March 12, 1959

To the Graduate Council:

I am submitting herewith a thesis written by Thomas Obed Shelby entitled "Cultural Problems With Grain Sorghum." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agronomy.

Lawrence V Skold

Major Professor

We have read this thesis and recommend its acceptance:

Henry A. Fribourg

Royal E. Shanks

Accepted for the Council:

Dale Hamblin

Dean of the Graduate School

CULTURAL PROBLEMS WITH GRAIN SORGHUM

A THESIS

Submitted to
The Graduate Council
of
The University of Tennessee
in
Partial Fulfillment of the Requirements
for the degree of
Master of Science

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by

Thomas Obed Shelby

March 1959

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CHAPTER I

INTRODUCTION

The problems related to grain sorghum (*Sorghum vulgare* Pers.) production are becoming increasingly important to farmers in Tennessee, as well as in other areas of the Southeast. However, the considerable experimental work that has been done on this subject has been confined largely to areas of the more arid Southwest. This information is of comparatively little value to farmers of the Southeast because of the differences in climatic and edaphic conditions.

In view of the scarcity of information on these facts, and the increasing importance of grain sorghum in Tennessee, the relationships among row spacing, planting rate, and planting date as they might affect grain yield, plant height, and number of days to mid-flowering were studied in the investigation herein reported.

CHAPTER II

REVIEW OF PERTINENT LITERATURE

Influence of Different Row Spacings on Yield

Kersting (7), working with sorghum culture in Kansas, found that when 20-inch rows were used, yield was increased 26 per cent above that obtained in 40-inch rows. He also found that, in 20-inch rows, water losses by evaporation, weed growth, and soil temperature were kept at a minimum.

In row spacing experiments at the University of Arizona Agricultural Experiment Station at Mesa, Clark and Stith (2) observed that narrowly spaced rows gave higher yields than widely spaced rows. In their tests, both 20- and 30-inch rows outyielded 40-inch rows.

Nelson (9) found no significant difference in yield among row spacings in a nitrogen x spacing test in Washington. Row spacings of 24, 30, and 36 inches were studied at different levels of nitrogen fertilization.

Bond, et al. (1), in spacing tests in Texas, found that row spacings, using 20- and 40-inch rows, had no measurable effect on yield.

Influence of Different Planting Rates on Yield

Painter and Leamer (10), in a New Mexico test to determine the effects of moisture, spacing, fertility, and their interrelationships on grain sorghum production, found that spacings of four inches between

plants in 36-inch rows gave an average yield of five bushels per acre more than did spacings of nine inches with the same row spacing. Significant interactions between fertility and spacings were obtained. Closer spacing of the plants in the row favored larger yield responses at the higher nitrogen rates.

Cook and Parmer (3), in Texas, found that 2.5-inch spacing in the row gave the highest yields for early plantings when tested under dry-land conditions. Other spacings used in the test were 1.5, 5.0, 7.5 and 10.0 inches.

Nelson (9) reported yields of 125 bushels per acre in spacing x nitrogen trials under irrigation at Moses Lake, Washington. Using three varieties of grain sorghum and populations ranging from 72,000 to 228,000 plants per acre, he found that spacing had no significant effect on yield. He noted no interaction between spacings and varieties, fertility levels and varieties, or fertility levels and spacings.

In tests conducted for three years at the University of Nebraska by Cushing, et al. (4) under dry-land conditions, no difference in yield was reported when spacing in 42-inch rows was two, four, six, eight, twelve, or eighteen inches.

Influence of Different Planting Dates on Yield

Sturkie and Rogers (11), in a study of planting dates in Alabama, reported yields in 1956 of 42.0, 31.2 and 20.7 bushels per acre from planting dates of June 18, July 5, and July 15, respectively.

In Texas, Cook and Parmer (3), using planting dates of March 13, March 26, April 9, May 8, May 21, June 7, and June 14, found that yields were reduced with each successively later date of planting.

