UTILIZATION OF MOISTURE
BY KENT AND CLARK 63 SOYBEANS

by

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INTRODUCTION

Soybean production in Kansas has increased from approximately 2,000 acres in 1924 to nearly one million acres in 1966. With this increase, soybeans now rank as the fourth major cash crop in Kansas.

The increased production in Kansas is due primarily to increased acreage in contrast to increased yield per acre as is true with the other three major cash crops. Herein lies one of the largest agronomic problems, to increase soybean yield per acre.

To obtain maximum yield per acre, most soybean research has been directed toward date of planting, row width, physiological studies, and to the development of new varieties. Most of this research has been done in the corn belt area which includes the states with greatest soybean production.

Farmers, using this reliable research information, are planting new varieties, reducing row widths, and increasing plant populations per acre in an effort to increase per acre yields of soybeans. However, more investigation is needed, especially in Kansas and other midwest states where weather and moisture availability are variable, to determine the best variety, row width, and plant population for maximum soybean yields.

This study reports the investigations made on the effects of plant population, row width, and within-row spacings on moisture utilization, yield, and yield components of Kent and Clark 63 soybeans.

REVIEW OF LITERATURE

Moisture Utilization. A study in Illinois by Peters and Johnson (18) showed a substantial amount of water was used by soybeans to depths below 30 inches during a year of average rainfall, a year of above average rainfall, and under irrigation. They also showed some moisture use to a depth of 51 inches. They also determined in their study that the root system of the soybean plant did not fully utilize the moisture available in rows spaced 40 inches apart, but full utilization did occur when the rows were spaced 20 inches. Differences in moisture utilization by the two row widths was thought to have accounted for some of the increased yields in the 20 inch rows. They also concluded that evaporation from the soil surface accounted for half or more of the total moisture lost during a wet year, but evaporation accounted for only one-fourth to one-half of the total moisture loss in a dry year.

Japanese workers, as summarized by Cartter and Hartwig (4), reported that pod drop was increased by a moisture deficit for two to four weeks after flower bud initiation and also by an increase to high moisture content after a severe drought. They also found yields were reduced by short periods of excess moisture after bud differentiation and by a water table in the root zone.

Runge and Odell (20) found that above average precipitation during the periods of major vegetative growth and grain-filling increased yields but above average precipitation during other growth periods decreased yields.

Howell (9) found soybeans are more susceptible to drought injury during pod filling than at any other period of plant development. He also showed early and late maturing varieties react differently to moisture stress periods depending upon the stage of growth at the time of stress.

Laing (11) studied the effects of water stress on soybeans at different stages of vegetative growth and how these stress periods affected yield and yield components. He found that yield per plant was greatly reduced when water stress was applied to the plant; the greatest reduction in yield occurred during stress periods two to seven weeks after first flowering. Pods per plant, seeds per plant, and seed weight were affected by stress periods at this time also. He found water stress affected pod number through both flower abortion and pod abortion. His study also determined that water stress interfered with pod filling and reduced the number of seeds per pod; he found that pod abortion and restricted pod filling occurred simultaneously when induced by a water stress. The study also showed that seed size was reduced with water stress.

He also found that water stress influenced the oil and protein content of soybeans. Maximum protein was found at the same stress period which produced the smallest seed size, while maximum oil content was found in beans produced under the stress period which gave the largest seed size.

Yield. Probst (19) found that spacings of two and three inches within the row gave maximum yields and also that the one inch spacing was superior to any spacing greater than three inches.

Several workers (2, 14, 16, 23, 24) have increased seed yield with a decrease in the between-row spacing. Pendelton *et al* (17) determined that yields of all varieties tested could be increased an average of 15 percent by decreasing row width from 40 inches to 24 inches if the same plant population was maintained. However, in comparing intertilled rows with drilled plantings, Burlison et al (2) and Weber et al (22) obtained lower seed yields from the drilled plantings. Wiggans (24) obtained yield increases in narrow rows, but determined that within-row spacings up to three inches had little effect on yield. He concluded the most profitable net yield was obtained from a plant population of six plants per square foot of area. McClelland (16) determined that higher yields could be obtained from the row-method of planting as compared with the drill or solid broadcast method. Donovan et al (5) found that highest yields were obtained from row widths of five inches and within-row spacings of three inches. Leffel and Barber (13) determined that by spacing seed more closely within the row, reduced seed yields resulted. Hinson and Hanson (8) reported that wider spacings between plants within the row gave increased seed yields per plant.

A study in Kansas by Mader et al (15) showed that under normal moisture conditions, 20-inch row widths and one and two inch within-row spacings increased yields over 30 and 40 inch rows and three and four inch spacings. Under dry conditions, however, 20 inch rows still produced highest yields, but with the three and four inch within-row spacings.

Probst (19) showed that varieties vary in yield with row width and within-row spacing changes, but the differences were not extensive. Camper and Smith (3) found that varieties vary in yield with changes in plant population, but the variation was due to the differences of planting date more than to differences between varieties.

Geographical location alters the effect of row width and within-row spacings on yield. Fleetwood (6) determined that narrow rows generally increase yields. Hartwig (7), in summarizing work from several Southern states, found that narrow rows and higher plant populations gave no increase in yield.

Yield Components. Probst (19) found seed size was not affected by changes in within-row spacings but did tend to be slightly larger with the closer plant spacings. Lehman and Lambert (14) found pods per plant, seeds per plant, seeds per pod, and branching decreased with an increase in plant population. They also found seed weight generally increased with wider within-row spacings but the results varied somewhat with varieties. Burlison *et al* (2) found more pods were produced per plant when grown in rows spaced 24 inches apart than in rows eight inches apart. Camper and Smith (3) found seed size was not affected by population changes. Weber *et al* (22) reported seed size was independent of row width, but slightly smaller seeds were produced in the intermediate plant populations. They also found the greatest number of pods and seeds per plant were produced from the 10 inch row width and determined that each component decreased with increased plant population. More seeds per pod were found in the 20 inch rows and the intermediate plant populations.

Height, Lodging and Maturity. Probst (19) reported that plant height was not affected by changes in within-row spacings. He also found lodging was most severe in the one inch plant spacing and very little lodging in the four and five inch plant spacings. Leffel and Barber (13) and Camper and Smith (3) in two separate studies found height was not affected by row widths or plant populations, but that increased seeding rates did increase lodging. Weber and Weiss (23) determined that lodging increased by eight percent for each one-half bushel increase in seeding rate up to 2.2 bushels per acre. They also found that plant height increased with the heavier seeding rates. Hartwig (7) also found that narrow rows and higher plant populations increased lodging. Weber _et al_ (27) found row width did not affect height or lodging, but that these factors did tend to increase with thicker plant populations.

Probst (19), Burlison _et al_ (2), and Leffel and Barber (13) determined that maturity was delayed when soybeans were planted in narrow rows and at closer within-row spacings. Weber _et al_ (22) reported that maturity was affected by plant population, but not by row width.

Protein and Oil. Donovan _et al_ (5) found that the highest oil content to be in soybeans planted in wider row widths and wider within-row spacings. Protein was highest in the seeds produced from the narrow rows and the closer within-row spacings. He determined protein content of the seed was affected less by plant spacing than was oil content. Hinson and Hanson (8) also found protein was highest in seed grown in closer plant spacings, while oil content was highest from seeds grown in the wider plant spacings.

MATERIALS AND METHODS

The purpose of the study was to determine the effect of row width and within-row spacing on moisture utilization, seed yield, and yield components of Kent and Clark 63 soybeans.

The field test was conducted at the Kansas State University Agronomy Farm at Manhattan, Kansas, during the summer of 1966. The experiment was located on an unnamed silt loam soil which was well drained and ideally suited for the study.

The experiment was arranged as a split-plot design and each treatment was randomized and replicated four times. Row widths were the main plots with varieties and within-row spacings the sub-plots.

Two recommended soybean varieties for Kansas, Kent and Clark 63, were used in the study. These two were selected because of their yield potential and also because of their differences in maturity date, which allowed comparisons to be made between a medium and late maturing varieties. Row widths of 20 and 40 inches and within-row spacings of one, two, three, and four inches were employed for each variety.

Plantings were first made on May 29 but were destroyed by a severe wind and rain storm; a replanting was made on June 14. Approximately 325 seeds were planted in each 21 foot row. Assuming 80 percent seedling emergence, the spacing would have provided plants approximately one inch apart within the row. Weeds were controlled by a pre-emergence application of one pound of Treflan per acre and by post emergence hoeing and hand cultivation. The seeds were not inoculated with Rhizobium, because soybeans had been grown on the area recently. The plots were not fertilized.

