Yield and Bloat Hazard of Berseem Clover and Other Forage Legumes in Montana

Legumes in this study show considerable potential as green manure and annual hay crops. Many are appropriate for pasture species although cautious management may be required for some.

By James R. Sims[1], D.J. Solum[1], Malvern P. Westcott[2], Grant D. Jackson[3], Greg D. Kushnak[3], David M. Wichman[4], Leon E. Welty[5], Robert K. Berg[6], Joyce L. Eckhoff[7], Gil F. Stallknecht[8] and Kenneth M. Gilbertson[8]

Introduction

The present expansion of the role of legumes in Montana cropping systems was initiated in 1978 when Sims et al. (1) explored the use of black medic (*Medicago lupulina* L.), several annual medics (*Medicago spp.*) and subterranean clovers (*Trifolium subterraneum* L.) from Australia and faba bean in rotation with small dryland grains. The relative success of these experiments by Sims and Koala (1,2) and those of Welty (3,4) under high rainfall and irrigation in western Montana led to a gradually increasing statewide interest in and testing of annual legumes as green manure, cash grain and forage crops (5,6). This paper reports on a series of field experiments conducted as a part of the ongoing effort to adapt additional legume species to Montana agriculture.

The 1990 Federal Farm Bill allows producers more flexibility to diversify their cropping patterns and in the management of certain non-program crops grown on the required diversion of 15 percent of base acres. A producer who chooses to plant an allowed legume on diverted land may manage it for green manure, hay, seed or graze it with livestock. Thus, in addition to the adaptability of these crops for biomass and seed-production other questions such as bloat hazard and presence of toxins arise. This paper reports on 25 annual legume entries grown at eight locations during 1988 and 1989.

Materials and Methods

Eleven small-seeded, four medium-seeded and ten large-seeded legumes were evaluated by the Montana Agricultural Experiment Station at the A.H. Post Field Research Laboratory near Bozeman and the seven area research centers near Conrad, Corvallis, Havre, Huntley, Kalispell, Moccasin and Sidney. The trials were irrigated at Kalispell and non-irrigated at all other locations. The cultivar, common and scientific names and seeding rates of the legumes tested are listed in Tables 1, 2, and 3. A randomized complete block design with four replications was used. Plot width varied up to eight rows but were generally four rows wide and 20 feet long with a 12 inch row spacing. All seed was inoculated prior to planting with the specific strain of *Rhizobium* bacteria appropriate for the species.

Seeding dates varied by location and year from May 5 to June 1 but generally were as early in May as field conditions, weather and work schedules allowed. Weather parameters considered for determining seeding date included potential for frost damage to dry bean and soybean.

[1]Plant & Soil Science Dept., Montana State University Agricultural Experiment Station, Bozeman, MT 59717; [2]MSU AES Western Agricultural Research Center, Corvallis, MT 59828; [3]MSU AES Western Triangle Research Center, Conrad, MT 59425; [4]MSU AES, Central Agricultural Research Center, Moccasin, MT 59462; [5]MSU AES Northwestern Agricultural Research Center, Kalispell, MT 59901; [6]MSU AES Northern Agricultural Research Center, Havre, MT 59501; [7]MSU AES Eastern Agricultural Research Center, Sidney, MT 59270; [8]MSU AES Southern Agricultural Research Center, Huntley, MT 59037.

Harvest procedure varied with location. All locations measured dry matter production by harvesting 16 to 80 square feet from the center rows of plots. They were cut with either sickle-bar or flail type forage harvesters or by hand clipping. Samples were dried and weighed or weighed fresh and sub-sampled to determine moisture content. Most species at most locations were harvested only once, generally at about mid-to-late bloom stage. However, at Kalispell, those species demonstrating regrowth capability were cut two or three times. The combined yields of all cuttings are used in this report. Harvest dates varied by species, location and year and generally ranged from July 15 to August 29. Exceptions included the later multiple cuts at Kalispell, some of which were as late as September 25, and late maturing plots and rain delayed harvests at Conrad which were as late as October 19.

