



Screening and Evaluation of Full-season Annual Forage Species in the Missouri Coteau Region of North Dakota

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Annual species can be used in forage production systems in the Missouri Coteau region. Annual forages add flexibility to row crop and livestock production. When a forage shortage or weather-limited row crop production occurs, annual crops can be harvested as high-quality forages by haying or grazing.

Annual forage species also can be used as cover crops to increase agricultural sustainability by improving soil fertility and quality; controlling soil water and wind erosion; suppressing weeds, pests and diseases; and increasing biodiversity and wildlife habitat.

In this study, annual legumes, warm-season grasses, cool-season grasses and brassicas were screened and evaluated in an extensively designed field trial. The information generated can be used for species selection for different management objectives.

Summary

Weed control is necessary for all annual forage species if weed pressure is high due to tillage and the weed seed bank. In this study, the species most competitive with common weeds (and without herbicide application) were forage pea, foxtail millet, oat and hybrid brassica from the legumes, warm-season grasses, cool-season grasses and brassicas, respectively. No-till with pre-planting glyphosate application, crop rotation and late seeding for annual warm-season grasses and legumes could be used to control the common weeds such as foxtails and pigweeds.

For full-season production, berseem clover, chickling vetch, peas and soybean are the promising annual legumes. Foxtail millet, sorghum and sorghum-sudan performed the best of the annual warm-season grasses. Barley, oat and triticale are the promising annual cool-season grasses, and among the brassicas, cabbage and radish produced well. The variability in all the species we screened and evaluated gives producers options for their management objectives.

Introduction

Interest in annual forage species has increased among agricultural producers in the Missouri Coteau region. Annual forage species can be used in row cropping systems to produce high-quality forages (McCartney et al., 2008; McCartney et al.,

2009; McCartney and Fraser, 2010; Hansen et al., 2013). Due to their different phenology, annual forages can provide increased flexibility to agricultural production systems.

For example, in this region, a forage shortage is likely due to the conversion of grasslands to croplands, and annual forage species can be planted in the row cropping system to overcome this shortage. By doing so, switching back to row crop production is easy in a year-by-year manner.

Spring seeding in the last two years in the Missouri Coteau region was delayed due to the late spring and/or wet soils. A delayed seeding season could harm the cash crop production, and an alternative is to plant late-season annual forages.

Annual forage species include annual legumes (McCartney and Fraser, 2010) such as soybean (Sheaffer et al., 2001), peas and beans (Fraser et al., 2001); annual warm-season grasses (McCartney et al., 2009) such as sorghum (Jahanzad et al., 2013) and pearl millet (Rostamza et al., 2011); annual cool-season grasses (McCartney et al., 2008) such as barley (Nakano et al., 2013), oat (Coblentz et al., 2011) and triticale (Cazzato et al., 2011); annual brassicas (McCartney et al., 2009) such as rape (Keogh et al., 2011) and turnip (Neilsen et al., 2008). Different groups of annual forage species have different growth habits and agronomic requirements. Even within each group, wide variation occurs in species production and seasonality.

A monoculture or a mixture of annual forage species also can be used as cover crops (Hansen et al., 2013). Cover crops are known to provide agricultural sustainability by improving soil health, controlling erosion, suppressing weeds, pests and diseases; increasing biodiversity; and improving habitat for wildlife. However, information about annual forage species selection for a specific management objective is often anecdotal and incomplete. Therefore, we initiated this field trial to study annual forage species extensively. Weed suppression potential, weed control practices, species performance and species production seasonality were studied.

Procedures

The study was carried out at the Central Grasslands Research Extension Center from 2011 through 2013. Thirteen species/cultivars of annual legumes, warm-season grasses and cool-

season grasses, as well as nine species/cultivars of annual brassicas, were seeded in mid-May 2011 (Table 1). Each of these species/cultivars was drilled into field plots that were prepared by disking and harrowing. Each plot was 20 by 20 feet. For the 2011 seeding, neither fertilizer nor herbicides were applied to study the forage species' weed-suppression potential with low agronomic input.

