



Evaluation of Pure Live Seed (PLS) Seeding Rates for Coated Crimson Clover

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ABSTRACT

Crimson clover (*Trifolium incarnatum*) is a low cost, easy to grow, cool season, annual legume used widely in the southeastern United States in many conservation and agricultural production practices. To ensure proper inoculation from rhizobia and to aid in planting, much of the crimson clover seed commercially available includes a seed coating. Seed coating often makes up 50% or more of the total seed weight. This results in very low seed purity for a coated seed lot and causes Pure Live Seed (PLS) calculations, recommended by some Natural Resource Conservation Service (NRCS) references and guidance documents, to at least double the bulk seeding rate to compensate for this low seed purity. 'Dixie' coated crimson clover was planted in 2016, 2017, and 2019 at seeding rates representing 100%, 75%, and 50% of the full recommended PLS seeding rate to determine if plant performance measures differed at these various rates. Additionally, a direct seed count comparison between coated and uncoated 'Dixie' crimson clover seed was included to examine any plant performance differences that could be directly attributed to the seed coating. Plant performance measures included percent ground cover, plant height, and biomass yield. There were no significant differences in the proportioned PLS seeding rates for any plant performance measure indicating all seeding rates were adequate for maximizing plant performance. Additionally, there were no significant differences observed in a direct comparison between coated and uncoated seed lots when planted at identical seed counts per square foot. This study indicates that utilizing PLS calculations for coated crimson clover seed lots can result in excess seed planted and seed coating alone does not provide any observable advantages over the uncoated seed for plant performance.

INTRODUCTION

Crimson clover is a very popular cool-season, annual legume grown in much of the southeastern United States for a wide-variety of purposes including cover cropping, grazing and forage production, and wildlife plantings (Ball et al., 2002; Clark, 2012). Several improved varieties have been developed and seed is readily available across the entire area, making it easy to grow and cost-effective for agricultural producers and landowners.

Seed coating is commonly available on crimson clover seed lots to produce a more uniform seed size across the entire seed lot and to include a clover seed inoculant on the seed. The convenience of seed coating makes it an attractive option when purchasing clover seed. When planting coated clover seed however, producers and landowners should consider the impacts the coating can have on seeding rate calculations. In many coated clover seed lots, the seed purity provided on the seed tag is reported as less than 50%, indicating at

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least half the weight of the bag is the inert seed coating material. Large percentages of inert materials can greatly influence seeding rate calculations and planter calibrations, which are often applied on a weight basis rather than on a seed count basis.

One method to account for variation and irregularity in seed lots is to use Pure Live Seed (PLS) seeding rates and calibrate planting equipment on a PLS basis rather than a bulk seed basis. Ball et al. (2002, p. 89) states that PLS can be used with seeding rates for seed that “frequently contain a substantial quantity of inert material.” Ball et al. continues, “This calculation is only necessary when the seeding rate provided specifies pure live seed or PLS.” Some NRCS references and guidance documents (Barrett, 2018; Natural Resources Conservation Service, United States Department of Agriculture, 2019; Young-Mathews, 2013) provide PLS seeding rates for use with crimson clover seedings. Many other technical references, including NRCS sources, do not specify the use of PLS seeding rates with crimson clover (Clover, Crimson, 2018; Natural Resources Conservation Service, United States Department of Agriculture, 2020; Surrency et al., 2000).

When considering seed on a PLS basis, bulk seed rates are adjusted to account for varying germination and purity percentages for each lot of seed. For coated crimson clover seed, this approach could result in greatly increased bulk seeding rates due to low seed purity caused by the inclusion of the seed coating material. In this case, the PLS calculation could result in excessive bulk coated clover seeding rates being used for conservation practices.

The objective of this study was to examine plant performance of crimson clover at seeding rates derived from carrying out PLS calculations on coated seed lots. Plant performance characteristics were compared to determine if PLS calculations are needed to maximize the performance of crimson clover plantings from coated seed lots, or if PLS calculations are overestimating seeding rates when using coated seed. Additionally, the performance of both coated and uncoated crimson clover plantings were evaluated to determine any observed effects on plant performance.