Since both animal and plant factors are involved in bloating, accurate information on bloat hazard of pasture forages can only be determined by grazing trials with live animals. However, laboratory foam production can be used as an indicator of possible

Table 1.
Small-seeded legumes tested for adaptation to various Montana environments during 1988-89.

Symbol	*Common and Scientific Names*	*Seeding Rate*	
		Kg/ha	*lbs/a*
BBC	Bigbee Berseem Clover, *Trifolium alexandrinum* L.	10	(9)
MBC	Multicut Berseem Clover, *Trifolium alexandrinum* L.	10	(9)
YSC	Common Yellow Sweetclover, *Melilotus officinalis* (L.) Desr.	10	(9)
SUB	Mt. Barker Subterranean Clover, *Trifolium subterraneum* L.	20	(18)
MSC	Maral Shaftal Clover, *Trifolium resupinatum* L.	5	(4.5)
YAC	Youchi Arrowleaf Clover, *Trifolium vesiculosum* Savi.	10	(9)
GBM	George Black Medic, *Medicago lupulina* L.	10	(9)
JBM	Jemalong Barrel Medic, *Medicago truncatula* Gaertn.	15	(14)
HSM	Harbinger Strand Medic [a], *Medicago littoralis* Rhode.	10	(9)
TDM	Tornafield Disc Medic [a], *Medicago tornata* Mill.	15	(14)
NAF	Nitro Alfalfa [b], *Medicago sativa* L.	10	(9)

[a] Grown only in 1988, (Sidney, 1989). [b] Grown only in 1989.

Table 2.
Medium-seeded legumes tested for adaptation to various Montana environments,1988-89.

Symbol	*Common and Scientific Names*	*Seeding Rate*	
		Kg/ha	*(lbs/a*
IHL	Indianhead Lentil, *Lens culinaris* Medik	30	(27)
RSM	Robinson Snail Medic, *Medicago scutellata* (L.) Mill	30	(27)
PGM	Paraponto Gamma Medic, *Medicago rugosa* Desr.	25	(23)
SGM	Sapo Gamma Medic [a], *Medicago rugosa* Desr	20	(18)

[a] Grown only in 1988, (Sidney, 1989).

Table 3.
Large-seeded legumes tested for adaptation to various Montana environments,1988-89.

Symbol	*Common and Scientific Names*	*Seeding Rate*	
		Kg/ha	*(lbs/a)*
AWP	Melrose Austrian Winter Pea, *Pisum sativum* ssp. *arvense* (L.) Poir	80	(72)
CKV	NC8-3 Chickling Vetch, *Lathyrus sativus* L.	120	(107)
TFP	Tinga Tangier Flat Pea, *Lathyrus tingitanus* L.	80	(72)
SFP	Sirius Feed Pea, *Pisum sativum* L.	100	(90)
RCL	Red Chief Lentil [b], *Lens culinaris* Medik.	70	(63)
UPB	UI 114 Pinto Bean [b], *Phaseolus vulgaris* L.	55	(49)
RKB	Sacramento Light Red Kidney Bean [b], *Phaseolus vulgaris* L.	130	(116)
MAS	Maple Amber Soybean [b], *Glycine max* (L.) Merr.	80	(72)
ULT	Ultra Lupine [a], *Lupinus albus* L.	100	(90)
PKL	Primorski Lupine [a], *Lupinus albus* L.	100	(90)

[a] Grown only in 1988. [b] Grown only in 1989.

bloat hazard. High foam production generally suggests a high bloat hazard. Foam production by fresh plant samples was measured at Bozeman and Moccasin using the procedure described by Rumbaugh (7). Three-gram samples of fresh plant material were weighed within one hour after collection in the field. This was added to 300 cc of a pH 5.6 buffer at room temperature in a high speed laboratory blender. After four minutes of operation, the blender contents were transferred to a 1000 cc graduated cylinder. Two minutes after transfer, the cylinder was shaken to eliminate any large trapped air spaces and the final volume was read from the cylinder scale.

