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SUDAN GRASS

BY

B. A. MADSON AND P. B. KENNEDY

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* Died February 12, 1917.

† In co-operation with office of Public Roads and Rural Engineering, U. S. Department of Agriculture.

SUDAN GRASS*

By B. A. MADSON and P. B. KENNEDY

CONTENTS

* The Sudan grass experiments were carried on in cooperation with the office of Forage Crop Investigations of the United States Department of Agriculture.

SUMMARY

1. Sudan grass was obtained by the United States Department of Agriculture from Sudan, Egypt, 1909.
2. It is closely related to the cultivated sorghums and like them is an annual.
3. In general appearance it resembles Johnson grass but lacks entirely the underground rootstocks that make Johnson grass a pest.
4. Two or three cuttings of hay can be obtained from it under favorable conditions.
5. The yield varies from one to eight tons of cured hay per acre, dependent on the length of the frostless season, the temperature, altitude, soil and amount of available moisture, either by natural precipitation or by irrigation.
6. It will grow in a wide range of soils from sand to clay, but prefers a rich, well-drained, sandy loam.
7. The seed may be sown broadcast, drilled or in cultivated rows after all danger from frost is past, and the soil has become thoroughly warm.
8. It has been grown to a greater or less extent in almost every county of the state.
9. After seeding it takes from 75 to 80 days to secure the first cutting, about 45 days more for the second cutting, and 50 days more for the third.
10. The hay is palatable to all classes of stock as it is sweet like the sweet sorghums.
11. It is probably as nutritious as the grass and cereal hays, but cannot compete with alfalfa in this respect.
12. A seed crop can be produced in from 95 to 100 days with an average yield of between 600 and 800 pounds per acre.
13. Sudan grass is not an ideal pasture plant as in light soils the plants are apt to be pulled while being grazed.
14. As in the case of the sorghums, prussic acid (hydrocyanic acid) may develop in the leaves under unfavorable conditions and cause stock poisoning. Up to the present time, however, little trouble of this nature has been reported, although Sudan grass has been pastured to a considerable extent.
15. Sudan grass is good to look at, easy to grow and handle, grows during the summer, gives large yields, and is well liked by stock.

INTRODUCTION

Sudan grass is one of the most important forage crops introduced into the United States in the last twenty years. Its introduction dates back to 1909, when C. V. Piper, in charge of forage crop investigations for the United States Department of Agriculture, secured a half pound of seed from R. Hewison, Director of Agriculture, Khartum, Egypt. It is cultivated there under the name of "garawi" and is probably a native of northern Africa. Piper says that there are strong reasons for believing this plant to be the wild original form of the cultivated sorghums with which it readily crosses wherever

the two are planted near each other. We have had sent to us a number of plants secured from seed of Sudan grass grown in close proximity to shallu, sometimes known as Arabian corn or Egyptian wheat, one of the sorghums. The plants had crossed one with the other so that nine distinct types could be recognized. In general appearance Sudan grass and Johnson grass resemble each other very closely, but the former is an annual and easily eradicated, while the latter is a perennial with underground rootstocks which are extremely difficult to kill by ordinary cultivation. Any portion of these rootstocks when separated from the parent plant, even if only an inch or so in length, is capable of producing new plants. They are also quite succulent and lose their moisture very slowly so that it is difficult to kill them even by exposure to drouth.

The leafage of Sudan grass and Johnson grass looks practically the some. Sudan grass in poor soil with insufficient moisture will rarely exceed three feet in height, while under ordinary conditions it averages five feet, or with very favorable conditions as high as ten feet. When sown thickly the stems are usually short and fine, about as thick as a lead pencil, but if grown in rows and cultivated, are taller with thicker stems.

The flowering parts are in the form of a loose panicle, or head, at the ends of the stems and closely resemble Johnson grass. The hulls are awned and often purplish in color. Commercial seed rarely has any awns as they are broken off in threshing. As many as one hundred stems may be produced from a single plant, but twenty-five is the usual number. The stems are quite leafy and remain firmly attached, both good points in a hay plant. Although the stems are coarse, this seems to be no objection as stock eat them quite readily.

Sudan grass is a heavy feeder, as would be expected from the large tonnage secured in a season. For this reason it would not be advisable even on rich soils to attempt to grow it on the same soil in two succeeding years. Unlike legumes, it is dependent solely on the soil for its source of nitrogen. Wherever possible it should be rotated with a leguminous crop, such as Canada field peas, with irrigation in the counties with cold winters; vetches, lima beans, common beans or horse beans in the coastal region of mild winters, and cowpeas, soy beans or garbanzos, as a summer crop in the southern interior counties where irrigation can be practiced.

The ideal way to grow Sudan grass would be with a legume as a mixture. This would have a tendency to maintain the fertility of the soil and to increase the protein content of the hay, making a well-balanced mixture of exceptional feeding value. On lands not subject

to irrigation there are not many suitable legumes that have the same drouth-resistant qualities to enable them to be grown as summer crops. The two most likely ones are the chick pea or garbanzo (*Cicer arietinum*) and the tepary bean.

With irrigation, cowpeas or soy beans have been grown successfully with both Sudan grass and the sorghums. The black-eye bean, which is a cowpea, can be grown in many of the warmer coast and interior valleys of California and would be the most likely to succeed in conjunction with Sudan grass as a mixture under irrigation.

ADAPTATION

Climatic Requirements.—Sudan grass is adapted to the same general climatic conditions as the other members of the sorghum family. It seems to prefer a warm climate of relatively low humidity and like the other sorghums it is very susceptible to frost so that its growing season is limited to the warmer months of the year. From observations made in various sections of the state, the conditions in California as a whole appear to be favorable to its growth. Good results have been obtained with the crop, not only in the large interior valleys, but also in the valleys adjacent to the coast as well as in the smaller mountainous valleys located at elevations of from three thousand to four thousand feet. There are certain locations in the mountain valleys that are not subject to killing frosts owing to air currents which cause atmospheric drainage, while in the immediate vicinitiy lands not so situated may be subject to frosts every month during the spring and summer. This accounts for the apparent contradiction in the ability of Sudan grass to succeed in some of the northern counties. In some instances good crops are produced, while in others it is a complete failure. Apparently, however, it does not do as well on the agricultural lands subject to the cold, damp ocean breezes, as in the more protected valleys of the interior. While conclusive information is lacking, it is just probable, judging from results obtained in other states, that the plant is but poorly adapted to altitudes above five thousand feet.

In the interior valleys, where the growing season is from six to seven months in length, three and occasionally four cuttings of hay can be obtained. The first cutting requires from sixty to eighty days to mature, depending upon the season and soil conditions and upon the time of planting, while the later cuttings reach maturity in from forty-five to fifty-five days.

