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Adaptation of 59 Cover Crop Cultivars in Western Oregon

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ABSTRACT

Cover crops have the potential to provide many soil health and crop production benefits, but their success depends on selection and use of species and cultivars adapted to the local climate and soils. The USDA-NRCS Plant Materials Center in Corvallis, Oregon participated in a 3-year trial along with twenty-two other Plant Materials Centers (PMCs) across the country to evaluate the adaptation and growth potential of common, commercially available cover crop species and cultivars. A total of 59 cultivars of eight cover crop species were evaluated for germination and establishment, pest and disease resistance, winter hardiness, bloom time, mature plant height, and biomass. Most cultivars of oat, cereal rye, hairy vetch, crimson clover, and Balansa clover tested at the Corvallis PMC showed good performance and adaptation. Austrian winter peas appeared to be poorly adapted to fall planting on our sometimes poorly-drained silt loam soils, with most cultivars not surviving the winter. Fungal leaf spot diseases among most daikon radish cultivars limited their canopy cover and biomass production. With their slow establishment, lack of cover over the winter, and susceptibility to weeds and slugs, the red clover cultivars tested did not appear to be a promising choice as a winter annual cover crop in western Oregon.

INTRODUCTION

Incorporating cover crops into a cropping system improves soil health, conserves energy, builds resilience, and manages climate risk (Lal, 2004; Reicosky and Forcella, 1998; Hargrove, 1986; Reeves, 1994). Leguminous cover crop species provide a nitrogen source for subsequent commodity crops (Singh et al., 2004; Smith et al., 1987). Non-leguminous cover crops, such as small grains, are effective in reducing nitrate leaching and soil erosion (Meisinger et al., 1991). Utilizing a mix of leguminous and non-leguminous cover crop species can provide multiple benefits. While cover crops provide numerous agronomic and environmental benefits, these benefits are not fully achieved unless cover crop cultivars are planted that meet the objective of the cover crop planting and the producer's expectations.

The purpose of this trial was to evaluate growth characteristics and production attributes of commercially available cultivars of important and commonly-used cover crops identified by Natural Resources Conservation Service (NRCS) Agronomists, Soil Health Specialists, and Plant Materials staff. Adaptation and growth data from Corvallis can be used to inform local recommendations for cover crop use in western Oregon and the greater Pacific Northwest.

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Table 1. Cover crop species, cultivars, seeds per pound, and seeding rates used in the 3-year trial at the Corvallis, OR Plant Materials Center.

Species	Common Name	Cultivar	Seeds/lb	Seeding Rate (PLS* seeds/ft^2)	Seeding Rate (PLS lb/ac)	Year Planted
Avena sativa	oat, black-seeded	Cosaque	12,000	42	152	2015, 2016, 2017
Avena strigosa	black oat	Soil Saver	30,000	42	60	2015, 2016, 2017
Secale cereale	cereal rye	Aroostook	23,000	42	79	2015, 2016, 2017
Secale cereale	cereal rye	Bates RS4	22,000	42	84	2016, 2017
Secale cereale	cereal rye	Brasetto hybrid	21,000	42	86	2015, 2016, 2017
Secale cereale	cereal rye	Elbon	32,000	42	57	2015, 2016, 2017
Secale cereale	cereal rye	FL 401	24,000	42	76	2015, 2016, 2017
Secale cereale	cereal rye	Guardian	15,000	42	122	2015, 2016, 2017
Secale cereale	cereal rye	Hazlet	13,000	42	138	2015, 2016, 2017
Secale cereale	cereal rye	Maton	21,000	42	88	2015, 2016, 2017
Secale cereale	cereal rye	Maton II	22,000	42	85	2015, 2016, 2017
Secale cereale	cereal rye	Merced	30,000	42	61	2015, 2016, 2017
Secale cereale	cereal rye	Oklon	20,000	42	89	2015, 2016, 2017
Secale cereale	cereal rye	Rymin	19,000	42	97	2017
Secale cereale	cereal rye	Wheeler	21,000	42	86	2015, 2016, 2017
Secale cereale	cereal rye	Wintergrazer-70	23,000	42	79	2015, 2016, 2017
Secale cereale	cereal rye	Wrens Abruzzi	19,000	42	94	2015, 2016, 2017
Pisum sativum	Austrian winter pea	Arvica 4010	3,300	6	78	2015, 2016, 2017
Pisum sativum	Austrian winter pea	Dunn	3,000	6	86	2015, 2016, 2017
Pisum sativum	Austrian winter pea	FrostMaster	2,800	6	94	2015, 2016, 2017
Pisum sativum	Austrian winter pea	Lynx	3,500	6	75	2015, 2016, 2017
Pisum sativum	Austrian winter pea	Maxum	2,300	6	113	2015, 2016, 2017
Pisum sativum	Austrian winter pea	Survivor 15	3,800	6	68	2015, 2016, 2017
Pisum sativum	Austrian winter pea	Whistler	2,800	6	95	2015, 2016, 2017
Pisum sativum	Austrian winter pea	Windham	3,100	6	85	2015, 2016, 2017
Raphanus sativus	daikon radish	Big Dog	27,000	5	8	2016, 2017
Raphanus sativus	daikon radish	Concorde	40,000	5	5	2016, 2017
Raphanus sativus	daikon radish	Control	45,000	5	5	2016, 2017
Raphanus sativus	daikon radish	Defender	27,000	5	8	2015, 2016, 2017
Raphanus sativus	daikon radish	Driller	27,000	5	8	2015, 2016, 2017
Raphanus sativus	daikon radish	Eco-till	27,000	5	8	2015, 2016, 2017
Raphanus sativus	daikon radish	Graza	30,000	5	7	2016, 2017
Raphanus sativus	daikon radish	Groundhog	27,000	5	8	2015, 2016, 2017
Raphanus sativus	daikon radish	Lunch	27,000	5	8	2015, 2016, 2017
Raphanus sativus	daikon radish	Nitro	27,000	5	8	2015, 2016, 2017
Raphanus sativus	daikon radish	Sodbuster Blend	27,000	5	8	2015, 2016, 2017
Raphanus sativus	daikon radish	Tillage	27,000	5	8	2015, 2016, 2017

Species	Common Name	Cultivar	Seeds/lb	Seeding Rate (PLS* seeds/ft^2)	Seeding Rate (PLS lb/ac)	Year Planted
Trifolium incarnatum	crimson clover	AU Robin	142,000	62	19	2015, 2016, 2017
Trifolium incarnatum	crimson clover	AU Sunrise	90,000	62	30	2015, 2016, 2017
Trifolium incarnatum	crimson clover	AU Sunup	129,000	62	21	2015, 2016, 2017
Trifolium incarnatum	crimson clover	Contea	73,000	62	37	2015, 2016, 2017
Trifolium incarnatum	crimson clover	Dixie	129,000	62	21	2015, 2016, 2017
Trifolium incarnatum	crimson clover	Kentucky Pride	129,000	62	21	2015, 2016, 2017
Trifolium michelianum	Balansa clover	Fixation	319,000	26**	3	2015, 2016, 2017
Trifolium michelianum	Balansa clover	Frontier	482,000	57	5	2015, 2016, 2017
Trifolium pratense	red clover	Cinnamon Plus	232,000	56	11	2016, 2017
Trifolium pratense	red clover	Cyclone II	247,000	56	10	2016, 2017
Trifolium pratense	red clover	Dynamite	247,000	56	10	2016, 2017
Trifolium pratense	red clover	Freedom!	196,000	56	12	2016, 2017
Trifolium pratense	red clover	Kenland	222,000	56	11	2016, 2017
Trifolium pratense	red clover	Mammoth	246,000	56	10	2016, 2017
Trifolium pratense	red clover	Starfire II	211,000	56	12	2016, 2017
Trifolium pratense	red clover	Wildcat	258,000	56	9	2016, 2017
Vicia villosa	hairy vetch	CCS-Groff	20,000	7	15	2015, 2016, 2017
Vicia villosa	hairy vetch	Lana	12,000	7	25	2015, 2016, 2017
Vicia villosa	hairy vetch	Purple Bounty	17,000	7	18	2016, 2017
Vicia villosa	hairy vetch	Purple Prosperity	16,000	7	19	2015, 2016, 2017
Vicia villosa	hairy vetch	TNT	18,000	7	17	2015, 2016, 2017
Vicia villosa	hairy vetch	Villana	14,000	7	22	2015, 2016, 2017

*pure live seed; **initial seed count for 'Fixation' Balansa clover was incorrect, so plots were mistakenly seeded at 26 seeds/ft^2 rather than 57.

MATERIALS AND METHODS

The trial at the Corvallis PMC was conducted from 2015 to 2018, with the 2015-2016 season acting as a pilot year, and a few more cultivars added for the last two years of the study. Seeding rates for all cover crop species/cultivars are listed in Table 1. Target seeding rates for each species in our study were standardized based on pure live seeds (PLS) per square foot, so actual pounds per acre seeding rates were adjusted accordingly for the seed size (seeds per pound) and purity/germination of each seed lot.

The soil type at the Corvallis PMC is Amity and Willamette silt loam, 0–3% slopes. Plots were installed on a different field for each of the three years of the trial. Soil test results for all fields are given in Table 2 (Kuo Testing Labs, Othello, WA); Bray's P was in the high range, while K, Mg, and Ca were generally in the medium range. All fields received 2 ton/ac agricultural lime in Sep. 2015, and lime was incorporated during field preparation, bringing the pH up to at least 6.0 in all fields.