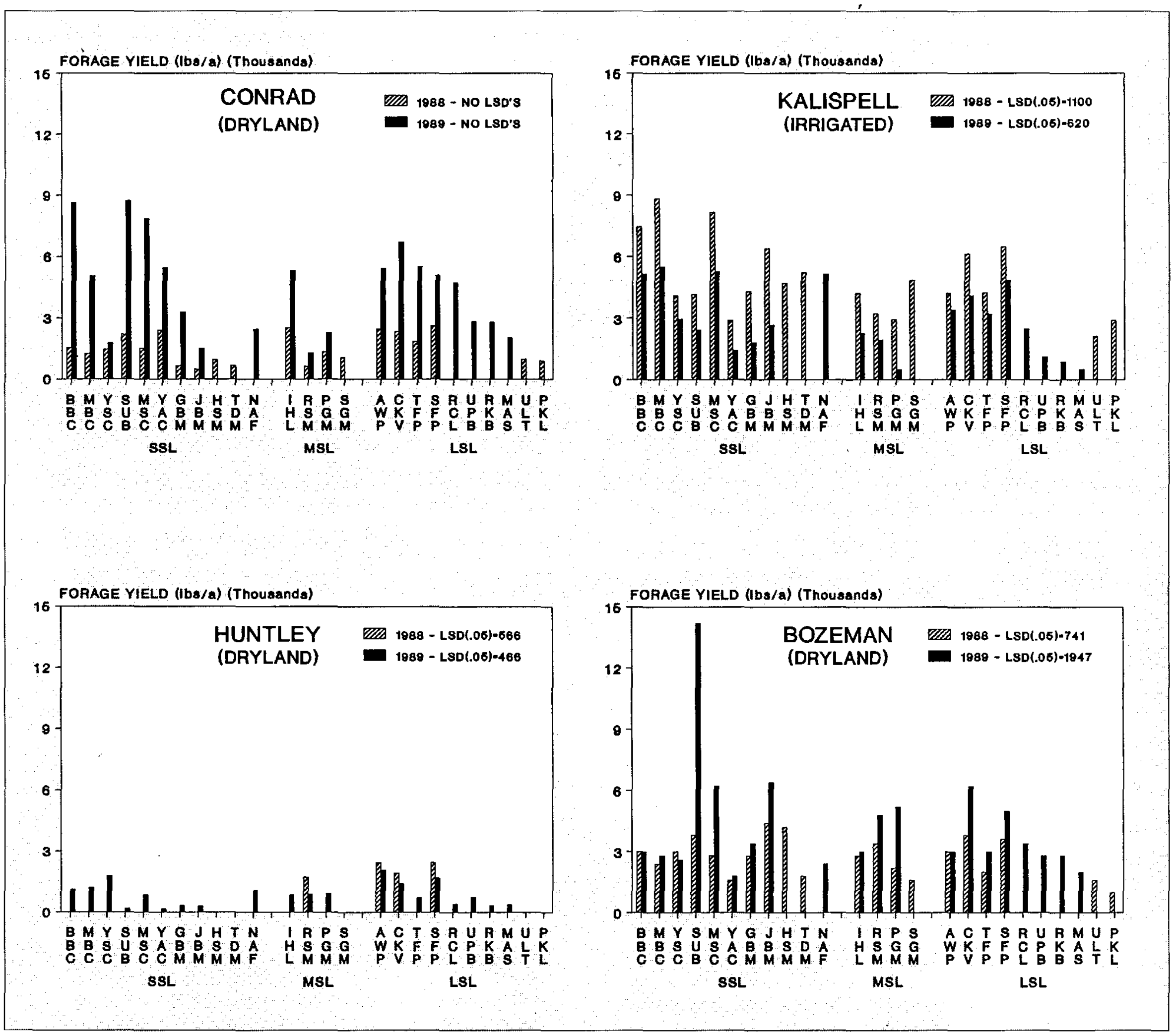
Data were analyzed statistically using the MPEP Program developed by the Montana Agricultural Experiment Station (8).

