Sudangrass Hay Production in the Irrigated Deserts of Arizona and California

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High-Value Sudangrass Hay Exports

Since 1989, high demand for fine-stemmed sudangrass hay by Pacific Rim countries has created a market opportunity for Arizona and hay producers. The compressed bale hay is shipped in 40-foot seagoing containers .

Foreign sudangrass hay buyers want dust-free hay with a bleached light green color and a stem diameter less than one quarter of an inch. Generally, Japanese hay buyers prefer sudangrass hay that resembles their familiar rice straw hay in appearance. Additionally, they will reject sudangrass hay with a nitrate-nitrogen concentration exceeding 1,000 parts per million. Hay growers have learned to adapt to these strict Japanese standards by using sudangrass seeding rates in excess of 120 pounds per acre to reduce stem size, by lengthening field curing time to give hay a bleached color, by carefully managing nitrogen and irrigation water to reduce nitrate accumulation, and by growing time-proven standard varieties.

Sudangrass Types and Hybrids

Common sudangrass has been grown in the United States since 1909. Varietal improvements have been made over the years for smaller stem diameter (less than 0.25 inch), superior leafiness, disease/insect pest resistance, lower potential for prussic acid and nitrate-nitrogen accumulation, and sweet, juicy stalks. Sudangrass is distantly related to Johnsongrass (**Sorghum halepense** L. Pers.), but sudangrass does not develop fleshy roots or rhizomes. Since sudangrass develops only fibrous roots, sudangrass never becomes a noxious weed. Many stems develop from a single seed when given plenty of space. Seed size ranges from 37,000 to 45,000 seeds/pound.

Two types of sudangrass hybrids are currently grown in the United States: true sudangrass hybrids and sorghum-sudan hybrids. True sudangrass hybrids resemble common sudangrass in growth and quality characteristics, however they tend to be taller, have an intermediate stem diameter (ranges from 0.20 to 0.28 inch), and are higher yielding than common sudangrass. These hybrids recover rapidly after harvest, and when managed properly are very productive. Seed size is variable, ranging from 25,000 to 45,000 seeds/pound. When planting for a given population, larger seeded sudangrass hybrids require a 15 to 30% higher seeding rate by weight compared to common sudangrass.

Sorghum-sudangrass hybrids are taller than sudangrass, have larger stems and coarser leaves, and give higher forage yield when harvested only two or three times per season at the flower stage for green chop or silage. Since they tiller less and have larger stems (stem diameter ranges from 0.28 to 0.35 inch) and coarser leaves, they are often used for silage and grazing. Sorghum-sudangrass hybrid stands often thin excessively after the third or fourth cutting, and these hybrids are more likely to accumulate prussic acid. They are large seeded ranging from 16,000 to 18,000 seeds/pound, thus they require a 30 to 50% higher seeding rate by weight when planting for population, compared to common sudangrass varieties.

Sudangrass Hay Production

General

Sudangrass and related hybrids are annual warm season grasses grown for pasture, green chop, silage, and hay. Sudangrass forages include common sudangrass (*Sorghum sudanense* Stapf.), sudangrass hybrids, and sorghum-sudangrass hybrids (*Sorghum bicolor* (L.) Moench x *Sorghum sudanense* Stapf.) As many as 4 to 5 cuttings can be obtained in a season on a 21 to 30 day cutting cycle. Sudangrass does well on all types of well drained soils from a heavy clays to light sands, however the yield may be low on sandy soil if the crop is not well fertilized. It tolerates moderately saline soils with an electrical conductivity of the soil extract up to 4.0 (2560 ppm) with yield reductions of 10% when soil EC > 5.0 (3200 ppm), 25% if > 7.0 (4480 ppm), and 50% at soil EC's > 11.0 (7040 ppm).

