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SUMMER PASTURE AND GREENCHOP FROM SUDANGRASS, HYBRID SUDANGRASS, AND SORGHUM X SUDANGRASS CROSSES

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CALIFORNIA AGRICULTURAL
Experiment Station
Extension Service

CIRCULAR 547

A NUMBER of sudangrass cultivars are grown in many localities throughout California—localities that differ widely in soil types, available moisture, and temperature ranges. Since all of these factors have a bearing on results that could be expected, it is almost impossible to make positive recommendations as to growing or using the crop that would apply equally under all conditions.

This circular, therefore, discusses the many factors involved in producing a successful stand of sudangrass, then of necessity, leaves some decisions to the grower who must interpret the information in the circular to his individual conditions and desires.

The principal factors discussed are:

September, 1968

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Summer Pasture and Greenchop from Sudangrass, Hybrid Sudangrass, and Sorghum x Sudangrass Crosses

Sudangrass is California's most important annual grass for summer pasture and greenchop. Yields are best under irrigation, although dryland plantings can do well, depending on soil and moisture characteristics. Temperature exercises the greatest control over productivity, but yield is also affected by available moisture, soil pH, and fertility. Because of the importance of temperature, stands in cooler coastal areas, or at intermediate elevations in mountain valleys, cannot be expected to match yields obtained in California's warmer Central Valley. Cool soils slow or prevent seed germination, cool air temperatures slow vegetative growth, and frost injures or kills the plants, depending upon severity.

Common Sudangrass, *Sorghum Sudanense* (Piper) Staph., was introduced into the United States in 1909. Since then selections and crosses have been made to improve yield, leafiness, and disease resistance, reduce prussic acid potential, and incorporate juicy, sweet stalks.

The relatively recent development of male sterile lines of sorghum has made possible mass commercial crosses with sudangrass. The result has been a large number of hybrids marketed for pasture and greenchop use. Some representative examples of sudangrass cultivars encountered in California are:

Sudan 23	Sudangrass
Piper	Sudangrass
Trudan, 1, 2, and 4	True hybrid sudangrass
Suhi-1	True hybrid sudangrass
Sweet Sioux	Sorgo x sudangrass cross
SX-11, 12	Sorghum x sudangrass cross
Greenlan	Sorghum x sudangrass cross
Grazer	Sorghum x sudangrass cross

Common sudangrass varieties reproduce themselves without loss of identity, if maintained in isolation. Hybrid sudangrass and sorghum x sudangrass crosses maintain their identities only under controlled pollination for production of the hybrid seed. Sorghum x sudangrass crosses may arise from a male sterile grain sorghum, forage sorghum, or from sorgo crossed with a sudangrass variety.

These hybrids and crosses are not varieties, technically speaking, since they are not selections out of the common sudangrass. The correct term is "cultivar," which is used herein in referring to these forage types including the original sudangrass selections. Sudangrass cultivars used in California as pasture and greenchop can produce high yields of quality feed and have proved valuable to dairymen, sheepmen, and stockmen during the summer months.

Stand Establishment

The following suggestions aim at reducing the cost of stand establishment, improving production efficiency, and obtaining satisfactory yields.

Seedbed

Prepare a well-worked, fine, firm seedbed. This will help control weeds, insure a better contact of seed with soil moisture, hasten seed germination and emergence, and produce a more uniform stand. For dryland production, winter fallow with such steps as weed control or mulching taken to conserve soil moisture is recommended. On irrigated land, final seedbed preparation should be preceded by an irrigation to help insure adequate soil moisture for seed germination.

When to seed

In determining when to seed, soil temperature at seeding depth is more important than the calendar date. A soil temperature at seeding depth (1 to 2 inches) of at least 60°F before seeding has long been recommended. Tests with Piper sudangrass, however, show the following germination response to temperature:

A constant temperature of:	Resulted in germination of	In number of days
50°F	27%	24
60°F	57%	14
68°F	95%	6
86°F	96%	4
104°F	54%	7

The difference between 60° and 68°F in the rapidity of germination could thus be critical, especially under conditions of minimum soil moisture, which illustrates the desirability of delaying seeding until soil temperatures at seeding depth is about 65°F.

In the lower Sacramento Valley area, soil temperatures at a depth of 1 to 1½ inches usually exceed 60°F around the middle of May, when excellent emergence can be expected in about 5 to 6 days. A mid-May seeding will usually produce 30 inches of growth in about 36 days; a 30-day delay in seeding will produce about the same height of growth in approximately 24 days. Thus, a delay in seeding from mid-May to early June would probably delay a 30-inch growth by only about 7 to 10 days. Early-season growth is dependent on soil and air temperatures, which vary from year to year. Experiments have shown that sorghum x sudangrass crosses do not have the ability to germinate at lower temperatures than sudangrass (Hart and Wells, 1965).[1] In establishing a dryland seeding, optimum soil temperatures may have to be sacrificed to insure adequate soil moisture at seed depth.

How to plant

Most acreage in California is planted by broadcast methods or with a grain drill. Drilling assures better control over seeding depth and seed distribution; produces more uniform stands with less seed; and generally outproduces broadcast stands.

