Production and Nutritional Benefits of Including Legumes in Pastures

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An ideal pasture could be characterized as being highly productivity, have high nutritional quality and excellent stand longevity. These can all be met through the selection and use of the right plant materials for any given situation. Studies conducted between 1945 and 1965, consistently showed increased yield, nutritional quality, and animal performance in mixed grass-legume pastures as opposed to grass monocultures. However, using forage legumes in pastures mixes with grass lost their popularity as inexpensive fertilizer became available. This and ease of weed control contributed to grass monocultures in most pastures.

With the increase in the cost of fossil fuels and a rising global demand for commercial nitrogen (N) fertilizer there has been a corresponding increase in the cost of N fertilizer. A pastures N requirement can be augmented or fully eliminated by including forage legumes such as alfalfa, clovers or birdsfoot trefoil. Table 1 shows amounts of nitrogen reported to be typically fixed by various legumes. The amount will vary greatly depending on the legume stand and growing conditions. Under most conditions the amount of nitrogen fixed by a legume that can be used by grass is significant.

Table 1. Quantities of nitrogen fixed by various legumes. Reports vary and the amount fixed will vary with the legume stand and growing conditions.

Legume	N fixed
	(lbs/acre/year)
Alfalfa	70-200
Birdsfoot trefoil	11-150
Cicer milkvetch	140
Kura clover	17-158
Red clover	60-200
Soybean	20-200
Sweetclover	120
White clover	115-180

The cool season grasses, such as; tall fescue, meadow bromegrass, and orchargrass, typically grown in pastures of the Intermountain Western US are very productive in the spring when they produce the majority of their growth but produce very little during hot summer months. This is referred to as the summer slump. Since most forage legumes when irrigated will continue to produce during the summer, including them in a pasture can have the added benefit of increased forage production during the summer slump common with the cool

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season grasses. In addition forage legumes typically have much higher nutritive value than grasses an additional benefit.

To determine the value of including forage legumes for both forage production and nutritive value a comprehensive study was undertaken to compare the forage production and forage quality of tall fescue, meadow brome, and orchardgrass in binary mixtures with alfalfa, birdsfoot trefoil and cicer milkvetch at planting rates to achieve grass-legume ratios of 25:75, 50:50, 75:25. Three monocultures of each grass were used for comparison one receiving no fertilizer, one 60 lb nitrogen (N) per acre and the last receiving 120 lb N per acre. The N was split into three applications and applied early in the spring when the grass was just starting to grow, following the second harvest and again following the third harvest.

Table 2. Forage yield of tall fescue (TF), meadow brome (MB), and orchardgrass (OG) in unfertilized and fertilized monocultures with two nitrogen (N) rates and in mixtures with alfalfa (ALF), birdsfoot trefoil (BFTF), and cicer milkvetch (CMV) (2011-2012).

	------ Mixture Yield ------			-- Grass Monoculture Yield --			
Species	Alf	BFTF	CMV	0 N	60 lb N	120 lb N	LSD (0.05)
	------------------------------ Ton per Acre ------------------------------						
TF	6.11	5.85	5.08	4.92	5.88	6.34	0.91
MB	5.89	5.50	4.68	4.35	5.24	5.74	0.64
OG	5.09	4.68	3.72	3.62	4.29	4.95	0.71
LSD (0.05)	0.38	0.47	0.50	0.93	0.99	0.63	--

The forage yields of the grass-legume mixtures were all higher when alfalfa and birdsfoot trefoil were grown in mixtures with each grass (Table 2). This yield advantage ranged from 20 to 41 percent higher than the unfertilized grass monocultures. Of importance is that the forage yield of the mixtures was statistically equal to the forage yield of the fertilized grass monocultures (Table 2). From the standpoint of the grasses the tall fescue mixtures were the highest yielding followed by the meadow brome and orchardgrass. From the legume stand point the alfalfa mixtures were the highest yielding followed by the birdsfoot trefoil and the cicer milkvetch.