The plants were thinned by hand to the required within-row spacing at the first trifoliate leaf stage of growth. Plant population for each row width and within-row spacing is shown in Table 1.

Table 1. Plant population per acre

Row Width (inches)	Within-Row Spacing (inches)	Plants per Acre
40	1	156,795
40	2	78,398
40	3	52,265
40	4	39,200
20	1	312,601
20	2	156,795
20	3	104,531
20	4	78,398

The plots were originally 21 feet in length but later trimmed to 16 feet for the purpose of yield determination. The 20 inch row width plots consisted of four rows; the two center rows were harvested for yield, while the 40 inch row width plots consisted of three rows, and the center row was harvested for yield. The border rows served as a source of plants for individual plant study.

Data taken in the field included plant height, lodging, and plant maturity.

Height - was determined as the distance in inches from the ground level to the topmost part of the plant at maturity. Five plants per plot were measured at random and the average was used as the plant height.

Lodging - was determined at maturity and a score was assigned to each plot using the following lodging criteria guide as a basis:

1. Almost all plants erect.
2. Either all plants leaning slightly or a few plants down.
3. Either all plants leaning moderately or 25 percent to 50 percent of the plants down.
4. Either all plants leaning considerably or 50 percent to 80 percent of the plants down.
5. All plants nearly prostrate.

Maturity - was determined as the number of days from planting until 95 percent of the stems and pods were brown and all leaves had dropped.

The plots were harvested when mature and the soybeans threshed with a plot sized experimental thresher.

Seed yield - was determined after the seed was allowed to air dry and reach a uniform moisture content. The threshed seed was weighed in grams, converted and reported as bushels per acre.

Seed size - was determined for each plot as the weight of 100 whole seeds in grams to the nearest tenth of a gram.

Five plants were collected at random from the border rows of each plot. The plants were cut at ground level and taken into the laboratory for individual plant study. Data were collected from each plant and the plot values reported are averages for five plants. Data collected were number of nodes per plant, pods per plant, and seeds per plant. The average number of seeds per pod was calculated by using the number of pods and seeds per plant.

Oil and protein content was determined from a composite sample of all replications of each treatment. The composite samples were sent to the United States Regional Soybean Laboratory at Urbana, Illinois for the oil and protein analysis.

All variables except oil and protein were subjected to an analysis of variance performed at the Kansas State University Computing Center. When the analysis of variance showed a significant F value, the treatment differences were measured by the L.S.D. (Least Significant Differences) procedure at the 0.05% level of probability.

Moisture Utilization. The plot arrangement for the moisture study was the same as for the yield study except that only two replications were used.

A six-foot aluminum tube, 2½ inches in diameter, was driven into each plot of two replications. The tubes were placed in the center of the plots between rows two and three, five inches from the planted row. The tube was left protruding six inches above ground level so that the first moisture reading could be made at a six inch depth in the soil.

Moisture data were taken at six inch intervals from a depth of six inches through 54 inches by use of a Nuclear Chicago neutron probe. The first reading was taken on July 1 and at weekly intervals until concluded on September 28. The readings were taken for a one minute duration at each six inch increment of the soil profile and by use of a conversion curve; the data were recorded as total moisture, in inches, present per six inch increment of soil.

Moisture use was determined for each six inch increment by obtaining the differences between each consecutive weekly reading. Weekly moisture use for each plot was obtained by summing all the moisture used by each soil increment and by adding to this total the rainfall received for the week. Total moisture used during the season by each plot was calculated by the summation of all weekly moisture use figures.

No attempt was made to divide moisture use into evaporation or transpiration. Runoff was not determined in this study. Therefore, the moisture removed from the soil from July 1 through September 28 was considered to have been utilized by the plants.

Moisture utilization is reported as total moisture used per plot and total moisture used per six inch increment of soil.

Total moisture used per plot was subjected to an analysis of variance. When a significant F value was reported, the treatment differences were measured by the L.S.D. (Least Significant Difference) test at the 0.05% level of probability.

WEATHER DATA

Daily precipitation and temperature figures are presented in the Appendix Tables I and II.

Weather conditions during the growing season were generally not favorable for optimum plant growth. Adequate soil moisture was available at planting time but as the growing season progressed, moisture was limited because of deficient precipitation, low humidity, and high temperatures.

From the date of planting until harvest, a total of only 7.15 inches of moisture was recorded. Only four rains of .50 inch or greater were reported during the growing season but they came at critical periods of growth and were very beneficial to the plant.

The entire month of July had abnormally high temperatures with 17 days having maximum temperatures greater than 95°F. However, the month of

August was somewhat cooler and weather conditions were more favorable for plant growth and development.

The abnormally high temperatures, low humidity, and prolonged periods of ineffective precipitation during the months of June and July probably influenced the results by subjecting the plants to abnormal heat and drought stress.

RESULTS AND DISCUSSION

The results of this experiment are concerned with the influence of plant population on moisture utilization, yield, and yield components of Clark 63 and Kent soybeans.

MOISTURE UTILIZATION

The study was originally designed to examine total moisture use, soil depth of maximum utilization, maximum depth of soil moisture extraction, and moisture use efficiency.

Weather conditions were unfavorable during the growing season for optimum plant growth and development. However, initial plant emergence and seedling development was good because the soil moisture was adequate at planting time, as shown by moisture data collected. At the date of the first moisture determination, July 1, there was an average of 2.06 inches of moisture per six inches of soil to a depth of 54 inches of the soil profile (Table 2).

Table 2. Total moisture per six inch increment of soil profile at date of first moisture determination (July 1).

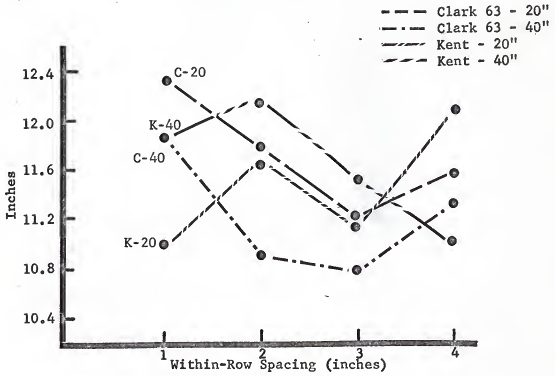
	Soil Depth (inches)									
	6	12	18	24	30	36	42	48	54	Ave.
Total moisture (inches)	1.80	1.95	2.08	2.04	2.07	2.18	2.18	2.13	2.12	2.06

Total moisture utilized by soybeans was not significantly affected by row widths, varieties, or within-row spacings (Appendix Table 3). Despite this fact, however, some interesting moisture use trends and patterns were apparent.

<u>Row Width</u>. Plants in the 20 inch rows used an average of approximately 0.2 of an inch more moisture than those in the 40 inch rows (Table 3). A comparison showed that 20 inch rows of Clark 63 used the most moisture and that 40 inch rows of Clark 63 used the least moisture. This trend was reversed with regard to Kent (Table 3).

<u>Variety</u>. An average of the moisture used by each variety determined that Kent used approximately 0.1 of an inch more moisture than Clark 63; however, moisture used by the varieties varied within the other treatments as shown in Table 3. Clark 63 used more moisture in the narrow rows and closer spacings, but Kent used more moisture in the wider rows and the closer spacings.

<u>Within-Row Spacing</u>. The greatest differences in moisture use were found in the within-row spacings. Plants in the one inch within-row spacings used the most moisture, while those in the three inch within-row spacings used the least moisture when variety and row width averages were used. The three inch spacings used 0.62 of an inch less moisture than the one inch spacings. As shown in Table 3, Clark 63 followed the same general moisture use trend as mentioned above, but Kent was quite variable. Kent had the highest moisture utilization in the two inch spacings and the lowest in the three inch spacings.


Clark 63 - 20"
Clark 63 - 40"
Kent - 20"
Kent - 40"
12.4
12.0
11.6
11.2
10.8
10.4
Inches
C-20
K-40
C-40
K-20
1
2
3
4
Within-Row Spacing (inches)

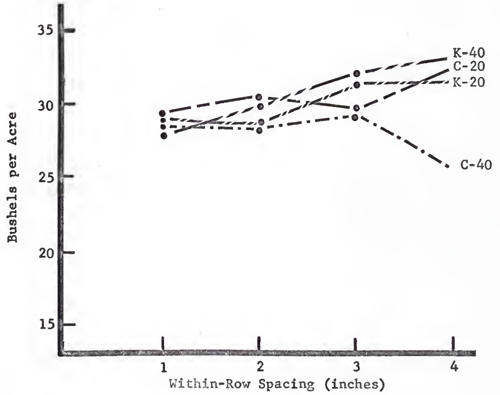

35
30
25
20
15
Bushels per Acre
K-40
C-20
K-20
C-40
1
2
3
4
Within-Row Spacing (inches)

Table 3. Total moisture use (inches), row width x variety x within-row spacings, Manhattan, Kansas, 1966.

