COOL- AND WARM-SEASON FORAGE LEGUME POTENTIAL FOR THE SOUTHEASTERN USA

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ABSTRACT

A majority of the cool-season legumes utilized for pasture in the Southeastern USA lack productivity or persistence during the hot, dry months of June, July and August. More information is needed concerning the forage potential of various legumes for this major pasture region of the USA. Our objective was to compare the nutritive value, relative palatability and yield of selected cool- and warm-season legumes grown during the summer months. Fifteen cool- and warm-season legumes were sown in late spring or early summer in 1985 and 1986 at Mississippi State, MS. Dry matter yield and nutritive value were measured twice each summer before selective grazing by ewes to measure palatability.

At the first harvest in both years (mid-June to late July), the crude protein and in vitro *digestible dry matter concentration of aeschynomene (*Aeschynomene amerciana *L.) and cowpea (*Vigna unguiculata *(L.) Walp.) were similar to or greater than that of red clover (*Trifolium pratense *L.) or lucerne (*Medicago sativa *L.). Dry matter yields were variable and tended to be influenced by planting date. Aeschynomene, alyceclover (*Alysicarpus vaginalis *(L.) DC), and lucerne were as palatable as red clover in both years. At the second harvest in both years (late August), the digestibility of aeschynomene and alyceclover was equal to or greater than that of lucerne and red clover (mean of 683 g/kg), while the digestibility of phasey bean (*Macroptilium lathyroides *(L.) Urb.) was only 3 to 6% less than either cool-season legume. Dry matter yield of aeschynomene, alyceclover, and phasey bean was 1 to 4 times as great as that of lucerne. Palatability of all warm-season legumes was considerably lower than that of the cool-season legumes. These results indicate that selected warm-season legumes have potential to provide greater quantities of high quality forage, particularly for late summer grazing, than lucerne or red clover, and to reduce deficiencies of quality feed common during this time period.*

RESUMEN

La mayoria de las leguminosas forrajéras de la estación fria utilizadas en el sureste de los Estados Unidos, carecen de productividad o persistencia durante los meses calientes y secos de Junio, Julio y Agosto. Es necesaria mayor información sobre el potencial forrajero de varias leguminosas para esta importante región de pasturas en Estados Unidos. Nuestro objetivo fue comparar el valor nutritivo, palatabilidad relativa y producción de leguminosas seleccionadas de climas frios y cálidos cultivados durante los meses del verano. Quince leguminosas fueron sembradas a finales de la primavera o principios del verano en 1985 y 1986 en el estado de Misisipi, MS. La producción de materia seca y el valor nutritivo fueron evaluados dos veces cada verano antes del pastoreo por ovinos con el fin de medir la palatabilidad relativa.

*En la primera cosecha en ambos años (mediados de Junio a finales de Julio), la concentración de proteina cruda y la digestibilidad in vitro de la materia seca de Aeschynomene (*Aeschynomene americana *L.) y caupi (*Vigna unguiculata *(L) Walp.) fueron similares o mayores que los del trébol rojo* (Trifolium pratense *L.) o alfalfa (*Medicago sativa *L.). La producción de materia seca fue variable y tendió a ser influenciada por la fecha de siembra. Aeschynomene, alyceclover (*Alysicarpus vaginalis

(L.) DC), y alfalfa fueron tan palatables como el trébol rojo en ambos años. En la segunda cosecha en ambos años (finales de Agosto), la digestibilidad de aeschynomene y alyceclover fue igual o mayor a la de alfalfa y trébol rojo (medio de 683 g/kg) mientras que la digestibilidad de phasey bean (Macroptilium lathyroides *(L.) Urb) fue solo de 3 a 6% menor que las dos leguminosas de clima templado. La producción de materia seca de aeschynomene, alyceclover y phasey bean fue de 1 a 4 veces mayor que la de alfalfa. La palatabilidad de todas las leguminosas de clima cálido fue considerablemente más baja que la de leguminosas de clima templado. Estos resultados indican que leguminosas seleccionadas de climas cálidos tienen potencial para proveer mayor cantidad de forraje de alta calidad, particularmente para pastoreo a finales de verano, que alfalfa y trébol rojo, reduciendo asi deficiencias de calidad de oferta de forraje durante este periodo.*

