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Evaluation of Cool Season Cover Crops in the Mid-South

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ABSTRACT

Cool season, annuals provide multiple benefits to production agriculture when planted as a cover crop such as weed suppression, controlling soil erosion, adding nitrogen, increasing soil organic matter and other soil health improvement. However, success of the cover crop planting depends on selection of the best adapted cultivar or variety that meets the planting objective. The purpose of this study was to evaluate fifty-nine commercially available cultivars and varieties of eight common annual, cool season species for their adaptation to the Mid-South. Oats (*Avena sativa* L. and *Avena strigosa* Schreb.), cereal rye (*Secale cereal* L.), Austrian winter pea (*Pisum sativum* L.), daikon radish (*Raphanus sativus* L.), crimson clover (*Trifolium incarnatum* L.), red clover (*Trifolium pretense* L.), balansa clover (*Trifolium michelianum* Savi), and hairy vetch (*Vicia villosa* Roth) and [*Vicia villosa* Roth ssp. *varia* (Host) Corb] were evaluated for field emergence, winter hardiness, plant height, days after planting to 50% bloom, and disease and insect resistance at the Jamie L. Whitten Plant Materials Center near Coffeeville, MS in 2016-2017 and 2017-2018. Fixation balansa clover had moderate to good field emergence and excellent winter hardiness. Both oat cultivars had excellent field emergence. Cosaque black seeded oats exhibited excellent winter hardiness while Soil Saver black oats winterkilled both years. Cereal rye exhibited outstanding winter survival and had excellent fall stand quality except for Guardian and Wheeler in 2018. Crimson clover exhibited good to excellent field emergence 4 weeks after planting except for Contea. AU Sunup and AU Sunrise crimson clover reached 50% bloom quicker than the other cultivars. Hairy vetch had moderate to excellent field emergence and exhibited excellent winter hardiness. Concorde, Control, and Graza daikon radish were the only cultivar that exhibited winter survival. Red clover had good to excellent early field emergence in 2016 and displayed excellent winter hardiness. Austrian winter pea had good to excellent fall stand quality. Arvica 4010, Dunn, and Maxum winter pea exhibited winter kill. Additional information is needed on biomass production of best performing cultivars to maximize their use as a cover crop and to further characterize their adaptation to the Mid-South.

INTRODUCTION

Utilizing annual, cool season grasses and legumes as cover crops improves soil health, conserves energy, builds resilience, and manages climate risk (Lal, 2004; Reicosky and Forcella, 1998; Hargrove, 1986; Reeves, 1994). Cool season, annual legumes such as hairy vetch and crimson clover reduce nitrogen inputs of subsequent commodity crops (Singh et al., 2004; Smith et al., 1987), while non-leguminous cover crops, such as small grains, effectively limit nitrate leaching and soil erosion (Meisinger et al., 1991). However, multiple benefits are not achieved unless the best adapted cover crop cultivar(s) are planted that meets the planting objectives (i.e. weed suppression, nitrogen scavenging, reduce soil erosion) and the end-user's expectations. The purpose of this study is to evaluate growth characteristics of annual, cool season grass, legume, and forb cultivars to determine their adaptation for cover cropping in the Mid-South.

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MATERIALS AND METHODS

The study was conducted at the USDA-Natural Resources Conservation Service Jamie L. Whitten Plant Materials Center, Coffeeville, MS in 2016-2017 and 2017-2018. Annual, cool seasons were planted on a pure live seed (PLS) basis (Table 1). Legumes were inoculated with appropriate rhizobia before seeding. Prior to planting, a firm, weed-free seedbed was prepared using tillage equipment and a culitpacker. Plots were drilled planted 14 October 2016 and 16 October 2017 with a Kincaid cone seeder (Kincaid Equipment, Haven KS) on 8" rows on an Oaklimeter silt loam. Plot size was 5-ft x 25-ft (2016) and 5-ft x 15-ft (2017). In 2016, all entries received 30 lb P/acre and 60 lb K/acre and no nitrogen fertilizer was used because a mature stand of soybean was incorporated by tillage in September (approximately 25-30 lb N/acre). In 2017, all non-legume entries received 40 lb N/acre and all entries received 50 lb P/acre and 50 lb K/acre. Plots (both years) were located within an 8-foot exclusion fence to stop deer browsing. In 2017, plots were planted perpendicular from the previous year to avoid contamination. No irrigation was applied either year.