Commercial seed guides recommend sudangrass seeding rates ranging from 10 to 30 pounds of seed per acre. However, sudangrass grown for export is planted at a higher density to decrease stem diameter and increase leafiness of the forage. When planted at drill seeding rates from 100 to 125 lb/acre, common sudangrass has stems about 0.2 inches in diameter and can grow to 3 to 5 feet high. For hay production, it should be cut at the boot growth stage. Hay yields ranging from 1.0 to 2.5 ton/acre/cutting can be expected at each of the four harvests. Sudangrass is often sheeped off at the final (fourth or fifth) harvest.

Sudangrass is normally planted in late spring when the soil has become warm, or about two weeks after corn planting time. After mid-March, western Arizona soil temperatures generally reach or exceed 65 degrees F, and sudangrass plantings can be safely made. When soil temperatures at planting are from 50 to 60 degrees F, sudangrass germination drops to 25 to 60%, and plants require 14 to 21 days to emerge. At soil temperatures above 60 degrees F, sudangrass germination is increased to 90 to 96%, requiring four to six days to emergence. Typical sudangrass planting dates are from March 15 through May 1 for low elevation desert locations. Hay production begins following 60 to 70 days after a mid-March planting. Sorghum sudangrass hybrids and sudangrass are equivalent in their ability to germinate at low temperatures.

Seedbed Preparation and Planting

Sudangrass produces well on all soil types, however best yields are obtained on well-drained, deep loam soils that have a high capacity to absorb and hold water. Sandy soils will produce good crops of sudangrass when fertilized and irrigated frequently. When impermeable soil layers are close to the soil surface, root development is reduced and water movement is restricted. Compacted soil layers below the plow depth, resulting from tillage and heavy equipment traffic, should be broken by subsoiling prior to seedbed preparation. Land leveling improves irrigation efficiency and increases production. High spots in a field may be less productive because they receive less irrigation water and salts tend to accumulate in these areas. Preliminary cultural operations such as plowing, disking, harrowing, and leveling should be completed before borders are established. Border widths vary from 50 to 200 feet or more, depending on side slope, size of irrigation head available, and width of machinery to be used.

Due to its tolerance of moderately saline soils and the high amount of residue or organic matter returned to the soil, sudangrass is often grown on fields with historically low cotton lint yields. Fields should be relatively level and laid out with low, wide borders spaced to fit haying equipment. The soil should be prepared well with a mellow, firm seedbed similar to that for alfalfa. A seedbed which gives good contact between seed and soil particles improves germination and early seedling growth. Pre-irrigation will reveal high and low areas where spot leveling may be necessary prior to planting. This preirrigation also sprouts weed seeds which can be killed during seedbed preparation at planting time. Heavy (silt or clay) ground is often bedded prior to planting sudangrass due to its lower water infiltration rate, while sandier soils are normally planted flat in narrow basins with a grain drill.

Use certified seed since poor quality seed may contain Johnsongrass or other varieties of sorghum. Johnsongrass and sorghum-sudan hybrids can produce more prussic acid than common and hybrid sudangrass. Suggested planting dates are similar to corn. Plant as soon as the soil temperature is 60 degrees F at a 1 ½ inch depth for several consecutive days at 8:00 a.m., along with a favorable five day forecast. Typical earliest planting dates for elevations below 3,000 feet range from March 15 through April 1, or from April 1 through May 15 at elevations above 3,000 feet. Cultipack before seeding and use a grain drill with press wheels or other equipment that will accomplish a firm loose seedbed. Plant from 100 to 120 pounds or 3,700,000 to 4,400,000 common sudangrass seeds per acre up to one inch deep in heavy soils or one and one half inch deep in sandier soils. Plant sudangrass with a six- to eight-inch drill row spacing on flat ground, or with five to seven six- to eight-inch wide rows on raised beds.

