THE PERFORMANCE OF SELECTED SOYBEAN STRAINS FOLLOWING SMALL GRAINS IN OKLAHOMA

By

BOBBY GENE BRATCHER

Bachelor of Science

Oklahoma State University

Stillwater, Oklahoma

1969

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
May, 1971

THE PERFORMANCE OF SELECTED SOYBEAN

STRAINS FOLLOWING SMALL GRAINS

IN OKLAHOMA

Thesis Approved:

James S. Kirby
Thesis Adviser

Lester W. Reed

David A. Sander

Robert D. Morrison

D. D. Durham
Dean of the Graduate College

ACKNOWLEDGMENTS

The author is grateful to the Agronomy Department of Oklahoma State University for the facilities and financial assistance which made this study possible.

Special appreciation is extended to Dr. James S. Kirby, major adviser, for his inspiration, guidance, and counsel throughout the course of this study. Grateful acknowledgments are also extended to Dr. David A. Sander, Professor of Agronomy, Dr. Lester W. Reed, Professor of Agronomy, and Dr. Robert D. Morrison, Professor of Statistics, for serving on the advisory committee and for their valuable assistance and constructive criticism in the preparation of this thesis.

Gratitude is expressed to Mr. Roy M. Oswalt and Mr. Bill Morris for their help in planting and harvesting the soybeans used in this study.

In addition, I would like to thank Mrs. Peggy Smith for the typing of this manuscript.

Finally, I would like to express appreciation to my wife, Joan, for her patience and encouragement during the course of this study.

TABLE OF CONTENTS

LIST OF TABLES

Table | Page

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The major problem of nutrition in the world today is related primarily to a shortage of protein. The soybean, Glycine max (L.) Merrill, has a high protein content and is, therefore, of great importance from a world standpoint as an adequate protein source. Its wide adaptability to environmental conditions makes it attractive as a cash crop in many areas.

Many developments have contributed to the rapid increase in soybean production, among them a steady expansion in the market for soybean oil and meal in this country and a strong export demand for the crop.

Recently, interest has increased in the possibility of using soybeans in a double-cropping system following small grains, particularly wheat. This allows for the land to be in production almost continuously, thereby yielding more return per acre to the farmer each year.

Historically, it has been necessary to grow soybeans in intertilled rows to control weeds adequately. New herbicides may control weeds more efficiently and economically than cultivation. This has raised the prospect of growing soybeans in row spacings less than those required for intertillage. This makes the crop attractive to more farmers, particularly those who lack the machinery required for growing the crop in rows and those whose labor load is heaviest when soybeans should be cultivated.

The objectives of this study were to evaluate, under weed free conditions, the performance of selected soybean strains at two row spacings in a double-cropping system following wheat. The variables measured on a plot basis were: yield, seed weight per 100 seeds, shatter percentage, protein percentage, oil percentage, testa percentage, first bloom date, and maturity date.

CHAPTER II

LITERATURE REVIEW

Soybeans were first grown in the United States by planting with a conventional grain drill, according to Weiss (36). He attributed the shift to the now commonly accepted row spacing method to a greater efficiency in weed control.

Numerous reports indicate that an increase in seed yield is generally obtained as spacing between intertilled rows is decreased. In New York, Wiggans (39) revealed that planting soybeans in rows eight inches apart produced highest yields.

In comparing intertilled rows with drilled plantings, Burlison, et al. (2), McClelland (22), and Zahnley (40) obtained lower yields from drilled plantings of soybeans.

Smith (30) found that soybean yields in Arkansas could be increased in some instances by using 10 and 20 inch rows. In most cases yield levels were low in tests where he obtained a response to narrow rows. Additional research in Arkansas by Frans (10) indicated that soybeans grown in rows narrower than the conventional 36 to 42 inch rows would on occasion produce higher yields than those in conventional rows. It appeared from this data that the major advantage from close spacing in cases where an increased yield was obtained was better control of weeds.

In Minnesota and Illinois, yields of soybeans grown in 18 to 24 inch rows have been about 15 percent greater than when grown in 36 to

40 inch rows, according to Lehman and Lambert (21) and Pendleton, *et al*. (25).

Weber and Shibles (34) found that ten inch rows gave the maximum level of yield, dry weight of plants and leaf area index for Hawkeye soybeans as compared to 4, 20, and 40 inch widths when these variables were averaged across populations. In addition, they found that maturity, plant height, and lodging were relatively unaffected by row width.

Reiss and Sherwood (28) found seed yield consistently highest in 24 inch rows, when compared to 8, 16, 32, and 40 inch row widths, regardless of seeding rates or fertility levels on low organic matter, silty soils of southern Illinois.

In Arkansas, research by Caviness (5) showed that seed yields were higher when soybeans were grown in 7 to 14 inch than in 40 inch rows.

Hicks (14) found that planting soybeans in 25 versus 76 centimeter rows had no effect on seed yield in 1966 and increased yield 6.5 percent in 1967. The two year average of 3.4 percent increase was not statistically significant.

In Kentucky, Shane, *et al*. (29) tested three soybean varieties in three row spacings in 1966, 1967, and 1968. Amsoy, Clark 63 and Hood showed yield in 20 inch rows to be 39.5 bushels per acre; 30 inch rows yielded 40.6 bushels per acre; and 40 inch rows yielded 38.7 bushels per acre over the three year period.

Cartter and Hartwig (4) noted maximum grain yields from soybeans grown in a short season will be obtained from narrow rows, and that the row width which will result in maximum yields also depends on the growth type of the soybeans, soil fertility, and location. They also stated that harvest losses may be reduced in soybeans grown in narrow rows, as changes in the microclimate tend to increase plant height and raise the height of the first pods.

Dougherty (9) found that when plant populations per acre were established in both 20 and 40 inch rows, the narrow rows outproduced the wider ones by 60 percent. He concluded that narrow row spacings are more suitable, irrespective of variety, date of planting, or weed control practice.

Oswalt, et al. (24) conducted a row spacing study in 1968 using Ford, Clark 63, and Hill soybeans. The spacings were 14, 21, and 28 inches between rows. Results indicated that all three varieties produced the highest yields at the 21 inch row spacing.

That elements of the climate might affect the composition of soybeans was suggested many years ago by Garner, et al. (11) who concluded that under usual conditions, climate is a more potent factor than soil in controlling size and oil content of soybean seeds.

Hinson and Hanson (15) reported that protein percentage and plant height decreased while oil and seed size increased under wide spacings.

Davidson (6) found higher protein percentage from soybeans grown in 28 inch rows as compared to those in 40 inch rows.

Torrie and Briggs (32) found protein content showing no tendency to decrease with a delay in planting from May 10 to June 10.

Howell (16) indicated that temperatures during the period of intensive oil synthesis were optimum at 85^{o}F. for the accumulation of oil in the soybean seed. He found protein level to be less affected by temperature than oil content.

A delay in planting generally results in a decrease in oil content and an increase in protein content, according to Dimmock and Warren (7).

Osler and Cartter (23) found that the highest oil content of 8 soybean varieties was attained at a May 1 planting and decreased progressively with later planting. However, this decrease was not consistent for all varieties. Protein content of the seed varied inversely to the general trend noted for oil content.

Donovan, et al. (8) found that oil and yield increased as plant spacing in the row increased from 1 to 3 inches, and the response to row spacing was the opposite. Yields and oil content increased as row widths decreased from 35 to 7 inches. The combination of narrowest row and widest plant spacing within the row (7 x 3) gave the highest yield.

Viljoen (33) studied the relation of temperature during the growing season to oil content at maturity. He found no correlation between minimum temperatures and oil percentage. He did, however, find a highly significant correlation between maximum temperatures and oil percentage, and between mean temperature and oil percentage. These correlations existed for two varieties and two growing seasons at from 9 to 12 field locations in South Africa. The temperatures at the different locations ranged from a monthly mean maximum of 91.3 degrees to a monthly mean minimum of 46.0 degrees. The extreme temperatures for a single day were 102.2 degrees and 34.5 degrees. There was a wide variation in rainfall from 1.88 inches to 25.67 inches.

Weber and Weiss (35) concluded that oil, protein, and iodine number were not affected by row spacings.

Plant height increases with higher plant populations and narrower row spacings, according to Hicks, et al. (14) and Leffel and Barber (20).

Weiss, *et al*. (37) found plant height to decrease with a delay in planting.

In Illinois, Osler and Cartter (23) found maximum height of plant was attained from May 1 planting and decreased progressively with delay in planting.

Greer, *et al*. (12) found that soybean seed quality was usually highest from late dates of planting. Exceptions to this general rule were noted when short season varieties which were planted early, matured before the occurrence of hot, dry weather and when full-season varieties were planted early but matured considerably after the hot, dry weather had ended. With only a few exceptions, smaller seed was associated with higher laboratory germination and field emergence percentages and also with later dates of planting.

Probst (27) in Indiana and Lehman and Lambert (21) in Minnesota found row width and seeding rate had little effect on seed weight. There was no correlation between plant height and seed yields.

Dimmock (7) showed that reductions in yield resulting from delayed planting were caused by a reduction in the number of seeds produced rather than by a decrease in seed size.

Burnside and Colville (3) and Johnson, *et al*. (18) found that seed size decreased as plant population per acre increased.

Reiss and Sherwood (28) were able to show that 40 inch rows produced heavier seed than 8, 16, 24, or 32 inch rows. An interaction of seeding rate and row width was statistically significant for seed weight at the 5 percent level of probability. The 40 inch row width at the 60-pound seeding rate produced the lightest seed. Plant height also was influenced by row width. The 24, 32, and 8 inch row widths produced the tallest plants; and 16 inch row widths produced the shortest plants. No explanation was offered for this occurrence.

In studies with 5 varieties at Purdue University, Weiss, et al. (37) found the following attributes to be significantly correlated: Lateness of maturity with high oil content, lateness of maturity with low protein content, and high protein content with low oil content. No appreciable association among variety means was found between: Seed size and oil content, seed size with protein content, days from flowering to maturity with oil content, and mean temperature with oil content.

In 1964, Burnside and Colville (3) in Nebraska got an increase in soybean height (37.1 inches to 36.6 inches) with tillage when compared to no-tillage plots. They concluded this was probably due to weed competition. Irrigated soybeans had a greater weight per 100 seeds (17.4 grams to 16.8 grams) than did non-irrigated ones. There was a highly significant positive correlation between protein percentage of seed and 100 seed weight. This was expected since Krober and Cartter (19) found that high protein seeds were the larger seeds in their study.

Gregory, et al. (13) noted that special problems exist in no-tillage practices that don't arise with conventional seedbed preparation. One of these problems occurs when the crop residues left on the surface produce conditions favorable for insect and disease development. Another is that herbicides must be carefully selected to give full season weed control in no-tillage fields. In spite of these conditions, he states the advantages offered by no-tillage offset by far the problems reported by growers. These advantages include: (1) reduced soil and moisture loss (2) ability to keep planting under wet conditions (3) yields equal to or higher than those from conventional tillage (4) better maintenance of the soil's physical condition. Gregory also noted that soils with crop residues tend to be colder by 3 to 7 degrees when compared to conventionally-prepared seedbeds; therefore, he suggests a delay in planting of 7 to 10 days in cool springs. His experiments indicated that yields tended to remain higher in no-tillage crops planted late than in the conventional early planting.