Planting in rows greater than 12 inches apart has advantages and should be considered by summer-pasture operators if weeds are not a problem. Pastures seeded on 18- or 20-inch rows have produced greater yields of dry matter than have narrow-drilled pastures (fig. 1). Other advantages of wide row seeding over narrow-drilled sudan are less waste and spoilage from trampling and manure. It has been estimated that such losses can amount to as much as 40 per cent of the feed produced. In row-seeded stands the animals tend to walk between the rows.

Seeding rate

Seeding rates can vary greatly with little effect upon yield. Experiments using seeding rates of 12–48 pounds of sudangrass seed per acre in narrow drill rows indicate no appreciable difference in total seasonal yield of dry matter. Light seeding rates result in fewer but thicker stems; high seeding rates produce a finer-stemmed forage.

Sudangrass tillers profusely after the first harvest or pasturing. This thickens the stand and compensates for lower seeding rates. Sorghum x sudangrass crosses on the other hand do not stool or tiller as well. This characteristic in addition to larger seed size is the reason higher seeding rates are needed for these cultivars.

Seed weight varies between cultivars, seed lot, and harvest years but the following is an approximation of the number of seeds per pound one may expect to find for the cultivars listed.

Sudan 23	46,900
Piper Sudan	36,800
Trudan 4	32,300
SX-12	20,800
Sweet Sioux	16,900

The table below gives the ranges of seeding rates within which most recommendations lie. Recommendations for broadcast seedings tend towards the high end of the range while drilled seedings tend towards the low end of the range. Generally, because rougher seed beds are

[1] See "Literature Cited for publications referred to in text by author and date.

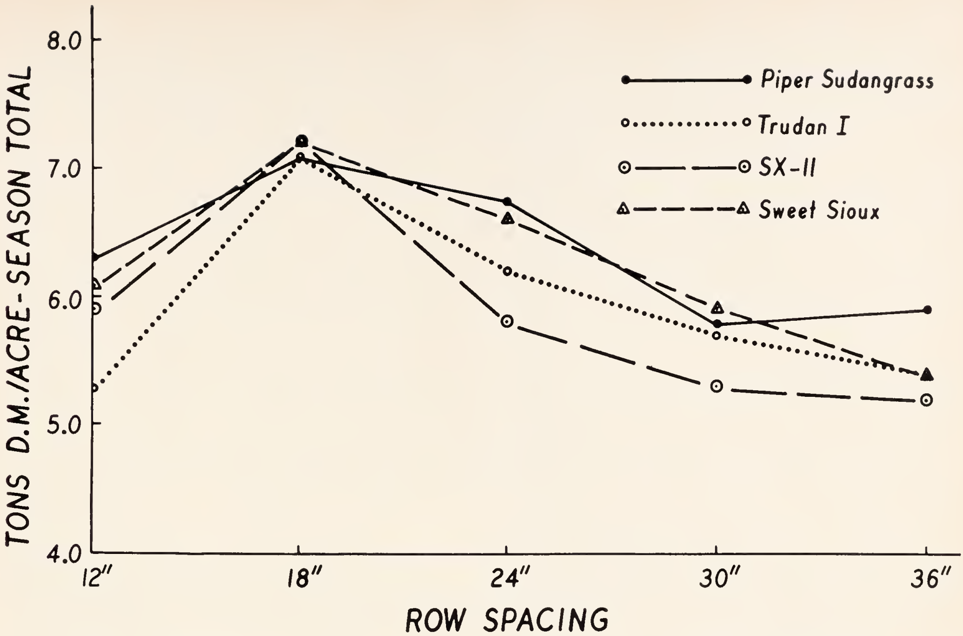


Fig. 1. Yield response (tons dry matter per acre) to row spacing when sudangrass cultivars are used for summer irrigated pasture.

prepared for broadcast seedings, higher seeding rates are needed to obtain the same approximate stand density as obtained by drilling.

	Irrigated		Dryland	
	Sudangrass	Crosses	Sudangrass	Crosses
Broadcast	20–25	30–50	15–20	20–30
Drilled	15–20	20–30	12–15	20–30
Row Seeded	5–10	10–20	5–10	10–20

The seeding rate (potential stand density) for dryland production should be governed by the amount of soil moisture available for the season. In dry areas seeding rates as low as 3–5 pounds per acre may be necessary to provide green feed as long into the summer as possible.

Seeding rates may also be expressed in terms of the number of seeds delivered per foot of row by a drill or planter. For narrow-drill rows (6 inches) under irrigation, the seeding rate should be adjusted to deliver about 6 seeds per foot of row. This will require approximately 15 pounds of seed per acre for the smaller-seeded cultivars, and 20 to 30 pounds for the larger-seeded cultivars. There is little reason for seeding more than 10–14 seeds per foot of row when row widths are 12 inches or greater. Under good seedbed and soil moisture conditions this is ample to assure an adequate stand of seedlings in the row. Table 1 illustrates the relationship between seeds per foot of row, row width, and pounds of seed per acre. These figures assume 100 per cent germination and emergence. Some growers overseed to assure a stand, but it is generally a waste of seed to use more than the amount recommended.