INTRODUCTION

Forage systems in the Southeastern USA are based primarily on warm-season perennial grasses, but late-season live weight gains decline relative to early gains. Experiments which reported gains at monthly intervals have shown that early season (April to June) gains on common and Coastal bermudagrass (*Cynodon dactylon* (L.) Pers.) and Pensacola bahiagrass (*Paspalum notatum* Flugge) were 343% greater than late season (July to September) gains (Chapman *et al.* 1972; Pund and Hogg 1969; Mendoza *et al.* 1985). Prates *et al.* (1974) demonstrated a similar decline in average daily gain (ADG) with steers on Pensacola bahiagrass. Forage availability remained high during the summer period but estimated intake declined.

The addition of cool-season legumes, such as white clover (*Trifolium repens* L.), has been shown to extend the grazing season and improve animal performance. However, most of the improved performance occurred in the April to June period with little improvement during the remainder of the season (Pund and Hogg 1969; Mendoza *et al.* 1985). Frequent droughts often reduce the productivity of cool-season legumes during the summer months. Summer annual grasses, such as sorghum (*Sorghum bicolor* (L.) Moench) and millet (*Pennisetum americanum* (L.) Leeke), have also been used to improve ADG during the summer. Animals grazing summer annual grass pastures have performed similarly to those grazing lucerne and orchardgrass (*Dactylis glomerata* L.) mixtures (Spahr *et al.* 1967).

These data suggest that a high quality warm-season legume growing in association with a warm-season grass may improve animal performance, especially during the late summer period. Annual (*Lespedeza stipulacea* Maxim. and *L. striata* (Thumb.) H & A.) and perennial sericea (*L. cuneata* (Dumont) G. Don) lespedezas have been reported to be more widely adapted in the Southeastern USA than any other warm-season forage legume (Hoveland and Donnelly 1985), although some cultivars of perennial lespedeza have been reported as having poor palatability (Cope and Burns 1971). Wheeler (1950) described several warm-season forage legumes examined by early researchers including kudzu (*Pueraria phaseoloides* (Roxb.) Benth.), crotalaria (*Crotalaria pallida* Ait.), hairy indigo (*Indigofera hirsuta* L.) and velvetbean (*Mucuna deeringiana* (Bort) Merr.).

Aeschynomene (jointvetch) has been evaluated in Florida for its forage potential (Kretschmer and Bullock 1980; Quesenberry and Ocumpaugh 1981), ability to establish in sod (Kalmbacher *et al.* 1978; Kalmbacher and Martin 1983; Sollenberger and Quesenberry 1985), reseeding ability (Tang and Rulke 1977; Sollenberger and Quesenberry 1986) and its potential for improving forage yield (Kretschmer and Snyder 1982) and animal performance compared to grass systems receiving no nitrogen fertilization (Pitman 1983).

The objective of this study was to compare the nutritive value, relative palatability and yield of selected cool-season and warm-season legumes during the summer, when the greatest contribution to forage quality and productivity could be expected.

MATERIALS AND METHODS

The study was performed at Mississippi State, MS (latitude 33°28′N), which has a humid, subtropical climate, and receives approximately 22% of the annual precipitation of 1310 mm during the summer months of June through August. Monthly maximum/minimum temperatures for June, July and August average 31.6/19.9, 33.0/21.4 and 33.0/20.7°C, respectively.

Fifteen selected cool- and warm-season legumes (Table 1) were inoculated with the appropriate *Rhizobium* strains and seeded at recommended rates in a cultivated seedbed on June 7, 1985 and April 2, 1986 on a Catalpa silty clay (fine, montmorillonitic, thermic Fluvaquentic Hapludoll). The soil had at least 90 kg available P/ha, 220 kg exchangeable K/ha, and a pH of 6.5 to 6.7 in both years of the experiment. Plots sown in 1985 had been sown in early April, but failed to establish due to lack of rainfall.

