EFFECT OF SPACING OF PLANTS BETWEEN AND WITHIN ROWS ON YIELD AND OTHER CHARACTERISTICS IN SOYBEAN

by

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A Thesis Submitted to the Graduate Faculty of
the School of Agriculture in Partial Fulfillment of
the Requirements for the Degree of
MASTER OF SCIENCE IN AGRICULTURE

Split Major: Agronomy - Seed Technology
Minor: Plant Pathology

Approved:

In Charge of Major Work

Chairman, Graduate Committee

American University of Beirut
1962

Cultural Trials in Soybean

ALI

ACKNOWLEDGEMENTS

I wish to acknowledge with deep gratitude the kind help, advice, guidance and encouragement extended to me by Dr. W.W. Worzella whose cooperation made this study possible.

My sincere thanks are also due to AID for giving me the opportunity to study at AUB.

I am also grateful to Mr. Nabil Banna, of animal nutrition section for the valuable help in chemical analysis, and to Mr. Salah Bu Shakra for help in field work.

My thanks are due to Mr. Saeed Chaudhry for cooperative attitude and patience shown in typing the final draft.

The above does not detract from my deep gratitude to all who have contributed directly or indirectly in my work for this thesis.

S.M. Ali.

ABSTRACT

A two-year study was conducted at the American University farm to determine the effect of planting soybeans 2, 3 and 4 cm. apart in rows 25, 50 and 75 cm. on different plant characteristics of three soybean varieties. The factors studied were seed yield, seed size, total weight at maturity (stem, pod and seed), plant height, seeds per pod, number of days from planting to flowering, protein and oil percentage in the seed.

Soybeans grown in 50 cm. rows produced the highest seed yield with the highest protein percentage. The seed size was maximum when the soybeans were grown under wider spacings of both within and between row. The total weights at maturity (stem, pod and seed) were found to be the highest in the soybeans planted in 25 cm. rows. Planting soybeans in various row-width did not affect the other plant characteristics studied.

The 2, 3 and 4 cm. within-row plant spacings did not affect significantly the seed yield, total weight at maturity (stem, pod and seed), plant height, seeds per pod, protein and oil percentage in soybean.

The variety Clark performed the best in both seed yield and protein content when compared to the other two varieties, Hawkeye and Grant.

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INTRODUCTION

The soybean is one of the oldest cultivated crops. Its early history is lost in antiquity. The first record of the plant in China dates back to 2838 B.C. (21). It was one of the five sacred grains upon which Chinese civilization depended. The soybean has had perhaps the most phenomenal history of any agricultural crop in the United States, if not in the world. In a period of less than a quarter of a century, the production of soybeans has grown from relative insignificance to first place among the oil seed crops of the Western Hemisphere. This legume has been responsible for the creation of new industries and the expansion of many long-established ones, and its derived products are consumed in a notable diversity of foods, feeds, and industrial products and processes.

The production of soybeans, however, was more or less localized until after the Chinese-Japanese war (1894-1895), to China and some other countries of Asia.

Since World War II practically all leading nations have become more and more interested in the culture and production of the crop. This is especially true of the United States, Netherland Indies, Rumania, U.S.S.R., Austria, Bulgaria and Poland. The principal zones of soybean production in the Orient are China, Manchuria, Korea and Japan, (21).

Soybeans are grown satisfactorily under a wide va-

riety of climatic and soil conditions. When the crop is properly inoculated, and perhaps because of other characteristics of the plant, soybeans give relatively better yields under unfavorable soil and moisture conditions than corn and many other crops.

The cultivated soybean probably was derived from a wild type, Glycine ussuriensis, that grows in eastern Asia. The present accepted botanical name for the soybean is Glycine max, formerly Soja max, (27).

Although the soybean has been the subject of considerable experimental work in practically all countries of the Europe and Asia, little progress has been made in commercial culture except in the United States and Canada.

The present study was undertaken in the Bekaa plain, one of the main agricultural areas of Lebanon, to study the effect of number of plants per unit area upon yield and other characteristics of the soybeans, Different populations were established by varying the spacing of plants both between and within rows.

In Lebanon and other Middle Eastern countries where people are dependent largely upon meat and fish products for their protein supply, this costly item might be substituted with soybean products through developing this versatile plant.

