United States Department of Agriculture

FINAL STUDY REPORT
NRCS Plant Materials Center, Corvallis, OR
December 2017

Seeding Rates for Legume-Grain Cover Crop Mixes in Western Oregon

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ABSTRACT

Farmers are increasingly planting fall cover crops in western Oregon for a number of purposes. Planting cover crop mixes of two or more species can help growers take advantage of the quick establishment of grasses for erosion control and the ability of legumes to fix nitrogen for subsequent crop use. The objective of this non-replicated demonstration study was to evaluate the cover and biomass production of three simple grain–legume cover crop mixes planted at four different seeding rates. In 2015-2016, the three mixes trialed at the USDA-NRCS Plant Materials Center in Corvallis, OR were oat–common vetch, cereal rye–crimson clover, and triticale–Austrian winter pea, each seeded at 150%, 100%, 75%, and 50% of the recommended seeding rates. For all three mixes, the highest seeding rate provided more cover at 30 days after planting (DAP), but by 60 DAP cover was similar for the 75, 100, and 150% rates. Biomass harvested in early May at 200 DAP was similar within mixes regardless of seeding rate. These observations suggest that seeding rates could be lowered to about 75% of the current recommendations and still achieve good erosion control cover and biomass production. If nitrogen production is the goal, the legume content of the mix should probably be increased to about 75%, calculated on a seeds per square foot basis, and the cover crop may need to be terminated earlier in April to avoid N immobilization by mature cereal grain residue.

INTRODUCTION

Fall planted cover crops in western Oregon can be used for a number of purposes, including preventing soil erosion during heavy winter rains, adding organic matter to the soil, cutting fertilizer costs for the subsequent cash crop by contributing nitrogen to the soil from N-fixing legumes, and improving crop yields by enhancing soil health (Sattell and Dick, 1998; Clark, 2007). The use of two or more cover crop species in a mix can help to maximize the benefits of the cover crop. Mixes often consist of a combination of one or more legume species and one or more small grains. Legume seed is generally more expensive, while grains tend to be cheaper and more widely available. With farms often on a tight budget, choosing a cover crop mix and seeding rate requires a cost-benefit analysis of the trade-offs between the higher initial cost of using high seeding rates (particularly of legumes) and the potential benefits of providing quick cover for erosion control and weed suppression, as well as biomass and nitrogen production to feed soil microbes and the subsequent crop.

The objective of this study was to evaluate the establishment and performance of three different legume-small grain cover crop mixes seeded at four seeding rates in order to assess the relative

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competitive advantage of the legume versus small grain in the mix, and the minimum seeding rate necessary for adequate winter cover, biomass production, and plant available nitrogen production for subsequent crop use.

MATERIALS AND METHODS

The species chosen for this trial are among the most commonly used, affordable, and readily available cover crops in western Oregon (Sattell and Dick, 1998): oat (*Avena sativa*), common vetch (*Vicia sativa*), cereal rye (*Secale cereale*), crimson clover (*Trifolium incarnatum*), triticale (*x Triticosecale*), and Austrian winter pea (*Pisum sativum*). The legume-cereal grain pairings were somewhat arbitrary, but based on commonly used combinations for our region. The full seeding rate for each mix was developed based on single-species seeding rates from the Pacific Northwest Cover Crop Selection Tool (Young-Mathews et al., 2016) and mix recommendations from *Managing Cover Crops Profitabl*y (Clark, 2007). When using common vetch in a mix, the recommendation is to seed at three quarters of the full single-species seeding rate for the vetch and two thirds the full rate for the grain; for crimson clover the recommendation is to use two thirds the rate for the clover and half the full rate for the grain; and for Austrian winter peas the recommendation is to plant at three quarters rate for the peas and two thirds the cereal grain rate (Clark, 2007). Cover crop mix and seeding rate information for this non-replicated observational study is given in Table 1. Each mix was planted at the full (100%) recommended seeding rate, as well as 50%, 75%, and 150%.

The study was installed on field 6-2 at the Schmidt Farm site of the USDA-NRCS Plant Materials Center (PMC) in Corvallis, OR on a soil classified as a Willamette silt loam, 0–3% slopes. The field was disked and rolled in early October to create a firm, well-prepared seedbed. The 32 by 200-ft non-replicated plots were each planted with a Nordsten seed drill (Kongskilde Agriculture, Albertslund, Denmark) on 6-inch row spacing on 15-16 Oct., 2015. All legume seeds were inoculated with the appropriate rhizobia prior to planting. Soil tests taken in June 2016 (Kuo Testing Labs, Othello, WA) showed that the field had a pH of 5.7, 3% organic matter, high levels of P (58 ppm), and medium levels of other nutrients (212 ppm K, 6.5 meq/100 g Ca, and 0.5 meq/100 g Mg). No fertilizer or lime was applied to the plots, nor did they receive any supplemental irrigation during the trial.