Fertilization and Irrigation

Sufficient nitrogen should be applied at planting to ensure establishment of the crop and hasten development. Typically, 40 to 80 pounds of actual nitrogen per acre are suggested at planting, based on results from a preplant nitrate-nitrogen soil test. This should be followed by split applications of 60 to 120 pounds actual nitrogen per acre in irrigation water following each cutting. Sudangrass planted in early spring into cool soil may benefit from an application of phosphorus (80-100 lbs. P_2O_5/acre). Nitrogen and phosphorus requirements at planting can be determined from a preplant soil test. Sudangrass has a seasonal nitrogen (N) requirement of 320 to 400 pounds actual N per acre, split applied at planting and following each cutting. Overfertilization with nitrogen, especially when combined with stand loss in the later cuttings, can result in unacceptably high levels of nitrate-nitrogen in the forage (> 1000 ppm). Nitrogen fertilizer can be water-run in the five to eight 4- to 6- acre inch flood irrigations that are normally applied during the growing season. This includes one irrigation at or near planting, one to two irrigations prior to the first hay harvest, then one to two irrigations following each of the first three hay harvests. Remember, one pound of actual nitrogen per acre is equivalent to approximately 0.24 gallon of anhydrous ammonia, 0.28 gallon of urea ammonium nitrate (UAN 32), or 2.2 pounds of urea (46-0-0).

Pre-irrigation on many soils requires about one acre-foot of water to wet the soil to a depth of six feet. This practice aids in irrigation control and helps reduce weed problems where the grower is unsure of field conditions. Another two or three acrefeet of water will be required in four to six irrigations during the growing season with sandy soils requiring a more frequent irrigation interval than heavy soils. It is important to avoid undue moisture stress of sudangrass since stress can cause accumulation of nitrate-nitrogen and/or production of prussic acid in forages that can be toxic to livestock.

Sudangrass uses from 7 to 11 acre-inches of water per month in May, June, July, and August. During the hottest periods this means irrigation about every two to three weeks on heavy loam, silt loam, and clay loam soils which hold more water than coarse textured sandy and sandy loam soils, which will require an irrigation interval of from one to two weeks. Generally, when grown for hay on fine textured soils, sudangrass will require a six to eight inch irrigation each month during April and September, and every 20 to 25 days during May through August in order to meet the water requirements. Sudangrass grown for hay on coarse textured soils will require from three to five inches of irrigation water applied every 15 to 25 days during April and September, and every 10 to 15 days, May through August.

Pest Management

Common sudangrass crop pests include weeds, and several diseases and insects. Normally, insecticide applications are not required, but a preplant or postemergence herbicide application may be necessary. Weeds probably cause the most damage to sudangrass stands as they compete for light, moisture and nutrients. Proper seedbed preparation and planting dates that allow rapid germination and stand establishment will help control weeds. Periodic cultivation is possible when forage is planted in rows.

Leaf blights which cause elongated straw-colored lesions with reddish margins on leaves and downy mildew which causes yellowish or reddish deformed leaves are the most serious sudangrass diseases. Insects including the greenbug, corn earworm, armyworms, wireworm, and southwestern corn borer are occasional pests of sudangrass. Tolerant varieties, crop rotations, early and frequent harvests, and crop destruction following the final harvest are the best controls for most disease and insect pests of sudangrass.

Greenbug aphids are potentially the most damaging insect pest since they inject a toxin into sudangrass plants and vector dwarf mosaic virus. When plants are infected by this virus early, they are stunted and their leaves are mottled. The leaves of older infected plants have necrotic areas that appear in streaks and their leaves have a reddish cast. Although genetically resistant, small sudangrass seedlings may incur enough damage from large greenbug infestations to thin the stand, thus chemical control may be justified.

The greenbug aphid is pale green and approximately 1/16 inch long, with a characteristic dark green stripe down its back. Scout for greenbugs from emergence up through the first cutting of sudangrass. A minimum of 40 randomly selected plants per field should be examined each week during this period. Greenbugs are seldom evenly distributed across a field, so examine plants from all parts of the field. In seedling sudangrass up to six inches tall, greenbugs may be found on any part of the plant including the whorl and occasionally in the soil at the base of the plant. On larger plants, greenbugs usually colonize on the undersides of lower leaves and move up the plant. The undersides of lower leaves on larger plants need to be examined carefully. Plants below six inches tall should be treated when unparasitized greenbugs are present, when there is visible yellowing and reddening of the plant, and when stand loss is probable. Larger plants can tolerate more greenbugs than seedling sudangrass.

