ON-FARM EVALUATION OF ALFALFA/GRASS MIXTURES IN MINNESOTA – Year 4

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FINAL REPORT (20 January 2012)

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Interest in the potential for perennial forage grasses to complement alfalfa for high-quality forage production continues to grow in the North Central USA. Forage mixtures of alfalfa with perennial cool-season grasses offer whole-system (soil, crop, and livestock) advantages over alfalfa monocultures. But data on the yield and forage-quality potential of alfalfa/grass mixtures with modern grass varieties and harvest management are lacking.

A team of 10 UMN-Extension personnel are assessing forage yield, quality, and species compatibility of alfalfa/grass mixtures vs. alfalfa monocultures on three Minnesota farms. We were fortunate to receive 2008, 2009, 2010 and 2011 funding from the MFRP to establish and conduct harvests, collect yield and composition data, and analyze forage quality for multiple years. 'Year 1', 'Year 2', and 'Year 3' (pending approval) reports are available to MFA members via the MFA website www.midwestforage.org. **This report is the final report of 'Year 4' (2011) activities funded by the MFRP.**

PROCEDURES

Alfalfa/grass mixture trials were seeded near Hutchinson (Red Cedar Farm, Bill Hard) on 25 August 2008, near Underwood (Jon Wold farm) on 29 August 2008, and near Avon (Jim and Karen Barg farm) on 4 May 2009. Treatments included binary mixtures of alfalfa (ALF) with nine different perennial grasses, and alfalfa seeded alone. Three different ALF varieties ('Rebound 5.0', '4S419', and 'Spredor 4') were tested alone and in binary mixtures with two varieties of each of the nine grass species.

Rebound 5.0 is a high-yielding hay-type that has performed well in previous UMN trials; the seed was coated, so 65% pure live seed (PLS). 4S419 is a hybrid-type that also did well in UMN trials. Spredor 4 is a grazing-type, fall-dormant variety with some yellow-flowering ('falcata') *Medicago* in its genetics. Three ALF varieties were used to determine if different alfalfa regrowth genetics affect compatibility with grasses, and to increase the overall robustness of our results. The alfalfa seeding rate in binary mixtures was 10 lb/ac, and 15 lb/ac when seeded alone. At Avon, three additional legumes including 'Norcen' birdsfoot trefoil, 'VNS' Kura clover, and 'Marathon' red clover were seeded with selected grass entries, since soil/fertility/history suggested potential limitations for alfalfa.

Two varieties of each of nine different grass species were seeded in the trials. Grass species (and seeding rates) included meadow bromegrass (MB, 10 lb/ac), smooth bromegrass

(SB, 10 lb/ac), festulolium (FL, 8 lb/ac), meadow fescue (MF, 8 lb/ac), perennial ryegrass (PRG, 8 lb/ac), tall fescue (TF, 8 lb/ac), orchardgrass (OG, 6 lb/ac), reed canarygrass (RCG, 6 lb/ac), and timothy (TIM, 4 lb/ac). Individual plots were 3' X 20', with legume and grass drilled together in 5 rows per plot. Two replications were seeded at all sites with ALF varieties as whole plots ('internal replications') and grass species as subplots. The two varieties of each grass species mixed with each ALF variety were seeded in side-by-side plots.

Plots were harvested with a small-plot flail-type machine to a ~4"residual height. The Underwood and Hutchinson sites were each harvested four times in 2011, whereas the Avon site was harvested only twice. The Avon site is an excessively-drained, sandy soil quickly sensitive to dry periods, resulting in only two machine harvests in 2011; but grazing may have enabled 1-2 more 'harvests'.

Table 1. 2011 monthly-average TEMPERATURES, total-monthly PRECIPITATION, and departures from long-term averages near 3 alfalfa/grass-mixture farm-research sites in MN.

LOCATION	MONTH	Temp.	Dep.	Precip.	Dep.
		---------- *°F* ----------		---------- *inches* ----------	
AVON					
	April	44.8	-0.9	2.49	+0.34
	May	58.1	-1.0	5.59	+2.09
	June	67.1	-0.4	4.78	+0.10
	July	77.2	+5.0	7.57	+3.94
	August	71.8	+1.7	6.82	+3.01
	September	61.2	+0.3	0.65	-2.53
HUTCHINSON					
	April	43.3	-1.5	3.91	+1.73
	May	55.2	-3.2	7.76	+4.67
	June	66.5	-1.3	3.94	-0.52
	July	76.2	+4.3	6.15	+2.34
	August	70.9	+1.9	3.05	-0.94
	September	60.0	+0.3	0.54	-1.81
UNDERWOOD					
	April	43	-1	1.88	0
	May	56	-1	3.57	+0.43
	June	65	-1	2.37	-1.69
	July	72	+2	6.42	+2.84
	August	68	-1	3.90	+0.70
	September	60	+1	0.73	-2.03

AVON and UNDERWOOD data from Collegeville and Fergus Falls (temperature only), MN, respectively.