In the mountain valleys or at high elevations, the growing season is usually relatively short so that ordinarily only one or two cuttings

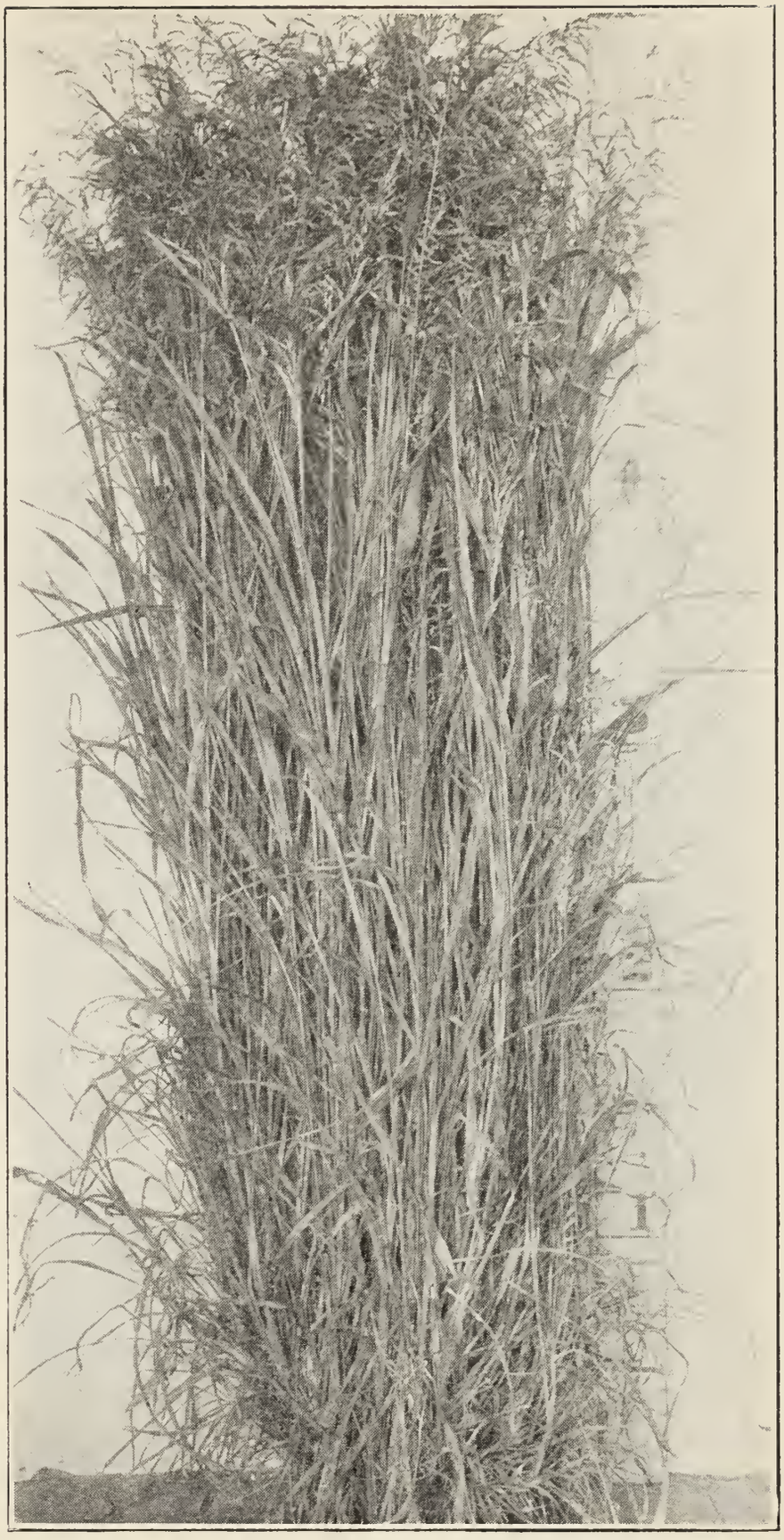

Fig. 1.—A single plant of Sudan grass produces many stems. They are leafy throughout their entire length.

of hay will be obtained. Obviously the total yield per season will not be as large as in the more favored sections.

Soil Requirements.—From the general observations made throughout the state, Sudan grass does not appear to be at all exacting in its soil requirements. Favorable results have been obtained with the crop in many sections representing a variety of soil types and conditions. Like the other sorghums, however, it does best on a rich, well-drained loam. Exceedingly heavy soils are apt to be cold and damp and of poor physical condition, necessitating somewhat later planting, and in many cases producing a rather stunted growth. On extremely sandy soil, the growth of the crop is usually somewhat lighter than on the more favorable soil types, probably due to low fertility, lack of moisture, or poor physical condition. On most soil types, however, the growth of Sudan grass will ordinarily compare quite favorably with that of almost any other forage crop grown under similar conditions. No actual tests have been made by this station to determine to what extent Sudan grass will succeed on soils containing alkali, nor do we find any records in the literature. We have every reason to believe, however, that as in the case of the sorghums small amounts of white alkali will not be injurious.

Drouth Resistance.—Perhaps the most important character of Sudan grass and the one which will be of greatest value in stimulating the use of the crop for hay purposes, is its resistance to drouth. This character is possessed to a marked degree by all members of the sorghum family, but is probably more pronounced in the Sudan grass than in any of the other types. This was strikingly illustrated by the performance of the crop on the University Farm at Davis in 1913, which was an exceedingly dry year, the total precipitation amounting to only 8.84 inches. The grass was seeded on land which had been cropped to cereals the previous season and under these conditions produced an average yield of 3554 pounds of hay to the acre. Regarding the ability of Sudan grass to continue growth throughout the drier portions of the season, it is worthy of note that under the conditions mentioned, the average yield of the first cutting was only 937 pounds of hay per acre, while the second cutting gave an average yield of 1834 pounds per acre. The yield of the third cutting was slightly less than that of the first. Apparently this plant has a remarkable ability to make use of the limited soil moisture after its shallow but extensive root system has become fully developed. In all probability there are but few localities in the state where the rainfall is insufficient to produce a fair growth. Sudan grass is in fact one of the few plants which will maintain growth throughout the

season under arid conditions. Obviously, however, the yields obtained will normally be in direct ratio to the moisture available, so that, for the best results, rigid conservation of the moisture supply should be practiced.

The most critical period in the growth of the Sudan grass seems to be while the plants are quite small or during the seedling stage. If the supply of water at the time of seeding is insufficient for prompt germination, or for the maintenance of normal growth until the plants are well established, permanent injury will result. This was clearly shown by the failure of the crop on the unirrigated Agronomy experimental plots in 1916. In the absence of spring rains after the first of March the soil dried out rapidly so that the moisture supply to a depth of six to eight inches was inadequate for rapid germination when the crop was seeded in April. As a consequence most of the seed failed to germinate, while the few plants which did appear were weak and spindling and soon perished. On a few spots in the plots where the soil had retained its moisture better, a fair stand was obtained, and the growth throughout the season was apparently normal. This would seem to indicate that after the plants have become well established they are able to hold their own under trying conditions.

Sudan Grass as an Irrigated Crop.—To what extent Sudan grass may become of importance as an irrigated crop is still a question, as on good, well-drained soils it must compete with alfala. While yields may be obtained which will compare favorably with or even exceed those of alfalfa, the total feed value per unit area will usually be considerably lower. Furthermore, because of the beneficial effect of the alfalfa on the soil, it is much to be preferred in any rotation system. On the other hand, Sudan grass being an annual may often be employed with profit as an emergency forage crop, and yet not interfere seriously with the general farming scheme. Alfalfa is more of a permanent crop requiring at least a year to reach its maximum productivity and is, therefore, not so applicable to the short rotation. Again, when the supply of water is limited, Sudan grass will produce much larger yields than will alfalfa under the same conditions.

It frequently happens that alfalfa yields, due to over-pasturing or the encroachments of weeds, or other causes, have become too low to be profitable. In the preparation of the land for reseeding to alfalfa no better crop could be utilized than Sudan grass, as there would be little loss in tonnage, the land would be benefited by the change and the weeds discouraged, leaving a good seed bed for fall or spring seeding of alfalfa.

There are large areas of land in California which could be utilized for alfalfa, but for the overflow from the rivers in winter and early spring. These lands are sufficiently drained by the time for seeding Sudan grass. In such localities large crops of hay can be produced.

During the season of 1913 and 1914, Sudan grass was grown at the University Farm both with and without irrigation. In 1913 the unirrigated plots gave an average yield of 1.8 tons of hay to the acre, while the irrigated plot yielded 3.9 tons per acre. In 1914 the average yield of the dry plots was six tons per acre, and of the irrigated plots 7.6 tons per acre. In neither case did the crop obtain the optimum amounts of water as only one light irrigation per cutting was applied. During the latter season the average yield of well established alfalfa was seven tons per acre, though this crop received considerably more water than did the Sudan grass.