Beale (1) studied the management of oat straw residues and tillage practices for soybean production in an oat-soybean rotation in South Carolina. The effects of tillage practices on soybean yields were not statistically significant. Burning the oat straw before planting soybeans had no significant effect on yields or soil properties. Fertilization of soybeans after growing the oats did not increase bean yields. Soybean stands were somewhat better if the oat straw was burned or moved from the seed zone.

Phillips (26) conducted tests comparing no-tillage planted soybeans, no-tillage double-crop plantings following the harvest of barley, and conventional seedbed preparation in 1968 near Hopkinsville, Kentucky. Mid- to full-season varieties tended to be higher yielding under no-tillage and late plantings in a double-cropping system with small grain. Results indicated taller plants yielding 40.7 bushels per acre in no-tillage.

In Nebraska, Burnside and Colville (3) obtained increased weed control when soybeans were planted in 10 or 20 inch rows rather than in 30 or 40 inch rows with 3-amino-2,5-dichlorobenzoic acid (Amiben) applied as a preemergence treatment at all spacings under irrigated and non-irrigated conditions.

CHAPTER III

MATERIALS AND METHODS

Eleven soybean strains plus a check variety, Hill, were used in this experiment. These strains were selected because of their small seed size. It is believed that small-seeded strains would retain their plumpness better than large-seeded varieties when grown under stress conditions such as those that might be experienced in a double-cropping system. The strains selected are shown below:

Oklahoma Accession No.	Strain Number	Pedigree
S-905	D65-2547-1-67	P.I. 196177 (2) x Hill
S-907	D65-2503-67	P.I. 196177 (2) x Hill
S-909	D65-2550-11-66	P.I. 196177 (2) x Hill
S-910	D65-2514-65	P.I. 196177 (2) x Hill
S-915	D65-2494-4-66	P.I. 196177 (2) x Hill
S-916	D65-2547-1-67	P.I. 196177 (2) x Hill
S-855	6417-3-64-1-65-4&5-66-159-60	P.I. 196177 (2) x Hill
S-864	6430-4-64-1-65-2-65-358	P.I. 196177 (2) x Hill
S-865	6430-4-64-2-65-2-66-372	P.I. 196177 (2) x Hill
S-872	6397-3-64-1-65-5-66-418	P.I. 196177 (2) x Hill
S-741	P.I. 196177	Unknown

In 1969, the experiment was located on a Vanoss loam soil on the Agronomy Research Station near Perkins, Oklahoma. The soybeans were planted with a Planet Jr. vegetable seed planter on May 26. Each strain was planted in plots having respectively eight rows that were 20 inches apart and four rows that were 40 inches apart within each replication. These factorial arrangements of 12 entries and two row spacings were layed out in a randomized block design having 3 replications. All plots were twenty feet long and the seeding rate was 10 to 12 seeds per foot of row for both spacings. Thus, the plant population for the narrow spacings was double that of the wide spacing.

In 1970, the same type of experiment was located on a Norge loam on the same research station. On June 23 the wheat stubble was burned from the area to be planted. The field was then disked twice and harrowed twice. The soybeans were planted the following day with a tractor drawn V-belt planter. A nitrogen fixing bacteria, Rhizobium japonicum, was applied to the seed prior to planting. Row widths and plot lengths were the same as those used in 1969. On June 26, 2-chloro-2',6'-diethyl-N-(methoxymethyl)acentanilide (Alachlor) was applied at 2 pounds of active ingredient per acre with an experimental plot tractor sprayer. The herbicide was applied in 30 gallons of water per acre.

The date of the first plant to bloom was recorded for each plot. The maturity date for a plot was defined to occur when 90 to 100 percent of all pods in that plot turned brown. Both first bloom and maturity were recorded as the number of days from planting.

The plots were cut by hand and threshed in the field with a plot thresher on November 5, 1969, and November 23, 1970. The two middle rows were harvested from each wide row plot, and the four middle rows were harvested from each narrow row plot. Thus, equal amounts of land area were involved. Fourteen feet and five inches of row were harvested from each row. When the threshed soybeans had air-dried to a uniform moisture content, they were cleaned and weighed in grams per plot. A random sample of 100 clean, whole seeds from each plot was weighed to determine 100 seed weight.

The amount of soybean shattering resulting from harvesting was obtained the day following harvest. Each plot was rated 1 to 5 depending on the amount of shattering that occurred. The scale used to estimate shattering corresponds to the following:

1- no shattering
2- 1 to 3% shattering
3- 4 to 8% shattering
4- 9 to 19% shattering
5- over 20% shattering

Protein content was determined by the Winkler modification of the macro Kjeldahl method as described by Jacobs (14). Crude protein percentage was determined by multiplying the Kjeldahl nitrogen by the factor 6.25.

Oil content was determined by an ether-extraction method. This involved drying a finely ground two gram sample at 105° C for approximately 18 hours. The samples were then placed on the oil extractor and ether was allowed to permeate each sample for 24 hours, thereby removing the oil from each sample into a weighed cup. The ether was then evaporated from each cup leaving only oil in the cup. These cups were then placed in a drying oven at 50° C for thirty minutes to assure total evaporation of the ether. The cups were weighed and the oil percentage calculated as follows: $\% \text{ oil} = \frac{\text{oil weight}}{\text{sample weight}} \times 100$. Duplicate determinations were made for each sample.

The testa percentage was determined on 25 seeds chosen at random. They were weighed on a torsion balance and then soaked in water for 1 hour. The seed coats were then removed with a pair of small forceps. Testa and cotyledons were placed in a forced-air oven for 12 hours at 50° C. The cotyledons were then weighed and the testa percentage calculated as follows: $100 - \frac{(\text{cotyledon weight in grams})}{(\text{total weight in grams})} \times 100$.

A preliminary analysis of variance was made on the data for the combined years. Since this analysis indicated a year x entry interaction and the analysis for each year showed large differences in experimental error, an analysis was made for each year. In cases where there was entry x spacing interaction within each year, the analysis was further separated by each spacing. Duncan's Multiple Range Test was applied, where applicable, on the responses for the entries.

CHAPTER IV

RESULTS AND DISCUSSION

Yield

The yields for the two years varied substantially. The 1969 yields were about what one could expect under dryland conditions with average summer rainfall. However, in 1970, inadequate rainfall throughout the grain filling stage of development severely reduced yields to about one-third of the 1969 level (Figure 1).

The analysis of variance for yield in 1969 showed entries to be significantly different at the 1 percent level of probability (Table 1). Strains S-864, S-865, S-907, S-909, S-916, and the Check yielded significantly higher than the other entries (Table II). Considering the two spacings, the wide rows averaged 57 pounds per acre more than the narrow rows.

The analysis of variance for yield in 1970 showed entries to be significantly different at the 5 percent level of probability while spacing was significantly different at the 1 percent level and an entry x spacing interaction was significant at the 5 percent level of probability (Table 1). Due to this interaction the entries were compared within spacings. Entries were significantly different at the 1 percent level within the narrow spacing (Table 1). Strains S-855, S-864, S-872, S-905, S-909, S-915, and the Check yielded significantly higher than the other strains (Table II). There were no significant

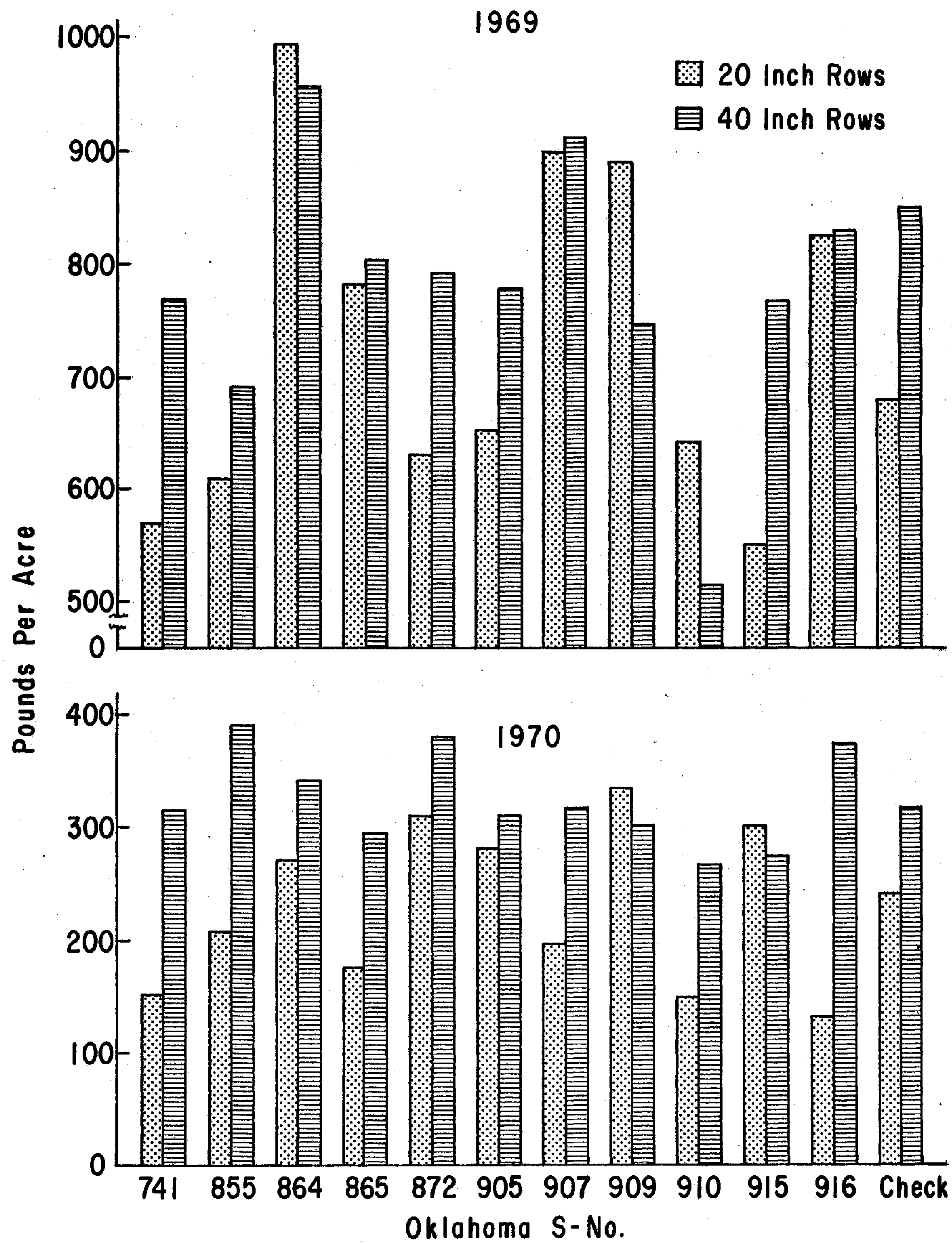

Figure 1. Average Yields for 12 Soybean Strains at 2 Row Spacings for 2 years

differences in yield among the entries at the wide spacing. However, entries at the wide spacings averaged almost 100 pounds per acre more (324 pounds to 228 pounds) than entries at the narrow spacings. The effects of drought were very apparent on plants at the narrow row spacings.

