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ANNUAL FORAGES: A MISSED OPPORTUNITY?

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RESEARCH SUMMARY

Annual crops can be grown to supplement and supplant perennial forage supplies. The objective of this research was to compare forage yield and quality among annual, cool-season cereal and legume crops, and to identify those having the greatest potential for forage production under dryland conditions in southwestern North Dakota. Barley (*Hordeum vulgare*), oat (*Avena sativa*), triticale (*Triticale*), lentil (*Lens culinaris*) and pea (*Pisum sativum* subsp. *sativum* var. *arvense)* were grown alone and in selected combinations in several experiments, each designed as a randomized complete block with four replications during 1996, 1997, and 1998. Greatest amounts of forage were produced by a triticale cultivar in each year in an experiment where cereal, legume, and cereal-legume crop mixtures were compared. In a separate experiment, forage yield averaged 1.1 tons DM/acre for eight pea cultivars in 1997, and 2.5 tons DM/acre in 1998. Semi-leafless pea cultivars produced as much or more forage than long-vined pea cultivars in each year. Forage yield averaged around 1 ton DM/acre for lentil cultivars in an adaptation experiment in 1997 and 1998. In a harvest date experiment, forage yield was maximized when cereal crops were harvested at the soft dough stage of kernel development, or after pods had begun to form on legumes, compared with earlier harvest dates. This harvest period did not correspond to peak forage quality, which occurred several days earlier. Results of these experiments indicate tremendous variation in forage yield and quality among annual crops and cultivars, and management strategies.

INTRODUCTION

Annual crops have been identified as a supplement to perennial forage supplies (Carr et al., 1998b). Some livestock producers are even substituting forage systems using annual crops for perennial forage systems (P. Klamm, per.

comm., 1998). These developments support evaluation of annual crops for forage yield and quality in southwestern North Dakota. The objective of this research was to compare the yield and quality of forage produced by annual cereal, legume and cereal-legume mixtures in different experiments under dryland conditions in southwestern North Dakota.

MATERIALS AND METHODS

Cool-Season Forage Experiment.

An experiment was conducted under dryland conditions at the Dickinson Research Extension Center during 1996, 1997, and 1998. 'Azure' barley, 'Frank' and '2700' triticale, 'Paul' and 'Whitestone' oat, and 'Arvika' pea were seeded on 14 May 1996, in an experiment designed as a randomized complete block with four replications. Barley and pea were seeded at 100 lb viable seed (PLS)/ac, triticale at 75 lb PLS/ac, and Paul and Whitestone oat at 70 and 65 lb PLS/ac, respectively. Seven cereal-pea intercrop treatments also were included: Frank triticale and 'Trapper' pea, seeded at 50 and 80 lb PLS/ac, respectively; 2700 triticale and Trapper pea (seeded at the same rates as the Frank triticale + Trapper pea intercrop); Paul oat and Trapper pea, seeded at 45 and 60 lb PLS/ac; Whitestone oat and Trapper pea, seeded at 35 and 80 lb PLS/ac; 'Robert' oat and Trapper pea, seeded at 43 and 67 lb PLS/ac; and 'Bay' oat and Trapper pea, seeded at 43 and 67 lb PLS/acre.

The experiment was seeded on 2 May in 1997. Seven forage treatments were evaluated in 1997 which had been evaluated in 1996: these included three cereal sole treatments (Paul oat, 2700 triticale, and Whitestone oat) and four intercrop treatments (Paul oat + Trapper pea, 2700 triticale + Trapper pea, Whitestone oat + Trapper pea, and Robert oat + Trapper pea). Additional treatments evaluated in 1997 included: 'Aladdin' faba bean, seeded at 150 lb PLS/ac; Trapper pea, seeded at 105 lb PLS/ac; 'Indian head' lentil, seeded at 25 lb PLS/ac; and 'Haybet' barley, seeded at 85 lb/ac.

The experiment was seeded on 30 April in 1998. All treatments were the same as those evaluated in 1997, except that the fababean treatment was omitted and a 'Stark' barley treatment was included.

Individual plot dimensions were 4.7 x 27 ft. Hay yield was determined by harvesting a 54-ft^2 area with a forage plot harvester within each plot when barley and oat were in the milk to early soft dough stages of kernel development (Zadoks growth stages 70-85 as described by Zadoks et al. [1974]), triticale was fully headed (Zadoks growth stage 69), pea was flowering and pods were around 1.5 inches long, and prior to pod formation but during flowering of both lentil and faba bean. A 1 lb subsample was randomly selected from the harvested portion of each plot and dried at 140^{o}F until a constant weight was obtained. Forage yield is expressed on a dry weight basis. Forage CP concentration, acid and neutral detergent fiber and relative feed value (RFV) were determined for a sub-sample from each plot in two replicates of the experiment in 1996, from each plot in four replicates in 1997, and from each plot in three replicates in 1998, by standard procedures (AOAC, 1990). The data for 1998 were not available when this manuscript was prepared and are not presented.