Table 1. Species, cultivars and seeding rates of annual cool seasons planted in 2016 and 2017 at the USDA NRCS Coffeeville, MS Plant Materials Center.

Common name	Species	Cultivar	PLS lb/acre	% PLS	Seeding rate lb/acre
Austrian winter pea	*Pisum sativum*	Arvica 4010	70	95	74
Austrian winter pea	*Pisum sativum*	Dunn	70	85	82
Austrian winter pea	*Pisum sativum*	Frost Master	70	85	82
Austrian winter pea	*Pisum sativum*	Lynx	70	98	71
Austrian winter pea	*Pisum sativum*	Maxum	70	92	76
Austrian winter pea	*Pisum sativum*	Survivor 15	70	80	88
Austrian winter pea	*Pisum sativum*	Whistler	70	90	78
Austrian winter pea	*Pisum sativum*	Windham	70	80	88
Balansa clover	*Trifolium michelianum*	Fixation	5	47	11
Balansa clover	*Trifolium michelianum*	Frontier	5	58	9
Black oats	*Avena sativa*	Cosaque	60	83	72
Black seeded oats	*Avena strigosa*	Soil Saver	60	98	61
Cereal Rye	*Secale cereale*	Aroostook	100	90	111
Cereal Rye	*Secale cereale*	Bates	100	88	113
Cereal Rye	*Secale cereale*	Brasetto	100	92	109
Cereal Rye	*Secale cereale*	Elbon	100	88	114
Cereal Rye	*Secale cereale*	FL 401	100	80	126
Cereal Rye	*Secale cereale*	Guardian	100	93	108
Cereal Rye	*Secale cereale*	Hazlet	100	84	119
Cereal Rye	*Secale cereale*	Maton	100	90	111
Cereal Rye	*Secale cereale*	Maton II	100	91	110
Cereal Rye	*Secale cereale*	Merced	100	84	119
Cereal Rye	*Secale cereale*	Oklon	100	90	112
Cereal Rye	*Secale cereale*	Rymin	100		
Cereal Rye	*Secale cereale*	Wheeler	100	82	122
Cereal Rye	*Secale cereale*	WinterGrazer 70	100	78	128
Cereal Rye	*Secale cereale*	Wren's Abruzzi	100	84	119
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*	Contea	18	60	30
Crimson clover	*Trifolium incarnatum*	Dixie	18	53	34
Crimson clover	*Trifolium incarnatum*	KY Pride	18	98	18

Approximately every 7 days field emergence was estimated in each plot for four weeks after planting using the following rating scale: 0 = poor (<25% germination), 1 = moderate (30-60%), 2 = good (65–85%), 3 = excellent 90-100%). Entries were evaluated twice for disease and pest damage (rated from 0–5, where 0 = no damage and 5 = severe damage) following spring green-up (early March) and at 50% bloom (varied by species and cultivar). Winter survival was evaluated from a 3-ft section of an interior row marked in each plot. Seedlings were counted at 1-inch increments to 36-inches in the fall (November) and following spring green-up (March) of the 2016-2017 and 2017-2018. Bloom period was monitored by noting the date of beginning bloom and 50% bloom. Average plant height was determined from measurements taken from the interior rows of the plot to the average absolute height.

Table 1 (cont.). Species, cultivars and seeding rates of annual, cool seasons planted in 2016 and 2017 at the USDA NRCS Coffeeville, MS Plant Materials Center.

Common name	Species	Cultivar	PLS lb/acre	% PLS	Seeding rate lb/acre
Hairy vetch	*Vicia villosa*	CCS Groff	18	90	20
Hairy vetch	*Vicia villosa*	Purple Bounty	18	78	23
Hairy vetch	*Vicia villosa*	Purple Prosperity	18	90	20
Hairy vetch	*Vicia villosa*	Villana	18	89	20
Woollypod vetch	*Vicia villosa* subsp. *varia*	Lana	18	98	18
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	59	15
Red clover	*Trifolium pratense*	Cyclone II	9	60	15
Red clover	*Trifolium pratense*	Dynamite	9	59	15
Red clover	*Trifolium pratense*	Freedom	9	59	15
Red clover	*Trifolium pratense*	Kenland	9	80	11
Red clover	*Trifolium pratense*	Mammoth	9	88	10
Red clover	*Trifolium pratense*	Starfire	9	59	15
Red clover	*Trifolium pratense*	Wildcat	9	59	15

The experimental design was a randomized complete block with 4 replications. To determine variation among cultivars within a species, a mean and standard deviation were reported for field emergence, % winter hardiness, plant height and days after planting (DAP) to 50% bloom using Microsoft Excel (2016).