Initial fertility and pH at Hutchinson were at optimum levels, so no amendments were applied at establishment. In contrast, Underwood and especially Avon had sub-optimal pH, P, and K levels for alfalfa production; so lime, P, and K fertilizer were applied at establishment. As in previous years, all sites received ~3 lb/ac B, ~50 lb/ac S, and P and K as needed to maintain high soil-test levels. In addition in 2011, as in previous production years, 50 lb N/ac was applied twice at each location (first as ammonium sulfate, second as urea or ammonium nitrate) to encourage grass productivity.

2011 harvest dates were as follows:

- Underwood – June 8, July 12, August 9, and September 28
- Hutchinson – May 26, June 27, July 29, and September 6
- Avon – June 11 and August 3

Growing-season 2011 climate data are shown in Table 1. In general, April-June was ***cooler*** than normal, and July-September ***warmer*** than normal; with Underwood experiencing temperatures nearest normal throughout the growing season. For April-June, Avon, Hutchinson, and Underwood averaged 0.8, 2.0, and ~1°F ***cooler*** than normal, respectively. In contrast, July-September at Avon, Hutchinson, and Underwood averaged 3.2, 2.2, and ~1°F ***warmer*** than normal, respectively.

At Avon, despite 9.48 inches ***more*** precipitation than normal April-August, September ***drought*** at this sandy site was enough to thwart a third harvest. At Hutchinson, precipitation in April-May and July totaled 8.74 inches ***more*** than normal; but June and August-September fell 3.27 inches ***short*** of normal, thwarting our goal of a fifth harvest in October. As with temperature, growing-season precipitation at Underwood was nearer normal than at Avon and Hutchinson, with May and July-August receiving 3.97 inches ***more***, and June and September 3.72 inches ***less*** than normal.

2011 RESULTS

In the third production year (2011) at Underwood, ALF/TF (with season-average 31% grass) stood alone as the top total-season yielder, producing 20% more total-season DM than ALF alone (Table 2). ALF mixed with MB, TIM, MF, or OG ranked second behind ALF/TF, yielding 7% less total-season DM; but these four mixtures were the top-yielders at the June 8 harvest. The remaining four mixtures had similar total-season yields to ALF alone. ALF/TIM and ALF alone yielded similarly to ALF/TF at the July 12 harvest, but ALF/TF stood alone as top yielder at the August 9 and September 28 harvests.

ALF/OG had the greatest grass content of all mixtures throughout the season, usually >50%. ALF/MB had similar season-average but somewhat more consistent grass content across harvests compared to ALF/TF. ALF/PRG had the least grass in the third production year, consistent with previous years.

Table 2. 2011 DM YIELDS (and % seeded grass) of alfalfa/grass mixtures seeded August 2008 at UNDERWOOD, MN, and harvested four times in 2011.

MIXTURE *(Averaged over 3 AlfVar and 2 GrsVar)*	**2011 Total**	**June 8**	**July 12**	**August 9**	**Sept. 28**
	---------- Ton DM per acre ----------				
Alf/Tall Fescue	**5.87** (31)	2.15 (21)	**1.03** (34)	**1.50** (28)	**1.18** (38)
Alf/Meadow Bromegrass	5.44 (32)	**2.29** (33)	0.92 (29)	1.16 (35)	1.06 (29)
Alf/Timothy	5.44 (27)	**2.37** (42)	**0.98** (26)	1.15 (22)	0.95 (17)
Alf/Meadow Fescue	5.42 (23)	**2.20** (29)	0.94 (22)	1.29 (19)	0.99 (22)
Alf/Orchardgrass	5.41 (**54**)	**2.24** (**55**)	0.84 (**56**)	1.26 (**48**)	1.07 (**57**)
Alf/Reed Canarygrass	5.16 (10)	1.96 (7)	0.95 (12)	1.30 (12)	0.95 (7)
Alf/Smooth Bromegrass	4.98 (15)	1.93 (17)	0.96 (17)	1.14 (13)	0.95 (14)
Alf/Festulolium	4.96 (12)	1.95 (5)	0.93 (14)	1.13 (15)	0.95 (15)
Alf/Perennial Ryegrass	4.93 (8)	1.92 (3)	0.90 (7)	1.17 (9)	0.95 (12)
Alfalfa Alone	4.89 (0)	1.78 (0)	**0.97** (0)	1.18 (0)	0.95 (0)
LSD (0.05)	**0.35 (3)**	**0.18 (7)**	**0.07 (4)**	**0.08 (4)**	**0.10 (5)**
Overall Average	*5.25 (21)*	*2.08 (21)*	*0.94 (22)*	*1.23 (20)*	*1.00 (21)*

Bolded value indicates statistical similarity (p=0.05) to the largest value within the same data column.
NA = not available.

Table 3. 2011 DM YIELDS (and % seeded grass) of alfalfa/grass mixtures seeded August 2008 at HUTCHINSON, MN, and harvested four times in 2011.