In 2012, 13 species/cultivars (Table 1) were seeded in mid-May with four different herbicide application protocols. Each of these species/cultivars was no-till drilled into 20- by 5-foot plots. Herbicide application treatment A was a pre-plant glyphosate burn-down, treatment B was A plus a pre-germination glyphosate burn-down, Treatment C was A plus a post-emergence herbicide application, and treatment D was B plus a post-emergence herbicide application.

For annual legumes, Pursuit (imazethapyr) and Volunteer (clethodim) were used as post-emergence herbicides to control broadleaf and grass weeds, respectively. For annual warm-season and cool-season grasses, Detonate (diglycolamine salt of dicamba) was used as a post-emergence herbicide to control broadleaf weeds. Volunteer and Stinger (clopyralid) were used as post-emergence herbicides to control grass and broadleaf weeds for annual brassicas, respectively.

In 2013, 26 species/cultivars within all four groups were seeded. Annual cool-season grasses and annual brassicas were seeded in mid-May, while annual legumes and annual warm-season grasses were seeded in the early part of June. Each of these species/cultivars was no-till drilled into field plots. Each plot was 20 by 10 feet.

Pre-planting glyphosate was used to burn down all weeds two to three days before planting. Pre-emergence glyphosate also was used for some plots if weeds were apparent. Urea was applied at 56 pounds of nitrogen (N)/acre for all groups of species, and potash and superphosphate were applied at 20 pounds of potassium (K) and phosphorus (P)/acre for annual legumes.

Each plot was visually evaluated for seeded species establishment. The establishment scale was: failed (no seedlings of seeded species and covered by weeds), poor (sparse seedlings of seeded species and covered by weeds at least 50 percent), fair (regularly spaced seedlings of seeded species and covered by weeds at most 50 percent) and excellent (dense seedlings of seeded species and covered by weeds at most 25 percent). Each plot was harvested at the pod-filling stage for legumes, soft dough stage for grasses and purple-leaf stage for brassicas. Oven-dried subsamples were used to calculate forage production on a dry-matter basis.

Results

Seeded in 2011 with tillage and without any herbicide application, forage pea, foxtail millet, oat and hybrid brassica were the most successful species within their corresponding groups with respect to competition with common weeds (Tables 1 – 4). In 2012, four treatments of herbicide application were used with no-till seeding technology. The weed pressure was much less even with the pre-plant glyphosate application alone (Tables 1 – 4). In 2013, weed control was successful with no or minimal weed problems.

For full-season production, berseem clover (0.84 tons/acre), chickling vetch (0.41 tons/acre), peas (0.81 tons/acre) and soybean (0.42 tons/acre) were the most productive legumes (Table 5). The best warm-season grasses were foxtail millet (0.55 tons/acre), pearl millet (0.53 tons/acre), proso millet (0.75 tons/acre), sorghum (0.94 tons/acre), sudangrass (1.04 tons/acre) and sorghum-sudan (1.09 tons/acre) (Table 6). Barley (0.64 tons/acre), oat (0.42 tons/acre) and triticale (0.42 tons/acre) were the most productive cool-season grasses (Table 7). Cabbage (2.52 tons/acre), rape (2.14 tons/acre) and radish (3.27 tons/acre) were the most productive brassicas (Table 8).

Discussion

Weed control is necessary for all annual forage species if weed pressure is high due to tillage and the weed seed bank. Unfortunately, that was the case for our trial in 2011.



We disked and harrowed the plots before they were seeded. Tillage disturbs soil and favors weed germination. The weed seed banks in this area include foxtails, barnyard grass, wild barley, pigweeds, kochia and lamb's quarters. No-till with pre-planting glyphosate application helps suppress the common weeds in this region.

Furthermore, crop rotation (grass – broadleaf – grass rotation) can smother the broadleaf weeds in the grass plots, as well as the grass weeds in the broadleaf plots, with post-emergence herbicide application to control them.

Late seeding for annual warm-season grasses and legumes not only fits their warmer seedbed requirement (as compared with the cool-season grasses and brassicas) but also is beneficial for controlling the common weeds such as foxtails and pigweeds. These weeds germinate later and can be sprayed with glyphosate pre-planting. For the early seeded species, their competitive potential in the early season gives them a chance to suppress the common weeds.