Influence of Different Cultural Practices on Other Characteristics of the Sorghum Plant

Lodging

Bond, et al. (1) found that lodging of the crop was greater in Texas when planted in 20-inch rows at the four-pound per acre rate than when planted in 40-inch rows and at two pounds per acre.

Cook and Parmer (3), working with planting rates and dates, found lodging to be more severe in close spacings and with later dates of planting.

Plant Height

Martin and Sieglinger (8) concluded from tests conducted for ten years in Oklahoma that plant height increased with closer spacing in the row and with later planting dates.

Kersting (7) observed that planting in narrow rows produced plants of more uniform height.

Head Size

In Nebraska, Cushing, Kiesselbach, and Webster (5) found a close relationship between acre grain yields and the yield of grain per plant. The latter varied directly with head size, i.e., the yield of grain per plant was determined by head size, but not by the amount of tillering.

Thus, the effects of date and rate of planting on acre grain yields were exerted largely through head size. On the average, the amount of grain per head increased with delay of planting and wider spacing in the row under Nebraska conditions.

Maturity

Painter and Leamer (10) reported that earliness of heading was increased by a proper balance of fertility and narrow row spacing.

Martin and Sieglinger (8) found that the number of days from planting to maturity was reduced with each later planting date.

CHAPTER III

METHODS AND MATERIALS

Soils and Previous Cropping History of Experimental Fields

This study was conducted to determine the optimum row spacing, planting rate and planting date for one hybrid grain sorghum under Tennessee conditions.

Experiments were initiated in 1957 and continued in 1958. The 1957 tests were located at the University of Tennessee Main Agricultural Experiment Station at Knoxville and at the Highland Rim Experiment Station near Springfield. The Knoxville test was so severely injured by birds and lodging that no data were taken. The test at Springfield was also discarded because of the poor stand in all plots due to adverse weather conditions.

The 1958 test was located on the Koella Farm in Blount County on Sequatchie loam with an A slope. For many years previously, corn had been grown continuously on the area.

Experimental Design

Two spacings were studied: 21- and 42-inch. Total plot size for both spacings consisted of .008 acre (14 by 25 feet). Each experimental plot of the 21-inch row spacing consisted of eight rows 25 feet long. The middle four rows were harvested for yield, the four outside rows serving as guard rows. Each plot of the 42-inch row spacing consisted of only four 25-foot rows, in which the middle two rows were harvested

for yield and the two outside rows served as guard rows.

A modified split plot design was used. The major treatments were spacings between rows: 21- and 42-inch. Each major treatment was subdivided to include four rates of planting: three, six, nine, and twelve pounds per acre, at each of two planting dates, June 12 and July 2. Planting rates and dates were completely randomized within each main plot. The main treatments were replicated four times. The combination of the two row spacings, four planting rates, and two planting dates made a total of sixteen treatments.

An application of 700 pounds per acre of 6-12-12 fertilizer was made, 300 pounds of which was broadcast and plowed under, and the remaining 400 pounds applied in 21-inch rows at planting time. The total fertilizer application was: N, 42 pounds; P_2O_5 and K_2O, 84 pounds each. This fertilizer application was considered adequate for an expected yield of 100 bushels per acre with optimum cultural practices.

The hybrid R.S.* 610 was used in the test. The experiment was planted using a "Planet Junior", a model of hand planter especially suited for experimental work. At each planting date, the planter was carefully calibrated in the laboratory and rechecked in the field for accuracy.

The two planting dates (June 12 and July 2) were harvested October 6 and November 12, respectively.

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* "R.S." stands for "Regional Sorghum" indicating wide acceptance by plant breeders.

Method of Measuring Certain Agronomic Characteristics

Yield

Each plot was hand harvested, the heads of grain from each plot placed in a burlap bag and transported to the plot barn for artificial drying. Each harvest was artificially dried for three days before storing. Because of the labor involved, the grain was not threshed until both harvests were completed. As each plot was threshed, weights were obtained, and one pint of the grain sealed in air-tight containers for moisture determinations. Per cent moisture was determined by use of a Steinlite Moisture Tester. Grain yields were corrected to 15.0 per cent moisture, the standard for U. S. No. 2 grain sorghum.

