Evaluating Rotations of Winter Annual and Summer Annual Forages for Yield, Nutritional Value, and Economic Sustainability as Forage Resources for Beef Cattle in Northern Iowa

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Summary and Implications

A winter annual- summer annual forage rotation can be used to break up the traditional corn - soybean rotation and produce 7-11 tons per acre of forage biomass on a dry matter basis per year.

Dry conditions in the fall of 2020 and again in the fall of 2002 through 2023, limited germination and early growth. Moisture in the spring of 2021 reinvigorated growth, but the drought in the spring of 2023 prevented germination of the summer annual so only a single harvest was taken on September 5, 2023. The 47-year average rainfall for the farm for April – November is 30.8 inches but from April – November 2023 there was only 13.8 inches of rainfall significantly reducing summer annual yields.

The variation between years indicates a double cropping system is very dependent on adequate rainfall for forage establishment and growth, as seen by the loss of the August harvest in 2023 where only half the average rainfall was received compared to 2021 and 2022.

Introduction

Interest in grazing cover crops and winter annuals has increased in recent years. Research on grazing winter and summer annuals in Iowa has been concentrated in southern Iowa, but because of differences in growing conditions, data on growth potential from the northern half of the state is needed. Similar interest has been developing on utilizing summer annuals to maximize production during the summer slump of Iowa pastures. This project is designed to replicate the winter annual - summer annual project at the McNay, Armstrong and Neely-Kinyon research farms, in order to measure and demonstrate the applicability of a winter annual - summer annual forage rotation in northern Iowa at the Northeast Research and Demonstration Farm at Nashua.

Materials and Methods

Three years of a winter annual – summer annual forage rotations have been completed. Eight winter annual treatments were established at the Northeast Research and Demonstration Farm on October 30, 2020, October 4, 2021, and October 5, 2022, with four replications. First year treatments include Elbon cereal rye, Willow Creek forage winter wheat, Flex 719 Brand triticale and Thompson hard red winter wheat, each with and without 50 pounds (lb) nitrogen (N) fertilizer per acre (ac). This was an exact replication of the trials at the southern Iowa research farms. Second- and third-year treatments were KWS Progas cereal rye, Hazlet cereal rye, Triticale, and Thompson hard red winter wheat, each with and without 50lb N. These varieties were based on forage yield recommendations and donation from Albert Lea Seed House. Each were seeded at a target rate of 100 lb of seed per ac and replicated 4 times in 10’ x 60’ plots. Dry conditions in the fall of 2020 and spring of 2021, delayed germination and growth. Dry conditions in the fall of 2022 and a killing frost on October 8 also slowed germination and growth in 2022. Fifty pounds of N per ac as urea was spread on half the plots on April 6, 2021, April 5, 2022, and April 14, 2023, as the forage started to break dormancy and just ahead of a predicted rainfall. Plots were mechanically harvested with the 3-foot-wide Carter Harvester on May 26, 2021, May 31, 2022, and May 30, 2023, and tested for crude protein (CP) and total digestible nutrients (TDN). The three-year average yield and nutritive value data is in Table 1.

All forage was removed from the plots and four summer annuals were drilled into these same plots on June 9, 2021, June 21, 2022, and June 8, 2023, at a target rate of 40 lb. per ac. The treatments in 2021 were Exceed hybrid brown mid-rib (BMR) pearl millet, Japanese millet VNS, Hybrid Piper sudangrass and Viking 232 Brachytic dwarf BMR sorghum-sudangrass. The 2022 and 2023 treatments were ExCeed BMR hybrid pearl millet, Viking BMR brand hybrid 200 and 232 sorghum x sudangrass, and hybrid Piper sudangrass, each with either 50 or 100 lb. of N per ac. Fifty pounds of N per ac as urea was applied to all plots on June 11, 2021, July 8, 2022, and July 19, 2023, and sprayed with

