EFFECT OF NORMAL VS. ABNORMAL SEED DEVELOPMENT ON THE DRY MATTER, NITROGEN, AND DIGESTIBLE NUTRIENT CONTENT OF THREE SORGO VARIETIES

By

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INTRODUCTION

Forage sorghums have been and will continue to be one of the important feed crops in many areas of the United States. There is a real need for improvement and standardization of the methods of evaluating the nutritive value of forage plants as a livestock feed. However, for the present, this complex problem will be left for more qualified workers to solve.

The primary objective of this research was to obtain information on the value of sterile or seedless forage hybrid plants. The immediate purpose of the study was to compare the effects of seed development and no seed development on the composition and nutritive value of forage sorghum plants. Sterile sorghum hybrids can be produced by the present plant breeding techniques, but, at present, it is not known if there would be an advantage in producing sterile hybrids rather than fertile hybrids.

Very little literature is available relating directly to this problem; however, there is considerable literature which deals indirectly with the problem involved.

Since the sorghum midge *Contarinia sorghicola* was the insect responsible for the abandonment of one thesis problem during the summer of 1958, and the insect that made possible the opportunity of studying this problem, a resume of the life cycle and the effects of the sorghum midge is included.

LITERATURE REVIEW

The Sorghum Midge

The sorghum midge is one of the most important insects attacking grain sorghums in the Southern States. Every year its damage to this crop amounts to several million dollars. Besides damaging the grain sorghums, this pest causes great losses in the seed crops of the sweet sorghums, sudangrass, and broomcorns. In many sections where the sorghum midge is especially abundant, as much as one-fifth of the crop may be lost, and in years particularly favorable to the midge these sections produce practically no sorghum grain. The known distribution of the sorghum midge in the United States is shown in Figure 1.

Martin and Stephens (18) [1/] stated that the damage due to the sorghum midge from a forage standpoint is slight, as the sorghum makes good fodder even when it has failed to form seed.

In 1908, Ball (2) reported on an experiment he conducted to determine the cause of sterility or "blasting" in sorghum. He found the causal agent was the sorghum midge, a very small two-winged fly. A close-up view of an adult female midge is given in Figure 2. His observations showed that egg-laying began as soon as the tips of the heads emerged from the boot or upper leaf sheath, and continued until

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1/ Figures in parenthesis refer to Literature Cited.

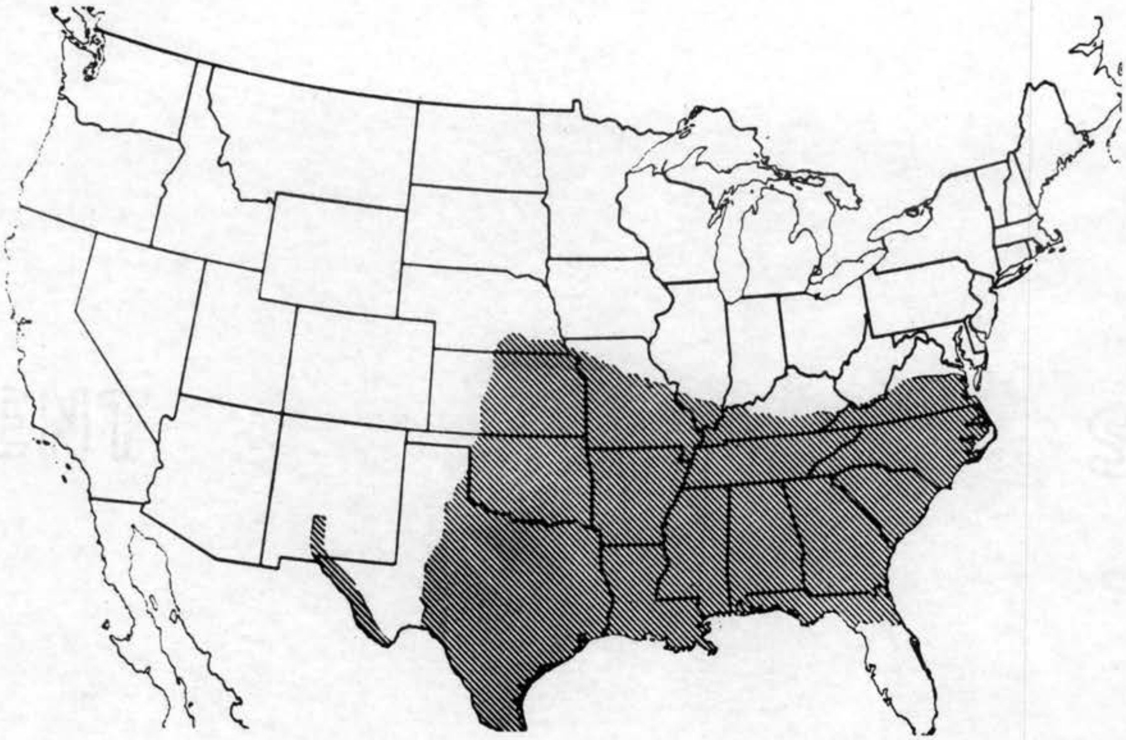

Figure 1. The Shaded Area of the Map Shows the Known Distribution of the Sorghum Midge in the United States. (From USDA, 1953.)