Data within the experiment were analyzed using the ANOVA procedure available from SAS (SAS Institute, 1985). Cereal crop cultivar and crop combination were considered fixed effects. Mean comparisons were made using Fischer's Protected LSD where *F*-tests indicated significant differences ($P < 0.05$) between treatments. The experiment was not analyzed across years since some treatments were not included in all years that the experiment was conducted.

Other experiments also were conducted, each with the same experimental design and protocol as the Cool Season Forage Experiment. These experiments included a: (i) Forage Pea Experiment, which included seven pea cultivars in 1997 and eleven in 1998; and a (ii) Forage Lentil Experiment, which included 3 cultivars in 1997 and four cultivars in 1998.

A Date of Cutting Experiment was conducted, where barley, oats, peas, and lentil were seeded alone and in several combinations (11 treatments), and harvested at four cereal growth stages. These growth stages were early heading (Feekes 10.1), kernel milky ripe (11.1), kernel soft dough (11.2), and kernel hard dough (11.3). Corresponding pea and lentil growth stages ranged from early flower formation to pod development and dessication. Experimental design, data acquisition and analyses were the same as those used in other experiments.

RESULTS AND DISCUSSION

Cool Season, Annual Cereals and Legumes

Forage yield among the eleven cereal and legume treatments averaged 2.9 tons DM/acre in 1998, which was comparable to the mean yield in 1996 (2.8 tons DM/acre) (Table 1). Mean forage yield was only 1.5 tons DM/acre in 1997 (1.5 tons DM/acre). In each year, the triticale cultivar 2700 produced as much or more forage when grown alone than any other treatment. By contrast, legume sole treatments generally produced less forage than some cereal sole treatments in both 1996 and 1998. These data suggest that annual legumes should not be seeded alone instead of cereal sole crops if the goal is to maximize forage yield.

Forage yield was not increased when peas were intercropped with cereal crops compared with seeding the cereal crops alone (Table 1). These data support previous research indicating that intercropping peas with cereals does not increase forage yield compared to cereal sole cropping in southwestern North Dakota (Carr et al., 1998a).

Forage of Aladdin fababean and Indianhead lentil contained more CP than that of other cereals or legumes, either alone or in combination, in 1997 (Table 1). The CP concentration of pea forage was greater than that of forage produced in some treatments with cereals, but not others. Similarly, the CP concentration of sole cereal forage was comparable to that of Arvika pea forage in 1996. These data show that the forage of some pea cultivars is not higher in CP than forage of selected cereal cultivars under certain environmental conditions.

The CP concentration of forage was not increased by intercropping cereals with peas compared with sole cereal forage in both 1996 and 1997 (Table 1). In other instances, forage CP concentration was increased by intercropping in southwestern North Dakota (Carr et al., 1998a). The data indicate the confounding effect that contrasting environments have on the impact of intercropping on forage quality.

Acid detergent fiber (ADF) concentration of pea forage generally was greater than that of some cereal treatments in 1996, but not in 1997 (Table 2). An exception existed for Whitestone oats, which produced forage with a comparable concentration of ADF to that of pea in both years. No consistent trends existed for NDF concentration between cereal and pea forage.

Forage Pea

Mean forage yield was 2.5 tons DM/acre for 10 pea cultivars and a barley-pea mixture in 1998 (Table 2). By comparison, yield for seven pea cultivars was 1.1 tons DM/acre in 1997. These data indicate that more favorable growing conditions existed for pea forage production in 1998 than in 1997.

The semi-leafless pea cultivars Bravo and Carneval produced as much or more forage than other pea cultivars, all of which were long-vined and leafy, in 1998 (Table 2). Carneval also produced as much forage as any other pea cultivar in 1997. These data suggest that long-vined, leafy pea cultivars may not be superior to semi-leafless cultivars for forage yield, under conditions similar to those encountered in this experiment. If there is no preference among livestock for long-vined cultivars, these data suggest that semi-leafless cultivars might be preferred since they generally are more upright and can be harvested more easily.

Mean CP concentration was 18.3% for pea forage in 1997, and 15.4% in 1998 (Table 2). The CP concentration varied by more than 3% between pea cultivars in both years. No clear trends existed among cultivars for ADF or NDF concentrations in either year. The RFV of pea forage averaged 141% in 1997, and 138% in 1998.