Results and Discussion

Dry matter yields are presented in Figures 1 and 2. Yields varied from a low of 168 lbs/acre for Youchi arrowleaf clover at Huntley in 1989 to a high of 14,200 lbs/acre for Mt. Barker subterranean clover at Bozeman in 1989. Growing conditions varied with year and location as indicated by higher yields in 1988 compared to 1989 at the two western Montana locations, Corvallis and Kalispell; whereas yields were greatest for 1989 at Bozeman, Conrad and Moccasin. Common data for the two years were obtained for only four species at Huntley and for only 1989 at Havre and Sidney.

Green Manure Potential. When growing a legume as green manure in lieu of summer fallow

Figure 1.
Forage yields of 25 annual legumes grown at Conrad, Kalispell, Huntley and Bozeman,1988 & 1989

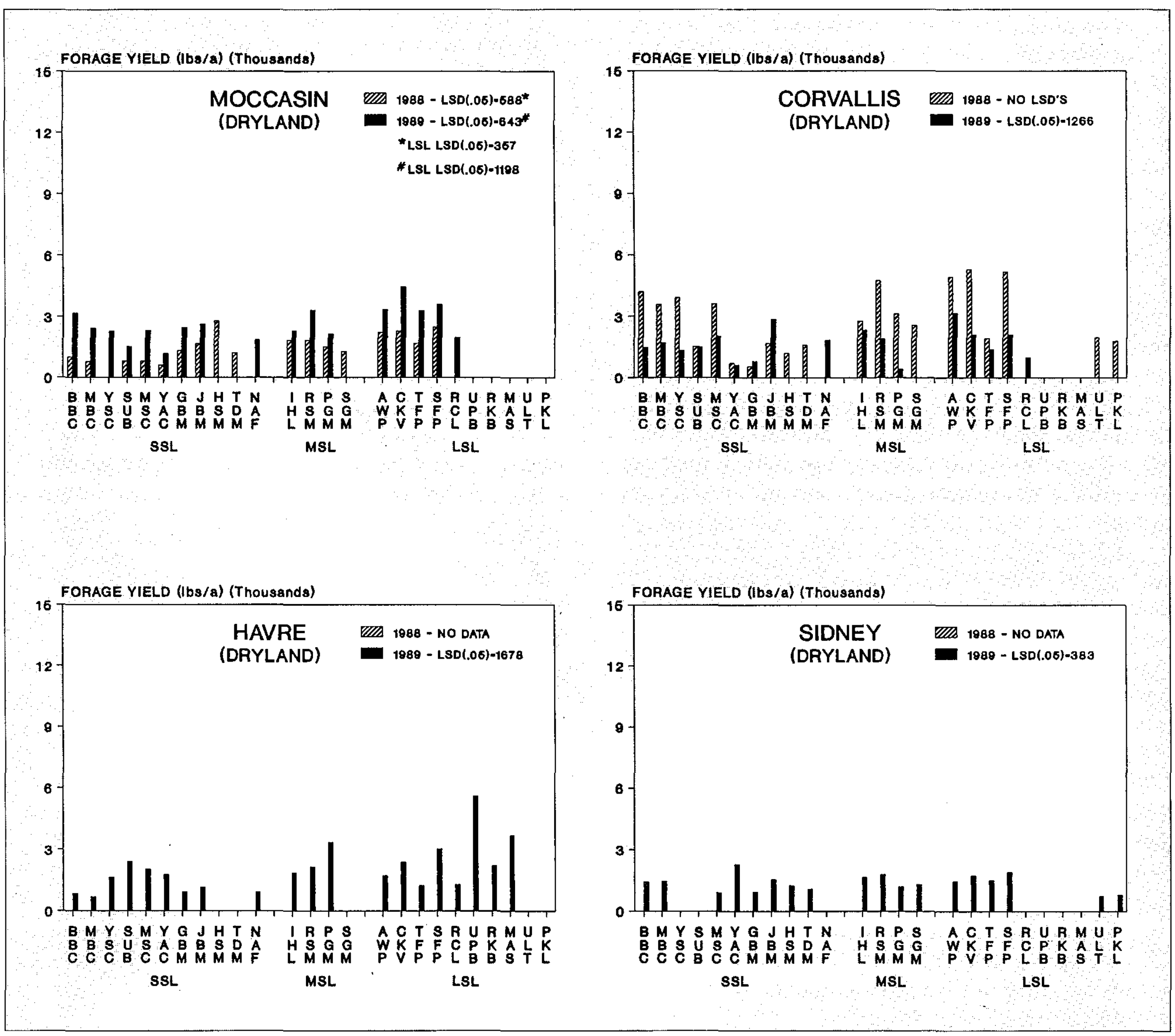


in a dryland, small-grain cropping system, maximum green manure production is not always desirable. Water is the most limiting factor in dryland farming and thus, maximum green manure production would likely be at the expense of creating a water deficit for the ensuing cereal crop (9). Also, maximum green manure production may produce fixed N much in excess of the ensuing cereal crop need. An earlier study indicated that 900 to 1500 lbs/acre of green manure was more effective than up to 4000 lbs/acre of green manure in augmenting spring wheat yields (10). Considering that 900 lbs/acre dry matter production is the threshold yield for green manure needs for lower yield potential environments, 23 of 25 legume entries met this requirement at least one year at the five locations with two years of tests.