CULTURE

Preparation of the Seed Bed.—The seeds of Sudan grass are rather small so that a well-prepared seed bed is necessary to insure prompt germination and a good stand. In most sections of California the best results will probably be obtained by plowing the land rather deep in the fall or early winter, and allowing it to lie in the rough state throughout the rainy season. In this condition, the absorption of the winter precipitation will be greatly facilitated, at the same time assuring a sufficient packing of the soil for a good seed bed.

If the field is reasonably free from weeds the seed bed may then be prepared with a disc and a harrow. If, however, the weed growth is rather heavy a shallow plowing early in the spring may be necessary before a good seed bed can be secured.

In some instances spring plowing has been recommended for crops of this character on the ground that the spring-plowed land warmed up somewhat more quickly, making earlier seeding possible. While definite information along this line is wanting, the fact that the soils in this state are subjected to rather cold rains during the month of March, makes this effect seem rather doubtful.

When the land has been plowed in the spring, as may sometimes be necessary, more labor is usually required to get the soil worked down into a good seed bed than when the land has been fall-plowed, since the rain falling upon the land at this season of the year is seldom sufficient to pack the soil properly. The bottom of the seed bed must be rather firm and compact in order to establish proper capillary connection with the soil beneath, as well as to provide a rather firm base on which to plant the seed. Only the surface two or three inches

of soil should be loose and finely pulverized, which is sufficient to check evaporation and provide the necessary aeration for the germination of the seed.

Seeding Sudan Grass.—Sudan grass is a new crop in this country and differs materially from any of the better known crops in its adaptation and manner of growth. For this reason, no precedent is available to guide the grower as to the most efficient means of handling the crop except such general knowledge as might apply to the plant family as a whole. To secure definite information as to the best time, rate and method of seeding, both with and without irrigation, experiments were undertaken at Davis in 1913. While this work has been

Fig. 2.—Sudan grass grows so tall and thick that weeds have no chance to grow.

in progress but three years, some rather striking results have been obtained.

Time of Seeding.—Inasmuch as Sudan grass is a warm-weather plant it should not be seeded until all danger of frost is past or until the soil has become thoroughly warm. If the seed is planted in soil that is too cold the germination is apt to be low, resulting in a poor stand. Then, too, the cold soil or atmospheric conditions encountered by too early seeding may materially stunt the early growth of the plants from which they will be rather slow to recover. The best time of seeding, however, will necessarily vary with the location and to some extent with the type and character of the soil. The results of tests conducted at the University Farm at Davis during the past three seasons to determine the effect of time of seeding Sudan grass for hay production are given in Table I.

TABLE I

DATE OF SEEDING

Date seeded	Yield of hay per acre, pounds — Dry: First cutting	Second cutting	Third cutting	Total for season	Irrigated: First cutting	Second cutting	Third cutting	Total for season
			1914					
Mar. 20	2,485.2	2,844.9	1,733.1	7,063.2	2,560	4,848	2,660	10,060
Apr. 15	6,114.9	2,943.0	2,844.9	11,902.8	7,080	4,400	3,440	14,920
May 1	1,275.3	3,646.0	.....	4,921.3	2,440	5,300	.....	7,740
May 15	2,861.2	4,888.6	.....	7,749.8	4,560	4,980	.....	9,540
June 1	1,635.0	2,011.0	.....	3,646.0	2,900	3,900	.....	6,800
			1915					
Mar. 17	3,561.6	6,025.0	4,569.8	14,156.3	.....	.....	.....	.....
Apr. 6	4,120.2	4,594.3	4,095.7	12,810.2	.....	.....	.....	.....
Apr. 20	4,169.2	5,320.1	2,681.4	12,170.7	.....	.....	.....	.....
May 3	6,556.3	5,559.0	1,765.8	13,881.1	.....	.....	.....	.....
May 18	6,425.5	5,714.3	.....	12,139.8	.....	.....	.....	.....
June 1	4,332.7	4,839.6	.....	9,172.3	.....	.....	.....	.....
			1916					
Mar. 17	.....	.....	.....	.....	540	5,000	6,950	12,490
Apr. 6	.....	.....	.....	.....	6,110	6,480	.....	12,590
Apr. 17	.....	.....	.....	.....	5,290	7,010	.....	12,300
May 1	.....	.....	.....	.....	5,820	5,910	.....	11,730
May 15	.....	.....	.....	.....	4,170	6,350	.....	10,520

On the whole, the highest yields were obtained from the April planting regardless of whether the plot was dry or irrigated. While in 1915 the highest yield was obtained from the earliest seeded plot, attention must be called to the fact that the season was quite favorable for growth during the latter part of March and the first of April, while the latter part of April to the middle of May was very cold and wet and on the whole unfavorable for growth.

Plantings made later than May 3 produced only two full cuttings of hay during the season as compared with three cuttings from the earlier seeded plots. While some growth was obtained after the second cutting, it failed to make enough growth for a hay crop before it was killed by the early fall frosts.

The low yield for 1914 from the plot seeded June 1 is due primarily to a poor stand. In 1915 better results were obtained as the soil contained more moisture at that date than the preceding year, due to the late spring rains. The stand, however, was not as good as that obtained on the earlier seedings. On the irrigated plot planted June 1, 1914, had the water been applied before seeding instead of after the plants were up, the stand as well as the yield would, in all prob-

ability, have been greatly improved. In 1916 the soil was so dry the latter part of March that the stand obtained, even on the early seeded plot, was very poor. The later plantings were irrigated immediately after seeding and much better results were obtained.

While in this experiment the latest seeding was made June 1, it has been observed that when the land can be irrigated before seeding, good crops of hay may be obtained in some localities by seeding as late as the first of August. On the whole, however, where the land can not be irrigated and when the maximum yield of hay is desired, it is advisable to seed as early as soil and climatic conditions will permit. By seeding comparatively early, the root systems of the plants become thoroughly established while the moisture supply is still abundant, thus enabling them to make a better growth throughout the drier portion of the year.

Method of Seeding.—For hay purposes Sudan grass may be seeded either in cultivated rows or in close drills. The latter method will probably meet with the greatest favor, especially when the supply of moisture is fairly abundant, as practically no attention is necessary after the crop has been seeded. When put in in this way the ordinary grain drill may be used for seeding the crop as almost any good implement can be set to seed as low as twelve to fifteen pounds to the acre.

In the drier sections better results will often be obtained by seeding in cultivated rows eighteen inches or more apart. This method provides the individual plants with a greater area from which to receive sufficient moisture to enable them to develop normally, and at the same time permits of the necessary cultivation for the conservation of the moisture. A considerable saving of seed is also effected, which may be an important consideration when the price of the seed is high.

For planting the crop in rows the ordinary grain drill may be used by stopping up enough of the holes to give the proper spacing. Fair results have also been reported by using a corn planter provided with special plates for dropping the seed.

Experiments to determine the effect of various methods of seeding on the relative yield of hay have been conducted on the University Farm during the seasons of 1913, 1914, 1915, and 1916. The results obtained are given in Table II.