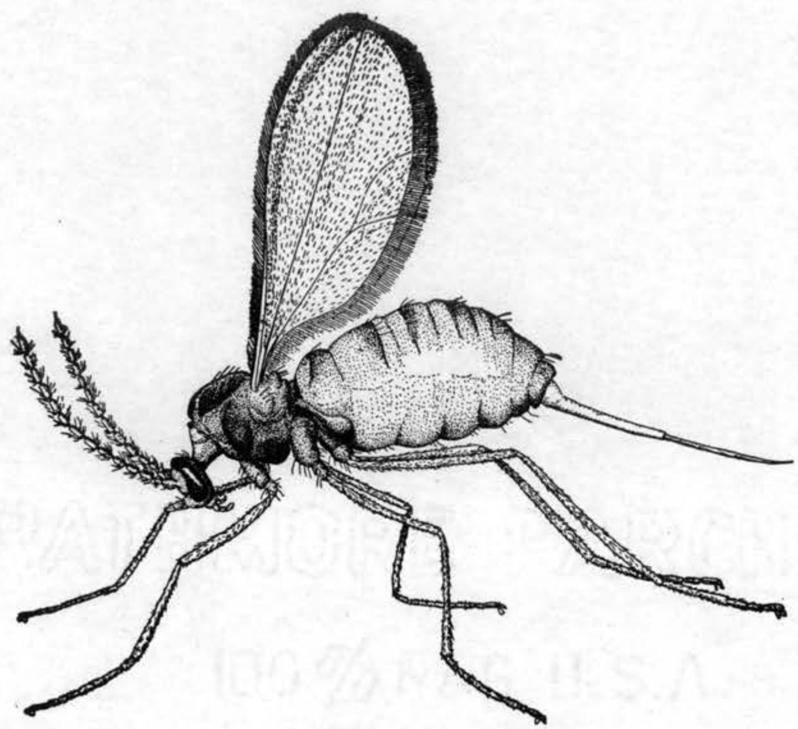

Figure 2. Adult Female Sorghum Midge, with Ovipositor Extended. Greatly Enlarged. (From USDA, 1953.)

the flowering period was terminated. Heads in every stage of development from the beginning of emergence to the close of anthesis were protected from the midges by means of paper bags. Heads protected from the midges were uniformly fertile, where normal growth continued. Heads exposed during the first half of anthesis and then protected were sterile in the upper portion but fertile below. Heads exposed until flowering was completed were uniformly sterile when midges were abundant during anthesis, and partially fertile when midges were scarce. From 500 to 1,160 midges were hatched from each of several infested heads.

Walter (28) stated that the adult female midges live only a day or two, while the adult males live only a few hours. Each female lays from 30 to 100 tiny white eggs in the spikelets or seed husks. Several midges are shown on sorghum spikelets in Figure 3. Only one egg is deposited at a time but several females can lay eggs in the same spikelet. In about 2 days the eggs hatch into small maggots, which gradually darken from pink to orange as they feed on the developing seed. In 9 to 11 days they are full-grown. The maggots then pupate and a new generation of adults emerges in about 3 days. The complete life cycle usually requires from 14 to 16 days. An infestation of one larva per spikelet is sufficient to cause complete loss of a seed, but as many as 8 or 10 larvae may develop to maturity in a single seed. These larvae extract the plant juices from the developing seeds, thus causing the seeds to shrivel and dry, leaving the floret barren. The adult midges do not feed on the developing seed.

Successive life cycles occur throughout the season from the first emergence of hibernating individuals in the spring until the host