MIXTURE *(Averaged over 3 AlfVar and 2 GrsVar)*	**2011 Total**	**May 26**	**June 27**	**July 29**	**Sept. 6**
	---------- Ton DM per acre ----------				
Alf/Orchardgrass	**4.03** (**36**)	**1.36** (**43**)	0.79 (**39**)	1.07 (**32**)	**0.82** (**29**)
Alf/Tall Fescue	**4.01** (20)	**1.27** (20)	0.87 (19)	1.10 (22)	**0.77** (16)
Alf/Festulolium	3.84 (15)	1.09 (23)	**0.98** (23)	1.05 (13)	0.72 (2)
Alf/Perennial Ryegrass	3.70 (13)	1.07 (15)	0.87 (18)	1.05 (14)	0.72 (3)
Alf/Meadow Fescue	3.69 (9)	1.09 (19)	0.81 (9)	1.08 (7)	0.72 (1)
Alf/Reed Canarygrass	3.67 (4)	1.07 (4)	0.80 (5)	1.05 (6)	0.74 (1)
Alf/Meadow Bromegrass	3.63 (3)	0.99 (3)	0.78 (2)	1.06 (4)	**0.79** (1)
Alf/Smooth Bromegrass	3.62 (3)	0.96 (2)	0.80 (2)	1.12 (5)	0.75 (1)
Alfalfa Alone	3.60 (0)	1.03 (0)	0.79 (0)	1.05 (0)	0.73 (0)
Alf/Timothy	3.53 (4)	0.98 (4)	0.81 (4)	1.04 (7)	0.70 (1)
LSD (0.05)	**0.17 (4)**	**0.10 (4)**	**0.07 (7)**	**NS (6)**	**0.06 (5)**
Overall Average	*3.73 (11)*	*1.09 (13)*	*0.83 (13)*	*1.07 (11)*	*0.75 (6)*

Bolded value indicates statistical similarity (p=0.05) to the largest value within the same data column.
NA = not available.

In the third production year (2011) at Hutchinson, ALF mixed with either OG or TF were the top total-season yielders, producing 12% more DM than ALF alone (Table 3). ALF/OG and ALF/TF were also top-yielders at the May 26 harvest, and among the top-yielders along with ALF/MB at the September 6 harvest. Interestingly, ALF/FL stood alone as the top yielder at the

June 27 harvest; and there were no yield differences among mixture treatments at the July 29 harvest. ALF/FL was the only other mixture besides ALF/OG and ALF/TF to exceed the total-season yield of ALF alone, ranking third in season-average grass content. As in previous years but in contrast to Underwood in 2011, ALF/TIM was among the lowest yielders throughout the season.

As in previous years, grass content at Hutchinson was generally less than at Underwood (avg. 11 vs. 21%, respectively). ALF/OG had by far the greatest grass percentage throughout 2011, almost double that of any other mixture. ALF/TF ranked second in season-average grass content. ALF/FL grass content equaled that of ALF/TF at the first two harvests, but dropped to only 2% at the September 6 harvest.

Table 4. 2011 total-herbage and 'weed'-free DM YIELDS (and % seeded grass) of alfalfa/grass mixtures seeded May 2009 at AVON, MN, and harvested twice in 2011.

MIXTURE *(Averaged over 3 AlfVar and 2 GrsVar)*	**2011 Total**		**June 11**		**August 3**	
	Tot-Herbage	**'Weed'-free**	**Tot-Herbage**	**'Weed'-free**	**Tot-Herbage**	**'Weed'-free**
	---------- Ton DM per acre ----------					
Alf/Tall Fescue	**3.92** (77)	**3.83**	**2.48** (78)	**2.48**	1.44 (**75**)	**1.35**
RC/Tall Fescue	**3.89** (73)	**3.73**	**2.31** (75)	**2.31**	**1.58** (70)	**1.42**
BFT/Tall Fescue	**3.69** (**85**)	**3.61**	**2.26** (**83**)	**2.25**	1.43 (**87**)	**1.36**
BFT/Meadow Brome	**3.87** (**85**)	**3.55**	**2.49** (**96**)	**2.49**	1.38 (**73**)	1.05
KC/Tall Fescue	**3.75** (**93**)	**3.55**	**2.32** (**99**)	**2.31**	1.43 (**87**)	**1.25**
RC/Reed Canarygrass	3.49 (67)	**3.49**	1.93 (45)	1.93	1.56 (**87**)	**1.56**
BFT/Meadow Fescue	3.53 (**87**)	**3.43**	**2.33** (**93**)	**2.33**	1.20 (**80**)	1.11
Alf/Smooth Bromegrass	3.53 (70)	**3.31**	**2.22** (71)	**2.22**	1.31 (67)	1.09
Alf/Timothy	3.34 (57)	**3.21**	1.91 (63)	1.91	1.43 (51)	**1.30**
RC/Meadow Brome	3.31 (61)	**3.20**	2.13 (60)	**2.13**	1.19 (60)	1.07
Alf/Orchardgrass	3.20 (**91**)	**3.15**	1.80 (**94**)	1.80	1.40 (**87**)	**1.36**
KC/Meadow Fescue	3.23 (**93**)	3.05	2.05 (**99**)	**2.03**	1.18 (**87**)	1.03
RC/Meadow Fescue	3.09 (73)	3.03	1.92 (80)	1.92	1.17 (65)	1.11
Alf/Meadow Bromegrass	3.27 (65)	2.92	2.01 (**83**)	2.00	1.27 (46)	0.92
Alf/Reed Canarygrass	**3.77** (58)	2.83	2.11 (53)	1.60	**1.66** (62)	1.23
KC/Meadow Brome	3.15 (**87**)	2.83	1.92 (**97**)	1.87	1.23 (**77**)	0.97
Alf/Meadow Fescue	3.44 (53)	2.81	2.11 (53)	1.82	1.33 (53)	0.98
BFT/Reed Canarygrass	**4.04** (67)	2.77	**2.29** (55)	1.25	**1.75** (**80**)	**1.53**
KC/Reed Canarygrass	**3.69** (59)	2.56	2.00 (57)	1.37	**1.69** (60)	1.19
Alf/Festulolium	3.13 (35)	2.51	1.82 (33)	1.55	1.31 (36)	0.96
Alf/Perennial Ryegrass	2.78 (28)	1.99	1.50 (25)	1.19	1.28 (30)	0.81
Alfalfa Alone	2.92 (0)	1.41	1.55 (0)	097	1.37 (0)	0.44
LSD (0.05)	**0.42 (14)**	**0.71**	**0.31 (17)**	**0.49**	**0.18 (17)**	**0.33**
Overall Average	*3.37 (58)*	*2.87*	*1.99 (59)*	*1.80*	*1.38 (55)*	*1.07*