While the results given in this table show considerable variation and are not readily comparable, the yield on the dry plots, for the past two seasons at least, was decidedly in favor of the eighteen-inch rows. In 1913, which was an exceedingly dry season, the difference in

TABLE II

METHOD OF SEEDING

Method for seeding	Yield of hay per acre, pounds: Dry — First cutting	Second cutting	Third cutting	Total for season	Irrigated — First cutting	Second cutting	Third cutting	Total for season
Drilled, 24 lbs.			1913					
per acre....	1,780	2,320	1,040	5,140*	4,710	2,380	1,920	9,010
18-inch rows	840	2,000	880	3,720	4,040	2,940	1,600	8,580
44-inch rows	1,100	1,840	800	3,740	1,460	4,680	880	7,020
* Received a partial irrigation early in the season by mistake.								
Drilled, 20 lbs.			1914					
per acre....	4,578.0	3,213.6	2,436.1	10,227.7	7,520	3,600	3,740	14,860
18-inch rows	7,390.2	4,202.0	2,812.2	14,404.4	6,600	6,600	4,820	18,020
36-inch rows	4,490.2	2,335.4	2,926.6	10,709.2	4,560	6,240	7,300	18,100
Drilled, 25 lbs.			1915					
per acre....	3,016.6	3,482.5	1,986.5	8,485.6	.....	.....	.....	.....
18-inch rows	3,008.4	3,964.9	1,765.8	8,739.1	.....	.....	.....	.....
36-inch rows	2,321.7	3,474.4	1,888.4	7,684.5	.....	.....	.....	.....
Drilled, 20 lbs.			1916					
per acre....	.....	.....	.....	.....	4,800	8,210	.....	13,010
18-inch rows	.....	.....	.....	.....	5,060	7,280	.....	12,340
36-inch rows	.....	.....	.....	.....	2,820	6,460	.....	9,280

yield between the eighteen-inch rows and the forty-four-inch rows was very slight. This would seem to indicate that when the supply of moisture is fairly abundant the highest production could be obtained by planting in rather narrow rows, while under drier conditions, at least equally as good yields would be obtained from the wider rows.

On the irrigated plots it is of interest to note that in 1913 and 1916 the yield decreased from the drill plots to the thirty-six and forty-four-inch row plots, while in 1914, both the row plantings decidedly outyielded the drill plot. During this latter season, however, the difference between the two row-plantings was too slight to be significant. It is quite probable that further experience will show that when the crop can be properly irrigated, the method of planting will have far less effect upon the yield than when it is grown as a dry land crop.

It has been stated that in some sections the hay produced from row plantings was somewhat coarser in quality than that grown in close drills. In the experiments at Davis, the difference in this respect was not as great as might have been expected, especially where the conditions for growth on the close-drilled plats were good. In

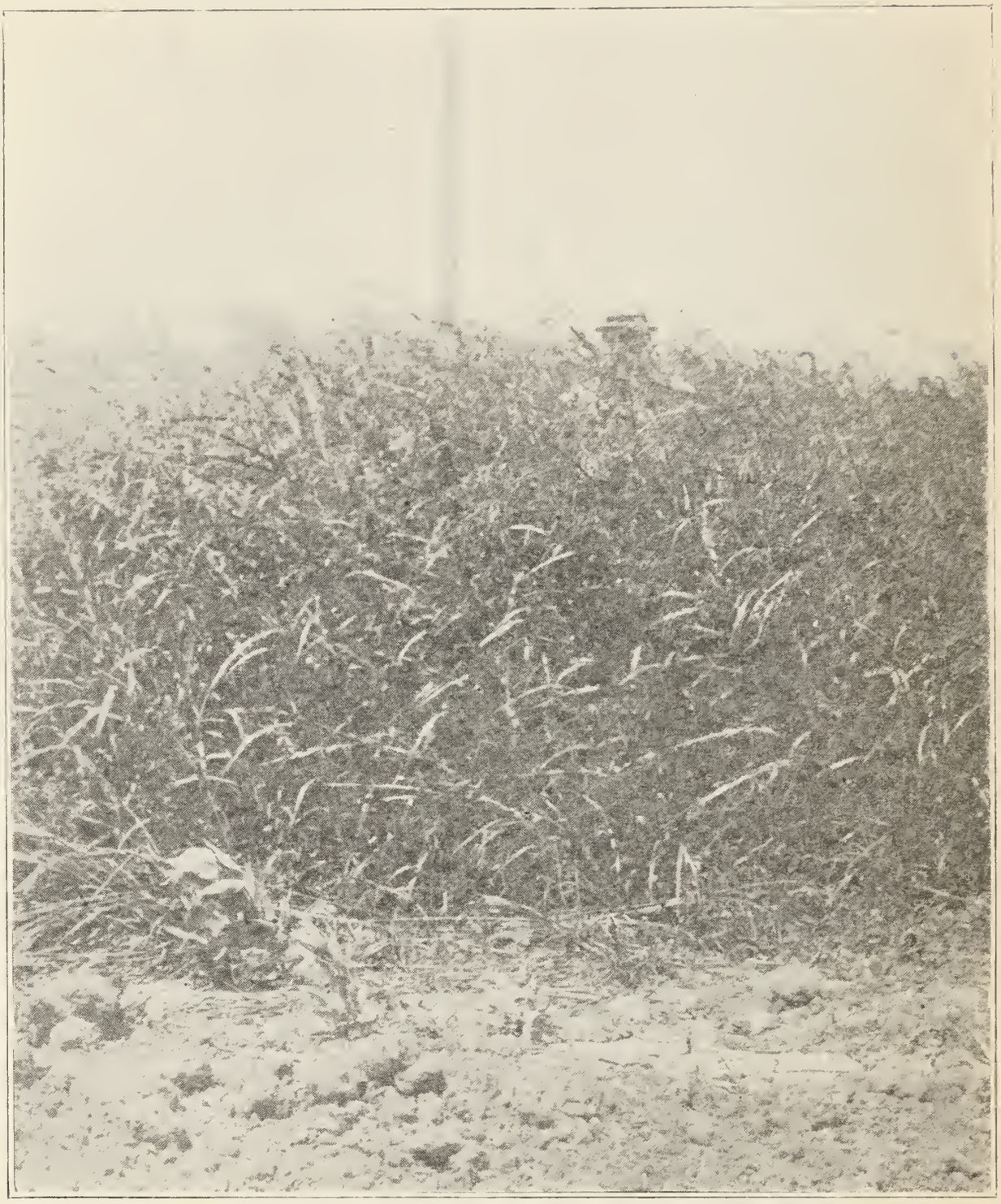

Fig. 3.—Under irrigation Sudan grass produces a rank growth. If cut at the proper time the hay is tender and palatable.

all cases, however, the plants stooled much more in the rows than in the close drills.

Rate of Seeding.—The proper rate of seeding Sudan grass will doubtless vary somewhat with the local soil and climatic conditions. It does not appear, however, that the rate of seeding bears as direct a relation to the moisture supply as does the method of seeding. Because of the free stooling character of the plant, the actual yield will be less affected by the rate of seeding than with most other annual crops. However, the excessive stooling which takes place when the stand is thin, may lower the quality of the hay owing to the wide range in time of maturity of the various parts of the plant. If the crop is harvested when the main portion of the plant is at the proper stage, many of the later suckers will be quite immature, while if harvesting is delayed until all suckers are fully headed, the central stem will become coarse and less palatable.

