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Preliminary Results from the Willamette Valley Cover Crop Adaptation Trial

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ABSTRACT

Cover crop use is increasing in the Pacific Northwest, but information is not readily available on the growth potential, biomass production, adaptability, winter hardiness, and bloom period of cover crop species and/or varieties for this region. A study was conducted in 2014-2015 at the USDA Natural Resources Conservation Service Corvallis Plant Materials Center, Corvallis, Oregon to evaluate commercially available cover crops for the Willamette Valley of western Oregon. The replicated trial included 41 fall-planted, 12 spring-planted, and 10 summer-planted species/varieties that were evaluated for emergence, canopy cover, vigor, pest and disease susceptibility, winter hardiness, bloom period, plant height, and biomass production. Top performers this year are summarized in Table 1. A select set of these species/varieties will be retested over the next two years to further evaluate their regional adaptation taking into account annual variations in weather.

Table 1. *Top performing cover crops according to four traits (biomass, quick cover, bloom abundance, and legume biomass) in the 2014-2015 cover crop adaptation trials at the USDA-NRCS Plant Materials Center, Corvallis, OR.*

Trait	**Biomass**	**Quick Cover**	**Bloom Abundance**	**Legume Biomass**
Purpose	*Increase soil organic matter*	*Erosion reduction & weed suppression*	*Food for pollinators/ beneficial insects*	*Nitrogen fixation*
Fall	barley triticale annual ryegrass berseem clover	barley daikon radish common vetch triticale flax	berseem clover crimson clover common vetch hairy vetch flax	berseem clover common vetch hairy vetch crimson clover subclover
Spring	triticale	triticale spring lentil	chickling vetch buckwheat phacelia	spring lentil chickling vetch
Summer	sorghum-sudangrass teff buckwheat sunflower sunnhemp hybrid pearl millet	buckwheat sorghum-sudangrass hybrid pearl millet phacelia	buckwheat phacelia sunflower safflower	soybean sunnhemp

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INTRODUCTION

Incorporating cover crops into cropping systems can improve soil quality and resiliency of agricultural lands by increasing soil organic matter and water holding capacity, serving as a nitrogen trap to improve water quality, serving as a nitrogen source for subsequent crops, and for suppression of weeds (Clark 2007). Cover crops are useful in both conventional row crops and organically grown crops. Often though, selecting the most useful species or varieties to fit into a cropping system is limited by a lack of data on growth potential, biomass production, adaptability, winter hardiness, and bloom time.

Understanding the adaptation and growth characteristics of different cover crop species/varieties in the Willamette Valley will assist conservation planners and growers with making improved cover crop selections. The purpose of this study was to evaluate the growth characteristics, production attributes, and winter hardiness of commercially available cover crop varieties/cultivars in the Willamette Valley. The plantings also served as a demonstration and training tool for conservation planning staff and local growers during Field Days at the Corvallis Plant Materials Center (PMC) in 2015.

MATERIALS AND METHODS

The soil type at the PMC in Corvallis, OR where the study took place is an Amity silt loam, 0 to 3 percent slopes, somewhat poorly drained. Soil tests taken in May 2015 (Kuo Testing Labs, Othello, WA) showed a pH of 5.0, high P levels (55 ppm), and medium levels of K (184-194 ppm), SO_4-S (8-13 ppm), Ca (5.4 meq/100 g) and Mg (0.6 meq/100 g). Climate data for the study period are given in Table 2. The field was prepared by disking and rolling to produce a firm, well-prepared seedbed prior to fall, spring, and summer seeding. Plots were hand-weeded once or twice throughout the growing period as needed to prevent excessive weed competition.

All crops were drill seeded in 3 replicate 8 x 21-ft plots with a Hege cone seeder on 8.5-inch row spacing according to the seeding rates given in Table 3. Fall plots were planted October 2-7, 2014, spring plots were planted March 10-13, 2015, and summer plots were planted on June 12, 2015. All legume seeds were inoculated with the appropriate rhizobia prior to planting. Fall and spring plots received no supplemental irrigation, lime or fertilizer. Summer plots were limed with $CaCO_3$ at 2 tons/acre prior to seedbed preparation (with a full farm lime application planned for fall 2015), non-legume plots were fertilized with 100 lb N/ac as urea (46-0-0) on June 26, 2015, and all plots received about 1 inch of sprinkler irrigation per week throughout the summer.