For Reference:

- Winter survival—Plant survival rating of Excellent >75%, Good 50-75%, Marginal 25-50%, Poor <25%,

- Maturity date— Days after planting to 50% bloom, data was grouped over the region by <140=Early, 141-160=Mid, >160=Late to identify varietal differences.

RESULTS AND DISCUSSION

Monthly rainfall for October through April in 2016-2017 and 2017-2018 was recorded from an official weather station near the study (Fig. 1). Total precipitation for October through April growing season was 27.5 inches in 2016-2017 and 18.3 inches in 2017-2018. In both years, January had the extreme coldest temperature, 9° F (2016) and 2° F (2017) (Fig. 2.). A low tempearutre of 3° F was observed in April 2018. Abnormally cold temperature between March-April 2018 lead to delayed blooming in all plant species.

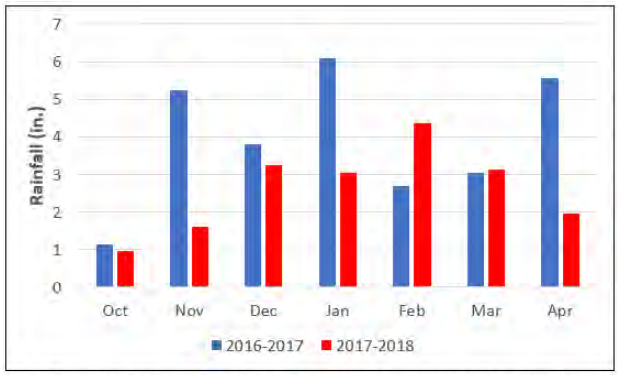

Fig. 1. Monthly and normal rainfall in Oct-Apr 2016-2017 and 2017-2018 Coffeeville, MS.

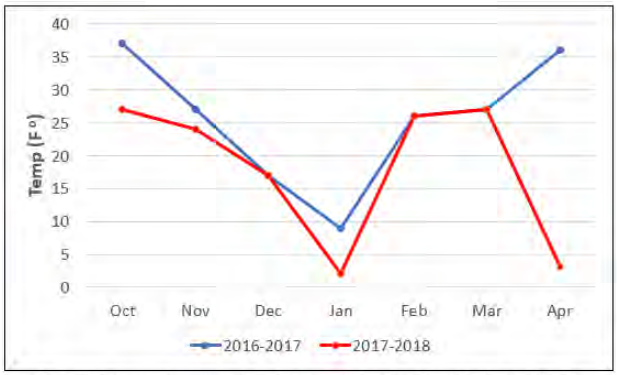

Fig. 2. Monthly lowest temperature in Oct-Apr 2016-2017 and 2017-2018 Coffeeville, MS.

Winter Pea

In 2016, winter pea achieved a mean good to excellent emergence at 7, 14, 21, and 28 DAP (Table 2). In fact, by 28 DAP all cultivars had excellent mean field emergence. In 2017, winter pea field emergence was poor to moderate 7 and 14 DAP, but by 28 DAP most cultivars improved to good field emergence. Percent winter hardiness varied among cultivars (Table 3). Clark (2007) reported winter damage to winter peas can occur at 10° F. Temperatures below 10° F occurred in December 2016 (9° F) and 2° F in January 2018 (Fig. 2). In 2017 Frost Master, Lynx, Survivor 15, Whistler, and Windham had excellent winter survival, but in 2018 only Frost Master exhibited excellent winter survival. In 2018, Survivor 15, Whistler, and Windham exhibited good winter survival. In 2017, Arvica 400, Dunn, and Maxum (7-8 inches) plant height were greater than the other cultivars (3 inches). In 2018, plants that survived the winter had a plant height between 16-31 inches. Arvica 4010, Dunn, and Maxum were earliest maturing cultivars while Frost Master and Survivor 15 were latest.

Table 2. Mean values and standard deviations of emergence groups (see below) of winter pea cultivars at 7, 14, 21 and 28 days after planting in 2016-2017. USDA-NRCS Coffeeville, MS.