Germination/emergence was visually estimated in each plot approximately every 7 days for the first three weeks after planting using the following rating scale: 0 = poor (<25% germination), 1 = moderate (25-64%), 2 = good (65-85%), 3 = excellent (>85%). At 30 days after planting (DAP), seedling counts were taken in 1-ft^2 plots of each treatment to quantify the establishment of the legume and grain components of each mix. Every 30 days, canopy cover data were collected in each plot using a point intercept technique, with points taken on 1-ft intervals along a 50-ft transect laid diagonally across the middle of the plot. Also every 30 days, average plant height (height of lush canopy growth, not including blooms or inflorescences) was calculated from five measurements for each component (legume and cereal grain) of each plot.

When the majority of 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. The biomass samples were separated into three components (legume, cereal grain, and weeds), and each was weighed separately. Biomass samples were oven dried to a steady weight, and dry matter biomass (lb/ac) was calculated for the total plot and each component. A composite sample of dried biomass from each plot was sent to Kuo Testing Labs for total %N analysis.

Table 1. Cover crop varieties and seeding rates for three mixes planted at four seeding rates (150%, 100%, 75%, and 50% of the recommended rate) in the 2015-2016 observational trial at the Corvallis Plant Materials Center.

Common name	Variety	Mix % (seed wt.)	Mix % (no. seeds)	Seeding Rate - Pure Live Seed							
				150%		100%		75%		50%	
				lb ac^{-1}	seeds ft^{-2}	lb ac^{-1}	seeds ft^{-2}	lb ac^{-1}	seeds ft^{-2}	lb ac^{-1}	seeds ft^{-2}
Mix A											
Oat	Cayuse	69%	84%	100	40	67	26	50	20	33	13
Common vetch	VNS*	31%	16%	45	7	30	5	23	4	15	2
			Total:	145	47	97	31	73	23	48	16
Mix B											
Cereal rye	VNS	81%	35%	75	25	50	17	38	13	25	8
Crimson clover	VNS	19%	65%	18	46	12	31	9	23	6	15
			Total:	93	72	62	48	47	36	31	24
Mix C											
Triticale	Forerunner	47%	66%	70	13	47	9	35	7	23	4
Austrian winter pea	VNS	53%	34%	79	7	53	5	39	3	26	2
			Total:	149	20	99	13	74	10	50	7

*VNS - variety not stated

Table 2. Seedling counts and mix composition of cereal grains and legumes at 30 days after planting in three cover crop mixes seeded at four rates at the Corvallis Plant Materials Center, 2015-2016.

Cover Crop Mix	Rate	Seedling Counts (plants/ft^2)			Mix Composition	
		Grain	Legume	Total	Grain	Legume
A. Oat−common vetch	150%	51	12	63	81%	19%
	100%	40	9	49	81%	19%
	75%	31	7	39	81%	19%
	50%	18	6	24	75%	25%
B. Cereal rye−crimson clover	150%	37	38	75	49%	51%
	100%	13	23	36	37%	63%
	75%	19	32	51	38%	62%
	50%	12	8	20	60%	40%
C. Triticale−Austrian winter pea	150%	27	13	40	68%	32%
	100%	21	13	33	62%	38%
	75%	19	7	26	74%	26%
	50%	13	7	21	65%	35%

RESULTS AND DISCUSSION

The 2015−2016 growing season at the Corvallis PMC was generally a warmer and wetter year than average, with a total of 47 inches precipitation from October to May, compared to a 20-year average of 39 inches, with most of the extra rainfall in December, January, and March.

Germination and emergence were fairly rapid and uniform in all of the planted mixes. The cereal rye−crimson clover plots had excellent germination (>85%) by just 14 days after planting (DAP), while the oat−common vetch and triticale−Austrian winter pea plots had good germination (61-85%) at 14 DAP, and excellent germination by 21 DAP. This slightly slower establishment in the latter treatments appeared to be due to peas, oats, and vetch that weren't planted deep enough and took longer to germinate on or near the soil surface. Seedling counts conducted at 30 DAP in mid-November were generally close to, or in some cases exceeded, the target seeds per square foot seeding rates, indicating excellent establishment (Table 2). Higher seedling counts were likely due to limitations in the precision of seeder calibration.