Exceptions were Youchi arrowleaf clover and George black medic at Corvallis. Both berseem clovers at Havre and both lupins at Sidney failed to produce at least 900 lbs/acre dry matter. Only four entries established successfully during 1988 at Huntley; however, in 1989, all 20 entries established but five each of the small- and large-seeded entries failed to produce the 900 lbs/acre threshold yield. First year yellow sweetclover failed at Moccasin in 1988 as the seedlings were devoured by the sweetclover weevil as soon as they emerged. Yellow sweetclover established but did not grow significantly and Mt. Barker sub–terranian clover failed for unknown reasons at Sidney in 1989.

Based on these data, Montana producers have a wide choice of legumes of various seed sizes which are well adapted as non-irrigated green manure/

Figure 2.
Forage yields of 25 annual legumes grown at Moccasin, Corvallis, Havre and Sidney,1988 & 1989



cover crops. Some of the large-seeded legumes are of more interest as seed crops than as either green manure or forage crops. Included in this group are Red Chief lentil, UI 114 pinto bean, Sacramento light red kidney bean, Maple Amber soybean, and Ultra and Primorski lupin.

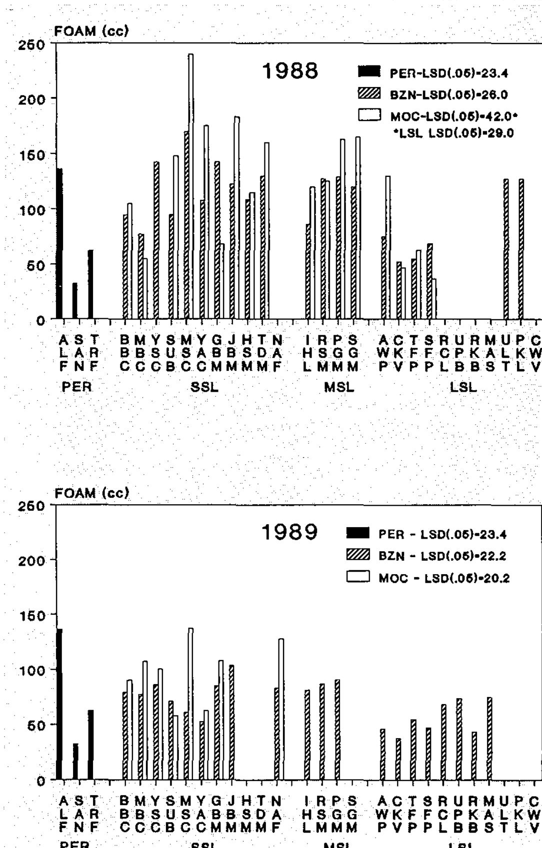
Individual producers should consider several factors in choosing a green manure legume. Included are: adaptability in terms of dry matter yield potential in comparison to the amount of N needed and the water resource; availability of seed and the appropriate *Rhizobium* inoculant; compatibility of the seed size and seeding rate with the drill or seeder; and, of utmost importance, are costs involved in managing the green manure in lieu of fallow. Green manure management costs include those for seed and inoculant, the seeding operation and killing the green manure crop at the appropriate time. Generally, these costs should be equal to or less than the cost of fallowing the field plus the cost of N fertilizer which the green manure replaces.

