Adaptability of tropical forages to California's Central Valley

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Warm-season forages, highly productive in the world's tropical and subtropical regions, have been grown in the southeastern United States, but only bermudagrass (*Cynodon dactylon* (L.) Pers.), sudangrass (*Sorghum sudanense* (Piper) Stapf.), and dallisgrass (*Paspalum dilatatum*) have been grown extensively in California. However, rhodesgrass (*Chloris gayana* Kunth), and kikuyugrass (*Pennisetum clandestinum* Hochst. ex Chiov.) have been tested in California. Since 1950 many improved tropical forages have been developed, but until 1980 no effort had been made to screen a wide selection of these forages to assess their adaptability to California climates.

Irrigated pastures in northern California are dominated by such cool-season (temperate) species as tall fescue, orchardgrass, perennial ryegrass, Ladino, and strawberry clover. These perennial forages reach peak productivity in late

Tropical forage grasses, such as elephantgrass (right), limpograss (lower left), and buffelgrass (lower right), offer high yields, but have low cold tolerance and low forage quality.

spring and frequently decline in productivity later in summer. Warm-season forages, because of their tropical origins, are more tolerant of warm temperatures and reach peak productivity later in summer when cool-season species decline in productivity.

These improved warm-season grasses and legumes vary in their tolerance to low temperatures. Some of the cold-tolerant species and varieties would have potential in the Central Valley and southern deserts of California where freezing temperatures occur briefly each year. The Imperial Valley has a growing season of 10½ months with infrequent killing frost. The lower Sacramento Valley has a nine-month growing season with frost occurring most years. Survival and yield of several tropical forages were determined in field experiments at the University of California, Davis, in 1980-1982.

Tropical forages planted

From April 7 through April 21, 1980, 102 tropical forage entries were planted on a Yolo silt loam at UC Davis. Entries were planted in 5-foot rows. Periodic observations of establishment and survival following winter dormancy were recorded to ascertain forage adaptation to California's Central Valley.

On April 14 and 15, 1980, 20 tropical and cool-season forage entries were planted in four 5-foot rows spaced 12 inches apart in five replications. Traditional California forages were included for yield comparisons. The yield trial was harvested on July 22, September 9, and November 3, 1980, and on June 10, July 31, and September 22, 1981. Selected entries were pooled and analyzed for modified crude fiber and crude protein.

Plots were overhead-irrigated for establishment, and from May through September they were flood-irrigated at seven- to ten-day intervals. Cool-season rainfall was 12 inches between October 1980 and May 1981, and 32 inches between October 1981 and May 1982. Grasses were fertilized with nitrogen at the rate of 16 pounds per acre and phosphorus (P_2O_5) at 20 pounds per acre, and the legumes were fertilized with phosphorus (P_2O_5) at 20 pounds per acre every 30 to 40 days from May through August.

The survivors

Several entries in the observation trial did not survive the winter of 1980-81. The first freezing temperature was on November 14, 1980, and the last on February 3, 1981. Light-to-moderate freezes occurred on a few mornings with temperatures reaching −2° to −3°C (27° to 29°F). Additional entries were lost or suffered severe stand reductions during the winter of 1981-82, when freezing temperatures of -4°C (25°F) occurred. During this period the first freezing temperature occurred on January 3, 1982, and the last on April 7, 1982.

Most of the grasses in the observation trial survived the first winter season; only a few legumes survived. Of the 34 buffelgrass (*Cenchrus ciliaris* L. and *C. setigerus* Vahl.) cultivars, four did not survive the first winter season. The remaining 30 regrew from the above-ground stems and plant crowns. All rhodesgrass, bermudagrass, limpograsses (*Hemarthria* spp.), kikuyugrass, and digitgrass (*Digitaria decumbens* Stent. and *D. pentzii* Stent.) entries regrew after the winter season. The rhodesgrass, kikuyugrass, and bermudagrass vigorously resumed spring growth, while the digitgrasses were somewhat slower.

During the winter season stands of three entries of guineagrass (*Panicum maximum* L.) were severely reduced; isolated plants of green panic survived. Elephantgrass (*Pennisetum purpureum* Schumach.) and the pearl millet interspecific hybrids (*Pennisetum americanum* X elephantgrass) regrew from old growth following the winter season, but in mid-March this growth was not vigorous. The two setaria entries regrew from belowground after the first winter.

Following the winter of 1981-82, several buffelgrasses, rhodesgrass, and guineagrasses regrew but with reduced stands. The stands of pearl millet hybrids were drastically reduced. Kleingrass (*Panicum coloratum* L.) elephantgrass, bermudagrasses, limpograsses, and digitgrasses, however, grew vigorously. Seven buffelgrass accessions had nearly complete stand survival and relatively rapid spring growth (PI numbers 409221, 409227, 409264, 409266, 409381, 409443, 409449).