With our wet winter, the drainage culvert failed on the north side of the field where the trial was planted, resulting in relatively continuous ponding in all of the oat–vetch plots from mid-December through March, and intermittent/partial ponding in the rye–clover plots and the highest rate of the triticale–pea plots from mid-January through early March. The oats were most affected by the ponding, with yellow-red leaf tips/edges and severe stunting by mid-January, while the vetch generally appeared to be more tolerant of the water-logged soils. The cereal rye also showed signs of ponding damage by March, with stunting and yellow to red/purple leaf tips, while the crimson clover also appeared stunted. The triticale and peas, with less severe ponding, showed minimal signs of damage, with some yellowed lower leaves.

Without replication in this observational study, the ponding makes comparison of the cover data for different seeding rates of the oat−vetch and rye−clover mixes fairly meaningless after mid-December. However, there were some general trends that appeared to hold true for all mixes and seeding rates. The grains tended to provide far more canopy cover than the legumes (30 to 60% cover versus 10 to 20%, respectively), especially earlier in the season, and weed cover was generally low, at 5 to 20%. Total planted canopy cover was lower in November and appeared to increase more slowly in plots seeded at the 50% rate, leaving more bare ground exposed to pounding winter rains, while the other three rates had similar trends for total cover (Figure 1).

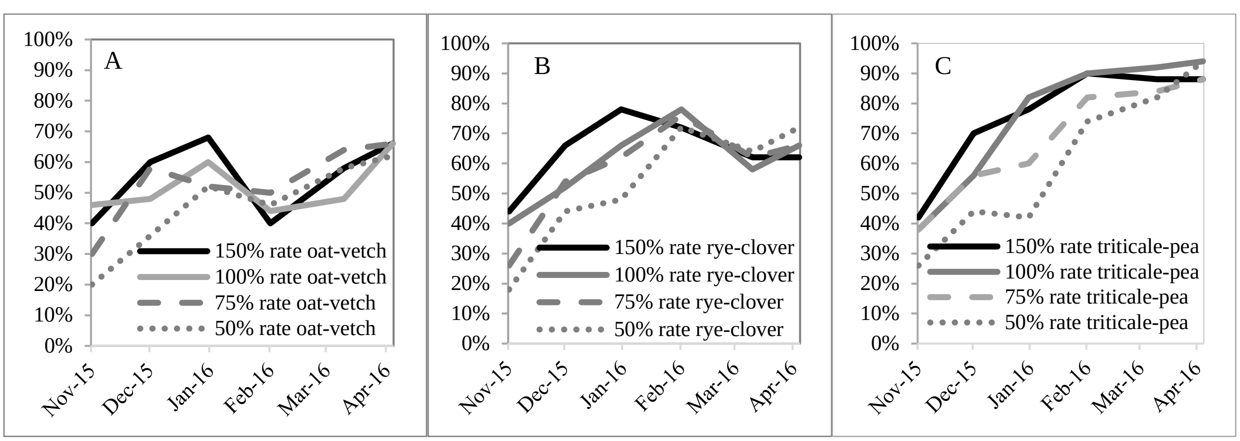

Figure 1. Total cover of planted species in (A) oat–common vetch, (B) cereal rye–crimson clover, and (C) triticale–Austrian winter pea plots planted at four seeding rates at the Corvallis Plant Materials Center, 2015-2016.

Table 3. Cover crop seed costs for the 2015 trial at the Corvallis Plant Materials Center.

Species	Price per pound*
oat	$ 0.35
cereal rye	$ 0.28
triticale	$ 0.46
common vetch	$ 0.77
crimson clover	$ 0.72
Austrian winter pea	$ 0.42

*2015 prices in Corvallis, OR

Table 4. Seed costs for three cover crop mixes planted at four seeding rates at the Corvallis Plant Materials Center, 2015.

Cover Crop Mix	Seeding Rate	Seed Cost per Acre£
A. Oat–common vetch	150%	$ 82.20
	100%	$ 54.80
	75%	$ 41.10
	50%	$ 27.40
B. Cereal rye–crimson clover	150%	$ 39.11
	100%	$ 26.07
	75%	$ 19.56
	50%	$ 13.04
C. Triticale–Austrian winter pea	150%	$ 70.59
	100%	$ 47.06
	75%	$ 35.30
	50%	$ 23.53

£based on 2015 retail seed prices in Corvallis, OR

This suggests that in terms of providing quick canopy cover to protect the soil surface from water erosion and crusting over the winter, the 75% seeding rate may be sufficient. Seed cost can certainly be a factor when a farmer chooses species and seeding rates for a cover crop mix. Based on our seed costs in 2015 (Table 3), planting the trial mixes at the 75% versus 100% rate would yield a savings of $7 to $13 per acre in seed costs (Table 4).