All recommended seeding rates as pounds per acre or seeds per foot of row should be based upon live-pure seed. Very rarely are seed lots comprised of nothing but whole seed all of which will germinate. The law requires that all seed moved in commerce be labeled to show the name of the variety, percentages of purity, germination, and seeds of weeds and other crops. Purity is the per cent by weight of pure seed present and germination is the per cent of pure seed that will germinate in laboratory tests. To find the live-pure seed content of a seed lot multiply the purity by the germination and divide by 100. Using this procedure any seeding rate can be corrected to live-pure seed.

TABLE 1

APPROXIMATE POUNDS OF SEED PER ACRE NEEDED TO GIVE DESIRED NUMBER OF SEEDS PER FOOT OF ROW AT VARIOUS ROW SPACINGS

Seed size	Approximate number of seeds per 1′ of row	Row spacing 6″	12″	18″	24″
	seeds	*lb. per acre*			
Sudangrass	5	12	6	5	3
(approximately 36,800 seeds per pound)*	10	24	12	10	6
	20	48	24	20	12
Sorghum x sudangrass	5	26	13	10	7
(approximately 16,900 seeds per pound)*	10	52	26	20	14
	20	104	52	40	28

* Number of seed per pound in round numbers. Seeds per pound vary between lots and harvest years.

In using quality seed (purity above 97 and germination 85 or higher) the need for correcting for live-pure seed is questionable. It is well however to correct to live-pure seed if purity and germination are much below the above figures.

Fertilization

Plant growth and protein content are influenced by available nitrogen, and nonleguminous feed crops will usually require both initial and top dressing nitrogen applications to maximize yields (tables 2 and 3). California's soil fertility levels vary, depending largely on soil type and past cropping history. Any soil known to be deficient or low in its ability to supply adequate amounts of P, K, and the minor elements, should be fertilized to correct this deficiency. A deficiency of any fertilizer element hampers plant growth and full use of any applied nitrogen.

How much nitrogen should be applied to maximize pasture and greenchop yield? Results obtained in field trials can be used only as a guide—growers should adapt

TABLE 2

YIELD RESPONSE TO NITROGEN FERTILIZATION, TONS DRY MATTER PER ACRE (PIPER SUDANGRASS HARVESTED AT INDICATED DATES)

Nitrogen applied preplant except*	Yield response and protein per cent: Harvest date July 18	Aug. 5	Aug. 23	Sept. 11	Oct. 8	Total yield	Crude protein (season mean)
	tons dry matter per acre						*per cent*
0	0.82	1.20	0.99	0.68	0.63	4.32	14.4
100	0.76	1.56	1.39	0 95	0.69	5 35	16.8
200	0.84	1 65	1.61	1.22	1.01	6.33	19 2
250*	0.77	1.51	1.60	1.35	1.16	6.39	18.0
300	0.82	1.65	1.60	1.40	1.19	6.66	21.1
400	0.68	1.72	1.62	1.45	1.28	6.75	21 0

* 50 pounds preplant and after each harvest.

Table 3

COMPARATIVE CRUDE PROTEIN PER CENT AND STAND CANOPY HEIGHT AS INFLUENCED BY RATE OF NITROGEN APPLICATION AND SUCCESSIVE CLIPPING

Clipping date	Total pounds of N applied per acre									
			Preplant		Preplant		Split*		Preplant	
	0		100		200		250		300	
	Protein %	Canopy height in.	Protein %	Canopy height in.	Protein %	Canopy height in.	Protein %	Canopy height in.	Protein %	Canopy height in.
July 18	17.3	32	20.2	31	22.0	32	18 7	32	21.5	31
August 5	14 9	31	19.4	35	19.9	35	18.2	34	20.7	35
August 23	12.9	24	16.2	30	19.2	32	16.0	32	20.1	33
September 11	13.3	16	14.6	19	18.5	24	18.5	25	22.1	26
October 8	13.4	11	13.2	14	16.0	17	18.8	20	21.3	22

* 50 pounds N preplant and after each clipping.

these findings to fit their local growing conditions.

After the initial growth of 30 to 35 inches the cultivars will produce about the same regrowth height about every 20 to 25 days. Field trials have shown that 40 to 50 pounds of nitrogen preplant and an equal amount immediately after each pasturing or cutting will maximize dry matter and protein yield without, under normal soil and weather condition, an accumulation of excess nitrate in the plants.

Because greenchopping does not allow cutting at a uniform growth stage throughout the season, it is difficult to formulate a precise fertilizer recommendation to fit all modes of usage. If late harvests from a greenchop field are to include plants approaching maturity, a preplant application of 100 to 200 pounds of nitrogen (to carry the crop to this stage of maturity) would be excessive for the portion of the field that was cut early. With such an application the early growth could accumulate dangerous amounts of nitrate (page 00). To maximize yields and provide a reasonably high protein level, nitrogen should be applied in split applications with the irrigation water at 40 to 60 pounds per acre at intervals of about 20 to 25 days. Higher nitrogen applications might be profitable on infertile soils, or soils previously used for unfertilized nonleguminous crops. Very fertile soils high in residual nitrogen may not benefit from higher rates, and in such cases it may be advisable to reduce or leave out the preplant application.

