June 2020

FINAL STUDY REPORT
Jimmy Carter Plant Materials Center
Americus, Georgia

Evaluation of Cool-Season Cover Crops in the Southern Coastal Plain

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ABSTRACT

Cool season cover crops have the potential to assist agricultural producers in improving a wide range of soil physical and biological properties. The usage of cover crops for issues such as soil erosion, reduced soil health, decreased insect biodiversity, and weed infestations continues to increase each year. Substantial research has been conducted on the benefits of using cool season cover crops in cash crop rotations, but much less work has been completed on the local adaptation of cover crop species and cultivars in any given region. The objective of this study was to evaluate the growth characteristics of 60 commercially available cool season annual cover crop cultivars of 9 species on the Southern Coastal Plain Major Land Resource Area (MLRA). Austrian winter Pea (*Pisum sativum*), balansa clover (*Trifolium michelianum*), black oat (*Avena strigosa*), black seeded oat (*Avena sativa*), cereal rye (*Secale cereale*), crimson clover (*Trifolium incarnatum*), hairy vetch (*Vicia villosa*), oilseed radish (*Raphanus sativus*), and red clover (*Trifolium pratense*) were evaluated for field emergence, winter hardiness, plant height, days from planting to 50% bloom, and disease and insect resistance at the Jimmy Carter Plant Materials Center in Americus, Georgia during the 2016-2017 and 2017-2018 growing seasons. Most of the cover crop species evaluated were adapted to the region and the cultivars tested had enough variability among them to allow producers to tailor their cover crop planting decisions to their specific cash crop rotation. Oilseed radish reached bloom very early and did not winterkill, likely limiting it from being recommended before late planted cash crops such as cotton (*Gossypium hirsutum*) and peanut (*Arachis hypogaea*). Red clover did not reach bloom until much later than the other cover crops evaluated and would likely delay cash crop planting too late to be widely acceptable. Continued research is needed to evaluate additional plant species and commercially available varieties as well as developing up-to-date planting and management recommendations for the plant species evaluated in this project.

INTRODUCTION

Cover crop usage has been steadily increasing nationwide (CTIC, 2017) as a strategy to prevent soil erosion, reduce fertilizer inputs, improve soil health, suppress weeds, attract and harbor beneficial insects, and conserve energy (Clark, 2007; Reicosky & Forcella, 1998). Widespread research has been conducted outlining the benefits cool-season cover crops provide, but locally specific information regarding cover crop selection is still lacking for many regions. Agricultural producers and conservation planners are faced with choosing from many cover crop options, often without knowing the expected growth and performance of those options. To maximize the benefits realized from cover crops, producers need to plant the best adapted cultivar(s) for their location. The purpose of this study was to evaluate the growth characteristics of commercially available cool season annual cover crop cultivars to determine their adaptation for cover cropping in the Southern Coastal Plain Major Land Resource Area (MLRA) of the southeastern U.S.

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MATERIALS AND METHODS

The study was conducted during two growing seasons at the USDA Natural Resources Conservation Service (NRCS) Jimmy Carter Plant Materials Center (PMC), Americus, Georgia from 2016-2018. The Jimmy Carter PMC is located on and represents the Southern Coastal Plain MLRA of the southeastern U.S. The 30-year (1981-2010) mean monthly maximum temperature during the growing season for this study ranges from 84.6^0 F to 58.5^0 F and the 30 year (1981-2010) mean monthly minimum temperature ranges from 59.7^{0}F to 38.3^0 F. The 30 year (1981-2010) mean precipitation during the growing season is 31.5 inches and includes both the month with the lowest mean monthly precipitation of the year, October, and the month with the highest mean monthly precipitation of the year, March (PRISM Climate Group, Oregon State University, 2020). During the study, mean monthly temperatures were mostly above normal during the 2016-2017 growing season and ranged from below normal to above normal during the 2017-2018 growing season. The 2016-2017 growing season saw a total of 30.9 inches of precipitation but did not receive any rainfall during October or November of 2016. The 2017-2018 growing season received 26.8 inches of precipitation but had measurable rainfall in every month of the growing season (Figure 1).

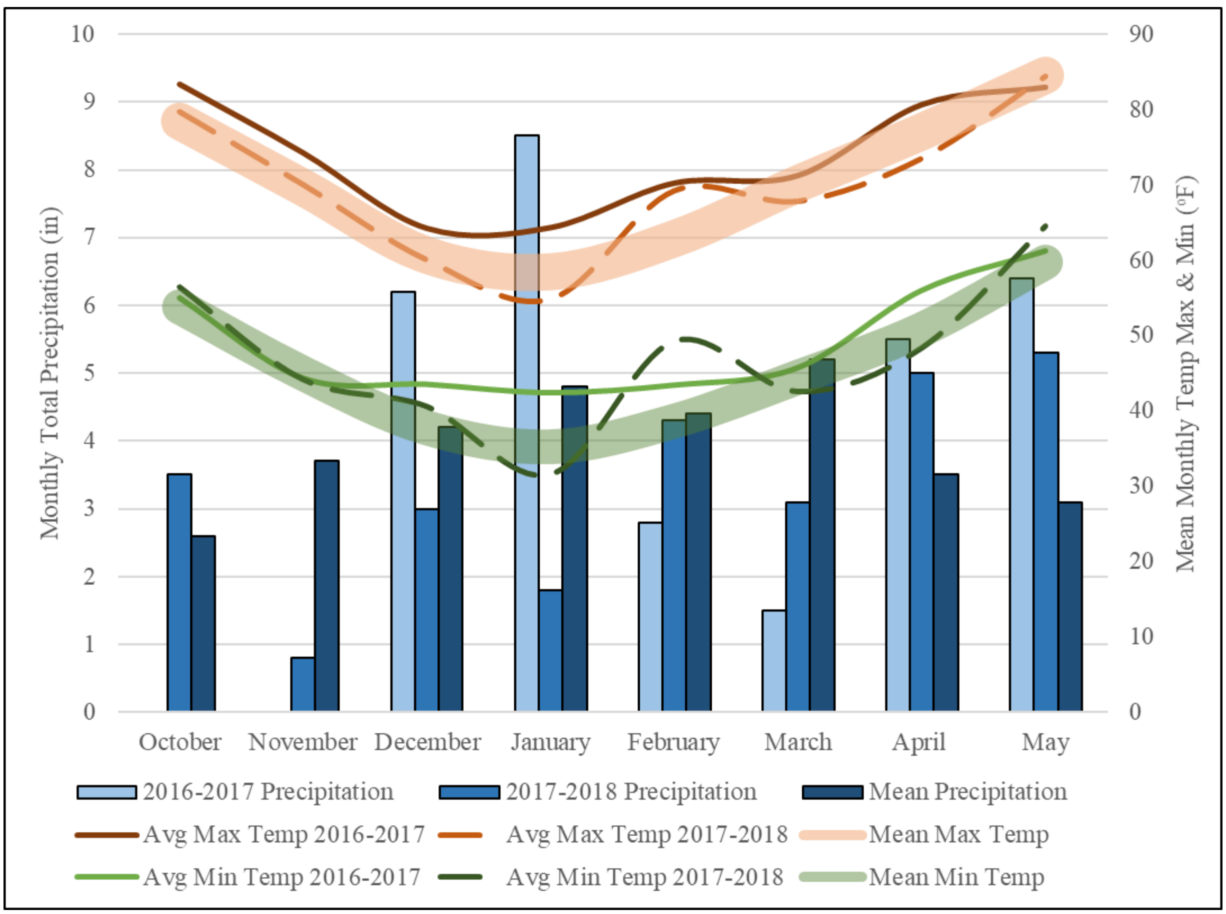

Figure 1. Monthly minimum temperatures, monthly maximum temperatures, and monthly precipitation amounts for the 2016-2017 and 2017-2018 growing seasons and 30-year means (PRISM Climate Group, Oregon State University, 2020)