A visual estimate of percent germination/emergence was performed in each plot approximately every 7 days for the first four weeks after planting. Fall and spring emergence were estimated to the nearest 5%, while summer emergence was rated using the following scale: 0 = poor (<25% germination), 1 = moderate (25-65% germination), 2 = good (65-85% germination), 3 = excellent (85-100% germination). Every 30 days (15 days for summer planting), all plots were rated for the following: vigor (general health and growth, rated on a scale of 1–9, where 1=poor and 9=excellent); disease (visual estimate of foliar diseases, rated from 0–5, where 0=no damage and 5=severe damage); pests (visual estimate of insect damage, rated from 0–5, where 0=no damage and 5=severe damage); and canopy cover (visual estimate of the percentage of ground covered by the plant, estimated to the nearest 5% for fall and spring plantings, and the nearest 10% for the summer planting).

Winter hardiness was determined on fall plantings by marking a 3-ft section of row within the interior rows in the middle of the seeded plot with stakes, and prior to first frost, counting the

number of live plants in the 3-ft row, then returning to the marked row in the spring and counting the number of live plants that survived. Initial counts were made on November 19, 2014, and final counts were taken for the brassicas on March 3, 2015, and for the rest of the plots on March 19, 2015.

Bloom period was monitored by noting the date of early, mid and late bloom (~25%, 50%, and 75% of the plants blooming, respectively). When plants reached 50% bloom, aboveground biomass samples were clipped at ground level from 0.5 x 1.0-m subplots in the center of each plot. Radish and turnip root biomass was sampled from the same 0.5 m^2-plots by digging the main edible portion (not the taproot or root hairs) of every plant within the plots. Average root length (cm) was calculated from measurements on 5 roots per plot. Aboveground and root biomass samples were oven dried and weighed to calculate percent dry matter and biomass on a pound per acre basis. Plant height measurements (height of lush canopy growth, not including blooms or inflorescences) were taken from 5 random locations in each plot at the time aboveground biomass was harvested. Plots were terminated by roller-crimper when they reached full bloom, and visual estimates of percent kill from the roller-crimper were made approximately 2 weeks after rolling each plot (fall and spring plantings only).

The experimental design was a randomized complete block with 3 replications (block 1 was arranged by crop type for demonstration/training purposes) and results were analyzed in Statistix 8.1 by AOV and Tukey HSD means comparisons within each crop type and planting date.

***Table 2**. Weather averages/totals from Hyslop weather station for Fall (10/2/2014 to 5/31/2015), Spring (3/10/2015 to 6/15/2015), and Summer (6/12/2015 to 9/10/2015) cover crop trials at the Corvallis Plant Materials Center.*

	Month	Air Temp Avg. Max (°F)	Air Temp Avg. Min. (°F)	Highest Daily Max (°F)	Lowest Daily Min. (°F)	Soil Temp @ 2-in. Avg. Max	Soil Temp @ 2-in. Avg. Min	Precip inches	Approx. Irrig. Inches
Fall-Planted	Oct-14	70	48	86	40	68	58	5.23	-
	Nov-14	53	37	66	19	51	46	6.42	-
	Dec-14	51	39	63	22	48	45	7.93	-
	Jan-15	50	36	62	23	47	43	3.59	-
	Feb-15	57	40	65	25	53	47	5.21	-
	Mar-15	62	38	71	27	58	49	4.27	-
	Apr-15	62	38	78	31	59	53	1.79	-
	May-15	70	46	83	35	66	60	0.81	-
							Total:	**35.25**	
Spring-Planted	Mar-15	63	41	71	32	59	51	4.20	-
	Apr-15	62	38	78	31	59	53	1.79	-
	May-15	70	46	83	35	66	60	0.81	-
	Jun-15	80	49	94	42	75	65	0.76	-
							Total:	**7.56**	
Summer-Planted	Jun-15	84	51	98	42	82	68	0.00	2.50
	Jul-15	87	53	104	45	90	75	0.00	4.50
	Aug-15	86	53	102	45	88	74	0.42	4.00
	Sep-15	76	49	86	40	76	64	0.33	0.00
							Total:	**0.75**	**11.00**

Table 3. *Cover crop species, varieties, and seeding rates for the 2014-2015 study at the Corvallis Plant Materials Center.*