Mature plant height in early May did not appear to vary much based on seeding rate, but did seem to be affected by the ponding, with the triticale, Austrian winter peas, and cereal rye ending up around 40 to 45 inches tall, while the crimson clover, oats, and common vetch showed signs of stunting, reaching only 19 to 28 inches (Figure 2). Both the cereal grains and legumes remained as fairly short rosettes throughout most of the winter (November through February), with most species doubling in height between mid-March and mid-April, and then some doubling again by early May.

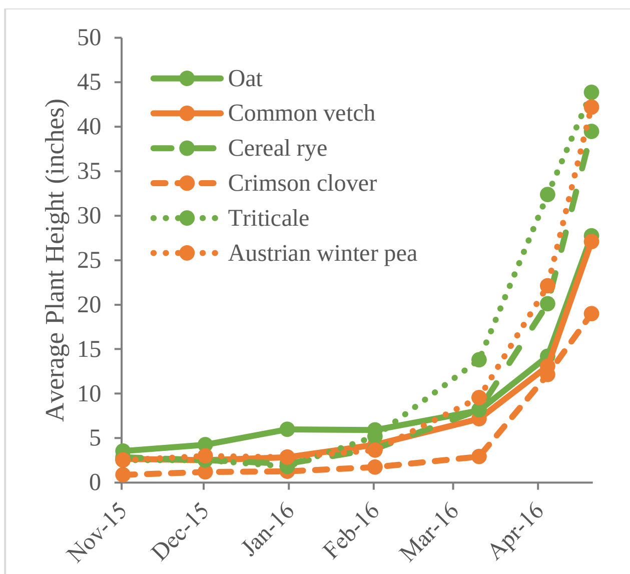

Figure 2. Average height of the components of each of the three cover crop mixes (oat–common vetch, cereal rye–crimson clover, and triticale–Austrian winter pea) planted at the full (100%) seeding rate at the Corvallis Plant Materials Center, 2015-2016.

Table 5. Biomass and nitrogen production in three cover crop mixes seeded at four rates at the Corvallis Plant Materials Center, 2015-2016.

Cover Crop Mix	Seeding Rate	Biomass DM lb/ac	Total N %	PAN[§] lb/ac	Mix Composition (DM)[¥] Grass	Legume	Weeds
A. Oat–vetch	150%	4,603	1.27	4.1	72%	19%	9%
	100%	4,644	2.14	25.0	45%	51%	3%
	75%	4,326	1.81	14.7	57%	36%	6%
	50%	3,677	1.90	14.4	51%	42%	6%
B. Rye–clover	150%	4,719	1.57	10.3	86%	6%	9%
	100%	4,785	1.37	6.2	83%	11%	6%
	75%	5,663	1.44	9.0	82%	13%	5%
	50%	6,339	1.42	9.5	79%	17%	4%
C. Triticale–pea	150%	9,554	1.12	3.6	93%	6%	1%
	100%	8,983	1.48	15.8	90%	7%	3%
	75%	10,322	1.28	9.7	95%	2%	3%
	50%	9,513	1.48	16.7	79%	12%	9%

[¥] dry matter from aboveground biomass harvested on 5/5/2016

[§] plant available nitrogen calculated from Organic Fertilizer & Cover Crop Calculator (Andrews et al., 2010)