TABLE I

MEAN SQUARES FOR YIELD WITHIN YEARS
FOR ENTRIES AND SPACINGS

Source	d.f.	Mean Squares	
		1969	1970
Reps	2	82,150.35	101,414.93
Spacing (S)	1	56,953.13	165,312.50**
Entries (E)	11	78,827.62**	9,761.62*
E x S	11	22,308.43	9,974.62*
Entries in narrow	11	-	14,970.39**
Entries in wide	11	-	4,765.85
Error	46	18,042.74	4,121.09
C.V.		17.77%	23.22%

*,** Significant at the 0.05 and 0.01 levels of probability, respectively.

TABLE II

MEAN YIELD IN POUNDS PER ACRE BY SPACING AND YEAR*

	1969			1970		
Entry	Narrow	Wide	Average	Narrow	Wide	Average
Check	680	850	765 abc	240 abcde	318	279
S-741	573	768	671 bc	150 cde	315	233
S-855	612	693	653 bc	207 abcde	390	298
S-864	995	958	977 a	272 abcd	342	307
S-865	782	803	793 abc	175 bcde	297	236
S-872	632	793	713 bc	310 ab	380	345
S-905	653	778	716 bc	282 abc	312	297
S-907	909	913	907 ab	195 bcde	318	257
S-909	890	743	817 abc	335 a	302	318
S-910	642	513	578 c	145 de	267	206
S-915	550	765	658 bc	300 ab	276	288
S-916	825	828	827 abc	132 e	375	253
Average	728	784	756	228	324	276

* Means followed by the same letter are not significantly different from each other at the 0.05 level according to Duncan's Multiple Range Test.

Yield was not significantly correlated to 100 seed weight, maturity date, first bloom date, protein, oil, or testa percentage either year. However, yield was positively correlated to shattering at the 5 percent level in 1969 and correlated at the 1 percent level in 1970.

100 Seed Weight

The mean 100 seed weight generally showed the same trend for each entry both years (Figure 2). The Check variety averaged higher seed weight than any other entry both years. This was expected since all other entries were selected on the basis of low seed weight.

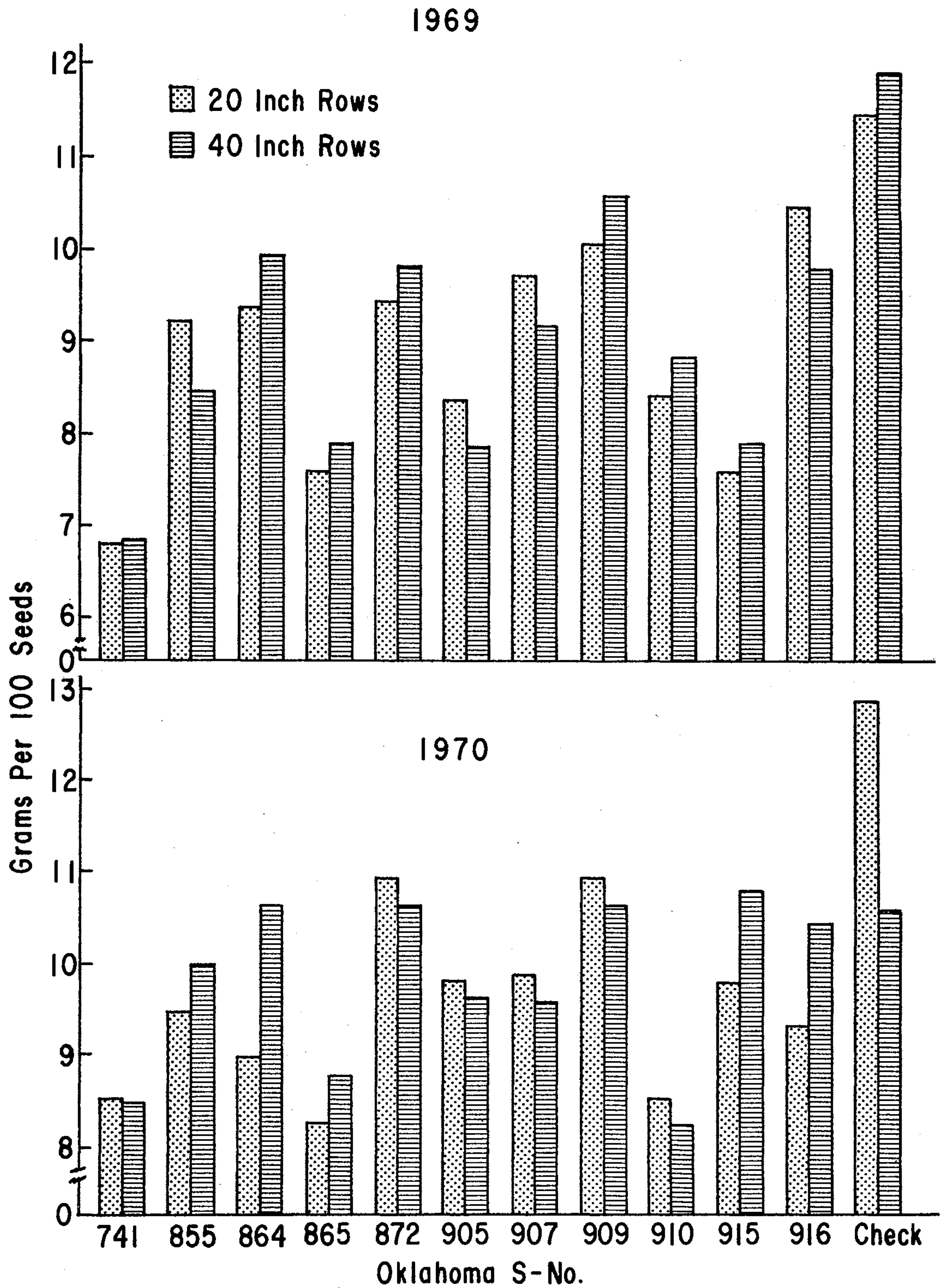

Figure 2. Average 100 Seed Weight for 12 Soybean Strains at 2 Row Spacings for 2 Years

The analysis of variance for 100 seed weight showed entries to be significantly different in 1969 (Table III). Spacing had no effect on the seed weight. Within the strains, S-864, S-872, S-907, S-909, and S-916 had significantly higher seed weights than the other entries (Table IV).

TABLE III

MEAN SQUARES FOR 100 SEED WEIGHT WITHIN YEARS FOR ENTRIES AND SPACINGS

		Mean Squares	
Source	d.f.	1969	1970
Reps	2	0.2143	2.9901
Spacing (S)	1	0.0006	0.1168
Entries (E)	11	11.0913**	5.9550**
E x S	11	0.3793	1.4892**
Entries in narrow	11	-	5.0130**
Entries in wide	11	-	2.4300**
Error	46	0.2798	0.3654
C.V.		5.84%	6.16%

*,** Significant at the 0.05 and 0.01 levels of probability, respectively.

TABLE IV

MEAN 100 SEED WEIGHT IN GRAMS BY SPACING AND YEAR*

	1969			1970		
Entry	Narrow	Wide	Average	Narrow	Wide	Average
Check	11.46	11.93	11.70 a	12.83 a	10.53 a	11.68
S-741	6.80	6.83	6.81 f	8.56 cde	8.50 cd	8.53
S-855	9.20	8.40	8.80 cd	9.46 cde	9.96 ab	9.72
S-864	9.36	9.93	9.65 bc	8.90 cde	10.63 a	9.77
S-865	7.60	7.86	7.73 e	8.26 e	8.76 bcd	8.52
S-872	9.46	9.80	9.63 bc	10.93 b	10.63 a	10.78
S-905	8.36	7.83	8.10 de	9.80 bcd	9.63 bc	9.72
S-907	9.70	9.16	9.43 bc	9.86 bc	9.56 abc	9.72
S-909	10.06	10.56	10.31 b	10.90 b	10.63 a	10.77
S-910	8.40	8.60	8.50 de	8.50 d	8.23 d	8.37
S-915	7.60	7.86	7.73 e	9.76 bcd	10.56 a	10.17
S-916	10.46	9.76	10.11 b	9.33 cde	10.43 a	9.88
Average	9.04	9.04	9.04	9.76	9.84	9.80

* Means followed by the same letter are not significantly different from each other at the 0.05 level according to Duncan's Multiple Range Test.

In 1970, the analysis of variance showed entries to be highly significantly different while spacings were not different (Table III). There was an entry x spacing interaction, so the entries were compared within each spacing. This analysis revealed that entries were highly significantly different within both the narrow and wide spacings (Table III). The Check, as expected, was significantly higher in seed weight than other entries in narrow rows. Within the strains, S-872, S-905, S-907, S-909, and S-915 had heavier seed weights than the other entries. The Check, however, had a seed weight of almost 2 grams more than these. In the wide spacings, only strains S-741, S-865, and S-910 were significantly different from the other entries. They had a low seed weight which was characteristic of these three at both spacings in 1970 (Table IV).

Strain S-741 was consistently low both years regardless of spacing. In contrast to the narrow row results, the Check variety was not significantly higher than all other entries in the wide rows in 1970. A weighing error may be the reason for this since it was expected to have a higher seed weight than all other entries.

One hundred seed weight was positively correlated to protein percentage in 1970 only. There was no significant correlation either year between 100 seed weight and oil or testa percentage.

Shattering

The amount of seed shattering that occurred was generally higher in narrow rows both years (Figure 3). This may be expected because of the higher plant populations within the narrow spacing offering more opportunity for shattering to occur per unit area.