32 oz per ac Roundup Powermax© on June 13, 2021, June 20, 2022, and June 23, 2023 to terminate winter annual forage regrowth. In 2021, less than 1.5" of rain fell during the month of June (Table 8). Drought also impacted the 2023 crop by delaying emergence for about 3 weeks. An additional 50 lb. per ac of nitrogen as urea was applied July 14, 2021, July 23, 2022, and July 19, 2023, to half the plots. First cutting was harvested on August 3 in the first two years with the Carter harvester. In 2021, the Japanese millet had a few seed heads showing at harvest, but no seed heads were visible on the Pearl millet, sorghum x sudangrass or sudangrass. In 2022, no seed heads were visible at the first harvest in any plot. Two passes on the north and south sides were cut with a discbine and the center 10-14' was not mowed to compare a single harvest system to the two-cut system. All mowers were set to leave at least 8-10" residue height. Mowed forage was baled as wet hay/baleage and removed from plots on August 6 in both years. The second harvest was cut September 14, 2021, and September 22, 2022, using the Carter harvester on the earlier harvested plot sections. In the uncut sections, 5 feet 3 inches of row (1/10,000th acre) were hand harvested, weighed and sampled. The remaining forage was mowed as low as possible and removed from the plots. In 2022 a leaf blight limited the yield and quality of the Piper hybrid sudangrass but did not affect the other treatments. Disease damage started to appear in late July and continued to worsen throughout the season and the ISU Plant Diagnostic Clinic reported that the blight was caused by *Exserohilum turcicum,* the same pathogen that causes Northern Corn Leaf Blight in corn.

Results and Discussion

Winter annual yields and forage quality results are in Table 1. In 2020-21, the forage wheat was the lowest yielding so was replaced in following years by a second cereal rye. Hazlet cereal rye was the highest yielding winter annual forage the following two years. As expected, cereal rye was the earliest to break dormancy and had the highest yields with 3.19 and 3.65 tons per acre DM in the two treatments, 0 and 50 lb. N respectively (Table 2). Triticale was intermediate in spring growth with 2.78 and 3.14 tons per acre DM, and winter wheat was the last to break dormancy and yielded 2.45 and 2.75 tons per acre DM when harvested on the same date.

The summer annual forage yields under a two-cutting system, and quality are in Tables 3 and 4. Table 5 shows the same species in a single harvest scenario. Japanese millet was the earliest maturing of the warm season annuals showing some seed heads at first harvest and fully headed at second harvest, and produced the lowest yields at all cuttings. It may work better in a more intensively grazed or harvested system but did not compete in yields with the other summer annuals in this study, therefore it was replaced with a second sorghum x sudangrass variety in years 2 and 3. Pearl millet and sudangrass were lower in yield to sorghum x sudangrass in the two-cutting system, and they both yielded better in a two-cut system than in the single harvest system. Sorghum x sudangrass was the highest yielding summer annual in both systems, however it performed best in the single harvest system (Tables 3-7). Sudangrass was susceptible to a leaf disease in 2022 which severely impacted late harvest yields, while other species were not affected by the leaf disease.

Because the additional 50 lb. of N was spread only 2 weeks prior to the first harvest, very little impact was seen on yield at the time of first cutting (Table 3). However, the additional N resulted in about and additional half pound of forage dry matter per ac in the second cutting (Table 4), and about one-quarter pound of forage dry in the single harvest plots (Table 5).

The dry conditions in 2023 resulted in only a single harvest and much lower total yields than the prior years (Table 5).

Table 6 shows the combined two-harvest system (Double harvest) yields compared to the single late fall harvest yields. Note the single harvest yields were much drier than the two-harvest moisture content.

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Table 1. Winter annual forage average yield and quality.