Commercially available, annual cool season cover crop cultivars were planted on 13 October 2016 and 3 November 2017 on a pure live seed basis following current seeding rate recommendations from NRCS (Table 1). Plots were planted using a Kincaid Plot Seed Drill (Kincaid Equipment, Haven KS) with 7.5-inch row spacing on a Red Bay Sandy Loam (fine-loamy, kaolinitic, thermic Rhodic Kandiudult) soil (USDA Natural Resources Conservation Service Web Soil Survey, 2020). Plots size was 6 feet x 12 feet. Plots were moved to a new field location each year to avoid contamination by volunteer plants from hard seed planted in previous years. Identical seed lots for each entry were used in both years.

Table 1. Common name, species, cultivar, and seeding rate of annual, cool season cover crops planted in 2016 and 2017 at the USDA NRCS Jimmy Carter Plant Materials Center, Americus, Georgia

Common Name	Species	Cultivar	PLS lb/acre	% PLS	Seeding Rate lb/acre
Austrian winter pea	*Pisum sativum*	Arvica 4010	70	94	75
Austrian winter pea	*Pisum sativum*	Dunn	70	85	83
Austrian winter pea	*Pisum sativum*	Frostmaster	70	85	83
Austrian winter pea	*Pisum sativum*	Lynx	70	98	71
Austrian winter pea	*Pisum sativum*	Maxum	70	91	77
Austrian winter pea	*Pisum sativum*	Survivor 15	70	96	73
Austrian winter pea	*Pisum sativum*	Whistler	70	90	78
Austrian winter pea	*Pisum sativum*	Windham	70	80	88
Balansa clover	*Trifolium michelianum*	Fixation	5	42	12
Balansa clover	*Trifolium michelianum*	Frontier	5	57	9
Black seeded oat	*Avena sativa*	Cosaque	60	83	72
Black oat	*Avena strigosa*	Soil Saver	60	98	61
Cereal Rye	*Secale cereale*	Aroostook	100	90	111
Cereal Rye	*Secale cereale*	Bates	100	78	128
Cereal Rye	*Secale cereale*	Brasetto	100	92	109
Cereal Rye	*Secale cereale*	Elbon	100	80	126
Cereal Rye	*Secale cereale*	FL 401	100	90	111
Cereal Rye	*Secale cereale*	Guardian	100	93	108
Cereal Rye	*Secale cereale*	Hazlet	100	84	119
Cereal Rye	*Secale cereale*	Maton	100	89	113
Cereal Rye	*Secale cereale*	Maton II	100	88	114
Cereal Rye	*Secale cereale*	Merced	100	84	119
Cereal Rye	*Secale cereale*	Oklon	100	80	126
Cereal Rye	*Secale cereale*	Prima	100	83	120
Cereal Rye	*Secale cereale*	Rymin	100	82	122
Cereal Rye	*Secale cereale*	Wheeler	100	95	105
Cereal Rye	*Secale cereale*	Wintergrazer 70	100	78	128
Cereal Rye	*Secale cereale*	Wrens Abruzzi	100	82	122

Table 1 (cont.). Common name, species, cultivar, and seeding rate of annual, cool season cover crops planted in 2016 and 2017 at the USDA NRCS Jimmy Carter Plant Materials Center, Americus, Georgia

Common Name	Species	Cultivar	PLS lb/acre	% PLS	Seeding Rate lb/acre
Crimson clover	*Trifolium incarnatum*	AU Robin	18	56	32
Crimson clover	*Trifolium incarnatum*	AU Sunrise	18	42	43
Crimson clover	*Trifolium incarnatum*	AU Sunup	18	91	20
Crimson clover	*Trifolium incarnatum*	Cantea	18	60	30
Crimson clover	*Trifolium incarnatum*	Dixie	18	84	21
Crimson clover	*Trifolium incarnatum*	Kentucky Pride	18	98	18
Hairy vetch	*Vicia villosa*	CCS Groff	18	90	20
Woollypod vetch	*Vicia villosa subsp. varia*	Lana	18	90	20
Hairy vetch	*Vicia villosa*	Purple Bounty	18	78	23
Hairy vetch	*Vicia villosa*	Purple Prosperity	18	91	20
Hairy vetch	*Vicia villosa*	TNT	18	90	20
Hairy vetch	*Vicia villosa*	Villana	18	89	20
Oilseed radish	*Raphanus sativus*	Big Dog	9	93	10
Oilseed radish	*Raphanus sativus*	Concorde	9	88	10
Oilseed radish	*Raphanus sativus*	Control	9	88	10
Oilseed radish	*Raphanus sativus*	Defender	9	97	9
Oilseed radish	*Raphanus sativus*	Driller	9	97	9
Oilseed radish	*Raphanus sativus*	Eco-till	9	88	10
Oilseed radish	*Raphanus sativus*	Graza	9	93	10
Oilseed radish	*Raphanus sativus*	Groundhog	9	85	11
Oilseed radish	*Raphanus sativus*	Lunch	9	93	10
Oilseed radish	*Raphanus sativus*	Nitro	9	98	9
Oilseed radish	*Raphanus sativus*	Sodbuster Blend	9	94	10
Oilseed radish	*Raphanus sativus*	Tillage	9	90	10
Red Clover	*Trifolium pratense*	Cinnamon Plus	9	61	15
Red Clover	*Trifolium pratense*	Cyclone II	9	49	18
Red Clover	*Trifolium pratense*	Dynamite	9	55	16
Red Clover	*Trifolium pratense*	Freedom	9	61	15
Red Clover	*Trifolium pratense*	Kenland	9	81	11
Red Clover	*Trifolium pratense*	Mammoth	9	87	10
Red Clover	*Trifolium pratense*	Starfire	9	48	19
Red Clover	*Trifolium pratense*	Wildcat	9	87	10

Soil pH and soil fertility were adjusted in each year following soil test recommendations to maintain a soil pH of 6.0 to 6.5 and a medium level of soil phosphorus and potassium. Legumes were inoculated with appropriate rhizobia prior to seeding. Supplemental irrigation was applied by water tank in 2016 and by overhead sprinkler irrigation in 2017, to facilitate seed germination. No other supplemental irrigation was applied in either year. Plots were protected by woven wire fence in the 2017-2018 growing season to prevent deer browse damage.