REVIEW OF LITERATURE

The rapid increase in the importance of the soybean in recent years has been due, in considerable measure, to its high oil and protein content and to the usefulness of these as a constituent of food, feed and industrial products (15). Cultural studies, therefore, were undertaken by various investigators to increase the yield so that soybeans could compete more efficiently with other field crops.

Smith and Whiteley, (30, 36), working with different row-widths in Arkansas, found that increased yields could be obtained in many instances by using 10 inches or 20 inches row-width, but that inability to control weeds often limited this type of production.

Frans (9) in 1956-58 in his studies with soybean spacing confirms the earlier work and observations of others that soybean grown in row-widths narrower than the conventional 36 to 42 inches will on occasion produce higher yields than those in wider rows. He obtained the highest yield in row-widths spacing of 10 inches and seven inches. He further concluded that soybeans in narrower rows probably shade the soil relatively earlier than those grown in wider rows, thus reduced weed competition and the resultant loss in yield. His studies indicate that the technique of growing soybeans in narrow rows in conjunction with herbicides has merit in lowering production requirements for cultivation while maintaining and even increas-

ing yields. Pendleton (25), in his works at Illinois showed that soybeans grown in narrow rows (21 inches to 28 inches) average 15 percent more in yield than soybeans grown in 40 inches rows.

To study the effects of plant spacing of soybeans on yield and several other characters commonly obtained in the evaluation of varieties, an experiment on spacing was carried out with four varieties of soybeans at Lafayette, Indiana, by the U.S. Regional Soybeans Laboratory and the Purdue University agricultural experiment station, co-operatively. The work was conducted over the four-year period from 1938 to 1941 (26). The results showed that lodging was most severe when spaced one inch apart and almost absent in the three, four and five inch spacing. Plant height was slightly influenced by the spacing with plant spaced five inches apart were slightly shorter than when spaced close together. Maturity was hastened when plants were spaced two to five inches in comparison with one inch spacing. The varieties averaged from two to four days earlier for spacing two to five inches apart in comparison with one inch spacing. Spacing has little effect on the size of seed, although in most cases seed was slightly heavier when the plants were spaced one inch apart than those spaced wider apart, but this difference was not significant.

Lipman (19) in greenhouse experiments found that the percentage of nitrogen in the dry matter was slightly higher when smaller number of plants were planted in the

pot. He concluded that the protein contents of soybeans may be influenced considerably by the rate of seeding. In the matter of the total nitrogen recovered, he found that the pots containing from 14 to 30 plants were far ahead of those with two to eight plants. This was assumed to be due largely to the greater yield of dry matter of the thicker planting. He further concluded that thicker plantings increased or intensified the utilization of atmospheric nitrogen by means of symbiotic bacteria.

Rouse (29) in his studies comparing different row-widths and seeding rate on yield found that the yield increased as the row-width was decreased from 40 to 20 or 10 inches. The yield was also highest when the seeding rate was 60 pounds per acre. The other three seeding rates i.e., 90, 120 and 240 pounds per acre gave lower yields. Three-year average yields at the 60 pounds per acre rate were 34 bushels per acre in 40-inch rows and 55 bushels in the 10-inch rows. These studies showed that on land not heavily infested with weeds or where weeds are controlled beans planted in narrow rows produced higher yields.

Wiggins (38) reporting on studies of varying rates of seeding of Cayuga soybeans as influenced both by the spacing within the rows and the width between the rows lead to the following general conclusions:

(i) "The nearer the arrangement of plants on a given area approaches a uniform distribution, the greater will be the yield. Other things being equal, the narrower

the distance between rows until the distance between rows equals the space between plants in the row, the greater yield."

(ii) "Within wide ranges the number of plants per square foot of area has little effect on net increases. There is nothing to be gained by seeding beyond a given optimum."

(iii) "The soybean plant, like many others, has the ability to make wide adjustment to space."

(iv) "A variety of soybeans has an optimum number of plants per unit area for the maximum net increase. On the Cayuga this rate is six plants per square foot."

Wiggins (38) reported further that yield increased 20 to 30 percent by decreasing the row-width from 32 to eight inches.

As a conclusion on three years of study on spacing Wiggins (37) concluded that the narrower the space between rows, the higher the yield of soybeans.