Table 2. Soil test results from fields used for the 3-year cover crop trial at the Plant Materials Center in Corvallis, OR.

Trial Year	Field ID	Crops	Sampling Date	pH*	Bray P (ppm)	K (ppm)	SO_4-S (ppm)	Ca (meq/ 100g)	Mg (meq/ 100g)
2015-2016	7-9	peas, vetch, radish	6/24/2016	6.1	51	181	13	6.9	0.5
	7-11	rye, oat	5/15/2015	5.4	60	186	8	5.1	0.5
	7-12S	clovers	5/15/2015	5.9	81	325	4	9.4	0.7
2016-2017	1-15	clovers, peas	5/15/2015	5.6	90	193	8	4.9	0.5
	7-8	vetch, radish	6/24/2016	6.3	47	241	-	9	0.7
	7-12N	rye, oat	5/15/2015	5.9	81	325	4	9.4	0.7
2017-2018	7-10	all species	4/19/2017	6.1	79	286	-	8.7	0.5

*2 ton/ac lime was applied/incorporated into all fields in fall 2015 prior to planting

Fields were disked and rolled in September each year to create a firm, well-prepared seedbed. All legume seeds were inoculated with the appropriate rhizobia prior to planting. The 5 x 20-ft plots were drill-seeded using a Hege cone seeder (Wintersteiger Inc., Salt Lake City, UT) on 6-inch row spacing. Plots were seeded the week of Sep. 29 – Oct. 2, 2015, Sep. 29–30, 2016, and Sep. 18–22, 2017. Metaldehyde slug bait was applied to all plots according to manufacturer's recommendations as soon as seedlings emerged in the fall. All non-legume plots (cereal rye, black oat, and radish) were fertilized with 40 lb N/ac in the fall each year once their true leaves had emerged; legume plots received no N fertilizer. Additional P and K fertilizer were not added, as soil tests for both nutrients were already in the medium to high range. Plots did not receive any supplemental irrigation during the trial. The clover plots were hand-weeded once each year in the early spring to reduce competition for light and nutrients.

Germination/emergence were visually estimated in each plot approximately every 7 days for the first four weeks after planting using the following rating scale: 0 = poor (<25% germination), 1 = moderate (25–64%), 2 = good (65–85%), 3 = excellent (>85%). Every 30 days, all plots were rated for canopy cover by a visual estimate of the percentage of ground covered by the plant, rated on the following scale: 1 = 1–20%, 2 = 21–40%, 3 = 41–60%, 4 = 61–80%, 5 = 81–100%. All plots were evaluated twice for disease and pest damage (rated from 0–5, where 0=no damage and 5=severe damage), first following "spring green-up" (early March), and again at 50% bloom (date varied by species and cultivar). To evaluate winter survival, 3-ft sections of an interior row were marked in each plot, and seedling counts were conducted in fall (November) and again following "spring green-up" (March) of the 2016-2017 and 2017-2018 growing seasons.

Bloom period was monitored by noting the date of beginning bloom and 50% bloom. When plants reached 50% bloom or anthesis, average plant height (height of lush canopy growth, not including blooms or inflorescences) was calculated from 5 measurements in each plot. At the same time, aboveground biomass samples were clipped at ground level from 0.5 x 1.0-m subplots in the center of each plot. Biomass samples were oven dried at 120°F to a steady weight to calculate dry matter biomass on a pound per acre basis. Dried biomass samples were analyzed for total Kjeldahl nitrogen (TKN) (Kuo Testing Labs, Othello, WA) (all species in year 1, just the legumes in years 2 and 3 of the trial).

The experimental design was a randomized complete block with four replications, and results were analyzed in Statistix 10 (Analytical Software, Tallahassee, FL) using the analysis of variance procedure (AOV) or Kruskal-Wallis one-way AOV. The $Log_{(10)}$ transformation was used on height and dry matter data when necessary to meet the assumptions of the AOV. Means separation was performed within each species at α=0.05 by Dunn's or Tukey Honestly Significant Difference (HSD). Red clover plots were not replicated in 2015-2016, so data were only analyzed for the 2016-2017 and 2017-2018 seasons.

RESULTS AND DISCUSSION

Weather

In general, the 2015-2016 season was warmer and wetter than average for western Oregon, the 2016-2017 season was cooler and much wetter than average, and the 2017-2018 season was warmer and slightly drier than average, with a particularly dry spring (Figure 1). Total precipitation for the October through May growing season was 47 inches in 2015-2016, 57 inches in 2016-2017, and 37 inches in 2017-2018, compared to a 20-year average of 39 inches.

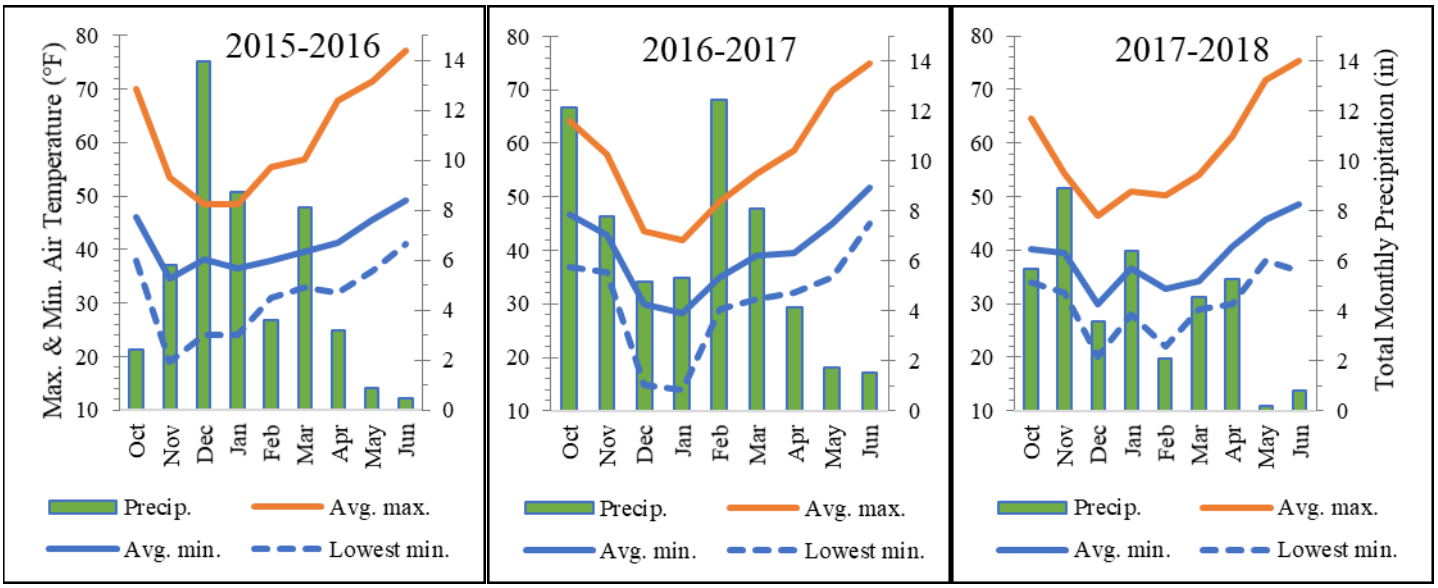

Figure 1. Weather data for the Corvallis Plant Materials Center for the three years of the cover crop cultivar trial, showing total monthly precipitation, average monthly maximum and minimum air temperatures, and lowest monthly minimum air temperature (https://agsci.oregonstate.edu/hyslop-weather-station).

Oats

Two oat cultivars were included in this trial: 'Cosaque', a black-seeded cultivar of common oat (*Avena sativa*), and 'Soil Saver' black oat (*Avena strigosa*). Both cultivars germinated quickly, with an average of over 65% emergence by 14 days after planting (DAP) and over 85% emergence by 28 DAP (Table 3). Soil Saver provided more canopy cover than Cosaque from March through May of 2016 and 2018, but in 2017, Soil Saver's canopy cover dropped in February and March during extensive periods of ponding (Figure 2). Soil Saver appeared to be far less tolerant than Cosaque of cold winter temperatures and saturated soil conditions during heavy rains in early spring, and Soil Saver had lower winter survival than Cosaque in 2017 (Table 4). Both cultivars had nearly 100% winter survival in the mild winter of 2018. Soil Saver

reached 50% anthesis on May 11, 2016, two weeks before Cosaque, but both reached 50% anthesis on the same dates in the second and third years of the trial (6/7/2017 and 5/30/2018).

Table 3. Average seedling emergence ratings for two cultivars of oat grown in a 3-year trial at the Corvallis Plant Materials Center, 2016-2018.

		Days after planting			
Crop	**Cultivar**	**7**	**14**	**21**	**28**
common oat, black-seeded	Cosaque	0.3[1/]	2.3	2.8	3.0
black oat	Soil Saver	0.3	2.3	2.7	2.8
Mean		0.3	2.3	2.7	2.9
SD[2/]		0.5	0.7	0.6	0.4

[1/]0 = poor (<25% germination), 1 = moderate (25–64%), 2 = good (65–85%), 3 = excellent (>85%).

[2/]Standard deviation.