Bolded values indicate statistical similarity (p=0.05) to the largest value within the same column.
NA = not available

In the second production year (2011) at Avon, where 12 additional legume/grass mixtures were included, there was significantly greater seeded-grass content (avg. 58%) and more weeds (primarily quackgrass) than at Underwood or Hutchinson. In addition, alfalfa growth was visibly stunted for unknown reasons. Since quackgrass has reasonably good forage characteristics, data for both total-herbage and weed-free DM yield are presented in Table 4. Four of the five mixtures that were among the top total-season yielders for both total-herbage and weed-free DM included TF with each of the four legumes. The fifth mixture was BFT/MB. For these five mixtures, total-herbage and weed-free DM yields averaged 3.82 and 3.65 ton DM/acre, respectively, 30 and 160% more than the respective total-season values for ALF alone. The considerable difference between yield values for 'ALF alone' was due to stunted alfalfa and quackgrass encroachment. RCG mixed with BFT, ALF, or KC had similar total-herbage production as the five aforementioned mixtures due likely to quackgrass encroachment during RCG's slow establishment; they were not, however, among greatest in total-season weed-free DM yield. Conversely, the following six mixtures had similar total-season weed-free DM yields as the aforementioned five mixtures, but were not among top yielders in total-herbage DM: RC/RCG, BFT/MF, ALF/SB, ALF/TIM, RC/MB, and ALF/OG.

Seven mixtures at Avon had greatest seeded-grass content, averaging 89% (Table 4). Three of these mixtures were also among the greatest yielders in total-herbage and weed-free DM, and two were among the greatest weed-free yielders; the two remaining mixtures that were not among greatest yielders in either category both included KC. RC was the only legume that wasn't among mixtures with greatest grass content due its strong establishment and vigor at the site. Among the 11 top-yielding weed-free mixtures; four included TF, two MB, one RCG, one MF, one SB, one TIM, and one OG. Three of the four RC mixtures, three of the four BFT mixtures, and only one of the four KC mixtures were among the top 11 weed-free yielders; the remaining mixtures were three of nine ALF mixtures.

Table 5. 2011 weighted-season-average FORAGE QUALITY (over 4 harvests) of 'Rebound 5.0' alfalfa/grass mixtures seeded August 2008 at UNDERWOOD, MN *(determined via NIRSC equations; mixture-treatments listed in descending Milk/Acre-order)*.

MIXTURE *(Rebound 5.0 with 1 GrsVar per GrsSpc)*	**%Grs**	**CP**	**ADF**	**NDF**	**ADL**	**NDFD**	**RFQ**	**Milk/ Ton**	**Milk/ Acre**	**RFV**
Legume/Grass	---------- *% DM* ----------					*%NDF*		*Lb/T*	*Lb/Ac*	
Alf/Tall Fescue	31	20.5	32.9	44.1	**5.2**	**48.4**	138	**2600**	**16,310**	135
Alf/Orchardgrass	**54**	20.5	33.1	44.6	**5.2**	**48.7**	139	**2650**	**15,060**	135
Alf/Timothy	27	20.7	**32.3**	42.5	**5.1**	**46.4**	143	**2630**	**14,380**	142
Alf/Reed Canarygrass	10	**21.9**	32.9	**41.2**	5.5	41.7	137	2470	14,110	145
Alf/Festulolium	12	**22.4**	**32.3**	**40.1**	5.5	41.5	141	2500	13,750	**149**
Alf/Meadow Fescue	23	21.0	32.7	42.9	**5.3**	**47.5**	141	**2620**	13,510	139
Alf/Meadow Bromegrass	32	**21.5**	**32.0**	41.3	**5.3**	44.9	143	**2610**	13,430	145
Alfalfa Alone	0	**22.3**	**32.5**	**40.2**	5.5	41.3	141	2490	12,790	**149**
Alf/Perennial Ryegrass	8	**22.1**	**32.4**	**40.6**	5.5	42.1	140	2520	12,640	**147**
Alf/Smooth Bromegrass	15	**21.7**	32.9	41.7	5.5	43.4	139	2520	12,460	143
LSD (0.05)	**3**	**1.1**	**0.6**	**1.2**	**0.3**	**3.1**	**NS**	**120**	**2090**	**4**
Overall Average	*21*	*21.5*	*32.6*	*41.9*	*5.3*	*44.6*	*140*	*2560*	*13840*	*143*

Bolded value indicates statistical similarity (p=0.05) to the largest value (smallest value for ADF, NDF, & ADL) within the same data column.