Plant Characteristics

Plant height was measured at time of harvest. The readings, to the nearest three inches, were taken only on heads of the main plants, disregarding the suckers. Since no lodging was evident in the 1958 test, notes on this characteristic were not taken. Because of the excessive lodging and bird damage to the Knoxville test in 1957, the earlier harvest and artificial drying were used in 1958 in an effort to prevent loss of the grain in the field.

The number of days to mid-flowering was recorded. Mid-flowering was defined as that stage of plant development when plants were shedding pollen on approximately one-half of the heads of the entire plot. Because of the large plant populations, no plant counts were made, but only estimates of the flowering progress at 48-hour intervals.

Presentation of Data and Statistical Analysis

Grain yields of the different treatments are presented in terms of 56-pound bushels per acre. In the text, the grain yields, plant heights, and numbers of days to mid-flowering are reported as the mean of the four replications for each treatment.

For the purpose of differentiating between treatment means, the multiple range test by Duncan (6) was utilized.

In the discussion of results, wherever the word "different" is used, it will be taken to mean "significantly different", at the indicated level of probability.

CHAPTER IV

EXPERIMENTAL RESULTS AND DISCUSSION

Insects and diseases caused relatively little damage in the 1958 test. Both plantings were sprayed with a DDT (dichloro-diphenyl-trichloroethane) solution while the grain was in the dough stage to control sorghum webworms (Celama sorghiella Riley). A small amount of foliage damage was done by fall armyworms (Laphygma frugiperda Smith and Abbott) migrating from adjacent corn fields, but damage was not extensive enough to warrant control measures.

Results are discussed by individual characteristics studied. Analyses of variance using individual characteristics were made to determine the variations due to row spacings, planting rates, planting dates, and their interactions. In Table I, a summary of yield, plant height, and number of days to mid-flowering is presented. More detailed tabulations and analyses of the data are presented in the appendices.

One plot of the late planting came up to a poor stand. Since no data were obtained, a standard formula was used to calculate yield, plant height, and days to mid-flowering for the missing plot.

The rainfall for the season was 3.09 inches less than normal for the months of May through November, with the greatest shortage during June, September, and October. Rainfall for the season is given in Appendix A.

Yield

Yield at the two row spacings differed significantly at the 0.05

TABLE I

YIELD AND CHARACTERISTICS OF R. S. 610 GRAIN SORGHUM GROWN AT VARIOUS ROW SPACINGS, RATES AND DATES OF PLANTING AT KNOXVILLE, TENNESSEE IN 1958

Distance Between Rows in Inches	Planting Date	Planting Rate Lbs. Per Acre	Yield Bu. Per Acre 1/	Plant Height in Inches 2/	Days to Mid-flowering 3/
21	June 12	3	100.1	42	60
		6	106.8	44	60
		9	110.7	50	61
		12	105.4	53	61
	July 2	3	63.5	36	58
		6	69.6	38	58
		9	95.4	50	58
		12	86.6	48	59
42	June 12	3	71.0	40	60
		6	98.0	47	60
		9	95.5	56	61
		12	93.8	57	62
	July 2	3	44.4	38	58
		6	58.6	48	58
		9	55.2	50	58
		12	57.6	52	59

1/ Corrected to 15.0 per cent moisture. See Appendix B

2/ See Appendix C

3/ See Appendix D

level of probability. Yield responses to planting rates and planting dates differed at the 0.01 level (Table I and Appendix B). The row spacing x planting dates, row spacing x planting rates, and row spacing x planting rates x planting dates interactions were different at the 0.01 level. The split plots x row spacing interaction was significant at the 0.05 level. The analysis of variance showed yield differences in favor of the earlier planting date and the 21-inch row spacing. The three-pound per acre planting rate gave lower yields for both row spacings and planting dates. This indicates that the plant population from the three-pound planting rate was too low to utilize efficiently the available moisture and fertility. The twelve-pound per acre planting rate evidently was too high for the available moisture supply and fertility level, since yields were reduced when planting rates exceeded nine pounds per acre.

