Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA

Sudangrass

FOR HAY · PASTURE · SEED

JONES • GOSS • MILLER • PETERSON

CALIFORNIA AGRICULTURAL
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CIRCULAR 462

Sudangrass

is California's most important annual pasture and hay crop and the acreage devoted to this crop is increasing annually.

Recent research and plant experimentation have developed new varieties and improved growing techniques to increase production while increased demand from California and other states has made seed production a major operation for many farmers.

This circular

describes the growth of Sudangrass in the over-all picture of California agriculture. New varieties are described and new techniques of production explained.

A detailed section has been devoted to the production and harvesting of Sudangrass seed.

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SUDANGRASS

for PASTURE · HAY · SEED

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NEARLY 175,000 ACRES of California farm land are planted to Sudangrass. Under irrigation and, to a lesser extent, dry farmed, Sudan is the state's most productive annual pasture and hay crop. Irrigated Sudan fields yield from 7 to 10 tons, and dry land fields average from 2 to 5 tons annually per acre.

Dry land acreage often produces from 500 to 1500 pounds of seed, and irrigated Sudan grown for seed usually yields from 1500 to 3500 pounds per acre. From 1945 to 1954 average per acre yield was 800 pounds, and the average total production was 8.8 million pounds. In 1955, seed production jumped to 37.5 million pounds. By 1956 the average per acre yield had risen to over 1300 pounds.

The highest yields, of course, were reported from farms where Sudan was planted in good soil, but good crops have often been obtained under less favorable conditions. Quite frequently Sudan is used as a soil conditioner on tight clay pan soils and newly leveled land. While Sudan has great drought tolerance, it responds vigorously to irrigation or rain. Greatly improved yields repay the cost and trouble of good management practices.

WHAT IT IS AND WHERE ADAPTED

Sudangrass was introduced into the United States as a result of a search for a type of Johnsongrass which would supply good feed and forage crops without the vigorous rootstocks and perennial characteristics which allow Johnsongrass to spread and become a serious problem. Once started Johnsongrass becomes almost impossible to control, but Sudan under cultivation remains an annual and plants have survived the winter only in completely frost free areas. In addition Sudan lacks the aggressive rootstocks of its relative and is never difficult to eradicate. Thinly spaced plants may produce 20 to 100 tillers, while thick, close-drilled or broadcast seedings show much less stooling.

Sudan grows four to eight feet tall in cultivated rows and three to six feet when sown broadcast or close-drilled. Although considered a rank grass, the stems are fine, rarely being larger than a small lead pencil, and the leaves are soft in texture. It is a warm-weather grass, being less resistant to cold than corn.

Sudangrass is one of California's best annual pasture crops, especially in mid-

Left to right, Sudan 23, Sweet Sudan and Johnsongrass. Notice the fibrous root system of Sudan in lower left and the coarse perennial rootstocks of Johnsongrass, lower right.

summer when permanent pastures are usually short. When cut at first heading to early bloom and properly cured, it makes good hay. In feed value, Sudan hay compares favorably with other grasses but is less palatable and lower in feed value than alfalfa hay.

Sudan Varieties

Until recent years, much of the Sudan seed in commercial trade throughout the United States was sold simply as Sudangrass because improved varieties had not been developed. An exception to this was Sudan 23 developed by selection from common Sudan at the California station a number of years ago. Recently, several new varieties have come into production and have been tested at the Experiment Station and in county trials.

Sudan 23. Of the varieties tested at Davis, Sudan 23 has proved to be one of the highest yielding types, producing 10 to 20 per cent more than Common or Sweet sudan. It also is a little later in time of heading and more uniform in growth characteristics than Common sudan. Its ability to recover very quickly from grazing makes Sudan 23 particularly desirable for pasture. Production during late summer and fall has ranged from 35 to 100 per cent greater than Sweet sudan. Sudan 23 is certified by the California Crop Improvement Association. The popularity of Sudan 23 has diminished with the introduction of the more recently released varieties from the Midwest.

Piper Sudan. Piper's popularity has grown rapidly in California and in the north central states because of its high productivity and low prussic acid content as well as its resistance to leaf blight and anthracnose. Since its introduction in 1950, in forage yield tests at Davis and county trials in central and northern California, Piper's production has equaled Sudan 23. Like Sudan 23, it recovers quickly from grazing or clipping and grows well into the fall. This variety was developed by the Wisconsin Agricultural Experiment Station and released in 1950. The original parents included selections from lines obtained from the Texas and Kansas Experiment Stations and Tift sudan.

Piper is certified by the California Crop Improvement Association and is grown extensively to produce seed for out-of-state use. In recent years Piper has become the leading variety for seed production with California farmers producing nearly 20 million pounds of Piper seed in 1955.

Sweet Sudan. Yields of Sweet sudan at Davis have been about equal to Common sudan, but lower than Sudan 23 and Piper. The difference in yield is due largely to the slower recovery of Sweet sudan after cutting. In Imperial and Palo Verde Valleys, this is usually one of the top yielding varieties and is recommended for forage production there.

Seed yields of Sweet sudan are good, and in recent years it has been grown widely in the state for seed production. Sweet sudan 372 is eligible for certification in California.

It is easily identified by its broad, dark green leaves and thick, juicy stems which often show a whitish "bloom." The mid-rib of Sweet sudan leaves is cloudy or milky colored, while those of most other varieties are clear. The stalk is sweeter and juicier than Common sudan, is less likely to shatter its seed, and is more resistant to foliage diseases in humid areas where such diseases are a problem. The seed hulls are dull brick red.