Cultivar	Days after planting							
	7		14		21		28	
	2016	2017	2016	2017	2016	2017	2016	2017
Arvica 4010	2.5	0.3	2.5	0.5	3.0	1.3	3.0	2.0
Dunn	2.3	1.0	2.0	1.3	2.5	1.8	2.8	2.0
Frost Master	2.0	0.5	2.0	0.8	2.0	0.8	3.0	1.5
Lynx	2.0	0.5	2.0	0.8	2.0	0.8	2.0	1.3
Maxum	2.0	0.5	2.0	1.0	2.0	1.3	3.0	1.8
Survivor 15	3.0	1.0	2.8	1.3	2.8	1.5	3.0	2.2
Whistler	2.3	0.5	2.3	1.3	2.3	1.5	3.0	2.0
Windham	2.3	0.5	2.0	1.0	2.0	1.8	2.8	1.8
Mean	2.3	0.6	2.2	1.0	2.3	1.3	2.8	1.8
SD[2]	0.5	0.6	0.4	0.7	0.5	0.8	0.4	0.7

[1] 0 = poor (<25% emergence); 1 = moderate (30-60% emergence); 2 = good (65-85% emergence); 3 = excellent (90-100% emergence). SD[2] standard deviation.

Table 3. Mean values for % winter hardiness, plant height and days after planting to 50% bloom for winter pea cultivars in 2017 and 2018 at the USDA-NRCS Coffeeville, MS.

Cultivar	% Winter hardiness		Plant height (in.)		DAP to 50% bloom	
	2017	2018	2017	2018	2017	2018
Arvica 4010	38	25	8	--	154	--
Dunn	25	25	7	--	154	--
Frost Master	96	89	3	25	181	210
Lynx	87	47	3	16	181	211
Maxum	45	25	8	--	154	--
Survivor 15	95	70	3	31	181	211
Whistler	100	69	3	21	167	213
Windham	100	69	5	17	147	213
Mean	73	52	5	22	165	--
SD[1]	36	43	2	6	14	--

[1] SD - Standard deviation.

Balansa Clover

Balansa clover cultivar Fixation emerged slowly after planting (both years) but achieved a mean moderate to good emergence by 28 DAP while Frontier had poor emergence both years (Table 4). Both cultivars had excellent winter hardiness in 2016-2017, but Frontier lacked the same winter hardiness in 2017-2018 (Table 5). In 2018, Frontier achieved 50% bloom approximately 3.5 weeks before Fixation (Table 5).

Table 4. Mean values and standard deviations of emergence groups (see below) of balansa clover at 7, 14, 21 and 28 days after planting in 2016-2017. USDA-NRCS Coffeeville, MS.

Cultivar	Days after planting/Year							
	7		14		21		28	
	2016	2017	2016	2017	2016	2017	2016	2017
Fixation	0.8	1.0	1.3	1.0	1.3	1.0	1.3	2.0
Frontier	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mean	0.4	0.5	0.6	0.5	0.6	0.5	0.6	1.0
SD[2/]	0.5	0.5	0.7	0.5	0.7	0.5	0.7	1.1

[1/] 0 = poor (<25% emergence); 1 = moderate (30-60% emergence); 2 = good (65-85% emergence); 3 = excellent (90-100% emergence). [2/] Standard deviation.

Table 5. Mean values and standard deviations for % winter hardiness and days after planting to 50% bloom for balansa cultivars in 2017 and 2018 at the USDA-NRCS Coffeeville, MS.

Cultivar	% Winter hardiness		DAP to 50% bloom	
	2017	2018	2017	2018
Fixation	98	90	--	188
Frontier	100	61	154	163
Mean	99	75	--	176
SD[1/]	3.5	28.7	--	13.7

[1/] Standard deviation.

Black Oats

Percent field emergence of black oats (Soil Saver) and black seeded oats (Cosaque) were similar among days after planting and years (Table 6). Both cultivars provided good to excellent field emergence both short and long term. Cosaque exhibited excellent winter hardiness while Soil Saver exhibited poor winter hardiness (Table 7). Soil Saver has done well in fall plantings in plant hardiness zone 8b but is not recommended north of this zone due to insufficient cold hardiness and risk of winterkill (USDA-ARS, 2016; USDA-ARS, 2012). In 2017, Soil Saver (14 inches) measured double the height of Cosaque (7 inches), but both cultivars had similar mean height in 2018 (Table 7). Both cultivars have a late maturity date (Table 7). Cosaque is a good choice as an overwintering cover crop in the upper Mid-South while Soil Saver may be a good choice in the lower Mid-South.