Nitrogen fertilization trials with Piper sudangrass were conducted in 1963 at the Experiment Station, Davis, on soil with the following cropping history: cereals (1962), beans (1961), green manure (1960). The results (tables 2 and 3) suggest that total nitrogen applications greater than 250 pounds per acre per season did not appreciably increase seasonal dry-matter yields. Where no nitrogen was applied, yields decreased rapidly at each subsequent cutting. A 100-pound preplant application carried the crop to about the third cutting before yields decreased appreciably. A split application of 50 pounds preplant and 50 pounds after each cutting maintained a more uniform dry-matter yield and protein level.

In the above trial applied nitrogen was not the only source available to the plants; the forage produced per acre with no supplemental nitrogen contained a total of 203 pounds. This residual nitrogen probably was left from previous crops or rain, and/or released by decomposition of residual soil organic matter, or both. This nitrogen was not all available at one time, but released slowly during the season, though not rapidly enough to produce continued high yields.

If the popular cultivars are to be harvested only at the boot, heading, or flowering stages of development, 100 to 150 pounds of nitrogen per acre per cutting is indicated for sudangrasses. To maximize yields and maintain comparable crude-protein levels, the taller, longer-growing crosses will require from 150 to 200 pounds for each cutting.

Irrigation

When left undisturbed, sudangrass cultivars develop deep and extensive root systems, often equalling in depth the above-ground vegetative height. But the root system is sharply curtailed by frequent cutting or pasturing. Normally, about the first 2 to 2½ feet of soil will contain at least 80 per cent of the root system—the support for the large volume of vegetative growth harvested as pasture or early greenchop.

Keep the soil in this root zone moist enough so the plants do not show signs of wilting. The frequency of applications and total amount of water needed to do this will depend on the soil's water-holding capacity. When the cultivars are used for pasture or early greenchop, irrigations may be needed as often as every 10 days. On deep soils and when the crop is to be greenchopped in the later stages of maturity, deeper and less frequent irrigations may be possible.

Weed Control

Control of broadleaf weeds is of prime importance. Some weeds commonly encountered (pigweed, milk thistle, lamb's-quarters, miners lettuce, fiddleneck, etc.) are known to accumulate nitrate. When these broadleaf weeds are shaded by sudangrass, that has received high nitrogen fertilizer applications, they may accumulate exceptionally high amounts of nitrate. Animals consuming these plants either as grazed pasture, greenchop, or sudan hay may be fatally poisoned.

Broadleaf weeds can be controlled by using 2,4-D amine at ¾ to 1 pound acid equivalent per acre. Spraying should be done when weeds are very small but not before the cultivars are at least past the seedling stage (six inches or more in height). Older, established broadleaf weeds may not be killed by the 2,4-D, but simply be stunted and deformed. Under these conditions they can accumulate exceptionally high nitrate concentrations.

Many weeds after being treated with 2,4-D become highly palatable to grazing animals, which have actually been observed seeking them out in preference to pasture plants. Therefore, early treatment of weedy sudangrass fields is recommended.

Weedy grasses seldom become a problem, for they are usually crowded out by sudangrass.

Diseases

Anthracnose is the only disease of any consequence in California and is most troublesome in the southern part of the state. This fungus disease causes very small tan to reddish-purple spots or lesions on the leaves. Under humid conditions, these can become so numerous that many leaves are killed. Information is limited on the relative susceptibility of the sudangrass cultivars to anthracnose in California. Susceptibility varies as much among the crosses as among the varieties. Generally, the most practical method for coping with the leaf disease problem is to provide optimum soil moisture and fertilization, thus making for maximum vigor of the plants.

Insects

The most common and destructive insects that attack these cultivars are cutworms and aphids. Causing the greatest damage in the Sacramento and San Joaquin valleys are the cutworms. In the day cutworms hide among the tillers at or near the ground surface, and at night they climb the tillers and consume great amounts of leaf tissue.

Aphids can build up to damaging, populations on new, tender growth near the top of the plants, but under pasturing it is doubtful that this will happen. If the crop is greenchopped at later stages of maturity, aphid populations may increase enough to stunt plant growth, and if such conditions seem to be developing, it may be wise to start greenchopping at an earlier growth stage.

Growers should contact their University of California Farm Advisor about methods of controlling any pest or disease.

