United States Department of Agriculture

July, 2019

FINAL STUDY REPORT
Booneville Plant Materials Center
Booneville, Arkansas

Evaluation of Annual, Cool Seasons for Conservation in the Southern Ozarks

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ABSTRACT

Cool season, annual grasses and legumes have multiple benefits as a cover crop for soil conservation and soil health, livestock forage and wildlife habitat improvement. Success of the 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, coo1 season species for their adaptation to the southern Ozarks. 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 Booneville, AR Plant Materials Center in 2016-2017 and 2017-2018. Balansa clover cultivars had favorable field emergence both years but data collection beyond field emergence was hindered by deer damage. 'Cosaque' black seeded oats exhibited satisfactory to excellent winter hardiness while 'Soil Saver' black oats winterkilled in both years. Cereal rye cultivars had good to excellent field emergence. 'Florida 101', 'Merced' and 'Rymin' suffered varying degrees of winter damage in 2017. Crimson clover cultivars exhibited good to excellent field emergence 2 weeks after planting with good winter hardiness. Hairy vetch cultivars exhibited outstanding winter hardiness with 'Lana' woollypod vetch blooming 3 to 4 weeks earlier than the other cultivars. The daikon radishes exhibited considerable variation in percent winter hardiness despite single-digit cold temperatures in 2016-2017 and 2018 with 'Graza' exhibiting percent winter hardiness of 75% and 58%, respectively. Red clover cultivars displayed excellent winter hardiness. Austrian winter pea cultivars had good to excellent emergence 2 weeks after planting with varying degrees of winter hardiness both years. Additional information is needed on biomass production of best performing cultivars to maximize their use as a cover crop and livestock forage, and to further characterize their adaptation to the southern Ozarks.

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). A mixture of annual, cool season grasses and legumes provides grazing and hay for livestock (Ball et al., 2002) and wildlife food and cover (Hambrick and Strickland, 2011). However, multiple benefits are not achieved unless the best adapted cultivar(s) are planted that meet the planting objectives (i.e. cover crop, forage, wildlife habitat) 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 conservation plantings in the southern Ozarks.

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MATERIALS AND METHODS

The study was conducted at the USDA-Natural Resources Conservation Service Booneville, Plant Materials Center, Booneville, AR 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. Plots were drilled planted 5 October 2016 and 27 September 2017 with a Kincaid cone seeder (Kincaid Equipment, Haven KS) on 8" rows on a Leadvale silt loam. Plot size was 5-ft x 10-ft. All non-legume entries received 40 lb N/acre, and all entries received 60 lb P/acre and 30 lb K/acre both years. Plots were moved to a new location in 2017 to avoid contamination from the previous year. A 3-wire electric fence was installed in late fall in 2017 to control deer browsing. Plots received one-inch of supplemental irrigation in October 2016 for 4 weeks using overhead sprinklers. No irrigation was applied in 2017. Monthly rainfall (October-April) and the minimum low temperature were recorded in 2016-2017 and 2017-2018.

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), but no apparent disease or insect damage was observed on

Table 1. Species, cultivars and seeding rates of annual cool seasons planted in 2016 and 2017 at the USDA NRCS Booneville, Arkansas 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 seeded oats	*Avena sativa*	Cosaque	60	83	72
Black 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

any cultivars during the study. 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 Booneville, Arkansas Plant Materials Center.

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*	Contea	18	60	30
Crimson clover	*Trifolium incarnatum*	Dixie	18	53	34
Crimson clover	*Trifolium incarnatum*	KY Pride	18	98	18
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 Statistix 10 (Analytical Software, Tallahassee, FL).

RESULTS AND DISCUSSION

Monthly rainfall for October through April in 2016-2017 and 2017-2018 was recorded from a an official weather station near the study (fig. 1). Due to extremely dry conditions in October 2016, 1-inch of irrigation water was applied for 4 weeks after planting. No additional water was applied in 2016 or in 2017. Total precipitation for the October through April growing season was 20.4 inches in 2016-2017 and 28.3 inches in 2017-2018, compared to the normal of 29.5 inches. The first killing frost occurred in November 2017 with the extreme coldest temperature occurring in December (9° F) 2016 and January 2017 (7° F) (fig. 2.). The first killing frost was in October 2017 with the lowest temperature of 5° F recorded in January 2018.