Table 6. Mean values and standard deviations of emergence groups (see below) of black seeded oats and blacked oats at 7, 14, 21 and 28 days after planting in 2016-2017. USDA-NRCS Coffeeville, MS.

Cultivar	Days after planting							
	7		14		21		28	
	2016	2017	2016	2017	2016	2017	2016	2017
Cosaque	3	2.3	3	2.5	3	2.5	3	3
Soil Saver	3	2.5	3	3	3	3	3	3
Mean		2.4		2.8		2.8		
SD[2/]		0.5		0.5		0.5		

[1/] 0 = poor (<25% emergence); 1 = moderate (30-60% emergence); 2 = good (65-85% emergence); 3 = excellent (90-100% emergence). SD[2/] standard deviation.

Table 7. Mean values and standard deviations for % winter hardiness, plant height and days after planting to 50% bloom for black oats cultivars in 2017 and 2018 at the USDA-NRCS Coffeeville, MS.

Cultivar	% Winter hardiness		Plant height (in.)		DAP to 50% bloom	
	2017	2018	2017	2018	2017	2018
Cosaque	97	100	7	24	170	206
Soil saver	17	38	14	23	170	206
Mean	57	69	11	24		206
SD[1/]	44	34	4	2		3.7

[1/] Standard deviation

Cereal Rye

In 2016, cereal rye generally had good to excellent early field emergence (7 DAP) but were slower to emerge in 2017 (Table 8). By 14 DAP, cultivars had good to excellent field emergence except Guardian, Maton II, and Wheeler in 2017. Late fall stand quality (28 DAP) was good to excellent except for Guardian and Wheeler in 2017. Winter cover crops that quickly emerge and accumulate fall growth are important attributes for protecting the soil from sheet and rill erosion, suppressing problematic weeds, and scavenging residual soil nitrate nitrogen after crops have matured (Shipley et al, 1992; Matias et al., 2004; Roberts, 2015b). Winter survival was good to excellent for all cereal rye cultivars (Table 9). Percent mean winter hardiness was 92 ± 14% (2017) and 96 ± 10% (2018). In 2017, Bates, Elbon, FL 101, Maton, Merced, Wintergrazer 70, and Wren Abruzzi plant height were equal to or greater than the overall mean among cultivars (Table 9). In 2018, FL 101 and Merced recorded smaller mean plant height than most other cultivars. DAP to 50% bloom varied among cultivars and across years (Table 9). Overall, cereal rye is a mid to late maturing crop.

Table 8. Mean values and standard deviations of emergence groups (see below) of cereal rye cultivars at 7, 14, 21 and 28 days after planting in 2016-2017. USDA-NRCS Coffeeville, MS.

Cultivar	Days after planting							
	7		14		21		28	
	2016	2017	2016	2017	2016	2017	2016	2017
Aroostock	3.0	2.3	3.0	2.8	3.0	3.0	3.0	3.0
Bates	3.0	2.0	3.0	2.8	3.0	3.0	3.0	3.0
Brasetto	2.5	2.0	2.8	2.5	2.8	2.8	2.5	3.0
Elbon	3.0	2.0	3.0	2.5	3.0	3.0	3.0	3.0
FL 401	3.0	2.3	3.0	2.8	3.0	3.0	3.0	3.0
Guardian	3.0	0.0	3.0	0.0	3.0	0.0	3.0	0.5
Hazlet	3.0	2.0	3.0	2.3	3.0	2.5	2.8	2.8
Maton	3.0	2.0	3.0	2.8	3.0	2.8	3.0	3.0
Maton II	2.3	0.8	2.8	1.3	2.8	1.3	2.8	2.0
Merced	3.0	2.5	3.0	2.8	3.0	3.0	3.0	3.0
Oklon	3.0	1.5	3.0	2.3	3.0	2.3	3.0	2.8
Rymin	3.0	1.5	3.0	2.3	3.0	2.3	3.0	2.8
Wheeler	3.0	0.0	3.0	0.3	3.0	0.3	3.0	0.3
Wintergrazer 70	3.0	2.3	3.0	2.8	3.0	2.8	3.0	3.0
Wren Abruzzi	3.0	2.0	3.0	2.8	3.0	3.0	3.0	3.0
Mean	3.0	0.95	3.0	1.5	3.0	1.8	3.0	2.5
SD[2/]	0.3	0.96	0.2	1.1	0.2	1.1	0.3	0.9

[1/] 0 = poor (<25% emergence); 1 = moderate (30-60% emergence); 2 = good (65-85% emergence); 3 = excellent (90-100% emergence). SD[2/] standard deviation.