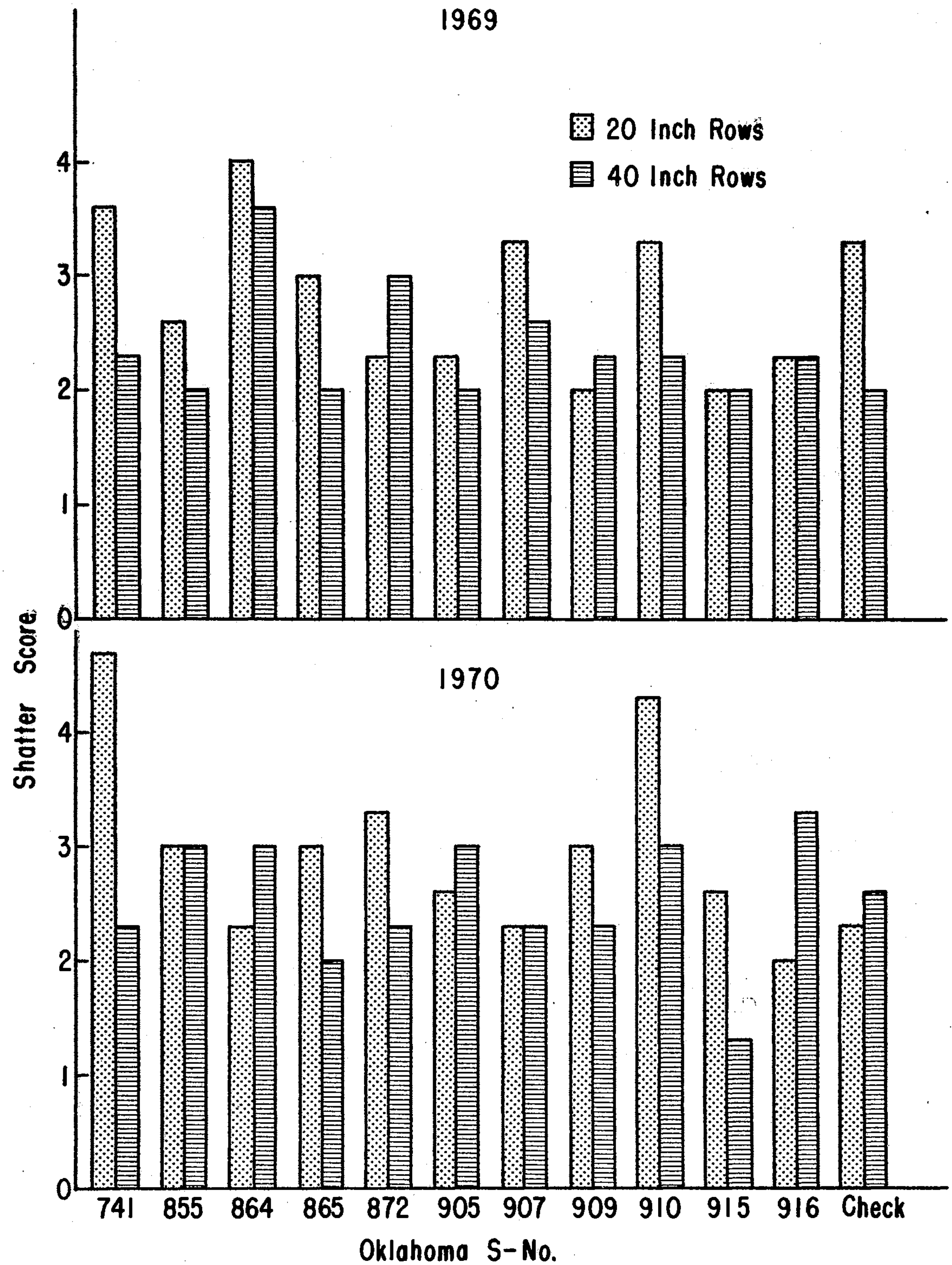

Figure 3. Average Shatter Score for 12 Soybean Strains at 2 Row Spacings for 2 Years

The analysis of variance showed both entries and spacings to be significantly different at the 1 percent level for shattering both years. Since an entry x spacing interaction was significant both years, the entries were compared within each spacing.

Results in 1969 showed entries to be significantly different at the 1 percent level for both spacings (Table V). Strains S-741, S-864, S-865, S-907, S-910, and the Check comprised the group which shattered most within narrow rows (Table VI). Of this group, only S-864 was a high shattering strain in the wide rows. This strain was also the highest yielder in either spacing in 1969. Strains S-855, S-865, S-905, S-909, S-915, and S-916 were consistently in the lowest shattering group regardless of spacing.

TABLE V

MEAN SQUARES FOR SHATTERING WITHIN YEARS
FOR ENTRIES AND SPACINGS

		Mean Squares	
Source	d.f.	1969	1970
Reps	2	0.5417	0.0972
Spacing	1	4.0139**	3.1250**
Entries in narrow	11	1.3610**	1.9670**
Entries in wide	11	0.7770**	0.9290*
Error	46	0.2663	0.3871
C.V.		19.65%	22.51%

*,** Significant at the 0.05 and 0.01 levels of probability, respectively.

TABLE VI

MEAN SHATTER SCORE BY SPACING AND YEAR*

	1969			1970		
Entry	Narrow	Wide	Average	Narrow	Wide	Average
Check	3.3 ab	2.0 c	2.6	2.3 cd	2.6 abc	2.5
S-741	3.6 ab	2.3 bc	3.0	4.6 a	2.3 bc	3.5
S-855	2.6 bc	2.0 c	2.3	3.0 cd	3.0 ab	3.0
S-864	4.0 a	3.6 a	3.8	2.3 cd	3.0 ab	2.6
S-865	3.0 abc	2.0 c	2.5	3.0 cd	2.0 cd	2.5
S-872	2.3 c	3.0 ab	2.6	3.3 bc	2.3 bc	2.8
S-905	2.3 c	2.0 c	2.1	2.6 cd	3.0 ab	2.8
S-907	3.3 ab	2.6 bc	3.0	2.3 cd	2.3 bc	2.3
S-909	2.0 c	2.3 bc	2.1	3.0 cd	2.3 bc	2.6
S-910	3.3 ab	2.3 bc	2.8	4.3 b	3.0 ab	3.6
S-915	2.0 c	2.0 c	2.0	2.6 cd	1.3 d	2.0
S-916	2.3 c	2.3 bc	2.3	2.0 d	3.3 a	2.6
Average	2.8	2.4	2.6	2.9	2.5	2.7

* Means followed by the same letter are not significantly different from each other at the 0.05 level according to Duncan's Multiple Range Test.

In 1970, entries were highly significantly different for both spacings (Table V). Three strains, S-741, S-872, and S-910 shattered significantly more in narrow spacings than other entries within that spacing (Table VI). Of this group, only S-910 continued to show high shattering at the wide spacing. At this wide spacing, strains S-865 and S-915 shattered significantly less than any of the other entries. Strain S-915 had a shatter score of 1.3 which was the lowest score for any strain either year regardless of spacing.

Field observations made on non-harvested plants in each plot approximately 2 weeks after harvest indicated that some of the plants had shattered almost 100 percent. However, no data was recorded for this shattering and no statistical analysis made.

Shattering at harvest was positively correlated to maturity at the 1 percent level in 1969 and at the 5 percent level in 1970.

First Bloom

First bloom dates followed the same general trend for both years (Figure 4). In all cases, the strains in the wide row plots bloomed as soon or sooner than any entry within the narrow spacing. This was probably due to the stress conditions of the plants in the narrow rows. Within entries, bloom date was never more than seven days later in the narrow rows either year and generally was within two days of the bloom date of the corresponding entry at the wide spacing.

Since the analysis of variance showed entry x spacing interaction highly significant both years, the entries were compared within spacings for each year. Entries were highly significantly different for both spacings both years (Table VII).

In 1969 and 1970, strains S-864 and S-910 bloomed significantly later than any other entry regardless of the spacing involved. Also, strain S-915 bloomed significantly earlier than any other entry in 1969 and was in the group which bloomed first at both spacings in 1970 (Table VIII).

First bloom date was positively correlated to maturity date at the 5 percent level in 1969 only.

Maturity

As with first bloom, maturity followed the same general trend both

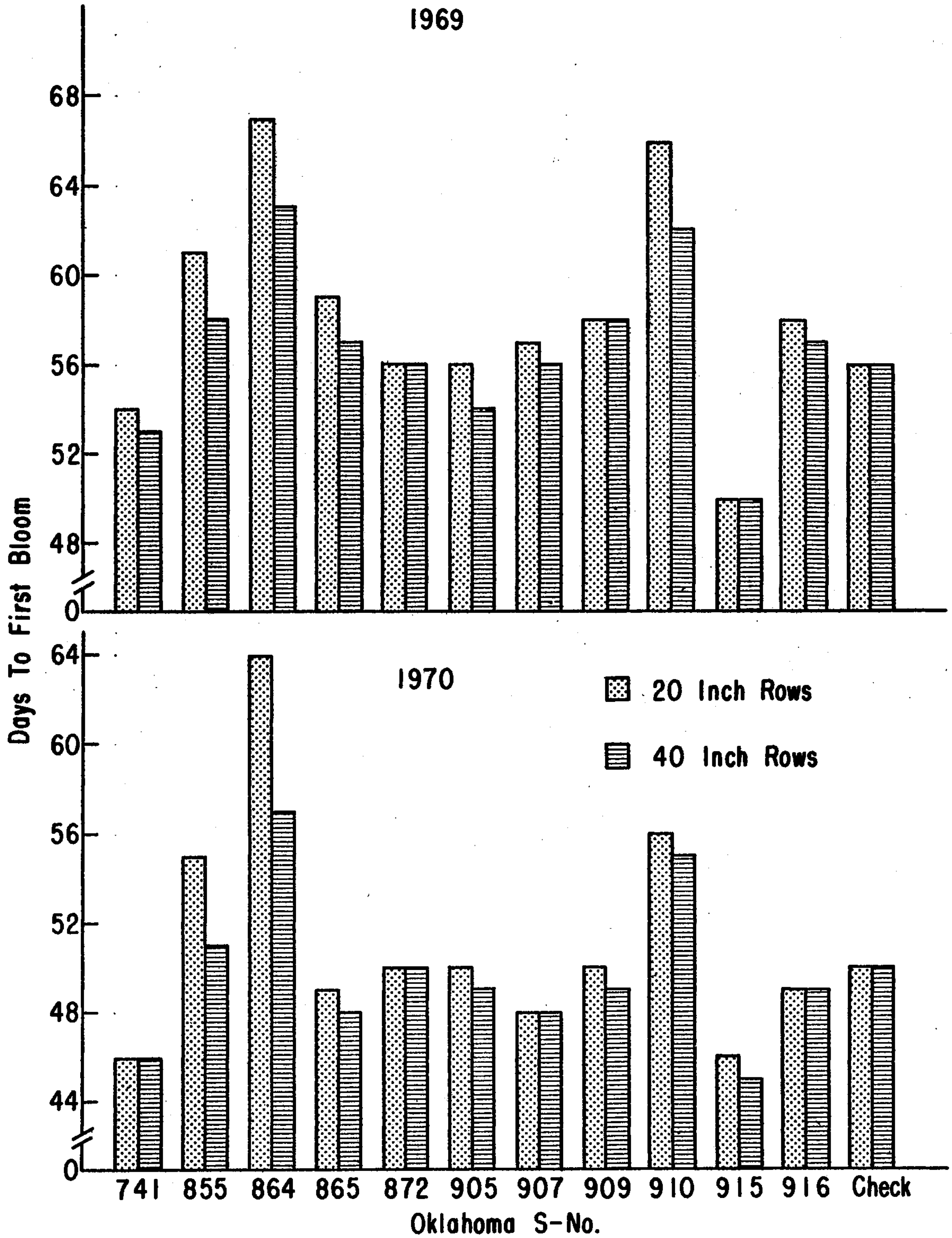

Figure 4. Average Days to First Bloom for 12 Soybean Strains at 2 Row Spacings for 2 Years

years at the two spacings (Figure 5). This could be expected since maturity is closely correlated with the first bloom date in most soybean varieties. Weber and Shibles (34) found maturity date unaffected by row width.