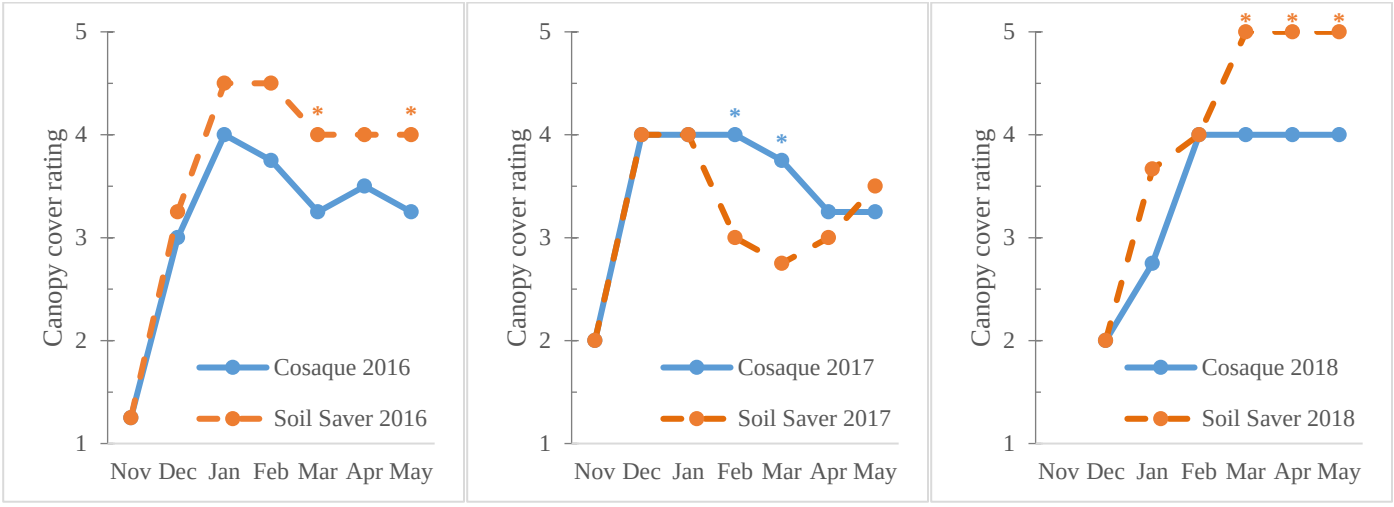

Figure 2. Average canopy cover of two oat cultivars in a 3-year trial at the Corvallis Plant Materials Center. Canopy cover was a visual estimate of the percentage of ground covered by the plant, rated on the following scale: 1 = 1–20%, 2 = 21–40%, 3 = 41–60%, 4 = 61–80%, 5 = 81–100%. For each date, means marked with an asterisk (*) are significantly different at α=0.05.

Table 4. Average winter survival, mature plant height, and biomass dry matter production of two cultivars of oats in a 3-year trial at the Corvallis Plant Materials Center.

		% Winter Survival		Mature Height (in)					Biomass Dry Matter (lb/ac)			
Crop	**Cultivar**	**2017**	**2018**	**2016**		**2017**	**2018**		**2016**	**2017**		**2018**
common oat, black-seeded	Cosaque	100	99	38	b[1/]	27	35	b	10,070	7,127	a	10,673
black oat	Soil Saver	87	100	49	a	31	46	a	10,822	3,370	b	6,945
Mean		93	100	43		29	40		10,446	5,249		8,809
SD.[2/]		14	1	6		3	7		1,383	2,170		2,159

[1/]Means in columns followed by the same letter are not significantly different at $P<0.05$.

[2/]Standard deviation

Soil Saver produced less than half the dry matter of Cosaque in the cold, wet year of 2017, and the Soil Saver plants were obviously stunted, reaching a mature height over a foot shorter than other years (Table 4). Both cultivars had impressive and comparable biomass yields in 2016 and 2018, at an average of 10,000 and almost 9,000 lb/ac, respectively.

Cereal Rye

There were 15 cultivars of cereal rye included in the trial. Germination and emergence were quick and relatively uniform for all cultivars, with an average of over 65% germination by 14 DAP, and many cultivars reaching greater than 85% germination by 21 DAP (Table 5). 'Elbon' had a significantly lower average final emergence rating at 28 DAP than several other cultivars, primarily due to lower emergence in 2018.

Table 5. Average seedling emergence ratings of 15 cultivars of cereal rye in a 3-year trial at the Corvallis Plant Materials Center, 2016-2018 (not all cultivars were grown every year).

	Days after planting				
Cultivar	**7**	**14**	**21**	**28**	
Aroostook	1.2[1/]	2.4	2.7	2.8	ab[2/]
Bates RS4	1.0	2.4	2.9	3.0	a
Brasetto	0.8	2.1	2.6	2.7	ab
Elbon	0.8	2.3	2.4	2.4	b
FL 401	0.8	2.4	2.7	2.8	ab
Guardian	1.3	2.6	3.0	3.0	a
Hazlet	0.9	2.3	2.7	2.8	ab
Maton	1.2	2.6	2.7	3.0	a
Maton II	0.7	2.5	2.8	2.8	ab
Merced	1.3	2.4	2.5	2.8	ab
Oklon	1.0	2.3	2.7	3.0	a
Rymin	1.0	2.5	2.8	3.0	ab
Wheeler	0.8	2.6	2.7	2.9	ab
Wintergrazer-70	1.0	2.6	2.8	2.9	ab
Wrens Abruzzi	0.8	2.5	2.9	3.0	a
Mean	1.0	2.4	2.7	2.9	
SD[3/]	0.6	0.6	0.5	0.4	

[1/]0 = poor (<25% germination), 1 = moderate (25–64%), 2 = good (65–85%), 3 = excellent (>85%).

[2/]Means in columns followed by the same letter are not significantly different at $P<0.05$.

[3/]Standard deviation.

Winter survival was high for all cultivars in 2017 and very high in the mild winter of 2018 (Table 6). Pest damage was minimal for all cultivars all three years of the trial, and there were no significant differences in pest damage among cultivars. Overall, 'Brasetto' had less disease than the most disease-prone cultivars ('Merced', 'FL 401', and 'Bates RS4') with an average disease rating of 1.5 compared to an average of 3, 2.7, and 2.6, respectively, on a scale from 1 to 5.

Canopy cover provided by the cereal rye plants reached over 60% for most cultivars by 90 DAP in January most years (data not shown). In 2016, 'Wheeler', 'Wrens Abruzzi', 'Brasetto', and 'FL401' all provided an average of over 80% cover by 90 DAP in January, but in 2017, cover

Table 6. Average winter survival, mature plant height, and dry matter biomass production of 15 cultivars of cereal rye in a 3-year trial at the Corvallis Plant Materials Center.

Cultivar	% Winter Survival	Mature Height (in)			Biomass (lb/ac)					
	2017/2018	2016	2017	2018	2016		2017	2018		
Aroostook	92	55	50	63	5,328	ab[1/]	2,958[2/]	5,477	ab	
Bates RS4	90	----[3/]	53	62	----[3/]		4,867	6,191	ab	
Brasetto	93	41	37	45	5,940	ab	3,741	4,907	ab	
Elbon	96	59	53	65	5,306	ab	3,483	5,822	ab	
FL 401	90	38	40	42	4,744	ab	3,021	4,185	b	
Guardian	92	49	44	58	6,698	a	3,799	4,958	ab	
Hazlet	93	46	39	53	6,285	ab	2,829	4,701	ab	
Maton	91	57	54	65	6,025	ab	4,497	6,440	ab	
Maton II	96	59	53	65	6,108	ab	4,274	6,316	ab	
Merced	92	33	36	36	3,574	b	2,524	4,173	b	
Oklon	98	54	53	66	4,825	ab	4,343	6,126	ab	
Rymin	99	----[3/]	----[3/]	53	----[3/]		----[3/]	5,578	ab	
Wheeler	98	60	52	70	6,204	ab	4,917	7,061	a	
Wintergrazer-70	90	52	48	63	4,907	ab	3,642	5,855	ab	
Wrens Abruzzi	95	59	51	61	5,921	ab	4,155	6,072	ab	
Mean	94	51	47	58	5,495		3,853	5,591		
SD[4/]	11	9	7	10	1,424		1,160	1,179		

[1/]Means in columns followed by the same letter are not significantly different at $P<0.05$.

[2/]There were significant differences among cultivars according to AOV, but no separation of the means was achieved with Tukey HSD all-pairwise comparison test.

[3/]Cultivar not planted that season.

[4/]Standard deviation.

was lower throughout the season, and Wheeler, ‘Maton’, and Brasetto had the top cover in January at an average of 60-80% cover. ‘Aroostook’, ‘Hazlet’, ‘Oklon’, and ‘Wintergrazer-70’ appeared to be less tolerant of the saturated soils and intermittent spring ponding in the wet winters of 2016 and 2017. In the winter of 2018, Wheeler, Wintergrazer-70, and Wrens Abruzzi were top providers of cover.

On average, all cultivars were shorter and produced less dry matter in the cold wet winter of 2017 than 2016 or 2018 (Table 6). Brasetto, Hazlet, FL401, and Merced were consistently among the shortest statured cultivars at maturity, generally remaining below 4 ft tall, while Wheeler was often the tallest cultivar, reaching nearly 6 ft in 2018. Because Brasetto is a hybrid, it had a more uniform and shorter stature than most open-pollinated cultivars in our trial, and a more uniform maturity date. These characteristics could make for easier termination and residue management of the cover crop. ‘Guardian’ was a top biomass producer in 2016, while Wheeler was a top producer in 2018.