Approximately every seven days for the first four weeks after planting, field emergence was estimated for each plot using the following visual rating scale: 0 = poor (<25% germination), 1 = moderate (25-64% germination), 2 = good (65-85% germination), 3 = excellent (>85% germination). Entries were evaluated for disease and insect damage twice during each growing season, once at approximately 28 days after planting and again at 50% bloom (varied by entry) using a 1-5 rating scale where 1=no damage and 5=severe damage. Percent Winter Hardiness was determined by comparing the number of plants present in the exact same 3 feet of row for each plot at approximately 28 days after planting and again in the spring once the plots had reached a stage of rapid growth. This method gave faulty results in the 2016-2017 growing season as additional plants often emerged in the evaluated length of row after the first plant counts were taken, when soil moisture conditions improved. As a result, the percent winter hardiness ratings in the 2016-2017 growing season were often severely inflated and therefore are not reported here. Bloom period was monitored by recording the date that 50% of the plants in each plot were blooming. Plant height was determined by measuring average plant height of plants on the interior of each plot to the nearest inch.

The experimental design was a randomized, complete block with 4 replications in the 2016-2017 growing season and 3 replications in the 2017-2018 growing season. To determine variation among cultivars within a species, a mean and standard deviation was reported for field emergence, % winter hardiness, plant height, and days after planting (DAP) to 50% bloom using Statistix 10 (Analytical Software, 2013)

RESULTS AND DISCUSSION

Austrian Winter Pea

In 2016, Austrian winter pea showed poor emergence at 7 days after planting but saw improved field emergence by 14 days after planting. This is likely due to the small, irregular irrigation amounts that were applied using the water tank application method employed in 2016. In 2017, Austrian winter pea showed moderate to good emergence by 7 days after planting and field emergence again improved at 14 days after planting. In both years, field emergence did not improve after 14 days after planting. (Table 2).

Table 2. Field emergence of Austrian winter pea cultivars planted in 2016 and 2017 at the Jimmy Carter Plant Materials Center, Americus, Georgia

	7 DAP[a]		14 DAP		21 DAP		28 DAP	
	2016	2017	2016	2017	2016	2017	2016	2017
Arvica 4010	0.0	2.0	2.5	2.3	2.0	2.0	2.0	2.0
Dunn	0.0	2.7	2.0	2.7	2.0	2.0	1.8	2.0
Frostmaster	0.0	2.0	2.0	2.3	2.0	2.0	2.0	2.0
Lynx	0.0	1.7	2.3	2.3	2.3	2.0	2.0	2.3
Maxum	0.0	2.0	1.5	2.0	1.3	2.0	1.3	2.0
Survivor 15	0.0	2.0	2.3	2.7	2.0	2.0	2.0	2.0
Whistler	0.0	1.7	1.8	2.0	1.8	2.0	1.8	2.0
Windham	0.0	2.0	1.8	2.7	2.0	2.0	2.0	2.0
Mean	0.0	2.0	2.0	2.4	1.9	2.0	1.8	2.0
SD[b]	--	0.4	0.7	0.5	0.4	--	0.5	0.2

Note: Germination and emergence ratings were based on a 0-3 scale where 0 = poor (< 25% germination), 1 = moderate (25-64%), 2 = good (65-85%), 3 = excellent (>85%)

[a] Days after Planting

[b] Standard deviation

Plant height and bloom period data were not collected on Austrian winter pea in the 2016-2017 growing season due to heavy deer browse damage to the plots during the growing season. In the 2017-2018 growing season, variation among cultivars was observed for winter hardiness, plant height, and bloom period. A substantial decrease in percent winter hardiness was observed in 'Dunn' and 'Maxum' cultivars when compared to the others in 2018. The winter pea cultivars separated into 3 different groups regarding bloom period with the earliest group reaching 50% bloom at 122 days after planting, the middle group reaching 50% bloom at 167 days after planting, and the late group reaching 50% bloom at 185-189 days after planting. Plant height was variable among the cultivars and which was expected as a large variability in the growth form and habit was observed among the selected Austrian winter pea cultivars. (Table 3).

Table 3. Winter hardiness, plant height, and bloom period of Austrian winter pea cultivars planted in 2016 and 2017 at the Jimmy Carter Plant Materials Center, Americus, Georgia

	% Winter Hardiness	Plant Height (in)		DAP to 50% Bloom[a]	
	2018	2017[b]	2018	2017[b]	2018
Arvica 4010	92	--	21.3	--	122
Dunn	55	--	16.7	--	122
Frostmaster	90	--	21.7	--	185
Lynx	96	--	12.0	--	167
Maxum	77	--	22.0	--	122
Survivor 15	90	--	20.3	--	189
Whistler	94	--	20.0	--	167
Windham	100	--	17.7	--	167
Mean	87	--	19.0	--	155
SD[c]	18	--	3.4	--	27

[a] Days after Planting to 50% of the plants in a plot blooming based on a visual estimate
[b] 2017 Plots were not able to be rated due to heavy deer browse damage
[c] Standard deviation

Disease and Insect ratings were very low early during the growing season across all winter pea cultivars. In 2018, late season disease ratings were more variable with 'Frostmaster' and 'Survivor 15' exhibiting the highest disease ratings. These two cultivars were also the latest maturing winter peas in the study, so it is unclear if they are more susceptible to disease or were just the only winter pea cultivars present in the field when environmental conditions were favorable for disease development. The late maturing cultivars also saw slightly higher insect ratings during the late season rating though all insect ratings were low and likely irrelevant in 2018 (Table 4).

Balansa Clover

In 2016, the balansa clover cultivars had poor field emergence ratings throughout the first 28 days of the growing season. In 2017, both balansa clover cultivars showed poor field emergence at 7 days after planting. At 14 days after planting, 'Fixation' exhibited moderate field emergence while 'Frontier' still showed poor field emergence. Neither cultivar's field emergence rating improved beyond 14 days after planting (Table 5). In 2017, small areas of balansa clover in each plot were observed to have much better field emergence. These small areas of better field emergence appeared to be associated with more compact soil conditions allowing for a slightly shallower planting depth by the grain drill. Poorer plant establishments of balansa clover have been reported when drilled into a cultivated seedbed than when surface sown suggesting that seeding depth is critical when planting balansa clover (Lattimore et.al, 1994). It is possible that the poor field emergence ratings observed for balansa

Table 4. Disease and insect ratings of Austrian winter pea cultivars planted in 2016 and 2017 at the Jimmy Carter Plant Materials Center, Americus, Georgia