Six legume entries survived the first winter season. Florida carpon desmodium (*Desmodium heterocarpon* (L.) DC) and greenleaf desmodium (*Desmodium intortum* (Mill.) Urb.) survived, but the spring regrowth in mid-March was not vigorous. Silver leaf desmodium (*Desmodium uncinatum* (Jacq.) DC) vigorously regrew from belowground. The leucaena (*Leucaena leucocephala* (Lam.) De Wit) entries survived winter and were resprouting from the previous year's stems. Not surviving the winter season were entries of gylcine (*Glycine wightii* (R. Grah. ex Wight and Arn) Verdc.), lablab beans (*Lablab purpureus* (L.) Sweet), mung beans (*Vigna radiata* (L.) Wilczek), pigeon peas (*Canjanus cajan* (L.) Millsp.), puero (*Pueraria phaseoloides* Benth.), siratro (*Macropilium atropurpureum* (DC) Urb.), Leichhardt dolichos (*Macrotyloma uniflorum* Verdc.), and Archer axillaris (*Macroptyloma axillare* Verdc.). During the summer months after establishment, the entries of stylo (*Stylosanthes guianensis* (Aubl.) Sw.) and galactia (*Galactia* spp.) died. Survival of mung and lablab beans is not expected, because they are generally annuals. After the winter of 1981-82, the only remaining warm-season legumes were silver-leaf desmodium and leucaena.

Of the legume species planted, leucaena and siratro were prolific seed producers. Leucaena seedlings were found the next spring, but siratro seedlings were not encountered.

Grass species producing viable seed included the buffelgrasses, Makueni guineagrass, kleingrass, Kazangula setaria, rhodesgrass, and two bermudagrasses. Bufflegrass and Makueni guineagrass seedlings became established as weeds in the observation trial.

Yield trial results

In 1980 the tallest species (elephantgrass, sudangrass and guineagrass) were among the top-yielding entries (table 1). Because of their height and the small size of the plots, edge effect may have contributed to the yields of these entries in spite of the removal of 12 to 18 inches of the plot edges before harvesting.

Productivity of limpograss (*Hemarthria altissima* (Poir.) Staf and Hubbard) was low the first year, because most of the biomass (stolons) was near the ground and not harvested the first date. In 1980 the cool-season grasses, tall fescue (*Festuca arundinacea* Schreb.), perennial ryegrass (*Lolium perene* L.), and orchardgrass (*Dactylis glomerata* L.), were less productive than most warm-season grasses. Siratro, a tropical legume, and the clovers produced significantly less biomass than most of the grasses in the study. These legumes started slowly and were not harvested on July 22, 1980.

In 1981 the Bigalta limpograss and Tifton-44 bermudagrass were second and third, respectively, in productivity behind elephantgrass. Their yields were substantially increased from 1980 yields. Perennial ryegrass and the other cool-season grasses and legumes are usually spring and early summer growers, and their production was higher at the first or second harvest than at the third harvest in 1981. Makueni guineagrass and Shrira buffelgrass suffered stand reduction during winter. The annual sudangrass was not replanted in 1981. The two siratro entries did not survive the 1980-81 winter and were not replanted.

The forage harvested in July 22, 1980, was analyzed for crude protein and modified crude fiber. Perennial ryegrass had the highest crude protein level at 18.5 percent and lowest modified crude fiber at 25.5 percent (table 2). Coastcross-1 bermudagrass was next highest in crude protein at 17.3 percent. The lowest crude protein levels were 6.4 percent in elephantgrass and 9.8 percent in Piper sudangrass. The highest modified crude fibers were 36.3 percent for NK-37 bermudagrass and 33.5 percent for elephantgrass.

Cutting, nitrogen effective

Cutting interval and nitrogen fertilization are important factors affecting productivity and quality of warm-season grasses. In this study the cutting interval was approximately eight weeks, and the nitrogen applied totaled 100 pounds per acre during the growing season. We were interested in species responses under low fertilization rates because of the high cost of nitrogen. Similar yields have been measured in Georgia under an eight-week cutting schedule but high nitrogen fertilization rates.

Sudangrass and bermudagrass have been grown in California for many years. Sudangrass yields in California are seldom as high as that measured in this study. However, under close row spacings (14 inches), similar yields of 12 to 15 tons per acre have been measured in the Imperial Valley. The row spacing in our study was 12 inches. Under high fertilization rates, bermudagrass can be extremely productive in California. In a study at the Imperial Valley Field Station, near El Centro, dry matter productivities of more than 11.5 tons per acre for fertilization rates above 600 pounds per acre of nitrogen were measured. This is higher than the bermudagrass productivity measured in this study.

Of the three bermudagrasses in the yield trial, NK-37 has been used extensively in California. NK-37 was equal to Coastcross-1 and Tifton-44 in yields, but its quality was lowest as measured by modified crude fiber and crude protein. Improved bermudagrasses, such as Coastcross-1 and Tifton-44, are not used widely in California but they offer the potential of higher yields, improved quality, and sufficient tolerance to low temperatures. If Tifton-44 and Coastcross-1 survive winters in new tests, they may be preferred to NK-37. These two varieties, however, do not produce viable seed and must be started by planting stolons. Bigalta limpograss productivity was similar to that of the bermudagrasses and could be an alternative to bermudagrass.