NS = no statistically significant difference at p=0.05.

In 2011 at Underwood, greatest milk production potential per acre occurred with ALF mixed with TF, OG, or TIM (avg. 15250), 20% more than for ALF alone (Table 5). The remaining six mixtures had similar total-season milk/acre as ALF alone. Greatest season-average RFV and lowest NDF concentrations (avg. 148 and 40.3%, respectively) occurred with ALF alone and ALF mixed with PRG or FL (avg. 7% grass). In contrast, ALF/TF and ALF/OG (avg. 43% grass) had the lowest RFV and greatest NDF concentrations (avg. 135 and 44.3%, respectively). The lack of treatment effects on RFQ likely reflects the relatively greater NDFD concentration in mixtures with relatively more grass. Four of the five mixtures with greatest milk/ton also had greatest NDFD. All treatments averaged >20% crude protein over the season.

Table 6. 2011 weighted-season-average FORAGE QUALITY (over 4 harvests) of 'Rebound 5.0' alfalfa/grass mixtures seeded August 2008 at HUTCHINSON, MN *(determined via NIRSC equations; mixture-treatments listed in descending Milk/Acre-order)*.

MIXTURE *(Rebound 5.0 with 1 GrsVar per GrsSpc)*	**%Grs**	**CP**	**ADF**	**NDF**	**ADL**	**NDFD**	**RFQ**	**Milk/ Ton**	**Milk/ Acre**	**RFV**
Legume/Grass	---------- *% DM* ----------					*%NDF*		*Lb/T*	*Lb/Ac*	
Alf/Orchardgrass	**36**	18.9	37.1	51.3	4.7	533	125	2640	**11,660**	110
Alf/Festulolium	15	**20.1**	35.8	**46.7**	4.3	525	137	2690	**11,090**	**121**
Alf/Tall Fescue	20	**20.1**	35.3	**47.5**	4.5	519	135	2680	**11,060**	**121**
Alf/Perennial Ryegrass	13	19.9	36.2	**47.9**	4.6	493	127	2570	**10,970**	**119**
Alf/Meadow Fescue	9	**20.1**	35.5	**46.7**	4.5	499	133	2620	10,260	**123**
Alf/Reed Canarygrass	4	**20.5**	34.9	**45.9**	4.5	495	135	2650	10,130	**125**
Alf/Smooth Bromegrass	3	**20.7**	35.1	**45.9**	4.7	483	133	2610	9,970	**125**
Alf/Timothy	4	**20.1**	36.1	**47.3**	4.5	503	131	2620	9,920	**120**
Alfalfa Alone	0	**20.5**	35.3	**46.3**	4.7	497	133	2650	9,890	**124**
Alf/Meadow Bromegrass	3	**20.3**	35.5	**46.9**	4.6	493	131	2600	9,390	**122**
LSD (0.05)	**4**	**0.8**	**NS**	**2.1**	**NS**	**NS**	**NS**	**NS**	**1,120**	**8**
Overall Average	*11*	*20.1*	*35.7*	*47.2*	*4.6*	*50.4*	*132*	*2630*	*10,430*	*121*

Bolded value indicates statistical similarity (p=0.05) to the largest value (smallest value for NDF & ADL) within the same data column.

NS = no statistically significant difference at p=0.05.

In 2011 at Hutchinson, greatest milk production potential per acre occurred with ALF mixed with OG, FL, TF, or PRG (avg. 11,190 lb/acre), 13% greater than for ALF alone (Table 6). The other five mixtures had similar season-total milk/acre as ALF. ALF/OG stood alone with the lowest RFV compared to all other treatments, likely due to its relatively greater grass content and greater NDF concentration. Similar to Underwood, however, there were no RFQ differences among mixture treatments ranging from 0 to 36% season-average grass content. Milk/ton, NDFD, ADF, and ADL were also unaffected by treatment.

Table 7. 2011 weighted season-average FORAGE QUALITY (over 2 harvests) of legume/grass mixtures seeded May 2009 at AVON, MN *(determined via NIRSC 'grass hay' equations; mixture-treatments listed in descending Milk/Acre-order, though NS)*.