Sweet sudan was developed by the Texas Agricultural Experiment Station, from a cross between Common sudan and Leoti, a sorghum which contributed the sweet, juicy stalk and non-shattering seed habit and some other desirable characteristics.

Tift Sudan. Tift sudan is highly resistant to various leaf diseases which are serious in the warm humid regions of southeastern United States. Leaves are broad like Sweet sudan and dark green in color. Seeds range in color from a dark mahogany to yellow or straw color and vary in size and shape. Tift was developed at the Georgia Coastal Plain Experiment Station, Tifton, Georgia, by crossing Leoti and Common Sudan. Although the sweet and juicy stem characteristics of Leoti were not retained in Tift sudan as they were in Sweet sudan, various other growth characteristics are common to the two varieties.

Because its main advantage is resistance to diseases which rarely occur in the arid regions of California, and because forage yields have been low, Tift is only recommended for forage production in Imperial and Palo Verde Valleys. However, seed production in the southeastern states, where Tift is adapted, is uncertain, if not impossible, because of the high humidity and frequent contamination with Johnsongrass. Seed production in California for export to these states could develop as the demand for seed develops. Seed yields of 1500 pounds per acre have been obtained under irrigation; however, commercial Tift seed growers expect 20 to 30 per cent less seed per acre than from Piper or Sudan 23. The variety is certified by the California Crop Improvement Association.

Greenleaf Sudan. This variety is being grown in California primarily as a seed crop for out-of-state use. Seed yields per acre under California conditions are considered comparable to Piper. In yield trials at Davis, forage production is similar to that of Sweet sudan or 10 to 20 per cent below Sudan 23 or Piper.

The variety was developed and released by the Kansas Agricultural Experiment Station in 1953. It originated from a Leoti-Sudan double cross made at the Texas Experiment Station and first grown in Kansas in 1940.

It is one of our leafiest varieties, having many wide, dark green leaves. The stems are juicy and palatable. The seeds are mahogany in color. Greenleaf is late maturing and slow in recovery after cutting. It has considerable resistance to foliar diseases which occur in the central region of the United States. Greenleaf is certified by the California Crop Improvement Association.

Lahoma. This is a wide-leafed, juicy stemmed, late-maturing Sweet sudan. The parent breeding material came from the Texas Agricultural Experiment Station and was released for certification by the Oklahoma Agricultural Experiment Station in 1954.

Lahoma has drought tolerance and greater resistance to leaf diseases than other Sweet sudan strains but is susceptible to leaf blight.

In limited tests in California, seed yields have been good; however, forage yields were below Sweet sudan and much below Piper and Sudan 23. Lahoma is not recommended for forage production in California. It has not yet been accepted for certification by the California Crop Improvement Association.

WHERE WILL SUDAN GROW?

Sudangrass does best on deep, fertile soils where the weather is warm and the growing season relatively long. It is injured or killed by light frosts.

The irrigated valleys are well suited for Sudangrass. It is the best summer annual forage crop for coastal areas south of San Francisco. In the north coast counties it is used only occasionally in inland valleys. The upper altitude limits for profitable production appear to be 5,000 to 6,000 feet in northern California and 6,000 to 8,000 feet in the southern part of the state.

It is grown on a wide variety of soils, ranging from heavy clay to light sands. On sandy soils irrigation and fertilizer applications must be well managed to

maintain yields. Good drainage is essential, and even small amounts of alkali will reduce yields.

The ability of Sudangrass to endure drought is equal to that of the best sorghum varieties, but lack of water lowers production. The plant has an extensive root system and will continue growth as long as the roots are able to reach moist soil.

Sudan is being used increasingly as a dry-farmed forage. A smaller acreage is grown as a seed crop in the rotation on California grain ranches, especially in coastal districts where annual rainfall is 15 inches or more. The aggressive root system apparently helps to "open up" the soil so that following the Sudan crop, subsequent winter rains are better able to penetrate into the sub-soil. In some cases, dry-farmed Sudan is used in place of summer fallowing. The cropping system thus becomes: first year—cereal grain; second year—volunteer cereal hay crop or pasturage; and third year—Sudan for pasturage or hay or both.

Sudangrass is also being used to "condition" choice rangeland areas prior to seeding improved pasture species. The year of Sudan helps to reduce the weed competition in the new pasture seeding. In addition, the Sudan stubble provides protection and a ready made seedbed in which to seed the improved pasture species.

PROFITABLE SUDAN MANAGEMENT TIPS

Prepare a good seedbed: Even germination is dependent upon this. A seedbed suitable for alfalfa should be the goal. Best results will be obtained by plowing in the fall or early winter and allowing the land to remain rough until spring.

Especially in dry-land farming it is important to conserve moisture in the soil during germination. When Sudan is to be irrigated, it is best to apply water before final seedbed preparation. This insures good surface moisture and prompt germination. The thick, quick growing

Dry farmed Sudan can be successful in California if the soil is deep and permeable and the rainfall averages 15 inches or more annually. This Orange County rancher rotates sudan with grain. After the hay is cured beef cattle are turned into the field to graze on green pasture and dry hay.

Sudan produced by pre-irrigation will crowd out weeds, such as watergrass, which might develop.

Before planting, disk the soil to kill weeds; follow with a harrow and a flat drag or cultipacker to smooth the surface and conserve moisture. Many farmers perform these final seedbed operations simultaneously so that the soil lies open only for a few minutes.