TABLE VII

MEAN SQUARES FOR FIRST BLOOM WITHIN YEARS FOR ENTRIES AND SPACINGS

Source	d.f.	Mean Squares	
		1969	1970
Reps	2	3.5972	0.8472
Spacing	1	48.3472**	39.0139**
Entries in narrow	11	68.6744**	84.5054**
Entries in wide	11	39.5651**	36.1813**
Error	46	1.0320	1.8907
C.V.		1.76%	2.72%

*,** Significant at the 0.05 and 0.01 levels of probability, respectively.

All entries in the wide spacings matured before the ones in the narrow spacings except S-864 and S-905 in 1969, and these two matured only two days prior to their counterparts at the wide spacing.

In 1970, all wide row plots matured as soon or sooner than any corresponding entry at the narrow spacing. Plants at the narrow

TABLE VIII

MEAN DAYS FROM PLANTING TO FIRST BLOOM BY SPACING AND YEAR*

	1969			1970		
Entry	Narrow	Wide	Average	Narrow	Wide	Average
Check	56 de	56 c	56	50 c	50 bc	50
S-741	54 e	53 d	53	46 d	46 de	46
S-855	61 b	58 b	59	55 b	51 b	53
S-864	67 a	63 a	65	64 a	57 a	60
S-865	59 c	58 b	58	49 cd	48 cd	48
S-872	56 de	56 c	56	50 c	50 bc	50
S-905	56 de	54 d	55	50 c	49 bc	49
S-907	57 cd	56 c	56	48 cd	48 cd	48
S-909	58 cd	58 b	58	50 c	49 bc	49
S-910	66 a	62 a	64	56 b	55 a	55
S-915	50 f	50 e	50	46 d	45 e	45
S-916	58 cd	57 bc	57	49 cd	49 bc	49
Average	59	57	58	52	50	51

* Means followed by the same letter are not significantly different from each other at the 0.05 level according to Duncan's Multiple Range Test.

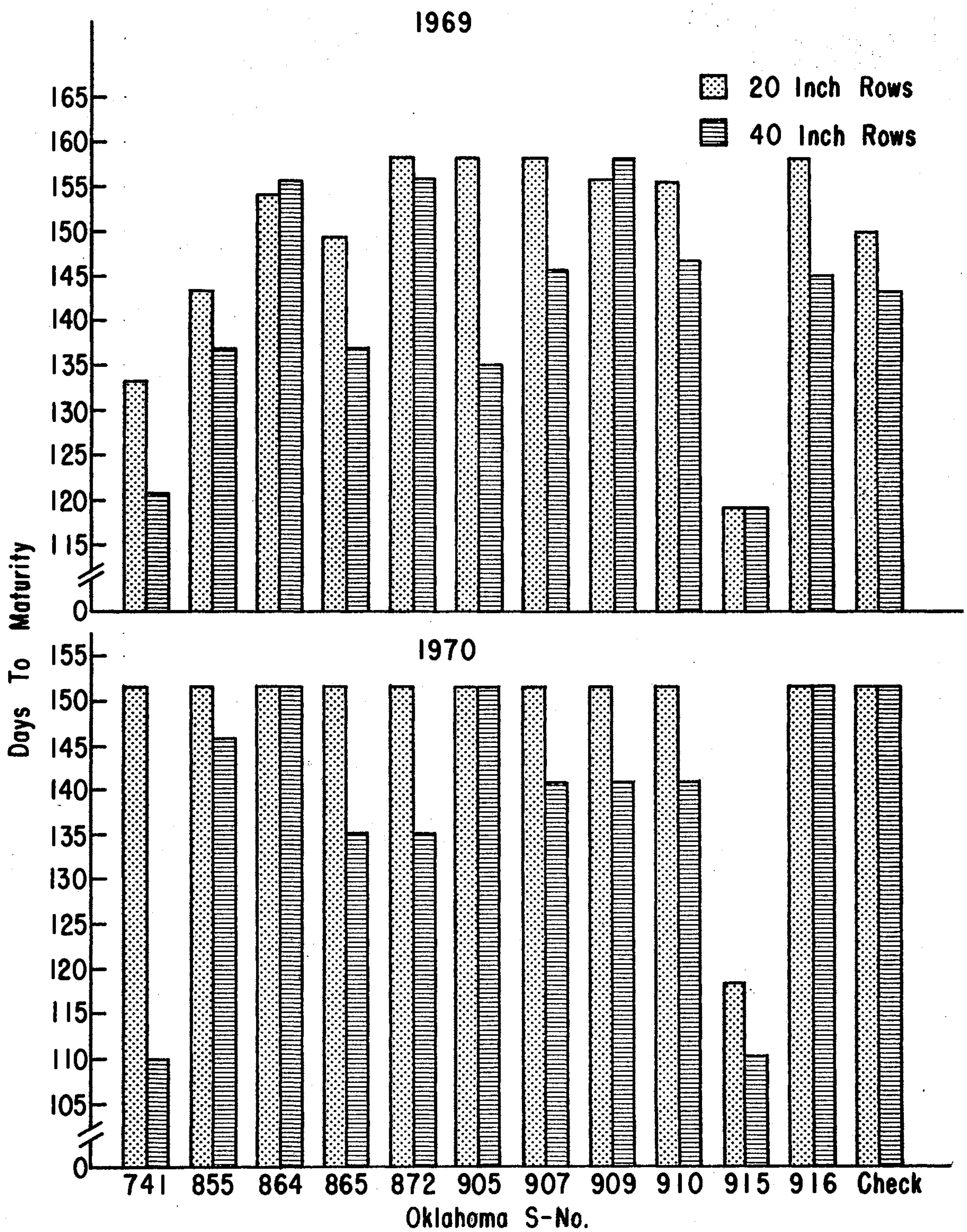

Figure 5. Average Days to Maturity for 12 Soybean Strains at 2 Row Spacings for 2 Years

spacings had been under more stress conditions than plants at the wide spacing throughout the growing season. With fall rains these plants began to grow more vegetatively than the wide row plots. Consequently, maturity occurred later for the narrow row entries.

Since the analysis of variance within years showed an entry x spacing interaction, the entries were compared within each spacing and year.

The analysis for 1969 showed entries to be highly significantly different at both row spacings (Table IX). At the narrow spacing strain S-915 matured significantly earlier than any other entry. Strains S-872, S-905, S-907, and S-916 were the last to mature (39 days later than S-915).

TABLE IX

MEAN SQUARES FOR MATURITY WITHIN YEARS FOR ENTRIES AND SPACINGS

		Mean Squares	
Source	d.f.	1969	1970
Reps	2	0.5139	60.3889
Spacing	1	1,065.6806**	1,922.0000**
Entries in narrow	11	445.1182**	283.3616**
Entries in wide	11	482.1821**	668.6944**
Error	46	21.2385	23.1860
C.V.		3.16%	3.34%

*,** Significant at the 0.05 and 0.01 levels of probability, respectively.

TABLE X

MEAN DAYS FROM PLANTING TO MATURITY BY SPACING AND YEAR*

	1969			1970		
Entry	Narrow	Wide	Average	Narrow	Wide	Average
Check	150 ab	143 bc	146	152 a	152 a	152
S-741	133 c	121 e	127	152 a	110 d	131
S-855	143 b	137 cd	140	152 a	146 ab	149
S-864	154 a	156 a	155	152 a	152 a	152
S-865	149 ab	137 cd	143	152 a	135 e	143
S-872	158 a	156 a	157	152 a	135 e	143
S-905	158 a	135 d	146	152 a	152 a	152
S-907	158 a	146 b	152	152 a	141 bc	149
S-909	156 a	158 a	157	152 a	141 bc	149
S-910	156 a	147 b	151	152 a	141 bc	149
S-915	119 d	119 e	119	118 b	110 d	114
S-916	158 a	145 b	151	152 a	152 a	152
Average	150	142	146	150	139	145

* Means followed by the same letter are not significantly different from each other at the 0.05 level according to Duncan's Multiple Range Test.

At the wide spacing, again S-915 matured first. There was no significant difference between strains S-864, S-872, and S-909 which matured last. The Check was intermediate in maturity both years (Table X).

At the wide spacing, strain S-741, in addition to S-915, matured significantly earlier than the other entries. On the other hand, strains S-855, S-864, S-905, S-916 and the Check matured significantly later than the other entries. These entries matured at the same time in both spacings--152 days after planting. The Check was within the group that matured last at both spacings.

Maturity was not significantly correlated to protein, oil, or testa percentage either year.

Protein

The two year average for protein percentage at both spacings was almost equal when all entries were considered (Figure 6). All strains gave higher protein content in 1969 than the Check at either spacing. The same was true in 1970 except at the wide spacing where the Check was in the upper one-half of the entries.

The analysis of variance for protein percentage within years showed entries to be significantly different at the 1 percent level of probability in 1969 and 1970 and an entry x spacing interaction significant at the 1 percent level in 1970 only (Table XI). Spacings were non-significant both years.

