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James E. "Bud" Smith Plant Materials Center
Knox City, Texas

Adaptation of Cool Season Commercial Cover Crop Cultivars and Source Cultivars in North-Central Texas and Southwestern Oklahoma

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ABSTRACT

Cool season, annuals provide multiple benefits to production agriculture when planted as a cover crop such as controlling soil erosion, weed suppression, adding nitrogen, increasing soil organic matter and other soil health improvements. 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, coo1 season species for their adaptation to North-Central Texas and Southwestern Oklahoma. 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 James E. "Bud" Smith Plant Materials Center in Knox City, Texas in 2016-2017 and 2017-2018. All cultivar and source cultivars emerged within the first 28 DAP except two cultivars of Austrian winter pea ('Dunn' and 'Arvica 4010'). All source cultivars of daikon radish winterkilled each year. Differences in maturity, height, and disease vulnerability were noticed in cereal rye, hairy vetch, crimson clover, and red clover cultivars. Additional information is needed on biomass production of best preforming cultivars to maximize their use as a cover drop to further characterize their adaptation.

INTRODUCTION

Incorporating cover crops into a cropping system improves soil health, conserves energy, builds resilience and manages climate risk (Lal, 2004; Reicosky and Forcella, 1998; Hargrove, 1986; Reeves, 1994). Cover crops can be leguminous or non-leguminous. Leguminous cover crop species provide a nitrogen source for subsequent commodity crops (Singh et al., 2004; Smith et al., 1987). Non-leguminous cover crops, such as small grains, are effective in reducing nitrate leaching and for soil erosion (Meisinger et al., 1991). Utilizing a mix of leguminous and non-leguminous cover crop species can provide multiple benefits. While cover crops provide numerous agronomic and environmental benefits, these benefits are not fully achieved unless cover crop cultivars and source cultivars are planted that meet the objective of the cover crop planting and the producer's expectations.

The objective of this evaluation is to evaluate growth characteristics and production attributes of commercially available cultivars and sources of selected cover crops identified by NRCS State agronomists/soil health specialists and PMC staff. This study will also provide cover crop

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adaptation and growth data of different cover crops for North-Central Texas and southern Oklahoma.

MATERIALS AND METHODS

The study was conducted at the USDA-Natural Resources Conservation Service James E. "Bud" Smith Plant Materials Center (PMC) in Knox City, Texas in 2016-2017 and 2017-2018. Annual, cool seasons cover crop cultivars and source cultivars included in the study and seeding rates are listed in Table 1. Target seeding rates were standardized based on pure live seeds (PLS) per square foot, so actual pounds per acre seeding rates were adjusted accordingly for the seed size (seeds per pound) and purity/germination of each seed lot.

Table 1. Species, cultivars and seeding rates of annual cool seasons planted in 2017 and 2018 at the USDA NRCS James E. "Bud" Smith Plant Materials Center, Knox City, TX.

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

Table 1 (cont.). Species, cultivars and seeding rates of annual, cool seasons planted in 2017 and 2018 at the USDA NRCS James E. "Bud" Smith 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 soil type at the PMC was a Miles fine sandy loam. Soil tests in 2016 and 2017 showed a pH of 7.9 and 8.2. The study was fertilized with 60 lb N/acre and 40 lb P/acre before planting and disked in to achieve medium fertility. Plots did not receive supplemental irrigation during the trial. In general, the 2016-2017 season in Knox City was about average and the 2017-2018 season was dryer than average (Figure 1). Total precipitation for the October through June growing season was 16 inches in 2016-2017, and 10 inches in 2017-2018, compared to an average of 17 inches.