Crimson Clover

Crimson clover had greater early field emergence in 2016 than in 2017 (Table 10). In general, AU Sunrise, Dixie, and Kentucky Pride exhibited good to excellent quick cover and fall stand quality while AU Sunup and Contea exhibited reduced field emergence. Crimson clover cultivars displayed outstanding percent winter hardiness, 95 and 100%, in 2017 and 2018, respectively (Table 11). In 2018, AU Sunup (8 inches) was the only cultivar with a mean plant height below the average (13± 6 inches) (Table 11). Mean DAP to 50% bloom was 165 ± 21 days in 2017 and 183 ± 19 days in 2018 (Table 11). In both years, AU Sunrise and AU Sunup bloomed approximately 2-3 weeks earlier than the other cultivars. Crimson clover is recognized as the standard for all clover comparisons in the Mid-South.

Table 9. Mean values and standard deviations for % winter hardiness, plant height and days after planting to 50% bloom for cereal rye cultivars in 2017 and 2018 at the USDA-NRCS Coffeeville, MS.

Cultivar	% Winter hardiness		Plant height (in.)		DAP to 50% bloom	
	2017	2018	2017	2018	2017	2018
Aroostock	89	90	5	38	154	175
Bates	95	100	11	33	154	163
Brasetto	96	94	6	37	181	177
Elbon	97	97	9	39	154	176
FL 401	72	86	13	27	147	156
Guardian	100	97	3	32	181	204
Hazlet	100	100	4	34	181	202
Maton	91	91	10	38	151	169
Maton II	95	100	7	38	151	171
Merced	72	91	12	22	147	156
Oklon	94	87	4	38	151	175
Rymin	97	100	5	39	167	204
Wheeler	100	100	6	39	181	202
Wintergrazer 70	95	100	8	38	151	169
Wren Abruzzi	81	100	10	36	147	165
Mean	92	96	8	35	160	177
SD[1/]	14	10	3	6	14	18

[1/]SD - Standard deviation.

Table 10. Mean values and standard deviations of emergence groups (see below) of crimson clover cultivars at 7, 14, 21 and 28 days after planting in 2016-2017. USDA-NRCS Coffeeville, MS.

Cultivar	Days after planting							
	7		14		21		28	
	2016	2017	2016	2017	2016	2017	2016	2017
AU Robin	2.5	0.0	2.5	0.8	2.5	1.5	3.0	1.8
AU Sunrise	2.5	0.5	3.0	1.8	2.8	2.5	3.0	3.0
AU Sunup	1.3	0.0	1.8	0.3	1.8	0.8	2.0	1.3
Contea	1.0	0.0	1.3	0.0	1.3	0.3	1.3	0.3
Dixie	2.3	0.5	2.5	1.8	2.5	2.8	3.0	3.0
Kentucky Pride	2.3	0.8	2.8	1.5	2.8	2.3	3.0	3.0
Mean	2.0	0.3	2.3	1.0	2.3	1.7	2.5	2.0
SD[2]	0.8	0.5	0.8	0.8	0.7	1.0	0.7	1.1

[1/] 0 = poor (<25% emergence); 1 = moderate (30-60% emergence; 2 = good (65-85% emergence); 3 = excellent (90-100% emergence). SD[2/] standard deviation.

Table 11. Mean values and standard deviations for % winter hardiness, plant height and days after planting to 50% bloom for crimson clover cultivars in 2017 and 2018 at the USDA-NRCS Coffeeville, MS.

Cultivar	% Winter hardiness		Plant height (in.)		DAP to 50% bloom	
	2017	2018	2017	2018	2017	2018
AU Robin	98	100	--	14	167	189
AU Sunrise	91	100	--	11	154	165
AU Sunup	94	100	--	8	154	163
Contea	97	100	--	14	181	194
Dixie	96	100	--	19	166	196
Kentucky Pride	91	100	--	16	166	194
Mean	95		--	13	165	183
SD[1/]	36		--	4	21	19

[1/]SD - Standard deviation.

Hairy Vetch

Hairy vetch had moderate to good early field emergence (14 DAP) and by 28 DAP exhibited good to excellent emergence (Table 12). Hairy vetch had outstanding winter hardiness (Table 13), which is one of the many attributes of hairy vetch (Clark, 2012). Hairy vetch is a later maturing cover crop. Mean DAP to 50% bloom was 183 ± 16 days in 2017 and 200 ± 12 days in 2018 (Table 13). Lana reached 50% bloom approximately 14 days sooner than the other cultivars in 2017 but not in 2018.