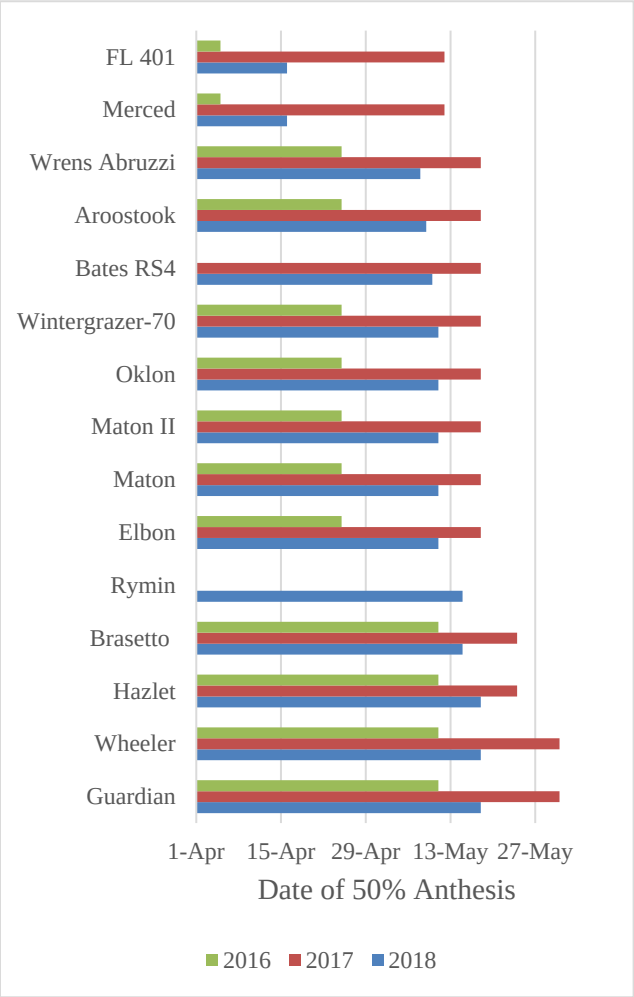

Figure 3. Date of 50% anthesis for 15 cultivars of cereal rye in a 3-year trial at the Corvallis Plant Materials Center.

Most plots had a wide range of maturation rates of individual plants within the plots, so it was sometimes difficult to determine the date of 50% anthesis for the whole plot, but on average Guardian, Wheeler, Hazlet, and Brasetto were among the latest maturing cultivars each year (Figure 3). Merced and FL 401 both entered their reproductive stage (stem lengthening) in December each year, suffering more extensive freeze and ponding damage than the other cultivars that were still basal rosettes, and had higher disease ratings than the other cultivars. They reached 50% anthesis an average of two weeks earlier than the other earliest cultivars, were significantly shorter than other cultivars, and produced less dry matter most years (Table 6). Merced is a release from the University of California that was selected for adaptation to the droughty and mild Mediterranean climate of the Central Valley of California (UC SAREP, 2018). FL 401 was developed by Florida Agricultural Experiment Station as a quick-establishing and early-maturing cultivar for erosion control and early grazing in Florida (Pfahler et al., 1986). Neither of these cultivars appear to be well adapted to fall cover crop use in the Willamette Valley.

Austrian Winter and Field Peas

Pea cultivars can be divided into two distinct groups: the semi-leafless or ‘afila’ type that has an erect growth habit with shorter vines that have many tendrils but few leaflets (‘Lynx’, ‘Whistler’, and ‘Windham’ in our trial belong to this group) and the forage type that produce long vines with more leaflets and biomass (‘Arvica 4010’, ‘Dunn’, ‘FrostMaster’, ‘Maxum’, and ‘Survivor 15’ in our trial) (Pavek, 2012). The semi-leafless types are preferred among grain producers for ease of harvest and are commonly known as field peas. Austrian winter peas are a forage type with purple flowers and pigmented seed coats that are generally favored as green manure crops (Dunn, Maxum, and Survivor 15). Some forage peas have been bred to have low levels of anthocyanins, giving them white flowers and unpigmented seed coats, which are said to be more palatable to livestock than peas with pink-red flowers and pigmented seed coasts (McGee et al., 2013). In our trial, FrostMaster, Lynx, Whistler, and Windham all have white flowers. Pea cultivars are further divided into spring- and fall-planted (or winter) types; Arvica 4010 is the only spring field pea included in this trial, and it has purple flowers.

Table 7. Average seedling emergence ratings for eight pea cultivars grown in a 3-year trial at the Corvallis Plant Materials Center, 2016-2018.

	Days after planting			
Cultivar	**7**	**14**	**21**	**28**
Arvica 4010	0.2[1/]	1.6 ab[2/]	2.2[3/]	2.5 abc
Dunn	0.1	1.8 a	2.3	2.7 abc
FrostMaster	0.1	1.8 a	2.1	2.1 c
Lynx	0.1	1.1 b	2.0	2.2 bc
Maxum	0.2	1.8 ab	2.5	2.8 a
Survivor 15	0.3	1.7 ab	2.3	2.5 abc
Whistler	0.3	1.7 ab	2.2	2.8 ab
Windham	0.3	1.7 ab	2.0	2.2 bc
Mean	0.2	1.6	2.2	2.5
SD[4/]	0.4	0.5	0.4	0.5

[1/]0 = poor (<25% germination), 1 = moderate (25–64%), 2 = good (65–85%), 3 = excellent (>85%).

[2/]Means in columns followed by the same letter are not significantly different at $P<0.05$.

[3/]There were significant differences in ranks between cultivars according to Kruskal-Wallis one-way analysis of variance, but no separation of the ranks was achieved with Dunn's all pairwise comparison test.

[4/]Standard deviation.

All the pea cultivars had good to excellent germination and emergence by 21 DAP all three years of the trial (Table 7). Lynx was slower to germinate/emerge than several other cultivars, and Lynx, FrostMaster and Windham had lower total emergence than several other cultivars at 28 DAP.

As would be expected, the leafy forage types (Maxum, Dunn, and Arvica 4010) tended to provide more early winter cover than the semi-leafless cultivars (Lynx and Windham) (Figure 4). In 2016 and 2017, canopy cover peaked in December or January and then rapidly declined as the plants died from disease brought on by stress from saturated soils, eventually reaching 100% kill in all cultivars by March or April. However, in the drier and milder winter of 2018, all except Lynx had at least some plants that survived to flowering stage in the spring, and Survivor 15 and FrostMaster were able to maintain at least 40% cover over the growing season (Figure 4, Table 8). The few surviving plants in the Maxum, Dunn, and Arvica 4010 plots reached 50% bloom about six weeks earlier than the other cultivars, but they were very stunted and didn't produce much biomass (Table 8). Survivor 15 and FrostMaster had the tallest plants and produced the most biomass and total N.

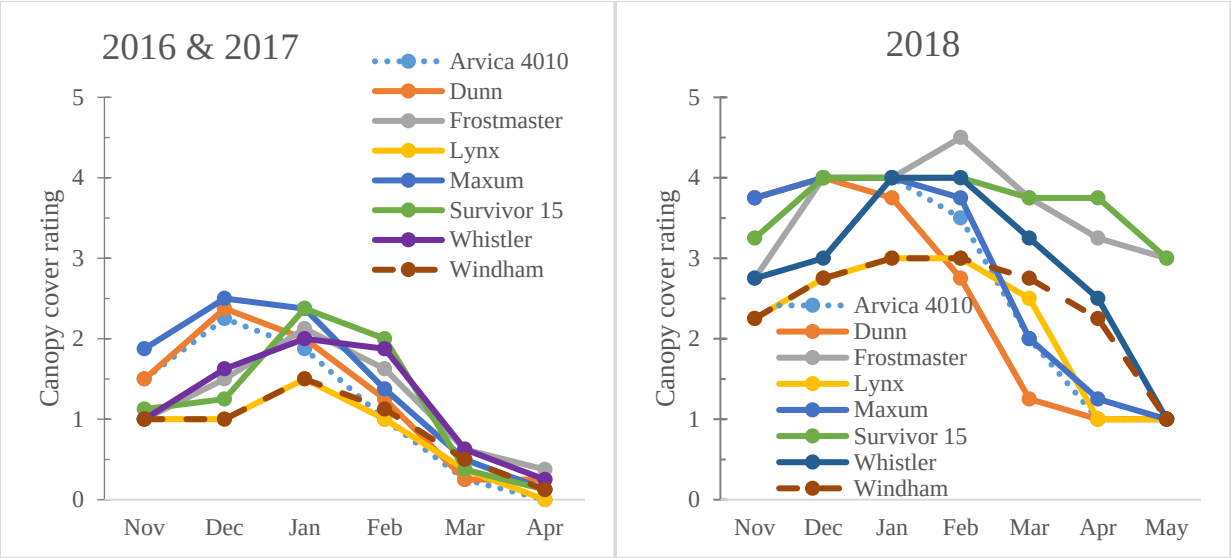

Figure 4. Average monthly canopy cover provided by eight pea cultivars in 2016 and 2017 (left) and 2018 (right) in trials at the Corvallis Plant Materials Center. Canopy cover was a visual estimate of the percentage of ground covered by the plant, rated on the following scale: 1 = 1–20%, 2 = 21–40%, 3 = 41–60%, 4 = 61–80%, 5 = 81–100%.

Table 8. Average winter survival, date of 50% bloom, mature plant height, dry matter biomass production, and total nitrogen production by eight pea cultivars in the 2018 trial at the Corvallis Plant Materials Center (no cultivars survived to maturity in 2016 or 2017).