	Early Disease		Late Disease		Early Insect		Late Insect	
	2016	2017	2017[a]	2018	2016	2017	2017[a]	2018
Arvica 4010	0.0	0.0	--	1.0	0.0	0.0	--	0.7
Dunn	0.0	0.0	--	1.0	0.0	0.0	--	0.7
Frostmaster	0.0	0.0	--	2.7	0.0	0.0	--	1.0
Lynx	0.0	0.0	--	1.0	0.0	0.0	--	0.7
Maxum	0.0	0.0	--	1.0	0.0	0.0	--	0.7
Survivor 15	0.0	0.0	--	3.0	0.0	0.0	--	1.0
Whistler	0.0	0.0	--	1.7	0.0	0.0	--	0.7
Windham	0.0	0.0	--	1.3	0.0	0.0	--	0.7
Mean	0.0	0.0	--	1.6	0.0	0.0	--	0.8
SD[b]	--	--	--	0.9	--	--	--	0.4

Note: Disease and insect damage ratings were based on 0-5 scale where 0=no damage and 5=dead plants. Each plot was rated early, 28 days after planting, in the growing season and late in the growing season, at 50% bloom.
[a] Plots could not receive a late rating in 2017 due to heavy deer browse damage
[b] Standard deviation

Table 5. Field emergence ratings of balansa clover planted in 2016 and 2017 at the Jimmy Carter Plant Materials Center, Americus, Georgia

	7 DAP[a]		14 DAP		21 DAP		28 DAP	
	2016	2017	2016	2017	2016	2017	2016	2017
Fixation	0.0	0.0	0.0	1.0	0.0	1.0	0.0	1.0
Frontier	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mean	0.0	0.0	0.0	0.5	0.0	0.5	0.0	0.5
SD[b]	--	--	--	0.6	--	0.6	--	0.6

Note: Germination and emergence ratings were based on a 0-3 scale where 0 = poor (< 25% germination), 1 = moderate (25-64%), 2 = good (65-85%), 3 = excellent (>85%)
[a] Days after Planting
[b] Standard deviation

clover was a result of planting method rather than cultivar performance in the study.

The balansa clover cultivars were not rated for plant height, bloom period, or disease and insect damage in the 2016-2017 growing season due to deer browse damage. In the 2017-2018 growing season, both cultivars exhibited high winter hardiness with little variation between cultivars. Plant height was variable between cultivars with ‘Fixation’ growing nearly 20 inches taller than ‘Frontier’ in 2018. Bloom Period was also variable in 2018 with ‘Frontier’ blooming 21 days earlier than ‘Fixation’ (Table 6). Both cultivars exhibited a bloom period that is comparable to other commonly used legume species in the study. Disease and Insect ratings were low and irrelevant for both cultivars during the early and late rating (data not shown).

Table 6. Winter hardiness, plant height, and bloom period for balansa clover cultivars planted in 2016 and 2017 at the Jimmy Carter Plant Materials Center, Americus, Georgia

	% Winter Hardiness	Plant Height (in)		DAP to 50% Bloom[a]	
	2018	2017[b]	2018	2017[b]	2018
Fixation	97	--	20.7	--	161
Frontier	100	--	5.8	--	140
Mean	98	--	13.3	--	150.5
SD[c]	4.5	--	8.2	--	11.5

[a] Days after Planting to 50% of the plants in a plot blooming based on a visual estimate
[b] 2017 Plots were not able to be rated due to poor emergence and heavy deer browse damage
[c] Standard deviation

Oats

One cultivar from each of two species of oats were included in this study. 'Cosaque' is a black-seeded common oat (*Avena sativa*), while 'Soil Saver' is a black oat (*Avena strigosa*). While both are from the oat family, their performance in the plant characteristics evaluated in this study were considerably different. Overall, field emergence ratings in 2016 were lower and more variable than in 2017 as a result of the drought conditions experienced during and immediately after planting in 2016. In both years, field emergence ratings were maximized at 14 days after planting. Both cultivars exhibited moderate to good field emergence despite the dry planting conditions of 2016 and good to excellent field emergence when good soil moisture was present, as in 2017 (Table 7).

Table 7. Field emergence of oat cultivars planted in 2016 and 2017 at the Jimmy Carter Plant Materials Center, Americus, Georgia

	7 DAP[a]		14 DAP		21 DAP		28 DAP	
	2016	2017	2016	2017	2016	2017	2016	2017
Cosaque	0.5	2.3	1.5	3.0	1.8	2.0	2.0	2.3
Soil Saver	0.8	2.7	1.8	3.0	1.8	3.0	1.8	3.0
Mean	0.6	2.5	1.6	3.0	1.8	2.5	1.9	2.7
SD[b]	0.9	0.6	1.2	--	1.0	0.6	1.0	0.5

Note: Germination and emergence ratings were based on a 0-3 scale where 0 = poor (< 25% germination), 1 = moderate (25-64%), 2 = good (65-85%), 3 = excellent (>85%)
[a] Days after Planting
[b] Standard deviation

Winter Hardiness for the oat cultivars in 2018 was excellent, however temperatures were typically mild throughout the growing season (Fig. 1). (Clark, 2007) reported black oat as being "adapted to the lower Coastal Plain of the USA", but that it "winterkilled one year of six at some locations" within this region. This would suggest that although not observed in this study, 'Soil Saver' could suffer from winter kill during years with colder winter temperatures in the Southern Coastal Plain MLRA. Plant height varied slightly between cultivars with 'Soil Saver' growing taller in both years of the study. Mean days after planting to reach 50% bloom for both cultivars were very different between two years due to delayed emergence in 2016 from drought conditions. Emergence was timely in 2017 and the days after planting to 50% bloom should be more indicative of what to expect from each cultivar. 'Soil Saver' bloomed 15 days earlier than 'Cosaque' in the 2017-2018 growing season (Table 8).

Table 8. Winter hardiness, plant height, and bloom period of oat cultivars planted in 2016 and 2017 at the Jimmy Carter Plant Materials Center, Americus, Georgia

	% Winter Hardiness	Plant Height (in)		DAP to 50% Bloom[a]	
	2018	2017	2018	2017	2018
Cosaque	100	29.5	48	195	175
Soil Saver	98.5	35.8	52	189	160
Mean	99.2	32.6	50.0	192	167.5
SD[b]	1.8	4.9	2.6	3.3	8.2

[a] Days after Planting to 50% of the plants in a plot blooming based on a visual estimate
[b] Standard deviation

Insect ratings were low and irrelevant in both years, regardless of cultivar. Early disease ratings were also very low in both years in both cultivars. Late disease ratings were variable by cultivar with 'Cosaque' having higher ratings than 'Soil Saver' in each year (Table 9). Late disease ratings were higher as a result of rust (*Puccinia* sp.) infections developing in both years. Variability observed among the two cultivars in regard to rust diseases is supported by other published sources as well. (Dubeux et al., 2016) reported increased leaf rust incidence on 'Cosaque' in 2015 in the Florida panhandle. This contrasts with 'Soil Saver' which was included in the authors' research but received no mention of leaf rust infection. (Clark 2007) also reported black oats to be "very resistant to rusts."