	0 lb. Nitrogen				50 lb. Nitrogen			
	% DM	Ton per ac	CP %	TDN %	% DM	Ton per ac	CP %	TDN %
2021								
2021 Elbon Cereal Rye	29.31	2.39[a]	11.54	55.42*	24.64	2.34[ab]	14.60	57.22*
2021 Flex 719 Triticale	18.17	1.93[b]	17.76	55.93*	18.06	2.22[ab]	18.48	56.45*
2021 Willow Creek Forage Wheat	20.00	1.56[b]	19.05	57.16*	17.50	1.72[b]	21.70	57.41*
2021 Thompson HR Winter Wheat	21.91	1.81[b]	18.02	56.44*	19.83	1.98[ab]	20.69	60.13*
Average		*1.92*				*2.06*		
LSD 0.05		*.38*				*.42*		
CV%		*12.7*				*13.2*		
2022								
2022 Progas Cereal Rye	28.21	3.47[a]	9.81	61.86**	26.26	3.97[b]	12.63	63.76**
2022 Hazlet Ceral Rye	27.93	3.66[a]	11.15	62.09**	24.89	4.37[a]	12.81	63.48**
2022 VNS Triticale	22.12	3.33[a]	14.17	63.60**	20.50	3.89[bc]	11.34	62.00**
2022 Thompson HR Winter Wheat	26.02	3.04[a]	14.23	63.13**	23.35	3.64[c]	9.80	62.12**
Average		*3.38*				*3.97*		
LSD 0.05		*.75*				*.32*		
CV%		*14.34*				*5.19*		
2023								
2023 Progas Cereal Rye	32.55	2.91[b]	10.24	62.78**	30.23	3.60[ab]	12.62	63.17**
2023 Hazlet Cereal Rye	33.82	3.52[a]	8.07	61.88**	30.75	3.98[a]	10.95	62.09**
2023 VNS Triticale	24.94	3.09[ab]	12.96	64.06**	22.67	3.33[b]	16.24	64.96**
2023 Thompson HR Winter Wheat	30.17	3.41[a]	11.83	64.68**	28.38	3.67[b]	14.05	64.56**
Average		*3.23*				*3.64*		
LSD 0.05		*.45*				*.55*		
CV%		*9.73*				*9.84*		

Numbers in same column with the same letter are not statistically different.
*TDN OARDC
**TDN ADF

Table 2. Winter annual forage yield across all years by species.

	0 lb. Nitrogen		50 lb. Nitrogen	
	% DM	Ton per ac	% DM	Ton per ac
Cereal Rye	30.36	3.19	27.35	3.65
Triticale	21.74	2.78	20.41	3.14
Winter Wheat	24.52	2.45	22.27	2.75

Table 3. First cutting summer annual forage yield and quality.

	50 lb. Nitrogen				100 lb. Nitrogen			
	% DM	Ton per ac	CP %	TDN %	% DM	Ton per ac	CP %	TDN %
2021								
2021 Japanese Millet VNS	22.03	1.11^{b}	15.70	55.47*	21.25	1.61^{cd}	17.79	57.87*
2021 ExCeed BMR Pearl Millet	22.92	1.19^{b}	14.52	58.89*	21.49	1.66^{bc}	16.43	58.03*
2021 Viking 232 BMR SxS	19.75	2.03^{a}	12.99	58.22*	18.75	2.17^{a}	16.24	58.21*
2021 Piper Hybrid Sudangrass	21.73	2.25^{a}	16.45	62.57*	19.25	2.02^{ab}	17.10	60.96*
Average		*1.65*				*1.87*		
LSD 0.05		*.35*				*.40*		
CV%		*13.73*				*13.77*		
2022								
2022 ExCeed BMR Pearl Millet	17.05	1.70^{c}	14.03	63.07**	18.16	1.82^{c}	16.95	64.73**
2022 Viking 200 BMR SxS	17.41	2.54^{abc}	12.83	60.41**	17.48	2.90^{a}	13.1	60.96**
2022 Viking 232 BMR SxS	16.44	2.86^{a}	14.59	63.67**	16.61	2.72^{ab}	12.82	62.39**
2022 Piper Hybrid Sudangrass	18.38	2.15^{bcd}	13.91	60.27**	17.42	2.00^{bc}	15.62	62.25**
Average		*2.31*				*2.36*		
LSD 0.05		*.62*				*.88*		
CV%		*17.4*				*24.11*		

Numbers in same column with the same letter are not statistically different.
*TDN OARDC
**TDN ADF

Table 4. Second cutting summer annual forage yield and quality.