Seeding may be done from mid-April to July, as Sudan requires a warm soil for good germination. Planting on dry land should be made at the earliest date to insure seedling establishment while moisture is still available near the soil surface. Delaying seeding until June or July reduces yield. Seed treatment with Ceresan M is recommended to prevent seed rot and to control covered kernel smut.

The most satisfactory method of seeding Sudan is with a grain drill equipped with press wheels, set to deliver seed from three to four inches below the surface and at least one inch into moist soil. Shallow seeding is best on heavy soil; deeper seeding may be required on sandy soil. Broadcasting and harrowing to cover the seed is less satisfactory. It is good practice to cultipack immediately after seeding to firm the soil around the seed and to conserve moisture.

Seeding rates may vary widely without markedly influencing forage yields; however, general practice has shown that rates of 15 to 20 pounds per acre provide satisfactory stands on irrigated land. On dry land, the rates are 12 to 15 pounds per acre for close-drilled or broadcast seedings, and 3 to 6 pounds for rows.

Lighter seeding rates tend to produce coarser plants. Thinly spaced plants may produce 20 to 100 shoots from their bases, whereas close-drilled or broadcast seedings show much less stooling.

Fertilizing irrigated Sudangrass with nitrogen is usually profitable. It is especially necessary on newly leveled fields, but may not be needed in rotation with alfalfa or irrigated pasture. Applications of up to 300 pounds ammonium sulfate per acre or equivalent amounts of other nitrogen fertilizers may be made before planting. On irrigated land where the crop may be sown two or more years in succession, fertilization rates should be stepped up to 400 to 600 pounds per acre. Sudangrass on dry land may not require fertilization but frequently benefits from an application of nitrogen fertilizer in amounts up to 150 pounds per acre before planting. Some California soils are deficient in phosphorus and may require, in addition to nitrogen, an application of single super phosphate at a rate ranging from 150 to 200 pounds per acre. Under irrigation, supplemental nitrogen fertilizer in amounts up to 250 pound per cutting per acre are frequently necessary for maximum forage yield. Fertilizers may be broadcast over the growing crop or applied in the irrigation water.

Keep weeds down by using 2,4-D. Most of the annual weeds encountered in Sudan production can be eliminated during seedbed preparation. The broadleaf weeds—star thistle, pig weed, and morning glory—can be controlled with 2,4-D weed spray.

The spray should be applied when the grass is 8 to 14 inches high. Use a mixture of three-quarters of a pound of 2,4-D acid equivalent in 30 to 60 gallons of water for a ground rig and 8 to 10 gallons of water by air, per acre. Pastures or hayfields can be sprayed because 2,4-D does not harm livestock. Precautions must be taken to avoid injury to susceptible crops in adjacent fields.

Weedy grasses are usually crowded out of Sudan and seldom become a problem except in poor stands. However, watergrass can become a problem in thin stands of irrigated Sudan.

Irrigation should be frequent enough to keep the plants in a healthy, vigorous

condition. On deep permeable loam type soils, once the crop is well established, an application of five to six inches of irrigation water every three to four weeks is usually sufficient. Sudan growing on less permeable soils or on sandy types may have to be irrigated as frequently as every seven to fourteen days.

If the seedbed moisture is lost before a stand is attained, the crop may be irrigated-up with one or two light, flushing type irrigations. This operation is strictly an emergency measure, because it may create a crusting problem on heavy soils and usually brings on a watergrass problem.

In close-drilled or twelve-inch spaced row planted Sudangrass, water is usually applied by the strip-check method but may be applied by contour checks or by sprinklers. Furrow irrigation is occasionally used on wider spaced row planting.

Heavy stocking to graze the stand down quickly, followed by a long recovery period, will yield a maximum of nutritious forage. Grazing can be started when the first seed heads begin to appear. Subsequent grazings should wait until the grass has regained a height of 18 to 24 inches.

Sudan pasture is used for all classes of livestock. Rate of gain for beef cattle or sheep is equal to that of other kinds of green feed.

Haying can be started at any time, from the beginning of heading until the field is fully headed. Although it can be deferred until the soft-dough stage, if cut when heading out or in early bloom, the hay is richer in protein and of higher feed value. Two cuttings are common in California, frequently followed by fall pasturage. Under exceptionally favorable conditions, a third hay cutting may be possible.

Sudan cures readily in summer. Cut in the morning of a warm day, it can be raked into windrows the next day. It should be left in windrows until the juicy stems have dried out. Sudan retains its leaves well and when cut at the right stage of maturity and handled properly it makes a bright, leafy, sweet, high quality hay.

Bloat from grazing succulent alfalfa, Ladino clover, or other legumes has been successfully overcome by night grazing of Sudangrass. Farmers who have had bloat problems with livestock might consider the use of Sudan in addition to other irrigated pastures.

Sudan silage is frequently made on California farms. In University tests it was determined to be worth about 10 per cent less than corn silage for dairy cattle.

To make good silage, it should be cut at the full heading stage of growth. An ensiling additive such as molasses should be mixed thoroughly with the green chopped Sudan as it goes into the silo. Liquid molasses at the rate of 80 pounds or ground barley at 125 to 150 pounds per ton of green material have given good results. Sodium metabisulfite at eight pounds per ton (use this material only in upright silos) or dehydrated molasses at 10 pounds per ton have also proven satisfactory.

Poisoning. Livestockmen in the northern United States have been concerned because of excessive prussic (hydrocyanic) acid content in Sudangrass which poisons animals. This seldom occurs in California or the southern states. A number of losses did occur in the Sacramento Valley on dryland Sudan in 1949.