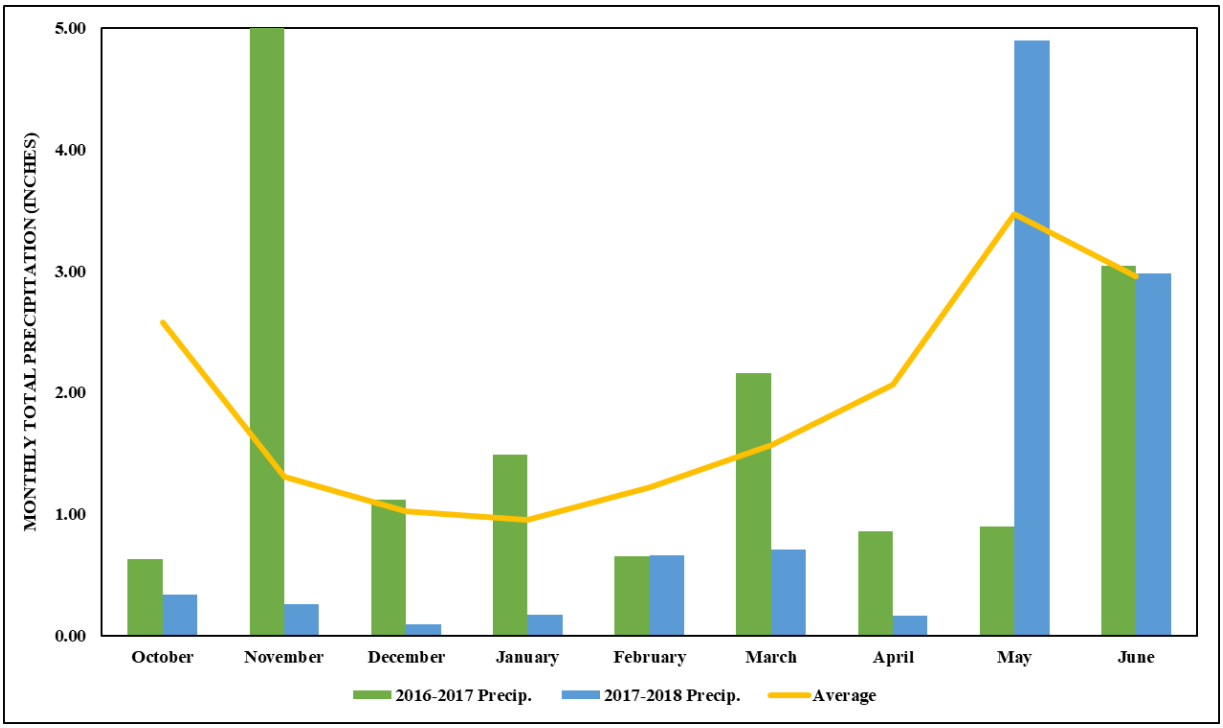

Figure 1. Monthly rainfall during 2016-2017 and 2017-2018 and 43-year Normal (average) data at the Knox City Plant Materials Center, Knox City, Texas.

Fields were disked and rolled in June each year to create a firm, well-prepared seedbed. All legume seeds were inoculated with the appropriate rhizobia prior to planting. The 1 row x 25-ft plots were drill seeded on 4 October 2016 and 11 October 2017 using a Kincaid cone planter (Kincaid Equipment Manufacturing Corp., Haven, KS) on 40-inch row spacing. Weeds were controlled by hand rouging as needed to reduce competition for light and nutrients. Plots were terminated following data collection in June 2017 and 2018.

Data Collection

Approximately every 7 days field emergence was estimated 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 any cultivars during the study. Winter survival was evaluated from a 3-ft section of an interior row. 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 to the average absolute height. 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

Oats

Germination and emergence were quick for black oats ('Soil Saver') and black seeded oats ('Cosaque') with 25-65% seven days after planting. The cultivars had greater than 65% fourteen days after planting and above 85% twenty-one days following planting (Table 2). These cultivars both show the potential to provide rapid soil cover.

Table 2. Mean values and standard deviations for field emergence groups (see below) of black seeded oats and blacked oats at 7, 14, 21 and 28 days after planting in 2017-2018. USDA-NRCS Knox City, TX.

	Days after planting							
Cultivar	7		14		21		28	
	2017	2018	2017	2018	2017	2018	2017	2018
Cosaque	1[1/]	1	2	2	3	3	3	3
Soil Saver	1	1	1	2	2	2	2	3
Mean	1	1	1	1	2	2	3	2
SD[2/]			1		1	2	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.