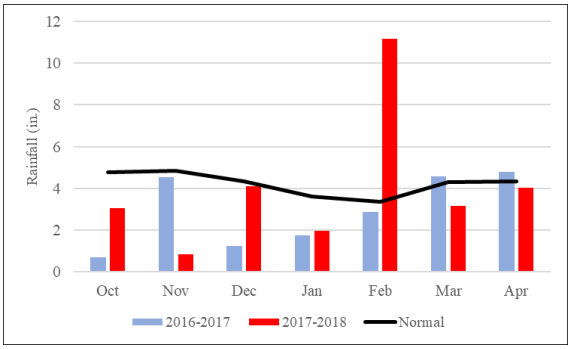

Fig.1. Monthly and normal rainfall in Oct-Apr 2016-2017 and 2017-2018 Booneville, AR.

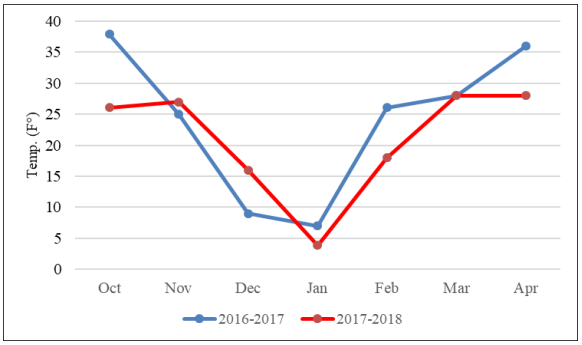

Fig. 2. Monthly lowest temperature in Oct-Apr in 2016-2017 and 2017-2018, Booneville, AR.

Balansa Clover

Balansa clover cultivars emerged slowly after planting in 2016 but achieved a mean moderate to good emergence at 14, 21, and 28 days after planting (Table 2). 'Fixation' rated slightly higher than 'Frontier' for emergence both years with a mean of good to near excellent by 28 days after planting. Both cultivars had moderate to heavy deer damage in 2016 that prevented any meaningful data collection in the spring 2017. Before installing a fence in early November 2017, both cultivars were once again severely damaged from deer browsing preventing the collection of useful data in the spring 2018.

Table 2. 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 Booneville, AR.

Cultivar	Days after planting/Year							
	7		14		21		28	
	2016	2017	2016	2017	2016	2017	2016	2017
Fixation	0[1/]	0	1.8	2.8	2.5	2.8	2.5	2.8
Frontier	0	0	1.3	1.5	1.5	2	2	2
Mean			1.5	2.1	2	2.4	2.3	2.4
SD[2/]			0.8	0.8	1.1	0.5	0.7	0.5

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

Black Oats

Percent field emergence of black oats ('Soil Saver') and black seeded oats ('Cosaque') were similar among days after planting and between years (Table 3). Both cultivars provided excellent percent field emergence 14 days after planting. 'Cosaque' exhibited satisfactory to excellent winter hardiness while Soil Saver was completely winterkilled both years (Table 4). 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). Soil Saver may be a good choice for producers needing a quick growing cool season cover crop requiring no chemical or mechanical termination prior to planting the cash crops in the spring. Plant height of Cosaque ranged from 13 inches in 2017 to twice the height in 2018. Ample rainfall in February 2018 and deer protection likely attributed to the increase in plant growth and extended the DAP to 50% bloom to 4 weeks later in 2018 compared to 2017.

Table 3. Mean values and standard deviations of emergence groups (see below) of black oats and seeded black oats at 7, 14, 21 and 28 days after planting in 2016-2017. USDA-NRCS Booneville, AR.

Cultivar	Days after planting							
	7		14		21		28	
	2016	2017	2016	2017	2016	2017	2016	2017
Cosaque	1.3[1/]	3	3	3	3	3	3	3
Soil Saver	1.8	3	3	3	3	3	3	3
Mean	1.5	3	3	3	3	3	3	3
SD[2/]	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 4. 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 Booneville, AR.