Weber and Weiss (33) summarized the data from four Corn Belt States which showed that rows spaced 21 inches apart gave slightly higher yields than those of 7, 14, 25, 28 or 42 inches. In contrast, studies by Hartwig (13) in the Southeastern states have not shown an advantage from row-spacing less than about 36 inches.

A survey conducted in 1955 by the National Soybean Crop Improvement Council of the United States (29) showed that most of the oil varieties of soybeans are planted in

36 to 42-inch rows.

Rouse (29) compared late-planted soybeans (about June 1 and July 1) in 30 and 40-inch rows at 30 and 60 pounds seeding rates for the Lee and Jackson varieties. Their results showed a three to five bushel advantage for the 30-inch rows over the 40-inch rows. The same advantage prevailed for the June 1 plantings over the July 1 plantings. There were no differences between 30 and 60 pounds seeding rates or between varieties.

In a study at Illinois, conducted in 1913-15, on method of seeding and spacing of soybeans, Hackleman, Sears and Burlison (11) concluded that 18 to 32-inch row-spacing was far better than row-spacing of 35 to 40-inch.

In 1925 Thatcher (31), at the Ohio Experimental Station, reported a test comparing soybeans planted solid with those grown in rows. This test included two varieties and covered a period of two years. The greatest total yield was produced where the beans were grown in 24-inch rows.

Research works at Indiana (2) showed that six to eight soybean plants evenly distributed per foot of row, in rows of 28 to 40 inches apart, gave the highest yield and minimized weeds.

Beeson and Probst (2) in their experiments found that the row widths of 24 to 32 inches usually produce the highest yields in early-maturing varieties. They further concluded that varieties with a more spreading type of growth yield best in somewhat wider rows. However, they in-

dicated that usually the 40-inch rows are too wide to obtain maximum soybean yields.

Ross (28) in early studies on the Central Illinois Farms (1928-29) reported that no greater yields were obtained from planting soybeans in rows than from drilling them in solid i.e., in rows seven inch apart by a grain drill. Eighty-five percent of the bean acreage on which records were taken were drilled solid, and the remaining acreage was drilled in rows ranging from 14 to 42 inches apart. The yields were 23.2 bushel per acre when drilled solid, 24.2 bushel per acre when the rows were spaced 14 inches, 22.3 bushel for the row spaced 20 to 24 inches and 17.8 bushel per acre in the 36 to 42-inch rows.

An experiment was carried out by Caviness and Smith (6), in the Northeast Delta of Arkansas during the four-year period, (1955-58). Two varieties of soybeans, Dorman and Lee, were planted at the three rates, one, three-fourth and one-third bushel per acre. The approximate number of seeds planted at each of the rates were as follows: one bushel, 15.9 seeds per foot; three-fourth bushel, 11.9 seeds per foot; and one-third bushel, 5.3 seeds per foot. No significant differences in yield were reported in the variety of Lee during any of the four years of the experiment. But the variety Dorman planted at the rate of one-third bushel of seed per acre yielded significantly less than when planted at the three-fourth and one bushel rates.

In a study on the effect of method of planting soy-

beans at Lafayette, Indiana (1) paired rows, consisting of 7-35 inches, 28-40 inches and 34-40 inches, gave about the same yield as the conventional 40-inch rows. The 28-inch rows gave an 11 percent increase in yield, and the seven-inch rows (drilled solid) gave a 24 percent increase over 40-inch rows as an average of the Lincoln and Hawkeye varieties. Differences between treatments were non-significant at the five percent level. Irrigated Hawkeye soybeans in 42-inch rows averaged 30.1 bushels per acre.

Confirming the results of earlier workers Lehman and Lambert in 1953 (18) concluded that seed yields tended to be higher at the narrow spacing between rows. They further observed that the effect on yield of spacing within rows was variable. Seed weight was heavier in the 40-inch spacing, but was not affected by changes in spacing within rows. Seeds per pod increased slightly but consistently as spacing was increased. Seeds per plant, pods per plant, and number of branches increased markedly as the spacing was increased.

Hanway (12), Weber and Weiss (33) found that branching increased as the spacing between plants increased. Burlison et al (5) reported a decrease in the number of pods per plant as both the spacing between row and the spacing within rows were decreased.

