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An Analysis of Seed Production of Native Kansas Grasses During The Drought of 1939

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AN ANALYSIS OF SEED PRODUCTION OF NATIVE KANSAS GRASSES DURING THE DROUGHT OF 1939

being

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A C K N O W L E D G M E N T S

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I N T R O D U C T I O N

The present interest in the control of soil erosion and the stabilization of agriculture has initiated a great amount of research to find suitable grasses and methods for restoring grass production. The results of these investigations have shown that the native climax grasses are best suited for reseeding in arid and semi-arid regions (10, 13).

Large quantities of native grass seed are needed to stabilize and to restore production on many acres of eroded, submarginal farm land. Native pastures damaged by drought, dusting, and overgrazing are now in need of additional native grass seed to restore their normal forage production.

Research men, who attempt to develop better strains of native grasses by selection and breeding, need more information pertaining to the seed producing ability of native grasses in order to enable them to judge their selections.

This needed information is not available in publications on native grasses because of the failure to record the seed yields clearly. In most cases germination tests were used as the standard by which grass seed was measured.

This test is not an adequate measure of grass seed yields, and its use has led to considerable confusion. Some investigators have used the Irish system of measuring germination; this system is based on the number of sprouts from a hundred florets. Others have used the procedure of the American seed testing laboratories, a system based on the per cent of caryopses producing sprouts.

The use of these two systems of measuring germination may explain why a certain species of grass showed very low viability in one study, while in other studies the same species of grass showed high viability. Sarvis (9), for example, reported that blue grama grass (Bouteloua gracilis) was very low in viability and produced only two or three plants from several hundred seeds sown. Wilson (13), however, obtained an average germination of 40.3 per cent from fifteen samples of blue grama seed collected over a period of seven years.

The caryopses of many native grasses have exhibited delayed germination (3, 5, 8, 11). This type of dormancy has been briefly summarized by Savage (10) as follows:

> Most native grass seeds require an after-harvest ripening period before they will germinate satisfactorily. Their viability usually increases gradually for several months to a year or two after harvest and then it commences to decline rapidly. Best results are obtained from planting seed the second spring, or about eighteen months after harvest.

Native grasses often produce an abundance of flower stalks and the florets attain natural size, but caryopses do not develop within the florets. This and the use of the word "seed" for both spikelets and florets, regardless of whether or not they contain caryopses, has led to further confusion about grass seed yields.

The need for information pertaining to seed yield of native grasses and a method of clearly recording this information suggested the study of which this paper is the report: namely, to make an analysis of seed production of the native grasses of Kansas during the drought of 1939 and to develop a method of clearly recording this information.

R E L A T E D S T U D I E S

Although much experimental work has been done on the germination of the seeds of native grasses, very little has been done on the ability of native grasses to produce caryopses. Anderson and Aldous (2) found a great reduction in the percentage of spikelets that produced caryopses in little bluestem (Andropogon scoparius), when the heads were enclosed in any kind of bag for the purpose of self-fertilization.

Burton (4) reported as follows:

> Numerous studies made with the aid of a seed blower indicate that from 50 to 75 per cent of the florets of many southern grasses often fail to form caryopses.

Stoddart and Wilkinson (11) found that from most collections examined, less than half the florets of Indian Ricegrass (Oryzopsis hymenoides) contained a developed embryo.

Blake (3) examined the seeds of Western wheat grass (Agropyron smithii) and found that many of the glumes were empty.

To the investigator's knowledge, no attempt has been made to study and record the percentage of florets of native grasses that produce caryopses during any definite growing season.

ENVIRONMENTAL CONDITIONS

The fall of 1939 offered an unusual opportunity to study the seed yield of native grasses under severe drought conditions. Practically every section of the state received below normal precipitation; the average over the state as a whole was 6.35 inches below normal. The year 1939 was the fifth driest year experienced in Kansas since the state-wide records have been kept. The fall drought, extending from August to the closing days of December, was the most severe on record for this time of year.