High concentrations of prussic acid are more likely to occur in Sudan that is growing slowly because of either drought or frost. For this reason, early spring or late fall growth is more likely to cause trouble. Precautions for avoiding injury are:

1. Use only pure Sudan seed. (The sorghums and Johnsongrass contain higher concentrations of prussic acid

than Sudangrass.) Use low prussic acid potential varieties like Piper for dryland plantings.

2. Allow 18 to 24 inches of growth before grazing.

3. Graze drought or frost-injured Sudan cautiously.

4. Do not allow excessively hungry cattle to feed on Sudan pasture which is just recovering from a drought or frost.

5. If you suspect poisoning troubles, call your veterinarian promptly.

GROWING SEED

Where Grown? Roughly 80 per cent of the nation's Sudan seed supply is produced in California, Texas, and Colorado. Nebraska, Kansas, Oklahoma, New Mexico and Oregon contribute the remainder. The principal seed producing centers in California are in the northern San Joaquin Valley, Sacramento Valley, Mohave area of San Bernardino County, Hemet Valley in Riverside County, Imperial Valley, and in the coastal area of San Luis Obispo County.

Where Used, and Returns to Grower: Outside of 2½ to 4 million pounds required for local replacement each year, the bulk of California Sudan seed goes to the central, north central, and western states. The returns to producers for certified seed have varied from 4½ to 15 cents per pound. When Texas and Colorado Sudan seed-producing areas have sufficient spring moisture for planting, and timely summer rains, production is greatly increased nationally and usually results in lower prices for all types of Sudan seed.

Production: Prior to 1953, Sudan seed production in California varied between 6 and 12 million pounds annually; since 1953, it has increased rapidly to a high in 1955 of 37½ million pounds. This big increase has been the result of two important developments. First, as a result of research affecting seed yields, the average per acre yield has risen from 800 pounds to 1300 pounds. Second, there is great demand for new, improved Sudan varieties. Sudan seed production is becoming a specialized industry, and the most successful growers are those who regard seed production as the main objective of their operation, rather than as incidental to the production of hay or pasturage.

Six Factors Affecting Seed Production.

1. Use Foundation or Registered Seed. The California Crop Improvement Association requires the use of foundation or registered seed stock to qualify for certification. Consumer farmers demand certified Sudan seed to insure variety purity and protection against noxious weeds. Johnsongrass seed is a common contaminate in uncertified Sudan seed.

2. Be Sure of Isolation. Careful selection of land for seed production is important. It must be free of Johnsongrass and volunteer sorghum plants, and morning glory must be controlled. Seeds of these plants are almost impossible to separate from Sudan seed. Because Sudan, sorghum crops, Johnsongrass and other varieties of Sudan will cross-pollinate one another, resulting in off-type low quality seed, Sudan for seed production should be planted at least 660 ft. away from these other crops and weeds.

3. Plant Conditioning. For maximum production, it is necessary to have healthy plants making normal growth. Irrigation should be controlled to keep the plants growing continuously, and particularly to prevent stress from lack of moisture during flowering through the soft dough stages. Stands intended for seed production should be allowed to reach maturity without grazing or cutting back. This will permit harvesting before the hard winds usual in Sept. and Oct. and reduce losses from shattering.

4. Weeds. Control of weeds is important from three standpoints: First, weeds compete with Sudan plants for water and nutrients. Second, weed seeds contaminate the Sudan seed and may be difficult or impossible to remove, thus resulting in rejection for certification, or in considerable losses in clean-out. Third, certain weeds and crop plants cross-pollinate with Sudan and result in undesirable seed and rejection.

5. Plant Population. In dry-land seed producing areas, growers use both close-drilled and wide-spaced row plantings. There is little difference in seed yield in rows spaced 18 to 44 inches apart. The wide-spaced row plantings, however, usually produce more seed than broadcast or close-drilled stands. The amount of seed recommended for wide-spaced rows is three to six pounds and for broadcast or close-drilled seedings, 10 to 15 pounds per acre.

Under irrigation thick uniform stands produce the highest yields, uniform maturity, better weed control, easy curing, and least difficult harvesting. Best results have been obtained in close-drilled seedings, rows 6 to 8 inches apart, using 20 to 30 pounds of seed per acre. For 9- to 12-inch row spacings, 18 to 25 pounds of seed are used. The use of wider row spacings under irrigation is recommended only if planting stocks are in short supply.

6. When to Harvest. Because of the numerous tillers which head and mature considerably later than the primary stem, the ripening of the first head is not the signal for harvest. Begin swathing when 85 to 95 per cent of the tiller heads have matured through the early dough stage. In poor stands or wide-spaced row plantings, tillering is continuous and harvest time must be based on seasonal conditions or on the extent of shattering of older and over-ripe heads. The production period should range from 110 to 130 days from planting.