	50 lb. Nitrogen				100 lb. Nitrogen			
	% DM	Ton per ac	CP %	TDN %	% DM	Ton per ac	CP %	TDN %
2021								
2021 Japanese Millet VNS	33.00	2.26[ab]	10.16	62.12*	30.50	2.73[ab]	10.25	60.41*
2021 ExCeed BMR Pearl Millet	24.63	2.51[a]	8.29	63.07*	23.16	3.00[a]	9.25	63.07*
2021 Viking 232 BMR SxS	22.88	2.06[b]	9.19	63.48*	21.25	2.51[b]	11.48	63.67*
2021 Piper Hybrid Sudangrass	23.50	2.42[a]	9.94	62.00*	23.75	3.10[a]	12.66	60.27*
Average		2.32				2.84		
LSD 0.05		0.31				0.40		
CV%		8.69				13.77		
2022								
2022 ExCeed BMR Pearl Millet	21.23	2.66[a]	8.67	64.88**	18.71	3.19[ab]	10.75	64.98**
2022 Viking 200 BMR SxS	20.46	2.48[a]	9.96	65.08**	18.23	3.46[a]	10.19	65.18**
2022 Viking 232 BMR SxS	20.66	2.56[a]	9.67	63.84**	19.98	2.75[b]	11.05	64.32**
2022 Piper Hybrid Sudangrass	22.93	1.68[b]	12.89	63.70**	20.84	1.75[cf]	14.41	64.19**
Average		2.35				2.79		
LSD 0.05		0.51				0.59		
CV%		13.99				13.83		

Numbers in same column with the same letter are not statistically different.
*TDN OARDC
**TDN ADF

Table 5. Single harvest summer annual forage yield and quality.

	50 lb. Nitrogen				100 lb. Nitrogen			
	% DM	Ton per ac	CP %	TDN %	% DM	Ton per ac	CP %	TDN %
2021								
2021 Japanese Millet VNS	42.73	2.78[b]	7.11	52.98*	39.55	3.33[b]	10.24	49.61*
2021 ExCeed BMR Pearl Millet	31.19	2.54[b]	10.93	49.60*	32.38	5.56[a]	9.41	49.61*
2021 Viking 232 BMR SxS	38.93	5.44[a]	5.73	49.61*	34.60	4.93[ab]	12.24	51.06*
2021 Piper Hybrid Sudangrass	41.92	4.45[a]	5.65	49.55*	39.97	4.28[ab]	6.98	52.43*
Average		*3.81*				*4.52*		
LSD 0.05		*1.39*				*2.1*		
CV%		*23.7*				*30.19*		
2022								
2022 ExCeed BMR Pearl Millet	23.20	3.35[b]	8.35	65.12**	22.64	3.44[b]	9.04	65.26**
2022 Viking 200 BMR SxS	29.14	7.42[a]	7.43	65.68**	29.55	7.37[a]	9.13	66.58**
2022 Viking 232 BMR SxS	29.23	6.71[a]	5.36	65.20**	31.44	7.48[a]	6.99	64.99**
2022 Piper Hybrid Sudangrass	32.11	2.66[b]	10.28	63.25**	30.15	2.78[b]	9.68	62.93**
Average		*5.04*				*5.27*		
LSD 0.05		*1.47*				*1.45*		
CV%		*18.97*				*30.16*		
2023								
2023 ExCeed BMR Pearl Millet	30.01	3.04[bc]	9.41	55.64**	31.26	3.80[ab]	10.94	57.44**
2023 Viking 200 BMR SxS	29.33	4.24[a]	6.77	57.37**	27.00	4.17[a]	10.84	58.55**
2023 Viking 232 BMR SxS	29.22	3.64[ab]	9.11	58.01**	27.16	3.48[b]	9.53	57.77**
2023 Piper Hybrid Sudangrass	35.42	3.01[c]	8.72	55.18**	38.80	3.36[b]	8.98	60.30**
Average		*3.5*				*3.70*		
LSD 0.05		*0.62*				*0.66*		
CV%		*11.62*				*11.64*		