Variety	Row Width (inches)	Within-Row Spacing (inches) 1	2	3	4	Average
Clark 63	20	12.33	11.76	11.19	11.55	11.71
	40	11.87	10.90	10.79	11.36	11.23
Average		12.10	11.33	10.99	11.46	11.47
Kent	20	11.00	11.72	11.16	12.13	11.50
	40	11.86	12.17	11.47	11.03	11.63
Average		11.43	11.95	11.32	11.58	11.57
Total Average		11.77	11.64	11.15	11.52	11.52

Depth of Moisture Use. The depth of maximum moisture extraction from the soil by soybeans was between 6 and 30 inches. Nearly 75 percent of the total stored moisture utilized from the soil was extracted from the top thirty inches of the profile (Table 4). Approximately 17 percent (0.85 inches) of the total stored moisture extracted came from the 18 inch depth of the soil profile (Fig. 3). Successively less amounts of moisture were removed from the soil to a depth of 54 inches. Approximately 0.25 of an inch of stored moisture was removed from the 54 inch depth (Table 4). By summing all average moisture use figures as shown in Table 4, it was determined that approximately 5.00 inches of stored moisture was extracted from the soil profile. All remaining moisture used was assumed to have been received as precipitation during the growing season. The moisture used from the precipitation was probably utilized in the top twelve inches of the soil profile. This was assumed because precipitation was very limited, and also because it is thought that the zone of greatest root concentration

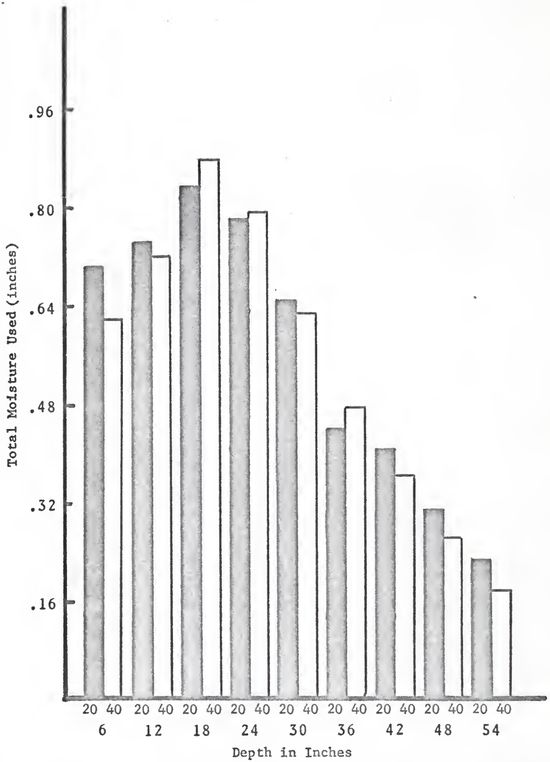


Fig. 3. Total stored moisture used per six inch increment of soil at each row width, Manhattan, Kansas, 1966.

of soybeans is in the surface foot of soil.

Table 4. Moisture used from each six inch increment of the soil profile from July 1 to September 28, 1966.

	Soil Depth (inches)								
Date	6	12	18	24	30	36	42	48	54
July 1 Total moisture	1.80	1.95	2.08	2.04	2.07	2.18	2.18	2.13	2.12
Sept. 28 Total moisture	1.14	1.23	1.23	1.25	1.42	1.74	1.80	1.82	1.89
Used from soil profile	0.66	0.72	0.85	0.79	0.65	0.44	0.38	0.31	0.23

Total used from the soil profile 5.03 inches.

Moisture Efficiency. The most efficient use of the available moisture was made by the three inch within-row spacings when moisture use was compared to yield. The three inch spacings required only 0.36 of an inch of moisture to produce a bushel of soybeans, while the one inch spacings required 0.41 of an inch (Table 5). By comparing row widths and varieties, it was noted that the 20 inch rows and Kent variety used the available moisture most efficiently.

Table 5. Summary of moisture used per bushel of soybeans produced, row width x variety x within-row spacing, 1966.

Variety		Row Width		Within-Row Spacing			
Clark 63	Kent	20	40	1	2	3	4
0.39	0.38	0.38	0.39	0.41	0.40	0.36	0.38

There were eleven periods of moisture data collected with most of these being one week in length. It can be seen from Table 6 that periods 4, 5, 6, 8, and 9 were the ones of greatest moisture use and that these periods correspond directly to the time that precipitation was received. Total moisture use declined drastically in period seven as compared to the periods preceding and succeeding. No appreciable rainfall was received during period seven; therefore, it can be concluded that soil moisture was not adequate and that the plants were depending primarily on precipitation received.

Table 6. Moisture use per week by row width and variety, 1966.

	Time Period											
	1	2	3	4	5	6	7	8	9	10	11	Mean
Rainfall	.31	-	-	2.10	.60	1.22	.12	1.73	.29	-	.16	
Row Width												
20 inches	.68	.87	.82	2.64	.93	1.39	.68	1.59	1.12	.45	.60	1.07
40 inches	.60	.57	.65	2.27	1.21	1.41	.65	1.96	1.05	.55	.53	1.04
Variety												
Clark 63	.64	.68	.78	2.56	1.07	1.35	.72	1.68	1.11	.48	.46	1.05
Kent	.64	.77	.69	2.35	1.10	1.45	.61	1.86	1.07	.52	.67	1.07

YIELD AND YIELD COMPONENTS

Seed Yield. No significant differences in yield were found between row widths, varieties, or within-row spacings as shown in Appendix Table IV.

Average yields were obtained for varieties, row widths, and within-row spacings (Fig. 2). The 20 inch row widths produced 1.2 bushels more per acre than 40 inch rows (Table 7). However, the two varieties reacted opposite within the two row widths. The highest yield of Clark 63 was produced in each within-row spacing of 20 inch rows, but the highest yield of Kent was produced from 40 inch rows in each within-row spacing, the one inch spacing being the exception (Table 7). Late date of planting usually favors narrow rows; therefore, the delayed planting date, June 14, may partially account for the higher yields of Clark 63 in the narrow rows even though moisture was limited.

Yields from both row widths and all within-row spacings were averaged and it was found that Kent produced an average of 1.2 bushels per acre more than Clark 63. The best yields of Clark 63 were obtained from the 20 inch rows and the one and two inch within-row spacings. Kent, on the other hand, produced the highest yields in the 40 inch rows and the three and four inch within-row spacings (Table 7).

Average yields from row widths and varieties showed that a general increase in yield was evident as within-row spacings widened. The four inch spacings averaged 2.1 bushels more per acre than the one inch spacings. Varietal differences were also noted. Clark 63 produced more than Kent in the one and two inch within-row spacings, but Kent produced more than Clark 63 in the three and four inch within-row spacings.

Table 7. Yield averages, row width x variety x within-row spacing, 1966.

		Within-Row Spacing				
Variety	Row Width	1	2	3	4	Ave.
Clark 63	20	29.5	30.6	29.8	33.0	30.7
	40	28.6	28.2	29.1	29.3	27.9
Average		29.1	29.4	29.4	29.3	29.3
Kent	20	29.0	28.7	31.5	31.7	30.2
	40	27.8	30.0	32.2	33.2	30.8
Average		28.4	29.4	31.9	32.5	30.5
Total Average		28.8	29.4	30.7	30.9	

The differences in yield between row widths may be partially attributed to the fact that twice as many plants were present in the 20 inch rows than in the 40 inch rows from which seed yields were obtained. Differences in seed yield between the within-row spacings are due to differences in plant competition within these spacings and to the increased production of yield components. The wider plant spacings produced higher yields than the closer spacings due to the fact that more moisture was available per plant; thus, more nodes, pods, and seeds per plant were produced. The moisture availability effect was also evident by the fact that plant height was reduced in the closer plant spacings which is the opposite of what would normally be expected.

The only significant interaction which had an effect on yield was row width x variety (Table 6). This can be accounted for by the sharp decrease in yield by the 40 inch row width treatment of Clark 63. This treatment averaged 2.7 bushels per acre less than the other three treatment means.

Table 8. Mean seed yield (bushels per acre), row width x variety, 1966.

Row Width (inches)	Varieties		
	Clark 63	Kent	Mean
20	30.7	30.2	30.45
40	27.9	30.8	29.35
Mean	29.3	30.5	

L.S.D. 0.05 = 2.27 bushels

Correlations between yield, yield components, and plant characters were run on the values of Kent and Clark 63 and also their combined values. Results of these correlations are shown in Tables 9, 10 and 11.