Plant Characteristics

Plant Height

Plant height was different at the 0.01 level for planting dates and planting rates. Height response to row spacing was different only at the 0.05 level (Table I and Appendix C). The interactions of planting rates x planting dates and split plots x row spacing were not significantly different. Row spacing x planting rates and row spacing x planting rates x planting dates interactions were different at the 0.05 level. Plants from the earlier planting were taller than from the later planting. Increased planting rate and wide row spacing also increased the height of plants.

Lodging

From data reported in the literature (1, 3) it is possible to infer that lodging would be greater at both heavier planting rates and narrow row spacing, due to the increased plant height. However, this test was harvested as soon as possible after maturity and no lodging was evident in any treatment. Had the plants been permitted to remain in the field until a later date, lodging possibly would have been a problem under the humid conditions which are usually prevalent in the late fall in Tennessee.

Days to Mid-flowering

No difference was found between the different row spacings as to this characteristic. Dates of planting and plant populations were different at the 0.01 level, with the later planting and lower populations flowering earlier (Table I and Appendix D).

Moisture Per Cent at Harvest

No measure of moisture content of grain was attempted at harvest. Because of the difficulty of threshing sorghum in the early stage of maturity, the taking of moisture samples was not feasible at harvest.

General Discussion

Under the conditions of the 1958 season, real differences in yields existed which can be attributed to row spacings, planting rates, and planting dates. Those results are contrary to the findings of many workers who worked in areas having considerably lower rainfall and

different lengths of growing season, and different temperatures and soils than in Tennessee. Recommendations based upon the results of this experiment must necessarily be considered tentative for several reasons. The data were obtained from grain sorghum which was grown in 21- and 42-inch rows, whereas row spacing might vary, under general farm practice, from those tested here. The nitrogen was all applied prior to planting, rather than according to the more usual practice of partial application at planting, the remainder being applied as a side-dressing in the early stage of growth. However, the results of this study are similar to those obtained in tests conducted under high rainfall conditions, as well as with some data obtained in areas of low rainfall.

In this experiment, as the planting rate was increased from the three-pound per acre rate to the nine-pound per acre rate in the 21-inch rows, and to the six-pound per acre rate in the 42-inch rows, there was a corresponding increase in grain yields at the two planting dates. Plant height increased with the increase in planting rates, wider row spacing, and earlier planting date. Days to mid-flowering were increased by the higher planting rates and earlier planting date, but were not affected by the different row spacings. The nine-pound per acre rate, in the 21-inch rows at the earlier planting date, was the highest producing treatment in this study.

It seems important to note that planting rate can be increased as much as 300 to 400 per cent and rows placed considerably closer than presently recommended in many areas with a resulting increase in yield, and without adversely affecting plant characteristics.

Lodging can be very serious under Southeastern conditions due to heavy rainfall during the harvest season. This problem should receive careful consideration. Early harvest and artificial drying to insure safe storage would be desirable. No lodging was evident in the 1958 test, for the experiment was harvested as early as possible and artificially dried. There was no accurate measure of maturity but it seems to be of little consequence due to the relatively long Tennessee growing season. The difference in number of days to mid-flowering gives some indication of the possible effect of the different treatments on maturity.

CHAPTER V

SUMMARY AND CONCLUSIONS

An investigation of the effects of different cultural practices on one hybrid grain sorghum was conducted at the University of Tennessee Agricultural Experiment Station, Koella Farm, in Blount County, during the summer of 1958. The objective of the study was to determine the effects of different row spacings, planting rates, and planting dates on grain yield, plant height, and number of days to mid-flowering.