The cicer milkvetch was much slower to establish with no measurable production early in the first year (Table 3). This slow establishment of cicer milkvetch made it difficult to compare with the other mixtures. However, as the growing season progressed the first year (2011) the yield increased and was equal to that observed in the second year (2012). The data indicate that cicer milkvetch will likely take at least

Table 3. Forage yield at four harvests of the cicer milkvetch monocultures in 2011 and 2012.

	Harvest				
Year	1	2	3	4	LSD (0.05)
	---------------- Ton per Acre -----------------				
2011	0.02	0.61	0.75	1.03	0.12
2012	1.50	1.21	1.13	0.76	0.12
LSD (0.05)	0.14	0.13	0.10	0.10	--

two growing seasons to become fully established and reach its yield potential.

The relative composition of grass to legume does impact forage yield (Table 4). For most grass-legume combinations a 50:50 planting ratio of grass to legume was the most productive. The exception was in the mixtures with cicer milkvetch where there was very little difference between the different ratios. This is undoubtedly a residual of the slow establishment of the cicer milkvetch relative to the grasses and the other legumes that it is compared to. The most critical result from this is that the top yielding grass-legume ratio for both the alfalfa and birdsfoot trefoil grass mixture combination was equal to or numerically higher yielding than the grass monocultures fertilized at the high rate (Table 4). Based on least significant difference (LSD) values, the highest yielding grass-legume mixtures were equal to the yield of the grass

Table 4. Forage yield of tall fescue (TF), meadow brome (MB), and orchardgrass (OG) in unfertilized and fertilized monocultures with two nitrogen (N) rates and in mixtures with with alfalfa (ALF), birdsfoot trefoil (BFTF), and cicer milkvetch (CMV). Each legume was grown with each grass in grass:legume ratios of 25:75, 50:50, 75:25. Mixtures were not fertilized (2011-2012).

Legume %	---- Tall Fescue ----			---- Meadow Bromegrass ----			---- Orchardgrass ----		
N (lb/A)	Alf	BFTF	CMV	Alf	BFTF	CMV	Alf	BFTF	CMV
	---------- Tons per acre ----------								
25	5.91	5.82	5.15	5.90	5.54	4.69	4.64	4.50	3.91
50	6.59	6.32	5.16	6.09	5.81	4.94	5.51	4.85	3.62
75	5.84	5.43	4.92	5.69	5.15	4.42	5.11	4.70	3.62
100	4.97	4.17	3.50	4.97	4.17	3.50	4.97	4.17	3.50
0 N	4.92	4.92	4.92	4.35	4.35	4.35	3.62	3.62	3.62
60 lb N	5.88	5.88	5.88	5.24	5.24	5.24	4.29	4.29	4.29
120 lb N	6.34	6.34	6.34	5.74	5.74	5.74	4.95	4.95	4.95
LSD (0.05)	0.70	0.84	0.70	0.54	0.57	0.53	0.50	0.59	0.72

Table 5. Forage yield at four harvests of tall fescue (TF) mixtures with alfalfa (ALF), birdsfoot trefoil (BFTF), and cicer milkvetch (CMV), their respective monocultures and TF with two N fertilizer treatments (2011- 2012).

	Harvest				
Crop/mix	1	2	3	4	LSD (0.05)
	---------- ton per acre ----------				
TF - ALF	2.23	1.12	1.29	1.47	0.08
TF - BFTF	2.40	1.07	1.18	1.20	0.13
TF - CMV	2.17	0.87	1.00	1.04	0.11
TF 0 N†	2.34	0.90	0.83	0.86	0.31
TF 60 lb N	2.49	1.06	1.04	1.29	0.31
TF 120 lb N	2.57	1.18	1.16	1.43	0.24
ALF	1.35	1.09	1.28	1.25	0.08
BFTF	0.97	1.34	0.97	0.89	0.08
CMV	0.76	0.91	0.94	0.89	0.09
LSD (0.05)	0.33	0.18	0.16	0.21	--

monocultures when fertilized at 120 lb N per acre.