	Species	Variety	Crop	Crop Type	Seeding Rate PLS lb/acre[1]	Seeds/ pound[2]	Seeding Rate PLS seeds/ft[2]
FALL PLANTED	*Avena sativa*	Cayuse	oat	Grass	95	14,248	31.1
	Avena sativa	CCS	oat	Grass	95	12,230	26.7
	Hordeum vulgare	Verdant	barley	Grass	80	11,723	21.5
	Triticum aestivum	VNS*	wheat, white winter	Grass	70	11,048	17.8
	xTriticosecale	CCS Winter Forage Triticale™	triticale	Grass	95	11,262	24.6
	Secale cereale	CCS	cereal rye	Grass	90	15,979	33.0
	Lolium perenne ssp. *multiflorum*	Assist	annual ryegrass	Grass	15	144,594	49.8
	Lolium perenne ssp. *multiflorum*	Tillage RootMax™	annual ryegrass	Grass	15	192,363	66.2
	Brassica napus var. *napus*	Rangiora	rape, winter	Brassica	8	106,021	19.5
	Brassica napus var. *napus*	Sub-zero	rape, winter	Brassica	8	97,344	17.9
	Brassica napus var. *napus*	Dwarf Essex	rape, spring	Brassica	8	98,471	18.1
	Brassica rapa var. *rapa*	White Egg	turnip	Brassica	6	208,038	28.7
	Brassica rapa var. *rapa*	Bouncer	turnip	Brassica	6	185,039	25.5
	Brassica oleracea	Bayou	kale	Brassica	8	115,634	21.2
	Brassica juncea	Shield	mustard	Brassica	8	195,908	36.0
	Raphanus sativus	GroundHog™	radish, daikon	Brassica	10	27,248	6.3
	Raphanus sativus	Enricher	radish, daikon	Brassica	10	25,464	5.8
	Raphanus sativus	The Buster™	radish, daikon	Brassica	10	43,344	10.0
	Raphanus sativus	Tillage Radish®	radish, daikon	Brassica	10	39,221	9.0
	Raphanus sativus	Driller™	radish, daikon	Brassica	10	30,147	6.9
	Raphanus sativus	Image Nematode Control Radish	radish, oil seed	Brassica	10	39,374	9.0
	Raphanus sativus	Cardwoodi Nematode Control Radish	radish, oil seed	Brassica	10	32,263	7.4
	Beta vulgaris	VNS	sugar beet	Broadleaf	10	29,294	6.7
	Fagopyrum esculentum	Koma	buckwheat	Broadleaf	60	14,774	20.3
	Linum usitatissimum	VNS	flax	Broadleaf	70	77,888	125.2
	Phacelia tanacetifolia	VNS	phacelia	Broadleaf	8	198,422	36.4
	Trifolium michelianum ssp. *balansae*	FIXatioN	Balansa clover	Clover	5	184,487	21.2
	Trifolium alexandrinum	Frosty	berseem clover	Clover	18	99,727	41.2
	Trifolium incarnatum	CCS Crimson Clover™	crimson clover	Clover	20	48,514	22.3
	Trifolium pratense	Mammoth	red clover	Clover	10	251,623	57.8
	Trifolium subterraneum	VNS	subclover	Clover	15	49,961	17.2
	Trifolium ambiguum	Rhizo	kura clover	Clover	11	208,070	52.5
	Trifolium fragiferum	O'Conners	strawberry clover	Clover	10	206,241	47.3

	Species	Variety	Crop	Crop Type	Seeding Rate PLS lb/acre[1]	Seeds/ pound[2]	Seeding Rate PLS seeds/ft[2]
	Trifolium repens	VNS	white clover	Clover	6	529,897	73.0
	Melilotus officinalis	VNS	sweetclover, yellow blossom	Legume	10	203,404	46.7
	Lens culinaris	Indian Head	lentil, spring	Legume	60	22,283	30.7
	Pisum sativum	FrostMaster	pea, Austrian winter	Legume	100	3,252	7.5
	Lathyrus sativus	AC Greenfix	chickling vetch (white pea)	Legume	60	2,946	4.1
	Vicia faba	VNS	fava	Legume	100	1,262	2.9
	Vicia sativa	VNS	common vetch	Legume	70	7,122	11.4
	Vicia villosa	Groff	hairy vetch	Legume	20	18,443	8.5
SPRING PLANTED	*Hordeum vulgare*	Conlon	barley, spring	Grass	80	~12,000¥	22.0
	Triticum aestivum	Glenn	wheat, hard red spring	Grass	90	~12,000¥	24.8
	xTriticosecale	CCS Winter Forage Triticale™	triticale	Grass	90	11,262	23.3
	Fagopyrum esculentum	Koma	buckwheat	Broadleaf	60	14,774	20.3
	Phacelia tanacetifolia	VNS	phacelia	Broadleaf	8	198,422	36.4
	Brassica napus var. *napus*	Dwarf Essex	rape, spring	Broadleaf	8	98,471	18.1
	Lens culinaris	Indian Head	lentil, spring	Legume	60	22,283	30.7
	Pisum sativum	VNS	pea, Austrian winter	Legume	120	~3,800¥	10.5
	Lathyrus sativus	AC Greenfix	chickling vetch (white pea)	Legume	60	2,946	3.9
	Trifolium incarnatum	CCS Crimson Clover™	clover, crimson	Legume	20	48,514	22.3
	Melilotus officinalis	VNS	sweetclover, yellow blossom	Legume	10	203,404	46.7
	Trifolium ambiguum	Rhizo	clover, kura	Legume	11	208,070	52.5
SUMMER PLANTED	*Pennisetum glaucum*	K Graze	millet, hybrid pearl	Grass	10	18,154	4.1
	Sorghum bicolor var. *bicolor x S. bicolor* var. *sudanense*	VNS	sorghum-sudangrass	Grass	35	18,021	14.5
	Eragrostis tef	Excalibur	teff	Grass	7	1,475,896	237.0
	Fagopyrum esculentum	Koma	buckwheat	Broadleaf	60	15,643	20.7
	Phacelia tanacetifolia	VNS	phacelia	Broadleaf	8	193,512	36.4
	Carthamus tinctorius	VNS	safflower	Broadleaf	25	15,773	9.1
	Helianthus annuus	VNS	sunflower, black oil	Broadleaf	4	12,650	1.2
	Vigna unguiculata	Iron & Clay	cowpea	Legume	60	4,577	6.3
	Glycine max	Surge	soybean	Legume	50	3,168	3.7
	Crotalaria juncea	Tillage Sunn	sunnhemp	Legume	25	7,862	4.5