'Soil Saver' winter-killed both years while 'Cosque' had a survival rate of 88% in 2017 and 100% in 2018. It reached 50% anthesis from 202 to 205 DAP with plants reaching a mature height of 10-15 inches (data not shown). both cultivars will germinate and establish before winter, Cosque is the only one that can be used as a full season cover crop.

Cereal Rye

Germination and emergence were quick for most cereal rye cultivars, with good emergence (65-85%) by 21 DAP and good to excellent emergence (>85%) by 28 DAP, except for 'Brasseto', 'Guardian', and 'Merced' which had poor emergence (<25%) by 28 DAP (Table 3). Cool season cover crops that quickly emerge and accumulate fall growth protect the soil from sheet and rill erosion, can suppress problematic weeds, and scavenge residual nutrients from previous crops (Shipley et al., 1992; Matias et al., 2004). Percent winter hardiness ranged from 97 to 76% with a mean of 90 ± 9% (mean and standard deviation) in 2017 and 99 ± 4% in 2018 (Table 4). The mean plant height of the cereal rye cultivars was 42 ± 11 in 2007 and 29 ± 7 in 2018. Mean DAP to 50% bloom was 176 ± 14 in 2017 and 194 ± 8 in 2018. In 2017, all cultivars suffered moderate-heavy leaf rust damage, but was not observed in 2018. No insect damage was noted during the evaluation. Based on these two years of data, Brasetto, Guardian do not appear to be well adapted to our region due to their low germination and emergence as well as vigor, maturity and height compared to the other cereal rye cultivars.

Table 3. Mean values and standard deviations for field emergence groups (see below) of cereal rye cultivars at 7, 14, 21 and 28 days after planting in 2017-2018. USDA-NRCS Knox City, TX.

Cultivar	Days after planting							
	7		14		21		28	
	2017	2018	2017	2018	2017	2018	2017	2018
Aroostock	1[1/]	1	1	2	2	3	3	3
Bates	1	1	2	2	3	3	3	3
Brasetto	1	0	1	0	2	0	3	0
Elbon	1	1	2	1	2	2	3	2
FL 101	1	1	1	1	1	2	2	3
Guardian	1	0	1	0	2	0	2	0
Hazlet	1	1	2	2	3	3	3	3
Maton	1	1	2	2	2	3	3	3
Maton II	1	0	1	0	2	1	2	1
Merced	1	0	1	1	2	1	2	1
Oklon	1	1	2	2	3	3	3	3
Rymin	1	1	2	1	3	2	3	2
Wheeler	1	0	2	0	3	1	3	1
Wintergrazer 70	1	1	2	2	3	2	3	3
Wren Abruzzi	1	1	2	2	2	3	3	3
Mean	1	1	2	2	2	2	3	2
SD[2/]		1	1	1	1	2	1	2

[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 cereal rye cultivars in 2017 and 2018 at the USDA-NRCS Knox City, TX.

Cultivar	% Winter hardiness		Plant height (in.)		DAP to 50% bloom	
	2017	2018	2017	2018	2017	2018
Aroostock	96	100	39	33	168	189
Bates	97	100	55	32	164	196
Brasetto	89	100	25	14	194	204
Elbon	89	98	43	33	168	190
FL 101	76	98	54	29	167	190
Guardian	91	94	29	18	195	204
Hazlet	95	100	28	26	195	201
Maton	90	100	50	37	167	190
Maton II	85	100	51	34	167	189
Merced	81	100	43	28	173	190
Oklon	87	100	44	35	168	187
Rymin	95	100	30	25	195	190
Wheeler	91	100	40	22	190	197
Wintergrazer 70	96	100	47	33	167	197
Wren Abruzzi	90	100	56	37	164	194
Mean	90	99	42	29	176	194
SD[1/]	9	4	11	7	14	8

[1/]SD - Standard deviation.