Forage Lentil

Forage yield averaged 1.1 tons DM/acre for four lentil cultivars evaluated in 1998, and 1.4 tons DM/acre in 1997 (Table 3). CDC Richlea and Indianhead produced as much or more forage than other cultivars in each year. These preliminary data suggest that the grain cultivar CDC Richlea can produce as much forage as Indianhead, which was developed for forage production, under conditions similar to those encountered in this experiment.

The CP, ADF, and NDF concentrations were similar for CDC Richlea and Indianhead lentil cultivars in both 1997 and 1998. The RFV for the lentil cultivars averaged about 143% in 1997, and almost 200% in 1998. These preliminary data suggest that lentil can produce superior-quality forage in southwestern North Dakota, when certain environmental conditions develop.

Contrasting Harvest Dates with Barley, Oat, Pea, and Lentil

Average forage yield was 1.5 tons DM/acre across sole crop and intercrop treatments when the cereal component was cut at the early heading growth stage in 1998, and 0.9 tons DM/acre in 1997 (Table 4). Forage yield averaged 1.7 tons DM/acre when cut at the same cereal growth stage in 1996. Average forage yield was 2.3 tons DM/acre across all treatments when harvesting was delayed until the kernel milky ripe stage in 1998 and 1996, and 1.6 tons DM/acre in 1996. Over three tons of forage DM/acre was produced when harvesting was delayed until the kernel soft dough stage in 1998, 2.0 tons DM/acre in 1997, and 2.5 tons DM/acre in 1996. Mean forage yield was similar when harvesting was delayed beyond the kernel soft dough stage in each year.

More forage generally was produced among intercrop treatments as seeding rates of cereal and pea components were increased in each year (Table 5). These data support previous research indicating that forage yield of cereal-pea intercrops is maximized by seeding the cereal component at a sole crop or heavier rate (Carr et al., 1998a).

Forage yield was not increased by intercropping compared with cereal sole-crop at any harvest date in any year (Table 5). These data support results of past research indicating that intercropping cereals with peas is not recommended if the goal of intercropping is to increase forage yield compared with cereal sole crop (Carr et al., 1998a).

Crude protein concentration sometimes was increased by intercropping peas with cereals compared to cereal sole crops (Table 5). The CP concentration of forage tends to decline as the harvest date is delayed from early heading to the hard dough stage of cereal kernel development. Preliminary results suggest that the CP concentration can be maximized by intercropping peas with cereals compared to cereal sole-crop, and harvesting the mixtures at the cereal heading stage of development. However, the best compromise between forage yield and forage CP concentration probably results if the harvest date is delayed until the cereal crop is at the milky ripe to soft dough stages of kernel grain development.

Conclusions/Implications of Research

Cool season, annual forages are being grown successfully for forage in southwestern North Dakota. Preliminary data indicate that triticale may be comparable or superior to barley and oats for forage yield, and comparable in CP concentration. If so, then triticale is being underutilized as a cool season, annual forage in southwestern North Dakota, as has been suggested (Carr et al., 1998b).

Preliminary data suggest that forage CP concentration of cool season, annual legumes is superior to that of barley, oat, and triticale, but legumes produce less forage. Results of other experiments support these observations, although additional data are needed. In some environments, peas may be capable of producing relatively large amounts of forage, as results of the forage pea experiment for 1998 indicate.

Forage yield and CP concentration are inversely related to harvest date of cool season, annual cereals, cereal-pea mixtures, and annual legumes. Preliminary analyses of data suggest that yield generally is highest when forage is harvested at the soft dough stage of cereal kernel development. Crude protein concentration is highest when forage is harvested at the early heading stage of cereal plant development. The best compromise between forage yield and CP concentration may be to harvest forage at the milky ripe stage of kernel development.

Lentil and pea cultivars vary for forage yield and CP concentration. More data are needed before pea cultivars can be identified which are consistently superior to others for yield or CP concentration. Preliminary data indicate that semi-leafless pea cultivars produce as much forage as long-vined, leafy cultivars. The lentil cultivar Indianhead compared favorably to other lentil cultivars for forage yield and CP concentration.

Table 1. Forage yield and forage crude protein (CP), acid detergent fiber (ADF),and neutral detergent fiber (NDF)concentration, of cool season, annual cereals and legumes during 1996, 1997, and 1998 at Dickinson, ND.