Biomass also appeared to be affected by the ponding, with the non-flooded triticale–pea mix producing an average of over 9,000 pounds dry matter (DM) per acre, while the oat–vetch and rye–clover mixes averaged just over 4,000 and 5,000 lb DM/ac, respectively (Table 5). The biomass in the rye–clover and triticale–pea mixes at all seeding rates was dominated by the cereal grains, which generally accounted for over 80% of the dry matter, despite being only 35 and 66% of the seed mix, respectively. The relatively small legume composition of these mixes resulted in lower total nitrogen in the dry matter, ranging from just 1.1 to 1.6% N, which in turn means that the cover crop residue is likely contributing less plant available nitrogen (PAN) for use by the subsequent crop. Studies in western Oregon have shown that when cover crop dry matter is 75% cereals and 25% legumes, the PAN is typically near zero when terminated in early May at legume bud stage and cereal boot stage (Sullivan and Andrews, 2012). According to PAN estimates based on the Organic Fertilizer and Cover Crop Calculator (Andrews et al., 2010), the rye–clover and triticale–pea mixes provided 3 to 16 lb PAN/ac, while the oat–vetch provided 4 to 25 lb PAN/ac (Table 5). This higher PAN estimate for the oat–vetch seeded at the 100% rate corresponds to the highest N percentage (2.14%) and the highest legume composition (51%) of any of the mixes and rates tested, likely due to the oats being particularly flooded out in that plot. However, this gives us an idea of how much more PAN could be produced by planting mixes with a higher legume composition and/or terminating the mixes earlier in April before the cereals reach boot or heading stage, since PAN is immobilized or made negative from cereal grains when they reach the heading growth stage (Sullivan and Andrews, 2012). As can be seen in Figure 3, our plots were probably terminated a couple weeks too late for optimal PAN since the oat was at boot stage, the cereal rye was at head emergence stage, and the triticale was at early anthesis, while the crimson clover was at 50% bloom and the common vetch and peas were at early bloom. This is also a good illustration of the challenge in managing a multi-species cover crop when each component of the mix has a different maturity date.

Figure 3. Mature stands of Mix A. oat–common vetch (left), Mix B. cereal rye–crimson clover (middle), and Mix C. triticale–Austrian winter pea (right) at the Corvallis Plant Materials Center on May 5, 2016.

Although there are often recommendations in the literature about what percentage of a cover crop mix should be cereal grains, legumes, or other components in order to achieve different objectives such as erosion control or production of PAN, it is not always clear on what basis that percentage is being calculated. Figure 4 provides an illustration of six different calculations of the percent composition of the triticale–Austrian winter pea mix planted at the full (100%) seeding rate. If the composition is calculated on the seeding rate in pounds per acre, the peas make up 53% of the mix, but if that seeding rate is converted to seeds per square foot based on the average number of seeds per pound for the triticale and peas, then the peas only make up 34%. The latter matches well with seedling counts conducted at 30 days after planting. Canopy cover data, however, tell a different story, with the peas only providing 10% cover in mid-January, and 18% cover by mid-April. But when the cover crop was terminated in early May and biomass was harvested, the peas only accounted for 7% of the dry matter. This suggests that the triticale seeding rate would have to be drastically reduced in order to end up with a mix where the peas accounted for a majority of the cover or biomass dry matter. It is still unclear whether planting a mix with 75% peas based on the seeds per square foot seeding rate would result in 75% pea biomass in the mature stand, but future studies at the Corvallis PMC will investigate this.