The combined correlation between seed yield and seed size was significant at the 0.05 level of probability. Individual variety correlations showed that seed size of Clark 63 was not correlated to yield, but the size of Kent seed was highly significant (0.01 level of probability) as correlated to yield.

Combined correlations between yield and nodes per plant, pods per plant, and seeds per plant were not significant. Individual variety correlations determined that Clark 63 was nonsignificant; however, Kent showed a significant correlation between yield and nodes per plant and a highly significant correlation between yield and pods per plant and seeds per plant. These correlations indicate that the varieties differ in the effect of these yield components on seed yield.

A correlation between yield and plant height was significant, indicating that yield increased as plant height increased. However, correlations on each variety were nonsignificant for the two characters.

Table 9. Correlation coefficients for nine agronomic characters of soybeans, Kent and Clark 63 combined.

	Yield	Plant Height	Lodg-ing	Maturity	Nodes per Plant	Pods per Plant	Seeds per Plant	Seeds per Pod	Seed Weight
Yield		.254*	-.095	.142	.174	.131	.120	.001	.315*
Plant Height			.072	-.019	.242	.245	.254*	.268*	.072
Lodging				.395**	-.494**	-.370**	-.355**	-.058	-.055
Maturity					-.216	-.274*	-.291*	-.323*	.740**
Nodes per Plant						.938**	.925**	.420**	.334**
Pods per Plant							.996**	.499**	.257*
Seeds per Plant								.563**	.237
Seeds per Pod									-.080
Seed Weight									

* Significant at the .05 level
** Significant at the .01 level

Table 10. Correlation coefficients for nine agronomic characters of the soybean variety Clark 63.

	Yield	Plant Height	Lodg-ing	Maturity	Nodes per Plant	Pods per Plant	Seeds per Plant	Seeds per Pod	Seed Weight
Yield		.299	.032	.124	-.012	-.104	-.114	-.171	.125
Plant Height			.274	.139	.032	.076	.089	.174	.029
Lodging				.790**	-.548**	-.408*	-.398*	-.110	-.005
Maturity					-.541**	-.396*	-.370*	.082	.149
Nodes per Plant						.949**	.935**	.315	.514**
Pods per Plant							.996**	.423*	.595**
Seeds per Plant								.494**	.613**
Seeds per Pod									.504**
Seed Weight									

* Significant at the .05 level
** Significant at the .01 level

Table 11. Correlation coefficients for nine agronomic characters of the soybean variety Kent.

	Yield	Plant Height	Lodg-ing	Maturity	Nodes per Plant	Pods per Plant	Seeds per Plant	Seeds per Pod	Seed Weight
Yield		.219	-.320	-.225	.379*	.450**	.461**	.321	.603**
Plant Height			-.264	-.159	.450**	.410*	.421*	.373*	.403*
Lodging				.738*	-.464**	-.361*	-.341	-.055	-.135
Maturity					-.304	-.219	-.196	.100	.023
Nodes per Plant						.947**	.945**	.582**	.686**
Pods per Plant							.997**	.552**	.783**
Seeds per Plant								.604**	.809**
Seeds per Pod									.691**
Seed Weight									

* Significant at the .05 level
** Significant at the .01 level

YIELD COMPONENTS

The yield components which were examined in the study were nodes per plant, pods per plant, seeds per plant, seeds per pod, and seed weight. All analyses of variance for the yield components are presented in Appendix Table VI.

Nodes Per Plant. Nodes per plant were significantly affected by row width. The 40 inch rows averaged 20 percent more nodes per plant than the 20 inch rows (Table 12, Fig. 4).

Within-row spacing had a highly significant effect on the number of nodes per plant. There was a general increase in number of nodes per plant from the closest within-row spacing to the widest spacing. The four inch spacing averaged nearly 27 percent more nodes per plant than the one inch spacing.

There were no differences in numbers of nodes per plant between varieties as shown in Table 12.

The number of nodes per plant was highly correlated with all other yield components in both varieties with the exception of seeds per pod in Clark 63 (Tables 9, 10, and 11).

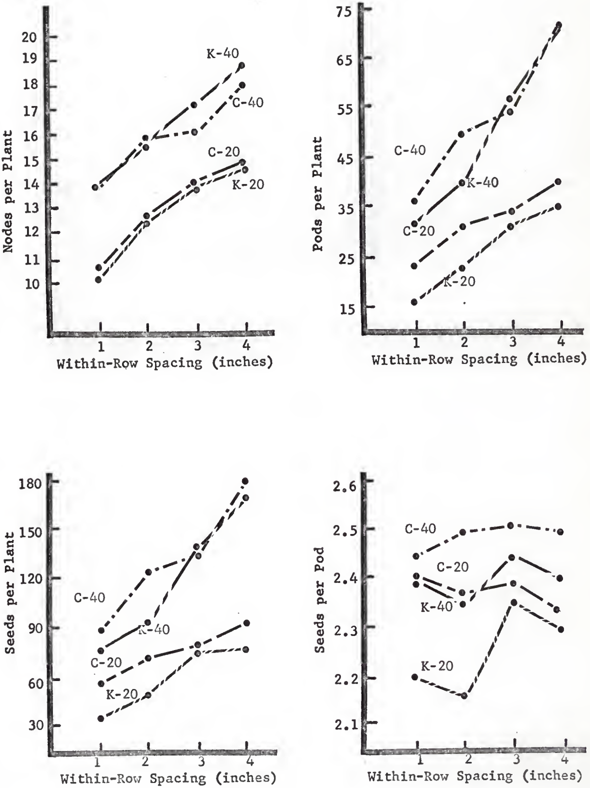
Pods Per Plant. Row width had a significant effect on pods per plant. Plants in the 40 inch rows averaged 44 percent more pods per plant than those of the 20 inch rows (Table 12, Fig. 5).

There was also a highly significant within-row spacing effect on pods per plant. The four inch within-row spacings averaged nearly 50 percent more pods per plant than the one inch spacings.

A highly significant difference was also noted in number of pods per

Table 12. Yield component means of row widths, varieties, and within-row spacings, 1966.

Variety	Nodes per plant	Pods per plant	Seeds per plant	Seeds per pod	Seed Weight (gms)
Clark 63	14.5	42.4	103.5	2.43	13.17
Kent	14.6	38.2	89.8	2.32	15.47
Row Width					
20 inch	12.9	29.0	67.3	2.31	13.87
40 inch	16.1	51.6	126.0	2.44	14.77
Spacing					
1 inch	12.1	26.9	63.9	2.36	14.16
2 inch	14.2	35.7	84.6	2.34	14.12
3 inch	15.3	44.1	107.4	2.43	14.42
4 inch	16.5	54.5	130.6	2.38	14.56



Nodes per Plant
20
19
18
17
16
15
14
13
12
11
10
K-40
C-40
C-20
K-20
1
2
3
4
Within-Row Spacing (inches)
Pods per Plant
75
65
55
45
35
25
15
C-40
K-40
C-20
K-20
1
2
3
4
Within-Row Spacing (inches)
Seeds per Plant
180
150
120
90
60
30
C-40
K-40
C-20
K-20
1
2
3
4
Within-Row Spacing (inches)
Seeds per Pod
2.6
2.5
2.4
2.3
2.2
2.1
C-40
C-20
K-40
K-20
1
2
3
4
Within-Row Spacing (inches)

plant between varieties. Clark 63 averaged 10 percent more pods per plant than Kent (Fig. 5).

There was a highly significant interaction between row width and within-row spacing which affected pods per plant. A significant interaction was also found between variety and within-row spacing which affected pods per plant (Tables 13, 14, and Figs. 8, 10).

The number of pods per plant was correlated with all other yield components as shown in Tables 9, 10, and 11.

Seeds Per Plant. The width of row had a significant effect on the total number of seeds per plant. The 40 inch row width averaged 47 percent more seeds per plant than the 20 inch rows (Table 12, Fig. 6).

Highly significant differences were found in the number of seeds per plant among within-row spacings. The four inch within-row produced an average of 51 percent more seeds per plant than the one inch spacings.

The varieties differed significantly in the number of seeds per plant. Clark 63 produced an average of 13 percent more seeds per plant than Kent.

Interactions between row width by within-row spacing and variety by within-row spacing were highly significant as they affected the number of seeds per plant (Tables 13, 14 and Figs. 9, 11).

Seeds per plant were highly correlated to all other yield components except seed weight (Tables 9, 10, and 11).

Seeds Per Pod. A significant difference was found in the number of seeds per pod between row widths. Pods from the 40 inch rows contained 5 percent more seeds than pods from the 20 inch rows (Table 12, Fig. 7).