Legumes were selected on the basis of known or inherent qualities that might make a particular entry suited for use as a pasture legume in the Southeastern region during the summer months (June, July and August). Delta lucerne and Redman red clover served as controls and were evaluated because of their known forage quality potential and relatively high palatability. The more winterhardy annual Bigbee berseem clover (*Trifolium alexandrinum* L.) was selected because of its excellent potential for spring and early summer growth (Knight 1985), while the less winterhardy berseem clover cultivars Fahl and Miscawi were chosen because of their high producivity when not damaged by freezing temperatures (W. L. Graves, Univ. of California; personal communication).

Traditionally, alyceclover, cowpea, aeschynomene and phasey bean have not been extensively utilized in the Southeastern USA, but are warm-season pasture legumes having potential (Skerman 1977). Fribourg *et al.* (1984) reported that hyacinth bean (*Lablab purpureus* (L.) Sweet) produced 2000 to 5000 kg/ha dry matter during the summer months in Tennessee. The annual and perennial lespedezas are well-adapted to the Southeastern USA (Hoveland and Donnelly 1985), particularly during the drought-prone summer months.

Entries were harvested and grazed twice each year (July 22 and August 27, 1985; June 16 and August 22, 1986), except in 1986 when lucerne, and Fahl and Miscawi berseem clover were clipped on May 21 in order to maintain in a vegetative state. Dry matter (DM) yield was measured before grazing by sheep in both years by harvesting two 0.25 m^2 quadrats to 7 cm stubble height from each 2 × 5 m plot, except cowpea, hyacinth bean and phasey bean, which were cut to 20 cm stubble height to insure regrowth was not reduced by a low cutting height. In 1986, two 0.25 m^2 quadrats were harvested after grazing to verify final palatability scores. Forage samples from each plot were combined, dried at 65°C for 48 hours, and ground to pass a 1 mm screen in a cyclone mill before quality measurements were made. Entries were grazed following DM yield sampling by 8 ewes for 6 hours/day for 5 days. Following grazing, they were visually scored for palatability once each day on a 1 to 10 scale, where 10 equalled complete rejection or 100% of the DM remained and 1 equalled complete acceptance or 10% of the DM remained (Barnes *et al.* 1970). After the first grazing period, all entries were cut to 7 cm stubble height, except cowpea, hyacinth bean and phasey bean, which again were cut to 20 cm stubble height.

In vitro digestible dry matter (IVDDM), crude protein (CP) and neutral detergent fiber (NDF) were determined for all legumes by near infrared reflectance spectroscopy (NIRS) after suitable analysis equations were developed (Marten *et al.* 1984). To accomplish this, subsamples of legumes harvested in 1985 and 1986 were assayed for CP concentration by the macro-Kjeldahl procedure, for IVDDM concentration by the direct acidification, two-stage method (Marten and Barnes 1980), and NDF concentration by the methods of Goering and Van Soest (1970), except that decalin was eliminated from the fiber extraction solutions and amylase was added during the

TABLE 1

Influence of legume entry on forage crude protein concentration at first (H1) and second (H2) harvest before grazing.

Common name	Scientific name	Entry	Abbreviation	H1 1985	H1 1986	H2 1985	H2 1986
				(g/kg)			
Cool-season							
Lucerne	*Medicago sativa* L.	Delta	DELT LUC	180	165	203	176
Berseem clover	*Trifolium alexandrinum* L.	Bigbee	BIGB BER	219	184	—	—
		Fahl	FAHL BER	161	135	—	—
		Miscawi	MISC BER	156	144	—	—
Red clover	*Trifolium pratense* L.	Redman	RMAN RED	189	204	214	179
Warm-season							
Alyceclover	*Alysicarpus vaginalis* (L.) DC	Common	ALYCLVR	162	—	182	166
Cowpea	*Vigna unguiculata* (L.) Walp.	Iron and Clay	IAC COWP	225	199	189	—
Hyacinth bean	*Lablab purpureus* (L.) Sweet	Tift-1	HYA BEAN	149	—	106	—
Aeschynomene	*Aeschynomene americana* L.	Florida common	AESCHNO	220	202	245	224
Sericea lespedeza	*Lespedeza cuneata* (Dumont) G. Don	AU Loton	AULO LES	159	171	143	129
		Interstate 76	IN76 LES	151	154	146	131
		Serala 76	SE76 LES	150	157	140	133
Korean lespedeza	*Lespedeza stipulacea* Maxim.	Summit	KREA LES	152	171	159	152
Striate lespedeza	*Lespedeza striata* (Thumb.) H&A.	Kobe	KOBE LES	164	184	163	131
Phasey bean	*Macroptilium lathyroides* (L.) Urb.	PI 376210	PHSY BEAN	175	212	141	133
LSD (P = 0.05)				25	22	27	17
CV (%)				9	8	9	6