We had a dry summer in 2013 (see page 48), and all the yields were low and the cool-season grasses were short. In comparison, because annual warm-season grasses are more drought-tolerant than cool-season grasses, they were a little more productive than the cool-season grasses. Surprisingly, annual brassicas were short and water-stressed in the early season. However, with rainfall in late August and early September, their regrowth was apparent and promising.

No simple recommendation is available for species selection. It depends on the management objectives and weather patterns. What we can do is study the diverse species pools to present different options in different situations.

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Table 1. Full-season annual legume species/varieties screened and evaluated at the CGREC in 2011—2013.

Common name	Latin Name	Seeding Year ¹	Variety ²	Seeding Rate ³	Establishment ⁴
Arrowleaf clover	<i>Trifolium vesiculosum</i> Savi	2012	Yuchi	21.81	NA
		2013	Yuchi	21.81	Excellent
Berseem clover	<i>Trifolium alexandrinum</i> L.	2011	VNS	17.01	Fair
		2012	VNS	21.81	NA
		2013	VNS	30.53	Excellent
Chickling vetch	<i>Lathyrus sativus</i> L.	2011	AC Greenfix	69.78	Fair
		2012	AC Greenfix	65.42	NA
		2013	AC Greenfix	87.22	Excellent
Common vetch	<i>Vicia sativa</i> L.	2012	VNS	39.25	NA
		2013	VNS	61.06	Fair
Cowpea	<i>Vigna unguiculata</i> (L.) Walp.	2011	Chinese Red	52.33	Poor
		2012	Iron & Clay	56.70	NA
		2013	Chinese Red	61.06	Fair
		2013	Iron & Clay	61.06	Fair
Crimson clover	<i>Trifolium incarnatum</i> L.	2011	VNS	19.97	Fair
		2012	VNS	30.53	NA
		2013	VNS	39.25	Excellent
Fava bean	<i>Vicia faba</i> L.	2011	VNS	162.24	Poor
Hairy vetch	<i>Vicia villosa</i> Roth	2011	Purple Bounty	32.32	Fair
		2012	Purple Bounty	39.25	NA
		2013	Purple Bounty	61.06	Excellent
Joint vetch	<i>Aeschynomene americana</i> L.	2013	VNS	69.78	Failed
Lablab bean	<i>Lablab purpureus</i> (L.) Sweet	2013	Rongiu	87.22	Fair
Lentil	<i>Lens culinaris</i> Medikus	2011	Indianhead	38.72	Fair
		2013	Indianhead	43.61	Excellent
Mung bean	<i>Vigna radiate</i> (L.) R. Wilczek	2011	VNS	48.50	Poor
Pea	<i>Pisum sativum</i> L.	2011	4010	82.47	Excellent
		2011	Austrian winter	58.92	Excellent
		2012	4010	91.59	NA
		2012	Austrian winter	91.59	NA
		2012	Midas	130.84	NA
		2013	4010	161.37	Excellent
		2013	Austrian winter	161.37	Excellent
		2013	Cruiser	161.37	Excellent
		2013	DS-Admiral	161.37	Excellent
		2013	Flex	161.37	Excellent
		2013	Majoret	161.37	Excellent
		2013	Mystique	161.37	Excellent
		2013	Perfection 326	161.37	Excellent
2013	Vegas	161.37	Excellent		
2013	Viper	161.37	Excellent		
Persian clover	<i>Trifolium resupinatum</i> L.	2011	Mihi	6.98	Fair
		2012	Mihi	21.81	NA
		2013	Mihi	13.08	Excellent
Soybean	<i>Glycine max</i> (L.) Merr.	2011	Derry	52.33	Fair
		2012	Eagle-RR	91.59	NA
		2013	Derry	87.22	Failed
		2013	Eagle-RR	87.22	Fair
Subterranean clover	<i>Trifolium subterraneum</i> L.	2013	VNS	21.81	Excellent
Sunn hemp	<i>Crotalaria juncea</i> L.	2011	VNS	45.36	Poor
		2012	VNS	47.97	NA
		2013	VNS	52.33	Poor

¹ Thirteen full-season annual forage legume species/varieties were seeded in 2011 and 2012, and 26 were seeded in 2013. The study plots were accidentally sprayed in 2012 with Milstone and none of the legume species germinated.

² VNS: variety not stated.

³ Pounds pure live seed per acre.