Annual Forage Potential. When adaptation of these legumes to various Montana environments is considered from the standpoint of annual forages, some distinct and dramatic differences are observed. In the wetter environments (Bozeman 1989, Conrad 1989, Corvallis 1988 and Kalispell both years), the small-seeded legumes often produced well over 8,000 lbs/acre dry matter and generally yielded more than the four large-seeded forage legumes. In the dryer environments, the small-seeded legumes seldom produced over 2,500 lbs/acre and generally were in the 1,700 lbs/acre or less range whereas the large-seeded legumes often produced over 2,000 lbs/acre. This is attributed to the fact that, in dryer environments, shallow seeding of small-seeded legumes often places the seed in dry soil thereby resulting in delayed emergence and reduced stand density. Large- and medium-seeded legumes, on the contrary, are seeded deeper and more often into moist soil, resulting in quicker emergence and a more ideal stand density.

The annual clovers tended to yield more than the annual medics except for the 1989 Havre, 1988 Moccasin and 1989 Sidney environments. Jemalong barrel medic is an exception as it generally produced yields comparable to the clovers and on occasion its yields were higher than some of the clovers. These results suggest that the annual clovers are generally better adapted to wetter and cooler environments whereas the annual medics may be better adapted to drouthy environments.

The upright growth habit of Nitro alfalfa and most annual clovers facilitates harvesting as hay, while it is difficult to hay Mt. Barker subterranean clover and most medics which have a more prostrate growth habit. In wetter environments with well distributed rainfall, the medics may achieve sufficient height to allow harvesting as hay. Additionally, the two berseem clovers, Maral Shaftal clover and Nitro alfalfa, have the potential for multiple hay cuts with sufficient regrowth for late summer/early fall grazing or green manure incorporation. Bigbee berseem clover yield was greater than the yields of Multicut berseem clover and Maral Shaftal clover in eight of the 13 environments. Maral Shaftal clover yielded more than Multicut berseem clover in eight of the 13 environments. Mt. Barker subterranean clover yielded more than any of the other clovers in four of the 12 environments where it grew. The yield of at least one of the berseem clover varieties was greater

Figure 3.
Foam generated by fresh samples of 25 annual legumes grown at Bozeman and Moccasin, 1988 and 1989.



than the yield of Nitro alfalfa in five of the seven environments in 1989. Jemalong barrel medic yielded more than the other medics in six of 13 environments.

The four large-seeded legumes with the most potential for forage crops are Melrose Austrian winter pea, Sirius feed pea, NC8-3 chickling vetch and Tinga Tangier flat pea. Yields of these species varied from a low of 730 lbs/acre to over 6,700 lbs/acre. NC8-3 chickling vetch consistently produced the most forage followed closely by Sirius feed pea with Melrose Austrian winter pea ranking third and Tinga Tangier flat pea generally being the lowest yielder. NC8-3 chickling vetch generally produced well in both the wetter and dryer environments. A possible explanation of its wide adaptability lies in its grass-like leaf morphology. This leaf morphology may provide some drought resistance via a mechanism of leaf rolling during periods of water stress similar to many grass species. Whether or not such leaf morphology is a factor in adaptation remains to be verified. Tinga Tangier flat pea has a similar leaf morphology but out-yielded the two *Pisum* entries in only one environment.