TABLE III

RATE OF SEEDING

Rate seeded per acre, pounds	Yield of hay per acre, pounds							
	Dry				Irrigated			
	First cutting	Second cutting	Third cutting	Total for season	First cutting	Second cutting	Third cutting	Total for season
	1913							
15	780	1,680	660	3,160	2,870	3,110	1,040	7,020
20	630	1,530	480	2,640	2,960	3,630	1,080	7,670
30	780	1,820	720	3,320	.....	.....	.....	.....
40	650	1,650	900	3,200	.....	.....	.....	.....
	1914							
10	5,460.9	4,937.7	3,580.6	13,979.2	5,640	8,540	5,000	19,180
15	6,180.3	4,643.4	3,041.0	13,864.8	6,480	6,100	2,820	15,400
20	6,180.3	3,335.4	2,828.5	12,344.2	6,680	4,320	2,960	13,760
25	5,657.1	3,417.1	2,583.3	11,657.5	4,800	4,560	2,960	12,320
35	6,861.0	4,447.2	2,926.6	14,240.8	7,320	5,020	4,160	15,500
	1915							
10	4,251.0	6,360.1	4,684.3	15,295.4	.....	.....	.....	.....
15	4,406.3	5,951.4	4,177.4	14,535.1	.....	.....	.....	.....
20	4,240.9	5,215.6	3,932.2	13,388.7	.....	.....	.....	.....
25	4,937.7	4,005.7	1,847.6	10,791.0	.....	.....	.....	.....
35	4,136.5	4,316.4	1,602.3	10,055.2	.....	.....	.....	.....
	1916							
10	.....	.....	.....	.....	5,140	7,770	.....	12,910
15	.....	.....	.....	.....	5,820	5,740	.....	11,560
20	.....	.....	.....	.....	6,570	8,790	.....	15,360
25	.....	.....	.....	.....	5,380	5,880	.....	11,260
35	.....	.....	.....	.....	4,340	4,810	.....	9,150

Results of tests conducted at Davis during the seasons of 1913–1916, inclusive, to determine the effect of various rates of seeding on the yield of hay are given in Table III.

The results for the four years taken as a whole are quite variable. In 1913, the highest yield was obtained by seeding thirty pounds per acre, while the next higher yield was obtained when the rate of seeding was forty pounds. In 1914, the yield decreased with an increase in the rate of seeding from ten to twenty-five pounds per acre both under dry culture and with irrigation. On the dry plats the thirty-five-pound seeding produced the highest total yield, though the difference between the yield on this plat and the one seeded at the rate of ten pounds per acre was not sufficient to warrant the use of the larger amount of seed. In 1915, the total yield decreased very rapidly with an increase in the rate of seeding. In 1916, on the other hand, seeding at the rate of twenty pounds per acre gave the best results, with the ten-pound seeding second. In the remaining cases the yield decreased with an increase in the amount of seed used. Apparently the most productive seeding rate where the crop is seeded in close drills and the conditions for growth are good is from ten to fifteen pounds per acre.

Cultivation.—When Sudan grass has been seeded in close drills, cultivation will seldom be necessary after the crop has been seeded, though if the soil becomes encrusted before the plants appear, or while they are still quite young, a light harrowing may be desirable. On the other hand, when the crop is seeded in rows, some cultivation will be necessary, primarily to maintain the surface mulch and check evaporation. Weed growth will seldom be a serious menace to Sudan grass, as the crop grows with such rapidity and vigor as to keep the weeds in check quite efficiently. It is only when seeded extremely early, in which case the growth is apt to be rather slow, or when seeded on very foul soil, that the weed growth will be likely to be injurious.

Two cultivations during the growth of the first crop and one cultivation after each cutting, or after each irrigation, will usually be sufficient. The first cultivation should be rather deep and should be given as soon as the plants are large enough so that the rows can be followed easily. Later cultivation should be more shallow in order not to injure the surface roots of the plants.

The most effective implement to use will depend somewhat upon the distance between the rows. When the rows are twenty-four inches or more apart, the ordinary two-horse corn cultivator may be used, though an implement with rather small shovels is to be preferred as

the small shovels have a greater pulverizing effect on the soil and leave a smooth surface. When the rows are less than twenty-four inches apart a one-horse cultivator of the type used for cultivating truck crops will probably be the most efficient.

Irrigation.—While Sudan grass will doubtless be used most extensively as a dry land crop, there is no question but that as a forage crop it will be employed to some extent under irrigation, either as a supplement to alfalfa hay or as a second crop to follow a spring-grown crop. Again, in sections where the precipitation is low and the supply of irrigation water is limited, much larger yields of forage will often be obtained by applying the small amount of water available to Sudan grass rather than to alfalfa. While no definite data are available on the amount of water necessary for a maximum crop, the best results will probably not be obtained with less than twenty-five inches, including the natural precipitation.

When Sudan grass is planted early in the spring, it will seldom be necessary to irrigate the ground before seeding, as the natural moisture will usually be sufficient to germinate the seed and start the plants. Ordinarily three or four irrigations throughout the growing season will be sufficient under most conditions. The first irrigation should be applied when the first growth is from eighteen to twenty-five inches in height or just before heading. The later irrigations may be applied after each cutting or as soon as the new growth has started. On light soil it will doubtless be better to give two light applications of water per cutting than one heavy application.

When Sudan grass is to be grown following a spring crop, such as grain, irrigation of the field will be necessary before the seed bed for the grass can be prepared. If a rather heavy application of water is given at this time, further irrigations will not be necessary until the first cutting is nearly mature. The flooding method of irrigation is to be preferred with Sudan grass even when seeded in rows, as furrowing between the rows might severely injure the extensive surface root system of the plants. With proper checking and leveling of the field before seeding no great difficulty should be experienced in securing a uniform distribution of the water.

SUDAN GRASS IN THE ROTATION

Inasmuch as Sudan grass is an annual crop, it can be worked into almost any rotation in much the same manner as sorghums, corn or other annuals of that character. Under dry farming it can be employed in the cereal rotation with profit to replace grain hay, since it is more drouth-resistant and much more productive as a hay crop

than any of the cereals. Being a sorghum, however, and a rank grower, it draws heavily upon the moisture and fertility of the soil and leaves but little in the soil for improvement except the decayed roots. It is quite probable that crops susceptible to effects of plants of this character, such as barley, should not be put upon the land immediately following Sudan grass.

It is also apparent that the best results will not be obtained with Sudan grass if it is put upon land used for Sudan grass the previous season. In 1915, the yield obtained on land which had been cropped to Sudan grass the previous season was only 4.24 tons of hay per acre, whereas the yield on land upon which a cultivated crop had been grown the previous season yielded 6.69 tons per acre. Both plots were seeded at the same time and at the same rate, and otherwise handled in identically the same manner. The fact that the crop can be seeded late and still produce large yields of forage will doubtless render it of great value as a second crop under irrigation. It can be employed in this way to follow a spring crop, such as grain or spring pasture or, in fact, any crop which could be removed from the land by the first to the middle of July.

THE HAY CROP

Time of Cutting.—In order to secure the highest quality of hay, Sudan grass should be cut when in full bloom. If harvesting is delayed until the seed is ripe, the hay will be a little coarse and a little less palatable than if cut earlier. The decrease in feeding value on maturity is probably not as great in Sudan grass as with some other crops, since in common with many of the other sorghums the stems and leaves remain green until after the seed is ripe. In addition to this fact, the plants stool extensively so that the later suckers will be quite immature even when the main stems of the plant are ripe. On the other hand, if the crop is cut before heading, the feeding value of the product is apt to be quite low though its palatability may not be impaired.

Method of Harvesting.—The most common way of harvesting the hay crop is with a mower. It is subsequently handled in much the same manner as millets and other coarse grasses. During the bright, warm days of the summer, grass cut one morning will usually be ready to rake into windrows or bunches the next day. To produce a bright hay of high quality, it should be put into cocks and allowed to cure for three or four days before being put into the mow or stack. While the leaves cure quite readily, the large juicy stems retain their moisture somewhat longer so that hay which appears to be well cured may

still contain a relatively high percentage of moisture. At Davis, hay cut in July, 1915, contained from 25 to 35 per cent of moisture after curing in the swath and windrows for three days. A few days of additional curing in the cock, however, reduced the moisture content to 20 per cent or less.

In some instances the grain binder has been used for harvesting the hay crop, the bundles being set into shocks to cure. While this method facilitates handling somewhat, it is not likely to become very popular owing to the difficulties encountered in harvesting a heavy crop. When the grass has been planted in rows, harvesting may be done with the row or corn binder. As neither of these implements is commonly found on the farms in California, the mower will doubtless be the most popular means of harvesting, the hay then being handled as any other hay crop.