*VNS - Variety Not Stated, [1]PLS - Pure Live Seeding Rate, [2]Seeds per pound calculated as average weight from 3 100-seed counts (¥ except three approximations from the literature)

RESULTS AND DISCUSSION

Fall Planting

Quick canopy cover is important for protecting the soil from crusting and erosion due to raindrop impact, and for suppressing weed growth (Clark 2007). Most fall-planted grasses and brassicas had 70% emergence within 2 weeks of planting, while the legumes and other broadleaf species were generally slower to emerge (Table 4). By 60 days after planting (DAP), only the Verdant barley had greater than 50% canopy cover, while a few other entries had reached at least 30% canopy cover, namely common vetch, daikon radish, triticale, cereal rye, oats, white winter wheat, and flax. By early March, at 150 DAP, the following entries had reached over 70% canopy cover: common vetch, CCS Winter Forage Triticale, annual ryegrass (Assist and Tillage RootMax), Verdant barley, and CCS oats.

Winter survival was generally high for the grasses and radishes, but mixed for other brassicas, broadleafs, and legumes (Table 4). Part of the reason for the lack of vigor and survival among the clovers and other legumes was likely the intense slug pressure during their slow growth period in the fall and winter. Our acidic soils may also have inhibited legume growth and vigor, since most rhizobia don't grow well and legumes don't nodulate below pH 5.0 – 5.5 (Zharan 1999). A few legumes were notable exceptions, with high winter survival, vigor, and biomass production, including common vetch, berseem clover, crimson clover, hairy vetch, subclover, and lentil. Crimson clover, hairy vetch, and subclover are all reported to have a preferred pH range as low as 5.5, while berseem clover is reported to prefer a pH of at least 6.2 (Clark 2007); other studies have noted the high acid tolerance of subterranean and Balansa clover (Evans et al. 1990).

At over 4 tons dry matter per acre, the largest producers of aboveground biomass from the fall-planted plots were triticale, barley, Assist annual ryegrass, berseem clover, oats, white winter wheat, and common vetch (Table 4). In February, the brassica plots were largely decimated by a fungal disease (light leaf spot, *Cylindrosporium concentricum*), resulting in relatively low aboveground and root biomass for most of the brassica varieties (Tables 4 and 5). Wet conditions and cool temperatures (~60°F), such as those experienced in Corvallis from late January through early March 2015, are known to be highly conducive to the spread of this disease (Pscheidt and Ocamb 2015). The recommended cultural control method for soil-borne fungal diseases such as light leaf spot is to bury residue by deep plowing and rotate the field out of brassicas for three years. This recommendation should be taken into account when planning rotations including brassica crops or cover crops.

Based on visual observations, the crops with the most abundant and longest bloom period were the berseem clover, crimson clover, common vetch, hairy vetch, flax, and favas. These flowers provide potential resources of pollen and/or nectar for bees and other beneficial insects. Most fall-planted plots reached 50% bloom between early May and mid-June, with the notable exception of the brassicas and subclover, which reached peak bloom from early March to early April (Table 4). This large difference in bloom times should be taken into account when formulating cover crop mixes since it complicates management. A cover crop mix would have to be terminated in March to prevent brassicas from setting seed, but the grasses tend to be difficult to kill in their vegetative growth stage at that point, and peak legume biomass and N content doesn't occur until early bloom in late April to early May.