⁴ Establishment level was evaluated visually one year after seeding in the early spring on a scale of 0 – 3: 0 – failed (no seedlings found); 1 – poor (sparse seedlings found); 2 – fair (regularly spaced seedlings found); 3 – excellent (dense seedlings found and few or no weeds found).

NA: not available.

Table 2. Full-season annual warm-season grass species/varieties screened and evaluated at the CGREC in 2011 – 2013.

Common Name	Latin Name	Seeding Year ¹	Variety ²	Seeding Rate ³	Establishment ⁴
Foxtail millet	<i>Setaria italica</i> (L.) P. Beasuv.	2011	Golden German	21.46	Excellent
		2012	Golden German	21.81	Excellent
		2013	Golden German	26.17	Excellent
Japanese millet	<i>Echinochloa esculenta</i> (A. Braun) H. Scholz	2011	VNS	28.52	Fair
		2012	VNS	21.81	Excellent
		2013	VNS	26.17	Excellent
Pearl millet	<i>Pennisetum glaucum</i> (L.) R. Br.	2011	PP102M	22.24	Fair
		2012	MS2500	21.81	Excellent
		2013	Gem-X	26.17	Excellent
		2013	MS2500	26.17	Excellent
Siberian millet	<i>Echinochloa frumentacea</i>	2011	Manta	20.93	Fair
		2012	Manta	21.81	Excellent
		2013	Manta	26.17	Excellent
Sorghum	<i>Sorghum bicolor</i> (L.) Moench	2012	Gene12	30.53	Excellent
		2012	MS7000	30.53	Excellent
		2013	Gene12 BMR	43.61	Excellent
		2013	LFS601	43.61	Excellent
		2013	LFS901 BMR	43.61	Excellent
		2013	MS7000	43.61	Excellent
		2013	Rox Orange Cane	43.61	Excellent
		2013	Sweetie	43.61	Excellent
		2013	Sweetie BMR	43.61	Excellent
		2013	WGF Grain	43.61	Excellent
Sudangrass	<i>Sorghum sudanense</i> (Piper) Stapf	2011	Piper	26.35	Fair
		2011	Pro-Max BMR	26.35	Fair
		2012	Hayking	30.53	Excellent
		2012	Piper	30.53	Excellent
		2013	Hayking	34.89	Excellent
		2013	Higest	34.89	Excellent
		2013	Piper	34.89	Excellent
Sorghum-Sudan	<i>Sorghum bicolor</i> × <i>S. sudanese</i>	2011	22053 BMR	24.42	Fair
		2011	Black Hawk BMR	24.42	Fair
		2011	Special Effort	24.42	Fair
		2011	Sweet Thing	24.42	Fair
		2011	Sweet Thing BMR	24.42	Fair
		2012	Cow Conditioner	39.25	Excellent
		2012	Sweet Thing	39.25	Excellent
		2012	Sweet Thing BMR	39.25	Excellent
		2013	Cow Conditioner	43.61	Excellent
		2013	Graze X2	43.61	Excellent
		2013	GW300 BMR	43.61	Excellent
		2013	MS9000	43.61	Excellent
		2013	Super Honey	43.61	Excellent
		2013	Sweet Thing	43.61	Excellent
		2013	Sweet Thing BMR	43.61	Excellent
Teff	<i>Eragrostis tef</i> (Zuccagni) Trotter	2011	Tiffany	11.95	Fair
		2012	Tiffany	10.47	Excellent
		2013	Tiffany	13.08	Excellent
		2011	Red	27.74	Fair
		2012	White	30.53	Excellent
		2013	Red	34.89	Excellent
		2013	White	34.89	Excellent

¹ Thirteen full-season annual forage warm-season grass species/varieties were seeded in 2011 and 2012, and 26 were seeded in 2013.

² VNS: variety not stated. ³ Pounds pure live seed per acre.

⁴ Establishment level was evaluated visually one year after seeding in the early spring on a scale of 0 – 3: 0 – failed (no seedlings found); 1 – poor (sparse seedlings found); 2 – fair (regularly spaced seedlings found); 3 – excellent (dense seedlings found and few or no weeds found).

Table 3. Full-season annual cool-season grass species/varieties screened and evaluated at the CGREC in 2011 – 2013.