Yield of Hay.—The yields of hay which may be obtained with Sudan grass will vary somewhat with the conditions of the soil, the supply of moisture and the other factors which enhance or retard plant growth, though the first two factors will doubtless be of the greatest importance.

During the three years in which Sudan grass has been grown at Davis, the yields of cured hay have varied from 1.32 tons to 9.59 tons per acre, on the individual plots. Considering the average yields obtained on the different plots for dry and irrigated land each season, the results have been as follows:

TABLE IV

YIELD OF SUDAN GRASS HAY

	Dry, tons per acre	Irrigated, tons per acre
1913	1.78	3.93
1914	5.26	6.74
1915	5.86	.....
1916	.....	5.94

The results here given include the average of all dry and all irrigated plantings regardless of the time, rate or method of seeding. Naturally, plantings made rather late, producing only two cuttings, will not, as a rule, give as high yields as earlier plantings. Furthermore, it is quite likely that the application of more water, or at least applications at more frequent intervals, would have increased the yields under irrigation materially. In these experiments only one light application per cutting was given, which may not have been enough for the maximum growth.

FEEDING VALUE OF SUDAN GRASS HAY

The feeding value of a product depends not only upon its composition and digestibility, but to a large extent upon its palatability to the animals which consume it. While no feeding tests have as yet been conducted with Sudan grass hay, observations indicate that it is relished by all classes of hay-eating animals, nor does it appear to have any deleterious effect on the digestive system. Instances have been brought to our attention where farm stock with long hours of heavy work have kept in good condition on Sudan grass hay without a grain ration.

Fig. 4.—The mower is well adapted to harvesting Sudan grass for hay.

The palatability of the product is doubtless enhanced by the juciness and sweetness of the plants, as it has been observed that even though the hay is rather coarse, but little waste occurs when it is fed.

Regarding the composition of the hay, claims have frequently been made that it compared favorably with alfalfa hay. These claims, however, have usually been advanced by parties having Sudan grass seed for sale. Analyses made of the hay grown at the University Farm in 1915 in comparison with some of the more common hay crops are given in Table V.

The data in this table clearly show that Sudan grass compares in composition more nearly with the other grass hays than with alfalfa. It is a little lower in protein than either barley hay or rye grass hay,

TABLE V

AVERAGE COMPOSITION OF VARIOUS HAY CROPS—WATER-FREE BASIS*

Kind of hay	Protein	Fat	Crude fiber	Nitrogen free extract	Ash
Sudan grass	6.9	3.0	27.9	55.0	7.2
Barley hay	10.3	2.8	29.0	53.0	4.9
Rye grass	10.5	3.5	27.5	49.3	9.2
Timothy	6.8	2.9	33.4	51.9	5.0
Alfalfa	16.8	2.3	30.1	42.0	8.8

* Analyses supplied by Professor Woll.

and about the same in fat and crude fiber. Its ash content is considerably higher than that of barley hay, and only slightly lower than that of rye grass hay. In comparison with timothy its protein and fat content are approximately the same, but it is considerably higher in carbohydrates and ash. The hay from which the above analyses were made was cut when in full bloom, which is the usual time recommended for harvesting crops of this character, though it may not necessarily give a product of the highest nutritive value.

When the nutritive value per unit of area is considered, Sudan grass is superior to any of the other grain hays because of its higher yield. The average yield of Sudan grass hay from all non-irrigated tests during the first three years has been 8640 pounds per acre. Under similar conditions 4000 pounds per acre is considered a good yield for either barley, rye grass or timothy hay.

In Table VI is shown the feeding value per acre of the grass hays given in the previous table, based on composition.

TABLE VI

YIELD OF CONSTITUENTS IN POUNDS PER ACRE FROM GRASS HAYS

Kind of hay	Yield per acre	Dry matter	Protein	Fat	Crude fiber	Nitrogen free extract	Ash
Sudan grass	8,640	6,367.7	439.4	191.0	1,794.6	3,485.2	457.5
Barley hay	4,000	3,400.0	350.2	95.2	996.0	1,792.0	166.6
Rye grass	4,000	3,520.0	369.6	123.2	968.0	1,735.5	323.8
Timothy	4,000	3,316.0	225.5	96.2	1,107.5	1,721.0	165.8

It will be noted that the acre yield of protein in the Sudan grass is about twice as great as that of timothy hay, and at least a fourth more than rye grass or barley hay. In the case of fat and ash the acre yield of Sudan grass is more than twice as great as for either barley or timothy and more than a third greater than rye grass, while its yield of carbohydrates is double that of the other grasses. While the value of Sudan grass hay, per unit of weight, is no greater than that of the other grass hays, the larger yields per acre and the

fact that it can be grown under conditions wholly unsuited to the other types will doubtless make it of inestimable value to the stock growers of the state.

SUDAN GRASS PASTURE

As yet but little definite information is available as to the value of Sudan grass for pasture, though from the character of the plant it would seem to lack some of the necessary properties of a good pasture crop. In the first place being an annual, considerable time would be required for the root system to develop sufficiently so that the plant would not be pulled out by grazing animals. Again, since the soil in which the seed is planted is naturally quite soft, the young plants would probably be severely injured if pastured too early. If the plants were allowed to attain some size before the stock is turned in but little injury would be likely to result. Another possible objection to Sudan grass as a pasture plant is that being a sorghum, it may, if subjected to extreme drouth, to too heavy grazing, or other unfavorable conditions, develop prussic acid (hydrocyanic), which is quickly fatal to stock.

The fact that the grass will maintain rather rapid growth throughout the drier portion of the year, however, is strongly in its favor. This ability is possessed by but few plants which could be used for pasture purposes. The danger from poisoning by members of the sorghum family has, on the whole, doubtless been over-estimated, as the death rate among live stock from this source is very low as compared with other causes.

In order to secure some information on the value of Sudan grass as a pasture crop, a pasturing experiment was begun in 1916 in cooperation with the Division of Animal Industry. While the results obtained were not wholly satisfactory, the ability of the crop to withstand rather heavy pasturing after the plants were well-established was amply demonstrated.

A two-acre field of silt loam was chosen for the experiment. Because of the dry spring it was necessary to irrigate the land before seeding. As soon as the soil was dry enough to work properly the seed bed was prepared and the crop seeded at the rate of twenty pounds per acre on June 17. The seed germinated quickly and a good stand was obtained over practically the whole tract. Since it was feared that the plants would be pulled up or otherwise injured if the stock was turned on while the plants were small, pasturing was not begun until July 24, at which time the plants had attained a height of about two feet. On this date thirty-five lambs were turned

into the field, and while they seemed to relish the feed highly, they made practically no reduction in the growth. Three days later eleven ewes were added to the flock, but even this heavy pasturing did not affect the growth of the crop. The Sudan grass headed about the first of August and on the 3rd the sheep were removed and the crop cut for hay, 4.65 tons of cured hay being removed from the two acres. Two weeks were allowed after cutting for the plants to recuperate before being again pastured. From this time until September 26 the field was pastured intermittently; on the latter date fifteen sheep were again put upon the field where they remained until October 29, a week after the growth was killed by frost. All the sheep made gains of about one-third of a pound per day throughout the period they were on pasture, and at no time was any injurious effect noted. Had the field been seeded earlier and had the proper stage of growth, as well as the carrying capacity of the field been better understood, a much longer period of pasturing would doubtless have been obtained.