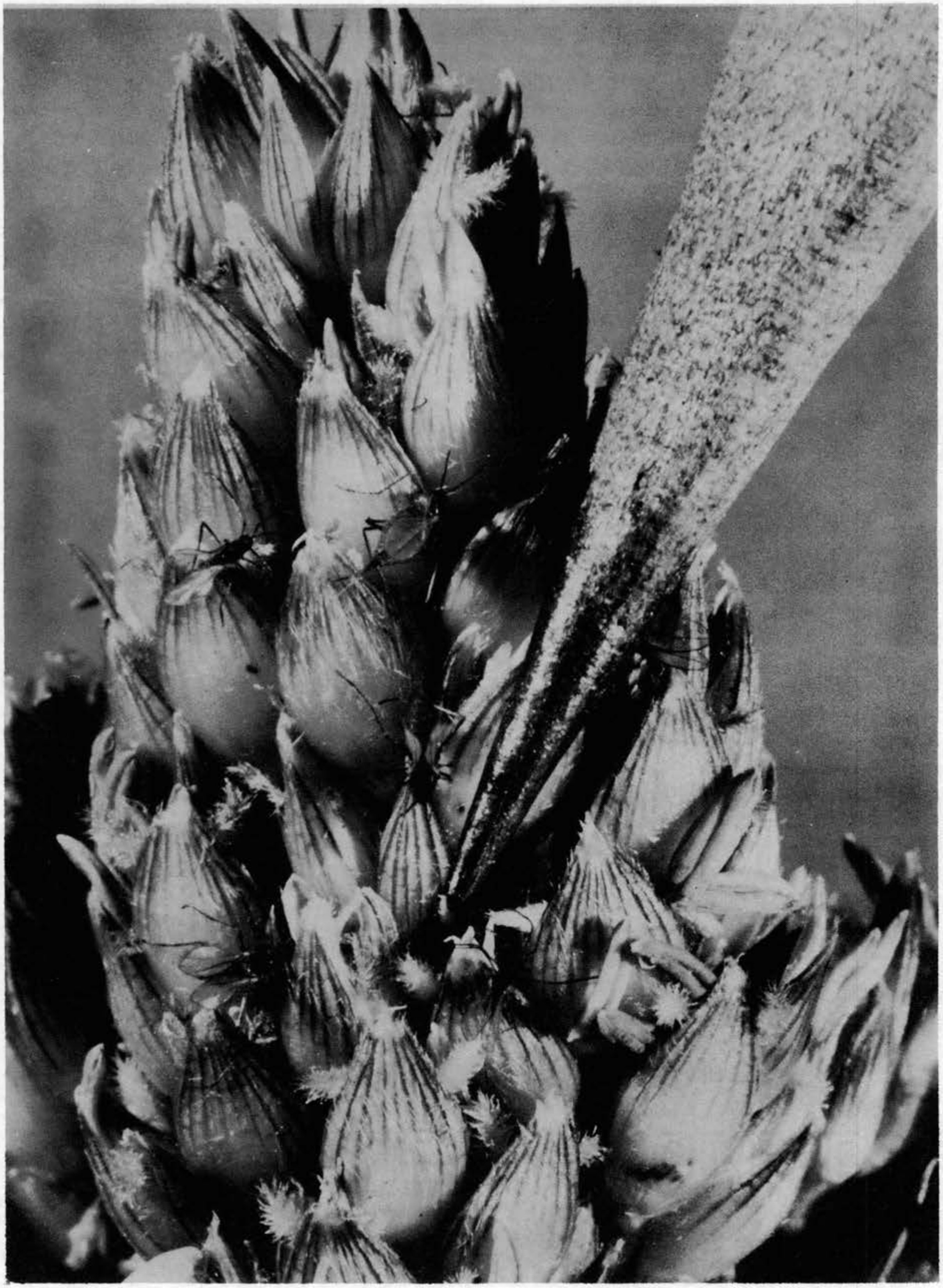

Figure 3. Enlarged View of Adult Sorghum Midges on Sorghum Spikelets. (From Successful Farming Magazine, 1958.)

plants are killed by freezing temperatures in the fall. The generations overlap to such an extent that no well-defined broods are apparent, and all stages of the insect may be found in the field at the same time.

The midges overwinter as larvae within light brown cocoons in the spikelets of their host plants, which include the grain sorghums, sorgos, broomcorns, Johnsongrass, sudangrass, and the wild grass Purpletop. Most of the larvae within their cocoons change to pupae and emerge as adults the following spring, but some do not transform and emerge until the second or third spring.

Apparently, there is as yet no varietal resistance to the sorghum midge. No practical control by the use of insecticides is available at present because the majority of the midge's life is passed within the seed husks. Alabama has reported some promising results with a 5% DDT dust applied at the rate of 25 pounds per acre at blooming time. In preliminary tests conducted at Stillwater, Oklahoma, in 1958, Henderson (11) found that DDT gave the best control. Next in effectiveness were Trithion and Diazinon.

According to Henderson (11), the sorghum midge possibly has caused some damage in Oklahoma in past years without detection, but was considered of economic importance in this area for the first time in 1958. This outbreak is thought to have resulted from the excessive rainfall of the previous year.

Early planting and other cultural practices are often used as control measures in the Southern States, as populations of the midge have to build up each season before severe damage results. Only the late planted sorghum was severely blasted by this insect in Oklahoma during 1958. In some areas, the late planted fields had losses of 20 to 100% in seed production.

Forage Sorghum

Collier (5) stated that there is a continual increase in dry matter in the sorghum plant up to maturity. Willaman et al. (32) found that the dry matter increased from about 12% to about 26% at maturity and was composed principally of fiber and nitrogen-free-extract. The percent of crude protein remained practically the same throughout growth, and the actual weight increased but slightly during the period of growth from the time the panicles first appeared to the time of mature seed. Three conclusions were drawn. First, the plant absorbs practically all of its mineral requirements, including nitrogen, during the early stages of growth. Secondly, the plant lays down the necessary structures of protein and fiber during these stages. Thirdly, during the final maturation periods all the energies of the plant are directed toward the filling out of the seed with starch and the storing of sugar in the cells of the cane.

Wiggans (30) stated that during about the last 20 days of the growing season, the increases in grain in corn will be greater than the increases in total dry matter. These differences must not represent dry matter development but dry matter transfer, that is, a translocation of previously elaborated plant material. This transfer means a loss of feed value in the stalk and a concentration in the ear, a difference of very doubtful value in silage. In fact this would seem a disadvantage, particularly if any part of the transfer were laid down in the form of "mature grain", a portion of which is often lost due to the inability of the animal to digest the whole grain completely.

The loss of grain in the droppings of cows fed sorghum silage was first reported by Cave and Fitch (4). They estimated that about 4% of the corn grain, 30% of the kafir grain, and 90% of the Sumac sorgo seeds passed through the cows undigested. Becker and Gallup (3) found by feeding cane silage and kafir silage to dairy cows that 33.91% of the cane seeds and 49.46% of the kafir seeds were voided in the manure. LaMaster and Morrow (16) found that 27.55% of the grain from sorghum silage as compared with 1.86% of the grain in corn silage was lost in the feces of dairy cows. Fitch and Wolberg (8) found that approximately 43% of the seeds in Kansas Orange sorgo silage and 36% of the seeds in Atlas sorgo silage were voided in the feces of dairy cows when fed in the dairy rations with alfalfa hay and a grain mixture. When Atlas silage was fed alone, 30% of the seeds were lost. When the two grains were fed with alfalfa hay, 62% of the Kansas Orange seeds and 51% of the Atlas sorgo seeds were voided in the feces. Darnell and Copeland (7) reported an average grain recovery in the feces of dairy cows of 67.8% when whole milo was fed. Atkeson and Beck (1) reported the recovery of grain in the feces of dairy cows averaged 42% for whole Atlas grain. In another experiment, which involved feeding immature silage with a grain content of only 1.3% by weight, they reported a 10.7% recovery of grain from the feces of a cow fed exclusively on this silage.