The effects of these treatments were measured in terms of grain yield in bushels per acre, plant height in inches, and number of days from planting to mid-flowering. From this study, the following conclusions may be drawn:

1. The 21-inch row spacing gave a significant yield increase over the 42-inch row spacing at the higher rates and at the earlier date of planting.

2. The three-pound per acre planting rate gave a significantly lower yield than did higher rates at both row spacings and at both planting dates.

3. The nine-pound per acre planting rate in 21-inch rows, and the six-pound per acre rate in 42-inch rows, gave the highest yields of all rates used. From this test, and from other experiences, these planting rates appear to be adequate for high yields under Tennessee conditions.

4. Plant height was reduced significantly with the later planting date, narrower spacing and lower planting rates.

5. Days to mid-flowering were significantly reduced at the later planting date and lower planting rates. Row spacing had no significant effect on days to mid-flowering.

6. Row spacings and planting rates had no noticeable effect on maturity. As the planting date progressed later into the season, maturity appeared to be more rapid.

7. Lodging did not exist in any treatment because of the early harvest.

LITERATURE CITED

LITERATURE CITED

1. Bond, J. J., Army, T. J., Lehman, O. R., and Cherry, J. F. Narrow-row sorghum for the hardlands of the high plains. Tex. Agr. Exp. Sta., Progress Report 2019. 1958.

2. Clark, G. W., and Stith, L. Grain sorghums in Arizona. Univ. of Ariz. Agr. Ext. Circ. 218. 1958.

3. Cook, E. D., and Parmer, W. R. Date of planting and spacing test for grain sorghum, Blackland Experiment Station, 1956-1957. Tex. Agr. Exp. Sta., Progress Report 2023. 1958.

4. Cushing, R. L., Kiesselbach, T. A., Gross, D. L., Frolik, F. F., and Webster, G. T. Report of the 1939 cooperative sorghum variety tests. Neb. Agr. Ext. Circ. 144 (Mimeograph). 1939.

5. _____, Kiesselbach, T. A., and Webster, O. J. Sorghum production in Nebraska. Neb. Agr. Exp. Sta. Bul. 329. 1940.

6. Duncan, D. B. Multiple range and multiple F tests. Biometrics 11: 1-42. 1955.

7. Kersting, J. Kansas farmers like narrow row sorghum. Crops and Soils 10:12. 1958.

8. Martin, J. H., and Sieglinger, J. B. Spacing and date of seeding experiments with grain sorghum. U. S. D. A. Tech. Bul. 131. 1929.

9. Nelson, C. E. Effects of spacing and nitrogen applications on yield of grain sorghums under irrigation. Agron. Jour. 44:303-305. 1952.

10. Painter, C. G., and Leamer, R. W. The effects of moisture, spacing, fertility, and their interrelationships on grain sorghum production. Agron. Jour. 45:261-264. 1953.

11. Sturkie, D. G., and Rogers, T. H. Grain sorghum production in Alabama. Ala. Agr. Exp. Sta., Progress Report Series No. 34. 1947.

APPENDIX A

APPENDIX A

PRECIPITATION AND TEMPERATURE DURING THE 1958 GROWING SEASON REPORTED AT THE WEATHER BUREAU, KNOXVILLE AIRPORT
(from U. S. Department of Commerce Weather Bureau Reports)

Month	Precipitation in Inches 1958 Mean	Departure From Long-term Mean	Temperature in Degrees Fahrenheit 1958 Mean	Departure From Long-term Mean
May	4.78	1.20	68.2	0.8
June	2.01	-1.46	75.5	-0.1
July	5.57	0.85	78.5	0.1
August	2.83	-0.60	77.2	0.2
September	1.49	-1.04	72.1	0.0
October	0.68	-1.95	59.8	-0.5
November	3.06	-0.09	51.4	3.0