Table 4. *Cover crop properties from fall-planted trial at the USDA-NRCS Corvallis Plant Materials Center in 2014-2015.*

	Crop	Variety	Days to 70% emerg-ence	Cover at 60 DAP (early Dec.)*		Cover at 150 DAP (early March)		Winter survival[1]		Pests[2]		Disease[3]		Vigor[4]		Date of 50% Bloom	Mature height (ft)		Above-ground biomass lb/ac	
Grass	oat	Cayuse	14	32%	bc	62%	bc	93%	ab	2.0	a	3.0	a	7.0	b	5/22/15	3.0	bcd	9,989	abc
	oat	CCS	14	38%	bc	77%	ab	98%	a	1.8	ab	2.7	ab	7.5	ab	5/13/15	2.7	cd	9,132	abc
	barley	Verdant	14	58%	a	80%	ab	100%	a	1.8	ab	2.3	ab	7.5	ab	5/5/15	3.4	abcd	16,141	ab
	wheat, white winter	VNS	14	33%	bc	48%	c	99%	a	1.7	ab	3.3	a	6.9	b	5/13/15	2.3	d	8,196	bc
	triticale	CCS Winter Forage Triticale™	13	40%	ab	92%	a	87%	ab	1.5	b	1.7	bc	8.0	a	5/5/15	3.6	abc	17,811	a
	cereal rye	CCS	13	38%	abc	50%	c	78%	ab	2.1	a	1.0	c	7.1	b	5/5/15	4.1	ab	6,482	c
	annual ryegrass	Assist	16	18%	c	88%	a	96%	a	1.4	b	1.7	bc	7.9	a	5/13/15	3.9	ab	11,782	abc
	annual ryegrass	Tillage RootMax™	13	19%	c	77%	ab	71%	b	1.5	b	1.7	bc	7.4	ab	5/29/15	4.5	a	7,318	bc
Brassicas (Mustard Family)	kale	Bayou	13	6%	f	7%	c	22%	d	3.4	ab	1.7	cd	3.0	d	3/3/15	2.6	ab	1,582	bcd
	mustard	Shield	13	20%	cde	7%	c	8%	d	3.1	ab	3.7	abc	4.3	bcd	3/3/15	1.5	d	286	d
	rape, winter	Rangiora	13	8%	f	8%	c	21%	d	3.7	a	1.0	d	3.1	d	3/3/15	2.2	abcd	952	cd
	rape, winter	Sub-zero	13	8%	f	8%	c	35%	cd	3.4	ab	1.7	cd	3.6	d	5/5/15	2.7	a	1,237	bcd
	rape, spring	Dwarf Essex	13	8%	f	8%	c	43%	abcd	3.6	ab	0.7	d	3.0	d	3/3/15	2.4	abc	874	cd
	turnip	White Egg	13	17%	def	57%	ab	45%	abcd	3.2	ab	2.3	bcd	5.5	abc	3/30/15	2.2	abcd	2,522	bc
	turnip	Bouncer	13	10%	ef	17%	c	43%	bcd	3.7	a	2.0	cd	4.2	cd	3/30/15	2.2	abcd	1,047	bcd
	radish, daikon	GroundHog™	13	27%	bcd	19%	c	79%	ab	2.8	ab	4.7	a	5.3	abc	3/3/15	1.4	d	636	cd
	radish, daikon	Enricher	18	28%	bc	20%	c	71%	abc	2.7	ab	4.3	ab	5.9	ab	3/3/15	1.7	cd	916	cd
	radish, daikon	The Buster™	13	40%	a	32%	bc	65%	abc	2.4	b	4.7	a	6.5	a	3/3/15	1.8	bcd	1,005	bcd
	radish, daikon	Tillage Radish®	13	45%	a	32%	bc	75%	ab	2.5	ab	4.3	ab	6.6	a	3/3/15	1.8	abcd	1,654	bcd
	radish, daikon	Driller™	13	37%	ab	20%	c	83%	a	2.7	ab	4.7	a	6.3	a	3/3/15	1.5	d	815	cd
	radish, oil seed	Image Nematode Control Radish	13	28%	bc	68%	a	83%	ab	2.7	ab	2.7	abcd	6.3	a	3/30/15	2.7	a	4,933	a
	radish, oil seed	Cardwoodi Nematode Control Radish	18	23%	cd	57%	ab	65%	abc	3.0	ab	2.7	abcd	5.5	abc	3/30/15	2.4	abc	3,117	ab
Other Broadleaf	sugar beet	VNS	34	4%	b	5%	bc	32%	b	4.2	a	1.0	a	1.9	c	none	0.6	b	149	b
	buckwheat	Koma	27	4%	b	0%	c	0%	b	1.0	b	N/A		1.0	c	N/A	N/A		N/A	
	flax	VNS	10	33%	a	50%	a	83%	a	0.7	b	0.7	a	7.7	a	5/5/15	2.5	a	6,672	a