Chemical analyses in all of these various experiments showed very little utilization of nutrients from whole kernels during their passage through the cow's digestive tract.

In a digestion experiment with steers in 1899, Holter and Fields (12) found that it paid to grind kafir corn, or grain. They stated that 100 pounds of kafir meal contained as much digestible matter as 167 pounds of kafir corn.

Hogs usually chew their grain more thoroughly than cattle, but even with hogs, Hale (9) found that when the hogs were hand-fed on whole kafir, 10% of the feed was recovered as whole grain in the feces. When the hogs were self-fed, 2% of the seed passed through unmasticated. Thompson (25) found after four years of feeding trials with swine that whole kafir was utilized less efficiently than ground kafir. He concluded that grinding increased the feeding value of cane seed and grain sorghums 10 to 25%.

The proper time to harvest sorghum to obtain the highest yield of nutrients has been studied by several workers. Kiesselbach et al. (13) found that when Black Amber sorghum was harvested at four stages of maturity ---- first heads appearing, well-headed, seed soft dough, and seed ripe -- the relative yields were 100, 117, 129, and 138%. Based on chemical tests, the yields of nutrients per acre corresponded with the acre yields of hay.

According to Harlan (10), some of the forage sorghums appear to improve somewhat in palatability toward maturity due to an increase in sugar content at that time.

Willaman et al. (32) showed a continual increase in total sugars and dry matter during a period of 10 to 20 days after apparent maturity. Kokina and Kokin (14) reported a decrease in sucrose and total sugars in overripe sorghum, however, for a month after full ripeness the sugar content decreased by only 5.8% of the dry substance of the stem, while at the same time the starch content increased by nearly 4%, so that the total amount of mobile carbohydrates had actually undergone an insignificant change from that at full ripeness.

According to Willaman et al. (32) a plant attempts to reach maturity as quickly as possible during periods of unfavorable growth conditions. Usually this is evidenced in the reproductive parts alone; however, in sorghum this is also apparent in the composition of the juice. This fact is supported by experiments involving the removal of the seed heads. Cowgill (6) summarizes these experiments by stating that the removal of heads before maturity was once thought to have a tendency to increase the proportion of sugar in the stalk, but that results of a number of experiments have shown that although the maturity of the plant is advanced by removing the head, the maximum quantity of sugar that ultimately would be obtained is not increased. However, some experiments have shown slight differences in favor of topping.

Walton et al. (29) found that topped sorgo stalks consistently produced sirup of better quality than the whole stalks, which gave better sirup than did the tops alone. Collier (5) reported that the removal of the seed before maturity by English sparrows hastened the maturity of the sorghum juice but did not affect its final composition. Willaman et al. (31) found that after removing the ears of both sweet and field corn at canning time and allowing the stalks to stand in the field from 10 to 20 days, the total sugar content of the stem juice increased as much as 50%.

Sayre et al. (22) found that preventing pollination, and consequently fruiting, was associated with a gradual accumulation of total sugars, that barrenness brought about by the drought resulted in a similar accumulation of total sugars, and that the changes in total sugar content were due to changes in the sucrose content of the tissue and not to free reducing sugars.

Swanson (24) stated that the importance of the sorghums as a feed crop lies in the fact that even in drought years there is rarely a complete failure from the standpoint of roughage. He has observed that if the heads of either a forage or grain sorghum are blasted by drought, and the crop is revived by later rainfall, the tonnage yield will be low but the fodder may be high in nutritive value.

In an experiment using two selections of red fescue *Festuca rubra*, one a heavy seed producer and the other a poor seed producer, Kuhn and Kemp (15) found that the poor seed producer accumulated more sugar than did the good seed type. The Collier variety of sweet sorghum is also an example of a plant that is a very poor seed producer but has a high sugar content.

MATERIALS AND METHODS

A study to determine the effect of normal vs. abnormal seed development on the dry matter, nitrogen, and digestible nutrient content of three sorgo varieties was conducted on the Oklahoma State University Perkins Agronomy Research Station and the Stillwater Agronomy Research Station in the summer of 1958.

The abnormal seed development in this instance was the failure of seed to develop due to severe infestations of the sorghum midge during the summer of 1958. Actually, this problem was undertaken after a previous problem had been discarded because of failure of the plants to yield grain, due to the midge infestation.

The three sorgo varieties studied were Sumac #1712, Atlas, and Sugar Drip. These three varieties were available at three different locations, at Perkins on a Vanoss sandy loam soil, at Perkins on a Norge loam soil, and at Stillwater on a Port loam soil. The Perkins Vanoss loam location was a forage yield trial with four replications. The other two locations had only one replication each.

There was a difference in the time of planting among the three locations; the Perkins Vanoss loam was planted June 7, the Perkins Norge loam July 2, and the Stillwater Port loam July 8. All were planted later than the optimum time to plant sorghum in this area because of the unfavorable moisture conditions at the normal planting time.

All locations had been exposed to the sorghum midge; however, some plants had been bagged for the purpose of maintaining a supply of pure seed. These bags also served to protect the heads from the sorghum midges, resulting in relatively normal seed development under the bags. All unprotected heads resulted in very little seed development. Thus, an adequate number of plants were available at each location with normal and abnormal seed development. Seed development typical of the plants used in this problem is illustrated by Figure 4.