Austrian Winter Pea

The Austrian winter pea cultivars had good germination and emergence (65-85%) by 21 DAP, and good to excellent emergence (>85%) by 28 DAP (Table 5). Percent winter hardiness ranged from 96 to 90% with a mean of 93 ± 6% (mean and standard deviation) in 2017 and 91 ± 24% in 2018 (Table 6). Winter survival of 'Survivor 15', 'Frost Master', 'Lynx', 'Whistler', and 'Windham' was 90% and higher for 2017 and 2018. 'Maxum' did not survive beyond winter dormancy in 2017 and had only a 33% survival in 2018. The other cultivars ('Dunn'and 'Arvica 4010') did not survive either year. The mean plant height of the winter pea cultivars was 12 ± 2 in 2007 and 10 ± 3 in 2018. Mean DAP to 50% bloom was 202 ± 10 in 2017 and 213 ± 3 in 2018. Survivor 15 and Whistler were the only cultivars that reached maturity at 203 DAP in 2017. In 2018, three cultivars (Survivor 15, Lynx, and Whistler) reached 50% bloom at about 213 DAP. The remaining cultivars failed to flower during the evaluation. In 2017, white powdery mildew (*Erysiphe* spp.) was observed at a moderate level on surviving cultivars (Frost Master, Lynx, Survivor 15, Whistler, and Windham) at greenup and increased as the plants reached 50% bloom, but no significant difference was observed between cultivars. Following two years of evaluation, only a few cultivars of Austrian winter pea shown adapted to the area. While all cultivars did germinate and emerge, only Survivor 15 and Whistler reached maturity. The remaining cultivars may have benefits for soil health but should not be expected to provide season long cover.

Table 5. Mean values and standard deviations for field emergence groups (see below) of winter pea cultivars at 7, 14, 21 and 28 days after planting in 2017-2018. USDA-NRCS Knox City, TX.

	Days after planting							
Cultivar	7		14		21		28	
	2017	2018	2017	2018	2017	2018	2017	2018
Survivor 15	1[1/]	1	2	2	2	3	3	3
Arvica 4010	0	1	1	2	2	3	3	3
Dunn	0	1	2	2	2	3	3	3
Frost Master	0	0	1	2	2	2	3	2
Lynx	0	1	1	1	2	2	3	3
Maxum	0	1	1	2	2	2	3	3
Whistler	1	1	1	2	2	2	3	3
Windham	0	1	1	2	2	2	3	2
Mean	1	1	2	2	2	3	3	3
SD[2/]	1	1	1	1		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 6. Mean values and standard deviations for % winter hardiness, plant height and days after planting to 50% bloom for winter pea cultivars in 2017 and 2018 at the USDA-NRCS Knox City, TX.

Cultivar	% Winter hardiness		Plant height (in.)		DAP to 50% bloom	
	2017	2018	2017	2018	2017	2018
Frost Master	92	98	NDC[2/]	NDC	NDC	NDC
Lynx	96	100	NDC	7	NDC	213
Maxum	NDC	33	NDC	NDC	NDC	NDC
Survivor 15	90	100	12	11	207	215
Whistler	96	100	11	12	198	212
Windham	92	100	NDC	NDC	NDC	NDC
Mean	93	91	12	10	202	213
SD[1/]	6	24	2	3	10	3

[1/]SD - Standard deviation.[2/]No data collected.

Daikon Radish

Daikon radish germination and emergence on most source cultivars reached moderate germination (25-65%) seven days after planting (DAP) in 2017 and 2018 (Table 7). ‘Garza’ was the only source cultivar that had a poor to moderate (<25%) germination and emergence rating after 28 DAP. ‘Big Dog’, ‘Driller’, ‘Goundhog’, ‘Lunch’, ‘Nitro’ and ‘Sodbuster’ reached good to excellent germination and emergence (>85%) ratings by 21 DAP. The remaining source cultivars reached an excellence rating by 28 DAP. Although most were established before first killing frost, zero survival was recorded following winter dormancy. These source cultivars will provide fall and early winter cover and provide soil health benefits but are not adapted to the area as a full season cover crop.

Table 7. Mean values and standard deviations for field emergence groups (see below) of daikon radish at 7, 14, 21 and 28 days after planting in 2017-2018. USDA-NRCS Knox City, TX.