Many reports have been obtained praising Sudan grass as a summer pasture for all classes of livestock, but the only exact data that have come to the writers' attention were submitted by Mr. F. F. Lyons, while Farm Adviser of San Joaquin County, citing the experience of a farmer in that section in 1915. The field in question was ten acres in size, the crop being planted in rows three feet apart, primarily for seed production purposes. The seed crop was cut the second week in July, yielding six hundred pounds of seed per acre. As soon as the new growth started, seven cows and five horses were turned in and maintained continually until the crop was killed by frost in November. The horses received some hay in addition to the pasture, but the cows received no other feed throughout the whole period. These results are indeed remarkable considering the manner in which the crop had been planted. If they may be taken as an indication of what can be expected of the plant for pasture, the future of the crop for this purpose is certainly bright, since in this instance at least, it equalled in carrying capacity a good stand of alfalfa.

SEED PRODUCTION

Up to the present time Sudan grass has been grown primarily as a seed crop, owing largely to the high price which this produce commanded. While these high prices can not continue, there will always be a considerable demand for seed, since the crop is an annual and must be seeded every year. The production of seed, therefore, will doubtless continue to be a profitable industry, especially in those sections where a good quality of clean seed can be grown.

Fig. 5.—In experimental plantings Sudan grass is tall and vigorous in growth. When in bloom it is ready to harvest.

The seed habits of Sudan grass are excellent. It is produced in large open panicles ten to fourteen inches in length, borne fairly high, upon erect stalks making the harvesting of the crop relatively easy. The seed is retained quite well so that under most conditions, but little loss from shattering will result. If, however, the crop is subjected to strong winds, when the seed is mature, a considerable portion of it may be lost by shattering.

The first crop of seed requires from ninety-five to one hundred days to mature under normal conditions. After cutting, the plants recover very quickly so that under favorable conditions when the growing season is of sufficient length a second crop of seed may be produced. This second crop, however, usually requires from one hundred and ten to one hundred and twenty days to mature, so there is always the danger of its being injured by frost before it is ripe. Furthermore, neither the yield nor the quality of the seed from the second cutting will be as good as from the first.

In most cases it will doubtless be more economical to utilize the growth after the seed crop either for hay or for pasture, or else to harvest the first crop of the season for hay, allowing the second to mature seed. In this latter case a seed crop could be matured in most sections of the state without the danger of injury by frost.

In growing a seed crop, however, care should be taken to see that it is grown on land that is absolutely free from Johnson grass, as the seed of these two plants are so nearly alike as to be distinguished only with great difficulty. In producing seed, farmers should aim to secure their supply from sections free from Johnson grass in order to avoid the danger of introducing this pest. In sections where Johnson grass is not present, it will probably be advisable for the farmer to grow his own seed, since ordinarily only a small area will be required to produce the desired amount. In sections favorable for the production of seed, good returns may be obtained from the seed crop even though the price drops as low as five or six cents as at present indicated.

Preparation of Soil.—As yet but little definite information is available as to the best means of handling the seed crop. The experiments conducted thus far have referred primarily to the method of seeding for maximum seed production and not to the other cultural practices. In the preparation of the seed bed, however, the same general cultural methods should be followed as in the production of a forage crop. It should be mellow and well prepared in order to secure a uniform stand of healthy plants.

Time of Seeding.—Early planting or as soon as the soil is sufficiently warm to maintain normal growth will in most cases be pro-

ductive of the best results. At this season of the year the supply of moisture is abundant and the plants will ordinarily make a better growth than if seeded later. On the other hand, if the land can be irrigated, later seeding may be practiced. It is probably never advisable, however, to plant a seed crop later than the first of July, since the season at the time of maturity will be too cool for the best development.

Method of Seeding.—For seed production Sudan grass may be planted either in close drills or in rows, in the same manner as described in the discussion on forage. Owing to the scarcity of seed during the past two or three years, most of the planting for seed production has been in cultivated rows, in order to secure as large yields as possible, by forcing the plants to stool extensively.

Results of tests conducted at Davis during the season 1913 to 1915 to determine the value of different methods of seeding on the relative yield of hay are given in Table VII.

TABLE VII

SEED PRODUCTION, METHOD OF SEEDING

	Yield of seed per acre, pounds							
	1913			1914			1915	1916
Method of seeding	1st cut.	2nd cut.	Total for season	1st cut.	2nd cut.	Total for season	One cut. only	One cut. only
Dry—								
36-inch rows	65	30	95	1,308	408.7	1,716.5	621.3	.....
18-inch rows	50	60	110	1,340	490.5	1,830.5	1,013.7	.....
20 lbs. drilled	150	35	185	1,303	457.8	1,765.8	964.6	.....
30 lbs. drilled	120	30	150	.....	.....	.....	.....	.....
Irrigated—								
36-inch rows	880	270	1,150	800	340	1,140	.....	740
18-inch rows	400	180	580	1,540	490	2,030	.....	940
20 lbs. drilled	280	30	310	1,240	530	1,760	.....	1,760
30 lbs. drilled	680	30	710*	.....	.....	.....	.....	.....

* Average of two plots.

The results given in this table for the seasons 1914 and 1915, at least, favor planting in eighteen-inch rows. In 1914, however, the difference when no irrigation was given is not as great as with irrigation. In 1916, on the other hand, when the crop was grown with irrigation much the best results were obtained from the close-drilled plots. The results for 1913 were, on the whole, extremely variable. One would naturally expect, with the light rainfall which obtained that season, that the thirty-six-inch rows would have given the highest yield. This expectation, however, was upset largely by the poor stand obtained.

Further trials under similar conditions will be necessary to verify these results.

Rate of Seeding.—Unfortunately no definite information is yet available on the rate of seeding for the maximum seed production. It has been stated that if a light rate of seeding was used, the strong tendencies to stool profusely would cause uneven ripening and therefore, a poor, immature quality of seed. This same objection might be raised with regard to growing the crop in cultivated rows. However, thus far the results obtained at Davis have not borne out this contention. When seeded in close drills the maximum yields will probably be obtained if seeded at the rate of from fifteen to twenty pounds per acre under most conditions. When seeded in cultivated rows the amount of seed required will vary with the distance between the rows, usually from four to seven pounds per acre.

Harvesting the Seed Crop.—The seed crop should be cut when the majority of the heads on the main portion of the plant are ripe. It is seldom wise to allow it to stand until all the heads on the later shoots are mature, for while it does not shatter easily, if subjected to the hard winds prevalent in many of the valleys of the state, a considerable loss is bound to occur. Furthermore, the plumpest seed is produced on the main heads and it is this portion that would be lost if shattering occurred. On the other hand, if the crop is cut too early, the seed will be light and chaffy, with the result that a considerable portion of it will be screened or blown out in the threshing and cleaning process. For harvesting the seed crop the ordinary grain binder is the most economical as well as the most efficient. The bundles can then be set into shocks to cure, where they should remain for a period of from ten days to two weeks. If desired, the bundles may be stacked like other grain, but this is seldom necessary in a dry climate such as prevails in California.

Harvesting may also be done with a mower, cutting and handling the crop like hay. This method, however, is not to be recommended as a considerable quantity of seed will be lost in the process of handling.

Threshing.—Sudan grass may be threshed with the ordinary grain separator. The only change necessary will be the reduction of the air blast from the fan to prevent the seed from being blown over with the chaff. If the cylinder is run at a high rate of speed, or if several rows of concaves are used, the coverings will be removed from a large proportion of the seed. While the presence or absence of the hulls does not appear to affect the germination of the seed, it has a better appearance if the glumes are retained. For this reason no greater

speed of the cylinder or no more concaves should be used than will be necessary to completely remove the seed from the heads.

Cleaning.—Even though most of the chaff and foreign material will be removed in threshing, it will usually be necessary to reclean the seed in order to secure a high-grade product. Any ordinary fanning mill fitted with proper screens will clean Sudan grass seed, though a machine possessing a vertical air blast will be found to be the most efficient for the removal of the chaff and light immature seed which can not be removed by the screen.