Utilization of feed

Quality vs quantity

Sudangrass cultivars need not be considered a filler roughage only, as they can contribute a considerable quantity of protein and carbohydrates to the ration. As the cultivars progress through the vegetative and maturing stages of growth, crude-protein per cent and digestibility decrease and per cent fiber and lignin increase. With this decrease in quality, dry-matter yield per acre increases. Experiments with sheep have shown that as sudangrass increases in maturity, voluntary animal intake decreases if there is free choice of feed. This decrease in acceptance is highly correlated with a decrease in dry-matter digestibility (Reid *et al*, 1964). Considering animal acceptance factors and the per cent dry-matter digestibility, investigators have shown that the dry-matter from sudangrass stands har-

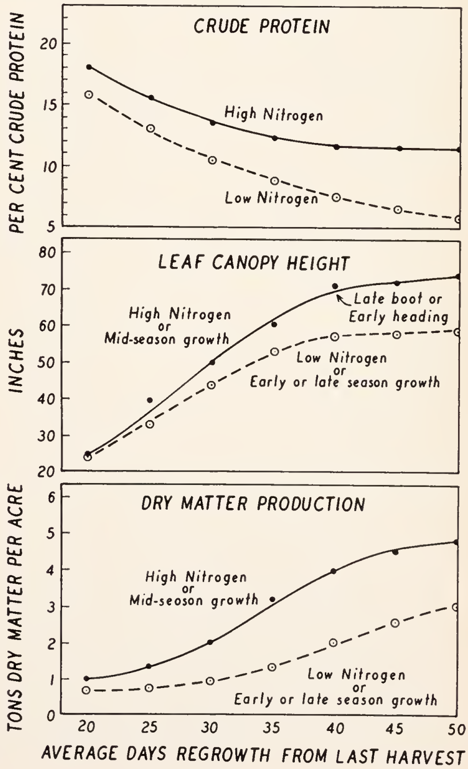


Fig. 2. Approximate relationship between per cent protein, leaf canopy height, and dry matter production in tons per acre of Piper sudangrass.

vested up to the boot stage of development will provide nearly twice the energy that is required for maintenance (Jung and Reid, 1966). For more mature sudangrass, energy values drop rapidly to near-maintenance levels. The quality of feed produced, within the vegetative growth stages, can be enhanced by the judicious application of nitrogen.

Figure 2 shows data obtained from trials with Piper sudangrass and illustrates the relationship between plant maturity, protein per cent, plant height, and yield. Variations can be expected between growth cycles—about 5 to 10 inches in leaf canopy height, 2 to 4 ± per cent points in protein, 0.75 to 1.0 ton dry-matter yield—depending largely on the season of growth and soil fertility. Early- and late-season growth can mature when it is at least 10 inches shorter than mid-season growth. This is presumably a daylength and/or temperature effect.

Protein and yield will vary according to soil fertility and season—figure 2 affords an opportunity for relative comparisons of quality with yield. If the crop is to be grown only for maximum yield of roughage, harvesting should be done at near maturity.

Comparative productivity

Table 4 summarizes the results of various clipping trials simulating pasture production. No single cultivar has been consistently the highest yielder, and the maximum yield differences within years range from 0.15 to 1.51 tons of dry matter per acre. These trials were conducted on different soils, and under different climatic conditions. Generally, the crosses will outyield the sudangrasses in the first cutting or harvest of the season. After the first cutting the sudangrasses tiller profusely and the stand thickens, but the characteristic stand thinning and the development of larger stems by the crosses results in yields no greater than that of sudangrass.

TABLE 4

COMPARATIVE SEASONAL YIELDS OF CULTIVARS WHEN CLIPPED TO SIMULATE PASTURE PRODUCTION

Cultivar	Tons dry matter per acre per season							
	Davis	Davis	Kearney Field Station	Davis 18″ row	Davis 24″ row	Fresno	Sonoma	Imperial Valley Field Station
	1962*	1963†	1963‡	1964§	1964¶	1965‖	1966**	1964††
Piper	7.63	7.42	6.5	7.11	6.73	6.29	4.64	6.77
Trudan 1		7.14	6.4	7.15	6.22			6.24
Trudan 2						6.12		
Trudan 4						5.55	4.64	
SX-11	7.55	7.10	5.9	7.26	5.79	5.18		6.42
SX-12						5.36	4.93	
Sweet Sioux		7.20	6.5	7.18	6.62		4.83	5.26
Greenlan						5.81	4.75	
Suhi 1	7.15							
Grazer		7.27						5.29

* Cut at 30″ height, 3″ stubble, 10 replications, 6 harvests.
† Cut at 24–30″ height, 3″ stubble, 6 replications, 7 harvests.
‡ Cut at 36″ height, 3″ stubble, 4 replications, 5 harvests.
§ Cut at 30″ height, 3″ stubble, 5 replications, 4 harvests.
¶ Cut at 30″ height, 3″ stubble, 5 replications, 4 harvests.
‖ Cut at 40″ height, 6″ stubble, 8 replications, 5 harvests.
** Cut at 40″ height, 7″ stubble, 5 replications, 4 harvests.
†† Cut at 36–40″ height, 4″ stubble, 4 replications, 6 harvests.
50 lb. N applied preplant and after each cutting, except at Imperial Valley Field Station where 120 pounds preplant and 46 pounds after each cutting was applied. Not all available cultivars have been tested, but representative of the three types were included in most trials.

