Emergence Ratings for Days after planting[1]							
	7 days		14 days		21 days		28 days	
	2017	2018	2017	2018	2017	2018	2017	2018
Cinnamon Plus	0.0	0.0	0.0	0.5	0.8	0.5	1.0	1.3
Cyclone II	0.0	0.0	0.0	0.5	1.0	0.5	2.0	1.3
Dynamite	0.0	0.0	0.0	1.0	1.0	1.0	1.5	1.5
Freedom	0.0	0.0	0.0	0.5	1.0	0.5	2.0	1.3
Kenland	0.0	0.0	0.0	0.5	1.0	0.5	1.3	1.3
Mammoth	0.0	0.0	0.0	0.8	1.0	0.8	1.8	1.0
Starfire II	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.8
Wildcat	0.0	0.0	0.3	1.0	0.3	1.0	2.5	1.5
Mean	0.0	0.0	0.03	0.6	1.0	0.6	1.5	1.2
SD[/2]	0.0	0.0	0.1	0.5	1.0	0.5	0.9	0.6

[1] 0 = poor (<25% emergence); 1 = moderate (30-60% emergence); 2 = good (65-85% emergence); 3 = excellent (90-100% emergence)

[2] SD - standard deviation

Table 24. Mean values for plant height, days after planting to 50% bloom, and insect and disease ratings for red clover cultivars in 2017 and 2018 at USDA-NRCS Bridger Plant Materials Center, Bridger, MT.

Red Clover Cultivar	Plant Height (in.)			DAP to 50% bloom		Insect[1] Damage	Disease[1] Damage
	2017	2018	Average[2]	2017	2018	Average	Average
Cinnamon Plus	22	10	16 ab	90	82	0.8	0.5
Cyclone II	26	8	17 ab	84	76	1.0	0.3
Dynamite	28	15	21 a	84	81	1.0	0.4
Freedom	23	8	16 ab	93	82	1.1	0.5
Kenland	25	7	16 ab	86	80	1.1	0.5
Mammoth	12	3	7 c	105	115	1.1	0.5
Starfire II	19	7	13 bc	92	82	1.3	0.5
Wildcat	2	11	18 ab	89	84	1.0	0.4
Mean	22	9	16	90	85	1.0	0.5
SD[3]	7	4	4	8	12	0.1	0.1

[1] 0= no damage and 5 = severe damage

[2] Means followed by different letters are significantly different for cultivar*year interaction according to Tukey's HSD at $P<0.05$.

[3] SD - Standard deviation

Table 25. Average aboveground biomass and forage quality of red clover at 50% bloom stage, USDA-NRCS Bridger Plant Materials Center, Bridger, MT.

Red clover Cultivar	Biomass	Protein (crude)	Fiber (acid detergent)	Fiber (neutral detergent)	Total digestible nutrients	Relative Forage Value	Nitrate (NO_3)
	lb/ac	%	%	%	%		%
Cinnamon Plus	1555	22	23	26	77	254	0.2
Cyclone II	1471	25	25	29	75	228	0.7
Dynamite	1361	25	29	32	70	192	1.6
Freedom	1350	24	25	32	75	201	0.3
Kenland	1128	22	25	32	74	203	0.7
Mammoth	1291	-	-	-	-	-	-
Starfire	967	-	-	-	-	-	-
Wildcat	1590	23	25	32	75	203	0.3
Mean	1339	24	25	31	74	214	0.6
SD[1]	211	1	2	3	2	23	0.5

[1]SD - Standard deviation

CONCLUSIONS

Choosing the best adapted cover crop is the first step to a successful cover crop planting. This two-year evaluation of commercially available Austrian winter pea, balansa clover, black oats, cereal rye, crimson clover, daikon radish, hairy vetch, and red clover provided beneficial information on best adapted cultivars and varieties for Montana and Wyoming. Most of the species and cultivars exhibited good adaptation based on field emergence, DAP to 50% bloom, aboveground biomass production, and forage quality. All species, except daikon radish, had low insect and disease ratings. The following is a summary of study recommendations.

- Austrian winter pea cultivars had “good” to “excellent” emergence, averaging 30 ± 9 inches in height, and having good quality forage. ‘Arvica 4010’, ‘Dunn’ and ‘Maxum’ exhibited the greatest height and aboveground biomass values making them effective cover crop choices.
- Balansa and crimson clovers did not perform well in this study and are not recommended as cover crops for Montana or Wyoming.
- Black oat cultivars were relatively “slow” to establish but had consistent overall growth averaging 53 inches in height and producing high amounts of aboveground biomass with relatively consistent forage quality regardless of the cultivar tested.
- Cereal rye cultivars had “good” to “excellent” emergence, a mean plant height that varied among cultivars but produced consistently high aboveground biomass across cultivars.
- Percent field emergence of daikon radish cultivars were consistently “good” to “excellent”, except for ‘Graza’ which performed poorly throughout the study. Daikon radish averaged 42 ± 12 inches in height and produced an average of 4010 ± 1864 lb/ac of good forage quality.
- Hairy vetch cultivars were “slow” to establish and varied in plant height but produced large amounts of high-quality aboveground biomass averaging 3890 ± 2424 lb/ac. ‘TNT’ and ‘Villana’ had the greatest aboveground biomass production with over 6000 and 7000 lb/ac, respectively.
- Red clover cultivars were “slow” to emerge, had a mean plant height of 16 ± 4 inches for both years, and produced an average of 1339 ± 211 lb/ac high quality aboveground biomass. Any of the tested red clover cultivars are recommended in Montana or Wyoming except ‘Mammoth’ or ‘Starfire II’.

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