MATERIALS AND METHODS

The study was conducted at the USDA-NRCS Jimmy Carter Plant Materials Center, Americus, Georgia in the fall/winter/spring of 2016-2017, 2017-2018, and 2019-2020. The Jimmy Carter Plant Materials Center is located on the Southern Coastal Plain MLRA (MLRA 133A) of the southeastern United States (Natural Resources Conservation Service, United States Department of Agriculture, 2006). Plots were planted on a Red Bay sandy loam soil (fine-loamy, kaolinitic, thermic Rhodic Kandiudult (Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture, 2020). The center is located within plant hardiness zone 8a, but very near the boundary of plant hardiness zone 8b (*Georgia-Plant Hardiness Zone Map*, 2012). The 30-year (1991-2020) mean maximum temperature during the growing season for this study is 64.7 °F and 30-year (1991-2020) mean minimum temperature is 41.1 °F (Prism Climate Group, Oregon State University, 2020). The 30-year (1991-2020) mean precipitation during the same time is 23.5 inches. During the three years of the study, monthly average temperatures were near or above the 30-year monthly minimum and monthly maximum temperatures in most months. Monthly precipitation amounts were variable by year (Figure 1).

Determining Seed Counts and Seeding Rates

Commercially available seed lots of ‘Dixie’ crimson clover, both coated and uncoated, were used for evaluation in this study. Identical seed lots of coated and uncoated seed were not commercially available from the same seed source, or any source, so coated and uncoated seed were purchased from different sources. The same set of seed lots were used in both the 2016 and 2017 planting years, however different seed lots were used in the 2019 planting year due to the age of the original seed lots used. A seed per pound value was determined for each lot by counting ten samples of a known number of seed using a Seedburo 801 seed counter (Seedburo Equipment Co., Chicago, IL), determining the weight of each sample, and rounding to the nearest 1,000 seeds per pound value of the average of the 10 samples. Seed germination and purity data were obtained for each seed lot from

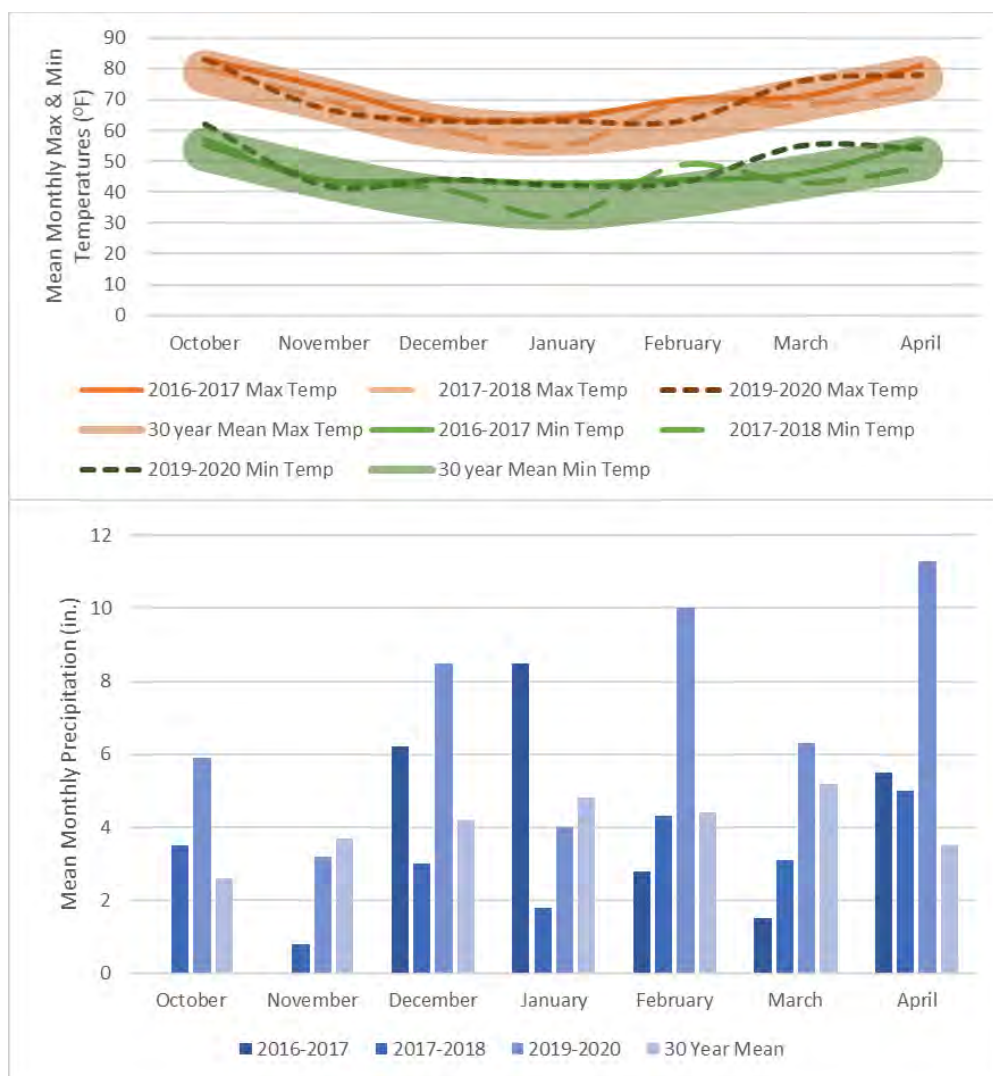


Figure 1. Mean monthly maximum and minimum temperatures (top) and mean monthly precipitation (bottom) for the 2016-2017, 2017-2018, and 2019-2020 growing seasons, and 30-year means for the Jimmy Carter Plant Materials Center (Prism Climate Group, Oregon State University, 2020)