	Crop	Variety	Days to 70% emerg-ence	Cover at 60 DAP (early Dec.)*		Cover at 150 DAP (early March)		Winter survival[1]		Pests[2]		Disease[3]		Vigor[4]		Date of 50% Bloom	Mature height (ft)		Above-ground biomass lb/ac	
	phacelia	VNS	25	12%	b	15%	b	13%	b	1.3	b	0.3	a	4.7	b	5/5/15	2.6	a	2,635	b
Clovers	Balansa clover	FIXatioN	26	1%	c	7%	b	32%	bcd	4.0	a	0.3	ab	2.8	c	5/13/15	1.4	abc	3,061	b
	berseem clover	Frosty	17	9%	ab	23%	ab	73%	a	2.0	c	0.7	ab	6.3	ab	6/9/15	2.3	a	10,973	a
	crimson clover	CCS Crimson Clover™	17	15%	a	48%	a	78%	a	1.6	c	1.0	ab	7.1	a	5/5/15	1.7	ab	6,848	ab
	red clover	Mammoth	17	2%	bc	6%	b	50%	abc	3.3	ab	0.0	b	3.0	c	6/9/15	0.4	bc	594	b
	subclover	VNS	22	5%	bc	20%	ab	62%	ab	2.3	bc	0.0	b	5.3	b	4/3/15	0.5	bc	4,095	ab
	kura clover	Rhizo	29	1%	c	1%	b	7%	d	3.7	a	0.0	b	1.2	d	none	N/A		0	b
	strawberry clover	O'Conners	17	1%	c	4%	b	20%	cd	3.5	a	1.3	a	2.4	cd	6/15/15	0.4	c	386	b
	white clover	VNS	20	1%	bc	4%	b	28%	bcd	3.4	a	0.3	ab	2.4	cd	6/15/15	0.5	bc	1,189	b
Other Legumes	lentil, spring	Indian Head	14	17%	bc	23%	b	79%	ab	1.8	cd	1.0	bc	5.7	b	5/13/15	1.0	b	3,453	bc
	pea, Austrian winter	FrostMaster	21	15%	bc	33%	b	90%	ab	2.9	abc	2.9	ab	5.5	b	5/13/15	1.8	ab	1,569	
	chickling vetch (white pea)	AC Greenfix	27	15%	bc	18%	bc	45%	b	2.6	bc	1.0	bc	4.9	b	5/13/15	1.3	b	2,277	bc
	fava	VNS	27	18%	b	15%	bc	71%	ab	3.0	ab	3.7	a	4.5	b	5/5/15	2.8	a	2,742	bc
	common vetch	VNS	14	42%	a	95%	a	97%	a	1.2	d	0.0	c	8.5	a	5/13/15	1.3	b	7,901	a
	hairy vetch	Groff	24	10%	cd	30%	b	72%	ab	2.6	bc	0.0	c	5.2	b	5/22/15	2.7	a	5,118	ab
	sweetclover, yellow blossom	VNS	14	1%	d	0%	c	0%	c	4.0	a	0.0	c	1.3	c	none	N/A		0	c

*Means within each crop category (Grasses, Brassicas, Other Broadleaf, Clovers, and Other Legumes) followed by the same letter are not statistically different in Tukey HSD comparisons at α=0.05.

[1]Plant counts taken in marked 3-ft section of row on 11/19/14 and 3/3/15 (brassicas) or 3/19/15 (all other species).

[2]Pest pressure rated on a scale of 0 to 5, where 0=no pests and 5=severe pest damage (average of all dates).

[3]Disease susceptibility rated on a scale of 0 to 5, where 0=no disease and 5=severe disease damage (evaluated just prior to biomass harvest).

[4]Vigor rated on a scale of 1 to 9, where 1=poor vigor and 9=excellent vigor (average of all dates).