refluxing portion of the extraction (Robertson and Van Soest 1977). Initial NIRS calibration equations for analysis of forage quality were developed from 60 of 90 samples from 1985. Calibration equations were then verified with the 30 remaining samples from 1985 and 30 samples from 1986. The R^2 of calibration (correlation of known values on NIRS values) for IVDDM, CP and NDF concentration were 0.94, 0.96 and 0.92, respectively, while the standard error of analyses were 3.18, 0.82 and 3.04, respectively.

Legumes were arranged in 3 replicates of a randomized complete block design. Because significant legume × year and legume × harvest interactions existed, treatment differences were determined for individual harvests in each year. Treatment means were separated by Fisher's least significant difference (LSD) test ($P = 0.05$).

RESULTS

First harvest

All of the warm-season legumes were at a vegetative stage at first harvest, while all the cool-season legumes except red clover were at first flower to full bloom stage. Alyceclover and hyacinth bean produced insufficient forage necessary for quality and utilization measurements in 1986 because of slow establishment and severe insect infestation, respectively.

Nutritive value

Among the cool-season legumes in 1985, Bigbee berseem clover had the greatest CP concentration, while in 1986 red clover had greater CP concentration than all other cool-season legumes except Bigbee (Table 1). Among the warm-season legumes, aeschynomene and cowpea had greatest CP concentration in 1985, while in 1986 greatest CP concentrations were measured in aeschynomene, cowpea and phasey bean. In 1985 and 1986, respectively, the CP concentrations of aeschynomene (220 and 202 g/kg) and cowpea (225 and 199 g/kg) were equivalent to or greater than that of red clover (189 and 204 g/kg) and Bigbee berseem clover (219 and 184 g/kg). The CP concentrations observed for aeschynomene were generally similar to those reported by Sollenberger (1987) for aeschynomene before grazing in Florida. With the exceptions of Korean, Interstate 76 and Serala 76 lespedeza and hyacinth bean in 1985, the CP concentration of all warm-season legumes in both years was equivalent to or greater than that of lucerne (180 and 165 g/kg; Table 1).

The NDF concentrations of the cool-season legumes were influenced principally by plant maturity. Nondormant Fahl and Miscawi berseem clover had greater NDF concentration than the other cool-season legumes (Table 2). Cowpea had the lowest NDF concentrations (284 and 292 g/kg) among all legumes in 1985 and 1986, while the NDF concentration of aeschynomene (316 and 339 g/kg) was similar to or less than that of red clover (359 and 332 g/kg) or lucerne (325 and 387 g/kg). Although harvested at a vegetative stage, the sericea lespedezas (AU Lotan, Interstate 76 and Serala 76) tended to have higher NDF concentrations than the other legumes, except Fahl and Miscawi berseem clover, which were at full bloom stage. Cope and Burns (1974) reported that the increaed NDF level of immature sericea lespedeza was due primarily to greater NDF level in the stems compared to the leaves.

In vitro digestible dry matter concentration of the legumes was generally inversely related to NDF concentration. The IVDDM concentration of the sericea lespedeza entries was lower than that of all other legumes (Table 3), reportedly due to the presence of tannin in the leaves (Cope and Burns 1974). The IVDDM of cowpea (772 and 834 g/kg) and aeschynomene (744 and 765 g/kg) was greater than or equivalent to that of lucerne (696 and 735 g/kg) and red clover (676 and 754 g/kg) in 1985 and 1986, respectively. Although forage of Korean and Kobe lespedeza was less digestible than a majority of the other warm-season legumes, it was as digestible as the cool-season berseem clovers Fahl and Miscawi (Table 3).

TABLE 2

Influence of legume entry on forage neutral detergent fiber concentration at first (H1) and second (H2) harvest before grazing.