Forage treatment	Dry matter basis								
	Yield			CP		ADF		NDF	
	1996	1997	1998	1996	1997	1996	1997	1996	1997
	tons/ac			%					
Arvika pea	2.4	--	--	11.2	--	47.1	--	39.3	--
Trapper pea	--	1.4	2.5	--	13.4	--	46.1	--	51.1
Aladdin Fababean	--	0.6	--	--	18.3	--	49.0	--	51.2
Indianhead lentil	--	0.7	1.7	--	16.2	--	34.9	--	40.5
Stark Barley	--	--	3.0	--	--	--	--	--	--
Haybet barley	--	1.8	3.5	--	11.3	--	32.7	--	52.4
Paul oat	2.3	1.2	2.7	12.4	11.8	38.4	43.5	54.4	60.3

Paul oat + Trapper pea	2.2	1.5	2.9	12.1	12.6	35.3	45.1	52.7	53.0
Triticale 2700	4.2	1.9	3.0	10.1	11.5	26.6	40.8	48.2	63.2
Triticale 2700 + Trapper pea	3.5	2.2	3.2	10.9	10.5	27.1	43.0	45.6	58.5
Whitestone oat	2.7	1.6	3.3	10.7	10.1	45.1	43.8	58.0	64.5
Whitestone oat + Trapper pea	2.6	2.0	3.3	12.3	11.8	36.1	43.5	56.3	57.6
Mean	2.8	1.5	2.9	11.8	12.7	34.5	42.3	49.0	55.3
CV(%)	9.2	17.0	14.1	10.4	13.0	11.1	6.7	13.7	5.3
LSD (.05)	0.4	NS[1]	0.6	NS	2.4	8.4	4.1	NS	4.2

[1]NS = not significant at the *P* < 0.05 level.

Table 2. Forage yield and forage crude protein (CP), acid detergent fiber (ADF), and neutral

Cultivar	Dry matter basis									
	Yield		CP		ADF		NDF		RFV	
	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998
	Tons/ac		%							
Algera	1.4	2.9	17.5	15.5	38	32	43	41	131	150
Carneval	1.2	2.8	17.0	11.8	33	40	44	52	134	112
Horsford + Carneval[1]	--	2.5	--	11.8	--	38	--	51	--	110
Trapper	--	2.5	--	19.1	--	32	--	39	--	156
Motazz	0.9	1.8	19.8	12.5	34	38	43	49	137	114
Pro 2100	1.2	2.3	16.9	15.2	33	33	42	42	141	139
SW Bravo	--	2.7	--	13.9	--	35	--	45	--	128
SW 92565	--	2.5	--	15.1	--	33	--	42	--	143

Grande	1.4	2.8	18.8	16.2	33	34	41	41	147	146
Yorkton	1.2	2.9	17.7	18.5	35	31	43	36	133	173
24 f	1.2	2.2	20.3	19.9	36	34	43	40	133	145
Mean	1.1	2.5	18.3	15.4	33.9	34.6	41.8	43.5	140.6	137.
C.V. %	15.7	9.1	9.0	13.5	11.9	17.6	7.8	16.0	11.7	23.6
LSD .05	NS[2]	0.3	2.4	3.6	5.8	NS	NS	NS	NS	NS

[1]Horsford = Horsford barley; Carneval = Carneval peas.
[2]NS = not significant at the *P* < 0.05 level.

Table 3. Forage yield and forage crude protein (CP), acid detergent fiber (ADF), and neutral

Cultivar	Dry matter basis									
	Yield		CP		ADF		NDF		RFV	
	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998
	Tons/ac		%							
Crimson	--	0.7	--	20.4	--	22.0	--	31.0	--	216.0
CDC Richlea	1.8	1.2	16.3	20.2	34.3	23.0	40.4	34.0	143.8	197.0
Indianhead	2.0	1.2	18.2	21.7	35.9	25.0	42.4	35.0	135.8	185.0
CDC Milestone	1.2	1.2	16.0	17.2	33.2	25.0	38.9	34.0	151.6	189.0
Mean	1.4	1.1	16.4	19.9	34.5	24.0	40.7	34.0	142.6	197.0
C.V. %	13.9	14.4	7.5	5.0	10.9	9.7	7.6	5.4	10.9	7.4
LSD .05	0.3	0.2	1.9	1.9	NS[1]	NS	NS	NS	NS	NS

[1]NS = not significant at the *P* < 0.05 level.