There was a two-week spread in the harvesting period with the Perkins Vanoss loam test harvested on October 22, the Perkins Norge loam on October 29, and the Stillwater Port loam on November 5. The plants were in the medium to hard-dough stage of maturity when they were harvested and prepared for analysis. Sampling of the plots was done by selecting at random five plants that had good seed development and five plants that had no seed development. Samples with good and those with no seed development were kept separate for the analyses. The heads were removed from the stalks at the top node of the culm. The green weight was taken for the stalks and for the heads in each case. The stalks were then run through a small chopper and placed in cloth bags in a forced-draft drying oven. The material was treated according to the method reported by Link (17). This method suggests that the tissue be heated for 30 minutes at 98° C. so the killing point will be reached faster, and that the subsequent drying be at a reduced temperature of approximately 65° C. in a well-ventilated oven, thereby minimizing losses by leaching and caramelization.

The heads and peduncles were placed in paper bags and hung up to

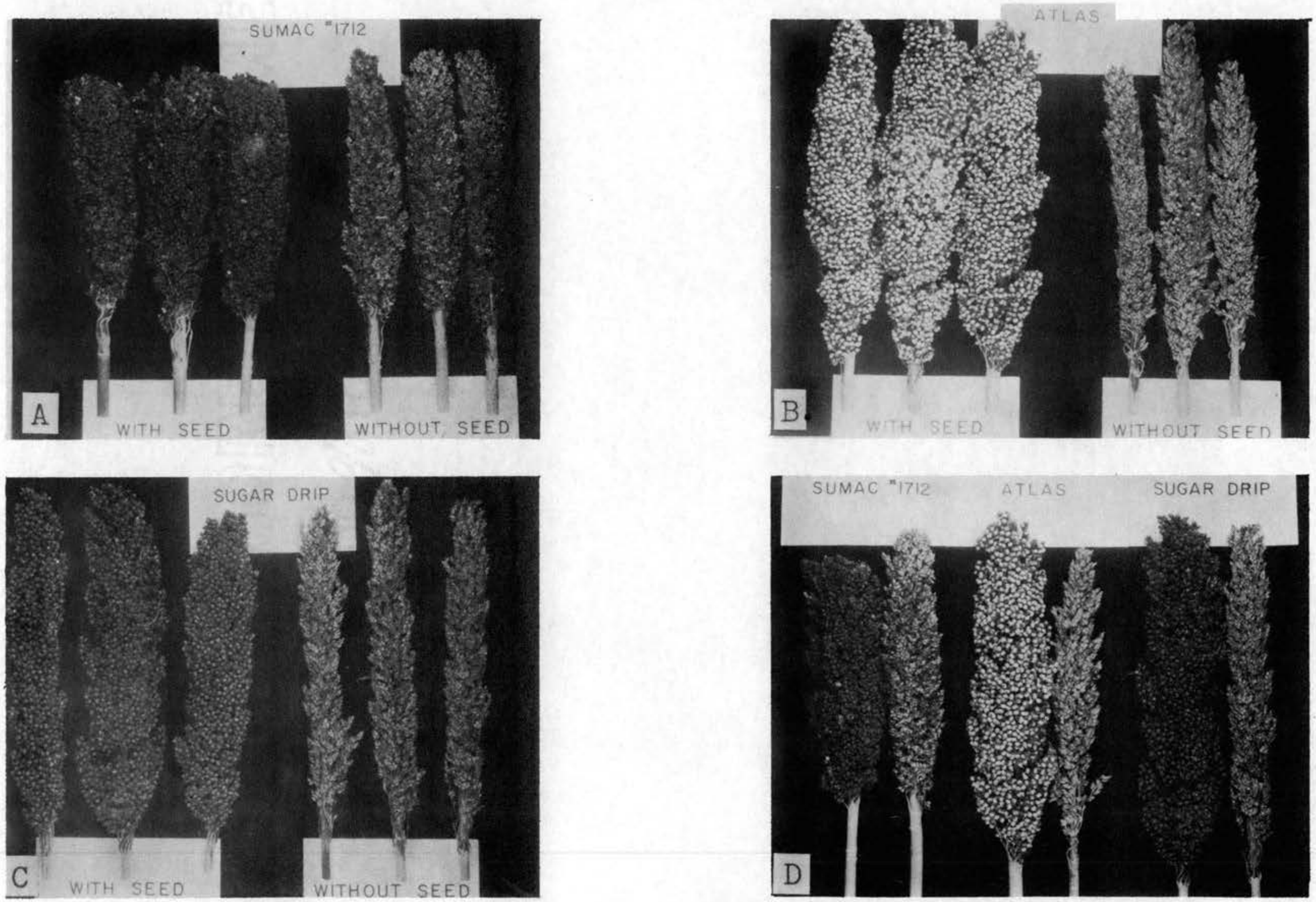

Figure 4. Seed Development Typical of the Plants Used in this Problem.

air-dry, with the exception of the heads from the six plots on the Stillwater Port loam which were placed in the oven and dried as were the stalks. The heads that were hung up to air-dry molded severely and were considered too spoiled to analyze.

After the other samples were oven-dried and the dry weights taken, they were finely ground through a Wiley mill. This material was then stored for future analysis.