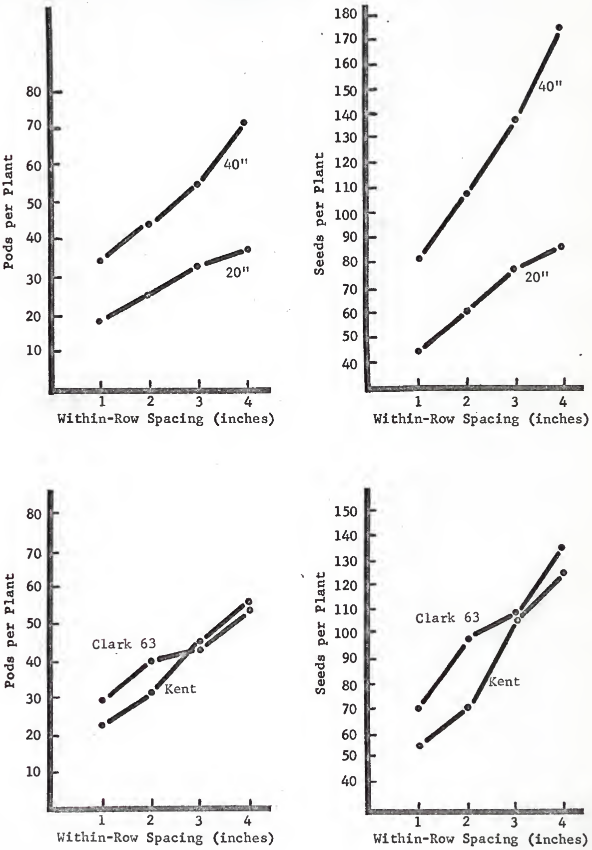
Seeds per pod were significantly affected by within-row spacing. There was a general increase in seeds per pod as the space between plants became

Table 13. Mean yield components, row width x within-row spacing, 1966.

Row Width (inches)	Spacing (inches)	Nodes per Plant	Pods per Plant	Seeds per Plant	Seeds per Pod	Seed Weight (grams/100 seeds)
20	1	10.40	19.30	44.85	2.30	13.87
	2	12.65	26.57	61.80	2.26	13.66
	3	13.95	32.50	77.30	2.36	13.89
	4	14.65	37.35	86.05	2.31	14.03
40	1	13.85	34.50	82.90	2.41	14.45
	2	15.70	44.70	108.45	2.41	14.58
	3	16.65	55.60	137.50	2.47	14.96
	4	18.35	71.70	175.05	2.45	15.10
L.S.D. .05		N.S.	3.50	8.70	N.S.	N.S.

Table 14. Mean yield components, variety x within-row spacing, 1966.

Variety	Spacing (inches)	Nodes per Plant	Pods per Plant	Seeds per Plant	Seeds per Pod	Seed Weight (grams/100 seeds)
Clark 63	1	12.2	29.8	72.1	2.42	13.13
	2	14.3	40.2	98.2	2.43	13.16
	3	15.1	43.6	107.5	2.45	13.07
	4	16.4	56.0	136.0	2.41	13.30
Kent	1	12.1	24.0	55.7	2.31	15.19
	2	14.1	31.2	71.1	2.25	15.08
	3	15.6	44.5	107.3	2.40	15.78
	4	16.6	53.1	125.1	2.34	15.83
L.S.D. .05		N.S.	3.50	8.65	N.S.	.32



Pods per Plant
80
70
60
50
40
30
20
10
40"
20"
1
2
3
4
Within-Row Spacing (inches)
Seeds per Plant
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
40"
20"
1
2
3
4
Within-Row Spacing (inches)
Pods per Plant
Clark 63
Kent
1
2
3
4
Within-Row Spacing (inches)
Seeds per Plant
Clark 63
Kent
1
2
3
4
Within-Row Spacing (inches)

greater. Pods of the four inch plant spacings averaged 4 percent more seeds than pods from the one inch plant spacings.

A highly significant difference was found between varieties in number of seeds per pod. Clark 63 averaged 4.5 percent more seeds per pod than Kent.

Correlations between seeds per pod and all other yield components were highly significant (Tables 9, 10, and 11).

Seed Weight. Seed weight was affected significantly by differences in row width. The weight of seeds from 40 inch rows averaged more than 6 percent heavier than seeds from the 20 inch rows (Table 12, Fig. 12).

A significant difference was found in seed weight as influenced by within-row spacings. Seed from four inch spacings were the heaviest, averaging nearly 3 percent heavier than seed from the two inch spacings which had the lightest seed.

Seed weight differences were highly significant as affected by varieties. The seed of Kent averaged 15 percent heavier than seed of Clark 63.

A significant interaction affecting seed weight occurred between variety and within-row spacing (Table 14).

Within each variety, seed weight was highly correlated with all other yield components (Tables 9, 10, and 11).

Table 15. Yield component treatment means by row width, variety, and within-row spacing, 1966.

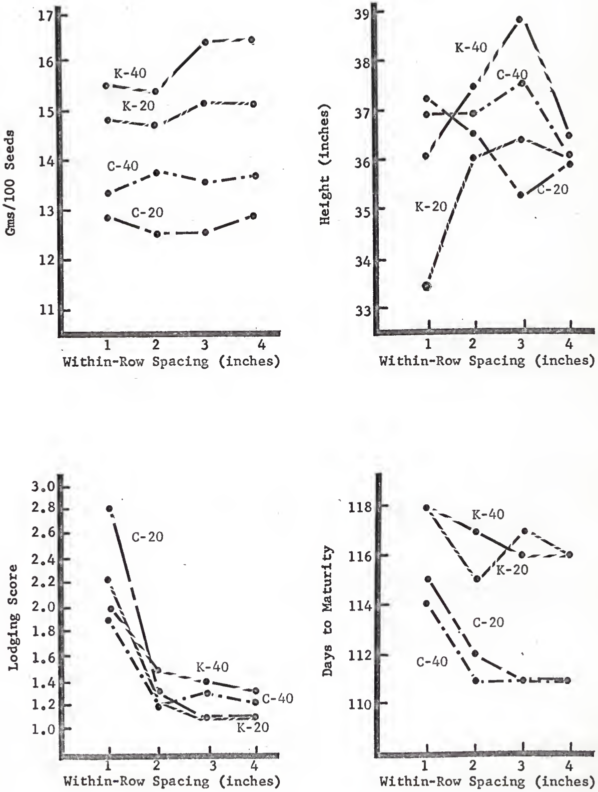
Variety	Spacing (inches)	Nodes per Plant	Pods per Plant	Seeds per Plant	Seeds per Pod	Seed Weight (grams/100 seeds)
20" Row Width						
Clark 63	1	10.6	22.8	55.0	2.40	12.88
	2	12.8	30.7	72.6	2.37	12.56
	3	14.0	33.2	79.6	2.39	12.59
	4	14.8	39.9	92.7	2.33	12.87
Average		13.1	31.7	75.0	2.37	12.73
Kent	1	10.2	15.8	34.7	2.20	14.86
	2	12.5	22.7	49.0	2.16	14.76
	3	13.9	31.8	75.0	2.36	15.18
	4	14.5	34.8	79.4	2.29	15.18
Average		12.8	26.3	59.5	2.25	15.00
Mean 20" Row Width		13.0	29.0	67.3	2.31	13.87
40" Row Width						
Clark 63	1	13.8	36.8	89.1	2.44	13.37
	2	15.8	49.7	123.7	2.49	13.75
	3	16.1	54.0	135.4	2.51	13.55
	4	18.0	72.0	179.3	2.49	13.73
Average		15.9	53.1	131.9	2.48	13.60
Kent	1	13.9	32.2	76.7	2.39	15.52
	2	15.6	39.7	93.2	2.34	15.40
	3	17.2	57.2	139.6	2.44	16.37
	4	18.7	71.4	170.8	2.39	16.47
Average		16.4	50.1	120.1	2.39	15.94
Mean 40" Row Width		16.2	51.6	126.0	2.44	14.77
Row Width L.S.D. 0.05		0.47	6.83	18.29	0.24	1.11
Spacing and Variety L.S.D. 0.05		1.31	7.00	17.30	0.13	0.64

Fig. 12. Effect of row width, variety, and within-row spacing on seed weight at Manhattan, Kansas, 1966.

Fig. 13. Effect of row width, variety, and within-row spacing on plant height at Manhattan, Kansas, 1966.

Fig. 14. Effect of row width, variety, and within-row spacing on lodging at Manhattan, Kansas, 1966.

Fig. 15. Effect of row width, variety, and within-row spacing on maturity at Manhattan, Kansas, 1966.