SEED HARVEST

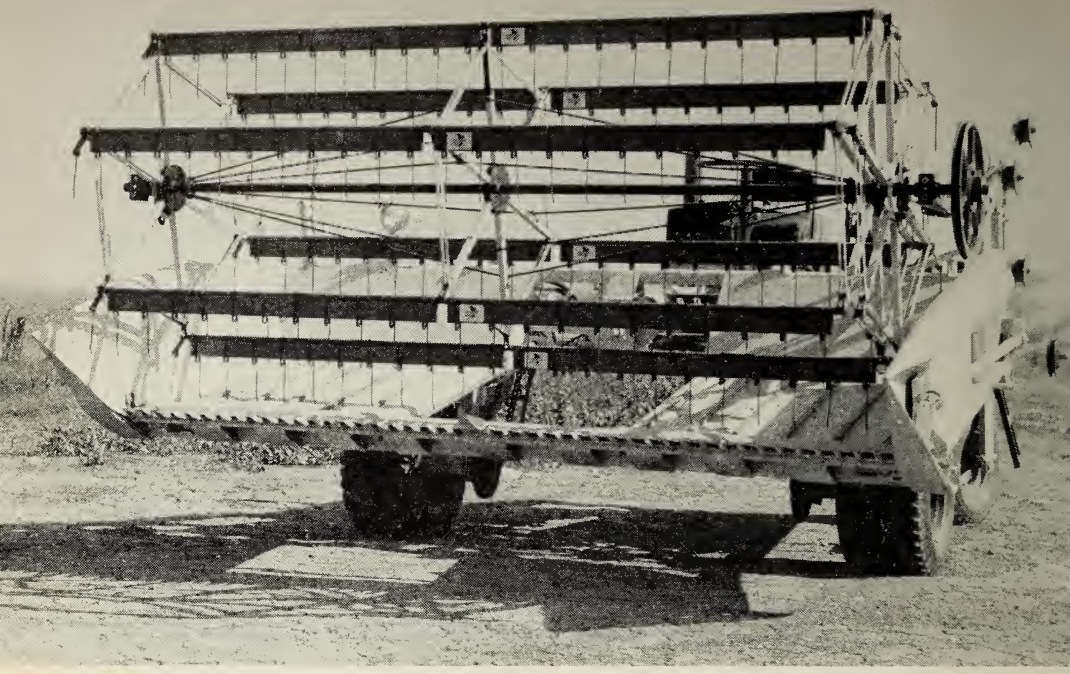
In harvesting Sudangrass seed, two separate management operations must be considered: pre-harvest preparation, or curing, and the actual threshing operation.

Curing. Almost all of the seed crop acreage is windrowed for curing. The cured windrows are threshed by combines equipped with windrow pickup attachments. In a few areas, located mostly in the San Joaquin Valley, recurrent growth can be controlled by withholding irrigation. Seed producers in these areas cure the seed crop by spraying with fortified oils, then direct combine the cured crop.

Swathing should begin when 85 to 95 per cent of the heads have matured through the early dough stage. Spray curing should not be done until 95 to 100 per cent of the heads have completely matured.

Windrowing. When the stand is heavy and recurrent growth cannot be controlled by withholding irrigation, the seed crop should be cured in windrows. A considerable amount of the immature seed that is placed in the windrow will be good seed when the windrow is threshed.

Windrow-swathers similar to that shown in the photo should be used to windrow a seed crop. Depending on the amount of growth, a 12-foot self-propelled swather can windrow 1.5 to 3 acres per hour. Usually swathing can be done during all hours of the day, and it is seldom necessary to stop the swathing operation because of excessive seed shatter. When windrowing a close-drilled stand, the swather bar should be set to leave a 12- to 18-inch stubble. Laying the windrow on this amount of stubble will hasten drying of the straw and green seed. With warm, dry fall weather, the crop can be threshed five to ten days after swathing. The windrowed seed crop is ready to thresh when immature seed can be



A custom made, self-propelled swather especially suited to windrowing a crop of Sudangrass seed. Note the opening in the center through which grass is delivered to windrows.

crushed without producing visible moisture.

Spray-Curing. Maturation sprays (spray-curing) are most effective in mature, open, and erect stands when recurrent growth has been practically stopped. The dinitro sprays of the Dow general or Sinox type, are used and applied by airplane at a rate of 1 to 3 pints in 10 to 15 gallons of weed oil per acre. For best results with one spray treatment, the application should be flown on in two passes of opposite direction at one-half the normal swath width. If a second spray treatment is necessary, it should be applied in the same manner as the first application.

The spray is effective in drying out the foliage, but usually fails to dry green seed enough for safe storage before direct combining must begin. All seed that is not in the hard dough stage when the spray is applied will eventually become light seed which is removed in the cleaning operation if threshed at all.

THRESHING

Proper threshing techniques can greatly increase the net income from the seed crop. Sudan seed is easily damaged and threshing losses can be high, but both seed damage and loss can be greatly reduced by careful machine adjustment and operation.

Harvesting Rate. With good harvesting conditions (a well cured crop in dry weather with uniform windrows or even stand), Table 1 lists forward speeds to give the proper range of feed rate into the combine.

Pick-up Attachment and Header Operation: Either the belt-type pick-up or the cylinder-type pick-up shown in the diagrams on pages 14 and 15 can be used when harvesting from the windrow. The proper arrangement between the back roller of the belt pick-up and front edge of the header is shown in the small inset. The block or cut-off bar shown at B in the same picture should be in good repair and is essential to prevent back-feeding

onto the ground at that point. Either type of pick-up should be ground driven, *i.e.*, from a ground wheel or from a shaft that has a constant relation with the forward speed of the combine. The belt speed of the belt pick-up should be 10 to 15 per cent faster than the forward speed of the combine. For the cylinder type pick-up a point on the fingers located directly above the finger shaft and level with the sheet metal apron should have a peripheral speed (see paragraph on cylinder and concave) that is also 10 to 15 per cent faster than the combine forward speed.

When the seed crop is direct-combined, the fixed-bat type of header reel should be used. If the crop should become partially lodged after spray-curing, the pick-up reel should be used to minimize header losses. In either case, the reel should be ground driven at a peripheral speed 25 to 50 per cent greater than the forward speed of the combine. The reel shaft should be positioned slightly ahead of the cutter bar and at a height such that the bats contact the straw just below the general zone of the seed heads.