The summer slump for all three grasses was pronounced where the yield at the second harvest was one half to one third that of the first harvest (Tables 5, 6, 7). For all three grasses the inclusion of either alfalfa or birdsfoot trefoil reduced the summer slump making the yield of the mixture equal to, or in the case of meadow brome higher, than the grass monocultures fertilized at 120 lb per acre. The same effect was not measured when cicer milkvetch was included. This is likely due in part to the slow establishment of the cicer milkvetch and also to its incompatibility with some species. A comparison of 2012 data only revealed that a yield increase was observed and the summer slump reduced when cicer milkvetch was included with meadow bromegrass and orchardgrass (data not shown). However, this was not observed with the cicer milkvetch-tall fescue mixtures and likely indicates that cicer milkvetch and tall fescue are not particularly compatible species for growing together in an irrigated pasture. In other research it has been observed that cicer milkvetch is best suited for use in drier range conditions or possibly where a single irrigation is possible rather than the intensely irrigated pastures where tall fescue is best adapted.

Table 6. Forage yield at four harvests of meadow bromegrass (MB) mixtures with alfalfa (ALF), birdsfoot trefoil (BFTF), and cicer milkvetch (CMV), their respective monocultures and MB with two N fertilizer treatments (2011- 2012).

	Harvest				
Crop/mix	1	2	3	4	LSD (0.05)
	-------------------- ton per acre --------------------				
MB - ALF	2.17	1.14	1.28	1.31	0.07
MB - BFTF	2.19	1.14	1.17	1.00	0.13
MB - CMV	2.11	0.76	0.92	0.90	0.08
MB 0 N†	2.28	0.64	0.75	0.69	0.31
MB 60 lb N	2.49	0.77	0.98	1.01	0.31
MB 120 lb N	2.54	0.87	1.20	1.13	0.22
ALF	1.35	1.09	1.28	1.25	0.08
BFTF	0.97	1.34	0.97	0.89	0.08
CMV	0.76	0.91	0.94	0.89	0.09
LSD (0.05)	0.35	0.15	0.13	0.15	--

Table 7. Forage yield at four harvests of orchardgrass (OG) mixtures with alfalfa (ALF), birdsfoot trefoil (BFTF), and cicer milkvetch (CMV), their respective monocultures and OG with two N fertilizer treatments (2011- 2012).

	Harvest				
Crop/mix	1	2	3	4	LSD (0.05)
	-------------------- ton per acre --------------------				
OG - ALF	1.69	1.08	1.17	1.14	0.12
OG - BFTF	1.62	1.10	1.08	0.88	0.13
OG - CMV	1.53	0.80	0.72	0.66	0.17
OG 0 N†	1.53	0.79	0.66	0.64	0.19
OG 60 lb N	1.66	0.91	0.86	0.87	0.36
OG 120 lb N	1.78	1.00	1.04	1.13	0.12
ALF	1.35	1.09	1.28	1.25	0.06
BFTF	0.97	1.34	0.97	0.89	0.08
CMV	0.76	0.91	0.94	0.89	0.09
LSD (0.05)	0.35	0.15	0.14	0.15	--

Crude protein and NDF (neutral detergent fiber) two indicators of forage nutritive value were measure on the harvested forage. NDF is a measure of the potential intake for a given forage, where the lower a number indicates a better quality forage. An NDF value of 20 to 30 % would be exceptional. The NDF values from this trial did not differ substantially between the different grass legume combinations (Table 8). Even so, there was a trend towards lower NDF in the grass legume mixtures than in the grass monocultures where the mixtures averaged 10% lower NDF than the grass monocultures. There were some differences between the grasses themselves where orchardgrass had the lowest (most desirable) NDF and meadowbrome the highest NDF.