Legume	H1		H2	
	1985	1986	1985	1986
		(g/kg)		
Cool-season				
Delta lucerne	325	387	363	401
Bigbee berseem clover	400	383	—	—
Fahl berseem clover	443	512	—	—
Miscawi berseem clover	444	467	—	—
Redman red clover	359	332	360	387
Warm-season				
Alyceclover	372	—	452	429
Iron and clay cowpea	284	292	400	—
Hyacinth bean	352	—	444	—
Florida common Aeschynomene	316	339	380	367
AU Lotan lespedeza	463	497	531	540
Interstate 76 lespedeza	460	531	523	534
Serala 76 lespedeza	465	539	531	542
Korean lespedeza	395	465	474	507
Kobe lespedeza	419	450	478	532
Phasey bean	413	348	463	563
LSD (P = 0.05)	22	35	45	24
CV (%)	3	5	6	3

TABLE 3

Influence of legume entry on forage in vitro *digestible dry matter concentration at first (H1) and second (H2) harvest before grazing.*

Legume	H1		H2	
	1985	1986	1985	1986
		(g/kg)		
Cool-season				
Delta lucerne	696	735	713	668
Bigbee berseem clover	661	700	—	—
Fahl berseem clover	613	578	—	—
Miscawi berseem clover	629	652	—	—
Redman red clover	676	754	703	601
Warm-season				
Alyceclover	729	—	687	676
Iron and clay cowpea	772	834	726	—
Hyacinth bean	757	—	689	—
Florida common Aeschynomene	744	765	715	703
AU Lotan lespedeza	497	459	395	416
Interstate 76 lespedeza	410	328	296	269
Serala 76 lespedeza	378	340	295	328
Korean lespedeza	622	658	625	551
Kobe lespedeza	620	685	606	500
Phasey bean	686	749	666	591
LSD (P = 0.05)	38	23	32	39
CV (%)	4	2	3	4

Relative palatability

The palatability of the cool-season legumes, as measured after 5 grazing days, was generally greater than that of the warm-season legumes in 1985, with the exception of Miscawi berseem clover (Fig. 1). Two warm-season legumes, alyceclover and aeschynomene (43 and 48% utilization, respectively), were as palatable as lucerne

(50% utilization) in 1985, but less so than red clover (70% utilization). Alyceclover and aeschynomene were also more palatable in 1985 than any of the other warm-season legumes, except hyacinth bean. Among the lespedeza cultivars, AU Lotan, Interstate 76 and Serala 76 were essentially rejected throughout the first grazing period. In contrast, the palatability of the warm-season legumes in 1986, with the exception of AU Lotan, Interstate 76 and Serala 76 lespedeza, was generally similar to or greater than that of the cool-season legumes (Fig. 1).