Most of this trial's forages were less productive than sudangrass. Sudangrass quality, however, was lower than that of most other entries. Sudangrass, an annual, has the disadvantage of requiring annual establishment. However, no perennial entry can replace the value of sudangrass as an annual rotation or fill-in crop.

Dallisgrass is present in many Central Valley irrigated pastures, because it was planted or becuase the seed contaminated the pasture via the irrigation water. Although dallisgrass is lower in quality, it is equal to or higher in productivity than most popular cool-season pasture species. Some cattle ranchers prefer dallisgrass because of its summer productivity in the Central Valley.

Kikuyugrass, buffelgrass, and limpograss 588 may not be as productive as other warm-season grasses, and the accessions tested should not be considered as potential irrigated pasture forages. Elephantgrass was the most productive throughout the trial, but of all the entries it was also lowest in quality. Elephantgrass of higher quality could be harvested by increasing the cutting frequency or planting cultivars with larger leaf-to-stem ratios.

For any warm-season forage to gain acceptance, it must be winter hardy, more productive, or of higher quality than currently used irrigated pasture forages. In the yield trial, only Makueni guineagrass, Shrira buffelgrass, and siratro appeared to lack sufficient winter hardiness to survive during this experiment. Productivity of other entries may have been reduced because of cold temperatures or the length of the cool season.

The outlook

Perennial warm-season forages offer the advantage of high yields but the disadvantages of lower cold tolerance and lower forage quality. Eventual utilization of high-yielding tropical forages will depend upon selection of plant materials with high quality and good low-temperature tolerance. Current cool-season irrigated pastures reach peak productivity at approximately the same time as foothill range, producing an overabundance of spring forage in most years. The warm-season forages may provide more balance to valley and foothill forage systems by shifting the peak productivity of irrigated pasture to summer months.

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TABLE 1. Forage dry matter yield for 20 tropical and cool season forages harvested in 1980 and 1981, University of California, Davis

Entry	Dry matter* 1980 total	1981 total	2-year mean	Type†
	tons/acre			
Elephantgrass (Merkeron)	20.1 a	15.7 a	17.9 a	WS
Sudangrass (Piper)	13.9 b	—	—	WS
Bermudagrass (Tifton 44)	8.8 cdefgh	11.1 bc	10.0 b	WS
Bermudagrass (NK-37)	10.1 c	8.9 bcd	9.5 b	WS
Limpograss (Bigalta)	6.2 fghi	12.5 ab	9.4 b	WS
Dallisgrass (Common)	8.5 cdef	9.7 bcd	9.1 b	WS
Guineagrass (Makueni)	9.5 cd	8.1 cd	8.8 bc	WS
Bermudagrass (CCI)	7.0 efghi	8.9 bcd	8.0 bcd	WS
Kikuyugrass (Whittet)	8.8 cde	7.1 cd	8.0 bcd	WS
Buffelgrass (Shrira)	8.1 cdefg	6.7 cd	7.4 bcd	WS
Perennial ryegrass (Ariki)	5.6 hij	8.9 bcd	7.3 bcd	CS
Kikuyugrass (Local)	6.0 ghij	8.0 cd	7.0 cde	WS
Buffelgrass (74092)	6.5 efghi	6.8 cd	6.6 cde	WS
Tall fescue (Fawn)	5.7 ghij	7.3 cd	6.5 cde	CS
Limpograss (588)	4.7 ijk	7.5 cd	6.1 cde	WS
Strawberry clover (Salina)	2.7 k	9.1 bcd	5.9 de	CS
Orchardgrass (Akaroa)	3.5 jk	6.9 cd	5.2 de	CS
Siratro (IRI 3316)	4.9 ijk	—	—	WS
Siratro (IRI 1938)	4.8 ijk	—	—	WS
Ladino clover	2.7 k	5.6 d	4.1 e	CS

*Means in the same column followed by the same letter are not significantly different at the 0.5 level.
†WS = warm season; CS = cool season.

TABLE 2. Percentage of modified crude fiber (MCF) and crude protein (CP) of 14 tropical and cool season grasses sampled July 22, 1980, UC Davis

Common name	MCF	CP
	%	%
Elephantgrass (Merkeron)	33.5	6.4
Sudangrass (Piper)	27.9	9.8
Bermudagrass (Tifton 44)	26.7	13.5
Dallisgrass (Common)	30.4	12.8
Bermudagrass (CCI)	27.0	17.3
Bermudagrass (NK-37)	36.3	12.3
Perennial ryegrass (Ariki)	25.5	18.5
Guineagrass (Makueni)	28.7	10.4
Kikuyugrass (Local)	27.6	12.0
Tall fescue (Fawn)	26.7	16.4
Kikuyugrass (Whittet)	26.8	15.3
Orchardgrass (Akaroa)	27.9	15.2
Buffelgrass (74092)	27.0	14.6
Buffelgrass (Shrira)	30.1	10.2