The nitrogen content of each sample was determined by the Kjeldahl method (20). Each sample was analyzed for digestible nutrients using the laboratory method developed by Thurman and Wehunt (27). This method involved treating a 1-gram portion of the dried ground material from each sample with 100 ml. of a solution prepared with 1 ml. of concentrated HCl per 19 ml. of distilled water and autoclaving in open Erlenmeyer flasks at 15 lbs. pressure for one hour. A drop of methyl red and enough 20% NaOH to nearly neutralize the acid present were added into the cooled flasks after autoclaving. The content of each flask was then filtered through a No. 42 filter paper, and the residue was rinsed, dried, and weighed. The original sample weight minus the weight of the dried residue, converted to percentage, was then referred to as D.L.N. (digestible laboratory nutrients). Thurman (26) stated that the correlation coefficient between the T.D.N. determined by feeding trials and the D.L.N. determined in the laboratory was +0.970. This was significant beyond the 5% level. Results obtained by this method compare very favorably with the average T.D.N. values reported by Morrison (19).

Only the data from the four-replicated plots on the Perkins Vanoss loam soil were eligible to analyze statistically. The analysis of variance and the F tests were calculated on the percent dry matter, nitrogen, and digestible nutrients, following methods presented by Snedecor (23).

For additional information, two samples of juice were taken from the Sugar Drip variety on the Perkins Norge loam plots and were analyzed for sugars by the Oklahoma State University Biochemistry Department.

RESULTS AND DISCUSSION

The best method of measuring the nutritive value of a forage is not known. According to the Proceedings of the Sixth International Grassland Congress (21), the estimation of the energy value of a feed, based on chemical analysis, is especially difficult. None of the present evaluating methods are entirely satisfactory.

However, it is generally agreed that the dry matter production of a forage should be known. Since nitrogen is usually an important factor in forage, the nitrogen content should be determined. A standard feed analysis gives the total digestible nutrients (T.D.N.) in a feed. The T.D.N. value is calculated to reduce various feeds to a common denominator, representing the approximate energy values available to the animal from any class of feed. However, it was considered too expensive and too time consuming to run a standard analysis and determine the T.D.N. Therefore, the short laboratory method for determining digestible nutrients which was recently developed by Thurman and Wehunt (27) was utilized to give some measure of the nutritive value of the plants.

According to Swanson (24), the ability of a forage sorghum to build up its sugar content is dependent to a considerable extent on an abundance of rainfall, a long growing season, and much sunshine. Under these conditions, the total carbohydrate yield will be very high. Although, at Perkins and Stillwater, moisture was lacking at the optimum planting date and planting was delayed somewhat, there was an abundance of rainfall later in the growing season, as shown in Table I. The summer of 1958 was definitely favorable for growing forage sorghum and a high carbohydrate yield was expected.

Suggestions have been made that the development of seed is merely a transfer of previously elaborated plant material. If this is so, then the failure of seed development would actually mean a higher nutritive value in the stalk of the plant. The failure of seed development can be caused by several different factors, all having generally the same end result of an accumulation of total sugars and of hastening the maturity of the juice of the plants.

The abnormal seed development obtained due to the sorghum midge infestation seemingly could cause a similar accumulation of nutrients in the stalks, and this, apparently, was the case. In every determination of dry matter, nitrogen, and digestible nutrients, the percentages were higher in the stalks of the plants without seed development than in the stalks of the plants with normal seed development. This is shown in Tables II, IV, VI, VIII, X, and XII. Differences were greater between the with and without seed within varieties than between any two varieties with the same treatment. The analysis of variance and the F tests indicate there was a highly significant difference between the with and without-seed treatments, Tables III, V, and VII.

The average determinations of dry matter, nitrogen, and digestible nutrients with all varieties and all locations combined are reported in Tables IX, XI, and XIII.

The analyses of the heads from the Stillwater location showed high-

TABLE I

DAILY RAINFALL AT PERKINS, OKLAHOMA, JANUARY 1, 1958 TO DECEMBER 1, 1958

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
1								.49			
2				.06	.13						
3					.91						
4			.01								
5		.39	.03				T				
6		.01	.80				.02		.01		
7				.32		.06	.16		.01		
8			.66					.08			
9		.27		.01	.06						
10			.24	T	.08			1.06	.02		
11	.18										
12	.03		.58	.13			1.88	.10		.44	
13	T			.49							.19
14				.01	.06		.13		.12	T	T
15			.05		.31	.85			.13	.26	
16			.06			1.84			2.49		.37
17			.34	.03	.02			.65			.28
18						.04					
19	1.09			.92		.02					
20	.11					1.29		2.36	.03		
21				.14		1.33	.11	.02			
22					T	.05	.03				
23		.01	.72					.07	.02		
24											
25						2.04					
26		.22					.38			.04	
27							1.42				.23
28			1.20	.03	.06						
29			.02						.16		
30					.07				.08		
31											
Totals	1.41	.90	4.71	2.14	1.70	7.52	4.13	4.83	3.07	.74	1.07

TABLE II

PERCENT DRY MATTER OF THE STALKS FROM PERKINS, VANOSS SANDY LOAM

	Seed	Rep. I	II	III	IV	Mean
Sumac #1712	with	25.8	24.3	22.4	23.6	24.0
	without	32.9	31.7	31.4	30.6	31.7
Atlas	with	25.0	25.0	24.8	29.0	26.0
	without	32.1	32.8	31.2	26.7	30.7
Sugar Drip	with	27.4	26.4	25.3	25.1	26.1
	without	33.3	30.0	33.6	30.1	31.8