Table 5

COMPARATIVE PLANT DEVELOPMENT AS EACH OF FIVE CULTIVARS OBTAINED 50 PER CENT LATE BOOT AT SECOND HARVEST

Cultivar	Height and maturity stage									
	August 12		August 16		September 9		September 14		September 20	
	Height (in.)	Maturity stage	Height (in.)	Maturity stage	Height (in.)	Maturity stage	Height (in.)	Maturity stage	Height (in.)	Maturity stage
Piper	69	50% late boot	72	90% late boot	81	Full flower	78*	Milk stage	76*	Early dough
Trudan-1	81	Mid boot	76*	50% late boot	96	90% headed	96	Full flower	101	Milk stage
SX-11	75	Vegetative	72*	Early boot	88	50% late boot	96	Headed	89*	Headed
Grazer	66	Vegetative	69	Late vegetative	84	Late boot	90	50% late boot	89*	80% late boot
Sweet Sioux	75	Vegetative	78	Vegetative	100	Mid-boot	102	Mid-boot	108	50% late boot

* Measurements taken from different plots, resulting in varying leaf canopy heights.
Fifty per cent late boot = approximately 50% of potential heads emerging, or emerged, from the boot.

As a consequence, under frequent harvests there is little difference between the types.

Findings of yield trials in other states, conducted over a number of years, can be summarized as follows: When cuttings are made four times per season or oftener (to simulate pasturing) hybrids and crosses are equal but not superior to the best sudangrass varieties. When cuttings are made three times per season or less, hybrids and crosses are superior in yield. When hybrids and crosses are harvested three times per season or less, they are usually in the heading or flowering stages of development when harvested. Because of their greater size and height the hybrids and crosses, though requiring more growing time, will greatly outyield the sudangrasses. Two- and three-year averages show no consistent yield differences among the crosses.

When these cultivars are harvested only at later stages of maturity (late boot, heading, flowering, etc.) the hybrids are much taller (table 5) and will outyield the sudangrass (table 6). The nitrogen applied in these tests apparently was close to the optimum amount for Piper sudangrass, considering the crude protein level for this stage of development. For the taller, longer-growing cultivars, 100 pounds of nitrogen per acre did not seem sufficient, as evidenced by lower crude-protein levels in the first and second harvests. These cultivars were running out of nitrogen, and yields would doubtless have been slightly higher if 50 to 100 pounds of additional nitrogen had been supplied. There is no logical reason why the protein levels for these cultivars should not be about equal at the same stage of development, if adequate nitrogen were applied to compensate for the additional growing days and yield.

Of particular interest is the vegetative growth in the third and fourth harvest periods. These plots had received the 100 pounds of nitrogen per acre after the preceding harvest but had attained only 22 to 32 inches in height before the final harvest. Note the rather high protein levels (table 6), which indicate a possible danger of nitrate poisoning.

TABLE 6

COMPARATIVE DATA FOR CULTIVARS HARVESTED AT 50 PER CENT LATE BOOT*

Cultivar	Maturity stage	Crude protein (%)	Fiber (%)	Dry matter (%)	Height (in.)	Date harvested	Days to harvest	Dry matter (tons/acre)	Total season yield
				1st harvest					
Piper	50% late boot	13.4	29.8	19.1	54	5 July	48	2.43	11.26
Trudan-1	"	12.4	28 7	15.1	66	8 July	51	2.95	12.34
SX-11	"	10.1	32.5	15 6	75	15 July	58	4 78	12.73
Grazer	"	8.4	32.4	17.6	80	17 July	60	4.66	11.80
Sweet Sioux	"	7 0	36.0	20.0	96	22 July	65	5.81	12.20
				2nd harvest					
Piper	50% late boot	11.3	34.0	20 0	69	12 Aug.	38	4.02	
Trudan-1	"	9.0	35.5	18.6	76	16 Aug.	39	4.52	
SX-11	"	7.0	34.2	19.9	88	9 Sept.	56	6.20	
Grazer	"	9.1	34.2	18.2	90	14 Sept.	59	5.81	
Sweet Sioux	"	9.9	34.9	19.9	108	20 Sept.	60	5.63	
				3rd harvest					
Piper	50% late boot	12.3	32.8	21.0	69	27 Sept.	46	3.24	
Trudan-1	"	10.3	36.2	19.8	89	4 Oct.	49	3.46	
SX-11	Vegetative	15.9	26.3	15.3	41	21 Oct.	42	1.75	
Grazer	"	20.4	24.4	13.7	32	21 Oct.	37	1.33	
Sweet Sioux	"	24.0	23.7	14.8	22	21 Oct.	31	0.76	
				4th harvest *Regrowth of Piper and Trudan-1. Harvested 21 October*					
Piper	Vegetative	20.3	26.8	16.7	29	21 Oct.	24	1.57	
Trudan-1	Vegetative	20.4	26.7	16.9	30	21 Oct.	17	1.41	

* Seeded May 18, 1963; three replications; 100 lbs. N preplant and after each harvest.
Fifty per cent late boot = approximately 50% of potential heads emerging or emerged from the boot.
All plots terminated 21 Oct., 1963, at Davis.

Danger of Poisoning

Prussic acid (HCN, or Hydrocyanic acid)

Although substantiated cases of prussic acid poisoning in California are rare, losses do occur most years. If the precautions listed below are followed, California producers should have little concern regarding prussic acid poisoning.

- Let original growth or any regrowth of sudangrass attain at least 18 inches in height and the sorghum x sudangrass crosses 25–30 inches before using.
- Do not turn hungry animals into short succulent pasture.
- Be extremely cautions in using pastures that are recovering from either drought or frost.