Table 9. Disease and insect ratings for oat cultivars planted in 2016 and 2017 at the Jimmy Carter Plant Materials Center, Americus, Georgia

	Early Disease		Late Disease		Early Insect		Late Insect	
	2016	2017	2017	2018	2016	2017	2017	2018
Cosaque	0.0	0.0	4.0	3.0	0.0	0.0	0.0	0.0
Soil Saver	0.0	0.0	1.8	1.0	0.0	0.0	0.0	0.0
Mean	0.0	0.0	2.9	2.0	0.0	0.0	0.0	0.0
SD[a]	--	--	1.3	1.1	--	--	--	--

Note: Disease and insect damage ratings were based on 0-5 scale where 0=no damage and 5=dead plants. Each plot was rated early, 28 days after planting, in the growing season and late in the growing season, at termination.
[a] Standard deviation

Cereal Rye

In the 2016-2017 growing season, cereal rye cultivars exhibited moderate to good field emergence ratings that continued to improve throughout the 28 days after planting rating. During the 2017-2018 growing season, field emergence ratings were maximized at the 14 days after planting rating. This difference was most likely a result of the low soil moisture conditions that were present during the first growing season. (Clark, 2007) reported that rye will germinate in "fairly dry soil" which is supported here as rye exhibited the best field emergence ratings in the study in the 2016-2017 growing season. Most cultivars saw equal or better ratings in the second growing season when soil moisture was adequate for seed germination. 'Brasetto', 'Hazlet', and 'Wheeler', had the worst field emergence ratings in the first growing season while 'Brasetto', 'Guardian', and 'Prima' had the worst field emergence in the second growing season (Table 10).

Winter hardiness ratings were generally very high among the cereal rye cultivars. This was expected as cereal rye is thought to be the "hardiest of the cereals" (Clark, 2007). Three cultivars, 'Guardian', 'Maton', and 'Merced', did exhibit winter hardiness ratings below 90%, however. Plant height was

Table 10. Field emergence ratings of cereal rye cultivars planted in 2016 and 2017 at the Jimmy Carter Plant Materials Center, Americus, Georgia

	7 DAP[a]		14 DAP		21 DAP		28 DAP	
	2016	2017	2016	2017	2016	2017	2016	2017
Aroostook	3.0	2.3	2.5	2.7	2.8	2.3	2.8	2.3
Bates	1.8	2.3	2.0	2.7	2.0	2.3	2.3	2.3
Brasetto	2.3	1.7	1.8	2.0	1.8	2.0	2.3	2.0
Elbon	2.5	2.3	2.3	3.0	2.3	2.7	2.8	2.7
FL 401	2.3	3.0	2.3	3.0	2.3	3.0	2.8	3.0
Guardian	2.0	0.7	2.3	1.0	2.0	1.0	2.0	1.0
Hazlet	1.8	2.7	1.8	3.0	1.8	2.7	1.8	2.3
Maton	1.8	2.7	2.0	3.0	2.0	2.7	2.0	2.7
Maton II	2.5	2.0	2.3	2.3	2.3	2.0	2.3	2.3
Merced	2.5	2.3	2.5	2.7	2.0	2.3	2.0	2.3
Oklon	2.0	2.0	2.0	2.7	2.3	2.3	2.3	2.3
Prima	1.5	1.7	2.0	2.0	2.0	1.3	2.5	1.3
Rymin	2.3	2.0	2.3	2.7	2.3	2.0	2.3	2.0
Wheeler	2.0	2.3	1.5	3.0	2.0	2.7	1.8	2.7
Wintergrazer 70	2.3	3.0	2.0	3.0	2.5	3.0	2.5	3.0
Wrens Abruzzi	2.0	2.0	2.3	2.7	2.3	2.3	2.5	2.7
Mean	2.1	2.2	2.1	2.6	2.2	2.3	2.4	2.3
SD[b]	1.1	0.7	0.8	0.6	0.8	0.7	0.7	0.7

Note: Germination and emergence ratings were based on a 0-3 scale where 0 = poor (< 25% germination), 1 = moderate (25-64%), 2 = good (65-85%), 3 = excellent (>85%)
[a] Days after Planting
[b] Standard deviation

variable by cultivar and all cultivars were taller in 2018 than in 2017. This was most likely a result of the deer browse damage that all cultivars endured during the 2016-2017 growing season. The two growing seasons exhibited a difference of 25 days in mean days to 50% bloom, further proving that growth among the cultivars was severely affected in the 2016-2017 growing season due to delayed emergence and deer feeding damage (Table 11). In the 2017-2018 growing season, the cultivars were subjected to more favorable growing conditions and the bloom period data for that year contains encouraging results regarding cultivar selection. ‘Wrens Abruzzi’ is one of the most recommended and popular cultivars of cereal rye used in Georgia due to seed availability and low seed cost (Cover Crop Information Sheet-Cereal Rye; Statewide Variety Testing-Rye), however its maturity does not fit every cropping system and seed can become scarce in some seasons. Bloom period data may suggest there are several rye cultivars available that can either fit into different cropping windows due to substantially different bloom timing or serve as a direct replacement as they have a similar bloom timing as ‘Wrens Abruzzi’.

Both insect ratings and early disease ratings were low and irrelevant for all cereal rye cultivars in both years. Late season disease ratings were elevated for the later blooming cultivars in 2017 as a result of rust infection beginning later in the growing season. The late onset of the rust fungus allowed all but the latest blooming cultivars to reach 50% bloom before rust established in the plots. Since disease ratings were not taken after 50% bloom, it is unclear if the elevated ratings in the late blooming cultivars in 2017 is a result of cultivar susceptibility to the disease or a result of when ratings were collected for each cultivar. In 2018, rust again elevated disease ratings. Late disease ratings were more mixed, but lower overall with ratings low to moderate and likely not high enough to greatly affect plant growth. ‘Wrens Abruzzi’,

Table 11. Winter hardiness, plant height, and bloom period for cereal rye cultivars planted in 2016 and 2017 at the Jimmy Carter Plant Materials Center, Americus, Georgia

	% Winter Hardiness	Plant Height (in)[a]		DAP to 50% Bloom[b]	
	2018	2017	2018	2017	2018
Aroostook	100	46.8	52.7	183	167
Bates	94.8	50.0	58.0	182	147
Brasetto	100	21.8	36.3	202	182
Elbon	100	48.5	54.0	183	160
FL 401	95.3	48.8	54.0	178	126
Guardian	87.7	32.0	39.3	197	178
Hazlet	94.3	26.0	42.0	197	175
Maton	85.9	49.0	57.7	180	160
Maton II	100	48.0	59.7	180	160
Merced	79.9	44.5	44.3	175	126
Oklon	97.8	48.8	58.3	181	160
Prima	100	30.8	45.0	198	178
Rymin	100	32.8	41.3	197	178
Wheeler	100	37.8	51.7	197	178
Wintergrazer 70	99.0	48.0	53.3	180	153
Wrens Abruzzi	100	51.5	58	181	153
Mean	95.9	41.5	50.4	186.7	161.3
SD[c]	8.7	10.0	8.0	8.9	17.2

[a] Average plant height in a plot at 50% bloom
[b] Days after Planting to 50% of the plants in a plot blooming based on a visual estimate
[c] Standard deviation

'Bates', 'FL401', and 'Wintergrazer 70' were the only cultivars to exhibit late disease ratings of below 2.0 in both years (Table 12).