TABLE III

ANALYSIS OF VARIANCE FOR THE PERCENT DRY MATTER OF THE STALKS FROM PERKINS, VANOSS SANDY LOAM

Source of Variation	d.f.	Sum of Squares	Mean Square	F
Total	23	289.76		
Reps.	3	11.32		
Treat.	5	230.91	46.18	14.57**
Error	15	47.53	3.17	

** Indicates significance at the 1% level.

TABLE IV

PERCENT NITROGEN OF THE STALKS FROM
PERKINS, VANOSS SANDY LOAM

	Seed	Rep. I	II	III	IV	Mean
Sumac #1712	with	.390	.445	.370	.510	.429
	without	.515	.670	.655	.660	.625
Atlas	with	.400	.505	.450	.433	.447
	without	.483	.575	.645	.485	.547
Sugar Drip	with	.395	.435	.380	.420	.408
	without	.530	.577	.575	.595	.569

TABLE V

ANALYSIS OF VARIANCE FOR THE PERCENT NITROGEN OF
THE STALKS FROM PERKINS, VANOSS SANDY LOAM

Source of Variation	d.f.	Sum of Squares	Mean Square	F
Total	23	0.212182		
Reps.	3	0.023175		
Treat.	5	0.155886	0.031177	14.12**
Error	15	0.033121	0.002208	

** Indicates significance at the 1% level.

TABLE VI

PERCENT DIGESTIBLE NUTRIENTS OF THE STALKS FROM PERKINS, VANOSS SANDY LOAM

	Seed	Rep. I	II	III	IV	Mean
Sumac #1712	with	71.10	70.20	71.89	72.74	71.48
	without	75.68	76.36	75.87	75.68	75.90
Atlas	with	69.60	69.00	70.32	70.40	69.83
	without	71.77	73.10	73.10	73.58	72.89
Sugar Drip	with	73.58	72.25	74.43	73.22	73.37
	without	77.32	75.87	77.92	75.99	76.78

TABLE VII

ANALYSIS OF VARIANCE FOR THE PERCENT DIGESTIBLE NUTRIENTS OF THE STALKS FROM PERKINS, VANOSS SANDY LOAM

Source of Variation	d.f.	Sum of Squares	Mean Square	F
Total	23	149.6982		
Reps.	3	4.3481		
Treat.	5	137.2370	27.4474	50.7439**
Error	15	8.1131	0.5409	

** Indicates significance at the 1% level.

TABLE VIII

PERCENT OF DRY MATTER IN STALKS AND HEADS
FROM THE VARIOUS PLOT LOCATIONS

	Seed	Perkins Vanoss	Perkins Norge	Still-water Port	Stalks Mean 3 Loc.	Heads
Sumac #1712	with	24.0	26.4	33.0	27.8	52.5
	without	31.7	31.2	34.6	32.5	46.3
Atlas	with	26.0	26.4	30.6	27.7	54.5
	without	30.7	33.1	31.7	31.8	46.9
Sugar Drip	with	26.1	27.0	29.3	27.5	45.3
	without	31.8	31.8	29.9	31.2	45.0

TABLE IX

AVERAGE PERCENT DRY MATTER WITH ALL VARIETIES
AND ALL LOCATIONS COMBINED

Seed	Stalks	Heads
with	26.5	50.8
without	31.6	46.1

TABLE X

PERCENT OF NITROGEN IN STALKS AND HEADS FROM THE VARIOUS PLOT LOCATIONS

	Seed	Perkins Vanoss	Perkins Norge	Still-water Port	Stalks Mean 3 Loc.	Heads
Sumac #1712	with	.429	.500	.515	.481	1.19
	without	.625	.670	.645	.647	0.96
Atlas	with	.447	.535	.420	.467	1.16
	without	.547	.725	.725	.666	1.13
Sugar Drip	with	.408	.465	.535	.469	1.31
	without	.569	.610	.620	.600	1.09

TABLE XI

AVERAGE PERCENT NITROGEN WITH ALL VARIETIES AND ALL LOCATIONS COMBINED

Seed	Stalks	Heads
with	.450	1.22
without	.609	1.06

TABLE XII

PERCENT OF DIGESTIBLE NUTRIENTS IN STALKS AND HEADS FROM THE VARIOUS PLOT LOCATIONS

	Seed	Perkins Vanoss	Perkins Norge	Still-water Port	Stalks Mean 3 Loc.	Heads
Sumac #1712	with	71.48	74.55	75.03	73.69	75.51
	without	75.90	78.41	76.84	77.05	65.62
Atlas	with	69.83	71.29	70.32	70.48	82.03
	without	72.89	75.99	72.98	73.95	69.00
Sugar Drip	with	73.37	72.62	74.31	73.43	79.73
	without	76.78	80.46	77.44	78.23	66.22

TABLE XIII

AVERAGE PERCENT DIGESTIBLE NUTRIENTS WITH ALL VARIETIES AND ALL LOCATIONS COMBINED

Seed	Stalks	Heads
with	72.05	79.09
without	75.80	66.95

er values in the with-seed heads as reported in Tables VIII, X, XII, and XIV. The total plant yield and the proportion of dry matter, nitrogen, and digestible nutrients in the stalks and heads are shown in Table XIV. In every case, except for nitrogen in Sumac #1712, the plants without seed development had a higher total yield than the plants with seed development. The statistical significance of these differences is not known.

Another point of interest noted in this problem was the formation of side branches on several of the plants that did not develop seed. No actual measurements were taken as to the quantity or quality of these side branches; however, Willaman et al. (32) stated that many analyses showed that the suckers had a composition very similar to that of the main canes at the same stage of maturity, but the suckers were always several stages behind the main canes in development.

