LEAF NUMBERS AND VEGETATIVE PERIOD

OF A

SORGHUM CROSS

LEAF NUMBERS AND VEGETATIVE PERIOD OF A SORGHUM CROSS

By

THOMAS SIDNEY CUNNINGHAM

Bachelor of Science

Oklahoma A. and M. College

Stillwater, Oklahoma

1942

Submitted to the Department of Agronomy

Oklahoma Agricultural and Mechanical College

In Partial Fulfillment of the Requirements

for the Degree of

MASTER OF SCIENCE

1944

APPROVED BY:

John B. Seiglinger.
Chairman, Thesis Committee

Frank Davies
Member of the Thesis Committee

J. F. Murphy
Head of the Department

D. G. McIntosh
Dean of the Graduate School

ACKNOWLEDGMENT

The writer wishes to express sincere appreciation and gratitude to his major advisor, Mr. Frank F. Davies, Professor of Agronomy, for his advice, ready assistance, constructive criticism, and unfailing encouragement; to Mr. John B. Sieglinger, Agronomist of the United States Department of Agriculture, for his many helpful suggestions in planning the experiment, for furnishing the materials needed for the study, and constructive criticism in organizing the data; and to Dr. H. F. Murphy, Head of the Agronomy Department, for his cooperation in making this work possible and for his beneficial suggestions, and to all faculty members under whom the required work was done.

TABLE OF CONTENTS

A--Early Juicy parent. B--Two rows of F2's. C--Nine rows of F3.

INTRODUCTION

To understand better the genetic and physiological interrelationship of the leaf numbers on the main stalk of sorghums (Sorghum vulgare Pers.) an intervarietal cross has been studied, in which careful leaf counts were made and the data analyzed to determine the existing relationship.

The vegetative period of the sorghum crop is of considerable economic importance to the grower. Apparent casual observations indicate in a general way that as the vegetative period increases, the yield of forage tends to become correspondingly greater. Not only is this expression of leafiness of interest to the producer, but also it is an important characteristic to be considered by the plant breeder.

The counting of leaves is not a new study; however, the majority of workers on this subject have taken into consideration only those leaves that are above ground level after the plant is approaching maturity. Obviously this method is lacking in exactness, since it is commonly known that the lower leaves die and dry up before the plant reaches maturity. Also in the process of cultivation it is not likely that the same number of leaves on the individual stalks will be covered below ground level. The sorghum plant resembles other cereals in that the number of leaves is analogous with the number of nodes. Since leaves are easier to count and are more readily observed than nodes, they have been used for this study.

Sieglinger (8) had made a study of leaf numbers using standard varieties and an F3 population of a cross between Dwarf Freed sorgo and Early dwarf feterita. The need for further investigations using controlled crosses was recognized and accordingly this study was inaugurated.

REVIEW OF LITERATURE

A study of the literature reveals that only a few workers have given consideration to the problem. Major contributions are found in the work of J. B. Sieglinger, of the United States Department of Agriculture, working at the Southern Great Plains Field Station, Woodward, Oklahoma. Sieglinger (8) notes that the number of leaves is not a fixed varietal characteristic, as had previously been assumed, but that the number varies with the date of planting, locality, and season as well as variety, showing that environment is an important factor.

Vinall (10) in studying the effect of temperature on the growth of sorghum, found a variation of three leaves in Blackhull kafir and six leaves in Sumac sorgo, both standard varieties, when grown under different climatic conditions. From this study he concluded that unfavorable conditions of growth cause a reduction in the number of leaves.

Rangaswami (5) suggests that the vegetative period is best expressed in terms of the number of days from planting to flowering of the first spikelets in the head. A modified form of this method, using the number of days from emergence to flowering of the first spikelets in the head, was used in this study.

Kuleshov (3) in working with corn, used the number of leaves on the main stem as an index to the length of the vegetative period, recognizing it as being less variable than other methods of determination.