Cultivar	Days after planting							
	7		14		21		28	
	2017	2018	2017	2018	2017	2018	2017	2018
Big Dog	1[1/]	1	2	2	2	3	3	3
Concorde	1	1	1	2	2	2	3	3
Control	1	1	1	2	2	2	3	3
Defender	1	1	1	1	2	2	3	3
Driller	1	1	2	2	3	3	3	3
EcoTill	1	1	1	2	2	2	3	3
Graza	0	0	1	0	1	1	2	1
Groundhog	1	1	2	2	3	2	3	3
Lunch	1	1	2	2	3	3	3	3
Nitro	1	1	2	2	3	3	3	3
Sodbuster	1	1	2	2	3	3	3	3
Tillage	1	1	1	2	2	3	3	2
Mean	1	1	2	2	2	3	3	3
SD[2/]	1	1	1	1	1	1	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.

Crimson Clover

All of the crimson clover cultivars tested had good germination and emergence (65-85%) by 21 DAP. 'AU Sunrise', 'Dixie', 'AU Robin', and 'Kentucky Pride' had good to excellent emergence (>85%) by 28 DAP, while 'AU Sunup' and 'Contea,' were slower and reached >85% emergence after 28 days from planting (Table 8). Percent winter hardiness ranged from 96 to 61% with a mean of 88 ± 19% (mean and standard deviation) in 2017 and 100% in 2018 (Table 9). The mean plant height of the crimson clover cultivars was 11 ± 2 in 2007 and 10 ± 2 in 2018. Mean DAP to 50% bloom was 173 ± 6 in 2017 and 183 ± 8 in 2018. All cultivars of crimson clover had excellent winter hardiness with similar maturity. AU Sunup reached 50% bloom earliest at 166 days after planting. The remaining cultivars matured up to 14 days later.

Table 8. Mean values and standard deviations for field emergence groups (see below) of crimson clover cultivars at 7, 14, 21 and 28 days after planting in 2017-2018. USDA-NRCS Knox City, TX.

Cultivar	Days after planting							
	7		14		21		28	
	2017	2018	2017	2018	2017	2018	2017	2018
AU Robin	1[1/]	1	1	1	2	2	2	2
AU Sunrise	1	1	2	1	3	2	3	3
AU Sunup	0	0	0	0	0	1	1	1
Contea	1	0	2	1	2	1	3	1
Dixie	1	0	2	1	2	1	3	3
Kentucky Pride	1	1	2	1	2	2	3	3
Mean	1	1	1	1	2	2	3	3
SD[2/]	1	1	1	1	1	1	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 9. 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 Knox City, TX.

Cultivar	% Winter hardiness		Plant height (in.)		DAP to 50% bloom	
	2017	2018	2017	2018	2017	2018
AU Robin	96	100	12	11	171	181
AU Sunrise	94	100	11	11	176	187
AU Sunup	61	100	12	8	165	169
Contea	94	100	11	10	178	187
Dixie	95	100	12	10	176	187
Kentucky Pride	87	100	10	7	177	190
Mean	88	100	11	10	173	183
SD[1/]	19		2	2	6	8

[1/]SD - Standard deviation.

Red Clover

The red clover cultivars generally had slow germination and emergence during 2017 and 2018. All cultivars except for 'Starfire II' had <25% germination and emergence 28 DAP in 2017. The other cultivars reached 25-65% germination 28DAP. In 2018, 'Dynamite', 'Freedom', and

'Wildcat' had moderate germination 14 DAP. Starfire II germination and emergence remained <25% 28 DAP in both years (Table 10). Percent winter hardiness ranged from 17 to 66% with a mean of 36 ± 35% (mean and standard deviation) in 2017 and 97 ± 15% in 2018 (Table 11). The low % winter hardiness in 2017 could be attributed to poor germination during the growing season. The mean plant height of the red clover cultivars was 15 ± 4 in 2007 and 6 ± 2 in 2018. The decrease in plant height in 2018 can be attributed to below precipitation during the growing season. Mean DAP to 50% bloom was 201 ± 37 in 2017 and 219 ± 4 in 2018. In 2017, Dynamite reached maturity earlier than the other cultivars at 156 DAP compared to 203-209 DAP for the other cultivars. However, in 2018, all cultivars matured 216-226 DAP.