Soil pests of sudangrass are not common, but can include wireworms, white grubs, corn rootworms, and cutworms. Crop rotation, cultivation practices, and/or the use of herbicides that reduce crop residues and provide weed free fields are important to control soil pests. Proper seedbed preparation that promotes rapid seedling emergence and stand establishment, and preplant inspection for the presence of soil insects are important in fields with a history of production problems due to these pests.

Wireworms are immature stages of click beetles. The larvae range in color from yellow to brown, can grow to approximately one inch long, and are shiny, cylindrical, and hard-bodied with six short legs close together near the head. White grubs are the larval stages of May or June beetles. Larvae are typically C-shaped, from ½ to one inch long, with a white body and tan to brown head. Soil samples one square foot by four inches deep should be examined thoroughly for the presence of these soil pests. If wireworm or white grub numbers exceed two or more per square foot, control measures should be implemented.

Cutworms are the immature stages of night-flying moths. The larvae are dull brownish smooth skinned caterpillars over one inch long that curl into a C-shape when disturbed. Insecticide-treated seed or planter box seed treatments have proven effective in controlling wireworms and cutworms, when these insects are present in damaging numbers in the soil.

Fall webworm, armyworm, corn earworm, and Southwestern corn borer moths can deposit eggs on the leaves of sudangrass plants. Larvae of these moths cause damage by feeding on sudangrass leaves and stems. They range in color from pale green to almost black, with longitudinal stripes running along the back. They often feed in the plant whorl, and as leaves emerge from the whorl, ragged "shot hole" damage is evident. Although this damage may be dramatic, control of worms in sudangrass beyond the seedling stage is seldom economically justified. Early planting and practices that encourage the development of beneficial insect populations aid in control of armyworms and earworms. Timely destruction of crop residues and crop rotation are important cultural controls of these sudangrass pests.

Spider mites can also damage young sudangrass plants. Adult spider mites are tiny, up to 1/20 inch long, with eight legs and an oval body often with a dark blotch on either side. They are easily seen with a 10X hand lense. Spider mites live in colonies mostly on the lower surfaces of leaves where they often spin a silken webbing resembling a spider web. They feed on leaves by piercing cells and removing plant juices. Yellow or red blotches are found on leaves damaged by spider mites. Eventually the entire leaf turns brown and dies. Infestations are often first observed on the lower leaves of plants located in the outside rows of fields, so edge treatments are possible with early detection. Mite density and sudangrass plant size will dictate the need for miticide applications. Spider mites have many natural enemies and frequently become a problem after other insecticides destroy natural enemies.

Grazing and Hay Harvest

Harvest sudangrass when it is at least 18 to 24 inches tall at the first cutting. This generally occurs from four to six weeks after planting. It may be pastured or cut for hay every three to four weeks thereafter. When sudangass is grazed down quickly it has a longer time for regrowth. Common and sudangrass hybrids recover more quickly than sorghum-sudangrass hybrids which tend to lose stand following two or three harvests. Rotation of livestock in strips or sections will facilitate irrigation after quick grazing, promote better regrowth, and avoid uneven grazing which can result in tall, unpalatable plants. Regrowth from stubble four to six inches tall will recover faster than shorter stubble heights.

Hay generally may be cut three or four times in a season, and sheeped off at the final harvest. A fifth cutting may be possible in late October or early November before frost, however this cutting is often sheeped off. Highest hay yields are obtained by cutting at the soft dough stage of growth, but curing is difficult at this stage and quality is unacceptable for export and feeding. Highest hay quality is obtained when sudangrass is harvested at the boot growth stage prior to heading. The feed value of good sudangrass hay is about equal to that of millet, timothy, Johnsongrass, and other grasses. Crude protein ranges from nine to twelve percent and TDN ranges from 55 to 60 percent.