Sieglinger (8) found that the vegetative period increased from 2.8 to 3.5 days for each additional leaf a plant produces, with an average of 3.3 days per leaf for all varieties under observation. From a study of twenty-one varieties the relationship of leaf numbers to the vegetative period was shown by a high positive correlation of 0.853 ± 0.029.

Also studying a population from an F3 generation, he obtained a correlation of 0.836±0.014. Davidowicz (1) reports a positive correlation of leaf numbers with the vegetative period in tobacco. Vinall (11) in describing varietal characteristics of sorghums states that the number of leaves is directly correlated with the period of maturity of varieties. Rangaswami (6) noted that the number of nodes increases with the duration of time in relation to maturity.

It is interesting to note that a mechanical reduction of leaf area prolongs the vegetative period. Eidelman (2) working with wheat showed that clipping off areas of leaves delayed the date of first blooming as much as eight days. Undoubtedly such a delay can only be due to a physiological disturbance of the normal plant processes, which is a point to be kept in mind, and should be taken into consideration when destructive forces that occur naturally, mutilate and reduce leaf area.

While the number of leaves is closely associated with maturity, there does not seem to be any correlation with grain yields. Swanson (9) recorded a variation in leaf numbers required to produce a bushel of grain, as varying from 4,000 to 11,400, depending upon the variety and season.

Other related factors include Kuleshov's (3) observation of the height in different varieties of corn which tended to vary in relation to the length of the growing season. Shafer (7) found a positive correlation between the total dry matter produced and the weight of dry shelled grain in Zea mays. Martin (4) found that the height of stalks of sorghum within a given variety is highly correlated with grain yield. While these findings do not bear directly upon the problem at hand, they are closely related and are worthy of recognition in a study of this type.

MATERIALS AND METHODS OF PROCEDURE

The data for this discussion were obtained at the Southern Great Plains Field Station, Woodward, Oklahoma, and is a compilation of two year's observations. The material studied consisted of a hybrid beginning in the F2 generation, and was carried into the F3. Both parents were used as checks. The F3 population consisted of nine selections which were made on the basis of plant height. The nine selections were planted by the head to row method which resulted in obtaining a heterogeneous distribution. The parents used in making this cross were Early Juicy sorghum and Big-seeded sorghum C. I. No. 692. Early Juicy is a fixed selection from a cross of Dwarf Freed sorgo, C. I. No. 971, and Early Dwarf feterita, C. I. No. 867, and is characterized by being short, averaging from eighteen to twenty-four inches in height, having small white seed, a juicy stalk, and maturing in fifty to sixty days. Big-seeded sorghum, an introduction from tropical Africa, is a tall plant ranging up to one hundred inches or more in height. It has large yellow seed, a dry stalk, and is extremely late in maturity. Often it is so late that its growth is terminated by frost before it can mature seed. The two parents are representative of extremes in their varietal characteristics, making a wide intervarietal cross.

The stock seed for this work was furnished by Mr. John B. Sieglinger who made the original cross in 1940 and grew the F1 population in 1941.

In the two years 1942 and 1943 the planting was done on June 17 and 18 respectively. A stand was secured four days after planting in each year. In each year leaf counting began thirteen days after planting. It was necessary to begin at this early date as it is characteristic of the sorghum plant to shed its lower leaves as it progresses

toward maturity.

Disregarding the shedding of leaves it was also desirable to make the initial count before the first cultivation, to insure against inaccuracy caused by a covering up of some of the lower leaves. In making the first count the fifth leaf was cut off at an oblique angle to the plant. This leaf stub was used as a marker for the beginning of subsequent counts. In order to mark later leaves in a way that they would be readily identified and still incur a minimum of damage to the plant, ticket punches with different shaped dies were used. In this manner the 10th, 15th, 20th, and in some instances the 25th, leaves were counted and punched on either side of the midrib. By this method it was possible to keep an accurate record of the individual plants. The final count was made when the flag leaf appeared, at which time each plant was tagged and a daily inspection made thereafter with the following information recorded: (1) total number of leaves, (2) date of first blooming, and (3) height of plant.