APPENDIX B

APPENDIX B

YIELD OF R. S. 610 GRAIN SORGHUM, IN BUSHELS PER ACRE, CORRECTED TO 15 PER CENT MOISTURE, GROWN AT VARIOUS ROW SPACINGS, RATES AND DATES OF PLANTING AT KNOXVILLE, TENNESSEE IN 1958

Distance Between Rows in Inches	Planting Date	Planting Rate Lbs. Per Acre	Replication 1	2	3	4	Mean
21	June 12	3	109.5	104.9	80.1	105.8	100.1
		6	109.9	102.5	105.7	108.9	106.8
		9	113.3	107.0	116.9	105.4	110.7
		12	103.8	102.0	99.6	116.4	105.4
	July 2	3	71.1	67.9	53.3	61.7	63.5
		6	78.8	66.4	63.6	70.5	69.6
		9	84.5	99.6	93.3	104.0	95.4
		12	58.3	104.7	96.0	87.5	86.6
42	June 12	3	70.4	70.7	78.8	64.3	71.0
		6	94.5	102.1	95.4	100.1	98.0
		9	90.2	104.9	102.8	84.0	95.5
		12	101.0	102.0	99.4	73.0	93.8
	July 2	3	29.9	64.0	36.7	47.2	44.4
		6	59.9	61.3	56.4	56.7	58.6
		9	46.2	78.4	53.6	42.7	55.2
		12	59.4	62.5	53.3	55.2	57.6

APPENDIX B

Analysis of Variance

Source	Degrees of Freedom	Estimates of Variance
Replications	3	218.72
Row Spacings	1	6,701.47**
Error (a)	3	198.37
Split Plots	7	2,780.59***
Planting Dates	1	15,678.17***
Planting Rates	3	1,160.87***
Dates x Rates	3	101.12
Split Plots x Row Spacings	7	248.30**
Row Spacings x Dates	1	300.59*
Row Spacings x Rates	3	235.76*
Row Spacings x Dates x Rates	3	243.41*
Error (b)	41	93.98
Missing Plot	1	
Total	63	

* Significant at the 0.10 level of probability.
** Significant at the 0.05 level of probability.
*** Significant at the 0.01 level of probability.

APPENDIX B

Multiple Range Test[1]

Planting Rate Lbs. Per Acre	Planting Date	Row Spacing	Mean Yields Bu.Per Acre	Multiple Range Groups [2]
3	July 2	42	44.4	
9	July 2	42	55.2	
12	July 2	42	57.6	
6	July 2	42	58.6	
3	July 2	21	63.5	
6	July 2	21	69.6	
3	June 12	42	71.0	
12	July 2	21	86.6	
12	June 12	42	93.8	
9	July 2	21	95.4	
9	June 12	42	95.5	
6	June 12	42	98.0	
3	June 12	21	100.1	
12	June 12	21	105.4	
6	June 12	21	106.8	
9	June 12	21	110.7	

[1] As derived by Duncan (6).

[2] Any two means joined by the same line are not significantly different at the 0.05 level of probability.

d.f. = 41

$s\bar{x}$ = 2.42

APPENDIX C

APPENDIX C

PLANT HEIGHT IN INCHES OF R. S. 610 GRAIN SORGHUM GROWN AT VARIOUS ROW SPACINGS, RATES AND DATES OF PLANTING AT KNOXVILLE, TENNESSEE IN 1958

Distance Between Rows in Inches	Planting Date	Planting Rate Lbs. Per Acre	Replication 1	2	3	4	Mean
21	June 12	3	45	39	42	42	42
		6	45	42	42	45	44
		9	51	48	48	51	50
		12	54	54	51	54	53
	July 2	3	36	36	36	36	36
		6	39	36	39	36	38
		9	54	45	48	51	50
		12	48	48	45	51	48
42	June 12	3	39	42	39	42	40
		6	48	48	45	48	47
		9	54	60	54	57	56
		12	60	54	57	57	57
	July 2	3	39	36	36	39	38
		6	48	48	45	51	48
		9	51	51	48	51	50
		12	51	54	51	54	52