Because of the large amount of juice in the stems of sudangrass, the leaves cure first and the hay often appears ready to bale when the stems are not dry. Use of hay conditioners or crimping to split stems will reduce the drying time and give better quality bright, leafy hay. Typical curing times range from 10 to 20 days after cutting depending on maturity at harvest, hay conditioning, and weather conditions. Sudangrass cut for hay is often raked once or twice prior to baling to turn windrows and facilitate drying. Sudangrass hay is easily baled when moisture content of the forage does not exceed 8 to 10 percent. Lengthening the field curing time to give the hay a bleached color is preferred if sudangrass hay is destined for the Japanese export market.

Potential Sudangrass Forage-Livestock Disorders

Nitrate Poisoning

Nitrates present in hay crops are considered toxic to many classes of livestock. There is considerable variation among animal species in their susceptibility to nitrate poisoning, with pigs being the most susceptible, followed by cattle, sheep, and horses. The higher susceptibility of cattle relative to sheep is due either to the ability of cattle to convert nitrate to nitrite in the rumen or to the greater ability of sheep to convert nitrite to ammonia in the stomach. The lethal dose (LD_{50}) of nitratenitrogen for pigs ranges from 19 to 21 mg/kg body weight; for cattle it ranges from 88 to 110 mg/kg body weight; and for sheep it ranges from 40 to 50 mg/kg body weight. Forages containing more than 2,000 ppm nitrate-nitrogen can cause toxic effects in cattle.

Nitrate poisoning in livestock is often results from the consumption of pasture or feedlot hay containing high levels of nitrate-nitrogen (NO_3-N). Sudangrass takes up nitrogen from the soil primarily in the form of nitrate. Under normal growth conditions this nitrate is converted to plant protein at about the same rate it is taken up by plant roots. However, when plant growth is slowed or stopped by stress conditions including low soil moisture, low humidity (hot, dry weather), cloudy conditions that reduce solar radiation, frost, or herbicide applications, nitrate can accumulate. Nitrate levels will be highest in the stalks or stems and lowest in the new leaf growth. Nitrate levels are usually higher in young plants and decrease as plants mature.

Another type of poisoning from nitrate occurs when nitrate is converted to nitrite in the plant or animal. Conditions may be conducive for nitrate to be reduced to nitrite in forages. This is especially true for forage produced during wet and hot weather conditions, or if the harvested hay is damp for some time before feeding. Nitrates can also be reduced to nitrites within the digestive tract of livestock. Nitrites can then oxidize the iron in blood hemoglobin and prevent adequate oxygen transport. Animal symptoms are labored breathing, muscle tremors, and a staggering gait after which the animal collapses, gasps for breath and dies quickly. The membranes of the eyes and mouth will appear bluish indicating a lack of oxygen, and the blood will be chocolate brown, but will turn bright red when exposed to air. Forages heavily fertilized with nitrogen often will accumulate toxic quantities of nitrate-nitrogen during periods of drought, cloudy weather, or when stands start to thin.

Export hay brokers prefer sudangrass with a nitrate-nitrogen concentration less than 1000 ppm and crude protein levels ranging from 9 to 12%. If you suspect nitrate accumulation in forage, it is a good idea to have the forage tested. If there is a good chance that weather or other factors causing nitrate accumulation may improve, it is a good idea to postpone harvesting for a couple of days. Generally, once the stress is removed, and normal plant growth has resumed, nitrate accumulation disappears quickly.

If it is necessary to harvest forage high in nitrate, it generally is recommended to hay producers that they mow higher than normal, because nitrate accumulation is greater in the lower parts of the plant and in regrowth. Also, postponing harvest until afternoon will allow sunlight to convert as much of the nitrate to plant protein as possible. Furthermore, ensiling can reduce nitrate levels by 40% or more compared to haying. Nitrate is fairly stable in harvested forages or hay. Damp hay high in nitrate seems to be more toxic when fed to susceptible animals than dry hay. Forages high in nitrate can be diluted to a safe level with other forages or grains that are low in nitrate.