the corresponding seed tag and % PLS calculated for each lot (Table 1).

A seeding rate of 15 PLS pounds per acre was used as it is a common rate given in NRCS practice standards and other technical resources when planting crimson clover with a grain drill in pure stands (Clover, Crimson, 2018; Natural Resources Conservation Service, United States Department of Agriculture, 2015, 2020). Seeding rates equivalent to 75%, and 50% of the full PLS rate were also evaluated to determine any effect reduced rates might have on plant performance in the coated seed lot.

For each of the PLS seeding rate treatments, a bulk seeding rate was calculated using the given seed lot information then a seed per square foot value was calculated using the bulk rate and the seed per pound value determined previously. Two additional seeding rate treatments were used to make a direct comparison between coated and uncoated commercial seed lots. In these treatments, a seed per square foot value was determined by applying the seed per pound value in the uncoated seed lot to a bulk rate of 15 pounds per acre. This seed per square foot value was planted in both the uncoated and coated seed lots to compare how seed coating might affect plant performance when lots were planted at identical seed counts (Table 2).

Table 1. Seed germination, purity, % PLS, and seed count for ‘Dixie’ crimson clover seed lots planted in 2016, 2017, and 2019 at Jimmy Carter Plant Materials Center, Americus, GA.

Seed Coating	Germination	Purity	PLS ^a	Seed Count ^b
	————— % —————			seed/lb
	2016 and 2017 Seed Lots			
Coated	85	48	40.8	52 000
Uncoated	90	99.6	89.6	80 000
	2019 Seed Lots			
Coated	80	46	36.8	43 000
Uncoated	85	98	83.3	96 000

Note: Germination and Purity were given by seed company on seed tags, % PLS was calculated, Seed per pound was determined using a seed counter

^a PLS = Pure Live Seed

^b Rounded to nearest 1,000 seeds

Plot Establishment and Maintenance

Plots were planted on 25 October 2016, 3 November 2017, and 24 October 2019 using a Kincaid Plot Seed Drill (Kincaid Equipment, Haven KS) with 7.5-inch row spacing. Plots were 6 feet x 14 feet planted in a randomized, complete block design with four replications. Plots were moved to a new field location each year to avoid contamination by volunteer plants from previous year’s plantings. Soil fertility and soil pH were adjusted each year to a medium P and K soil test level and a pH at or above 6.0; however, no nitrogen fertilizer was added in any year. To offset rhizobia performance issues, seed for each plot was inoculated with True Clover rhizobia (*Rhizobium leguminosarum* biovar *trifolii*) prior to seeding to ensure equal inoculation in each year, regardless of seed lot or coating. Irrigation was applied with overhead sprinklers at a rate of 2 tenths of an inch immediately after planting each year to facilitate seed germination. No other irrigation was applied in any year. Plots were protected by fencing each year to control deer browsing of the desirable plant species.

Evaluation

Beginning 20 days after planting, plant height was measured and percent ground cover was visually estimated approximately every 10 days until biomass harvest. Plant height was determined by measuring the average height of 3 plants on the interior of the plot while percent ground cover was estimated using a visual rating scale of 1-10 where 1 = less than 10% ground cover and 10 = 100% ground cover. Biomass was harvested when 50% of the plants within the plot were blooming based on a visual estimate. Biomass samples were clipped by hand to the ground from the interior rows of the plot using a randomly placed 1.92 ft² harvesting frame to allow for the simple unit conversion to pounds per acre, as described by Pratt and Rasmussen (2001). The biomass sample was dried at 60° C until dry and dry biomass production was calculated on a per acre basis. Percent ground cover estimates were subjected to a Kruskal-Wallis one-way analysis of variance (ANOVA) procedure for the PLS seeding rate comparison and to a Wilcoxon Rank Sum test for the seed coating comparison. Plant height is reported as treatment means. Biomass data was analyzed using the ANOVA procedure for the PLS seeding rate comparison and a t-test for the seed coating comparison. All data analysis was performed using Statistix 10 (Analytical Software, Tallahassee, Florida).