Common name	Latin Name	Seeding Year ¹	Variety ²	Seeding Rate ³	Establishment ⁴
Barley	<i>Hordeum vulgare</i> L.	2011	Haybet	88.90	Fair
		2011	Hayes	88.90	Fair
		2011	Lavina	88.90	Fair
		2012	Haybet	91.59	Excellent
		2012	Stockford Hay	91.59	Excellent
		2013	Haybet	126.48	Fair
		2013	Robust	126.48	Fair
		2013	Stockford Hay	126.48	Fair
Black oat	<i>Avena strigosa</i> Schreb.	2011	Soil Saver	45.10	Excellent
Italian ryegrass	<i>Lolium multiflorum</i> Lam.	2011	VNS	18.14	Fair
		2012	Feast II	21.81	Excellent
		2012	Gulf	21.81	Excellent
		2012	Tetilia	21.81	Excellent
		2012	Tetraploid	21.81	Excellent
		2013	Crusader	26.17	Excellent
		2013	Feast II	26.17	Excellent
		2013	Green Spirit	26.17	Excellent
		2013	Gulf	26.17	Excellent
		2013	Tetilia	26.17	Excellent
2013	Tetraploid	26.17	Excellent		
Naked oat	<i>Avena nuda</i> L.	2011	Paul	95.60	Excellent
		2013	Streaker	87.22	Fair
Oat	<i>Avena sativa</i> L.	2011	Everleaf126	75.80	Excellent
		2011	Hifi	75.80	Excellent
		2011	Kona	75.80	Excellent
		2012	Everleaf126	109.03	Excellent
		2012	Morgan	109.03	Excellent
		2012	Shelby 427 SD	109.03	Excellent
		2013	Athacasca	126.48	Fair
		2013	Colt	126.48	Fair
		2013	Everleaf126	126.48	Fair
		2013	Jim	126.48	Fair
		2013	Kona	126.48	Fair
		2013	Monida	126.48	Fair
		2013	Morgan	126.48	Fair
		2013	Rockford	126.48	Fair
		2013	Shelby 427 SD	126.48	Fair
		2013	Souris	126.48	Fair
Regreen	<i>Triticum aestivum</i> × <i>Elytrigia elongata</i>	2012	VNS	109.03	Excellent
		2013	VNS	43.61	Fair
Rye	<i>Secale cereale</i> L.	2011	Rymin	109.03	Fair
		2013	Rymin	126.48	Fair
Triticale	<i>Triticum aestivum</i> × <i>Secale cereale</i>	2011	Trical 141	112.47	Fair
		2011	Trical Mertin	112.47	Fair
		2012	Pronghorn	109.03	Excellent
		2012	Trical 141	109.03	Excellent
		2013	Pronghorn	126.48	Fair
		2013	Trical 141	126.48	Fair
		2013	Tyndal	126.48	Fair
Wheat	<i>Triticum aestivum</i> L.	2011	Hard Red Winter	109.03	Fair
		2012	Hard Red Spring	109.03	Excellent
		2013	Hard Red Spring	126.48	Fair

¹ Thirteen full-season annual forage cool-season grass species/varieties were seeded in 2011 and 2012, and 26 were seeded in 2013.

²VNS: variety not stated. ³ Pounds pure live seed per acre.

⁴ Establishment level was evaluated visually one year after seeding in the early spring on a scale of 0 – 3: 0 – failed (no seedlings found); 1 – poor (sparse seedlings found); 2 – fair (regularly spaced seedlings found); 3 – excellent (dense seedlings found and few or no weeds found).

Table 4. Full-season annual brassica species/varieties screened and evaluated at the CGREC in 2011 – 2013.