Table 12. Mean values and standard deviations of emergence groups (see below) of hairy vetch cultivars at 7, 14, 21 and 28 days after planting in 2016-2017. USDA-NRCS Coffeeville, MS.

Cultivar	Days after planting							
	7		14		21		28	
	2016	2017	2016	2017	2016	2017	2016	2017
CCS Groff	1.3	0.0	2.3	0.8	2.0	1.0	2.3	1.5
Lana	2.0	0.0	2.0	1.0	2.0	1.0	2.8	1.8
Purple Bounty	1.0	0.3	1.3	1.5	1.0	1.5	1.8	2.0
Purple Prosperity	1.0	0.0	1.5	1.3	1.8	1.3	2.5	1.5
TNT	2.0	0.5	2.0	1.8	2.0	1.8	2.0	2.8
Villana	1.5	0.5	2.0	1.0	2.0	1.0	2.8	1.5
Mean	1.5	0.2	1.8	1.2	1.8	1.3	2.4	1.8
SD[2]	0.5	0.4	0.5	0.5	0.5	0.4	0.6	0.8

[1/] 0 = poor (<25% emergence); 1 = moderate (30-60% emergence); 2 = good (65-85% emergence); 3 = excellent (90-100% emergence). SD[2/] standard deviation.

Table 13. Mean values and standard deviations for % winter hardiness, plant height and days after planting to 50% bloom for hairy vetch cultivars in 2017 and 2018 at the USDA-NRCS Coffeeville, MS.

Cultivar	% Winter hardiness		Plant height (in.)		DAP to 50% bloom	
	2017	2018	2017	2018	2017	2018
CCS Groff	84	90	--	32	181	196
Lana	96	87	--	30	167	204
Purple Bounty	96	87	--	31	181	203
Purple Prosperity	95	92	--	30	181	200
TNT	100	94	--	31	193	188
Villana	95	90	--	32	192	204
Mean	95	90	--	31	183	200
SD[1/]	38	13	--	2	16	12

[1/]SD - Standard deviation.

Daikon Radish

Daikon radish early field emergence (14 DAP) was good to excellent except for Graza, Sodbuster, and Defender (2017 only) (Table 14). By 28 DAP, daikon radish exhibited good to excellent field emergence except for Graza (poor to moderate field emergence). There was considerable variation in percent winter hardiness among cultivars (Table 15). Concorde, Control, and Graza had good to excellent winter survival. Winter surviving cultivars generally exhibited mid to late maturity (Table 15) and ranged from 10-14 inches in height (Table 15).

Table 14. Mean values and standard deviations of emergence groups (see below) of daikon radish sources at 7, 14, 21 and 28 days after planting in 2016-2017. USDA-NRCS Coffeeville, MS.

Cultivar	Days after planting							
	7		14		21		28	
	2016	2017	2016	2017	2016	2017	2016	2017
Big Dog	2.0	2.3	2.0	2.3	2.0	2.5	2.5	2.8
Concorde	2.3	1.8	2.3	2.5	2.3	2.5	2.8	2.8
Control	2.5	2.0	2.8	2.5	2.8	2.8	2.8	3.0
Defender	2.3	0.3	2.5	0.8	2.5	1.3	2.8	1.8
Driller	2.0	1.5	2.0	2.0	2.0	2.3	2.3	2.8
EcoTill	2.3	1.5	2.5	2.0	2.5	2.3	2.8	2.8
Graza	1.0	0.0	1.0	0.3	1.3	0.3	1.3	0.3
Groundhog	2.0	2.0	2.5	2.0	2.3	2.8	2.8	3.0
Lunch	1.8	0.3	1.8	0.8	1.8	1.0	2.3	1.8
Nitro	1.8	2.5	2.0	2.5	2.3	2.5	2.3	2.8
Sodbuster	1.5	0.8	1.3	1.0	1.5	1.0	1.8	2.0
Tillage	1.5	2.0	1.8	2.0	2.3	2.8	2.3	2.8
Mean	1.8	0.8	2.0	1.7	2.2	2.0	2.4	2.4
SD[2/]	0.6	0.9	0.7	0.9	0.6	1.0	0.7	0.9

[1/] 0 = poor (<25% emergence); 1 = moderate (30-60% emergence); 2 = good (65-85% emergence); 3 = excellent (90-100% emergence). SD[2/] standard deviation.