Cultivar	% Winter hardiness		Plant height (in.)		DAP to 50% bloom	
	2017	2018	2017	2018	2017	2018
Cosaque	61	99	13	26	196	225
Soil Saver	---[1/]	---				

[1/]Winterkilled.

Cereal Rye

Cereal rye cultivars had good to excellent emergence within 7 to 14 days after planting in both years (Table 5). 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, Roberts et al., 2018). Quick establishment is crucial for fall grazing of cereal rye in Arkansas to attain the target stocking rate of 1 to 1.5 calves per acre in November (Beck et al., 2013). Percent winter hardiness ranged from 100 to 32% with a mean of 84 ± 26% (mean and standard

deviation) in 2017 and 99% in 2018 (Table 6). 'Florida 101', 'Merced' and 'Rymin' suffered winter damage (> 60% loss) in 2017 when temperatures reached < 10° F in December 2016 and January 2017 but recovered in the spring. Other cultivars maintained greater than 90% winter hardiness. Merced and Florida 101 experienced winter damage in 2018 but the plants recovered by early spring. Despite a low temperature of 5° F in January 2018 none of the cultivars were winter damaged. The mean plant height of cultivars was 29 ± 3 inches in 2017 and 33 ± 4.6 inches in 2018 (Table 6). Mean DAP to 50% bloom was 186 ± 12 days in 2017 and 196 ± 14 days in 2018. 'Bates', 'Florida 101', 'Maton' and 'Wrens Abruzzi' bloomed early making them more compatible for interseeding into a warm season grass forage base because earlier blooming cultivar allows for a quicker spring recovery.

Table 5. Mean values and standard deviations for field emergence of emergence groups (see below) of cereal rye cultivars at 7, 14, 21 and 28 days after planting in 2016-2017. USDA-NRCS Booneville, AR.

Cultivar	Days after planting							
	7		14		21		28	
	2016	2017	2016	2017	2016	2017	2016	2017
Aroostock	2[1/]	3	3	3	3	3	3	3
Bates	2	3	3	3	3	3	3	3
Brasetto	2	3	2.8	3	2.8	3	2.8	3
Elbon	2	3	3	3	3	3	3	3
FL 101	2	3	3	3	3	3	3	3
Guardian	2	3	2.3	3	3	3	3	3
Hazlet	2	3	3	3	3	3	3	3
Maton	2	3	3	3	3	3	3	3
Maton II	2	3	3	3	3	3	3	3
Merced	2	3	3	3	3	3	3	3
Oklon	2	3	3	3	3	3	3	3
Rymin	2	3	3	3	3	3	3	3
Wheeler	2	3	3	3	3	3	3	3
Wintergrazer 70	2	3	3	3	2.8	3	2.8	3
Wren Abruzzi	2	3	2.8	3	2.8	3	2.8	3
Mean	2	3	2.9	3	2.9	3	2.9	3
SD[/2]			0.28		0.22		0.22	

[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 6. 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 Booneville, AR.

Cultivar	% Winter hardiness		Plant height (in.)		DAP to 50% bloom	
	2017	2018	2017	2018	2017	2018
Aroostock	97	100	27	32	196	190
Bates	97	100	31	31	169	183
Brasetto	100	100	25	32	196	216
Elbon	100	100	31	34	196	190
FL 101	35	100	32	27	169	180
Guardian	75	100	32	39	196	215
Hazlet	99	100	25	36	196	215
Maton	97	100	31	33	169	187
Maton II	100	100	33	35	196	187
Merced	32	100	23	25	196	180
Oklon	98	100	31	34	181	192
Rymin	38	100	26	36	196	215
Wheeler	99	99	30	30	196	196
Wintergrazer 70	91	91	31	31	181	181
Wren Abruzzi	100	100	30	30	169	169
Mean	84	99	29	33	186	196
SD[1/]	26		3	4.6	12	14

[1/]SD - Standard deviation.