Cultivar	% Winter Survival	Date of 50% Bloom	Height (in)	Biomass Dry Matter (lb/ac)		Total N (lb/ac)	
Arvica 4010	0	4/3/2018	n/a[1/]	n/a		n/a	
Dunn	1	4/3/2018	n/a	n/a		n/a	
FrostMaster	55	5/15/2018	17	2,157	a[2/]	78	a
Lynx	0	n/a	n/a	n/a		n/a	
Maxum	5	4/3/2018	n/a	n/a		n/a	
Survivor 15	65	5/21/2018	25	2,205	a	63	ab
Whistler	54	5/15/2018	5	939	ab	39	ab
Windham	80	5/15/2018	5	417	b	17	b
Mean	32		13	1,429		49	
SD[3/]	36		9	1,014		30	

[1/]Height, biomass, and total N data were not analyzed for cultivars with 5% or less winter survival.

[2/]Means in columns followed by the same letter are not significantly different at $P<0.05$.

[3/]Standard deviation.

Overall, the pea cultivars tested did not appear to be well adapted to fall planting in the heavy silt loam soils and wet spring conditions of the Willamette Valley. However, peas are successfully grown for processing and seed production in parts of western Oregon, though they're generally spring-planted on well-drained, sandier soils, especially in the foothills (Thompson et al., 2001). Peas are also sometimes grown in fall-planted cover crop mixes with a cereal grain that the pea vines can climb, keeping them off the ground and helping prevent disease. Peas are noted to have no tolerance for waterlogged soils, so should only be grown on well-drained sites (Sattell and Dick, 1998).

Daikon Radish

The radish cultivars included in this trial belong to two distinct groups: oilseed radishes that generally have purple flowers and have been bred for higher levels of glucosinolates for use as biofumigants ('Concorde', 'Control', and 'Defender') and the white-flowered daikon radishes bred for larger taproots and improved forage quality ('Big Dog', 'Driller', 'Eco-till', 'Graza', 'Groundhog', 'Lunch', 'Nitro', 'Sodbuster Blend', and 'Tillage') (Tilley and Pickett, 2019).

Germination and emergence were quick for most cultivars, with Big Dog leading the pack as soon as 7 DAP, and Graza, Defender, and Sodbuster Blend having among the lowest emergence ratings (Table 9). Graza had very poor establishment in 2017-2018, possibly due to a decline in seed viability, only reaching an average emergence rating of 0.25 (or less than 25%) at 28 DAP. Most radish cultivars provided at least 50% canopy cover by early January each year, but there were few significant differences in cover among cultivars (data not shown). Graza provided significantly less canopy cover than several other cultivars in February and March of 2018, largely due to poor establishment.

Table 9. Average emergence ratings for 12 radish cultivars planted in a 3-year trial at the Corvallis Plant Materials Center, 2016-2018.

	Days after planting							
Cultivar	**7**		**14**		**21**		**28**	
Big Dog	0.5[1/]	a[2/]	1.9	a	2.8	a	2.9	a
Concorde	0.0	ab	1.4	ab	2.0	ab	2.3	ab
Control	0.1	ab	1.4	ab	2.1	ab	2.4	ab
Defender	0.0	b	0.8	ab	1.3	b	2.0	ab
Driller	0.2	ab	1.3	ab	1.8	ab	2.4	ab
Eco-till	0.1	ab	1.3	ab	2.0	ab	2.4	ab
Graza	0.0	ab	0.4	b	1.0	b	1.1	b
Groundhog	0.1	ab	1.2	ab	2.1	ab	2.5	ab
Lunch	0.2	ab	0.8	ab	1.4	ab	1.9	ab
Nitro	0.2	ab	1.1	ab	1.9	ab	2.3	ab
Sodbuster Blend	0.0	b	0.8	ab	1.3	b	1.6	b
Tillage	0.0	b	0.9	ab	1.8	ab	2.1	ab
Mean	0.1		1.1		1.8		2.2	
SD[3/]	0.3		0.8		0.9		0.7	

[1/]0 = poor (<25% germination), 1 = moderate (25–64%), 2 = good (65–85%), 3 = excellent (>85%).

[2/]Means in columns followed by the same letter are not significantly different at $P<0.05$.

[3/]Standard deviation.

The cooler and wetter than average conditions and extended periods of saturated soils in the spring of 2017 led to high levels of fungal leaf spot disease (light leaf spot and white leaf spot) among most daikon radish cultivars that limited their canopy cover and biomass production that year. Disease ratings for all cultivars were higher in 2017 than 2016 or 2018 (Table 10). Graza had less disease than Driller in 2017 and less disease than Nitro and Lunch in 2018. To avoid infestations of black leg and other fungal leaf spot diseases, OSU Extension recommends at least three-year brassica rotations (longer in severely infested fields) (Andrews, 2017; Ocamb, 2016).

Table 10. Average foliar disease ratings for 12 radish cultivars planted in a 3-year trial at the Corvallis Plant Materials Center.

	Harvest Year					
Cultivar	**2016**	**2017**		**2018**		
Big Dog	----[1/]	4.8[2/]	ab[3/]	2.0	ab	
Concorde	----[1/]	3.5	ab	1.5	ab	
Control	----[1/]	3.8	ab	1.5	ab	
Defender	2.3[4/]	4.0	ab	1.3	ab	
Driller	3.0	5.0	a	2.0	ab	
Eco-till	2.8	4.8	ab	2.0	ab	
Graza	----[1/]	2.8	b	1.0	b	
Groundhog	3.0	4.8	ab	2.0	ab	
Lunch	2.0	4.8	ab	2.3	a	
Nitro	3.0	4.8	ab	2.3	a	
Sodbuster Blend	2.8	4.8	ab	2.0	ab	
Tillage	2.8	4.8	ab	2.0	ab	
Mean	2.7	4.4		1.8		
SD[5/]	0.5	0.8		0.5		

[1/]Cultivar not planted in 2015-2016 season.

[2/]0 = no damage, 1 = slight, 3 = moderate, 5 = severe (visual rating of foliar disease taken in early spring).

[3/]Means in columns followed by the same letter are not significantly different at $P<0.05$.

[4/]There were significant differences in ranks between cultivars according to Kruskal-Wallis one-way analysis of variance, but no separation of the ranks was achieved with Dunn's all pairwise comparison test.

[5/]Standard deviation.

There was some winter kill of Eco-till, Nitro, and Sodbuster Blend in 2017 when temperatures dipped into the low teens in December and January, but winter survival was good for all cultivars in the mild winter of 2018 (Table 11). The earliest maturing daikon radishes entered their reproductive phase (started bolting) in February and started to flower by early March each year. The oilseed radishes (Concorde, Control, and Defender) reached 50% bloom 10 to 20 days later than the other cultivars, while Graza was consistently the latest blooming cultivar at 24 to 27 days after the other daikon cultivars (Table 11). Many plants started setting mature seed quickly after reaching 50% bloom, emphasizing the importance of prompt termination of a radish cover crop to avoid reseeding and weed problems for the subsequent crop.

Mature plant heights and biomass production varied dramatically among the three years of the trial, with 2017 being a very bad year for all radish cultivars due to winter kill and disease (Table 11). The oilseed radishes (Concorde, Control, and Defender) were consistently among the tallest and top biomass producers each year, while Big Dog, Eco-till, Lunch, Nitro, Sodbuster Blend, and Tillage were among the lowest biomass producers each year.

To protect the production of specialty brassica seed crops in the Willamette Valley and other parts of Oregon, the state has mandated 3-mile isolation distances from seed production fields in Oregon's rapeseed control areas (Oregon State Legislature, 2017). This means that cover crops would not be allowed to flower if they are located within a 3-mile radius of pinned production fields. This restriction, along with the need for longer brassica rotations to avoid fungal diseases, severely limits the usefulness of radishes and other brassicas as cover crops in western Oregon.

Table 11. Average winter survival, date of 50% bloom, mature plant height, and dry matter biomass production of 12 radish cultivars planted in a 3-year trial at the Corvallis Plant Materials Center.

Cultivar	% Winter Survival		Date of 50% Bloom			Height (in)						Biomass Dry Matter (lb/ac)					
	2017	2018	2016	2017	2018	2016		2017		2018		2016		2017		2018	
Big Dog	84	94	----[1/]	4/11/2017	4/3/2018	----[1/]		16	cd[2/]	26	cdef	----[1/]		239	d	3,868	bcd
Concorde	96	96	----[1/]	4/21/2017	4/23/2018	----[1/]		25	a	36	a	----[1/]		1,385	ab	4,316	abc
Control	94	87	----[1/]	4/21/2017	4/16/2018	----[1/]		21	abc	32	ab	----[1/]		984	abc	6,381	a
Defender	97	89	4/5/2016	4/21/2017	4/16/2018	33	a	23	ab	30	bc	5,119	a	1,422	a	4,975	ab
Driller	91	97	3/24/2016	4/11/2017	4/3/2018	28	abc	14	d	25	def	3,109	ab	322	d	3,280	bcd
Eco-till	64	98	3/24/2016	4/11/2017	4/3/2018	29	abc	16	cd	25	def	2,178	b	406	cd	3,610	bcd
Graza	96	94	----[1/]	5/5/2017	4/30/2018	----[1/]		25	a	29	bcd	----[1/]		1,240	ab	1,820	d
Groundhog	88	93	3/24/2016	4/11/2017	4/3/2018	29	ab	15	d	25	ef	3,044	ab	286	d	2,856	cd
Lunch	100	97	3/24/2016	4/11/2017	4/3/2018	23	c	17	bcd	22	f	1,953	b	473	bcd	3,162	bcd
Nitro	65	89	3/24/2016	4/11/2017	4/3/2018	26	bc	14	d	24	ef	2,684	ab	317	d	2,728	cd
Sodbuster Blend	74	96	3/24/2016	4/11/2017	4/3/2018	28	abc	15	cd	25	def	2,709	ab	259	d	3,000	bcd
Tillage	88	93	3/24/2016	4/11/2017	4/3/2018	29	abc	18	bcd	26	cde	2,875	ab	351	cd	3,305	bcd
Mean	86	94				28		18		27		2,959		640		3,608	
SD[3/]	17	8				4		4		5		1,217		514		1,393	

[1/]Cultivar not planted in 2015-2016 season.