Gms/100 Seeds
17
16
15
14
13
12
11
K-40
K-20
C-40
C-20
1
2
3
4
Within-Row Spacing (inches)
Height (inches)
39
38
37
36
35
34
33
K-40
C-40
C-20
K-20
1
2
3
4
Within-Row Spacing (inches)
Lodging Score
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
C-20
K-40
C-40
K-20
1
2
3
4
Within-Row Spacing (inches)
Days to Maturity
118
116
114
112
110
K-40
K-20
C-20
C-40
1
2
3
4
Within-Row Spacing (inches)

AGRONOMIC CHARACTERS

The agronomic characters examined in the investigation were plant height, lodging, and days to maturity. Analyses of variance for these characters are presented in Appendix Table V.

Plant Height. Plant height was not influenced significantly by variety, row width, or within-row spacing in this study.

By averaging all treatments, Clark 63 and Kent were very similar in plant height. However, when examined separately, Clark 63 was taller in the narrow rows and closer within-row spacings, while Kent was taller in the wider rows and wider spacings (Table 19, Fig. 13).

Workers in the past have reported taller plants in narrow rows but in this study, though not significant, the plants averaged 1.7 inches taller in the 40 inch rows when compared to the 20 inch rows (Table 19). This may be accounted for by reduced competition between plants in the wider rows for the limited supply of available moisture.

Correlations between plant height and other characters studied are shown in Tables 9, 10, and 11. Plant height correlations were quite different between varieties in this study. Plant height of Kent was significantly correlated to all yield components while plant height of Clark 63 was not correlated to any yield component.

Lodging. Row width and variety did not have a significant effect on lodging. However, highly significant differences were noted among within-row spacings. Lodging increased as within-row spacing was reduced. The greatest increase in lodging occurred with the decrease from two inches between plants to one inch between plants within the row (Table 13, Fig. 14).

Correlations between lodging and maturity were significant, indicating that an increase in lodging delayed maturity (Tables 9, 10, and 11). Correlation between lodging and yield components produced significant and negative coefficient values. As lodging increased, nodes per plant, pods per plant, and seeds per plant were reduced in numbers.

There were significant interactions between row width x variety and between row width x within-row spacing which affected lodging (Tables 16 and 17).

Table 16. Mean lodging, row width x variety, 1966.

Row Width	Variety	Lodging
20 inch	Clark 63	1.58
	Kent	1.53
40 inch	Clark 63	1.40
	Kent	1.55

L.S.D. 0.05 = 0.18

Table 17. Mean lodging, row width x within-row spacing, 1966.

Row Width	Spacing	Lodging
20 inch	1	2.5
	2	1.25
	3	1.1
	4	1.1
40 inch	1	1.95
	2	1.35
	3	1.35
	4	1.25

L.S.D. 0.05 = 0.18

Maturity. Row width did not have a significant effect on maturity. Highly significant differences were found in days to maturity between varieties and within-row spacings.

Kent averaged five days later in maturity than Clark 63. Kent is normally seven to ten days later in maturity than Clark 63, so this difference was expected (Table 19, Fig. 15).

There was a general delay in maturity with a decrease in within-row spacing; the one inch spacing matured an average of three days later than the four inch spacings.

Correlations between maturity and yield components resulted in negative and significant coefficient values in Clark 63, but were not correlated to yield components of Kent (Tables 9, 10, and 11).

There was a highly significant interaction between variety and within-row spacing which affected maturity (Table 18).

Table 18. Mean days to maturity, variety x within-row spacing, 1966.

Variety	Spacing	Days to maturity
	1	114.5
Clark 63	2	111.5
	3	111.0
	4	111.0
	1	118.0
Kent	2	116.0
	3	116.5
	4	116.0

L.S.D. 0.01 = 0.72 days

Table 19. Agronomic character treatment means by row width, variety, and within-row spacing, 1966.

Variety	Spacing (inches)	Plant Height (inches)	Lodging	Days to Maturity
20" Row Width				
Clark 63	1	37.2	2.8	115
	2	36.5	1.3	112
	3	35.2	1.1	111
	4	35.8	1.1	111
Average		36.2	1.6	112
Kent	1	33.4	1.6	118
	2	36.0	2.2	115
	3	36.4	1.2	117
	4	36.0	1.1	116
Average		35.5	1.5	117
Mean 20" Row Width		35.6	1.6	115
40" Row Width				
Clark 63	1	36.9	1.9	114
	2	36.9	1.2	111
	3	37.6	1.3	111
	4	36.0	1.2	111
Average		36.9	1.4	112
Kent	1	36.0	2.0	118
	2	37.4	1.5	117
	3	38.8	1.4	116
	4	36.4	1.3	116
Average		37.2	1.6	117
Mean 40" Row Width		37.1	1.5	115
Spacing L.S.D. 0.05		N.S.	0.36	1.06
Variety L.S.D. 0.05		N.S.	0.36	1.06

PROTEIN AND OIL CONTENT

Analysis of variance was not determined for protein or oil content because the plot samples for each treatment were composited for oil and protein determination. However, some interesting trends are evident and are presented in Table 20 and Figs. 16 and 17.

Protein. Differences in protein content were very small between varieties. By averaging all plots, it was found that Kent had 0.4 percent higher protein content than Clark 63. A similar comparison between row widths determined that 20 inch rows averaged 0.6 percent more protein than 40 inch rows. Within-row spacings had similar effects with protein content; that is, the wider the within-row spacing, the less the protein. One inch spacings averaged 1.3 percent higher protein content than four inch spacings.

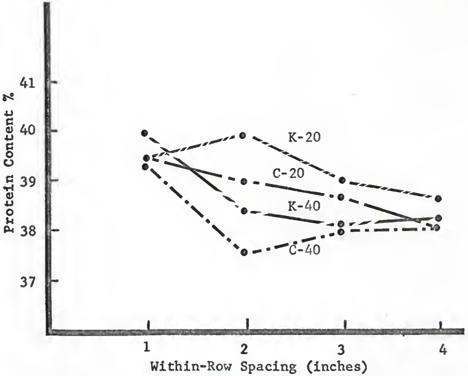
Oil. Oil content was also affected by variety, row width, and within-row spacing, but was directly opposite that of protein. Clark 63 averaged 0.2 percent higher oil content than Kent. Oil content was highest in the 40 inch row widths and four inch spacings; the 40 inch rows averaged 0.8 percent more oil than the 20 inch rows and the four inch spacings averaged 0.7 percent more oil content than one inch spacings.

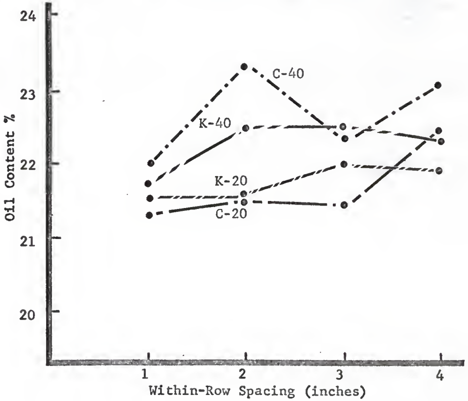
Table 20. Average oil and protein content by variety, row width, and within-row spacing, 1966.

	Variety		Row Width (inches)		Within-row Spacing (inches)			
	Kent	Clark 63	20	40	1	2	3	4
% Protein	39.0	38.6	39.1	38.5	39.6	38.7	38.5	38.3
% Oil	22.0	22.2	21.7	22.5	21.7	22.2	22.1	22.4

Fig. 16. Effect of row width, variety, and within-row spacing on protein content at Manhattan, Kansas, 1966.

Fig. 17. Effect of row width, variety, and within-row spacing on oil content at Manhattan, Kansas, 1966.


Protein Content %
41
40
39
38
37
K-20
C-20
K-40
C-40
1
2
3
4
Within-Row Spacing (inches)


Oil Content %
24
23
22
21
20
C-40
K-40
K-20
C-20
1
2
3
4
Within-Row Spacing (inches)

SUMMARY AND CONCLUSIONS

No significant differences were found in total moisture utilization between row widths, between varieties, or among within-row spacings. However, it was determined that plants in 20 inch rows used an average of 0.2 of an inch more moisture than those in the 40 inch rows. Similar comparisons revealed that Kent used 0.1 of an inch more moisture than Clark 63 and that three inch within-row spacings used 0.62 of an inch less moisture than one inch spacings. Thus, it appears from these data that within-row spacings had more effect on total moisture used than row widths or varieties.

All plots used an average of 11.52 inches of moisture from July 1 to September 28. Approximately 5.00 inches of the total moisture used was extracted as stored moisture from the soil profile, the remainder obtained from precipitation. Approximately 75 percent of the moisture removed from the soil was extracted from the top 30 inches of the soil profile. The heaviest extraction occurred at the 18 inch depth.