MIXTURE *(1 LegVar with 1 GrsVar)*	**%Grs**	**CP**	**ADF**	**NDF**	**ADL**	**NDFD**	**RFQ**	**Milk/ Ton**	**Milk/ Acre**	**RFV**
Legume/Grass	---------- *% DM* ----------					*%NDF*		*Lb/T*	*Lb/Ac*	
BFT/Reed canarygrass	67	12.7	39.7	63.8	NA	**50.9**	91	2250	9,090	85
BFT/Meadow brome	**85**	13.5	41.5	63.1	NA	**51.5**	93	2230	8,580	83
BFT/Meadow fescue	**87**	12.5	38.9	**59.8**	NA	**54.2**	104	2410	8,480	**91**
BFT/Tall fescue	**85**	12.5	38.8	61.1	NA	**52.7**	97	2290	8,430	**89**
Alf/Meadow fescue	53	14.6	39.0	**58.7**	NA	**52.9**	104	2390	8,300	**93**
RC/Tall fescue	73	14.4	39.9	61.5	NA	49.8	89	2120	8,280	87
Alf/Tall fescue	77	12.9	39.3	61.2	NA	**51.2**	94	2220	8,160	**89**
Alf/Timothy	57	14.8	38.7	**57.0**	NA	48.1	99	2280	8,080	**96**
Alf/Meadow bromegrass	65	**15.1**	42.1	61.1	NA	48.3	89	2100	7,680	85
RC/Meadow bromegrass	61	**15.7**	41.3	**57.5**	NA	49.4	100	2250	7,470	**93**
Alf/Smooth bromegrass	70	**15.4**	40.3	**60.1**	NA	46.7	87	2060	7,310	**89**
RC/Reed canarygrass	67	**15.3**	40.3	**58.9**	NA	46.5	89	2080	7,210	**91**
Alf/Festulolium	35	14.9	38.5	**58.3**	NA	50.0	99	2250	7,130	**95**
Alf/Reed canarygrass	58	12.6	41.3	63.8	NA	46.8	81	1970	7,000	83
Alf/Orchardgrass	**91**	13.1	40.9	64.5	NA	**52.5**	91	2230	6,980	82
RC/Meadow fescue	73	14.9	39.7	**59.3**	NA	49.1	93	2190	6,750	**91**
Alfalfa Alone	0	**16.5**	40.9	**57.5**	NA	44.8	89	2020	6,180	**93**
Alf/Perennial ryegrass	28	14.5	39.4	**59.4**	NA	46.1	89	2060	5,720	**91**
LSD (0.05)	**14**	**1.6**	**NS**	**3.3**	NA	**3.7**	**NS**	**NS**	**NS**	**8**
Overall Average	*58*	*14.2*	*40.0*	*60.4*	NA	*49.5*	*93*	*2190*	*7,600*	*89*

Bolded value indicates statistical similarity (p=0.05) to the largest value (smallest value for NDF & ADL) within the same data column.

NA = not available.

NS = no statistically significant difference at p=0.05.

When 2011 results from Avon are observed, it is important to note that forage-quality analyses were conducted on total-herbage samples which in some cases included significant quackgrass. **At Avon in 2011**, there were no statistical differences in milk/acre across 18 mixture treatments despite a range from 5720 to 9090 lb/ac (Table 7); and as with the other two locations, RFQ was unaffected. In addition, milk/ton and ADF were unaffected. However, there were differences for RFV, NDFD, NDF, and CP. Six of the seven mixture treatments with greatest NDFD were among the seven mixtures with greatest numeric milk/acre values.

Table 8. 2011 total-season DM-, CP-, NDF-, and dNDF-YIELDS of 'Rebound 5.0' alfalfa/grass mixtures seeded August 2008 and harvested 4 times during 2011 at Underwood, MN *(in descending dNDFYield-order)*.

MIXTURE (*Averaged over 3 AlfVar and 2 GrsVar)*	**DM Yld**	**Grass**	**CP Yield**	**NDF Yield**	**dNDF Yield**
	Ton DM/ acre	*%*	*lb CP/acre*	*lb NDF/acre*	*lb **digestible**-NDF/acre*
Alf/Tall Fescue	**5.87**	31	2570	**5530**	**2670**
Alf/Orchardgrass	5.41	**54**	2330	**5070**	**2490**
Alf/Timothy	5.44	27	2270	4650	2170
Alf/Meadow Fescue	5.42	23	2160	4430	2110
Alf/Reed Canarygrass	5.16	10	2510	4710	1970
Alf/Meadow Bromegrass	5.44	32	2220	4250	1910
Alf/Festulolium	4.96	12	2460	4410	1830
Alf/Smooth Bromegrass	4.98	15	2150	4130	1800
Alf/Perennial Ryegrass	4.93	8	2220	4080	1710
Alfalfa Alone	4.89	0	2290	4130	1710
LSD (0.05)	**0.35**	**3**	**NS**	**650**	**320**
Overall Average	*5.25*	*21*	*2320*	*4540*	*2040*

Bolded value indicates statistical similarity (p=0.05) to the largest value within the same data column.
NS = no statistically significant difference at p=0.05.

At Underwood, ALF/TF and ALF/OG produced the greatest NDF- and dNDF-yields, 30 and 50% more, respectively than ALF alone (Table 8). Despite similar NDF yields, ALF/TIM and ALF/MF produced more digestible fiber per acre than ALF alone due to greater NDFD concentration. The remaining five mixtures did not differ from ALF alone in NDF- or dNDF-yields. CP yield was unaffected by mixture treatment.

Table 9. 2011 total-season DM-, CP-, NDF-, and dNDF-YIELDS of 'Rebound 5.0' alfalfa/grass mixtures seeded August 2008 and harvested 4 times during 2011 at Hutchinson, MN *(in descending dNDFYield-order)*.