From this information coefficients of correlation were obtained for three combinations of the leaf numbers, plant height, and the vegetative period, as recorded in the number of days from emergence to first blooming.

RESULTS OBTAINED

Table 1, page 13, shows the frequency distribution of leaves on the main stalk for the selections under observation. It will be noted that the Early Juicy parent in 1942 had an average of 12.2 leaves per stalk as compared with 10.8 leaves in 1943, a variation of 1.4 leaves for the parent or check variety. This variation could possibly be due to an insufficient population for the 1942 season, or which is more likely, a major difference in the environment for the two years under consideration. This seasonal difference is presented in Chart 1 on page 16. This chart gives the total amount of rainfall during the growing season, subdivided into periods of ten days each. A moving average over three ten day periods is used to smooth out the sharp erratic fluctuations. The F2 population averaged 21.6 leaves, and 21.1 leaves per stalk, respectively, for the two years with an overall variation from 10 to 33 leaves. The F3 population averaged 20.1 leaves per stalk in 1943 with a total variation from 9 to 30 leaves. There were no F3's grown in 1942. The Big-seeded sorghum averaged 28.5 leaves per stalk in 1942. The adverse environmental conditions of 1943 depressed the growth of this heavy-feeding, late-maturing variety to such an extent that it failed to reach the fruiting stage. It will be noted that in the F2 and F3 population the extremes in the leaf number of the two parents were obtained.

The picture on page 1 gives a view of the variation in plant height and leafiness. Because of the untimely termination of growth in the Big-seeded parent no picture could be made of it; however some of the taller plants in the F2 rows are approaching the characteristics of the late parent.

The distribution of plants according to the length of the vegetative

period is shown in Table 2, page 14. The average length of the vegetative period for the early parent in 1942 and 1943 was 36.4 and 35.7 days respectively. For the F2 the average time was 55.0 days in 1942 and 55.3 days in 1943. The F3 had an average vegetative period of 54.0 days in 1943, while the average for the late parent in 1942 was 83.4 days.

Considering only the number of leaves on the main stem, Table 3, page 15, shows the average number of days required per leaf for the plant to reach maturity. In general the early parent with an average of 11.5 leaves required 2.99 days per leaf in 1942, and 3.31 days per leaf in 1943. In the F2, 2.54 days per leaf were required in 1942, with a slight increase, up to 2.62 days per leaf in 1943. The F3 required 2.68 days per leaf and the late parent 2.92 days. Here is shown a smaller average per leaf for the hybrids than for either of the parents.

From the data presented coefficients of correlation were calculated to determine the true relationship of leaf numbers to the other factors. A definite relationship of leaf number to the vegetative period is shown by the following high coefficients.

1. Using the Early Juicy parent
   in 1943, $r^1 = 0.917 \pm 0.011$.

2. Using the F2 population
   in 1942, $r = 0.903 \pm 0.008$;
   in 1943, $r = 0.845 \pm 0.019$.

3. Using the F3 population
   in 1943, $r = 0.820 \pm 0.011$.

Other coefficients of correlation were determined using the F2 population only. For the relationship of plant height to leaf numbers in 1942 the value for r was 0.649 ± 0.025 which is a coefficient that has significance. In 1943 for the same factors, the value for r was

---

[1] r = coefficient of correlation.

0.435 ± 0.056 which probably has some significance but is at variance with the one for the preceding season.

Another combination investigated was plant height to the vegetative period. In 1942 the value for r was 0.654 ± 0.024, while in 1943 the value was 0.207 ± 0.059. Obviously there is in existence some reason which would explain such a variation. It is generally accepted that the climatic conditions are responsible for a great number of fluctuations in plant responses. From the rainfall chart in this discussion it is obvious that while the 1942 season was almost optimum, at least average, and favored normal plant development, the 1943 season was somewhat abnormal and had its depressing effects. Whether this factor alone would explain the variation in the value of the coefficients of correlation for the two factors in the different years cannot be definitely shown from the data presented. Further study along these lines would possibly reveal some information worthy of consideration.