Cylinder and Concave: After a field has passed examination for certification the most important steps in harvesting are the proper adjustments of the cylinder speed and the cylinder-concave clearance. Because Sudangrass seed is readily damaged by the combine threshing mechanism, the cylinder speed adjustment is very important, and the minimum cylinder-concave clearance adjustment is critical to assure harvesting seed that will not be rejected for certification because of low germination.

The rasp-bar cylinder has been exten-

Table 1. Suggested Harvesting Rates

Windrowed Sudan—recurrent growth not specifically controlled. Combining from 10-foot windrows with 12-foot combine.

	Dry Hay Yield	*Forward Speed*	*Harvesting Rate**
Light hay crop	1 to 1½ tons/acre	2.7 to 1.8 mph.	2.7 to 1.8 A/hr.
Medium hay crop	1½ to 2 tons/acre	1.8 to 1.4 mph.	1.8 to 1.4 A/hr.
Heavy hay crop	2 to 3 tons/acre	1.4 to 0.9 mph.	1.4 to 0.9 A/hr.
Spray-cured Sudan—recurrent growth specifically controlled. Direct combine with 12-foot combine.			
Light hay crop	¾ to 1 ton/acre	3.2 to 2.4 mph.	3.7 to 2.7 A/hr.
Medium hay crop	1 to 1½ tons/acre	2.4 to 1.6 mph.	2.7 to 1.8 A/hr.
Heavy hay crop	1½ to 2 tons/acre	1.6 to 1.25 mph.	1.8 to 1.4 A/hr.

* Includes reasonable lost time for turning, unloading grain tank, and minor machine stoppages.

The above table is based upon a feed rate of 70 to 100 pounds of straw and chaff per minute into the combine. To obtain this feed rate range for different windrow spacings or combine header widths, the forward speed of the machine will be slower when the cut is wider and, of course, faster with a narrower cut.

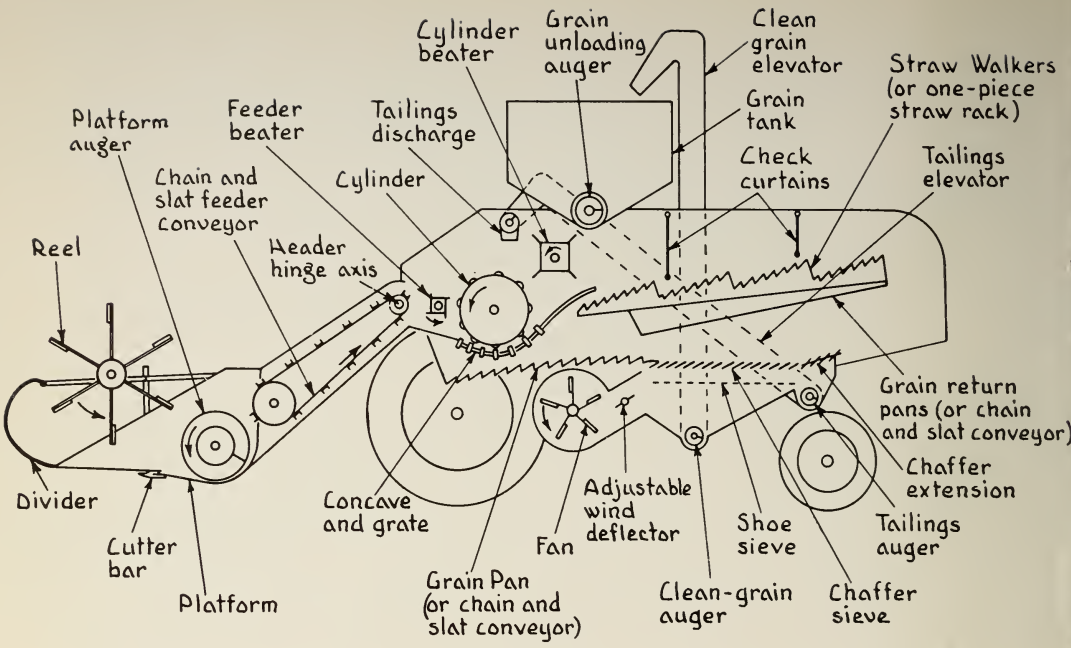
Example: Suppose the windrow spacing was 11 feet rather than 10 feet as given in the table; then for a heavy hay crop (3 tons/acre) the forward speed would be:

$$0.9 \text{ mph} \times \frac{10}{11} = 0.82 \text{ mph.}$$

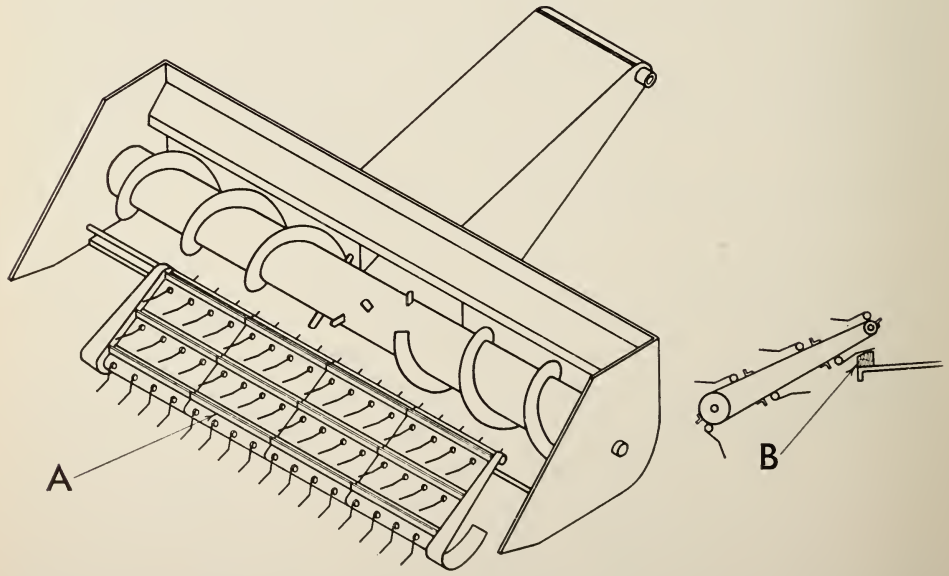
and the harvesting rate would be:

$$0.9 \text{ A/hr} \times \frac{10}{11} = 0.82 \text{ A/hr.}$$

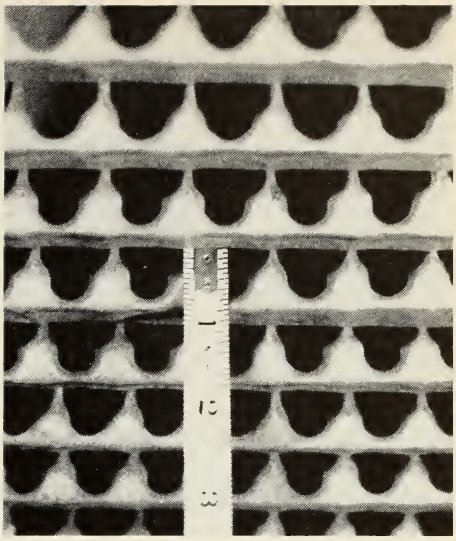
When the stand is uneven, the combine forward speed should be varied so that the amount of straw fed into the harvester remains about constant. When the engine is in good repair and the windrows are dry and uniform, the governor will seldom call for full throttle if the harvester is being operated at the proper forward speed.



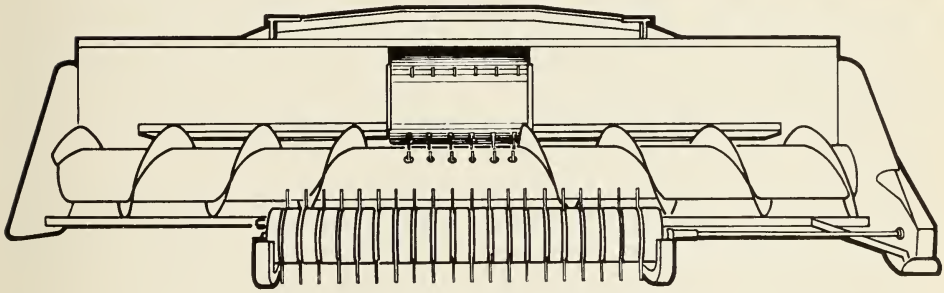
Cross section of a typical combine showing the various parts referred to in this publication.



Windrow pickup attachment, belt type. The metal cleats (A) reduce the loss of seed shattered during the pick-up operations. The block or cut-off bar (B) minimizes back-feeding onto the ground.



An adjustable type chaffer used in harvesting Sudangrass seed. Note method of measuring opening.



Windrow pick-up attachment, cylinder type.

sively field tested and found to harvest Sudangrass seed satisfactorily. The spike-tooth cylinder has been observed to perform equally well. The minimum clearance between the closest bars on the cylinder and concave should not be less than $\frac{5}{16}$ inch. If at any time before harvest the mature seed has been subjected to rain, the minimum clearance should be not less than $\frac{3}{8}$ of an inch. On some combines, it is possible to adjust the clearances at the front and rear of the concave. It will seldom be necessary to use more than a one-half inch clearance at the front. The concave grate should be open. Flax rolls are not necessary; if the machine is equipped with them, they need not be removed but merely opened enough to not cause feeding stoppages. When the spike-tooth cylinder is used, no less than the equivalent of four full rows of teeth should be used in the concave. The lateral clearances between concave and cylinder teeth must be equal on both sides of the concave teeth. The amount of overlap between cylinder and concave teeth will depend on threshing conditions; in any case, do not raise the concave beyond the point where less than $\frac{3}{8}$ inch clearance remains between the end of the cylinder teeth and face of the concave. Bent or broken cylinder and concave teeth should be replaced immediately upon discovery.

The cylinder speed adjustment is made on the basis of peripheral speed. (Periph-

eral speed is the linear speed of the tip of a spike or the threshing surface on the bar of the cylinder.) The two equations for peripheral speed in feet per minute (fpm) and the cylinder speed in revolutions per minute (RPM) are:

1. Cylinder peripheral speed (fpm) = 3.14 × cylinder diameter in feet × cylinder rpm.

2. Cylinder RPM = $\frac{\text{cylinder peripheral speed (fpm)}}{3.14 \times \text{cylinder diameter in feet}}$

Recommended cylinder speeds for either windrowed or spray-cured Sudangrass seed crops are 3300 to 3700 feet per minute. Use the lower speeds whenever possible especially when the seed has received some rainfall. Revolutions per minute required for various peripheral speeds and cylinder diameters are given in Table 2. Cylinder speed should never be adjusted by changing the engine governor setting. The governor should be adjusted to give the combine reference shaft speed recommended by the operator's manual; then the desired speed is obtained by proper selection of sprockets or adjustment of sheave pitch diameters.