Numbers in same column with the same letter are not statistically different.
*TDN OARDC
**TDN ADF

Table 6. Yield comparison of single and double harvests summer annual forages.

	50 lb. Nitrogen		100 lb. Nitrogen	
	Double harvest	Single harvest	Double harvest	Single harvest
Pearl Millet				
2021 Pearl Millet	3.70	2.54	4.66	5.56
2022 ExCeed BMR	4.36	3.35	5.01	3.44
2023 ExCeed BMR		3.04		3.80
Sorghum Sudangrass				
2021 Sorghum Sudangrass	4.09	5.44	4.68	4.93
2022 Viking 200 BMR	5.02	7.42	6.36	7.37
2022 Viking 232 BMR	5.42	6.71	5.47	7.48
2023 Viking 200 BMR		4.24		4.17
2023 Viking 232 BMR		3.64		3.48
Hybrid Sudangrass				
2021 Piper	4.67	4.45	5.12	4.28
2022 Piper	3.83	2.66	3.75	2.78
2023 Piper		3.01		3.36
Japanese Millet 2021	3.37	2.78	4.34	3.33

Table 7. average yield of all summer annual plots across years by species.

	% DM	Ton per ac	% DM	Ton per ac
Average all 1st cutting by species	50# Nitrogen		100 # Nitrogen	
Ave All Japanese Millet	22.03	1.11	21.25	1.61
Ave All Pearl Millet	22.84	1.45	22.37	1.74
Ave All Sorghum Sudangrass	21.00	2.47	20.50	2.60
Ave All Sudangrass	21.87	2.20	20.25	2.01
Average all 2nd cutting by species	50 lb. Nitrogen		100 lb. Nitrogen	
Ave All Japanese Millet	33.00	2.26	30.50	2.73
Ave All Pearl Millet	25.32	2.58	23.68	3.10
Ave All Sorghum Sudangrass	23.09	2.37	22.35	2.91
Ave All Sudangrass	23.65	2.05	23.68	2.42
Average 2 cuttings Combined by species	50 lb. Nitrogen		100 lb. Nitrogen	
Ave All Japanese Millet		3.38		4.34
Ave All Pearl Millet		4.03		4.84
Ave All Sorghum Sudangrass		4.84		5.50
Ave All Sudangrass		4.25		4.44
Average Single harvest by species	50 lb. Nitrogen		100 lb. Nitrogen	
Ave All Japanese Millet	42.73	2.78	39.55	3.33
Ave All Pearl Millet	31.95	3.20	32.59	3.62
Ave All Sorghum Sudangrass	38.69	5.49	36.53	5.49
Ave All Sudangrass	38.62	3.38	38.79	3.47

Table 8. Precipitation (inches) during the 2021–2023 growing seasons at the ISU NE Research Farm, Nashua, IA.

	Apr	May	June	July	Aug	Sept	Oct	Nov	Total
2021	0.63	3.48	1.42	2.53	10.58	1.61	4.50	2.02	26.77
2022	3.62	4.10	5.22	2.55	6.74	1.03	0.75	2.02	26.03
2023	1.85	1.93	1.63	1.17	1.50	3.30	2.16	0.29	13.83
1976-2021 Avg	3.61	4.50	5.38	4.53	4.80	3.51	2.71	1.75	30.79