The average temperature for the state was 2.9°F. above normal and was only 0.7° below the all time record of 1934. During the months of September, October, and December, new high temperature records for the state were established. The mean monthly temperatures for July, September, and October, 1939, were 4.3, 5.7, and 3.9°F. respectively, above normal.

The evaporation from a free water surface at Hays, Kansas, during the months of April to September, inclusive, was 60.89 inches, which was about 25 per cent more than the thirty-two year average.

In general, the months of July to October, inclusive, the period when flowering and seed formation take place in most of the native grasses of Kansas, was characterized by extremely low precipitation, low relative humidity, and high temperatures and wind movement.

EXPERIMENTAL PROCEDURE

Collection of Samples

The map of Kansas (Fig. 1) indicates the places where samples of grass seed were collected. An attempt was made to collect seed from all the grass regions of Kansas outlined by Aldous (1). Each black dot represents a sampling of all the more important species present at the location. The number of species present at a location

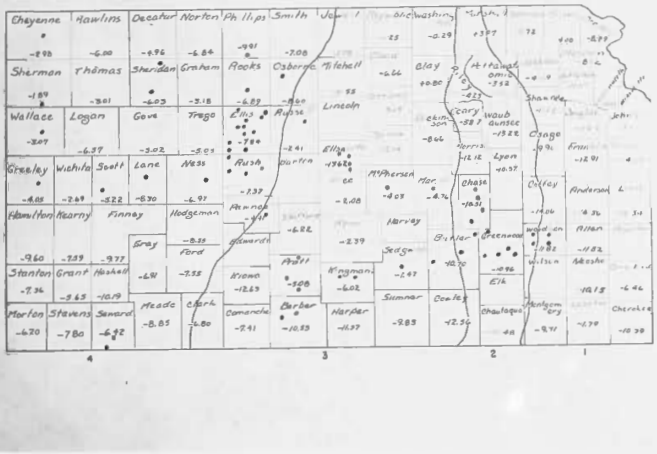

FIG. 1 Locations where samples were collected and major grass regions.

. = Location where seed was collected.

varied from one to eight. Heads were collected from flower stalks scattered over the general habitat.

The vegetation in the bluestem region is composed largely of the two bluestems, side-oats grama, switchgrass (Panicum virgatum), Indian grass (Sorghastrum nutans), big dropseed (Sporobolus asper), and hairy grama (Bouteloua hirsuta). Figure 2 illustrates the general appearance of the vegetation in the bluestem region at the time samples were collected.

FIG. 2 Typical view of bluestem vegetation near Teterville, Kansas. Oct. 20, 1939.

The region of mixed-bluestem and short-grass region is composed mainly of the short grasses, buffalo (Buchloe

dactyloides) and blue grama, with the grasses of the bluestem region occurring in the more mesic habitats such as north slopes and ravines. Figure 3 shows the general topography of this region and the appearance of the vegetation in October, 1939.

FIG. 3 General view of the mixed prairie region near Ellsworth, Kansas. Oct. 20, 1939.

In the short-grass region, buffalo and blue grama grasses are the dominant species, with the major grasses of the bluestem region occurring sparingly in the most favorable habitats.

Figure 4 portrays the condition that exists in much of the region where sand sage (Artemisia filifolia) has come in as the result of drought and overgrazing.

FIG. 4 Picture taken four miles south of Sun City, Kansas. Oct. 22, 1939.

Each sample was placed in a paper bag and the date, location, habitat, soil type, etc. recorded at the time of collection.

The sample was next brought into the laboratory and all except side-oats grama (Bouteloua curtipendula) thrashed to the floret stage and filed in heavy paper envelopes.

Analysis of Samples

The determination of the per cent of caryopses present in any sample was made by pouring the entire sample on a piece of cardboard. One hundred florets were then selected by taking a few florets from each portion of the sample. The hundred florets selected were spread in a single layer on a glass plate, illuminated from below by electric light. Empty florets were transparent, while those containing caryopses, unopened anthers, or smut were opaque. All florets that appeared to contain caryopses were examined with tweezers in order to eliminate those diseased or with unopened anthers.