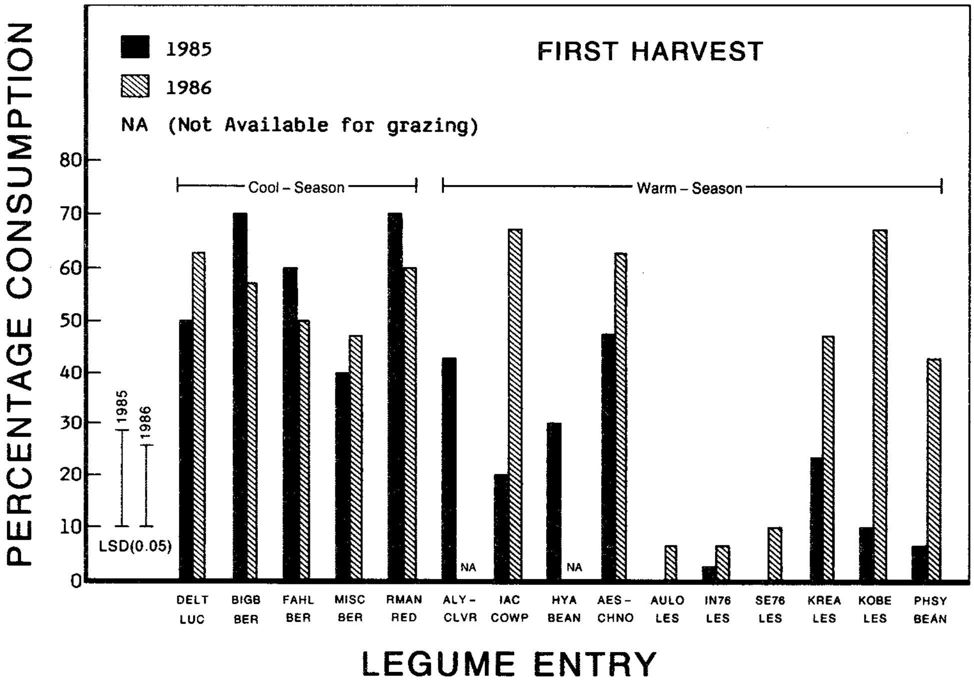

FIGURE 1

Effect of legume entries on percent consumption of original herbage of legumes after 5 days of selective grazing by 8 ewes at first harvest; refer to Table 1 for description of legume abbreviations.

Dry matter yield

The warm-season legumes cowpea and phasey bean provided 108 and 79%, respectively, greater dry matter yield in 1985 than lucerne (Table 4). Dry matter yield of red clover and Bigbee berseem clover were similar to those of alyceclover and aeschynomene. However in 1986, when legumes were planted 65 days earlier, DM yield of Bigbee berseem clover (3790 kg/ha) and red clover (2480 kg/ha) was greater than that of any warm-season legume except Korean lespedeza (3010 kg/ha).

Second harvest

By the second harvest in both years, all the berseem clover entries had senesced and were not available for grazing. Hyacinth bean was not available for grazing in 1986 due to severe insect damage, while cowpea failed to regrow following the first grazing period. All legumes were at a vegetative state in both years, except phasey bean, which had begun to produce seed.

Nutritive value

Aeschynomene had greater CP concentration (245 and 224 g/kg in 1985 and 1986, respectively) than any other legume (Table 1). Among the other warm-season

TABLE 4

Forage dry matter yield of legume entries at first (H1) and second (H2) harvest before grazing.

Legume	H1		H2	
	1985	1986	1985	1986
	(kg/ha)			
Cool-season				
Delta lucerne	840	1050	1590	630
Bigbee berseem clover	610	3790	—	—
Fahl berseem clover	1020	1310	—	—
Miscawi berseem clover	850	1680	—	—
Redman red clover	440	2480	480	670
Warm-season				
Alyceclover	570	—	1270	1260
Iron and clay cowpea	1750	1550	5120	—
Hyacinth bean	990	—	2310	—
Florida common Aeschynomene	460	1230	1690	2390
AU Lotan lespedeza	440	1010	810	1190
Interstate 76 lespedeza	370	1150	860	1920
Serala 76 lespedeza	360	1470	1160	1520
Korean lespedeza	1190	3010	920	1850
Kobe lespedeza	900	1270	1020	2230
Phasey bean	1500	1730	5360	2890
LSD (P = 0.05)	500	690	820	920
CV (%)	35	23	23	30

legumes, only alyceclover had CP concentration equivalent to red clover or lucerne in both years. Differences in CP concentration among the remaining legumes were generally small. Aeschynomene, lucerne and red clover also had the lowest NDF concentration (range of 360 to 401 g/kg) in 1985 and 1986 (Table 2). Similar to the first harvest, Serala 76, Interstate 76 and AU Lotan lespedeza tended to have the greatest NDF concentration among the legumes in 1985 and, with the exception of phasey bean and Kobe lespedeza, in 1986 as well. In both 1985 and 1986, the IVDDM concentration of aeschynomene (715 and 703 g/kg) and alyceclover (687 and 676 g/kg) was similar to or greater than that of lucerne (713 and 668 g/kg) and red clover (703 and 601 g/kg; Table 3). Lowest IVDDM concentrations were measured in Serala 76, Interstate 76 and AU Lotan lespedeza both years.

Relative palatability

Red clover and lucerne were the most preferred legumes, with utilization exceeding 80% in both years (Fig. 2). Among the warm-season legumes, sheep had greater preference for aeschynomene in 1985 and alyceclover in 1986. Phasey bean and the annual lespedezas (Korean and Kobe) had low to intermediate palatability (10 to 40% utilization) in both years, while the sericea lespedezas were essentially rejected.