Table 10. Mean values and standard deviations for field emergence groups (see below) of red clover cultivars at 7, 14, 21 and 28 days after planting in 2017-2018. USDA-NRCS Knox City, TX.

Cultivar	Days after planting							
	7		14		21		28	
	2017	2018	2017	2018	2017	2018	2017	2018
Cinnamon Plus	0[1/]	0	0	0	1	1	1	1
Cyclone II	0	0	0	0	1	1	1	1
Dynamite	0	0	0	1	1	1	1	1
Freedom	0	0	0	1	1	1	1	1
Kenland	0	0	0	0	0	1	1	1
Mammoth	0	0	1	0	1	1	1	1
Starfire II	0	0	0	0	0	0	0	0
Wildcat	0	0	0	0	1	1	1	1
Mean			1	1	1	1	1	1
SD[2/]			1	1	1	1	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 red clover cultivars in 2017 and 2018 at the USDA-NRCS Knox City, TX.

Cultivar	% Winter hardiness		Plant height (in.)		DAP to 50% bloom	
	2017	2018	2017	2018	2017	2018
Cinnamon Plus	66	100	14	7	205	220
Cyclone II	17	98	17	6	208	216
Dynamite	39	97	13	6	156	216
Freedom	31	100	15	6	209	217
Kenland	24	97	18	6	206	217
Mammoth	47	100	15	3	209	226
Starfire II	31	80	16	6	208	220
Wildcat	66	100	14	7	205	220
Mean	36	97	15	6	201	219
SD[1/]	35	15	4	2	37	4

[1/]SD - Standard deviation.

Balansa Clover

The Balansa clover cultivars failed to germinate and emerge during the 2017 growing season. In 2018, both were relatively slow to germinate and emerge. 'Fixation' had a moderate germination by 28 days after planting, while 'Frontier' remained poor (Table 12). Both cultivars did continue to emerge and had high survival following winter dormancy at 100% for Frontier and 89% for Fixation (Table 13). Frontier reached 50% bloom 172 days after planting and Fixation matured at 184 days after planting. Although both cultivars show to be adapted to the area, their slow germination and emergence may be a disadvantage when competing for moisture and nutrients from weeds or in cover crop mixes.

Table 12. Mean values for field emergence groups (see below) of balansa clover cultivars at 7, 14, 21 and 28 days after planting in 2018. USDA-NRCS Knox City, TX.

	Days after planting			
Cultivar	7	14	21	28
CCS Groff	0[1/]	0	1	1
Lana	0	0	0	0
Mean			1	1

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

Table 13. Mean values for % winter hardiness and days after planting to 50% bloom for balansa clover cultivars in 2018. USDA-NRCS Knox City, TX.

Cultivar	% Winter Hardiness	DAP to 50% bloom
CCS Groff	100	184
Lana	89	172
Mean	95	178
SD[1/]	12	2

[1/] SD- Standard deviation.

Hairy Vetch

Most of the hairy vetch cultivars had moderate to good emergence (25-85%) by 14 DAP and good to excellent emergence (>85%) by 28 DAP. 'Purple Prosperity' rated poor (<25%) at 14 DAP, but by 28 DAP had a moderate to good rating. 'Lana' reached greater than 85% emergence by 21 DAP (Table 14). Percent winter hardiness ranged from 100 to 87% with a mean of 96 ± 5% (mean and standard deviation) in 2017 and 100% 2018 (Table 15). The mean plant height of the hairy vetch cultivars was 20 ± 6 in 2007 and 20 ± 3 in 2018. In 2017, TNT grew tallest at 25 inches while Lana only grew 15 inches. Lana recorded the tallest mature foliage at 24 inches in 2018 while CCS Groff only grew 17 inches. Mean DAP to 50% bloom was 187 ± 17 in 2017 and 194 ± 14 in 2018. Lana was the first to reach 50% bloom at 166 DAP, while TNT and Villana matured 202-208 DAP. The other cultivars reached maturity 187-194 DAP. The differences in hairy vetch cultivars must be considered when planning and managing a cover crop planting.