APPENDIX C

Analysis of Variance

Source	Degrees of Freedom		Estimate of Variance	
Replications	3		22.26	
Row Spacings	1		213.89**	
Error (a)	3		6.89	
Split Plots	7		314.98***	
Planting Dates		1		236.39***
Planting Rates		3		651.89***
Dates x Rates		3		4.27
Split Plots x Row Spacings	7		29.07***	
Row Spacings x Dates		1		3.51
Row Spacings x Rates		3		34.27***
Row Spacings x Dates x Rates		3		32.39***
Error (b)	41		3.19	
Missing Plot	1			
Total	63			

** Significant at the 0.05 level of probability.
*** Significant at the 0.01 level of probability.

APPENDIX C

Multiple Range Test

Planting Rate Lbs. Per Acre	Planting Date	Row Spacing	Mean Plant Height in Inches	Multiple Range Groups[1]
3	July 2	21	36	
6	July 2	21	38	|
3	July 2	42	38	|
3	June 12	42	40	
3	June 12	21	42	
6	June 12	21	44	
6	June 12	42	47	|
12	July 2	21	48	|
6	July 2	42	48	|
9	June 12	21	50	|
9	July 2	21	50	|
9	July 2	42	50	|
12	July 2	42	52	|
12	June 12	21	53	|
9	June 12	42	56	|
12	June 12	42	57	|

[1] Any two means joined by the same line are not significantly different at the 0.05 level of probability.

d.f. = 41

$s\bar{x}$ = .45

APPENDIX D

APPENDIX D

DAYS FROM PLANTING TO MID-FLOWERING OF R. S. 610 GRAIN SORGHUM GROWN AT VARIOUS ROW SPACINGS, RATES AND DATES OF PLANTING AT KNOXVILLE, TENNESSEE IN 1958

Distance Between Rows in Inches	Planting Date	Planting Rate Lbs. Per Acre	Replication 1	2	3	4	Mean
21	June 12	3	60	59	60	59	60
		6	61	59	59	62	60
		9	61	59	61	62	61
		12	61	60	62	62	61
	July 2	3	58	56	58	58	58
		6	59	57	58	59	58
		9	59	58	59	58	58
		12	60	57	59	59	59
42	June 12	3	59	60	60	61	60
		6	60	60	59	61	60
		9	61	60	61	61	61
		12	61	61	62	62	62
	July 2	3	59	57	58	57	58
		6	58	57	59	58	58
		9	58	57	59	60	58
		12	59	59	58	60	59

APPENDIX D

Analysis of Variance

Source	Degrees of Freedom		Estimate of Variance	
Replications	3		6.18	
Row Spacings	1		.15	
Error (a)	3		1.05	
Split plots	7		13.98***	
Planting Dates		1		78.77***
Planting Rates		3		6.18***
Dates x Rates		3		.18
Split Plots x Row Spacings	7		.14	
Row Spacings x Dates		1		.01
Row Spacings x Rates		3		.31
Row Spacings x Dates x Rates		3		.02
Error (b)	41			
Missing Plot	1			
Total	63			

*** Significant at the 0.01 level of probability.

APPENDIX D

Multiple Range Test

Planting Rates Lbs. Per Acre	Planting Date	Row Spacing	Mean Days to Mid-flowering	Multiple Range Groups[1]
3	July 2	21	58	
6	July 2	21	58	
9	July 2	21	58	
3	July 2	42	58	
6	July 2	42	58	
9	July 2	42	58	
12	July 2	21	59	
12	July 2	42	59	
3	June 12	21	60	
6	June 12	42	60	
3	June 12	42	60	
6	June 12	42	60	
9	June 12	21	61	
12	June 12	21	61	
9	June 12	42	61	
12	June 12	42	62	

[1] Any two means joined by the same line are not significantly different at the 0.05 level of probability.

d.f. = 41

$s\bar{x}$ = .19