DISCUSSION

The results obtained show that there exists a definite relationship between leaf numbers and the vegetative period of sorghum plants. A high positive correlation between these factors is apparent under diverging types of environment, showing that the relationship of the two factors continues to exist even though outside influences weigh heavily upon them. Conditions which affect one factor likewise affect the other. Therefore, it may be concluded, on the basis of the data presented, that leaf numbers of a variety may be used as an index for the vegetative period of that variety.

From this study it is apparent that although leaf number and the vegetative period has a stable relationship, such is not true of other factors studied. The number of leaves has been suggested to have been correlated with plant height. From the first year's observations that relationship was true; however under the adverse environmental conditions of 1943, in which there was a low rainfall, accompanied with low humidity during the growing season, that relationship was greatly altered. This suggests that the expression of the factor for plant height was subject, within limits, to the influencing environmental conditions. That the expression of the height factor is to some degree controlled by environment is further shown in the study of this factor and its relation to the vegetative period. The high correlation under good growing conditions would lead one to believe that such a relationship did exist, whereas under less optimum conditions the very low correlation would indicate that such a relationship is nil.

Considering the opposing results from the two year's data, it appears that while leaf number may be associated with height, it is not a

stabilized relationship, and that the expression of the height factor is modified somewhat by environment.

SUMMARY

A cross of Early Juicy and Big-seeded sorghum was grown and studied for number of leaves and length of vegetative period.

The parents used represent extremes in leaf numbers. The Early Juicy parent averaged 11.5 leaves per plant. The Big-seeded parent averaged 28.5 leaves per plant.

The average number of leaves for the F2 population was 21.6 and 21.1 leaves per plant for the two years. The F3 population, grown only one year, averaged 20.1 leaves per plant.

The average length of the vegetative period was from 2.54 days per leaf for the F2 to 3.31 days per leaf for the early parent.

The number of leaves and the vegetative period were highly correlated. Coefficients of correlation obtained from different populations were as follows:

Early Juicy	$r = 0.917 \pm 0.011$
F2	$r = 0.903 \pm 0.008$ $r = 0.845 \pm 0.019$
F3	$r = 0.820 \pm 0.011$

The relationship of leaf number to height as well as the interrelationship of plant height and the vegetative period seem to be modified by environment.

Table 1. Showing the frequency and distribution of leaves on the main stalk

Selection	Year	Classes for number of leaves per main stalk																									Plants total	Mean leaves
		9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33		
Early Juicy	1942	-	1	8	21	10	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	43	12.2
Early Juicy	1943	26	87	56	35	20	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	228	10.8
Hybrid F2	1942	-	-	-	5	13	28	34	29	18	16	24	25	33	56	54	51	31	49	45	33	5	3	1	-	1	556	21.6
Hybrid F2	1943	-	2	-	4	3	7	15	19	11	4	7	6	12	15	31	26	20	10	13	6	2	-	-	-	-	213	21.1
Hybrid F3	1943	2	6	19	12	24	36	80	95	59	16	8	29	41	73	106	99	66	31	24	14	10	5	-	-	-	855	20.1
Big-seed. #692	1942	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	16	20	14	8	5	2	1	69	28.5