Table 2. Seeding rates of various ‘Dixie’ crimson clover seed lots planted in 2016, 2017, and 2019 at Jimmy Carter Plant Materials Center, Americus, Georgia

	Bulk Seeding Rate		Seed Count	
Seeding Rate Treatments	2016/2017	2019	2016/2017	2019
	———— lb/A ————		—— seed/square foot ——	
PLS Seeding Rates ^a				
15	36.8	40.76	44	40
11.25	27.6	30.57	33	30
7.5	18.4	20.38	22	20
Seed Count Comparison				
Uncoated	15	15	28	33
Coated	--	--	28 ^b	33 ^b

^a Pure live seed seeding rates given in lb/A

^b Coated direct comparison seed counts were an identical seed count to those established for the uncoated direct comparison seed lot

RESULTS AND DISCUSSION

Median ground cover ratings for the three-year dataset did not increase above 10% until 50 days after planting, at any seeding rate treatment (data not shown). Ground cover continued to slowly increase until 140 days after planting (Table 3). There were no statistical differences ($p < .05$) in the distribution of median ground cover ratings at any evaluation period. Three-year mean plant height slowly increased throughout the season until approximately 110 days after planting, when the rate of change for plant height increased from 1-2 inches every 10 days to 3-4 inches every 10 days (Table 4). Increasing seeding rates from 50%, 75%, and 100% of the full PLS seeding rate did not provide quicker ground cover or faster plant growth. Likewise, the seed coating did not provide any plant performance advantages in terms of ground cover when compared to uncoated seed in this study.

The clover plots reached 50% bloom and were sampled for biomass production at 157, 154, and 158 days after planting in 2017, 2018, and 2020, respectively. In 2017 and 2020, clover biomass production averaged across seeding rates was 4450 lb/acre and 4192 lb/acre, respectively (Table 5). This aligns with other studies, which have reported similar biomass production from crimson clover in the region (Clark, 2012; Vann et al., 2018). In 2018, biomass production was substantially higher in every treatment, equaling 7562 lb/acre when averaged across seeding rates (Table 5). While biomass production from crimson clover has been reported to be as high as 7,800 lb/acre in Maryland (Clark, 2012, p. 131), more realistic biomass yields for the southeast have been reported to range between 2,000-5,500 lb/acre (Clark, 2012, pp.130-131; Clover, Crimson (*Trifolium Incarnatum*), 2018). In 2018, the clover plots were noted to have a substantial amount of plant lodging when the biomass samples were harvested. This lodging could have resulted in complications during the biomass harvest and resulted in higher biomass estimates across all treatments.

Table 3. Three-year median (Interquartile Range) ground cover rating for ‘Dixie’ crimson clover seeding rate treatments planted at the Jimmy Carter Plant Materials Center, Americus, GA

Treatment	Days After Planting									
	50	60	70	80	90	100	110	120	130	140
Ground Cover Rating ^a										
PLS Seeding Rate ^b										
15	1.5	1.0	2.0	1.5	4.0	4.0	6.0	7.0	8.0	9.5
	(1.0-2.0) ^c	(1.0-2.0)	(1.0-4.8)	(1.0-5.8)	(2.0-6.0)	(2.0-7.0)	(4.3-9.8)	(4.0-9.8)	(6.0-9.8)	(7.0-10.0)
11.25	2.0	2.0	2.5	3.0	3.5	5.0	6.5	8.0	9.0	10.0
	(1.0-2.0)	(1.0-2.0)	(2.0-3.0)	(1.0-4.0)	(2.0-5.0)	(4.3-5.8)	(4.3-8.0)	(7.0-8.8)	(8.0-9.0)	(9.0-10.0)
7.5	1.5	1.0	2.0	2.5	2.5	4.5	5.5	5.5	8.0	9.5
	(1.0-2.0)	(1.0-2.0)	(1.0-3.0)	(1.0-4.0)	(2.0-5.0)	(1.3-6.8)	(3.5-8.0)	(3.3-9.0)	(6.3-9.8)	(7.0-10.0)
Seed Coating Comparison										
Uncoated	2.0	2.0	3.0	3.0	4.0	6.0	7.5	9.0	9.0	9.5
	(1.0-2.0)	(1.0-2.8)	(2.0-4.8)	(2.0-5.8)	(3.0-6.0)	(4.0-7.8)	(4.3-9.0)	(6.0-10.0)	(7.3-10.0)	(7.3-10.0)
Coated	1.5	1.5	2.0	2.5	2.5	4.5	5.5	6.5	7.5	9.5
	(1.0-2.0)	(1.0-2.0)	(1.0-3.8)	(1.0-4.8)	(1.3-4.0)	(2.5-6.5)	(3.3-7.8)	(4.0-8.5)	(7.0-8.8)	(7.3-10.0)

^a Ground cover rating - 1-10 visual estimate where 1 = <10% ground cover and 10 = 100% ground cover

^b Pure Live Seeding Rates given in lb/A

^c Values in parenthesis are the Interquartile range presented as (Q1-Q3)

Table 4. Three year mean plant height for ‘Dixie’ crimson clover seeding rate treatments planted at the Jimmy Carter Plant Materials Center, Americus, GA.