Crimson Clover

Crimson clover cultivars exhibited mixed field emergence ratings throughout the study. In the drought conditions of 2016, emergence was poor to moderate for all cultivars. In 2017, 'Cantea' and 'AU Sunup' had the lowest field emergence ratings at 7 days after planting and they continued to stay in the moderate rating throughout the 28 days after planting rating. 'AU Sunrise' and 'Dixie' had the highest ratings at 7 days after planting and those two cultivars continued to exhibit the highest field emergence ratings observed among the crimson clover cultivars in 2017. Overall, mean field emergence ratings for all crimson clover cultivars was maximized at 14 days after planting (Table 13).

Winter hardiness was excellent among all cultivars in the 2017-2018 growing season with all cultivars showing very little to no reduction in plant counts during the winter months. Plant height was reasonably uniform among the cultivars except for 'AU Sunup' which was over 5 inches shorter than the mean plant height for all cultivars in 2018. Bloom period was variable by cultivar with 'AU Sunup' blooming first, followed by 'AU Sunrise' and 'AU Robin' (Table 14). The relative blooming order of the cultivars were similar to reports in multiple literature sources (Cover Crop Information Sheet- Crimson Clover; Clark, 2007), but the number of days between cultivars was less in this study than what has been reported by

Table 12. Disease and insect ratings for rye cultivars planted in 2016 and 2017 at the Jimmy Carter Plant Materials Center, Americus, Georgia

	Early Disease		Late Disease		Early Insect		Late Insect	
	2016	2017	2017	2018	2016	2017	2017	2018
Aroostook	0.0	0.0	1.3	2.0	0.0	0.0	0.0	0.0
Bates	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
Brasetto	0.0	0.0	3.8	2.3	0.0	0.0	0.0	0.0
Elbon	0.0	0.0	1.0	2.3	0.0	0.0	0.0	0.0
FL 401	0.0	0.0	1.0	1.7	0.0	0.0	0.0	0.0
Guardian	0.0	0.0	3.8	2.0	0.0	0.0	0.0	0.0
Hazlet	0.0	0.0	4.0	2.0	0.0	0.0	0.0	0.0
Maton	0.0	0.0	1.0	2.7	0.0	0.0	0.0	0.0
Maton II	0.0	0.0	1.0	2.3	0.0	0.0	0.0	0.0
Merced	0.0	0.0	1.3	2.0	0.0	0.0	0.0	0.0
Oklon	0.0	0.0	1.0	2.3	0.0	0.0	0.0	0.0
Prima	0.0	0.0	4.0	2.0	0.0	0.0	0.0	0.0
Rymin	0.0	0.0	4.0	2.0	0.0	0.0	0.0	0.0
Wheeler	0.0	0.0	3.3	2.0	0.0	0.0	0.0	0.0
Wintergrazer 70	0.0	0.0	1.0	1.3	0.0	0.0	0.0	0.0
Wrens Abruzzi	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
Mean	0.0	0.0	2.1	1.9	0.0	0.0	0.0	0.0
SD[a]	--	--	1.4	0.6	--	--	--	--

Note: Disease and insect damage ratings were based on 0-5 scale where 0=no damage and 5=dead plants. Each plot was rated early, 28 days after planting, in the growing season and late in the growing season, at 50% bloom.
[a] Standard deviation

Table 13. Field emergence of crimson clover cultivars planted in 2016 and 2017 at the Jimmy Carter Plant Materials Center, Americus, Georgia

	7 DAP[a]		14 DAP		21 DAP		28 DAP	
	2016	2017	2016	2017	2016	2017	2016	2017
AU Robin	0.0	1.7	0.5	1.7	0.5	1.3	0.5	1.3
AU Sunrise	0.8	2.3	1.8	2.3	1.5	2.0	1.3	2.3
AU Sunup	0.0	0.7	0.0	1.0	0.0	1.0	0.0	1.0
Cantea	0.3	0.7	1.8	1.3	1.8	1.3	1.0	1.3
Dixie	0.3	2.0	1.0	2.7	0.5	2.0	0.3	2.3
Kentucky Pride	0.5	1.7	1.5	2.0	1.3	1.7	1.5	1.7
Mean	0.3	1.5	1.1	1.8	0.9	1.6	0.6	1.7
SD[b]	0.5	0.8	0.3	0.7	0.9	0.5	0.8	0.7

Note: Germination and emergence ratings were based on a 0-3 scale where 0 = poor (< 25% germination), 1 = moderate (25-64%), 2 = good (65-85%), 3 = excellent (>85%)
[a] Days after Planting
[b] Standard deviation

Table 14. Winter hardiness, plant height, and bloom period for crimson clover cultivars planted in 2016 and 2017 at the Jimmy Carter Plant Materials Center, Americus, Georgia

	% Winter Hardiness	Plant Height (in)		DAP to 50% Bloom[a]	
	2018	2017[b]	2018	2017[b]	2018
AU Robin	99	--	22.3	--	151
AU Sunrise	100	--	19.7	--	144
AU Sunup	100	--	14.3	--	140
Cantea	100	--	21	--	154
Dixie	100	--	21	--	154
Kentucky Pride	100	--	18.7	--	167
Mean	99	--	19.5	--	152
SD[c]	0.8	--	3	--	9

[a] Days after Planting to 50% of the plants in a plot blooming based on a visual estimate
[b] 2017 Plots were not able to be rated due to heavy deer browse damage
[c] Standard deviation

others. This could be a result of planting the cultivars at the end of the recommended planting window or a result of the environmental conditions that the cultivars endured during the growing season. Disease and Insect ratings were very low and irrelevant regardless of rating timing or cultivar (data not shown).

Vetch

(Clark, 2007) reported that "dry conditions often reduce germination of hairy vetch," which explains the poor field emergence exhibited in 2016 when dry soil conditions were present. Field emergence ratings were in the moderate to good range when adequate soil moisture was present in 2017. Field emergence ratings increased gradually throughout the 28 days after planting in 2016 due to limited moisture. In 2017, the cultivars maximized their field emergence ratings at 14 days after planting. Only minimal differences were observed between cultivars except for 'Villana', which had improved field emergence ratings over the other cultivars in the dry conditions of 2016 (Table 15). This difference was not observed when soil moisture conditions were adequate.