In 1969, there was no significant difference in protein percentage for strains S-741, S-855, S-865, S-872, S-910, S-905, S-907, S-909, and S-915 which gave consistently higher protein contents. The Check

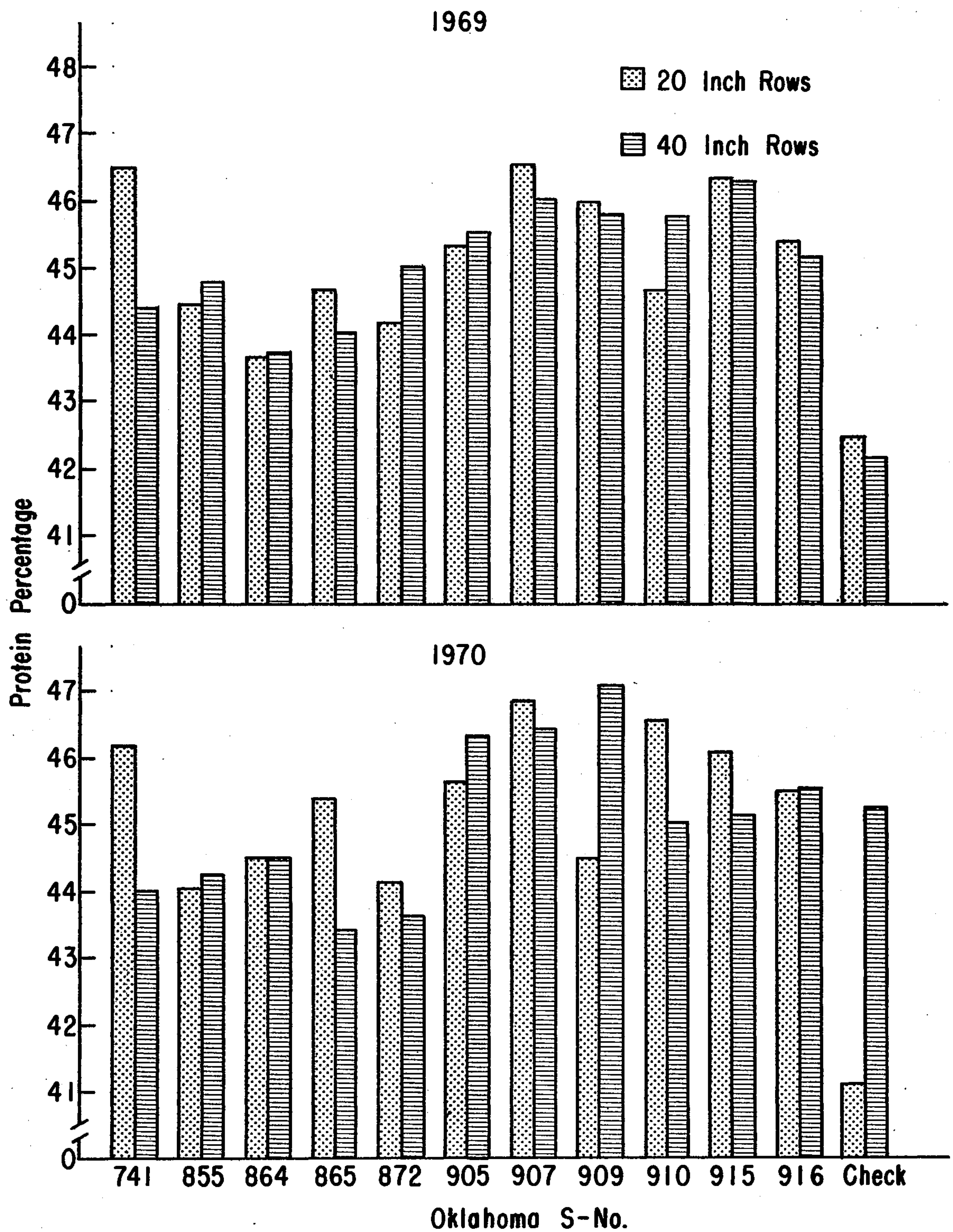

Figure 6. Average Protein Percentage for 12 Soybean Strains at 2 Row Spacings for 2 Years

was significantly lower than all other entries (Table XII).

TABLE XI

MEAN SQUARES FOR PROTEIN PERCENTAGE WITHIN YEARS
FOR ENTRIES AND SPACINGS

Source	d.f.	Mean Squares 1969	Mean Squares 1970
Reps	2	1.0761	2.1506
Spacing (S)	1	0.2713	0.1217
Entries (E)	11	7.8074**	5.8052**
E x S	11	0.9833	5.2668**
Entries in narrow	11	-	7.2759**
Entries in wide	11	-	3.7961**
Error	46	1.3381	0.9160
C.V.		2.57%	2.12%

*,** Significant at the 0.05 and 0.01 levels of probability, respectively.

Because of the entry x spacing interaction in 1970, the entries were compared within each spacing. They were significantly different at the 1 percent level of probability for both spacings (Table XI). The Check had significantly lower protein content in the narrow rows, while strains S-741, S-865, S-905, S-910, S-915, and S-916 had consistently higher protein content than the other strains (Table XII).

TABLE XII

MEAN PROTEIN PERCENTAGE BY SPACING AND YEAR*

Entry	1969 Narrow	1969 Wide	1969 Average	1970 Narrow	1970 Wide	1970 Average
Check	42.5	42.2	42.3 c	41.1 e	45.3 bc	43.2
S-741	46.5	44.4	45.4 ab	46.3 ab	44.0 cde	45.2
S-855	44.4	44.7	44.6 ab	44.1 d	45.3 bc	44.7
S-864	43.6	43.7	43.7 bc	44.5 bcd	44.5 cde	44.5
S-865	44.7	44.1	44.4 ab	45.4 abcd	43.4 e	44.4
S-872	44.1	45.0	44.6 ab	44.1 cd	43.6 de	43.9
S-905	45.3	45.5	45.4 ab	45.6 abcd	46.3 ab	46.0
S-907	46.6	46.1	46.3 a	46.8 a	46.4 ab	46.6
S-909	46.0	45.8	45.9 a	44.5 bcd	47.1 a	45.8
S-910	44.7	45.8	45.2 ab	46.6 a	45.0 bcd	45.8
S-915	46.4	46.3	46.3 a	46.1 abc	45.1 bcd	45.6
S-916	45.4	45.2	45.3 ab	45.5 abcd	45.5 bc	45.5
Average	45.0	44.9	44.95	45.1	45.1	45.10

* Means followed by the same letter are not significantly different from each other at the 0.05 level according to Duncan's Multiple Range Test.

At the wide spacing, strains S-905, S-907, and S-909 produced significantly higher protein percentage than the other strains. The Check was intermediate in protein content at this wide spacing averaging slightly over 45 percent protein.

For both spacings in 1970, strains S-905 and S-907 yielded the highest protein percentage. Strains S-864, S-865, and S-872 were consistently low at both spacings that year.

Oil

When combining entries at both spacings, the oil content in 1970

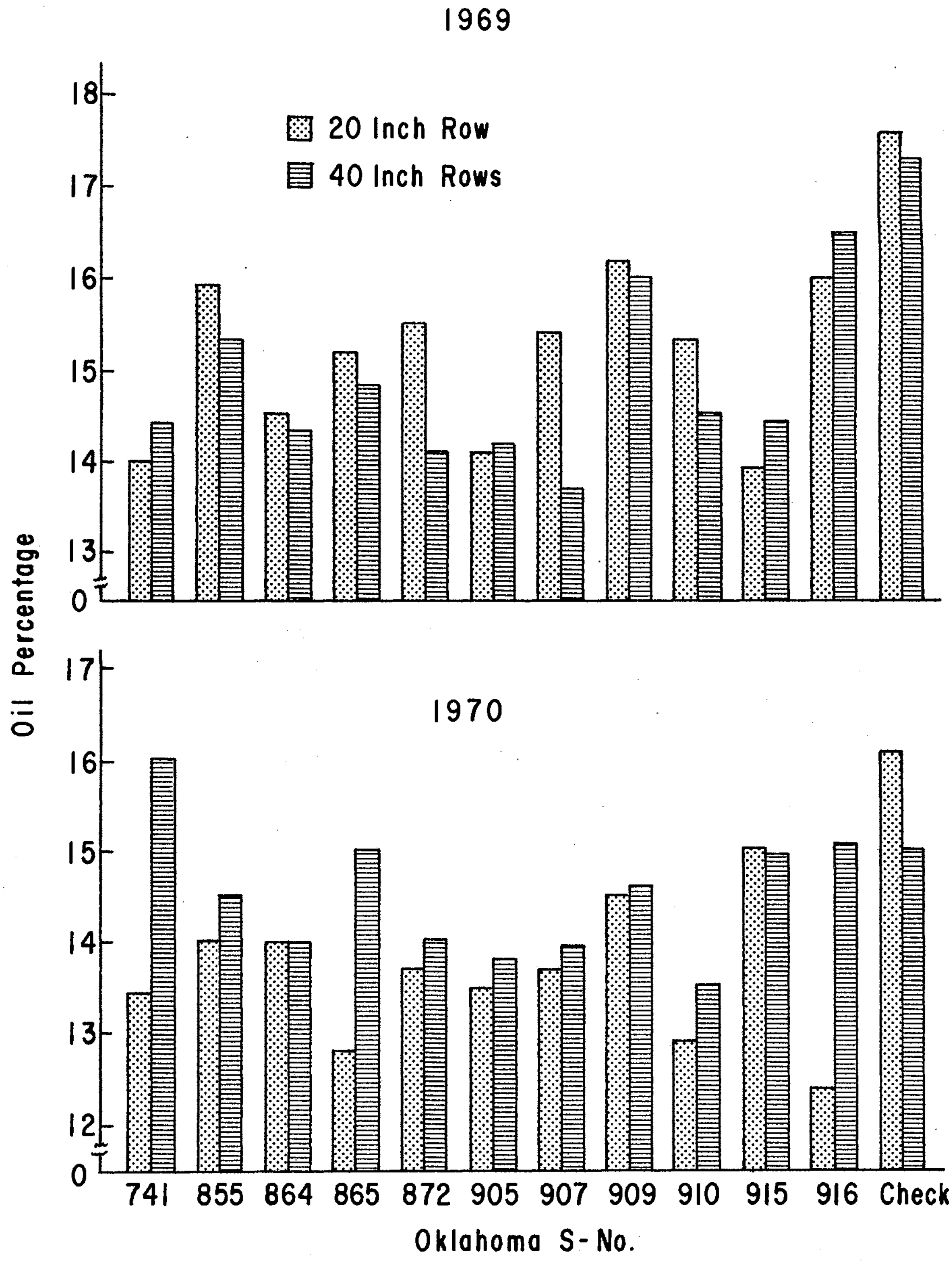

Figure 7. Average Oil Percentage for 12 Soybean Strains at 2 Row Spacings for 2 Years

averaged almost 1 percent lower than in 1969. Since the protein content was higher in 1970, this was expected because oil and protein are usually negatively correlated.

In 1969, the oil percentage followed the same pattern at both spacings, but in 1970 there were some wide variations among entries (Figure 7).

The analyses of variance for oil percentage within years and spacings showed entries to be significantly different at the 1 percent level both years. Spacings were highly significant in 1970 and a highly significant interaction occurred between entries and spacings (Table XIII).

TABLE XIII

MEAN SQUARES FOR OIL PERCENTAGE WITHIN YEARS FOR ENTRIES AND SPACINGS

Source	d.f.	Mean Squares 1969	Mean Squares 1970
Reps	2	5.7665	1.4592
Spacing (S)	1	2.0842	9.0312**
Entries (E)	11	6.4175**	2.6559**
E x S	11	0.6903	2.1581**
Entries in narrow	11	-	3.1835**
Entries in wide	11	-	1.6305**
Error	46	1.0745	0.2862
C.V.		6.83%	3.76%

*,** Significant at the 0.05 and 0.01 levels of probability, respectively.