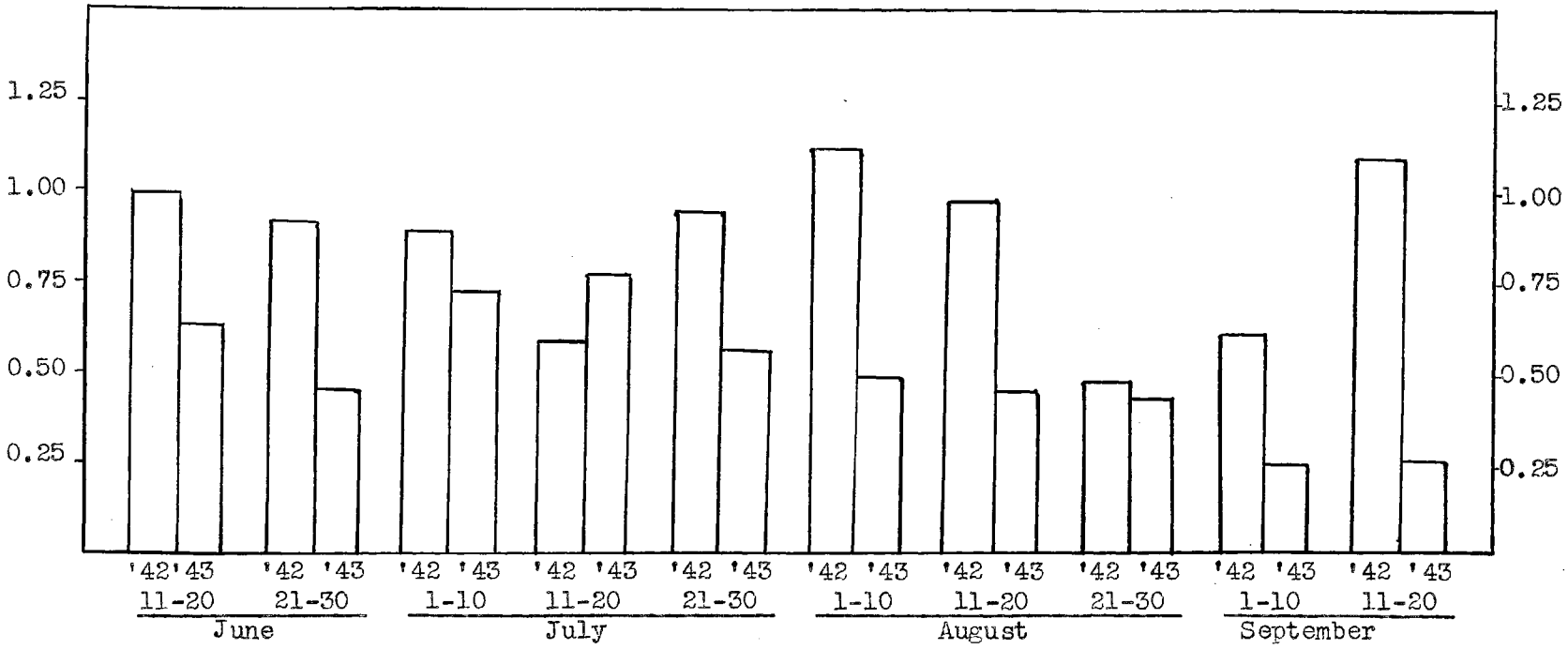
Table 2. Showing the distribution of plants according to time of blooming

Selection	Year	No. of days from emerging to blooming																															Plants Total	Mean days
		30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90		
Ea. Juicy	1942	-	-	2	23	14	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	--	-	-	43	36.4
Ea. Juicy	1943	1	24	82	55	39	16	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	228	35.7
Hybrid F2	1942	-	-	-	12	31	28	27	24	29	28	38	35	34	22	25	25	26	23	32	28	20	32	13	9	7	1	7	-	-	-	-	556	55.0
Hybrid F2	1943	-	1	2	1	6	7	15	15	15	11	12	20	13	4	18	17	3	8	8	3	5	6	5	1	3	-	2	4	2	6	-	213	55.3
Hybrid F3	1943	-	1	8	18	24	37	68	92	62	46	33	40	46	29	41	63	41	38	37	16	11	19	18	2	23	9	5	11	13	4	-	855	54.0
Big-seed	1942	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19	11	10	8	20	1	69	83.4

Table 3. Showing the average number of days required per leaf from emergence to date of flowering.