Table 5. *Root biomass and length for fall-planted turnip and radish varieties in the 2014-2015 cover crop trial at the Corvallis Plant Materials Center.*

Crop	Variety	Root biomass (lb/ac)		Root length (cm)	
turnip	White Egg	1,240	a	11.5	b
turnip	Bouncer	327	b	11.8	ab
radish, daikon	GroundHog™	286	b	13.7	ab
radish, daikon	Enricher	446	b	13.9	ab
radish, daikon	The Buster™	286	b	12.5	ab
radish, daikon	Tillage Radish®	749	ab	12.9	ab
radish, daikon	Driller™	470	b	14.1	ab
radish, oil seed	Image Nematode Control Radish	1,148	a	15.8	a
radish, oil seed	Cardwoodi Nematode Control Radish	1,160	a	15.7	a

Means followed by the same letter are not statistically different in Tukey HSD comparisons at α=0.05.

Spring Planting

Most of the spring-planted cover crops emerged within two to three weeks after planting in mid-March, but they generally lacked vigor and were slow to establish canopy cover, with only the triticale and spring lentil achieving greater than 25% cover by 70 days after planting in mid-May, and only the spring lentil and chickling vetch reaching at least 50% cover at termination in mid-June (Table 6). Most plants appeared stunted and many were afflicted by disease and pests. Only the triticale and wheat reached higher than 2 feet tall and produced just over one ton of aboveground biomass per acre (Table 6). This poor performance in 2015 is likely due to a combination of factors, including lower than average spring precipitation (Table 2), the low soil pH, and competition from a winter cover crop that re-sprouted after disking. This trial should be replicated in future years with better seedbed preparation, liming, and fertilization to more accurately assess the performance of spring-planted cover crops.

Summer Planting

Buckwheat provided by far the quickest emergence and canopy cover of the summer-planted species, reaching 70% cover in less than 23 days and full bloom in 49 days. The sorghum-Sudangrass, hybrid pearl millet, and phacelia also had good establishment and quick cover (Table 7). The legumes generally had lower vigor than the grasses and broadleaf entries included in this trial, and took longer to reach 70% cover.

For aboveground biomass production, the sorghum-Sudangrass was the hands-down winner at over 6 feet tall and more than 7 tons dry matter per acre. Other top biomass producers included teff, buckwheat, sunflower, sunnhemp, and hybrid pearl millet (Table 7). Buckwheat and phacelia provided the longest and most abundant bloom period for many bees and other floral visitors, followed by sunflower and safflower. The soybeans bloomed early, but their small flowers appeared inaccessible to many bees; the sunnhemp had few flowers; and the cowpeas hadn't bloomed by the time they were terminated 90 days after planting, though this may be remedied by selection of a more appropriate cultivar for our region.

Table 6. *Cover crop properties from spring-planted trial at the USDA-NRCS Corvallis Plant Materials Center in 2015.*

	Crop	Variety	Days to 70% emerg-ence	Cover at 70 DAP (mid-May)*		Cover at termination (mid-June)		Pests[1]		Disease[2]		Vigor[3]		Mature height (ft)		Above-ground biomass lb/acre		Dry Matter
Grasses	barley, spring	Conlon	22	17%	a	23%	a	1.3	a	1.9	a	5.0	a	1.8	a	1,426	a	54.0%
	triticale	CCS Winter Forage Triticale™	17	29%	a	43%	a	1.4	a	1.4	a	7.1	a	2.7	a	2,370	a	50.1%
	wheat, hard red spring	Glenn	17	22%	a	33%	a	1.6	a	2.9	a	5.9	a	2.1	a	2,076	a	53.1%
Broad-leaf	buckwheat	Koma	23	18%	a	11%	b	4.3	a	3.1	a	3.8	a	0.3	b	123	b	42.5%
	phacelia	VNS	17	18%	a	20%	a	0.8	b	0.3	b	4.3	a	1.4	a	796	a	42.0%
	rape, spring	Dwarf Essex	14	22%	a	17%	ab	4.7	a	1.4	b	3.6	a	no measurable biomass				
Legumes	lentil, spring	Indian Head	16	28%	a	63%	a	1.1	d	0.6	b	6.1	a	1.1	b	1,567	a	39.9%
	chickling vetch (white pea)	AC Greenfix	25	22%	ab	50%	a	1.8	cd	0.8	b	5.8	a	1.7	a	1,186	ab	34.0%
	pea, Austrian winter	VNS	16	18%	ab	22%	b	3.3	ab	3.1	a	3.9	b	1.5	a	534	b	38.6%
	crimson clover	CCS Crimson Clover™	14	15%	bc	16%	b	2.3	bc	0.7	b	3.2	b	0.8	c	314	b	40.1%
	kura clover	Rhizo	23	3%	d	1%	b	3.3	ab	0.1	b	1.0	c	no measurable biomass				
	sweetclover, yellow blossom	VNS	26	5%	cd	1%	b	4.0	a	0.2	b	1.7	c	no measurable biomass				

*Means within each crop category (Grasses, Broadleaf, or Legumes) followed by the same letter are not statistically different in Tukey HSD comparisons at α=0.05.