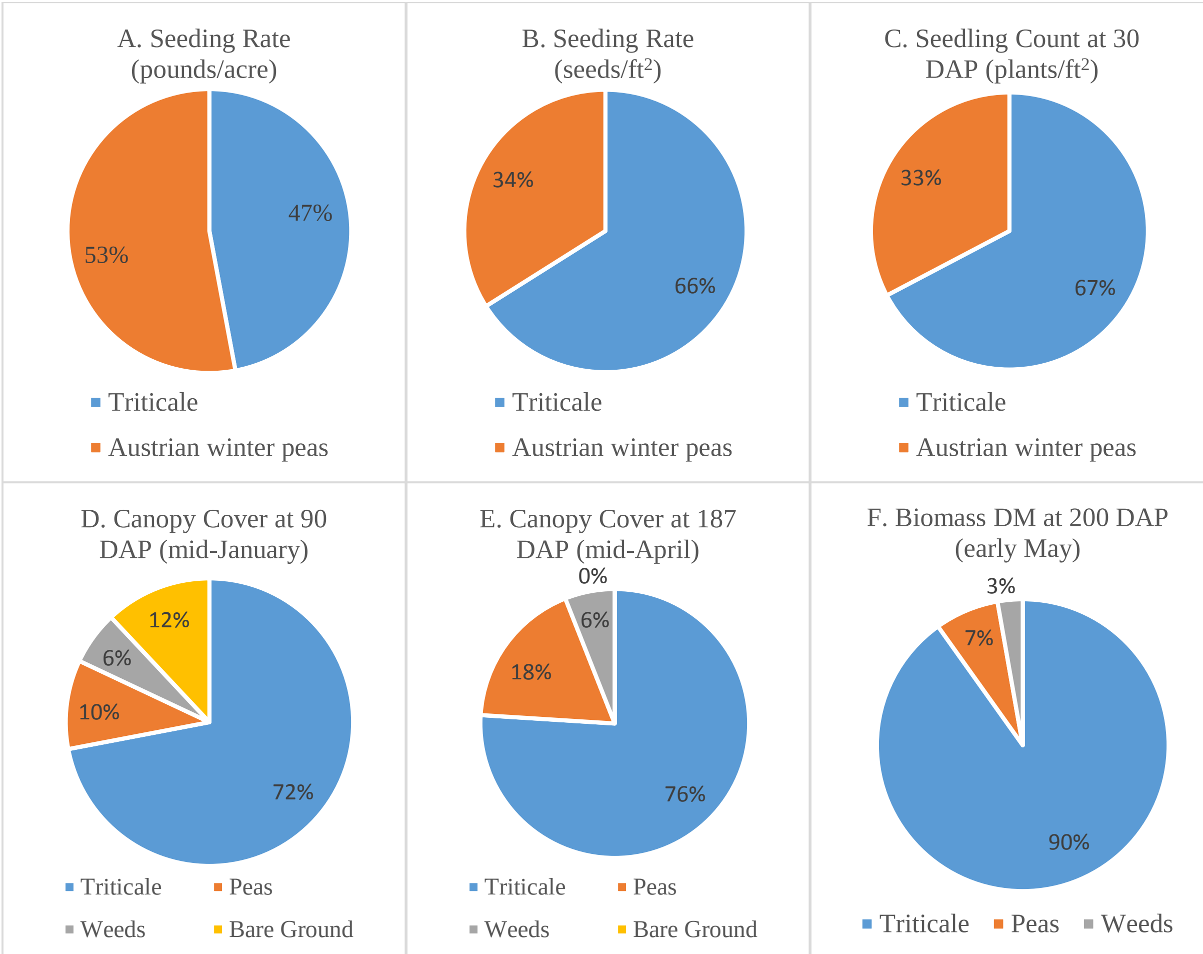

Figure 4. Cover crop mix composition for the triticale–Austrian winter pea mix planted at the full (100%) seeding rate in 2015-2016 trial at the Corvallis PMC illustrating: A. mix composition based on the weight of each seed component in the mix, B. mix composition based on the seeds per square foot planted, C. mix composition based on seedling counts taken 30 days after planting (DAP), D. mix composition based on canopy cover transects taken at 90 DAP, E. mix composition based on canopy cover transects taken at 187 DAP, and F. mix composition based on percent dry matter in biomass harvested at 200 DAP.

CONCLUSION

Observations from this non-replicated trial suggest that cover crop canopy cover and biomass production objectives can likely be met even with seeding at 75% of the standard recommended rate for the oat–common vetch, cereal rye–crimson clover, and triticale–Austrian winter pea mixes trialed, assuming that seed is drilled into a good seedbed. However, in order to maximize plant available nitrogen for the subsequent crop, the percentage of legumes in the mixes should be increased substantially, and the cover crop may need to be terminated earlier in mid-April before the legumes actually begin to flower in order to avoid the cereal grains reaching a growth stage where their residue will immobilize nitrogen in the soil.

LITERATURE CITED

Andrews, N., D. Sullivan, J. Julian, and K. Pool. 2010. Organic fertilizer and cover crop calculator – west of the Cascades, v.4. Oregon State Univ., Small Farms Program, Corvallis, OR. http://smallfarms.oregonstate.edu/calculator

Clark, A. (ed). 2007. Managing cover crops profitably, 3rd edition. Handbook 9. Sustainable Agriculture Research & Education (SARE) program, College Park, MD. http://www.sare.org/Learning-Center/Books/Managing-Cover-Crops-Profitably-3rd-Edition/Text-Version

Sattell, R., and R. Dick (eds.). 1998. Using cover crops in Oregon. EM 8704. Oregon State Univ. Ext. Service, Corvallis, OR. http://extension.oregonstate.edu/crook/sites/default/files/oregoncovercrops.pdf

Sullivan, D.M., and N.D. Andrews. 2012. Estimating plant-available nitrogen release from cover crops. Pacific Northwest Extension Publication 636. Oregon State Univ., Corvallis. https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/pnw636.pdf

Young-Mathews, A., P. Pavek, and D. Tilley. 2016. WNTSC Plant Materials Technical Note No. 2: Pacific Northwest Cover Crop Selection Tool. USDA-NRCS West National Technology Support Center, Portland, OR. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/plantmaterials/technical/toolsdata/plant/?cid=nrcseprd894840