Classes for leaves	Selection and year					
	Early Juicy		Hybrid F2		Hybrid F3	Big-seed
	1942	1943	1942	1943	1943	1942
9	--	3.66	--	--	3.83	--
10	3.50	3.40	--	3.40	3.45	--
11	3.17	3.37	--	--	3.29	--
12	3.02	3.11	2.95	3.04	3.02	--
13	2.83	2.97	2.84	2.87	3.00	--
14	2.86	2.89	2.75	2.82	2.93	--
15	2.73	2.77	2.67	2.88	2.85	--
16	--	--	2.64	2.73	2.76	--
17	--	--	2.66	2.64	2.66	--
18	--	--	2.55	2.60	2.58	--
19	--	--	2.51	2.56	2.82	--
20	--	--	2.49	2.49	2.67	--
21	--	--	2.47	2.62	2.63	--
22	--	--	2.41	2.52	2.60	--
23	--	--	2.54	2.49	2.54	--
24	--	--	2.35	2.41	2.57	--
25	--	--	2.66	2.50	2.66	--
26	--	--	2.58	2.77	2.61	3.21
27	--	--	2.56	2.86	2.80	3.08
28	--	--	2.54	2.80	2.74	2.94
29	--	--	2.48	2.79	2.80	2.88
30	--	--	2.50	--	2.68	2.82
31	--	--	2.35	--	--	2.74
32	--	--	--	--	--	2.72
33	--	--	2.48	--	--	2.61
Mean group average	2.99	3.31	2.54	2.62	2.68	2.92

Chart 1. Showing the rainfall data for the growing season on the basis of a moving average over three ten-day periods.



Total Rainfall for June through September -- 1942	11.08 inches
Total Rainfall for June through September -- 1943	6.29 inches

BIBLIOGRAPHY

1. Davidowicz, S. B. Experiments on the Genetics and Culture of Tobacco. Sta. Acclim. Lening. Agri. Inst.: Bul. No.7, 1928. Abstract Exp. Sta. Record, 60:688. 1930

2. Eidleman, Z. N. Effect of Mechanical Reduction of Leaf Area upon Growth and Development of Cultivated Plants in Connection with Methods of Appraising Injuries from Disease, Trudy po Zasch. Rast. Series 3, No. 3. 1933.

3. Kuleshov, M. N. World Diversity in Phenotypes in Maize, Jour. Amer. Soc. of Agron., 25:688. 1933.

4. Martin, John H. Plant Characters and Yield in Grain Sorghum. Jour. Amer. Soc. of Agronomy, 20:117-1182. 1928.

5. Rangaswami, G. N., Ayyanger, Ayyar, Sankar, M. A., and Nambiar, A. Kanhikoran. The Inheritance of Height Cum Duration in Sorghum. The Madris Agri. Jour., 25:No. 4. 1937.

6. _____, Rao, V. Pandurango, and Reddy, T. Venkataramana. Studies in Sorghum -- Internodes and Leaf Sheaths. Proc. of Ind. Acad. of Sci., 7: No. 4. 1938.

7. Shafer, John Jr., and Wiggans, R. G. Correlation of Total Dry Matter with Grain Yields in Maize. Jour. Amer. Soc. of Agron., 33:927. 1941.

8. Sieglinger, John B. Leaf Number of Sorghum Stalks. Jour. Amer. Soc. of Agron., 28:636. 1936.

9. Swanson, A. R. Relation of Leaf Area to Grain Yields in Sorghum. Jour. Amer. Soc. of Agron., 33:908-914. 1941.

10. Vinall, H. N., and Reed, H. R. Effect of Temperature and Other Meteoroligical Factors on the Growth of Sorghums. Jour. of Agri. Res., 13: No. 2. 1918.

11. _____, Stephens, J. C., and Martin, J. H., Identification, History, and Distribution of Common Sorghum Varieties. U. S. D. A. Tech. Bul. 506, (page 30). 1936.

Typed by:

Ann Brown