Common Name	Latin Name	Seeding Year ¹	Variety ²	Seeding Rate ³	Establishment ⁴
Cabbage	<i>Brassica oleracea</i> L.	2011	Ethiopian	3.66	Excellent
		2012	Ethiopian	6.98	Excellent
		2013	Ethiopian	8.72	Excellent
Canola	<i>Brassica napus</i> L.	2011	Sumner Winter	6.37	Fair
		2012	Sumner Winter	6.11	Excellent
		2013	Kronos	8.72	Excellent
Hybrid brassica	<i>Raphanus sativus</i> L.	2011	Hunter	3.66	Excellent
		2011	Winfred	3.66	Excellent
		2012	Hunter	6.98	Excellent
		2012	Pasja	6.98	Excellent
		2012	Vivant	6.98	Excellent
		2013	Hunter	8.72	Excellent
		2013	Pacer	8.72	Excellent
		2013	Pasja	8.72	Excellent
		2013	Vivant	8.72	Excellent
Kale	<i>Brassica oleracea</i> L.	2013	Dwarf Siberian	8.72	Excellent
		2013	Kestrel	8.72	Excellent
		2013	Siberian	8.72	Excellent
Mustard	<i>Brassica juncea</i> L.	2012	AC Pennant	6.11	Excellent
		2013	AC Pennant	11.34	Excellent
Radish	<i>Raphanus sativus</i> L.	2011	Graza	10.90	Fair
		2012	Bio Till	11.34	Excellent
		2012	Daikon	11.34	Excellent
		2012	Graza	11.34	Excellent
		2012	Soil Buster	11.34	Excellent
		2013	Bio Till	13.08	Excellent
		2013	Daikon	13.08	Excellent
		2013	Graza	13.08	Excellent
		2013	Ground Hog	13.08	Excellent
		2013	Jack Hammer	13.08	Excellent
		2013	Soil Buster	13.08	Excellent
Rape	<i>Brassica napus</i> L.	2011	Dwarf Essex	6.37	Fair
		2012	Dwarf Essex	6.98	Excellent
		2013	Athena	8.72	Excellent
		2013	Barnapoli	8.72	Excellent
		2013	Barsica	8.72	Excellent
		2013	Dwarf Essex	8.72	Excellent
Sugar beet	<i>Beta vulgaris</i> L.	2011	VNS	3.66	Poor
Swede	<i>Brassica napus</i> L.	2013	Major Plus	8.72	Excellent
Turnip	<i>Brassica rapa</i> var. <i>rapa</i> L.	2011	New York	6.37	Fair
		2011	Purple Top	6.37	Fair
		2012	New York	6.11	Excellent
		2012	Purple Top	6.11	Excellent
		2013	Appin	8.72	Excellent
		2013	Barkant	8.72	Excellent
		2013	New York	8.72	Excellent
		2013	Purple Top	8.72	Excellent

¹Nine full-season annual forage brassica species/varieties were seeded in 2011, 13 were seeded in 2012, and 26 in 2013.

²VNS: variety not stated. ³ Pounds pure live seed per acre.

⁴Establishment level was evaluated visually one year after seeding in the early spring on a scale of 0 – 3: 0 – failed (no seedlings found); 1 – poor (sparse seedlings found); 2 – fair (regularly spaced seedlings found); 3 – excellent (dense seedlings found and few or no weeds found).

Table 5. Forage yield (tons/acre) of full-season annual legume species/varieties at the CGREC seeded in 2011 and 2013.

Species	Variety	Year	
		2011	2013
Arrowleaf clover	Yuchi		0.21g ¹
Berseem clover	VNS	2.63	0.84a-d
Chickling vetch	AC Greenfix	2.57	0.41d-g
Common vetch	VNS		0.27g
Cowpea	Chinese Red	2.23	0.61b-g
	Iron & Clay		0.40e-g
Crimson clover	VNS	2.75	0.25g
Fava bean	VNS	2.99	
Hairy vetch	Purple Bounty	2.61	0.20g
Joint vetch	VNS		0.35fg
Lablab	Rongiu		0.45c-g
Lentil	Indianhead	1.38	0.48c-g
Mung bean	VNS	2.30	
Pea	4010	2.33	1.09a
	Austrian Winter	2.57	0.93ab
	Cruiser		0.57b-g
	DS-Admiral		0.61b-g
	Flex		0.84a-e
	Majoret		0.85a-d
	Mystique		0.87a-c
	Perfection326		0.53b-g
	Vegas		0.81ae
Viper		0.96ab	
Persian clover	Mihi	2.77	0.32fg
Soybean	Derry	2.14	0.42d-g
	Eagle-RR		0.34fg
Subterranean clover	VNS		0.46c-g
Sunn hemp	VNS	2.42	0.75a-f

¹ Forage yields within a column followed by same letter are not statistically different at $p \leq 0.05$.