Bloat Hazard and Toxins. In addition to those whose initial objective is forage production for grazing by livestock, some producers who intended to grow these species for green manure or hay may change their management plans to include grazing. In both cases, not only is yield level important, but consideration must be given to bloat hazard for ruminants as well as the possible presence of toxins in the forage.

Results of laboratory foam tests for most of the annual legumes grown at Bozeman and Moccasin in 1988 and 1989 are shown in Figure 3. Foam test results for three perennial legume forages of known bloat potential familiar to Montana producers, alfalfa, sainfoin and birdsfoot trefoil are included for comparison. Although Cooper (11) found a good relationship between foam formation and known bloat potential of 27 legume species, the reader is reminded that this test is not perfect and, at best, should be used only as a rough index of potential bloat hazard. The mechanisms of bloating by ruminants ingesting legume forage are very complex and involve poorly understood animal, ruminant microorganisms, plant species and growing condition factors.

There are no reported cases of bloat in ruminants feeding on berseem clover (12). During annual visits to Egypt over the past 13 years, we routinely observed cattle, sheep and goats grazing irrigated berseem clover fields without seeing or hearing of a single case of bloat. It is interesting to note that our data show foam production by berseem clover to be significantly less than that for alfalfa, which has a known high bloat hazard. Foam production by most of the other clovers was generally less than that for alfalfa, higher than that for sainfoin and similar to birdsfoot trefoil. Maral Shaftal clover is an exception in that foam production for three out of the four environments was as high or higher than that for alfalfa. Foam production by Nitro, a non-dormant type alfalfa, was similar to that of perennial alfalfa at Moccasin but somewhat less at Bozeman. Except for Maral Shaftal clover, foam production by the annual clovers was generally less than foam production by the annual medics. There appears to be a relationship between growing conditions and/or yield level and foam production. Foam production was greater at Moccasin compared to Bozeman for the majority of the entries whereas yield levels were greatest at Bozeman. Also, foam production was generally greater in 1988 under dryer conditions and lower yields than for 1989 at both locations. The two sweet lupins were the only large-seeded species that produced foam in amounts comparable to alfalfa. Thus, Maral Shaftal clover, Nitro alfalfa, sweet lupins, and the annual medics appear to be in a bloat hazard class similar to perennial alfalfa whereas the remaining clovers, especially berseem, and the other large-seeded legumes appear to be in a lower bloat hazard class.

In addition to bloat hazard, producers should concern themselves with other possible problems of grazing these legumes. Previous reports have described problems with livestock ingesting some of these species. A high coumarin content in yellow sweetclover forage is the origin of dicoumarol which causes hemorrhaging (13). Many clovers contain compounds which cause a dermatitis associated with photosensitization as well as estrogenic compounds which may lead to infertility. Berseem clover is reportedly lower in content of these compounds than most clovers (12). Tangier flat pea and chickling vetch are of the genus *Lathyrus*, members of which have been reported to contain toxins which cause a malady called lathyrism which affects humans and animals (13). Toxic properties become evident about the time the seeds are formed and primarily results from eating the seeds, but the disease has been linked to consumption of other plant parts as well. Symptoms in man are paralysis of the muscles below the knees, pains in the back followed by weakness and stiffness of the legs. Symptoms in animals are similar to those in man, evidenced mainly by weakness and paralysis in the legs and loins. Horses and pigs seem to be highly susceptible with fatal cases being reported.

Summary

Our data show considerable potential for a wide variety of annual legumes, including berseem clover, as green manure, annual hay crops or a combination hay and green manure. Many of the entries in this study are appropriate for pasture species although cautious management may be required for some.

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