[2/]Means in columns followed by the same letter are not significantly different at $P<0.05$.

[3/]Standard deviation.

Crimson Clover

Crimson clover seedling germination and emergence were quick and uniform, with most cultivars reaching 65-85% emergence by 14 DAP and over 85% by 28 DAP, with the exception of 'AU Sunup', which was slower to germinate and never achieved an average emergence rating over 65% (Table 12). Disease and pest damage were low for all cultivars all three years of the trial, although AU Sunup had slightly higher average insect damage ratings at harvest than 'Dixie' and 'Contea' (1.3 vs. 0.4 and 0.6, respectively, on a scale from 0 to 5). 'AU Sunrise', Contea, and Dixie provided significantly more canopy cover than AU Sunup from December through May (Figure 5). AU Sunrise had particularly impressive early canopy cover, reaching an average of over 60% cover by 90 DAP in January. All cultivars had excellent winter survival in both 2017 and 2018 (Table 13).

AU Sunup, AU Sunrise, and AU Robin reached 50% bloom a few days earlier than Dixie and Contea two out of three years of the trial, while Kentucky Pride consistently bloomed one to two weeks later than Dixie (Figure 6). All three 'AU' (Auburn University) cultivars were developed in Alabama and Georgia as early-blooming selections for the southeastern US (Owsley 2009, 2012). Kentucky Pride is a newer cultivar that was selected as a late-maturing forage crop with improved cold tolerance (Grassland Oregon, 2017).

Table 12. Average seedling emergence ratings for six cultivars of crimson clover in a 3-year trial at the Corvallis Plant Materials Center, 2016-2018.

	Days after planting					
Variety	**7**	**14**	**21**		**28**	
AU Robin	0.5[1/]	1.5	2.3	a[2/]	2.7	a
AU Sunrise	0.8	2.1	2.7	a	2.9	a
AU Sunup	0.1	0.8	1.3	b	1.8	b
Contea	0.2	1.8	2.3	a	2.7	a
Dixie	0.4	1.7	2.2	ab	2.8	a
Kentucky Pride	0.3	1.5	2.3	a	2.7	a
Mean	0.4	1.6	2.2		2.6	
SD[3/]	0.6	1.1	0.7		0.6	

[1/]0 = poor (<25% germination), 1 = moderate (25–64%), 2 = good (65–85%), 3 = excellent (>85%).

[2/]Means in columns followed by the same letter are not significantly different at $P<0.05$.

[3/]Standard deviation.

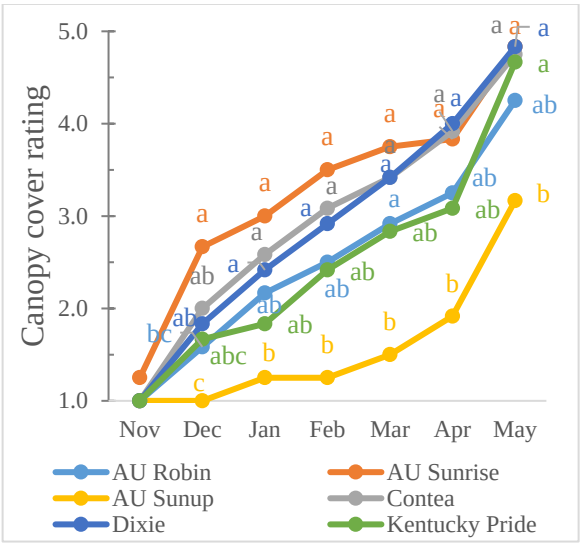

Figure 5. Average canopy cover ratings for six cultivars of crimson clover in a 3-year trial at the Corvallis Plant Materials Center, 2016-2018. Canopy cover was a visual estimate of the percentage of ground covered by the plant, rated on the following scale: 1 = 1–20%, 2 = 21–40%, 3 = 41–60%, 4 = 61–80%, 5 = 81–100%. For each date, means marked with the same letter are not significantly different at $\alpha=0.05$.

Table 13. Average winter survival, height, dry matter biomass, and nitrogen production of six crimson clover cultivars in a 3-year trial at the Corvallis Plant Materials Center.

Cultivar	% Winter Survival	Mature Height (in)			Biomass Dry Matter (lb/ac)			Total N (lb/ac)		
	2017/2018	2016	2017	2018	2016	2017	2018	2016	2017	2018
AU Robin	94	17 a[1/]	15	26 ab	2,235 a	1,995 ab	5,887 ab	42 bc	42 ab	121 ab
AU Sunrise	99	21 a	17	25 ab	3,040 a	3,494 a	7,266 a	65 ab	66 a	132 ab
AU Sunup	98	12 b	13	20 b	822 b	1,484 b	3,721 b	18 c	33 b	91 b
Contea	97	21 a	17	30 ab	3,335 a	2,988 ab	8,341 a	63 ab	60 a	170 a
Dixie	99	20 a	17	31 a	3,414 a	2,851 ab	7,519 a	76 a	49 ab	144 ab
Kentucky Pride	98	21 a	16	31 a	3,315 a	2,734 ab	7,384 a	69 ab	58 ab	138 ab
Mean	98	18	16	27	2,693	2,591	6,686	55	51	133
SD[2/]	5	4	2	4	1,068	1,119	1,870	24	22	36

[1/]Means in columns followed by the same letter are not significantly different at $P<0.05$

[2/]Standard deviation

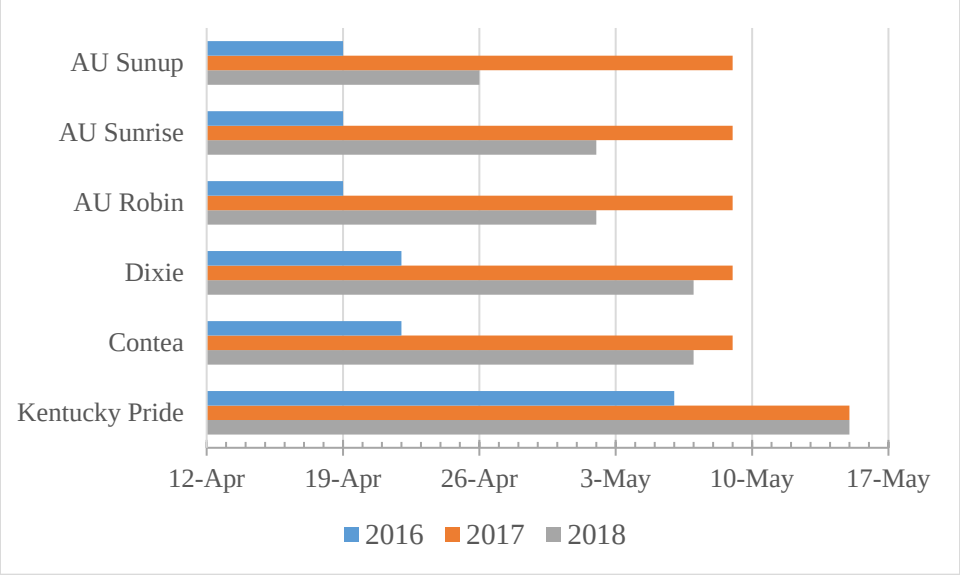

Figure 6. Date of 50% bloom of six crimson clover cultivars in a 3-year trial at the Corvallis Plant Materials Center.

AU Sunup was significantly shorter than other cultivars at maturity and produced less biomass and total nitrogen at least two out of three years of the study (Table 13). In 2018, all cultivars were taller and produced an average of twice as much biomass as the previous two years of the study, apparently benefitting from the relatively mild winter. Average nitrogen production for all cultivars in 2016 and 2017 was around 50 lb/ac but shot up to an impressive 130 lb N/ac in 2018.

Balansa Clover

Both Balansa clover cultivars were slow to germinate and emerge, with 'Frontier' lagging significantly behind 'Fixation' at 21 DAP, and neither quite reached an average of over 65% emergence by 28 DAP (Figure 7). Both cultivars had excellent winter survival in both 2017 and 2018 (Table 14). Disease damage was very low for both cultivars, and both had low to moderate

levels of pest damage, mostly due to slug predation of the small seedlings. The small rosettes provided little canopy cover over our rainy fall-winter seasons, but started active growth in March, and both reached over 75% cover by May (Figure 8).

Frontier reached 50% bloom three to four weeks before Fixation in late April to mid/late May all three years of the trial (Table 14). Fixation was over twice as tall as Frontier at maturity and produced significantly more dry matter biomass and total nitrogen than Frontier two out of three years of the trial. 2018 was a particularly good year for Fixation, with over 10,000 pounds of dry matter and over 170 lb N/ac.