The amount of hulled seed in the grain tank should be kept under 5 per cent. The amount of seed that is hulled can often be reduced by opening the clean grain screen slightly to reduce the amount of seed returned to the cylinder by the tailings return elevator. If this cannot be done without putting too much straw in the grain tank and sufficient wind is being used on the shoe screens, then the cylinder speed should be decreased. If no more than 10 per cent of the harvested seed has sustained visible mechanical damage (hulled seed and seed that has the seed coat broken or one end knocked off), the grower can expect his seed to germinate 85 per cent or better after cleaning.

Straw Walker or Rack: The straw walker or rack should always be operated at the speed recommended by the manufacturer. When each grain tank of seed is emptied, the straw carrier should be checked for plugging with straw and the walker curtain (or curtains) examined to see that it is not torn and is in the down position. If the walker curtain is slightly torn or partially missing, it should be immediately replaced. Operating straw carriers at speeds varying more than 10 per cent from the recommended speed, plugging with straw, or a curtain that is in poor condition or not in the down position can all result in excessive threshed seed loss over the straw rack or walkers.

Cleaning Shoe: The adjustable-lip, riffle, and Peterson chaffers can all do a good job of separation. The Peterson and riffle chaffers will generally give the cleanest seed in the grain tank. If the adjustable lip chaffer is used, it should be set with an opening of about ½ inch. The

Table 2. Revolutions per Minute Required for Various Peripheral Speeds and Cylinder Diameters

Cylinder Diameter Inches	*RPM to give 3300 fpm*	*RPM to give 3500 fpm*	*RPM to give 3700 fpm*
15	840	891	942
19	662	702	742
20	630	668	706
22	*573*	608	643

Example: Say we have a 22-inch cylinder and want to start harvesting with a cylinder speed of 3300 fpm—this means that the cylinder RPM is 573 as indicated by the italicized figures in Table 2.

For safety's sake...

There are a few precautions to observe as protection for yourself and your machine:

1. Check all safety clutches to be sure they are operating properly before going to the field. Make sure they will slip if there is trouble, but will not slip in normal operation.
2. Keep all shields and guards in place. If they are removed for repairs or adjustments, replace them before starting the machine again.
3. Remove all loose tools and parts from the machine before starting.
4. Never fill the gasoline tank while the engine is running. Gasoline spilled on a hot manifold can result in a disastrous fire.
5. Keep hands and clothing away from moving parts. Always stop the machine when making repairs or adjustments.
6. Place a fire extinguisher on the combine so the operator has easy access to it.

Peterson chaffer should be operated with a slightly larger opening, about $\frac{5}{8}$ of an inch (see picture page 15). The adjustable lip clean grain sieve is normally used with an opening of about $\frac{1}{4}$ inch. The opening should be adjusted so that short pieces of straw in the grain tank and threshed seed in the tailings return are at a minimum. A large amount of threshed seed in the tailings return generally results in excessive mechanically damaged seed.

The cleaning shoe fan speed should be set near the low end of the speed range if it is adjustable. Air blast deflectors should direct most of the wind onto the front part of the shoe sieves. The chaffer extension should be set in the level position with an opening of about $\frac{5}{8}$ inch if the extension is the adjustable type. The amount of short, broken straw in the grain tank is generally high when the finger-type chaffer extension is used.

The wind should be adjusted by starting with an excess amount, then gradually decreasing it by closing the fan shutters until a minimum amount of threshed seed is lost over the shoe. When the wind is properly adjusted, there should be only an occasional seed in the air stream above the chaffer sieve, and the loss of threshed seed riding over the chaffer sieve with the chaff should be at a minimum.

Harvesting Losses and Their Determination: When the combine is operated in the recommended feed rate range, the total seed loss from the rear of the harvester should range from 3 to 5 per cent of the seed taken into the combine (about one-half of this loss is good seed when put on a clean seed basis). About three-quarters of the lost seed will be on unthreshed heads. There should be negligible seed loss by the pick-up attachment. Header reel losses for a direct combining operation should not exceed 3 per cent if the reel adjustment recommendations are followed.

To determine the loss of threshed seed over the shoe or straw carrier, use a No. 10 by $\frac{3}{4}$ inch slotted seed dockage pan placed on top of a blank dockage pan, and hold in the area where chaff is discharged from the shoe, in the air stream above the shoe, or where straw is discharged from the straw carrier. The dockage pans should be given a rather vigorous motion similar to that of the shoe and held in position for five paces (15 feet). Check each side and the center of the shoe, air stream and straw carrier.

Estimate the number of good threshed seeds collected for each of the three positions and take the sum to get the number of seeds lost at each place that material is discharged. When harvesting from windrows with an average spacing of 10 feet, each 100 seeds collected in the sample pan over a distance of 15 feet amounts to about one-half pound per acre.

Overloading the combine will cause large amounts of threshed seed to ride out with the chaff and straw. If reducing the combine forward speed does not decrease the amount of threshed seed riding out with the straw, then the walker speed, curtain, and openings should be checked. With the shoe screens and wind adjusted as recommended herein, excessive loss of threshed seed in the chaff from the shoe is generally the result of overloading the combine. The combine shell and elevator housings should be periodically inspected for seed leakage.

Lubrication-Maintenance-Safety. The best recommendations for lubrication and maintenance are in the operator's manual which comes with each new harvester. If you don't have a manual, ask your dealer for another copy, so that you can follow the lubrication chart or table that it contains. Keep the operator's manual in a handy place.

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