Ten counts of one hundred florets each were made on a sample of hairy grama and big bluestem (Andropogon furcatus) to determine the variations in per cent of florets yielding caryopses from different counts. The results from the counts on the sample of hairy grama showed 25 per cent caryopses on the first count, an average of 19.9 for the ten counts, and a range of 14 to 26 per cent. Big bluestem yielded 29 per cent caryopses on the first count, averaged 29.7 for the ten counts, and ranged between 26 and 40 in per cent of caryopses. These results indicate that an analysis of one hundred florets gave about the same percentages as an analysis of a thousand florets.

In all cases where the first hundred florets examined failed to yield any caryopses, a second hundred florets were examined. Only about once in fifteen cases did an analysis of the second hundred florets yield even a single caryopsis.

The results of the above tests indicate that the percentages of caryopses shown by an analysis of one hundred florets were very close to the actual percentages for the whole sample.

The advantages of using the caryopses count in recording native grass seed yields are: (1) It is not necessary to determine the number of caryopses that are dormant, because all healthy caryopses will germinate when their dormancy is broken; (2) Very little apparatus is required; (3) The method is simple enough that the layman can use it even in the field; and (4) It can easily be changed to caryopses per head or per plant by determining the number of florets per head or per plant.

The studies of Blake (3) showed some of the problems of determining the germinating ability of the seeds of native grasses. She studied germination in the seed of seven native grasses at intervals of about two months for a year following the collection of seeds in the fall of 1930. She reports:

> Power of germination increased gradually from very low or none at harvest time to a maximum in mid-spring.

She further states:

> Monthly fluctuations of considerable magnitude were the rule with all species.

Her annual testing of grass seeds from two and one-half to five and one-half years after they were placed in dry storage at room temperatures showed that big bluestem germinated better when stored three and one-helf years than it did when stored only two and one-half years. She also found that Indian grass and big dropseed gave their maximum germination in the sixth year after harvest.

Wilson (13), in New Mexico, tested the germination of native grasses for range planting possibilities. His extensive tables give dates of planting and percentages of germination which show that aging when the seeds were stored at room temperatures, had a tendency to increase the percentages of germination. Sixty-eight of the one hundred nine cases showed increased germination with age, and twenty-two cases neither increased or decreased.

The germinating ability of the seed of native grasses is not easily determined; only with complete germinating equipment and recently developed scientific procedure can this ability be measured with any degree of accuracy. This equipment and information are not available to many investigators and ranchers. Therefore, caryopses count was believed to be the best method to use in measuring the yields of native grass.

PRESENTATION OF FINDINGS

Big dropseed yielded a greater percentage of caryopses per hundred florets than any of the other grasses studied. It yielded an average of 90.8 caryopses per hundred florets and varied from 69 to 100 per cent caryopses in the seventeen samples examined. This grass has increased in abundance in the Kansas bluestem pastures during the present cycle of years with below normal rainfall (Table I).

The explanation for this increase may lie in the ability of this grass to produce an abundance of caryopses when the more valuable species produced none or very few.

Big bluestem, one of the dominant species of the bluestem region of Kansas and found in the more mesic places throughout the state, yielded few caryopses except in places where the climatic conditions were ameliorated. Thirteen of the forty-three samples failed to yield any caryopses. The average yield for the forty-three samples was 10.7 per cent, with a range of 0 to 52 per cent. Twenty-four samples collected in previous years averaged 35 per cent caryopses.