Treatment	Days After Planting										
	40	50	60	70	80	90	100	110	120	130	140
Plant Height ^a											
PLS Seeding Rate ^b											
15	1.2	1.5	1.3	2	2.5	3.2	4.7	6.2	8.5	12.3	16.6
11.25	1.2	1.8	1.5	1.8	2.5	3.2	4.3	5.7	8.3	11.8	15.7
7.5	1.2	1.5	1.6	1.8	2.5	2.9	4.2	5.8	8.2	11.5	15.4
Seed Coating Comparison											
Uncoated	1.2	1.7	1.5	2.1	2.7	3.3	4.7	6.6	9	12.5	16.4
Coated	1.2	1.5	1.6	1.9	2.5	3.2	4.3	5.4	8.5	11.9	16.8
Mean	1.2	1.6	1.5	2	2.5	3.1	4.4	5.9	8.5	12	16.2
SD ^c	0.2	0.6	0.7	0.5	1.1	0.8	1	2	2.1	2.7	3.8

^a Treatment

^b Plant Height in inches

^c Standard deviation

Table 5. Biomass of ‘Dixie’ crimson clover seeding rate treatments harvested in 2017, 2018, and 2020 at the Jimmy Carter Plant Materials Center, Americus, GA

Treatment	Harvest Year		
	2017	2018	2020
lb/acre			
PLS Seeding Rate ^b			
15	5470	8175	4262
11.25	4270	7920	4456
7.5	3745	7920	4877
Mean	4495	8005	4532
SD ^b	1852	1238	1363
Seed Coating Comparison			
Uncoated	3970	7707	4190
Coated	4795	6086	3178
Mean	4383	6896	3683
SD	1147	1808	1411

^a Pure Live Seeding Rates given in lb/A

^b Standard deviation

There were no significant differences ($p < .05$) in biomass production between the treatments in the PLS seeding rate comparison or between treatments in the seed coating comparison (Table 5). It is important to understand however, that the proportioned PLS seeding rate plots used 18.4 lb/acre of bulk seed as the lowest seeding rate, while the seed coating comparison plots used a seeding rate equivalent to 15 lb/acre. Similar results of no significant difference in biomass have been reported in Texas at seeding rates above 16 lb/acre (Corriher, et al., 2010), and in North Carolina at seeding rates above 20 lb/acre (Vann et al., 2018). This suggests that all seeding rates evaluated in this study were above the seeding rate levels needed to observe maximum crimson clover biomass production. Corriher et al. (2010) did find significant differences in biomass production with lower seeding rates of 8 and 12 lb/acre and noted differences between coated and uncoated seed when yields were averaged across all seeding rates. While we did not observe plant performance differences in the direct comparison of coated and uncoated seed, it is possible that differences may have been observed if seeding rates were lower in this study.

CONCLUSION

Coated crimson clover seed will likely continue to be widely used by farmers, landowners, and conservationists who want to plant cool season, annual legumes due to its availability, cost-effectiveness, and ease of use. It is anticipated that coated seed lots will have lower seed purity due to the inert material that is associated with the seed coating process. When a lower seed purity value is used for the PLS calculations along with a 15 lb/acre PLS base seeding rate, as suggested in several NRCS practice standards, bulk seeding rates will exceed recommended seeding rates for crimson clover. If PLS seeding rates are specified in NRCS documents, it is vital that the author ensure that the seeding rate given is intended to be used with the PLS calculation. Combining the PLS calculation with a seeding rate that was not intended to be adjusted using PLS calculations will likely result in the recommendation of excessive seeding rates.

In this study, there was no increase in ground cover estimates or biomass production when seeding rates were adjusted using PLS calculations. This study suggests that the lower seeding rates were adequate for ground cover and biomass production. Additional studies are needed to determine if lower crimson clover seeding rates should be recommended and if adjusting seeding rates for crimson clover based on coated or uncoated seed is warranted across the area of adaptation for 'Dixie' crimson clover.

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