Table 15. Field emergence of vetch cultivars planted in 2016 and 2017 at the Jimmy Carter Plant Materials Center, Americus, Georgia

	7 DAP[a]		14 DAP		21 DAP		28 DAP	
	2016	2017	2016	2017	2016	2017	2016	2017
CCS Groff	0.0	2.0	0.0	2.3	0.5	2.0	0.8	2.0
Lana	0.0	2.0	0.0	2.7	0.3	2.0	0.8	2.3
Purple Bounty	0.0	1.7	0.0	2.3	0.5	2.0	0.5	2.0
Purple Prosperity	0.0	2.0	0.0	2.7	0.3	2.0	0.8	2.3
TNT	0.0	2.0	0.0	2.3	0.5	2.0	0.8	2.0
Villana	0.0	1.7	0.8	2.0	1.0	2.0	1.3	2.0
Mean	0.0	1.9	0.1	2.4	0.5	2.0	0.8	2.1
SD[b]	--	0.3	0.3	0.5	0.6	--	0.8	0.3

Note: Germination and emergence ratings were based on a 0-3 scale where 0 = poor (< 25% germination), 1 = moderate (25-64%), 2 = good (65-85%), 3 = excellent (>85%)
[a] Days after Planting
[b] Standard deviation

Table 16. Plant height and bloom period for vetch cultivars planted in 2016 and 2017 at the Jimmy Carter Plant Materials Center, Americus, Georgia

	Plant Height (in)		DAP to 50% Bloom[a]	
	2017	2018	2017	2018
CCS Groff	26.8	21.7	188	167
Lana	21.3	21	166	151
Purple Bounty	29.5	22.7	188	167
Purple Prosperity	31.5	21.3	188	167
TNT	24.8	21.7	215	185
Villana	27.3	21.3	188	174
Mean	26.8	21.6	189	169
SD[b]	4.2	1.2	15	10

[a] Days after Planting to 50% of the plants in a plot blooming based on a visual estimate
[b] Standard deviation

Though (Wilke & Snapp, 2008) reported no difference in vetch cultivars' winter survival when exposed to air temperatures like were present in this study, winter hardiness ratings reported in this study were lower than expected and variable among cultivar. This is likely the result of a reduction in plant stands throughout the winter from some other reason or the difficulty of differentiating individual vetch plants during spring counts. Either cause resulted in what was likely artificially low spring plant counts and skewed the winter hardiness results. For that reason, the winter hardiness results were not reported. Plant height was variable by cultivar in 2017, ranging from 21 inches to 31 inches in height, but the cultivars were very similar in height in 2018. The cultivars differed mostly in bloom period, where the earliest cultivar, 'Lana', reached 50% bloom at 151 days after planting in 2018 while the latest cultivar, 'TNT', did not reach 50% bloom until 185 days after planting. Mean bloom period ratings in 2017 were 20 days later than in 2018 though some cultivars bloomed as much as 30 days later in 2017 than in 2018 (Table 16). The delayed emergence and deer browse pressure most likely explain the difference observed between growing seasons. Insect and early disease ratings were low in both years for all cultivars. Late-season disease ratings were low to moderate in both years and disease damage did not limit plant growth in either year (Table 17).

Table 17. Disease and insect ratings for vetch cultivars planted in 2016 and 2017 at the Jimmy Carter Plant Materials Center, Americus, Georgia

	Early Disease		Late Disease		Early Insect		Late Insect	
	2016	2017	2017	2018	2016	2017	2017	2018
CCS Groff	0.0	0.0	1.5	1.0	0.0	0.0	0.0	0.3
Lana	0.0	0.0	2.0	2.3	0.0	0.0	0.0	0.3
Purple Bounty	0.0	0.0	1.5	1.0	0.0	0.0	0.0	0.0
Purple Prosperity	0.0	0.0	1.5	1.3	0.0	0.0	0.0	0.3
TNT	0.0	0.0	2.0	1.0	0.0	0.0	0.0	0.0
Villana	0.0	0.0	1.5	1.3	0.0	0.0	0.0	1.0
Mean	0.0	0.0	1.7	1.3	0.0	0.0	0.0	0.3
SD[a]	--	--	0.5	0.7	--	--	--	0.5

Note: Disease and insect damage ratings were based on 0-5 scale where 0=no damage and 5=dead plants. Each plot was rated early, 28 days after planting, in the growing season and late in the growing season, at 50% bloom.
[a] Standard deviation

Oilseed Radish

Oilseed radish cultivars were also plagued by low field emergence in 2016 as a result of the dry planting conditions. In 2017, the radishes showed good field emergence by 7 days after planting and improved again by 14 days after planting. In both years, field emergence was maximized at 14 days after planting. ‘Graza’ exhibited the lowest field emergence ratings in both years (Table 18). While other differences between cultivars were recorded for field emergence, they were likely not meaningful or relevant.

Table 18. Field emergence ratings for oilseed radish cultivars planted in 2016 and 2017 at the Jimmy Carter Plant Materials Center, Americus, Georgia

	7 DAP[a]		14 DAP		21 DAP		28 DAP	
	2016	2017	2016	2017	2016	2017	2016	2017
Big Dog	0.5	2.3	1.0	2.3	0.8	2.3	0.8	2.3
Concorde	1.3	2.0	1.8	2.3	1.0	2.0	0.8	2.0
Control	1.0	2.3	2.0	3.0	1.5	2.0	1.0	2.3
Defender	0.3	1.7	1.5	2.0	1.0	2.0	1.0	2.0
Driller	0.8	2.0	1.3	2.7	1.5	2.0	0.8	2.0
Eco-Till	0.8	2.0	1.5	2.3	1.0	2.0	1.0	2.0
Graza	0.0	0.7	0.3	1.3	0.8	1.0	0.3	1.0
Groundhog	1.0	2.3	1.3	2.7	1.3	2.0	0.5	2.0
Lunch	0.8	2.0	1.0	2.0	1.0	2.0	0.3	2.0
Nitro	1.5	2.7	1.3	3.0	1.0	2.0	1.0	2.0
Sodbuster Blend	0.8	1.7	1.3	2.0	1.0	2.0	0.8	2.0
Tillage	1.5	2.0	1.3	2.7	1.3	2.0	0.8	2.0
Mean	0.8	2.0	1.3	2.4	1.1	1.9	0.7	2.0
SD[b]	0.8	0.6	0.6	0.6	0.5	0.3	0.5	0.4

Note: Germination and emergence ratings were based on a 0-3 scale where 0 = poor (< 25% germination), 1 = moderate (25-64%), 2 = good (65-85%), 3 = excellent (>85%)
[a] Days after Planting
[b] Standard deviation

Radishes as a cover crop are often terminated by winterkill, thus avoiding early seed set before termination. However, unlike most other portions of the country, radish does not reliably winterkill in the Southern Coastal Plain (Cover Crop Information Sheet- Daikon Radish). Winter hardiness ratings from this study reflect lack of reliable winterkill, with most of the cultivars having greater than 80 percent winter hardiness. Two cultivars, ‘Big Dog’ and ‘Driller’, did exhibit decreased winter hardiness in 2018, but still was not low enough to make winterkill a successful termination strategy in the Southern Coastal Plain.