Prussic acid potential varies with crop years, within and between species, strains, varieties, and hybrids. Herbage is considered safe if it contains less than 500 ppm of HCN; doubtful at 500 to 750 ppm; and dangerous above 750 ppm. These figures are only relative as the amount ingested is critical. Well fertilized sudangrass can contain about 2,000 ppm of HCN when 4 inches high, 1,200 ppm at 8 inches, 600 ppm at 16 inches, and 400 ppm at 20 inches (Boyd *et al.* 1938). Piper of the sudangrasses, and the Trudan series of hybrid sudangrass, are known to be unusually low in prussic acid potential. On the other hand, sorghum x sudangrass crosses have been reported to range from 3 to 9 times higher than Piper in HCN content (Harrington 1966). The potential HCN content for all cultivars decreases with increase in plant height and maturity. Once the forage has attained or passed the minimum safe height for usage, frost or drought has but little effect upon HCN content. Frost or drought has been shown to increase the already high HCN content of plants shorter than the minimum recommended height for use. If forage is at a safe height to feed prior to frost, it is safe after frost.

The real danger in using frosted plants is not the affected plant material but the new growth shorter than the recommended minimum 18–30 inch height developing from the crowns if warm weather follows a frost. Grazing animals will select this new growth in preference to the frosted material.

Nitrate Poisoning

The increasing incidences of animal losses in California due to nitrate poisoning warrants a discussion of this hazard. Most losses occur because of the lack of understanding by the operator that such a problem exists, what causes it, and what can be done to help prevent it. The following suggestions are offered as measures to lessen this hazard.

- High luxury amounts of nitrogenous fertilizer is not only a waste of nitrogen but causes nitrates to accumulate within plants.
- Sudangrass cultivars exhibiting an unusually dark-green color may contain abnormally high nitrate levels and should be suspect.
- Many weeds common to California farm and irrigated pasture lands are known to accumulate high amounts of nitrate. These weeds have caused fatal poisoning of livestock feeding on otherwise safe forage.
- Do not incorporate old, well-seasoned corrals and barnyards into annual pasture areas. Such sites are usually high in soil nitrates.
- Avoid storing chopped forage in bank-out wagons to be fed next day or over a weekend. The nitrate in chopped green-moist forage, though in sub-toxic levels, can be reduced in substantial amounts by microbial action to the nitrite form within about 24 hours. The nitrite form is about 10 times as lethal as an equal amount of nitrate.
- At times weather may influence the nitrate content of these forages. If during periods of very rapid growth, under high

luxury amounts of nitrogen, a drop in temperature or sudden overcast or cloudy condition develops, the growth rate is sharply reduced causing a temporary accumulation of nitrates within the plants.

• When forage is known or suspected to have accumulated lethal amounts of nitrate it can be used by diluting with other feedstuffs. Accumulated nitrate in harvested forage is not dissipated by time or curing. If the forage is standing, delay pasturing or chopping, apply no additional nitrogen, until the plants outgrow the condition.

The nature of nitrate poisoning has been described as follows: When the ruminant ingests forage containing nitrate, the microflora in the rumen reduce the nitrate to nitrite; convert the nitrite to ammonia; then to the amino acids. When this conversion is rapid, ingested nitrates will have little effect upon the ruminant animal. If the rate of or the amount ingested is more than the microflora can readily convert, nitrites accumulate. The efficiency of the rumen microflora can be impaired through low availability of carbohydrates, or their numbers reduced by the prior administration of antibiotics.

The unconverted nitrite is readily absorbed into the blood and is capable of changing normal hemoglobin to methemoglobin which cannot transport oxygen from the lungs, and it is believed that the animal dies when oxygen in the tissue is depleted. This may require 3 to 6 hours, depending on the amount and rapidity of ingestion of the nitrate.

Vital factors in nitrate poisoining are the nitrate content of forage, rate of ingestion, and the condition of the animals. A rather small amount of plant material having a high concentration of nitrate (as in some weeds) can be lethal, while the same total amount of nitrate ingested over a longer period may cause no ill effects. Ingesting sublethal amounts of nitrate can, it is believed, cause failure to gain, loss in milk production, and abortion, though there is no conclusive proof as yet.