MIXTURE (*Averaged over 3 AlfVar and 2 GrsVar)*	**DM Yld**	**Grass**	**CP Yield**	**NDF Yield**	**dNDF Yield**
	Ton DM/ acre	*%*	*lb CP/acre*	*lb NDF/acre*	*lb **digestible**-NDF/acre*
Alf/Orchardgrass	**4.03**	**36**	1670	**4530**	**2430**
Alf/Tall Fescue	**4.01**	20	1650	3920	2030
Alf/Festulolium	3.84	15	1660	3850	2020
Alf/Perennial Ryegrass	3.70	13	1700	**4080**	2020
Alf/Meadow Fescue	3.69	9	1580	3670	1830
Alf/Timothy	3.53	4	1530	3590	1800
Alf/Reed Canarygrass	3.67	4	1560	3510	1730
Alfalfa Alone	3.60	0	1530	3460	1720
Alf/Smooth Bromegrass	3.62	3	1580	3510	1700
Alf/Meadow Bromegrass	3.63	3	1470	3380	1670
LSD (0.05)	**0.17**	**4**	**NS**	**540**	**250**
Overall Average	*3.73*	*11*	*1590*	*3750*	*1890*

Bolded value indicates statistical similarity (p=0.05) to the largest value within the same data column.
NS = no statistically significant difference at p=0.05.

At Hutchinson, ALF/OG stood alone with greatest digestible fiber yield, 40% greater than for ALF alone (Table 9). ALF mixed with TF, FL, or PRG also yielded more digestible fiber than ALF alone, almost 20% more. ALF/OG and ALF/PRG produced greatest NDF yields, 25% greater than ALF alone. The remaining seven mixtures has similar NDF yield to ALF alone. As at Underwood, CP-yield was unaffected by mixture treatment.

Table 10. 2011 total-season DM-('weed'-free); and CP-, NDF-, and dNDF-(total-herbage) YIELDS of legume/grass mixtures seeded May 2009 and harvested twice during 2011 at Avon, MN *(in descending dNDFYield-order)*.

MIXTURE (*Averaged over 3 AlfVar and 2 GrsVar)*	**DM Yld**	**Grass**	**CP Yield**	**NDF Yield**	**dNDF Yield**
	Ton DM/ ac	*%*	*lb CP/ac*	*lb NDF/ac*	*lb **digestible**-NDF/ac*
BFT/Reed canarygrass	2.77	67	1030	5150	**2620**
BFT/Meadow bromegrass	**3.55**	**85**	1030	4910	**2510**
RC/Tall fescue	**3.73**	73	1120	4780	**2380**
BFT/Tall fescue	**3.61**	**85**	920	4500	**2370**
Alf/Tall Fescue	**3.83**	77	950	4510	**2310**
BFT/Meadow fescue	**3.43**	**87**	890	4230	**2290**
Alf/Meadow bromegrass	2.92	65	1100	4480	**2160**
Alf/Meadow bescue	2.81	53	1010	4100	**2160**
Alf/Orchardgrass	**3.15**	**91**	820	4050	**2130**
Alf/Reed canarygrass	2.83	58	900	4580	**2130**
Alf/Smooth bromegrass	**3.31**	70	1080	4220	1970
Alf/Timothy	**3.21**	57	1030	4080	1960
RC/Reed canarygrass	**3.49**	67	1070	4130	1910
Alf/Festulolium	2.51	35	930	3770	1870
RC/Meadow bromegrass	**3.20**	61	1040	3810	1870
RC/Meadow fescue	3.03	73	920	3660	1800
Alfalfa Alone	1.41	0	1000	3550	1590
Alf/Perennial Ryegrass	1.99	28	790	3320	1520
LSD (0.05)	**0.71**	**14**	**NS**	**NS**	**530**
Overall Average	*2.87*	*58*	*980*	*4210*	*2090*

Bolded value indicates statistical similarity (p=0.05) to the largest value within the same data column.
NS = no statistically significant difference at p=0.05.

At Avon, 10 mixtures shared top dNDF-yields; they included all four of four BFT mixtures, five of nine ALF mixtures, and only one of four RC mixtures. They also included 3 MF mixtures, 2 RCG, 2 MB, 2 MF, and 1 OG mixture. Mixtures with greatest digestible-fiber yields were often among the greatest in total-herbage (including quackgrass) yield. Mixture treatment affected neither NDF- nor CP-yields.

Table 11. ALFALFA VARIETY effects on 2011 total 'weed'-free DM yield (and % seeded grass) of alfalfa/grass mixtures at Underwood, Hutchinson, and Avon, MN.

Alfalfa Variety in Mixture (*Averaged over 18 grass species/variety entries*)	**Underwood**	**Hutchinson**	**Avon**
	---------- Ton DM/ac (% seeded grass) ----------		
4S419	5.34 (18%)	3.90 (9%)	2.99 (58%)
Rebound 5.0	5.44 (18%)	3.78 (10%)	2.68 (48%)
Spredor 4	4.97 (**28%**)	3.51 (**13%**)	2.73 (55%)
LSD (0.05)	***p<0.10* (4%)**	**NS (2%)**	**NS (NS)**
AlfVar x GrsSpc?	NS (*p<0.005*)	*p<0.10* (NS)	NS (NS)

NS = no statistically significant difference at p=0.05.