Hydrocyanic or Prussic Acid Poisoning

Most cases of hydrocyanic or prussic acid poisoning are caused by the ingestion of plants that contain cyanogenetic glucosides. Cyanogenetic glucoside itself is non-toxic but hydrocyanic acid (also known as prussic acid) may be liberated from the organic complex by the action of an enzyme which may also be present in the same or other forage plants, or by the activity of rumen microorganisms. Horses and pigs are much less susceptible to the glycosides because the acidity of the stomach in monogastric animals helps to destroy the enzyme. Sheep are much more resistant than cattle, apparently because of differences between enzyme systems of the forestomachs of the two animals. The minimum lethal dose of hydrocyanic acid is about 2 mg/kg body weight for cattle when taken in the form of a glucoside. Plant material containing more than 200 ppm hydrocyanic acid can cause toxic effects in cattle.

Prussic acid causes death in livestock by interfering with the oxygen transferring ability of the red blood cells, causing animals to suffocate. Symptoms include excessive salivation, rapid breathing, and muscle spasms. Symptoms normally occur within 10 to 15 minutes after the animal consumes toxic quantities of prussic acid-containing forage. Animals may stagger, collapse, and die within 2 to 3 minutes of first showing symptoms. The greatest danger of poisoning exists when hungry animals gorge themselves on forages containing toxic levels of prussic acid.

Naturally occurring glycosides may form prussic acid which can build up to toxic levels in young plants and leaves of sudangrass. As with nitrate accumulation, some stress usually triggers HCN production. Since prussic acid is most likely to build up to dangerous levels immediately after a killing frost, the last sudangrass hay cutting of the season can likely be suspect. Occasionally, hot, dry winds induce temporary moisture stress on sudangrass plants which also can increase the potential for prussic acid accumulation by sudangrass. The potential for poisoning of livestock by forage is greater with excessive soil nitrogen and young plants. Toxicity is also more likely when periods of rapid growth are followed by cool, cloudy weather. Lush regrowth after cutting for hay or frost is particularly dangerous. Stress resulting from high rates of herbicide that stunt sudangrass growth may temporarily increase prussic acid levels in the plant.

Livestock may be poisoned if they eat large amounts of forage with a prussic acid content above 600 ppm. Milking cows and stockers may show reduced performance if they eat large amounts of forage with a prussic acid content above 200 ppm. Danger of poisoning is minimal by the time sudangrass reaches a height of 18 to 22 inches. Prussic acid levels are normally highest in lush regrowth following a period of stress, and also higher in the leaves compared to the stems.

As with nitrate, most problems with prussic acid can be avoided with proper management of forage and animals. Since sheep are much more resistant to prussic acid poisoning than are cattle, and because of the low tonnage of the final sudangrass cutting in fall or early winter, this cutting is often sheeped off, rather than harvested for hay. Glycoside levels increase during the morning, then level off and begin declining in the afternoon and evening. Postponing harvest till the evening can reduce the potential for prussic acid production in forage.

Sudangrass fertilized heavily with nitrogen and stunted by moisture stress, inclement weather, or an herbicide application can produce toxic levels of prussic acid. Hay producers can reduce risk of livestock poisoning by using a maximum of 60 to 80 pounds of actual nitrogen per fertilizer application. Proper field curing before baling or ensiling results in considerable loss of prussic acid. Test any forage thought to contain high levels of prussic acid or nitrate-nitrogen before animals are grazed or fed. Grazing or hay cutting should not begin until plants have reached 24 inches in height or more. Do not harvest sudangrass regrowth following a frost for hay. Frosted sudangrass may be used for silage, however do not feed new silage for two to three weeks since this delay will allow prussic acid to escape. Do not pasture or sheep off sudangrass following a killing frost until plants thaw and wilt for a few days.

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