Table 15. Mean values and standard deviations for % winter hardiness, plant height and days after planting to 50% bloom for daikon radish cultivars in 2017 and 2018 at the USDA-NRCS Coffeeville, MS.

Cultivar	% Winter hardiness		Plant height (in.)		DAP to 50% bloom	
	2017	2018	2017	2018	2017	2018
Big Dog	6	0	10	--	147	--
Concorde	92	44	10	--	147	173
Control	68	62	14	--	147	177
Defender	33	8	15	--	147	177
Driller	4	0	11	--	154	--
EcoTill	6	0	13	--	167	--
Graza	56	92	11	--	147	176
Groundhog	13	0	14	--	147	--
Lunch	11	0	11	--	147	--
Nitro	0	0	13	--	167	--
Sodbuster	17	0	10	--	154	--
Tillage	0	0	14	--	147	--
Mean	25	17	12	--	152	--
SD[1/]	36	32	2	--	7	--

[1/]SD - Standard deviation.

Red Clover

In 2016, red clover exhibited good to excellent quick fall cover and fall stand quality (Table 16). In 2017, early percent field emergence was poor to moderate but by 28 DAP most cultivars had good emergence except for 'Starfire II' (moderate emergence). Red clover cultivars had outstanding winter survival (Table 17). Mean percent winter hardiness was 96 and 100% in 2017 and in 2018, respectively. Red clover reached maturity on average between 190 to 200 day after planting (Table 17).

Table 16. Mean values and standard deviations of emergence groups (see below) of red clover cultivars at 7, 14, 21 and 28 days after planting in 2016-2017. USDA-NRCS Coffeeville, MS.

Cultivar	Days after planting							
	7		14		21		28	
	2016	2017	2016	2017	2016	2017	2016	2017
Cinnamon Plus	3.0	0.0	3.0	1.0	3.0	2.0	3.0	2.0
Cyclone II	2.5	0.0	2.5	1.0	3.0	1.8	3.0	2.3
Dynamite	3.0	0.8	3.0	1.3	3.0	2.0	3.0	2.0
Freedom	3.0	0.5	3.0	1.0	3.0	1.8	3.0	2.3
Kenland	1.8	0.3	2.0	0.8	2.0	1.3	2.5	1.8
Mammoth	2.8	0.5	2.8	1.3	2.8	1.5	3.0	2.0
Starfire II	2.0	0.0	2.3	0.3	2.5	1.3	2.5	1.3
Wildcat	3.0	1.0	3.0	1.5	3.0	2.0	3.0	2.3
Mean	2.6	0.4	2.7	1.0	2.8	1.7	2.9	2.0
SD[2]	0.6	0.5	0.5	0.6	0.4	0.6	0.3	0.6

[1/] 0 = poor (<25% emergence); 1 = moderate (30-60% emergence; 2 = good (65-85% emergence); 3 = excellent (90-100% emergence). SD[2/] standard deviation.

Table 17. Mean values and standard deviations for % winter hardiness, plant height and days after planting to 50% bloom for red clover cultivars in 2017 and 2018 at the USDA-NRCS Coffeeville, MS.

Cultivar	% Winter hardiness		Plant height (in.)		DAP to 50% bloom	
	2017	2018	2017	2018	2017	2018
Cinnamon Plus	98	100	--	23	189	200
Cyclone II	93	100	--	25	189	197
Dynamite	99	100	--	25	189	198
Freedom	100	100	--	21	189	197
Kenland	97	100	--	22	189	199
Mammoth	96	100	--	19	189	--
Starfire II	97	100	--	20	189	204
Wildcat	91	100	--	13	189	205
Mean	96	--	--	22	--	200
SD[1/]	6	--	--	4	--	7

[1/]SD - Standard deviation.

CONCLUSIONS

Choosing the best adapted cover crop is the first step to a successful cover crop planting. The 2-year evaluation of commercially available cereal rye, crimson clover, hairy vetch, red clover, Austrian winter pea, balansa clover, and black oats and black seeded oats provided beneficial information on best adapted cultivars or varieties for the Mid-South. Most of the species and cultivars exhibited good adaptation based on field emergence, winter hardiness, and DAP to 50% bloom. Additional information is needed on biomass production of best performing cultivars to maximize cover crop benefits and to further describe their productivity and adaptation in the region (Roberts, 2015b).

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