Table 6. Forage yield (tons/acre) of full-season annual warm-season grass species/varieties at the CGREC in 2011 – 2013.

Species	Variety	Year					
		2011	2012				2013
			Herbicide Treatment ¹				
		A	B	C	D		
Foxtail millet	Golden German	2.39	3.05	3.78	3.14	2.47	0.55hi ²
Japanese millet	VNS	2.65	2.48	2.55	2.69	2.06	0.39i
Pearl millet	Gem-X						0.58g-i
	MS2500		2.78	2.68	2.33	2.72	0.48hi
	PP102M	2.75					
Red proso	VNS	2.82					0.75e-h
Siberian millet	Manta	2.76	3.19	3.37	3.40	3.05	0.67f-i
Sorghum	Gene12		3.34	3.54	3.60	4.12	
	Gene12 BMR						1.16ab
	LFS601						0.88c-e
	LFS901 BMR						0.83d-g
	MS7000		3.02	2.89	3.90	2.69	0.95b-e
	Rox Orange Cane						0.87c-f
	Sweetie						1.10a-d
	Sweetie BMR						1.11a-d
	WGF Grain						0.65f-i
Sudangrass	Hayking		3.92	3.21	3.51	3.23	1.10a-d
	Higest						0.96b-e
	Piper	3.20	3.18	3.09	3.30	2.88	1.07a-d
	Pro-Max BMR	3.06					
Sorghum-Sudan	22053 BMR	2.92					
	Black Hawk BMR	3.56					
	Cow Conditioner		3.55	3.26	3.25	2.63	1.03a-d
	Graze X2						1.13a-c
	GW300 BMR						0.98a-e
	MS9000						1.16ab
	Special Effort	3.17					
	Super Honey						1.06a-d
	Sweet Thing	3.43	5.17	3.98	4.13	3.91	1.24a
	Sweet Thing BMR	3.31	3.28	3.52	3.63	3.11	1.05a-d
Teff	Tiffany	2.86	3.30	2.83	3.20	2.57	0.44i
White proso	VNS		3.25	2.82	3.21	3.16	0.75e-h

¹ A: Pre-seeding glyphosate application
 B: A + Pre-emergence glyphosate application
 C: A + post-emergence Detonate application
 D: B + post-emergence Detonate application.

² Forage yields within a column followed by same letter are not statistically different at $p \leq 0.05$.

Table 7. Forage yield (tons/acre) of full-season annual cool-season grass species/varieties at the CGREC in 2011 – 2013.

Species	Variety	Year					
		2011	2012				2013
			Herbicide Treatment ¹				
A	B	C	D				
Barley	Haybet	2.68b-d ²	2.45b-d	2.61ab	2.30b-d	2.15a-d	0.66ab
	Hayes	3.07a-c					
	Lavina	2.48b-d					
	Robust						0.56a-c
	Stockford Hay		3.05ab	3.01a	2.70ab	2.69a	0.70a
Black oat	Soil Saver	2.80bc					
Italian ryegrass	Crusader						0.13fg
	Feast II						0.14e-g
	Green Spirit		1.84c-e	1.39e	1.86d-f	1.60cd	0.14e-g
	Gulf						0.17d-g
	Tetilia		1.89c-e	2.11b-d	1.95d-f	1.91b-d	0.13fg
	Tetraploid		1.91c-e	1.80c-e	1.76d-f	1.90b-d	0.16d-g
	VNS		1.65de	1.81c-e	1.50f	1.79b-d	
Naked oat	Paul	2.93a-c					
	Streaker						0.48a-d
Oat	Athacasca						0.42a-g
	Colt						0.19d-g
	Everleaf126	3.67a	3.08ab	2.71ab	2.76ab	2.73a	0.37b-g
	Hifi	2.57b-d					
	Jim						0.24c-g
	Kona	3.19ab					0.67ab
	Morgan		2.63a-c	2.75a	2.73ab	2.36ab	0.28c-g
	Monida						0.66ab
	Rockford						0.43a-f
	Shelby427 SD		1.97c-e	2.18b-d	2.12c-e	2.27a-c	0.38a-g
	Souris						0.47a-e
Regreen	VNS		1.56e	1.73de	1.66ef	1.46d	0.17d-g
Rye	Rymin	1.69ef					0.11g
Triticale	Pronghorn		3.08ab	2.45a-c	2.64a-c	2.84a	0.40a-g
	Trical141	2.35c-e	3.28a	2.89a	2.90a	2.51ab	0.37b-g
	Trical Mertin	2.53b-d					
	Tyndal		3.08ab	2.45a-c	2.64a-c	2.84a	0.44a-f
Wheat	Hard Red Spring		2.92ab	2.56ab	2.91a	2.22a-d	0.53a-c
	Hard Red Winter	1.46f					