Dry matter yield

Phasey bean provided 237 and 359% greater DM yield than lucerne in 1985 and 1986, respectively, while the DM yield of aeschynomene exceeded that of lucerne by 6 and 279% (Table 4). The DM yield of the remaining warm-season legumes was similar to or greater than that of lucerne or red clover in both years.

DISCUSSION

Growth of cool-season legumes is often limited during the summer in many parts of the Southeastern USA due to high temperatures and frequent droughts. Results of this study indicate that selected warm-season legumes have equivalent or greater quality and productivity potential as the cool-season legumes tested, especially during the latter portion of the summer season. Three warm-season legumes in particular compared favourably with lucerne, generally the most productive cool-season legume in late summer. Alyceclover and aeschynomene generally had equivalent or superior forage quality and productivity at the second harvest compared to lucerne, while phasey bean, though having somewhat lower whole-plant quality than lucerne, produced approximately 3 to 4 times as much forage yield. Utilization of these warm-season legumes could contribute greatly to reducing quality deficiencies common in pastures during late summer. Grazing trials are needed to support this inference, and to define the grazing pressure or clipping management necessary to maintain stands for natural reseeding, or whether annual sod-seeding will be required.

While the palatability of some warm-season species was lower than the cool-season entries at different times, this factor may be of less importance when livestock are not offered a choice. Differences in palatability between legumes were also likely due to climatic conditions following the 2 different planting dates. Climatic conditions from planting until the first harvest in 1985 (June 7 to July 22) were characterized by greater daytime temperatures and lower average precipitation (data not shown), compared to 1986 (April 2 to June 16). Thus, plant factors responsible for palatability differences in 1985 may have been altered by these conditions compared to 1986.

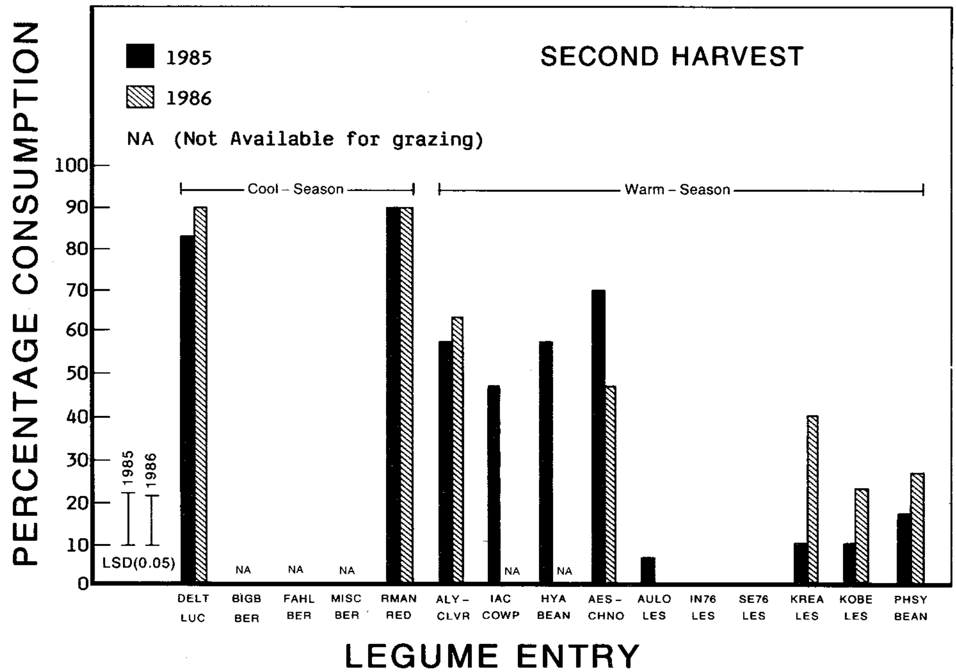

FIGURE 2

Effect of legume entries on percent consumption of original herbage of legumes after 5 days of selective grazing by 8 ewes at second harvest; refer to Table 1 for description of legume abbreviations.

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