The most efficient use of available moisture was made by the three inch within-row spacings, 20 inch row widths, and the Kent variety. Plants in the three inch spacings required only 0.36 of an inch of moisture to produce one bushel of soybeans as compared to the 0.41 of an inch required by the one inch spacings.

The periods of greatest moisture use correspond directly to the periods of greatest precipitation. It appeared toward the end of the growing season that soil moisture was deficient and the plants were depending upon precipitation for the moisture required to complete growth.

Very little difference was found in seed yield between varieties, row widths, or within-row spacings. Kent produced 1.2 bushels more per acre than Clark 63. Plantings made in 20 inch rows produced 1.2 bushels more per acre than those made in 40 inch rows and the plants of four inch within-row spacings averaged 2.1 bushels more per acre than those planted one inch apart.

Highest yields from Clark 63 were produced in 20 inch rows from plants spaced one and two inches within the row. Kent produced best in 40 inch rows from plants spaced three and four inches within the row.

Correlations between yield and yield components varied between varieties. Yield of Kent was significantly correlated to yield components but the yield of Clark 63 was not.

Yield was positively correlated to plant height indicating that yield increased as plant height increased.

Differences in yield components were noted between row widths, varieties, and within-row spacings. Plants from the 20 inch row widths produced fewer nodes, pods, and seeds per plant; fewer seeds per pod; and smaller seeds than plants from the 40 inch rows. The same trend was also true among within-row spacings; that is, all components were reduced in the closer spacings. Clark 63 consistently had more pods and seeds per plant than Kent but Kent had heavier seeds.

Correlations between the yield components were generally positive, indicating that as one component increased, all other components increased respectively.

Plant height was not significantly affected by row widths, varieties, or within-row spacings. Plants in the 40 inch rows averaged 1.7 inches taller than the plants of the 20 inch rows. Clark 63 produced taller plants in the narrow rows and closer within-row spacings, but Kent produced taller plants in the wider rows and wider within-row spacings.

Lodging was not influenced by row width or variety but closer within-row spacings increased lodging significantly. The one inch spacings lodged more than any other spacing.

Kent matured an average of five days later than Clark 63. Closer within-row spacings also delayed maturity. The one inch spacings matured an average of three days later than the four inch spacings. Row width did not affect maturity.

Protein and oil content were quite variable between row widths, varieties, and within-row spacings.

Kent averaged 0.4 percent more protein than Clark 63. Protein content was 0.6 percent higher in the 20 inch rows than in the 40 inch rows and 1.3 percent higher in the one inch within-row spacings than in the four inch within-row spacings.

Oil content was directly opposite that of protein. Clark 63 averaged 0.2 percent more oil than Kent. Oil content was 0.8 percent higher in the 40 inch rows than in the 20 inch rows and 0.7 percent higher in the four inch within-row spacings than in the one inch within-row spacings.

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APPENDIX

Appendix Table I. Daily maximum temperature in degrees Fahrenheit, Kansas State University, Agronomy Farm, Manhattan, Kansas, 1966.

Date	June	July	Aug.	Sept.	Oct.
1	79	97	94	88	60
2	76	95	94	89	69
3	83	96	84	84	76
4	87	96	83	85	76
5	85	98	87	84	68
6	89	105	90	91	69
7	82	99	93	77	80
8	82	93	89	80	84
9	71	99	78	81	84
10	72	100	69	84	75
11	76	105	75	88	79
12	93	105	80	86	84
13	89	107	81	83	84
14	82	105	79	82	85
15	84	105	89	66	82
16	79	85	89	71	56
17	79	90	95	62	60
18	73	100	99	70	56
19	82	108	85	72	48
20	87	95	84	74	57
21	89	91	92	78	70
22	90	82	74	82	73
23	89	87	72	79	62
24	90	89	74	81	66
25	94	94	78	90	72
26	98	96	84	64	77
27	90	98	84	61	81
28	91	88	86	65	84
29	100	91	88	78	75
30	99	88	89	80	58
31	--	86	88	--	70
Average	85.3	95.9	84.7	78.5	71.6

Appendix Table II. Daily precipitation in inches, Kansas State University Agronomy Farm, Manhattan, Kansas, 1966.

Date	May	June	July	Aug.	Sept.	Oct.
1					.04	
2		.11		.60	.17	
3					.08	
4						
5						
6						
7			.31			
8		.34				
9		.24		T		
10				1.22		
11	.14					
12	.27					.14
13		.19				
14					T	
15		.30	T			
16		T				
17		.11				
18				.01	.16	.31
19	T			.05		.33
20	.03			.06		
21	.82			1.73		
22			T			
23						
24						
25						
26						
27		.24	1.72			
28		.09				
29	.02		.38		.03	
30	.37				.09	
31	T					
Total	1.65	1.62	2.41	3.67	.57	.78
Normal	4.37	5.11	4.00	4.18	3.71	2.32
Deviation	-2.72	-3.49	-1.59	- .51	-3.14	-1.54

Normal for May through October = 23.69 inches
Total Received May through October = 10.70 inches
Deviation from Normal = 12.99 inches

Appendix Table III. Analysis of variance for total moisture use, Manhattan, Kansas, 1966

Source of Variation	D.F.	Mean Square	F
Replications	1	.02	.04
Row Width	1	.24	.57
Error (a)	1	5.98	
Varieties	1	.08	.18
Within-Row Spacings	3	.56	1.34
Row Width x Varieties	1	.74	1.79
Row Width x Spacings	3	.26	.61
Varieties x Spacings	3	.60	1.45
Row Width x Varieties x Spacings	3	.55	1.34
Error (b)	14	.41	

Appendix Table IV. Analysis of variance for yield, Manhattan, Kansas, 1966.

Source of Variation	D.F.	Mean Square	F
Replications	3	26.89	2.69
Row Width	1	22.93	2.29
Error (a)	3	56.05	
Varieties	1	25.14	2.51
Within-Row Spacing	3	16.44	1.64
Row Width x Varieties	1	44.69	4.47*
Row Width x Spacings	3	6.69	.66
Varieties x Spacings	3	13.04	1.30
Row Width x Varieties x Spacings	3	15.79	
Error (b)	36	10.00	

* Significant at the 0.05 level

Appendix Table V. Analysis of variance for agronomic characters, Manhattan, Kansas, 1966.

Source of Variation	D.F.	Plant Height Mean Square	Lodging Mean Square	Maturity Mean Square
Replications	3	20.95	0.04	2.23
Row Width	1	23.51	0.01	
Error (a)	3	5.34	0.06	
Varieties	1	0.61	0.02	332.70**
Within-Row Spacings	3	4.34	3.87**	27.83**
Row Width x Varieties	1	4.12	0.34	3.40*
Row Width x Spacings	3	2.92	0.44**	0.63
Varieties x Spacings		9.26	0.08	3.07**
Row Width x Varieties x Spacings	3	1.62	0.07	1.93
Error (b)	36	4.65	0.06	0.54

* Significant at the 0.05 level
** Significant at the 0.01 level

Appendix Table VI. Analysis of variance for yield components, Manhattan, Kansas, 1966.

Source of Variation	D.F.	Nodes per Plant Mean Square	Pods per Plant Mean Square	Seeds per Plant Mean Square	Seeds per Pod Mean Square	Seed Weight Mean Square
Replications	3	2.58	68.80	470.13	.0105	0.28
Row Width	1	165.76**	8,217.40**	55,148.40**	.2428*	13.04**
Error (a)	3	.35	73.77	528.53	.0035	1.94
Varieties	1	.10	280.50**	2,966.00**	.1754**	84.63**
Within-Row Spacing	3	55.59**	2,232.01**	13,243.36**	.0224*	0.76*
Row Width x Varieties	1	2.33	23.60	53.50	.0041	0.03
Row Width x Spacing	3	.73	285.63**	1,954.13**	.0022	0.23
Varieties x Spacing	3	.53	71.25*	499.50*	.0131	0.57*
Row Width x Varieties x Spacing	3	.24	9.37	51.80	.0086	0.20
Error (b)	3	.83	23.77	145.16	.0077	0.20

* Significant at the 0.05 level
** Significant at the 0.01 level

Appendix Table VII. Summary data -- yield, yield components, and agronomic characters, Manhattan, Kansas, 1966.