Little bluestem, the other dominant species of the bluestem region, showed considerably poorer caryopses yields. This was unexpected because the average yield of little bluestem from former years' collections was about

TABLE I

CARYOPSES YIELD PER HUNDRED FLORETS FROM 1939 SAMPLES AND NORMAL YIELDS

Species	Common name	Number samples	Average yield %	Variation per cent	*Normal yield %
Bouteloua gracilis	Blue grama	61	3.5	0 - 38	20
Bouteloua curtipendula	Side-oats grama	33	3.4	0 - 20	20
Bouteloua hirsuta	Hairy grama	26	15.0	1 - 48	
Andropogon furcatus	Big bluestem	43	10.7	0 - 52	35
Andropogon scoparius	Little bluestem	41	3.5	0 - 25	36
Sorghastrum nutans	Indian grass	36	3.0	0 - 26	40
Sporobolus asper	Big dropseed	17	90.8	59 - 100	

* Based on samples collected previous to 1939.

the same as for big bluestem. Both bluestems were collected from the same habitat twenty-two times; fifteen times big bluestem yielded the larger per cent of caryopses, while little bluestem gave the greater yield only twice; furthermore, in five habitats both species failed to produce any caryopses.

Indian grass, a species distributed throughout the state, showed about the same seed set as little bluestem. Only the samples collected from protected habitats produced any caryopses. Seventeen of the thirty-six samples failed to yield any caryopses. Only eight seed samples of this species were available from previous years, but these averaged 40 per cent caryopses. The average yield from the 1939 samples was only 7.5 per cent of the average caryopses yield of the samples collected in other years.

Hairy grama yielded a larger per cent of caryopses than any of the other more valuable prairie grasses. This species was found in all the counties where grass seed was collected. Of the twenty-five times that this grass was collected from the same habitat with other species studied, it out-yielded all others except big dropseed. Since hairy grama flowers earlier than most of the other species studied, it may have been able to escape the severe drought conditions of the latter part of August and September.

Blue grama, one of the dominant grasses of both the short-grass region and the mixed-prairie region, produced

very few caryopses. One-half the samples analyzed yielded no caryopses and only those samples collected from habitats in which the climatic factors were ameliorated produced over 2 or 3 caryopses per hundred florets.

Side-oats grama, a valuable forage species throughout the state, showed the same extremely low yield as did blue grama. This grass, along with big bluestem, was collected from the same habitat fifteen times. Big bluestem gave the greatest yield eight times, side-oats grama, four times, and three times neither species produced any caryopses. Of the eight times that side-oats grama and blue grama were collected from the same habitat, the former gave the greatest yields twice and the latter three times.

Discussion

An analysis of seed samples of the same species of grass collected from different sections of the state did not show caryopses yields to be consistently higher in any section of the state. The explanation for this was believed to be that any species of grass was usually found growing in habitats of similar growing conditions regardless of the section of the state from which it was collected. Big bluestem, for example, was found in abundance on the high prairie in the blue stem region of eastern Kansas where the precipitation is about 30 inches

annually. In the western section of the state, however, where the annual precipitation is about 20 inches, it was found only in the more mesic places such as ravines, "buffalo wallows," and roadside ditches.

The comparative study of seed samples collected from opposite slopes in the same pastures did not show that more caryopses were produced on any certain clope.

There was no indication that any one climatic factor determined the yield of caryopses in native grasses. Highest yields were produced only in places where all the climatic factors were least intense.

Apparently the fall drought of 1939 was severe enough to prevent the native grasses from producing caryopses except in the most protected areas. Also, the intensity of the drought may have prevented slight variations in habitats from manifesting such in the caryopses yields.

EFFECTS OF CLIMATIC FACTORS ON PRODUCTION

To determine the effects of different climatic factors upon the production of caryopses in the native grasses, a study was made of the seed collected in Ellis county during 1937, 1938, and 1939.