Crimson Clover

Mean percent field emergence was good to excellent for crimson clover cultivars except for early 2016 (Table 7). The slow seedling emergence was probably related to limited soil moisture at planting, but field emergence quickly improved after the plots received supplemental irrigation approximately one week after planting, producing vigorous seedlings prior to the first killing frost. Crimson clover is recognized as the standard for all clover comparisons in Arkansas and has exceptional seedling vigor (Phillip et al., 2013). 'AU Sunup' was slow to emerge both years but achieved good to excellent stands thereafter. Mean percent winter hardiness was 95 ± 10% in 2017 and 88 ± 18% in 2018 (Table 8). 'AU Sunup' exhibited slight winter damage in 2018 while the other cultivars displayed outstanding percent winter hardiness both years. Plant height was similar among cultivars with a mean plant height of 19 ± 3 inches in 2017 and 18 ± 5 inches in 2018 (Table 8). Mean days after planting to 50% bloom was 188 ± 10 days in 2017 and 196 ± 14 days in 2018 (Table 8). 'Dixie' and 'Tibbee' are recognized as the standard cultivars for forage in Arkansas (Philipp et al., 2013); however, 'Kentucky Pride', 'AU Sunrise', 'AU Robin' and 'Contea' may have similar attributes and could provide a broader selection of crimson clover cultivars for the southern Ozarks. Additional comparative trials are needed to verify areas of adaptation of these cultivars in other regions of Arkansas where crimson clover is grown for cool season forage, cover cropping and other conservation plantings.

Table 7. 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 Booneville, AR.

Cultivar	Days after planting							
	7		14		21		28	
	2016	2017	2016	2017	2016	2017	2016	2017
AU Robin	0.5[1/]	3	3	3	3	3	3	3
AU Sunrise	0.8	2.5	3	3	3	3	3	3
AU Sunup	0.3	0.8	2	2.5	3	2.5	3	2.5
Contea	0.8	2.3	3	3	3	3	3	3
Dixie	0.8	3	3	3	3	3	3	3
Kentucky Pride	0.8	3	3	3	3	3	3	3
Mean	0.6	2.4	2.8	2.9	3	2.9	3	3
SD[/2]	0.5	0.9	0.4	0.3		0.3		

[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 8. 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 Booneville, AR.

Cultivar	% Winter hardiness		Plant height (in.)		DAP to 50% bloom	
	2017	2018	2017	2018	2017	2018
AU Robin	78	89	18	17	196	205
AU Sunrise	97	96	21	17	180	205
AU Sunup	97	66	14	12	169	198
Contea	99	90	20	19	190	209
Dixie	100	92	16	21	196	210
Kentucky Pride	100	95	19	25	196	217
Mean	95	88	19	18	188	207
SD[1/]	10	18	3	5	10	6

[1/]SD - Standard deviation.

Hairy Vetch

Hairy vetch cultivars had poor early field emergence in 2016 and 2017 but had good to excellent field emergence after 14 days (Table 9). The cultivars also exhibited outstanding winter hardiness both years (Table 10), which is one of the many attributes of hairy vetch (Clark, 2012). Plant height varied among cultivars and was similar between years with 19 ± 4 inches in 2017 to 22 ± 5 inches in 2018 (Table 10). Mean DAP to 50% bloom was 192 ± 8 days in 2017 and 219 ± 12 days in 2018. Lana woollypod vetch reached 50% bloom 22 and 30 days sooner than the other hairy vetch cultivars in 2017 and 2018. As an early blooming vetch, Lana may be beneficial as a nitrogen producing cover crop for corn (*Zea mays* L.) and vegetable production systems in Arkansas (Andersen, 2009; Ross et al., 2018).

Table 9. 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 Booneville, AR.

Cultivar	Days after planting							
	7		14		21		28	
	2016	2017	2016	2017	2016	2017	2016	2017
CCS Groff	0	0	3	3	3	3	3	3
Lana	0	0	2	2.3	3	3	3	3
Purple Bounty	0	0	2.3	3	3	3	3	3
Purple Prosperity	0	0	2	3	3	3	3	3
TNT	0	0	2	3	3	3	3	3
Villana	0	0	3	3	3	3	3	3
Mean			2.4	2.9				
SD[/2]			0.5	0.3				

[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 10. 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 Booneville, AR.