Table 4. Forage yield of barley, oat, lentil and pea seeded alone and in combination when harvested at heading (HDT), kernel milky ripe (MR), kernel soft dough (SD), and kernel hard dough (HD)cereal growth stages during 1996 (96), 1997 (97), and 1998 (98) at Dickinson, ND. headiunbdoifjdslkfj

Cultivar[1]	Dry matter basis											
	HDT			MR			SD			HD		
	96	97	98	96	97	98	96	97	98	96	97	98
	tons/acre											
Horsford/Trapper [1.5]	1.8	1.0	2.0	2.6	1.8	2.8	2.9	1.9	3.3	1.9	2.0	3.7
Horsford/Trapper [1.0]	1.5	1.0	1.8	2.4	1.6	2.5	2.8	1.9	3.3	2.5	2.1	3.5
Horsford/Trapper [0.5]	1.4	1.0	1.3	2.2	1.7	2.4	2.5	1.8	3.0	2.4	1.9	3.0
Horsford	1.6	0.9	1.9	2.7	1.6	2.8	2.9	1.7	3.2	2.6	1.8	3.3
Dumont/Trapper [1.5]	2.2	1.0	2.3	2.6	1.8	2.7	2.8	2.2	3.6	2.9	2.1	3.0
Dumont/Trapper [1.0]	2.1	0.8	1.8	2.4	1.6	2.5	2.8	2.2	3.6	2.6	2.1	3.5
Dumont/Trapper [0.5]	1.9	0.8	1.3	2.2	1.4	2.2	2.3	2.3	3.2	2.7	2.0	3.1
Dumont	2.0	1.0	1.5	2.4	1.9	2.7	2.6	2.4	4.0	2.9	2.3	3.3
Dumont/Indianhead	2.0	1.0	2.0	2.4	1.9	2.6	2.6	2.2	3.9	2.9	2.0	3.1
Indianhead lentil	0.4	0.3	0.1	0.9	0.9	0.7	1.2	1.5	1.4	2.1	1.7	2.0
Trapper pea	--	0.6	0.8	--	1.3	1.5	--	1.8	2.4	--	2.0	3.4

Mean	1.7	0.9	1.5	2.3	1.6	2.3	2.5	2.0	3.2	2.6	2.0	3.2
CV(%)	11.	18.	25.	7.0	17.	10.	10.	12.	14.	15.	10.	14.
LSD .05	0.3	NS[2]	NS	0.2	NS	0.4	0.4	0.4	0.6	0.6	0.3	0.6

[1]Horsford/Trapper = Horsford barley and Trapper pea seeded together at respective rates of 26 and 11 kernels and seeds/ft^2 [1.5], 17 and 7 kernels and seeds/ft^2 [1], and 9 and 4 kernels and seeds/ft^2; Dumont/Trapper = Dumont oat and Trapper pea seeded together at respective rates of 26 and 11 kernels and seeds/ft^2 [1.5], 17 and 7 kernels and seeds/ft^2 [1], and 9 and 4 kernels and seeds/ft^2.
[2]NS = not significant at the $P < 0.05$ level.

Table 5. Forage crude protein concentration of barley, oat, lentil and pea seeded alone and in combination when harvested at heading (HDT), kernel milky ripe (MR), kernel soft dough (SD), and kernel hard dough (HD) cereal growth stages during 1996 (96) and 1997 (97) at Dickinson, ND.

Crop[s]	Cultivar[s]	Seeding rate		Crude protein							
				-- HDT --		--- MR ---		--- SD ---		--- HD ---	
		Cereal	Legume	96	97	96	97	96	97	96	97
		kernels or seed/ft^2		%							
barley/pe	Horsford/Trapper	26	11	17	17	12	16	11	15	10	12
barley/pe	Horsford/Trapper	17	7	16	16	13	15	10	15	9	12
barley/pe	Horsford/Trapper	9	4	18	15	16	15	11	14	10	11
barley	Horsford	17	--	15	16	12	14	11	13	10	9

oat/pea	Dumont/Trapper	26	11	14	15	11	14	11	11	7	9
oat/pea	Dumont/Trapper	17	7	15	16	12	15	11	13	10	9
oat/pea	Dumont/Trapper	9	4	15	17	14	15	12	13	10	8
oat	Dumont	17	--	13	15	10	12	12	9	10	8
oat/lentil	Dumont/Indianhea	17	6	14	16	12	13	11	10	10	8
lentil	Indianhead	--	6	22	24	20	22	18	18	15	15
pea	Trapper	--	7	--	18	--	20	--	17	--	10
Mean				16	17	13	16	12	13	10	10
CV(%)				7	8	8	7	9	9	10	15
LSD .05				2	2	2	2	2	2	2	NS[1]

[1]NS = not significant at the $P < 0.05$ level.

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