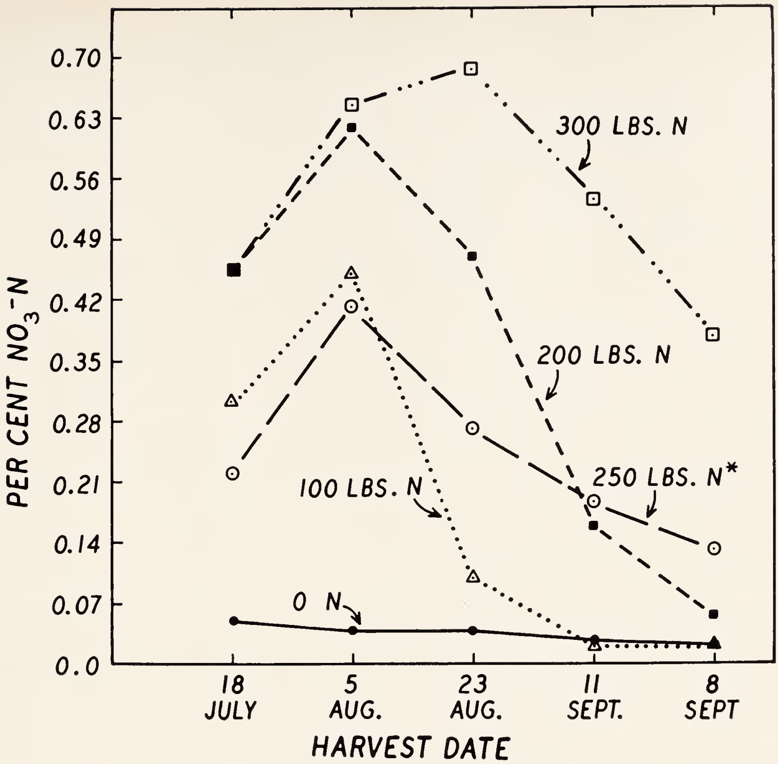
There is little agreement throughout the United States, as to how much nitrate is toxic, dangerous, or safe. Some researchers suggest that the maximum safe amount in forage is 0.07 per cent NO_3-N. (The nitrate content of feed is reported in several ways—as nitrate nitrogen (NO_3-N), nitrate (NO_3-) or potassium nitrate (KNO_3)—and may be expressed in parts per million (ppm or per cent (%).) See table below.

Figure 3 shows that it would not be safe to apply any nitrogenous fertilizer under the conditions of an experiment conducted at Davis. Investigators at Cornell report that short-time experiments did not show abortion or loss in milk production when animals were fed hay containing 0.57 per cent NO_3-N. They also state that, as a general rule, forages containing more than 0.46 per cent NO_3-N may be lethal when they are the sole component of the ration for cattle or sheep. Workers in a southern state, however, report no losses from forage containing 0.92 per cent NO_3-N.

Equivalents in per cent and parts per million when nitrate nitrogen is expressed as nitrate, and potassium nitrate.

Nitrate nitrogen			**Nitrate**			**Potassium nitrate**	
NO_3-N			NO_3-			KNO_3	
0%	ppm		%	ppm		%	ppm
0.70	7,000	=	3.0	30,000	=	5.00	50,000
0.63	6,300	=	2.7	27,000	=	4.5	45,000
0.56	5,600	=	2.4	24,000	=	4.0	40,000
0.49	4,900	=	2.1	21,000	=	3.5	35,000
0.42	4,200	=	1.8	18,000	=	3.0	30,000
0.35	3,500	=	1.5	15,000	=	2.5	25,000
0.28	2,800	=	1.2	12,000	=	2.0	20,000
0.21	2,100	=	0.9	9,000	=	1.5	15,000
0.14	1,400	=	0.6	6,000	=	1.0	10,000
0.07	700	=	0.3	3,000	=	0.5	5,000

As indicated previously, a total seasonal split application of 250 pounds of nitrogen was about optimum for sudangrass used as pasture. Higher rates did not increase yields appreciably. Under normal conditions this rate of nitrogen application should be safe. However, 150 to 200 pounds of nitrogen applied preplant to taller, higher-yielding crosses grown to be harvested at the heading or flowering stage of growth could prove toxic or lethal if feeding plans were changed and the stand used for pasture or greenchop in the early or medium vegetative stage of



* 50 pounds preplant and after each harvest.

Fig. 3. Nitrate nitrogen content of sudangrass pasture, on dry weight basis, resulting from five rates of applied nitrogen (harvested when approximately 30 inches tall).

growth. Pasture growth containing subtoxic amounts of nitrate may be grazed without difficulty but may be toxic when utilized as hay, greenchop, or silage, for these practices make it possible for animals to consume a large quantity of feed in a shorter period of time.

Publications recommended for further reading on nitrate poisoning are listed on page 16.

Cystitis syndrome in horses

The American Seed Trade Association, in cooperation with veterinarians at Texas A&M, has released the following information on cystitis:

"There appears to be some evidence that sorghum x sudangrass type forage hybrids as well as the sudangrasses, used extensively for cattle grazing and greenchop may be injurious to horses. These widely used grazing and feed crops appear to be a factor in causing a cystitis syndrome in horses. The disease has been noted mostly in Texas and a few isolated areas of the southwest. It has been reported in Georgia, Alabama, Oklahoma, Washington, Iowa, Kansas, California, and Arizona. Exact cause of the ailment has not been pinpointed, and thousands of horses have probably grazed these forage crops with no ill effects; however, horsemen should be warned of the danger and be cautious until continuing research can establish the exact cause of the syndrome."

Cattlemen, however, have no reason to become alarmed, according to the Texas A&M scientists, for no cystitis has been reported from grazing or feeding these forages to ruminants.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the cooperation extended by the Kearney Field Station and yield data supplied by George Worker, Imperial Valley Field Station.

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Recommended Reading on Nitrate Poisoning

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15m-10,'68(J2779)WP 141