There was considerable variation in the climatic conditions during these three years (Tables II, III, IV,

TABLE II

MONTHLY AND SEASONAL EVAPORATION FROM A FREE WATER SURFACE (INCHES)*

Year	April	May	June	July	August	September	Seasonal
1937	6,827	8,417	9,896	11,483	11,783	7,879	56,285
1938	5,222	4,722	7,724	11,201	12,442	7,752	49,063
1939	5,901	9,525	11,251	13,597	9,846	10,770	60,890
1907-1938	5,852	6,761	8,429	10,471	9,596	7,377	48,486

* Data on evaporation was secured from measurements made at Hays, Kansas, by the Division of Dry Land Agriculture, Bureau of Plant Industry, United States Department of Agriculture.

TABLE III

MONTHLY WIND MOVEMENT AT HAYS, KANSAS*

Year	April	May	June	July	August	September	Seasonal
1937	325.4	288.0	263.1	226.1	243.7	221.7	945.6
1938	354.4	236.6	206.6	209.4	277.3	195.2	887.5
1939	313.7	296.6	295.3	262.4	224.0	269.0	1040.7

* Data on wind movement was secured from measurements made at Hays, Kansas, by the Division of Dry Land Agriculture, Bureau of Plant Industry, United States Department of Agriculture.

TABLE IV

PRECIPITATION AT HAYS, KANSAS, DURING 1937 to 1939, INCLUSIVE*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Dep. from Normal
1937	0.94	0.39	0.43	0.38	1.49	2.68	4.94	2.82	1.62	1.59	0.40	0.18	17.87	-5.83
1938	0.06	0.65	1.87	2.58	8.21	2.73	1.08	2.47	2.13	0.03	0.30	T	22.11	-1.58
1939	0.48	1.05	0.98	1.65	1.00	4.71	1.04	3.53	0.42	0.18	0.11	0.70	15.85	-7.84

* Data on precipitation was secured from measurements made at Hays, Kansas, by the Weather Bureau, United States Department of Agriculture, Topeka, Kansas.

and V). The greatest annual precipitation occurred in 1938, but the seasonal precipitation for the four months, June to September, inclusive, was the least during this year. The highest precipitation for the four-month period occurred during 1937.

In general, the caryopses yield of the native grasses, that normally flower and mature seed during this four-month period, was highest from the 1937 crop (Tables VI and VII). The fact that the highest caryopses yield and precipitation for the four-month period occurred during 1937 indicates that soil moisture during the period of flowering and seed maturing was the controlling factor in seed production. Soil moisture samples taken weekly in the college pasture at Hays, Kansas, showed that moisture was available during 1937, except the weeks beginning May sixth and twenty-sixth and August twenty-ninth. Hence, during the season of 1937 no period over one week in length was without available soil moisture for plant use. Soil samples from the same area in 1938 showed that no moisture was available for plant use from the week beginning July eleventh to August fifteenth, and from August twenty-ninth to October fifteenth, making moisture unavailable for plant use for a continuous period of five weeks. The condition for 1939 was similar, with no available moisture from the week beginning July eleventh to August seventh, a period of four weeks.

TABLE V

MEAN MONTHLY TEMPERATURE AT HAYS, KANSAS, DURING 1937 to 1939, INCLUSIVE*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	Dep. from Normal
1937	18.4	31.2	39.6	53.9	67.2	74.4	82.2	84.1	71.3	56.2	40.6	31.1	54.2	+ .03
1938	33.9	36.0	49.0	53.9	62.0	72.6	82.0	83.7	72.1	64.0	41.4	35.2	57.2	+3.3
1939	22.8	28.7	43.2	53.7	68.6	75.4	84.7	78.0	75.2	59.7	43.0	37.2	55.8	+1.9

* Data on temperature was secured from measurements made at Hays, Kansas, by the Weather Bureau, United States Department of Agriculture, Topeka, Kansas.