Plant height and bloom period measurements divided the cultivars into two groups, with one group reaching 23-26 inches in height and reaching 50% bloom 119 days after planting, and the other group reaching 41-44 inches in height and reaching 50% bloom at 140-151 days after planting (Table 19). The cultivars within each grouping were very similar in most plant growth characteristics measured, and differences were mostly observed across the two groups of radish cultivars, not within an individual group. Disease and insect ratings were low to moderate and similar regardless of cultivar (data not shown). Though disease and insect ratings were acceptable in this study, it is possible that radishes could serve as overwinter hosts for disease and insect pests of cash crops (Clark, 2007). Additionally, the

Table 19. Winter hardiness, plant height, and bloom period for oilseed radish cultivars planted in 2016 and 2017 at the Jimmy Carter Plant Materials Center, Americus, Georgia

	% Winter Hardiness	Plant Height (in)		DAP to 50% Bloom[a]	
	2018	2017[b]	2018	2017[b]	2018
Big Dog	76.1	--	26.0	--	119
Concorde	100	--	43.7	--	140
Control	96.7	--	41.3	--	140
Defender	100	--	44.0	--	140
Driller	53.5	--	24.7	--	119
Eco-Till	90.5	--	26.3	--	119
Graza	88.9	--	42.3	--	151
Groundhog	83.3	--	25.7	--	119
Lunch	87.8	--	23.0	--	119
Nitro	85.7	--	25.0	--	119
Sodbuster Blend	86.7	--	24.7	--	119
Tillage	88.9	--	26.7	--	119
Mean	86.7	--	19.0	--	155
SD[c]	18.2	--	3.6	--	27

[a] Days after Planting to 50% of the plants in a plot blooming based on a visual estimate
[b] 2017 Plots were not able to be rated due to heavy deer browse damage
[c] Standard deviation

shorter growing season and the tendency of radishes to avoid winterkill may make them a poor choice for later planted cash crops, like cotton (Cover Crop Information Sheet- Daikon Radish).

Red Clover

Red clover field emergence ratings were very low in 2016 across all cultivars and rating timings due to poor soil moisture conditions. In 2017, field emergence was improved at every rating period. Mean field emergence ratings were maximized at the 14 days after planting rating. One cultivar, 'Starfire II', had similar emergence ratings as the other cultivars at 14 days after planting, but exhibited substantially lower emergence ratings at 21 and 28 days after planting (Table 20). This is most likely the result of the limited number of replications included in the data and not necessarily indicative of the cultivar.

Although red clover is winter hardy throughout much of the U.S. (Clark, 2007), winter hardiness data collected in 2018 showed lower winter hardiness for every cultivar than was expected. This was likely due to inadvertent errors in spring plant counts. Because winter hardiness data is questionable and red clover has been documented to withstand much colder temperatures than are experienced in the Southern Coastal Plain, winter hardiness data was not reported.

There are two types of red clover, medium and mammoth (St. John & Ogle, 2008). Cultivars included in this study, other than 'Mammoth', fall under the medium type. The most relevant differences observed for plant height and bloom period were among red clover types rather than red clover cultivars. For plant height, medium type cultivars ranged from 24-28 inches while 'Mammoth' was less than 16 inches tall. Days after planting to 50% bloom was also similar among medium type cultivars while 'Mammoth' reached 50% bloom 25 days later than the mean (Table 21). The red clover cultivars were the last to reach 50% bloom in the study and would likely delay cash crop planting too long if they were allowed to reach bloom before termination. As a result, red clover would likely not fit well into most

Table 20. Field emergence of red clover cultivars planted in 2016 and 2017 at the Jimmy Carter Plant Materials Center, Americus, Georgia

	7 DAP[a]		14 DAP		21 DAP		28 DAP	
	2016	2017	2016	2017	2016	2017	2016	2017
Cinammon Plus	0.0	1.7	0.3	2.0	0.0	1.7	0.0	1.7
Cyclone II	0.0	2.0	0.3	2.0	0.0	2.3	0.3	2.3
Dynamite	0.0	1.7	0.0	1.7	0.0	1.7	0.3	1.7
Freedom	0.0	1.7	0.0	2.0	0.3	2.0	0.0	2.0
Kenland	0.0	1.7	0.0	2.0	0.0	1.7	0.0	1.7
Mammoth	0.0	1.7	0.0	2.0	0.0	2.0	0.0	2.0
Starfire II	0.0	0.7	0.0	1.7	0.0	1.0	0.0	1.3
Wildcat	0.0	2.0	0.3	2.0	0.3	2.0	0.5	2.0
Mean	0.0	1.6	0.1	1.9	0.06	1.8	0.9	1.8
SD[b]	--	0.6	0.3	0.3	0.26	0.5	0.3	0.5

Note: Germination and emergence ratings were based on a 0-3 scale where 0 = poor (< 25% germination), 1 = moderate (25-64%), 2 = good (65-85%), 3 = excellent (>85%)
[a] Days after Planting
[b] Standard deviation

Table 21. Plant height and bloom period for red clover cultivars planted in 2016 and 2017 at the Jimmy Carter Plant Materials Center, Americus, Georgia

	Plant Height (in)		DAP to 50% Bloom[a]	
	2017[b]	2018	2017[b]	2018
Cinnamon Plus	--	24.7	--	199
Cyclone II	--	24	--	192
Dynamite	--	26.7	--	199
Freedom	--	27	--	199
Kenland	--	28.3	--	199
Mammoth	--	15.7	--	227
Starfire II	--	26.3	--	202
Wildcat	--	28.3	--	199
Mean	--	25.1	--	202
SD[c]	--	4.2	--	10

[a] Days after Planting to 50% of the plants in a plot blooming based on a visual estimate
[b] 2017 Plots were not able to be rated due to poor emergence and heavy deer browse damage
[c] Standard deviation

cash crop rotations in the Southern Coastal Plain MLRA, but could still be utilized for other, non-traditional crop rotations or in grazing systems.

CONCLUSION

Selection of the best adapted cover crop cultivar(s) is vital to maximize the benefits for the end-user. While most of the cover crops options examined in this 2-year study were well adapted to the Southern Coastal Plain MLRA of the Southeast, some options were more appropriate for the cash crop rotations of the region. Oilseed radishes may need to be positioned before the earliest planted cash crops to avoid seed set before cover crop termination and red clover would likely delay cash crop planting too long to be a feasible cover crop choice. Producers and conservation planners that wish to use cool season cover crops as part of their overall land management plan however, can utilize cultivar selection within cover crop species such as Austrian winter pea, black oat, cereal rye, crimson clover, and hairy vetch to tailor cover crop performance to their specific needs. Still more research is needed on cool season cover crops in the Southern Coastal Plain MLRA as there are many other possible cultivars and additional plant species that may be well suited for cover cropping. Additionally, research needs to progress on topics such as seeding rates, planting dates, and optimum cover crop/cash crop rotations to provide the best cover crop information to land managers.

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