Yield of Seed.—The yield of seed will be quite variable, according to the character of the soil, the supply of moisture and the general seasonal condition for growth. During the past three years, the yields of seed at Davis have ranged from ninety-five pounds per acre to two thousand and thirty pounds per acre. The average yields for the four years are as follows:

Year	Dry	Irrigated
1913	135.0	687.5
1914	1,770.9	1,643.0
1915	866.5	.....
1916	.....	1,146.6

From these results it will be noted that there was a very wide difference in seed production in different seasons. The extremely low yield in 1913 was due to the combined effect of extreme drouth and a poor stand. The conditions in 1914, 1915, and 1916, however, were excellent for seed production, though in 1914 two cuttings of seed were obtained while in 1915 and 1916 only one seed crop reached maturity, which accounts for the difference in these two seasons. From these data and from observations made under field conditions in several sections of the state it is indicated that when but one seed crop is obtained, 1000 pounds or over may be considered an excellent yield, while the average production will probably range from 600 to 800 pounds per acre.

ENEMIES

Diseases.—As yet but few diseases have occurred on Sudan grass with sufficient severity to greatly injure the growth of the plants. Probably the worst and most prevalent disease is the sorghum blight or red spot, mentioned by Vinall in Farmers' Bulletin no. 605, and described as follows: "This disease is characterized by the appearance of distinct reddish spots or blotches on the leaves, these spots gradually spreading until the leaves turn brown and die. Its effect on

the plant is much the same as rust and like rust, is most destructive in warm humid regions—but it seems possible to overcome this weakness by the production of disease-resistant strains.'' This disease has been observed upon nearly all Sudan grass plantings in this state, but in no case has it appeared to injure the growth severely.

Another disease to which Sudan grass is subject is sorghum smut. As yet, however, no reports of infection of this character have been received, nor is it apt to become prevalent or cause much damage since the grass will be used primarily as a hay crop.

Insects.—Probably the worst insect enemy of Sudan grass in California is the grasshopper. While no severe infestations have as yet been reported, it is known that grasshoppers feed abundantly on the green plants and may cause considerable damage during periodic outbreaks. Probably the best means of controlling this pest is by the distribution of poisoned baits around the edges of the field or between the rows. While the grass is small, the hopper dozer may also be employed with success.

Weeds.—Since Sudan grass is an annual and must be seeded every year and because of the rapidity and vigor with which it grows, weeds are not likely to be a serious menace to the crop. Such perennial weeds as Johnson grass and morning glory may, if present, reduce the stand and stunt the growth somewhat. The former plant is especially objectionable when a seed crop is to be grown since the plant itself and the seed can be distinguished from Sudan grass only with great difficulty. For this reason, a seed crop of Sudan grass should never be grown where Johnson grass is known to be present.

Source of Seed.—The original supply first distributed by the United States Department of Agriculture contained no Johnson grass seed. Seed growers and others who have produced their supply from this original source and have grown it on lands free from Johnson grass and on those not in close proximity to Johnson grass, should have pure seed. Our supply at the University Farm at Davis was secured and multiplied in this manner.

Sudan grass seed has now become a staple seed crop, and we find it quoted in the farm papers along with timothy and other well known seeds.

The seed has been grown to such an extent in states in which Johnson grass is known to flourish and produce seed that there is every possibility that some Johnson grass seed has crept in. It is very evident therefore that the above questions can not be satisfactorily answered. In regard to the probabilities of Sudan grass containing Johnson grass seed, however, we may be able to throw some light.

Johnson grass is a perennial and produces strong pernicious underground stems or rootstocks, commonly called roots, each part of which when broken up in pieces, is capable of producing a new plant. These may descend to a depth of four or five feet in the soil. Under ordinary conditions of exposure, these roots are killed by freezing so that in those states where the soil freezes to a depth of several feet, Johnson grass is not likely to survive. This would include, in a general way, all the states north of Kansas and a large area in an irregular line where low winter temperatures prevail. Even in the states of Iowa and Michigan, the rootstocks have been known to survive the winters occasionally, but only under favorable conditions for protection from cold. According to Vinall, Sudan grass seed has been produced in Ohio, Minnesota and eastern South Dakota. Growers of Sudan grass for hay in states with cold winters, need not have the same fear of introducing Johnson grass, since if any seed should be present the plants from these would most likely be killed during the first winter.

It has been stated that Sudan grass can be readily distinguished from Johnson grass by its larger size and different color. Looking at either of them in bulk Sudan grass is generally plump and Johnson grass seed slender, but this can not be relied upon as individuals from a single plant of Sudan grass will vary greatly in this respect, due to the different stages of maturity of the seed and the cultural treatment of the plant. Again, Sudan grass is supposed to have light-colored seed, while Johnson grass is dark-colored. But there are good strains of Sudan grass that are quite dark in color, as well as light-colored Johnson grass seeds, so that color can not be relied upon in determining the purity of Sudan grass.

DISTINCTION BETWEEN SUDAN GRASS AND JOHNSON GRASS SEED

F. H. Hillman of the Seed Laboratory, United States Department of Agriculture, has recently discovered a method by which the dreaded Johnson grass can be distinguished from Sudan grass. We quote the following from the Weekly News Letter, U. S. D. A., vol. III, no. 36, April 12, 1916:

> Careful study of the seeds of these crops, which, though closely related and quite similar in appearance, differ greatly in their agricultural value, has resulted in the development of a method by which they can be distinguished through a careful and thorough examination with the aid of an ordinary magnifying glass which enlarges objects to the extent of six or eight diameters. A detailed technical description of the method has been prepared and will be published in the near future by the department, but in view of the widespread interest in the

subject at this season of the year, when plantings of Sudan grass will soon be made, the following nontechnical description is published.

Seeds of Johnson grass are noticeably smaller than those of Sudan grass. When the two are mixed, seeds evidently smaller than others may be suspected to be Johnson grass.

In nearly all samples part of the seed is unhulled and part hulled. This is true of seed of both Johnson grass and Sudan grass. The smaller size of the Johnson grass seed is evident in both the unhulled and hulled seeds.

On closer examination under the magnifier, most of the unhulled seeds of Sudan grass are seen to have a short stem. Besides this, the two slender appendages lying on one face of the seeds are broken at the end. Most of the unhulled seeds of Johnson grass have no stem, but a smooth scar instead. The two appendages are mostly expanded and cup-shaped at the end. The stem and the broken appendages in Sudan grass seed and the smooth scar and entire expanded appendages in Johnson grass seed result from the fact that nature has made no special provision for the fall of the seed in Sudan grass, while in Johnson grass provision is made for the seed to separate from the plant at the junction of the seed with its stems cleaving a clean-cut scar. At this point a distinct line across the stem marks the point of separation. Exceptions to the general rule stated occur in both kinds of seeds. Some of the Sudan grass seeds have no stem, but the appendages are rarely entire and expanded at the end. Some Johnson grass seeds have a stem because of the weaker stem having broken more readily below its junction with the seed than at this junction. The appendages are rarely broken, and narrow at the end. Johnson grass seeds bearing a stem usually can be recognized by the distinct division line across the stem at its junction with the seed.

Some of the seeds of both Sudan and Johnson grass have a longer stem which is a part of the branch bearing the seed cluster.

Lastly, the free grains or hulled seeds of Johnson grass are smaller and darker colored than those of Sudan grass, and are usually oval in form, while those of Sudan grass are elliptical.

The Branch Seed Laboratory of the United States Department of Agriculture, at the College of Agriculture, Berkeley, is now prepared to report on the presence of impurities in Sudan grass seed, including Johnson grass.