¹ A: Pre-seeding glyphosate application;
 B: A + Pre-emergence glyphosate application;
 C: A + post-emergence Detonate application;
 D: B + post-emergence Detonate application.

² Forage yields within column followed by same letter are not statistically different at $p \leq 0.05$.

Table 8. Forage yield (tons/acre) of full-season annual brassica species/varieties at the CGREC in 2011 – 2013.

Species	Variety	Year							
		2011	2012				2013		
			Herbicide Treatment ¹				First and Second Harvests		
			A	B	C	D	August	October	Total
Cabbage	Ethiopian	3.50a ²	1.88a	1.88ab	1.29a-c	1.48ab	0.34c-g	2.19bc	2.52bc
Canola	Kronos						0.19e-i	1.34d-h	1.54f-j
	Sumner Winter	2.69ab	1.34b-e	1.17d-f	0.79d	0.77e			
Hybrid brassica	Hunter	2.54a-c	1.24c-e	1.26c-f	0.71d	1.01b-e	0.25d-i	1.29d-h	1.54f-j
	Pacer						0.10g-i	1.39d-g	1.50f-j
	Pasja		1.60a-d	1.29c-e	0.84cd	0.99c-e	0.16f-i	1.22e-i	1.38g-j
	Vivant		1.42a-e	1.14ef	1.00a-d	0.78de	0.28d-i	1.23e-i	1.51f-j
	Winfred	2.21b-d					0.36c-g	1.47d-f	1.83d-i
Kale	Dwarf Siberian						0.34c-g	1.62c-e	1.97c-g
	Kestrel						0.40b-f	1.49d-f	1.90c-h
	Siberian						0.46a-d	1.40d-g	1.86c-i
Mustard	AC Pennant		1.67a-c	2.01a	1.46a	1.26b-d	0.32c-h	0.86g-i	1.18ij
Radish	Bio Till		1.41a-e	1.36c-e	1.37ab	1.46a-c	0.57a-c	2.81a	3.38a
	Daikon		1.73ab	1.55bc	1.43ab	1.18b-e	0.68a	2.48ab	3.16ab
	Graza	2.45a-c	1.23c-e	1.17d-f	0.69d	0.75e	0.04i	1.71c-e	1.75e-i
	Ground Hog						0.42a-f	2.08bc	2.50b-d
	Jack Hammer						0.30d-i	1.87cd	2.17c-f
	Soil Buster		1.79a	2.11a	1.46a	1.84a	0.67ab	1.67ce	2.34c-e
Rape	Athena						0.32c-h	1.41d-g	1.73e-i
	Barnapoli						0.45a-e	1.69c-e	2.15c-f
	Barsica						0.45a-e	1.67c-e	2.12c-f
	Dwarf Essex	2.27b-d	1.51a-e	1.49b-d	0.95b-d	0.91de	0.34c-g	1.33d-h	1.67e-i
Sugar beet	VNS	3.33ab							
Swede	Major Plus						0.22d-i	1.01f-i	1.23h-j
Turnip	Appin						0.21d-i	0.97f-i	1.19ij
	Barkant						0.26d-i	1.45d-g	1.71e-i
	New York	1.13d	1.05e	1.10ef	0.80d	0.69e	0.17f-i	0.69i	0.86j
	Purple Top	1.43cd	1.12de	0.96f	0.71d	0.86de	0.06hi	0.81hi	0.87j

- ¹ A: Pre-seeding glyphosate application
 B: A + Pre-emergence glyphosate application
 C: A + post-emergence Volunteer and Stinger application
 D: B + post-emergence Volunteer and Stinger application.

² Forage yields within a column followed by same letter are not statistically different at $p \leq 0.05$.