Concerning ALF variety effects on mixture performance (Table 11), there was a trend towards greatest yield with 4S419, and least yield with Spredor 4. At Underwood and Hutchinson, mixtures with Spredor 4 had greater grass content than mixtures with 4S419 or Rebound 5.0; but there was a highly significant interaction between ALF variety and grass species at Underwood. Grass content was unaffected by ALF variety at Avon.

Table 12. GRASS VARIETY effects on 2011 total-season DM yields and season-average alfalfa and seeded-grass percentages for alfalfa/grass mixtures at Underwood (3rd year), Hutchinson (3rd year), and Avon (2nd year), MN.

Grass Variety and Species*	Underwood			Hutchinson			Avon		
	Yield	**Alfalfa**	**Grass**	**Yield**	**Alfalfa**	**Grass**	**Yield**	**Alfalfa**	**Grass**
	Ton/ac	*%*	*%*	*Ton/ac*	*%*	*%*	*Ton/ac*	*%*	*%*
'Barfest' FL	4.90	89	11	3.89	83	14	2.57	49	33
'Spring Green' FL	5.02	86	14	3.79	80	16	2.46	41	37
LSD (0.05)	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*
'Fleet' MB	5.34	72	28	3.58	92	3	2.94	22	64
'Paddock' MB	5.54	65	35	3.67	94	2	2.90	23	65
LSD (0.05)	*NS*	*NS*	*NS*	*NS*	*P<.10*	*P<.10*	*NS*	*NS*	*NS*
Forage First MF	5.51	87	13	3.58	89	6	2.37	35	36
'Pradel' MF	5.33	67	34	3.79	83	13	3.24	21	71
LSD (0.05)	*NS*	*9*	*10*	*NS*	*P<.10*	*4*	*0.57*	*P<.10*	*14*
'Baridana' OG	5.47	50	50	4.15	61	37	3.21	9	90
'Potomac' OG	5.35	42	58	3.92	63	35	3.10	8	91
LSD (0.05)	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*
'Aubisque' PRG	4.93	91	8	3.74	85	12	2.09	44	29
'BG-24T' PRG	4.94	92	8	3.65	83	13	1.89	46	27
LSD (0.05)	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*
Forage First RCG	5.06	89	11	3.67	91	3	2.82	18	58
'Marathon' RCG	5.27	92	8	3.67	91	5	2.85	19	57
LSD (0.05)	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*
Albert Lea SB	4.87	83	17	3.53	92	2	3.28	23	70
Forage First SB	5.08	86	14	3.71	93	3	3.33	24	70
LSD (0.05)	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*
'Fawn' TF	5.78	71	29	4.03	76	22	3.64	22	76
'Select' TF	5.95	68	32	3.99	81	17	4.03	19	78
LSD (0.05)	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*
'Barliza' TIM	5.41	71	30	3.45	90	3	3.16	38	58
'Climax' TIM	5.46	76	25	3.61	90	4	3.27	39	57
LSD (0.05)	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*

*****FL = festulolium, MB = meadow bromegrass, MF = meadow fescue, OG = orchardgrass, PRG = perennial ryegrass, RCG = reed canarygrass, SB = smooth bromegrass, TF = tall fescue, and TIM = timothy; data averaged over 3 alfalfa varieties.

NS = no statistically significant difference at p=0.05.

In general across grass species, when analyzed within sites, grass variety had no effect on weed-free yield, ALF content, or grass content. The exception was for MF, where mixtures had more grass and less alfalfa with Pradel than with Forage First MF. Only at Avon did this result in greater mixture yield with Pradel.

KEY FINDINGS

- Alfalfa and grass content varied widely across locations despite identical seeding rates and methods, making it difficult to project herbage alfalfa/grass proportions based on seeding rates. Contrasting environmental/climatic conditions across the three locations during the critical seedling establishment phase likely affected this.
- Some alfalfa/grass mixtures consistently yielded more forage DM than alfalfa alone. Tall fescue was the grass most commonly associated with greater mixture yield. Orchardgrass ranked second. Mixtures never yielded less than alfalfa alone. However, all treatments received 100 lb N/ac/year each production year.
- Of nine grasses tested, orchardgrass was consistently the most abundant in mixtures. Different seeding rates may have produced different results.
- The 4 lb/ac seeding rate for timothy resulted in excess competition with alfalfa and suppressed yields in early production years at Underwood. By the third production year, however, this mixture 'recovered' and was among the greatest in milk/acre.
- Mixtures with tall fescue or orchardgrass produced the most digestible-fiber and the most milk-production potential per acre, significantly more than alfalfa alone. Though RFV of these mixtures was often among the least, RFQ was unaffected by mixture treatment at all three locations.
- Red clover and birdsfoot trefoil were good legume alternatives for mixtures at a marginal, sandy site where alfalfa did poorly. Kura clover failed to establish at that site.
- Alfalfa and grass content were visually estimated. Post-harvest observations of stubble suggested that we may have underestimated grass content.
- 'Long'-term mixture herbage composition seemed to be set by the end of the seedling establishment phase; reed canarygrass was the most visible exception to this, increasing at all three locations from establishment through 2011.
- We considered only binary mixtures in order to keep the experiment of manageable size. More complex mixtures may be advantageous when complementary species are selected.