[1]Pest pressure rated on a scale of 0 to 5, where 0=no pests and 5=severe pest damage (average of all dates).

[2]Disease susceptibility rated on a scale of 0 to 5, where 0=no disease and 5=severe disease infestation (average of all dates).

[3]Vigor rated on a scale of 1 to 9, where 1=poor vigor and 9=excellent vigor (average of all dates).

Table 7. *Cover crop properties for summer-planted trial at the USDA-NRCS Corvallis Plant Materials Center in 2015.*

	Crop	Variety	Days to 70% emerg-ence	Days to 70% cover	Days to Full Bloom	Days to Termin-ation	Cover at 28 DAP (mid-July)*[1]		Cover at 69 DAP (late Aug.)[1]		Pests[2]		Disease[3]		Vigor[4]		Mature height (ft)		Above-ground biomass DM lb/ac		Dry Matter	
Grasses	hybrid pearl millet	K Graze	13	37	77	70	70%	ab	90%	a	1.3	b	0.4	a	4.9	a	3.6	b	8,212	a	17.8%	b
	sorghum-sudangrass	VNS	7	33	69	70	77%	a	100%	a	2.1	a	0.6	a	5.0	a	6.7	a	14,168	a	18.5%	b
	teff	Excalibur	21	47	69	70	40%	b	93%	a	1.6	b	0.0	b	4.4	b	2.4	b	9,515	a	28.8%	a
Broadleaf	buckwheat	Koma	7	< 23	49	70	100%	a	100%	a	1.7	b	0.3	b	4.8	ab	1.9	c	8,772	a	17.9%	b
	phacelia	VNS	11	40	56	70	67%	b	90%	a	0.3	c	0.1	b	4.8	ab	2.4	b	4,956	a	18.7%	ab
	safflower	VNS	7	44	69	70	43%	c	87%	a	1.5	b	0.8	a	5.0	a	1.8	c	6,431	a	24.9%	a
	sunflower, black oil	VNS	25	56	69	70	17%	d	87%	a	2.7	a	0.3	b	4.5	b	4.4	a	8,517	a	14.1%	b
Legumes	cowpea	Iron & Clay	13	59	no bloom	90	30%	a	80%	a	1.8	c	2.5	a	3.8	a	2.3	b	3,784	b	15.7%	b
	soybean	Surge	20	59	56	70	33%	a	83%	a	2.3	b	0.0	c	3.7	a	2.5	b	5,071	ab	20.0%	b
	sunnhemp	Tillage Sunn	15	62	90	90	27%	a	70%	a	3.0	a	0.5	b	3.8	a	5.0	a	8,370	a	34.3%	a

*Means within each crop category (Grasses, Broadleaf, or Legumes) followed by the same letter are not statistically different in Tukey HSD comparisons at α=0.05.

[1]Visual estimate of the percentage of ground covered by the plant, rated according to cover categories (0 to 10), converted to % cover by multiplying by 10.

[2]Pest pressure rated on a scale of 0 to 5, where 0=no pests and 5=severe pest damage (average of all dates).

[3]Disease susceptibility rated on a scale of 0 to 5, where 0=no disease and 5=severe disease infestation (average of all dates).

[4]Vigor rated on a scale of 1 to 5, where 1=poor vigor and 5=excellent vigor (average of all dates).

CONCLUSIONS

Although we only have preliminary results from one year of data so far, many of the "tried and true" cover crops appeared to be well adapted to our region and performed well for a variety of functions. These crops included barley, triticale, oats, wheat, cereal rye, annual ryegrass, hairy vetch, common vetch, crimson clover, subterranean clover, buckwheat, and sorghum-Sudangrass. Other, "non-traditional" cover crops that performed well this year and that warrant further attention included berseem clover, flax, phacelia, chickling vetch, spring lentil, sunnhemp, hybrid pearl millet, teff, and sunflower. Brassicas were highly impacted by disease this year, and proper rotations must be incorporated into any cover crop recommendations. Crops that performed very poorly this year, largely due to poor establishment and low seedling vigor, included sugar beet, kura clover, and yellow blossom sweetclover.

Data from this and future years of this study will be used to inform cover crop seeding recommendations in the new NRCS *Cover Crop Selection Tool for the Pacific Northwest* and the *Seeding and Planting Guide for Western Oregon and Washington* in the electronic NRCS Field Office Technical Guide (eFOTG).

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