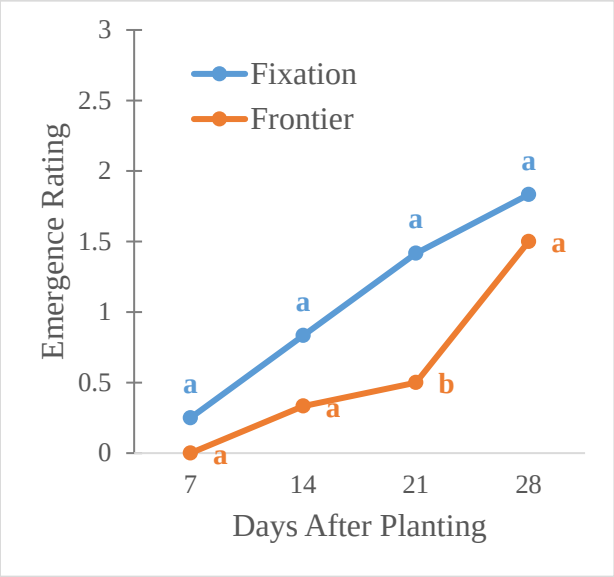

Figure 7. Average seedling emergence ratings of two cultivars of Balansa clover grown at the Corvallis Plant Materials Center over three seasons, 2016-2018. Emergence was visually estimated using the following rating scale: 0 = poor (<25% germination), 1 = moderate (25–64%), 2 = good (65–85%), 3 = excellent (>85%). For each date, means marked with the same letter are not significantly different at α=0.05.

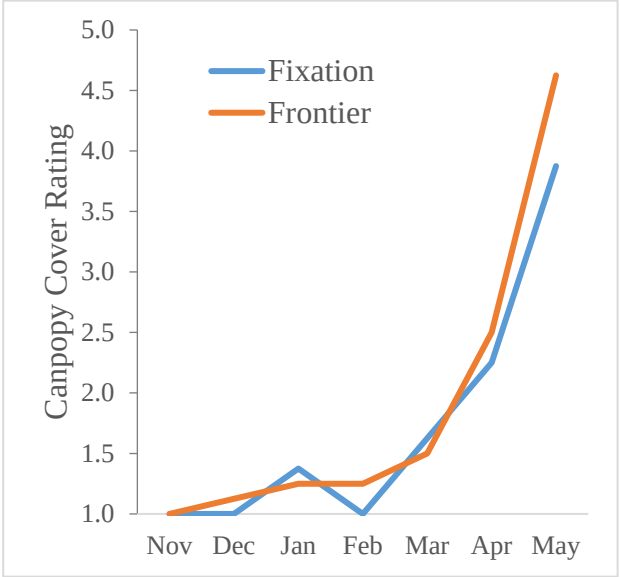

Figure 8. Average monthly canopy cover rating of two cultivars of Balansa clover grown at the Corvallis Plant Materials Center over three seasons, 2016-2018. Canopy cover was a visual estimate of the percentage of ground covered by the plant, rated on the following scale: 1 = 1–20%, 2 = 21–40%, 3 = 41–60%, 4 = 61–80%, 5 = 81–100%.

Table 14. Average winter survival, date of 50% bloom, mature height, biomass, and total nitrogen production of two cultivars of Balansa clover at the Corvallis Plant Materials Center in a 3-year trial.

Cultivar	% Winter Survival	Date of 50% bloom			Mature Height (in)	Biomass Dry Matter (lb/ac)			Total N (lb/ac)		
	2017/2018				3 yrs	2016	2017	2018	2016	2017	2018
Fixation	100	5/10/2016	5/24/2017	5/21/2018	26	2,320	3,382a[1/]	10,363a	45	73a	178a
Frontier	96	4/18/2016	5/2/2017	4/23/2018	11	1,491	1,868b	1,988b	34	41b	55b
Mean	98				18	1,905	2,625	6,176	39	57	116
SD[2/]	6				9	639	1,375	4,880	12	25	81

[1/]Means in columns followed by the same letter are not significantly different at $P<0.05$

[2/]Standard deviation

Red Clover

Germination and emergence of the red clover seedlings was generally slow and patchy. 'Freedom!' had better emergence than 'Kenland' as soon as 14 DAP (Table 15). By 28 DAP, most plots had good emergence, but few reached excellent emergence. Freedom! had higher final emergence than Kenland and 'Starfire II'.

Table 15. Average seedling emergence ratings for eight cultivars of red clover grown at the Corvallis Plant Materials Center in a 3-year trial, 2016-2018.

	Days after planting			
Cultivar	**7**	**14**	**21**	**28**
Cinnamon Plus	0.3[1/]	1.7 ab[2/]	2.1 ab	2.7 ab
Cyclone II	0.2	1.6 ab	2.2 ab	2.6 ab
Dynamite	0.4	1.8 ab	2.3 ab	2.7 ab
Freedom!	0.4	2.1 a	2.7 a	2.9 a
Kenland	0.0	0.9 b	1.4 b	1.9 b
Mammoth	0.3	1.4 ab	1.8 ab	2.3 ab
Starfire II	0.1	1.3 ab	1.9 ab	1.9 b
Wildcat	0.4	1.7 ab	2.3 ab	2.7 ab
Mean	0.3	1.5	2.1	2.4
SD[3/]	0.5	0.7	0.7	0.6

[1/]0 = poor (<25% germination), 1 = moderate (25–64%), 2 = good (65–85%), 3 = excellent (>85%).

[2/]Means in columns followed by the same letter are not significantly different at $P<0.05$.

[3/]Standard deviation.

Pest and disease ratings were low for all red clover cultivars all years of the trial, though there was some early slug predation of seedlings when they were just emerging. All the red clover cultivars tested had over 75% winter survival in 2017 and over 90% survival in 2018 (Table 16). However, plots were extremely weedy and had to be hand-weeded in early spring to avoid being completely choked out with weeds. All cultivars were slow to develop over the fall and winter, mostly remaining as small rosettes with less than 40% canopy cover through March or April (Figure 9). Growth rates finally increased in April or May and most cultivars entered their reproductive phase in May to June. All cultivars reached 50% bloom between mid-June and mid-July each year, although maturity and bloom were often uneven among individual plants within plots, apparently due to varying degrees of drought stress. There were no consistent differences in maturity dates among cultivars over the three years of the trial (Table 16).

Mature height for all cultivars in 2017 averaged 19 inches and in 2018 averaged 32 inches, with no significant differences among cultivars. On average, the red clover plots produced more than twice as much biomass in the relatively warm-dry 2018 season than in the cold-wet 2017 season, but there were no significant differences in biomass production among cultivars (Table 16). In 2017, Starfire II produced more total nitrogen than Mammoth or Wildcat. At an average of 50 to 100 pounds N per acre, red clover nitrogen production was comparable to that of other clover species, but much lower than hairy vetch.

Table 16. Average winter survival, date of 50% bloom, biomass dry matter production, and total nitrogen production of eight red clover cultivars grown in a 3-year trial at the Corvallis Plant Materials Center.

Cultivar	% Winter Survival		Date of 50% Bloom			Biomass DM (lb/ac)		Total N (lb/ac)		
	2017	2018	2016	2017	2018	2017	2018	2017		2018
Cinnamon Plus	88	96	6/21/2016	7/11/2017	6/18/2018	2,462	7,318	43	ab[1/]	134
Cyclone II	77	100	6/21/2016	7/11/2017	6/18/2018	2,236	7,661	42	ab	139
Dynamite	86	96	6/21/2016	7/11/2017	6/18/2018	2,522	5,497	43	ab	105
Freedom!	82	92	6/30/2016	7/11/2017	6/18/2018	3,231	6,887	64	ab	104
Kenland	77	97	6/30/2016	7/11/2017	6/18/2018	2,839	5,823	55	ab	100
Mammoth	83	100	----[1/]	7/11/2017	6/26/2018	1,891	4,387	32	b	86
Starfire II	76	96	6/21/2016	7/11/2017	6/18/2018	3,829	5,263	80	a	88
Wildcat	85	98	6/21/2016	7/11/2017	6/18/2018	1,977	7,115	35	b	117
Mean	82	97				2,623	6,244	49		109
SD[2/]	11	5				1,175	1,823	24		35

[1/]Means followed by the same letter are not significantly different at $P<0.05$.
[2/]Standard deviation.

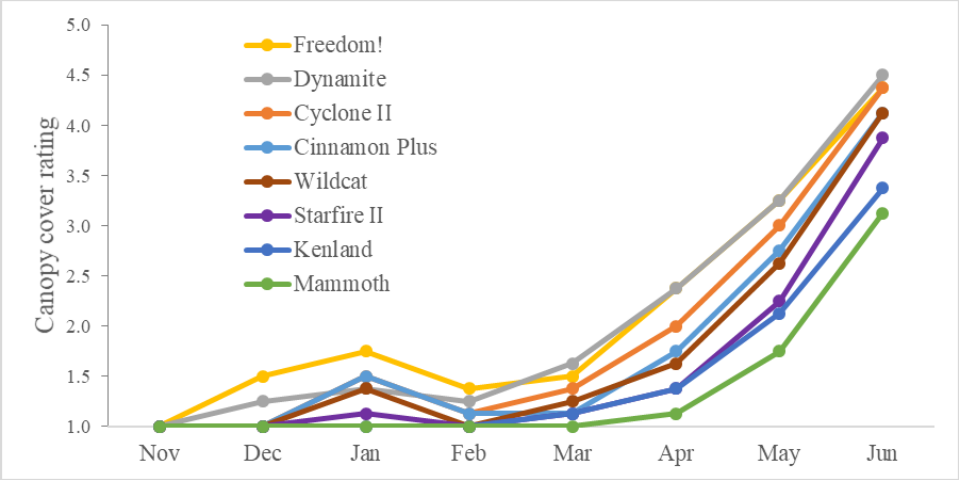

Figure 9. Average monthly canopy cover ratings for eight red clover cultivars grown at the Corvallis Plant Materials Center over the 2016-2017 and 2017-2018 seasons. Canopy cover was a visual estimate of the percentage of ground covered by the plant, rated on the following scale: 1 = 1–20%, 2 = 21–40%, 3 = 41–60%, 4 = 61–80%, 5 = 81–100%.