Table 14. Mean values and standard deviations for field emergence groups (see below) of hairy vetch cultivars at 7, 14, 21 and 28 days after planting in 2017-2018. USDA-NRCS Knox City, TX.

Cultivar	Days after planting							
	7		14		21		28	
	2017	2018	2017	2018	2017	2018	2017	2018
CCS Groff	0[1/]	0	1	1	2	1	2	2
Lana	0	1	2	2	3	2	3	3
Purple Bounty	0	0	1	1	1	1	2	2
Purple Prosperity	0	0	1	0	2	1	2	2
TNT	0	0	2	1	2	2	3	2
Villana	0	0	1	2	2	2	2	3
Mean		1	2	1	2	2	2	3
SD[2/]		1	1	1	1	1	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 15. 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 Knox City, TX.

Cultivar	% Winter hardiness		Plant height (in.)		DAP to 50% bloom	
	2017	2018	2017	2018	2017	2018
CCS Groff	96	100	23	17	191	194
Lana	100	100	15	24	164	168
Purple Bounty	89	100	21	20	182	194
Purple Prosperity	98	100	16	18	176	193
TNT	93	100	25	22	202	206
Villana	97	100	20	18	208	206
Mean	96	100	20	20	187	194
SD[1/]	5		6	3	17	14

[1/]SD - Standard deviation.

CONCLUSION

Choosing the best adapted cover crop is the first step to a successful cover crop planting. Based on two years of data from commercially available cereal rye, crimson clover, red clover, Austrian winter pea, hairy vetch, balansa clover, and black oats and black seeded oats provided beneficial information on best adapted cultivars and varieties for North-Central Texas and southwestern Oklahoma. Many cultivars survived and matured throughout the evaluation, but others died before winter dormancy ended. Selecting cultivars with common regrowth, maturity, and height helps growers and conservationists when planning and managing cover crop plantings to address resource concerns and achieve individual goals. 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.

LITERATURE CITED

Hargrove, W.L. 1986. Winter legumes as a nitrogen source for no-till grain sorghum. Agron. J, 78:70-74.

Lal, R. 2004. Soil carbon sequestration impacts on global climate change and food security. Sci.: 304 no. 5677 pp. 1623-1627.

Matias, R.L., D.G. Bullock and G.A. Bollero. 2004. Soybean yield as affected by biomass and nitrogen uptake of cereal rye in winter cover crop rotation. Agron. J 96:800-805.

Meisinger, J.L., W.L. Hargrove, R.L. Mikkelsen, J.R. Williams, and V.W. Benson. 1991. Effects of cover crops on groundwater quality. *In* Cover Crops for Clean Water; W.L. Hargrove: Soil Water Conserv. Soc., Ankeny, IA p 9-11.

Reeves, D.W. 1994. Cover crops and rotations. pp 125-172. *In* J.L. Hatfield and B.A. Stewart (eds). Advances in Soil Science; Crops and Residue Management. Lewis Publishers, CRC Press Inc., Boca Raton, FL.

Reicosky, D.C. and F. Forcella. 1998. Cover crop and soil quality interactions in agroecosystems. J. Soil and Water Conserv. p. 224-229.

Shipley, P.R., J.J. Meisinger, and A.M. Decker. 1992. Conserving residual corn fertilizer nitrogen with winter cover crops. Agron. J. 84:869-876.

Singh, Y., B. Singh, J.K. Ladha, C.S. Khind, R.K. Gupta, O.P. Meelu, and E. Pasuquin. 2004. Long-term effects of organics inputs on yield and soil fertility in the rice-wheat rotation. Soil Sci. Soc. of Amer. Journal, 68: 845-853.

Smith, M.S., W.W. Frye, and J.J. Varco. 1987. Legume winter cover crops. Advances in Soil Sci., 7:95-139.

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