Cultivar	% Winter hardiness		Plant height (in.)		DAP to 50% bloom	
	2017	2018	2017	2018	2017	2018
CCS Groff	98	100	14	25	196	226
Lana	100	97	23	12	174	194
Purple Bounty	95	100	14	21	196	222
Purple Prosperity	98	100	21	22	195	222
TNT	100	100	20	25	196	226
Villana	100	100	21	25	196	229
Mean	98	99	19	22	192	219
SD[1/]	5		4	5	8	12

[1/]SD - Standard deviation.

Daikon Radish

Percent field emergence of daikon radish cultivars were consistently good to excellent both years, except for 'Graza' (Table 11). Graza was inconsistent in performance ranging from poor early emergence followed by moderate to good field emergence thereafter in 2017 and 2018. There was considerable variation in percent winter hardiness among cultivars (Table 12). Radishes are tolerant of light frosts but generally show injury when temperatures drop below the mid-20s but overwintering of plants is not uncommon with mild winters or snow cover (Gruver et al., 2017). Varieties with partial tuber exposure were partially or completely winterkilled (Table 12). According to Robert et al. (2015a), radishes with tubers 3 to 4 inches above the soil surface are prone to winterkill in Arkansas. 'Concorde', 'Control', 'Defender' and Graza showed varying degrees of winter hardiness in 2017 with Graza showing the greatest % winter hardiness both years (75% and 58%). It is anticipated less winter damage occurred to these cultivars because the plants remained in a rosette stage and close to the soil surface where they were less exposed to winter damage (Gruver et al., 2017). Plant height and DAP to 50% bloom were similar among cultivars (Table 12). Although the surviving plants exhibited low plant vigor and foliar diseases, they produced seed in late April and early May. Volunteer seedlings were observed the following year in the fallowed areas where the trial was previously conducted in 2016-2017.

Red Clover

Red clover cultivars were slow to emerge in 2016, likely related to dry conditions (Table 13). Irrigating a week after planting greatly improved field emergence 14, 21 and 28 DAP in 2016. Field emergence was good to excellent for all cultivars at 7, 14, 21, and 28 DAP in 2017. All cultivars had 100% winter hardiness in 2017 and very favorable winter hardiness in 2018 (86 ± 16%) (Table 14). Philipp et al. (2013) stated that red clover had excellent cold tolerance in Arkansas but will not survive the hot summers in southern Arkansas. Mean plant height was 20 ± 2.5 inches in 2017 and 23 ± 2 inches in 2018. Mean DAP to 50% bloom was 192 ± 5 days in 2017 to 232 ± 8 days in 2018 (Table 14).

Table 11. 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 Booneville, AR.

Cultivar	Days after planting							
	7		14		21		28	
	2016	2017	2016	2017	2016	2017	2016	2017
Big Dog	2[1/]	3	3	3	3	3	3	3
Concorde	2	3	3	3	3	3	3	3
Control	2	3	3	3	3	3	3	3
Defender	2	3	3	3	3	3	3	3
Driller	2	3	2.5	3	3	3	3	3
EcoTill	2	3	3	3	3	3	3	3
Graza	0.8	0	2	0.3	2.3	1	2.3	1
Groundhog	2	3	3	3	3	3	3	3
Lunch	2	3	3	3	3	3	3	3
Nitro	2	3	3	3	3	3	3	3
Sodbuster	2	3	3	3	3	3	3	3
Tillage	2	3	2.8	3	3	3	3	3
Mean	1.9	2.8	2.9	2.8	2.9	2.8	2.9	2.8
SD[2/]	0.4	0.8	0.4	0.8	0.2	0.6	0.2	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 12. Percent winter hardiness, plant height and days after planting to 50% bloom for daikon radish sources in 2017 and 2018 at the USDA-NRCS Booneville, AR.

Cultivar	% Winter hardiness		Plant height (in.)		DAP to 50% bloom	
	2017	2018	2017	2018	2017	2018
Big Dog	0	0				
Concorde	27	2	25	NDC[/1]	188	
Control	18	0	24		188	
Defender	26	0	24		188	
Driller	0	0				
EcoTill	8	0	NDC		NDC	
Graza	75	58	27		181	
Groundhog	0	0				
Lunch	0	0				
Nitro	0	0				
Sodbuster	0	0				
Tillage	0	0				

[1/] No data collected

Table 13. 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 Booneville, AR.