Over all, red clover, with its slow establishment, lack of cover over the winter, late maturity date, and susceptibility to weeds and slugs, does not appear to be a promising choice for use as a winter annual cover crop in our region.

Hairy Vetch

Emergence of most vetch cultivars was greater than 65% by 14 DAP, and most had excellent emergence by 28 DAP (Table 17). ‘Lana’ had quicker and better overall emergence than ‘CCS-Groff’. Pest and disease damage were minimal for all six vetch cultivars all three years of the trial. In early spring of 2018, there were some *Botrytis* patches observed in the lush new growth of several vetch plots, but most of the plants recovered and the disease did not appear to affect bloom or biomass.

Table 17. Average seedling emergence ratings for six cultivars of hairy vetch grown at the Corvallis Plant Materials Center in a 3-year trial, 2016-2018.

	Days after planting			
Cultivar	**7**	**14**	**21**	**28**
CCS-Groff	0.3[1/]	1.7	2.0 b[2/]	2.3 b
Lana	0.3	2.2	2.6 a	3.0 a
Purple Bounty	0.0	1.5	2.0 ab	2.4 ab
Purple Prosperity	0.5	1.9	2.5 ab	2.7 ab
TNT	0.4	1.8	2.6 a	2.8 ab
Villana	0.4	1.8	2.4 ab	2.5 ab
Mean	0.3	1.8	2.4	2.6
SD[3/]	0.5	0.6	0.5	0.5

[1/]0 = poor (<25% germination), 1 = moderate (25–64%), 2 = good (65–85%), 3 = excellent (>85%).
[2/]Means in columns followed by the same letter are not significantly different at $P<0.05$.
[3/]Standard deviation.

Winter survival was greater than 80% for all vetch cultivars in both 2017 and 2018 (Table 18). Because winter temperatures in Corvallis don't typically drop below about 15-20°F, most winter mortality can be attributed to predation by slugs or other pests.

'Lana' (technically a woollypod vetch, *Vicia villosa* ssp. *varia*) provided significantly more canopy cover than most other hairy vetch varieties for much of the winter and early spring (Figure 10). This early growth habit is particularly important for erosion control and protecting the soil surface from crusting during the heavy winter rains in western Oregon, as well as serving a potential role in weed suppression. Lana also reached 50% bloom a couple weeks earlier than the other cultivars of hairy vetch (Figure 11), potentially making it a better choice for situations where earlier cover crop termination is desired.

Table 18. Average winter survival, biomass dry matter production, and total nitrogen production of six cultivars of hairy vetch grown at the Corvallis Plant Materials Center in a 3-year trial.

Cultivar	**% Winter Survival**		**Biomass (DM lb/ac)**				**Total N (lb/ac)**		
	2017	2018	2016	2017		2018	2016	2017	2018
CCS-Groff	89	82	7,781	6,956	ab[1/]	10,515	231	208	253
Lana	99	91	6,123	4,247	b	9,082	173	104	311
Purple Bounty	87	100	----[2/]	7,078	ab	10,137	----[2/]	190	218
Purple Prosperity	100	93	7,724	9,473	a	10,918	233	258	308
TNT	87	92	6,720	8,301	ab	9,751	222	211	301
Villana	95	74	6,862	6,202	ab	8,678	268	166	268
Mean	93	88	7,042	7,043		9,847	225	190	277
SD[3/]	10	16	1,098	2,398		1,769	68	92	81

[1/]Means followed by the same letter are not significantly different at $P<0.05$.
[2/]Cultivar not planted in 2015.
[3/]Standard deviation.

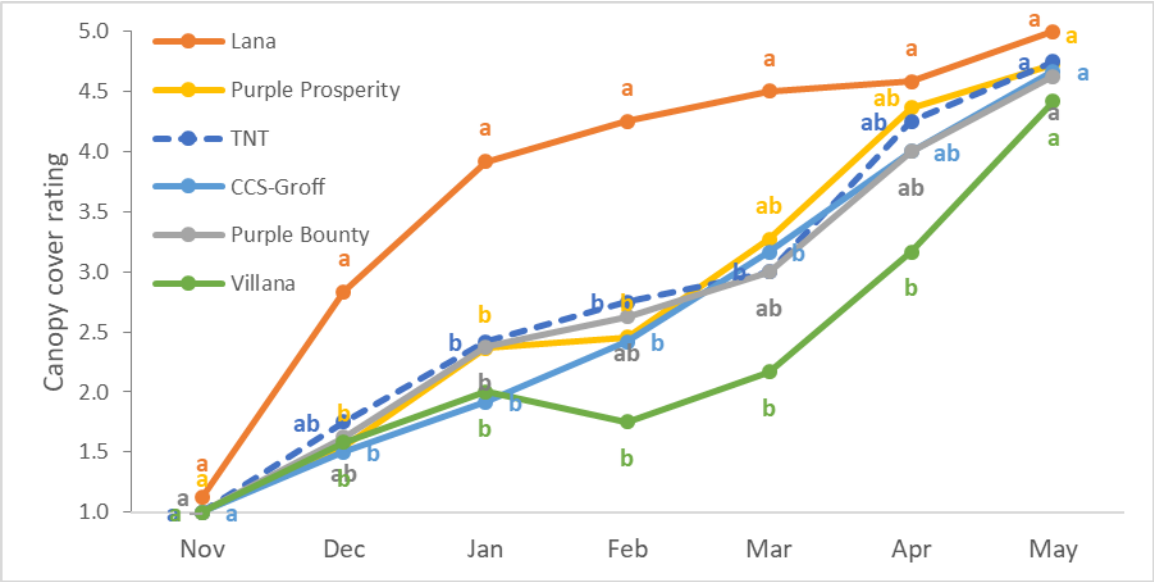

Figure 10. Average canopy cover ratings of six hairy vetch cultivars grown at the Corvallis Plant Materials Center for the 2016, 2017, and 2018 harvest seasons. Canopy cover was a visual estimate of the percentage of ground covered by the plant, rated on the following scale: 1 = 1–20%, 2 = 21–40%, 3 = 41–60%, 4 = 61–80%, 5 = 81–100%. For each date, means marked with the same letter are not significantly different at α=0.05.

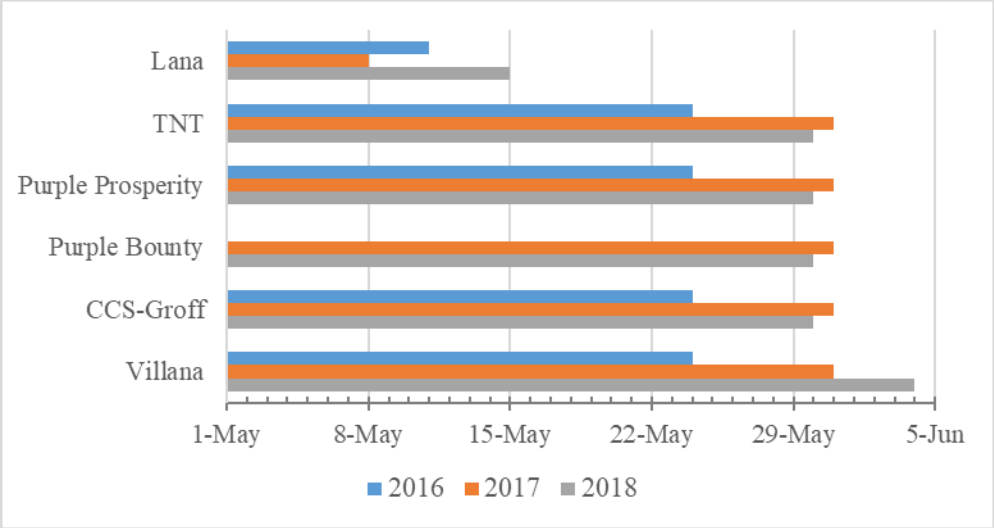

Figure 11. Date of 50% bloom of six hairy vetch cultivars at the Corvallis Plant Materials Center in 2016, 2017, and 2018.

Average mature height of the hairy vetch plots at 50% bloom ranged from 28 to 34 inches, depending mostly on the amount of lodging, since the vetch didn't have a companion cereal grain to support its long vines. Almost all the vetch cultivars produced at least 6,000 pounds of dry matter per acre each year of the study, and an impressive 100 to 300 pounds of nitrogen per acre (Table 18). There were no significant differences in biomass production among cultivars in 2016 or 2018, but in the cooler and wetter 2016-2017 growing season, 'Lana' produced less biomass than the top producer, 'Purple Prosperity'. Due to wide variability among plots, there were no significant differences in N production among cultivars.

CONCLUSION

Based on three years of data from cover crop trials at the Corvallis PMC, most cultivars of oat, cereal rye, hairy vetch, crimson clover, and Balansa clover appeared well adapted to the generally mild, Mediterranean climate of western Oregon. There were, however, some significant differences among cultivars in terms of bloom date, mid-winter canopy cover, biomass, and nitrogen production, so this information should help growers and conservationists select appropriate species and cultivars for their intended rotations and cover cropping purposes.

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