TABLE VI

SHORT-GRASSES COLLECTED IN ELLIS COUNTY

Per cent Caryopses	Date collected	Habitat	Location
		Bouteloua gracilis	
09	1937	highland	College pasture
07	1938	highland	College pasture
00	1939	highland	1 E Hays
00	1939	highland	7 E Hays
06	1939	N. slope	N Hays
00	1939	highland	2 E Hays
01	1939	highland	15 S Ellis
00	1939	highland	12 N 10 E Hays
00	1939	lowland	12 N 10 E Hays
00	1939	highland	2 W Hays
00	1939		5S Hays
		Bouteloua hirsuta	
03	1937	rocky slopes	
03	1938	rocky slopes	
17	1939	rocky slopes	9 N 7 E Hays
20	1939	rocky slopes	College pasture
06	1939	rocky slopes	15 S Ellis

TABLE VII

TALL-GRASSES COLLECTED IN ELLIS COUNTY

Per cent Caryopses	Date collected	Habitat	Location
		Andropogon furcatus	
39	1937	Ravine	College pasture
62	1937	Ravine	Campus
13	1938	Ravine	College pasture
20	1939	Ravine	5 Mi. S Hays
00	1939	bottom land	9 N 7 E Hays
00	1939	winter pasture	9 N 7 E Hays
30	1939	roadside ditch	½ Mi. W Hays
		Andropogon scoparius	
51-	1937		College pasture
20	1938		College pasture
05	1939	east slope	College pasture
00	1939	west slope	N. Hays
		Sorghastrum nutans	
30	1937	Ravine	College pasture
18	1938	Ravine	S. Hays
01	1939	Ravine	College pasture
02	1939	Ravine	N. Hays
		Bouteloua curtipendula	
22	1937	slopes	College pasture
03	1938	south slope	College pasture
20	1939	east slope	College pasture
04	1939	low ground	N. Hays
01	1939	east slope	15 Mi. S. Ellis
09	1939	north slope	N. Hays
00	1939	Ravine	5 S Hays
06	1939	Buffalo wallow	3 E 5 S Hays
01	1939	east slope	9 N 7 E Hays

Discussion

Hairy grama was the only species that produced more caryopses in 1938 or 1939 than it did in 1937. Hairy grama gave its greatest yield in 1939. This species usually flowers earlier than the other grasses and probably was able to mature its seed before the soil moisture was exhausted.

The study of native grasses during these three years would indicate that the production of caryopses correlates closely with the available soil moisture during the period of flowering and seed maturity, and that other climatic factors were indicators of caryopses production to whatever extent they affected soil moisture.

S U M M A R Y

The purpose of the study was to determine the production of caryopses in the native grasses of Kansas during the drought of 1939. Samples of native grass seed were collected from all the grass regions of the state of Kansas. These samples were analyzed to determine the per cent of perfect and staminate florets containing caryopses.

The method of recording the seed set of the native grasses studied was the per cent of caryopses per hundred florets. Although this method of recording seed set has been used but very little in the past, its use by investigators should clarify the confusion that now exists in

literature pertaining to the production of caryopses by native grasses.

Big dropseed yielded the largest per cent of caryopses of all the grasses studied. From seventeen samples, it showed an average yield of 90.8 caryopses per hundred florets.

Hairy grama gave an average yield of 15 per cent from twenty-six samples, the highest average yield shown by all of the more valuable grasses. When collected from the same location, this species consistently out-yielded all other grasses except big dropseed.

All other species studied yielded very few caryopses except when collected from places where drought conditions were less intense.

Analysis of seed samples of the same species of grass collected from different sections of the state did not show caryopses yields to be consistently higher for any section.

Comparative study of the caryopses yields from different slopes did not show that higher yields were produced on any certain slope. This was believed to be caused by the fact that the fall drought of 1939 was severe enough to prevent the production of caryopses except in the more protected areas.

A study of the seed of the native grasses collected during 1937, 1938, and 1939 in Ellis county, Kansas, was made to determine the effect of different climatic factors

upon the production of native grasses.

This study indicated that the production of caryopses by native grasses correlated with the available soil moisture during the period of flowering and seed maturing, and that other climatic factors were indicators of caryopses production to whatever extent they affected soil moisture.

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