TABLE XIV

MEAN OIL PERCENTAGE BY SPACING AND YEAR*

	1969				1970			
Entry	Narrow	Wide	Average		Narrow		Wide		Average
Check	17.7	17.3	17.5	a	16.2	a	15.1	ab	15.6
S-741	14.1	14.4	14.3	c	13.4	def	16.1	a	14.8
S-855	15.9	15.3	15.6	bc	14.0	cd	14.6	bcd	14.3
S-864	14.5	14.3	14.4	bc	14.1	cd	14.1	bcd	14.1
S-865	15.3	14.8	15.0	bc	12.8	fg	15.1	ab	14.0
S-872	15.5	14.2	14.8	bc	13.8	cde	14.0	bcd	13.9
S-905	14.2	14.3	14.2	c	13.5	def	13.8	cd	13.7
S-907	15.4	13.8	14.6	bc	13.8	cde	13.9	cd	13.8
S-909	16.3	16.0	16.1	ab	14.5	b	14.7	bc	14.6
S-910	15.3	14.9	15.0	bc	12.9	efg	13.5	d	13.2
S-915	13.9	14.4	14.2	c	15.1	b	14.9	bc	15.0
S-916	16.1	16.6	16.3	ab	12.4	g	15.2	ab	13.8
Average	15.3	15.0	15.15		13.9		14.6		14.25

* Means followed by the same letter are not significantly different from each other at the 0.05 level according to Duncan's Multiple Range Test.

In 1969, strains S-909, S-916, and the Check had significantly higher oil contents than the other entries (Table XIV). This was expected for the Check since it had a low protein content. However, this was not expected for S-909 and S-916 since they had relative high protein content in 1969.

Because of the entry x spacing interaction in 1970, the entries were compared within each spacing. This analysis showed entries to be highly significantly different for both the narrow and wide spacings (Table XIII).

Within the narrow spacing, the Check had significantly higher oil content than any other entry (Table XIV). This was expected since it possessed the lowest protein percentage of all narrow row entries. Within the narrow spacing, the entries varied in oil content by almost 4 percent.

Strains S-741, S-865, S-916 and the Check yielded significantly higher oil content at the wide spacing than did any of the other entries. Variation within the wide spacing was not as pronounced as within the narrow spacing, being slightly over 2.5 percent.

Oil content was not significantly correlated to protein content at the 5 percent level either year, although it approached negative significance in 1970.

Testa

Although the testa percentage was fairly constant for all entries within years, there were wide variations between years for some entries (Figure 8). The testa percentage in 1970 was almost 1 percent lower than in 1969.

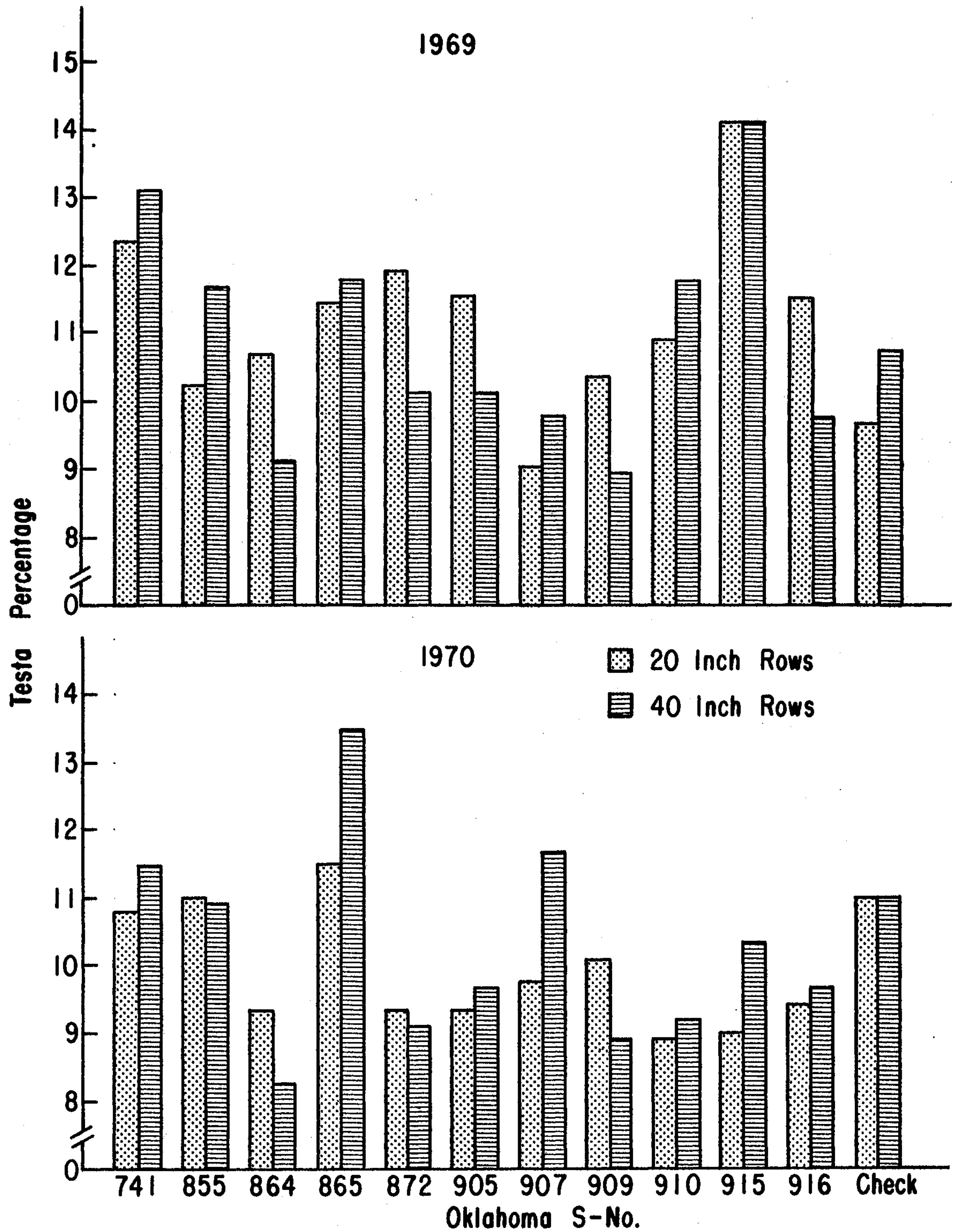

Figure 8. Average Testa Percentage for 12 Soybean Strains at 2 Row Spacings for 2 Years

The analyses of variance for testa percentages within years showed entries to be highly significantly different both years. Spacings were not statistically significant for testa percentage either year. However, entry x spacing interaction occurred both years (Table XV). Because of these interactions, the entries were compared within each spacing.

TABLE XV

MEAN SQUARES FOR TESTA PERCENTAGE WITHIN YEARS
FOR ENTRIES AND SPACINGS

Source	d.f.	Mean Squares	
		1969	1970
Reps	2	0.6202	2.5373
Spacing (S)	1	1.0418	2.0235
Entries (E)	11	10.8937**	7.4685**
E x S	11	2.3217**	1.9069*
Entries in narrow	11	5.4470**	2.3269*
Entries in wide	11	7.7916**	7.0408**
Error	46	0.6199	0.9557
C.V.		7.13%	9.60%

*,** Significant at the 0.05 and 0.01 levels of probability, respectively.

TABLE XVI

MEAN TESTA PERCENTAGE BY SPACING AND YEAR*

	1969			1970		
Entry	Narrow	Wide	Average	Narrow	Wide	Average
Check	9.6 ef	10.7 bcd	10.2	11.0 ab	11.1 bc	11.0
S-741	12.4 b	13.2 a	12.8	10.8 abc	11.5 b	11.2
S-855	10.3 def	11.6 bc	10.9	11.0 ab	10.9 bcd	11.0
S-864	10.6 cde	9.2 de	9.9	9.6 abc	8.1 f	8.9
S-865	11.4 bcd	11.7 b	11.6	11.5 a	13.5 a	12.5
S-872	11.9 bc	10.1 cde	11.0	9.3 bc	9.2 def	9.2
S-905	11.6 bcd	10.2 bcde	10.9	9.3 bc	9.6 cdef	9.5
S-907	9.1 f	9.7 de	9.4	9.8 abc	12.0 ab	10.9
S-909	10.4 def	8.8 e	9.6	10.2 abc	8.9 ef	9.5
S-910	10.9 cde	11.7 b	11.3	9.0 c	9.3 cdef	9.1
S-915	14.2 a	14.2 a	14.2	9.0 c	10.3 bcde	9.7
S-916	11.6 bcd	9.7 de	10.7	9.5 bc	9.6 cdef	9.5
Average	11.2	10.9	11.05	10.0	10.3	10.15

* Means followed by the same letter are not significantly different from each other at the 0.05 level according to Duncan's Multiple Range Test.

Results in 1969 showed entries to differ in testa percentage at the 1 percent level of probability for both row spacings (Table XV). Within the narrow spacing, strain S-915 had a significantly higher testa percentage than any other entry. The Check was intermediate for testa percentage at the wide spacing. The range for testa percentage was almost the same at both spacings.

Results in 1970 showed entries to be highly significantly different for testa percentage at the wide spacing and significantly different at the 5 percent level in the narrow spacing (Table XV). In the narrow rows, strains S-741, S-855, S-864, S-907, S-909 and the Check had significantly higher testa percentages than the other entries (Table XVI). Strains S-865 and S-907 had significantly higher testa percentages at the wide spacing. The Check was in the upper one-third of the entries at both spacings. The range in testa percentage at the wide spacing was more than double that of the narrow spacing. It appears that under stress conditions the amount of seedcoat produced does not vary much from one strain to another, especially at the narrow spacing. However, total variation was almost equal within each year.

Testa percentage was not significantly correlated to protein percentage, oil percentage, or 100 seed weight either year.

CHAPTER V

SUMMARY AND CONCLUSIONS

The objectives of this study were to evaluate, under weed free conditions, the performance of selected soybean strains at two row spacings in a double-cropping system following wheat. The variables measured on a plot basis were yield, seed weight per 100 seeds, first bloom date, maturity date, shatter percentage, protein percentage, oil percentage, and testa percentage.

Mean yields varied from 755 pounds per acre in 1969 to 276 pounds per acre in 1970. Wide row plots produced more seed than narrow row plots both years (57 pounds per acre more in 1969 and 96 pounds per acre more in 1970). Averaging both years, strain S-864 produced 60 pounds per acre more than any other entry.

One hundred seed weight was slightly higher in 1970 than in 1969. Spacing had no effect on seed weight.

Shattering percentages were almost equal for the two years. However, plants at the narrow spacing gave consistently higher shattering results than did plants at the wide spacing.

The means for first bloom dates showed entries to bloom 7 days earlier in 1970 than in 1969 due to the later planting date in 1970. The two year average indicated that narrow row plants bloomed 2 days later than plants at the wide spacing.

Mean maturity dates were 146 and 145 days after planting in 1969 and 1970 respectively. The two year average also showed plants at the narrow spacing maturing 9 days after plants at the wide spacing. Strain S-915 matured first both years regardless of spacing.