Cultivar	Days after planting							
	7		14		21		28	
	2016	2017	2016	2017	2016	2017	2016	2017
Cinnamon Plus	0.8	3	2.8	3	2.8	3	3	3
Cyclone II	0.5	2.2	1.8	3	3	3	3	3
Dynamite	1	3	2.5	3	3	3	3	3
Freedom	0.5	2.8	1.5	3	2.8	3	2.8	3
Kenland	0.3	2	2.2	3	3	3	3	3
Mammoth	0.8	2.5	2.5	3	2.8	3	2.8	3
Starfire II	0.8	2	2.8	3	3	3	3	3
Wildcat	0.8	3	2.5	3	3	3	3	3
Mean	0.7	2.6	2.3		2.9		2.9	
SD[/2]	0.5	0.6	0.6		0.2		0.2	

Table 14. 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 Booneville, AR.

Cultivar	% Winter hardiness		Plant height (in.)		DAP to 50% bloom	
	2017	2018	2017	2018	2017	2018
Cinnamon Plus	100	76	20	25	194	229
Cyclone II	100	80	20	25	196	229
Dynamite	100	86	21	22	194	230
Freedom	100	87	21	22	196	231
Kenland	100	79	21	24	196	230
Mammoth	100	80	14	21	194	254
Starfire II	100	88	20	24	188	230
Wildcat	100	85	21	23	188	232
Mean	100	86	20	23	192	232
SD[1/]		16	2.5	2	5	8

[1/]SD - Standard deviation.

Austrian Winter Pea

Austrian winter pea cultivars had poor to moderate early field emergence in 2016 and 2017, but good to excellent emergence thereafter (Table 15). The cultivars likely benefitted from the supplemental irrigation received after planting in 2016 compared to September 2017 when soil moisture was likely not a limiting factor for germination and emergence. Percent winter hardiness varied among cultivars (Table 16). Clark (2007) reported winter damage to winter peas can occur at 10° F. Temperatures below 10° F occurred in December 2016 (9° F) - January 2017 (7° F) and 5° F in January 2018 (fig. 2). Despite the low temperatures in 2016-2017, 'Survivor 15' and 'Windham' had very good winter survival but lacked the same winter hardiness in 2018 (Table 16). 'Whistler' and 'Lynx' exhibited the highest winter hardiness in 2018 but the surviving plants did not have the density and coverage to be effective for soil conservation.

Table 15. 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 Booneville, AR.

Cultivar	Days after planting							
	7		14		21		28	
	2016	2017	2016	2017	2016	2017	2016	2017
Arvica 4010	0	1.8	3	3	3	3	3	3
Dunn	0	1.5	2.8	3	3	3	3	3
Frost Master	0	1.3	2.3	3	3	3	3	3
Lynx	0	1.5	2.5	3	3	3	3	3
Maxum	0	1.3	2.5	3	3	3	3	3
Survivor 15	0	0	3	0.8	3	0.8	3	0.8
Whistler	0	1.8	2.3	3	3	3	3	3
Windham	0	1.8	2.5	3	3	3	3	3
Mean		1.3	2.6	2.7	3	2.7	3	2.7
SD[/2]		0.7	0.2	0.9		0.9		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 16. 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 Booneville, AR.

Cultivar	% Winter hardiness		Plant height (in.)		DAP to 50% bloom	
	2017	2018	2017	2018	2017	2018
Arvica 4010	0	0				
Dunn	0	0				
Frost Master	41	24	20		197	
Lynx	0	54				
Maxum	0	2				
Survivor 15	86	0	20		189	
Whistler	0	62				
Windham	92	34	19		197	

CONCLUSIONS

Choosing the best adapted annual, cool season grass or legume cultivar(s) is the first step to a successful planting as a cover crop to improve soil health or protect the soil from erosion, provide forage for livestock or develop wildlife habitat. 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 and varieties for conservation plantings in the southern Ozarks. Most species and cultivars showed good performance and 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 (Roberts, 2015b) and livestock forage (Beck et al., 2013) to further describe their productivity and adaptation in the region.

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