Variety	Spacing (inches)	Yield bu/A	Plant Height (inches)	Lodging	Days to Maturity	Nodes per Plant	Pods per Plant	Seeds per Plant	Seeds per Pod	Seed Weight	% Protein	% Oil
20" Row Width												
Clark 63	1	29.5	37.2	2.8	115	10.6	22.8	55.0	2.40	12.88	39.5	21.3
	2	30.6	36.5	1.3	112	12.8	30.7	72.6	2.37	12.56	39.0	21.5
	3	29.8	35.2	1.1	111	14.0	33.2	79.6	2.39	12.59	38.7	21.4
	4	33.0	35.8	1.1	111	14.8	39.9	92.7	2.33	12.87	38.1	22.4
Kent	1	29.0	33.4	2.2	118	10.2	15.8	34.7	2.20	14.86	39.5	21.6
	2	28.7	36.0	1.2	115	12.5	22.7	49.0	2.16	14.76	39.9	21.6
	3	31.5	36.4	1.1	117	13.9	31.8	75.0	2.36	15.18	39.0	22.0
	4	31.7	36.0	1.1	116	14.5	34.8	79.4	2.29	15.18	38.7	21.8
40" Row Width												
Clark 63	1	28.6	36.9	1.9	114	13.8	36.8	89.1	2.44	13.37	39.4	22.0
	2	28.2	36.9	1.2	111	15.8	49.7	123.7	2.49	13.75	37.6	23.3
	3	29.1	37.6	1.3	111	16.1	54.0	135.4	2.51	13.55	38.0	22.3
	4	25.6	36.0	1.2	111	18.0	72.0	179.3	2.49	13.73	38.1	23.1
Kent	1	27.8	36.0	2.0	118	13.9	32.2	76.7	2.39	15.52	40.0	21.7
	2	30.0	37.4	1.5	117	15.6	39.7	93.2	2.34	15.40	38.4	22.5
	3	32.2	38.8	1.4	116	17.2	57.2	139.6	2.44	16.37	38.1	22.5
	4	33.2	36.4	1.3	116	18.7	71.4	170.8	2.39	16.47	38.2	22.3

Appendix Table VIII. Summary data -- moisture utilization, Manhattan, Kansas, 1966.

Variety	Spacing (inches)	Inches Used Per Time Period											Total Use (inches)
		1	2	3	4	5	6	7	8	9	10	11	
20" Row Width													
Clark 63	1	1.06	1.30	1.01	2.54	.87	1.43	.65	1.30	1.18	.39	.63	12.33
	2	.73	1.10	.91	2.78	.77	1.32	.67	1.37	1.12	.54	.48	11.76
	3	.46	.42	.64	3.27	.80	1.22	.81	1.53	1.13	.43	.50	11.19
	4	.61	.58	.91	2.89	.87	1.53	.55	1.62	1.07	.45	.49	11.55
Kent	1	.72	.84	.80	2.04	1.34	1.48	.49	2.01	.79	.45	.58	11.00
	2	.69	.95	.80	2.54	.87	1.35	.70	1.43	1.25	.47	.68	11.72
	3	.55	.52	.64	2.61	.85	1.38	.79	1.61	1.09	.43	.72	11.16
	4	.60	1.25	.83	2.46	1.09	1.40	.79	1.81	1.31	.45	.71	12.13
40" Row Width													
Clark 63	1	.75	.97	.88	2.34	1.25	1.00	.89	1.78	1.09	.57	.38	11.87
	2	.54	.34	.66	2.67	1.06	1.44	.43	2.12	.83	.43	.42	10.90
	3	.50	.35	.51	2.46	1.23	1.08	.80	1.55	1.52	.42	.39	10.79
	4	.42	.35	.69	1.49	1.71	1.76	.97	2.18	.90	.57	.35	11.36
Kent	1	.86	.90	.66	2.61	.97	1.42	.45	1.87	1.05	.54	.60	11.86
	2	.66	.65	.81	1.87	1.20	1.60	.76	2.02	1.16	.74	.78	12.17
	3	.59	.45	.55	2.24	1.33	1.57	.44	2.07	.91	.62	.74	11.47
	4	.46	.58	.44	2.46	1.15	1.40	.48	2.08	.96	.48	.57	11.03

Appendix Table IX. Summary data -- moisture utilization vs. yield, Manhattan, Kansas, 1966.

Variety	Spacing (inches)	Yield (Bu/A)	Total Moisture Use (inches)	Moisture per Bushel (inches)
20" Row Width				
Clark 63	1	29.5	12.33	.418
	2	30.6	11.76	.384
	3	29.8	11.19	.376
	4	33.0	11.55	.350
Kent	1	29.0	11.00	.379
	2	28.7	11.72	.408
	3	31.5	11.16	.354
	4	31.7	12.13	.383
40" Row Width				
Clark 63	1	28.6	11.87	.415
	2	28.2	10.90	.387
	3	29.1	10.79	.371
	4	25.6	11.36	.444
Kent	1	27.8	11.86	.427
	2	30.0	12.17	.406
	3	32.2	11.47	.356
	4	33.2	11.03	.332

UTILIZATION OF MOISTURE BY KENT AND CLARK 63 SOYBEANS

By

GARY LLOYD COOPER

B. S., Kansas State University, 1961

AN ABSTRACT OF A MASTER'S THESIS

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MASTER OF SCIENCE

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Row width, within-row spacing, and variety studies on soybeans were conducted during the summer of 1966 on the Agronomy Farm of the Kansas Agricultural Experiment Station at Manhattan, Kansas.

Two soybean varieties recommended in Kansas, Clark 63 of intermediate maturity and Kent of late maturity, were used in the study. Each variety was planted in 20 and 40 inch row widths and thinned by hand to the desired within-row spacings of 1, 2, 3, and 4 inches.

Two individual experiments were conducted simultaneously. Factors examined in the first experiment were total moisture utilization, depth of moisture extraction, and moisture use efficiency. In the second experiment seed yield, nodes per plant, pods per plant, seeds per plant, seed weight, plant height, lodging, maturity, oil content, and protein content were examined. Analysis of variance was run on all characters except protein and oil.

Adequate soil moisture was available at time of planting allowing good emergence and seedling development. Weather conditions throughout the remainder of the growing season were unfavorable for optimum plant growth. Precipitation received from time of planting until harvest was only 7.15 inches. June and July were abnormally hot and dry but August was cool and near normal precipitation was recorded.

Plants in 20 inch rows used an average of 0.2 of an inch more moisture than those in 40 inch rows. Similar comparisons between varieties showed that Kent used an average of 0.1 of an inch more moisture than Clark 63. The greatest differences in moisture use were found among the within-row spacings. The three-inch spacings used 0.62 of an inch less moisture than one-inch spacings. None of the differences were significant.

All plots used an average of 11.52 inches of moisture from July 1 to September 28. Approximately 5.00 inches of the total moisture used was extracted from the soil profile, the remainder obtained from precipitation. Approximately 75 per cent of the moisture removed from the soil was extracted from the top 30 inches of the soil profile. The heaviest extraction of moisture occurred at the 18 inch depth.

The most efficient use of available moisture was made from the three inch within-row spacings, 20 inch row widths, and the Kent variety.

Kent produced 1.2 bushels more soybeans per acre than Clark 63. Plantings made in 20 inch rows produced 1.2 bushels per acre more than those in 40 inch rows and the plants of the four inch within-row spacings averaged 2.1 bushels per acre more than those planted one inch apart. Highest yields of Clark 63 were produced in 20 inch rows from plants spaced 1 and 2 inches within the row. Kent produced best in 40 inch rows from plants spaced 3 and 4 inches within the row. The yield differences were not significant.

Nodes per plant, pods per plant, seeds per plant, and seeds per pod increased in numbers in the 40 inch row widths and in the wider within-row spacings. Heavier seeds were also produced in the wider rows and wider within-row spacings.

Varietal differences were also noted. The seeds of Kent were heavier than the seeds of Clark 63. Clark 63 produced more pods per plant, seeds per plant, and seeds per pod than Kent.

Plants in the 40 inch rows averaged 1.7 inches taller than those in 20 inch rows. Clark 63 produced taller plants in the narrow rows and closer within-row spacings but Kent produced taller plants in the wider rows and wider within-row spacings. None of the plant height differences were significant.

Lodging was not affected by row width or variety but closer within-row spacings increase lodging significantly. The one-inch spacings lodged more than any other spacing.

Kent matured an average of five days later than Clark 63. Closer within-row spacings also delayed maturity. The one-inch spacings matured an average of three days later than the four-inch spacings. Row width did not affect maturity.

Kent averaged 0.4 per cent more protein than Clark 63. Protein content was 0.6 per cent higher in the 20 inch rows than in the 40 inch rows and 1.3 per cent higher in the one inch within-row spacings than in the four inch within-row spacings.

Clark 63 averaged 0.2 per cent more oil content than Kent. Oil content was 0.8 per cent higher in the 40 inch rows than in the 20 inch rows and 0.7 per cent higher in the four inch within-row spacings than in the one inch within-row spacings.