The mean protein percentage was almost equal regardless of year (44.95% in 1969 vs. 45.10% in 1970) or row spacing (45.05% in the narrow rows vs. 45.00% at the wide spacing). All entries had higher protein percentage than the Check except at the wide spacing in 1970.

Mean oil percentage was almost 1 percent higher in 1969 than in 1970. Row spacing had no effect on the oil content. The Check had the highest oil content of all entries except at the wide spacing in 1970.

The 1969 and 1970 growing seasons were such that the strains used in this experiment yielded more in the 40 inch rows than in the 20 inch rows both years. In 1969, the test was planted at a time when soybeans would normally be planted in this area for a full season crop. Total moisture and distribution were such that yields were about what one would expect in an average year for this location. Several earlier row spacing studies with soybean varieties in the southern states have similarly indicated no advantage to narrow row spacings. Maximum response to narrow rows is normally expected with shorter season and smaller plant type varieties. Since the test in 1970 was not planted until after wheat harvest, all entries were expected to produce less vegetative growth and perhaps show a response to the narrow rows. The fact that no response to narrow rows was obtained in 1970 is explained by the poor distribution of rainfall. Although total precipitation for 1970 was actually greater than 1969, the distribution in the grain-filling period of July and August was extremely low and all varieties were essentially under severe stress for their entire growth period as evidenced by the extremely low yield of all entries even in the wide row spacing.

Although total yields for 1970 were drastically reduced from the 1969 levels, the actual seed weight of the grain produced in 1970 was slightly larger than the 1969 crop. The percent testa of the seeds was slightly reduced in 1970 indicating that the seeds that were produced were plump seeds of good quality. The reduction in yield apparently was at the expense of the number of seeds produced.

Even though the yields obtained in 1970 certainly were not economically feasible, it is assumed that most summers in Oklahoma would not be quite as dry as the summer of 1970, particularly during the latter half of July and the entire month of August. The fact that these small-seeded soybean strains maintained their plumpness and quality under these severe stress conditions lends encouragement to the idea that a soybean of this type might fit economically into a double-cropping system in Oklahoma.

LITERATURE CITED

(1) Beale, O. W., and G. W. Longdale. 1967. Tillage and Residue Management Practices for Soybean Production in a Soybean-Small Grain Rotation. Agron. Jour. 59:31-33.

(2) Burlison, W. L., C. A. Van Doran, and J. C. Hackleman. 1940. Eleven Years of Soybean Investigations. Ill. Agr. Exp. Sta. Bull. 462.

(3) Burnside, O. C. and W. L. Colville. 1964. Yield Components and Composition of Soybeans as Affected by Mechanical, Cultural and Chemical Weed Control Practices. Agron. Jour. 56:348-351.

(4) Cartter, J. L. T., and E. E. Hartwig. 1962. The Management of Soybeans. Advances in Agronomy. Academic Press Inc., New York, N. Y.

(5) Caviness, C. E. 1959. Effect of Different Dates and Rates of Planting Soybeans. Ark. Agr. Exp. Sta. Rep. Ser. 88.

(6) Davidson, M. F. 1957. Influence of Between-Row and Within-Row Plant Spacings on Leaf Area, Internode Length, and Agronomic Characters of Soybean Varieties. M.S. Thesis, University of Nebraska, Lincoln, Nebraska.

(7) Dimmock, F., and F. S. Warren. 1953. The Influence of Time of Planting on the Yield and Comparison of Soybean Seed. Can. Jour. Agr. Sci. 33:550-558.

(8) Donovan, L. S., F. Dimmock, and R. B. Carson. 1962. Some Effects of Planting Pattern on Yield, Percent Oil and Percent Protein in Mandarin (Ottawa) Soybeans. Can. Jour. Plant Sci. 43:131-140.

(9) Dougherty, C. T. 1969. The Influence of Irrigation, Row Spacing, Plant Population, and Innoculation on the Yield of Soybeans in Canterbury. New Zeal. Jour. Agr. Res. 12:367-380.

(10) Frans, R. E. 1959. Effect on Soybean Yields of Herbicide and Narrow Row Width Combinations. Ark. Agr. Exp. Sta. Rpt. Series 84.

(11) Garner, W. W., H. A. Allard, and C. L. Foubert. 1914. Oil Content of Seeds as Affected by the Nutrition of the Plant. Jour. Agr. Res. 3:227.

(12) Greer, D. E., E. L. Pinnell, L. E. Cavanah, and L. F. Williams. 1965. Effect of Planting Date and Maturity Date on Soybean Seed Quality. Agron. Jour. 57:165-168.

(13) Gregory, W. W., J. W. Herron, C. H. Gulley, and S. H. Phillips. 1970. No-Tillage Recommendations. Kentucky Univ. Ext. Misc. 382:1-5.

(14) Hicks, D. R., J. W. Pendleton, R. L. Bernard, and T. J. Johnson. 1969. Response of Soybean Plant Type to Planting Pattern. Agron. Jour. 61:290-293.

(15) Hinson, K. and W. D. Hanson. 1962. Competition Studies in Soybeans. Crop Sci. 2:117-123.

(16) Howell, R. W. 1960. Physiology of the Soybean. Advances in Agronomy. Academic Press Inc., New York, N. Y.

(17) Jacobs, M. B. The Chemical Analysis of Foods and Food Products. D. Van Nostrand Company, Inc., Princeton, N. J.

(18) Johnson, B. J. and H. B. Harris. 1967. Influence of Plant Population on Yield and Other Characteristics of Soybeans. Agron. Jour. 59:447-449.

(19) Krober, O. A. 1962. Quantitative Interrelations of Protein and Non-Protein Constituents of Soybeans. Crop Sci. 2:171-172.

(20) Leffel, R. C. and G. W. Barber, Jr. 1961. Row Widths and Seeding Rates in Soybeans. Maryland Agr. Exp. Sta. Bull. 470.

(21) Lehman, W. F. and J. W. Lambert. 1960. Effects of Spacing Plants Between and Within Rows on Yield and Its Components. Agron. Jour. 52:84-86.

(22) McClelland, C. K. 1940. Methods and Rate of Planting Soybeans. Ark. Agr. Exp. Sta. Bull. 390.

(23) Osler, R. D. and J. L. Cartter. 1954. Effect of Planting Date on Chemical Composition and Growth Characteristics of Soybeans. Agron. Jour. 46:267-270.

(24) Oswalt, R. M., J. D. Arnold, and R. S. Matlock. 1969. Soybean Row Spacing. Okla. Agr. Exp. Sta. Progr. Rep. P 620:35-36.

(25) Pendleton, J. W., R. L. Bernard, and H. H. Hadley. 1967. For Best Yields Grow Soybeans in Narrow Rows. Ill. Agr. Exp. Sta. Ill. Res. 2:3-4.

(26) Phillips, S. H. 1969. No-Tillage Crop Production. Kentucky Univ. Ext. Misc. 377:25-26.

(27) Probst, A. H. 1945. Influence of Spacing on Yield and Other Characteristics in Soybeans. Jour. Am. Soc. Agron. 37:549-554.

(28) Reiss, W. D. and L. V. Sherwood. 1965. Effects of Row Spacings, Seeding Rate, and Potassium and Calcium Hydroxide Additions on Soybean Yields on Soils of Southern Illinois. Agron. Jour. 57:431-433.

(29) Shane, J. F., Charles Tutt, and Stuart Brabant. 1969. Soybean Varieties and Row Spacing. Kentucky Univ. Ext. Misc. 377:25-26.

(30) Smith, R. L. 1952. Soybean Yields as Affected by Row Widths. Ark. Farm Res. Vol. I, No. I.

(31) _____. 1959. Soybean Production in Western Florida. Soil and Crop Sci. Soc. Florida Proc. 19:226-231.

(32) Torrie, J. M. and G. M. Briggs. 1955. Effect of Planting Date on Yield and Other Characteristics of Soybeans. Agron. Jour. 47:210-213.

(33) Viljoen, N. J. 1937. An Investigation Into the Composition of the Soybean in South Africa. Union South Africa, Dept. Agr. and For., Sci. Bull. 169.

(34) Weber, C. R., and R. M. Shibles. 1966. Effect of Plant Populations and Row Spacing on Soybean Development and Production. Agron. Jour. 58:99-102.

(35) _____, and M. G. Weiss. 1948. Let's Push Up Soybean Yields. Iowa Farm Sci. 2:10-12.

(36) Weiss, M. G. 1949. Soybeans. Advances in Agronomy. Academic Press Inc., New York, N. Y.

(37) _____, C. R. Weber, L. F. Williams, and A. A. Probst. 1950. Variability of Agronomic and Seed Compositional Characters in Soybeans, as Influenced by Variety and Time of Planting. U.S.D.A. Tech. Bull. 1017.

(38) _____. 1952. Correlation of Agronomic Characters and Temperature with Seed Compositional Characters in Soybeans, as Influenced by Variety and Time of Planting. Agron. Jour. 44:289-297.

(39) Wiggans, R. G. 1939. The Influence of Space Arrangement on the Production of Soybean Plants. Jour. Amer. Soc. Agron. 31:314-321.

(40) Zohnley, J. W. 1942. Soybean Production in Kansas. Kan. Agr. Exp. Sta. Bull. 306.

APPENDIX

TABLE XVII

MONTHLY PRECIPITATION IN INCHES AT PERKINS FOR 1969 AND 1970

	1969	1970
Month	Amount	Amount
January	0.27	0.25
February	2.28	0.17
March	2.37	2.20
April	2.67	7.29
May	2.73	0.87
June	5.00	3.44
July	1.63	4.19
August	2.96	0.27
September	4.94	7.42
October	3.42	4.53
November	0.11	0.60
December	1.47	0.45
Total	29.85	31.68
30-Year Average	32.61	32.39

VITA

Bobby Gene Bratcher

Candidate for the Degree of

Master of Science

Thesis: THE PERFORMANCE OF SELECTED SOYBEAN STRAINS FOLLOWING SMALL GRAINS IN OKLAHOMA

Major Field: Agronomy

Biographical:

Personal Data: Born in Pauls Valley, Oklahoma, April 26, 1947, the son of Garland and Jeanine Bratcher.

Education: Attended elementary school at Maysville, Oklahoma, Graduated from Maysville High School in 1965. Received the Bachelor of Science degree in Agronomy in August of 1969. Completed requirements for the Master of Science degree at Oklahoma State University in May, 1971.

Professional Experiences: Reared and worked on a farm near Maysville, Oklahoma, until after high school graduation. Employed by the Burford Company, International, as a general laborer during the summer of 1966. Employed as a seed analyst for the Oklahoma Crop Improvement Association, Stillwater, Oklahoma, from February, 1967, to September, 1969, working part time during the school year and full time during the summer. Employed as a Graduate Teaching Assistant, Department of Agronomy, Oklahoma State University during the school years 1969-1971. Worked full time as an employee of the Agronomy Department during the summer of 1970 in the area of Turf Management.