In the juice samples of Sugar Drip that were analyzed for sugars, more nutrients were present in the without-seed plants, as is illustrated by Table XV. The Brix° scale indicates the amount of soluble solids in a juice; however, the Brix° reading is usually a little high because of colloidal insoluble impurities in the juice. The amount of soluble solids is an estimate of the total sugars. There was a decrease in the reducing sugars and an increase in the sucrose in the without-seed plants; thus, the accumulation of total sugars can be attributed to the increase in sucrose rather than reducing sugars.

These data seem to support the evidence that the seed is developed at the expense of nutrients from the stalk. If this is true, then the next question is whether or not the seed is of any benefit on forage

TABLE XIV

TOTAL PLANT YIELD AND PROPORTION OF (A) DRY MATTER, (B) NITROGEN, AND (C) DIGESTIBLE NUTRIENTS IN THE STALKS AND HEADS FROM STILLWATER, PORT LOAM

(A) DRY MATTER

		Grams			% Total	
	Seed	Stalks	Heads	Total	Stalks	Heads
Sumac #1712	with	465	235	700	66.4	33.6
	without	562	149	711	79.0	21.0
Atlas	with	630	269	899	70.1	29.9
	without	812	179	991	81.9	18.1
Sugar Drip	with	519	244	763	68.0	32.0
	without	671	172	843	79.6	20.4

(B) NITROGEN

		Grams			% Total	
	Seed	Stalks	Heads	Total	Stalks	Heads
Sumac #1712	with	2.39	2.80	5.19	46.1	53.9
	without	3.62	1.43	5.05	71.7	28.3
Atlas	with	2.65	3.12	5.77	45.9	54.1
	without	5.89	2.02	7.91	74.4	25.6
Sugar Drip	with	2.78	3.20	5.98	46.5	53.5
	without	4.16	1.87	6.03	68.9	31.1

(C) DIGESTIBLE NUTRIENTS

		Grams			% Total	
	Seed	Stalks	Heads	Total	Stalks	Heads
Sumac #1712	with	349	177	526	66.3	33.7
	without	432	98	530	81.5	18.5
Atlas	with	443	221	664	66.8	33.2
	without	593	124	717	82.8	17.2
Sugar Drip	with	386	195	581	66.5	33.5
	without	520	114	634	82.0	18.0

sorghums that will be fed to livestock, principally in the form of silage.

TABLE XV

YIELD OF SOLIDS AND SUGARS IN JUICE SAMPLES OF SUGAR DRIP STALKS TAKEN FROM THE PERKINS NORGE LOAM PLOTS

	% Volume of Juice			Sugars		
Seed	Solids	Acidity N/10/100 ml.	Brix°	Red.	Suc.	Total
with	11.96	24	15.2	3.14	8.77	11.91
without	16.90	37	20.4	1.89	14.60	16.49

Note: Analysis made by Dr. James E. Webster, Biochemistry.

There is much evidence showing the inability of livestock to completely digest the whole grain of sorghums. Heading sorghums before ensiling has actually been recommended, according to Becker and Gallup (3), but the economic feasibility of this is questioned.

Therefore, if very little of the grain or seed of sorghums is utilized by the animal, and if there is actually the possibility of getting more nutrients from plants that do not develop seeds, then a seedless forage sorghum type might be beneficially utilized.

As has been stated previously, sterile forage hybrid plants can be produced by the present plant breeding techniques in sorghum, but the advantage in producing sterile hybrids rather than fertile hybrids is not known.

Realizing that the data presented herein are preliminary, a conclusive statement cannot be made. However, based on these data, some advantages in producing sterile hybrid plants seem apparent.

Much more work along this line is needed. It is hoped that the working of this problem has been of some help in showing what future work is needed and possibly how some of the future problems may be approached.

SUMMARY AND CONCLUSIONS

A study was conducted on the Oklahoma State University Perkins Agronomy Research Station and the Agronomy Research Station at Stillwater in the summer of 1958 to determine the effect of normal vs. abnormal seed development on the dry matter, nitrogen, and digestible nutrient content of the three sorgo varieties, Sumac #1712, Atlas, and Sugar Drip. The primary objective was to obtain information on the value of sterile or seedless forage hybrid plants.

Three locations were used, one with four replications, and the other two with one replication each.

The abnormal seed development in this instance was the failure of seed to develop due to severe infestations of the sorghum midge *Contarinia sorghicola* during the summer of 1958. The normal seed development was obtained by protecting the sorghum heads from the midges by means of paper bags.

Stalks of representative plants from each location and heads of plants from the Stillwater location were analyzed for dry matter, nitrogen, and digestible nutrients. In every determination of dry matter, nitrogen, and digestible nutrients, there was a higher percent in the stalks of the plants without seed than in the stalks of the plants with normal seed. The analyses of the head samples showed higher values in the with-seed heads than in the without-seed heads. The total plant yields showed slight differences in favor of the without-seed plants.

Two samples of juice were taken from the Sugar Drip variety in the Perkins Norge loam plots and were analyzed for sugars. Results showed a 38% increase in total sugars in the stalks of the without-seed plants over the stalks of the with-seed plants.

Since there is evidence that very little of the whole seed of sorghums is utilized by livestock and there is the possibility of getting more nutrients from seedless plants, then it appears that a sterile forage sorghum type might be beneficially utilized and that there would be an advantage in producing sterile hybrid plants.

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