Table 8. Neutral detergent fiber (NDF) of tall fescue (TF), meadow brome (MB), and orchardgrass (OG) in monocultures and mixtures with alfalfa (ALF), birdsfoot trefoil (BFTF), and cicer milkvetch (CMV) (2011- 2012).

Species	ALF	BFTF	CMV	0 N	60 lb N/A	120 lb N/A	$LSD_{(0.05)}$
	-- % --						
TF	490	508	534	552	555	539	38
MB	480	512	550	583	574	569	44
OG	453	469	484	503	519	526	33
$LSD_{(0.05)}$	25	28	19	26	24	ns	--

Excepting cicer milkvetch, crude protein ranged from four to almost six percentage points higher in the grass-legume mixtures than the unfertilized grass monocultures. Without exception when alfalfa or birdsfoot trefoil were included in a mix with a grass the crude protein was higher than the unfertilized grass monoculture and in the case of meadowbrome it was higher than the monoculture fertilized at the high rate (Table 9).

Table 9. Crude protein of tall fescue (TF), meadow brome (MB), and orchardgrass (OG) in monocultures and mixtures with alfalfa (ALF), birdsfoot trefoil (BFTF), and cicer milkvetch (CMV) (2011- 2012).

Species	ALF	BFTF	CMV	0 N	60 lb N/A	120 lb N/A	$LSD_{(0.05)}$
	-- % --						
TF	15.9	14.0	12.6	11.6	13.3	14.9	2.4
MB	16.3	14.0	12.3	10.4	12.4	12.9	2.2
OG	15.9	13.3	11.9	10.8	12.5	14.3	2.1
$LSD_{(0.05)}$	2.4	ns	ns	ns	ns	ns	--

Based on the data from this research it is obviously that the inclusion of a legume with a grass in an irrigated pasture can result in increases of forage yield equal to that obtained through fertilization. Furthermore, there appears to be an increase in forage nutritive value that is not achieved with fertilization. It is also obvious that some grass legume combinations are more productive than others, in particular cicer milkvetch should not be grown with tall fescue. The yield advantage of alfalfa is obvious however, both birdsfoot trefoil and cicer milkvetch have an advantage over alfalfa in that they do not cause bloat. Birdsfoot trefoil contains tannins that bind protein and prevent bloat and can be used with alfalfa with a reasonable expectation to reduce bloat. Cicer milkvetch on the other hand does not contain tannin and would have no such benefit for growing with alfalfa. However, cicer milkvetch, once established, is very drought tolerant and will persist even under heavy grazing and without the danger of bloat.

There are several things this study did not consider, particularly the effect that the grazing animal will have on the plant material but are essential parts of good management. For example, alfalfa and birdsfoot trefoil are different in the basic way they assimilates stored energy or root reserves. Trefoil and alfalfa initiate their first spring growth from stored energy in their roots. After the growth is removed, alfalfa will replenish its root reserve in about 35 to 45 days throughout the growing season. Trefoil does not replenish its root reserves until fall and must depend upon photosynthesis from its leaves to supply energy for all of its regrowth during the late spring and summer. After about the first of September, trefoil once again will attempt to build up its root reserves that have been depleted since the first spring growth. Consequently trefoil must be managed different, failure to do so will result in depleted stands and disappointed growers. Controlled grazing that never completely removes all the trefoil leaves from the plants followed by a rest period gives better results than continuous, complete defoliation. Fall management of trefoil is especially important; avoid grazing between September and the middle of October. After this period, the growth may be used, but avoid extremely close grazing. There is also some evidence that cicer milkvetch will have much better nutritional value going into the late fall and winter and would be a good choice when fall and winter grazing are desired.

Varieties: cultivars used were ‘Fawn’ tall fescue, ‘Cache’ meadow brome, ‘Intensiv’ orchardgrass, ‘Rugged’ alfalfa, ‘Norcin’ birdsfoot trefoil, and ‘Monarch’ cicer milkvetch

Proper rhizobia

Planting timing

Planting rate

Establishment time

Grazing to soon