Borst (4) in Ohio and McClelland (20) in Arkansas found that thick to moderate spacings, one-half to four or five inches, tended to give similar yields. The thin

spacings, about four to five inches apart or greater, almost invariably produced lower per-acre seed yields.

In an investigation over a four year period on the effects of annual weed infestations on growth and yield of soybeans, Weber and Staniforth (34) observed that the soybean stands below nine to 11 plants per foot of row were of considerable importance in increasing the severity of yield loss from weeds. They reported that weeds had little effect on maturity, height, lodging and seed size of soybeans.

Howell (17) in reviewing the studies of Williams (1950) and Yakada and Horinchi (1953) stated that it is a common observation that crowded soybean plants have fewer branches than spaced plants. Individual plants adjacent to the end of a row or to a gap in the row are therefore more productive than interior plants. Plants that are shaded at about the start of seed development lose a substantial number of pods within a few days. Yakada and Horinchi (1953) considered light to be the initial causal factor in inter-variety competition. In variety composites, varieties which are taller and have the greater branching habit have a competitive advantage.

Studies by Feaster (8) and Osler and Cartter (22) indicate that generally early planting gave maximum seed yield. They (8, 22) reported that early varieties should be planted later than late varieties for maximum yields.

Osler and Cartter (22) found an increase in lodging with later plantings.

Chemical composition of the seed is one of the important characteristics being considered in the development of improved soybean varieties. The use of chemical data as a basis for selection of promising lines of soybeans or other crops require an evaluation of the effects of environmental factors on chemical composition of the seeds.

Collins (7) reports the findings of Sessons and Schillel on differences in chemical composition of seed from different position of the pod in the plant. Seed analyzed from the lower nodes had a higher oil content than those from higher nodes.

Collins and Cartter (7) reported that oil content was one-half percent higher from the seed of the lower quarters of the plant and the protein content one percent lower than that from the upper quarters of the plant. He also found that higher yielding plants consistently produce seed with higher oil content than seed from the low yielding plants in the same planting.

Feaster (8) stated that planting date had little influence on seed quality of late varieties but that seed quality was the poorest from early plantings of early varieties. Feaster and Oster and Cartter (8, 22) further stated that in general a delay in planting resulted in a decrease in the oil content and an increase in the protein content.

Torrie and Briggs (32) found no effects of date of planting on lodging. The protein content showed no tendency

to decrease with delay in planting.

Weiss et al (35) studied the agronomic characters and temperature with seed compositional characters in soybeans, as influenced by variety and time of planting. Among the means of the five varieties studied the following attributes were found to be significantly correlated: Large seed size with low iodine number of oil; lateness of maturity with high oil content, and low protein content; low mean temperature during the period from flowering to maturity with high iodine number of oil; high oil content with low iodine number of oil, and high protein contents with low oil contents. No appreciable association among variety means was found between: Seed size with oil content; protein content, days from flowering to maturity with oil content, and mean temperature with oil content.

To study the physiological factors affecting chemical composition of soybean seed a greenhouse experiment was conducted under controlled temperature conditions by Howell and Cartter (16). Soybean seed averaged 23.2 percent, 20.8 percent and 19.5 percent oil when grown at temperatures of 85, 77 and 70 degrees Fahrenheit, respectively during the pod-filling stage. To determine the effect of a brief period of elevated temperature, plants were held at 70 degrees Fahrenheit during the day and 65 degrees at night throughout their life except for one week. During this period the temperature were 85 degrees during the day and 65 degrees at night. Elevated temperature during the fourth to seventh

week before maturity resulted in oil content of about 22 percent as compared to 19.6 percent when elevated temperature was given the second week before maturity.

That the elements of the climate might affect the composition of soybeans was suggested many years ago by Garber et al (10) who concluded that under usual conditions climate is a more potent factor than soil in controlling the seed size and the percentage of oil in the soybean.

Howell (15) reviewing the work of Kierstead (1945-1950) stated that an increase of one degree Fahrenheit in temperature during the growing periods was associated with an increase in oil contents of 0.41 to 0.47 percent. He also stated that the oil percentage of soybean is greatly affected by temperature during seed development. The temperature during a period of about three weeks beginning shortly after the start of seed development is particularly critical. It was demonstrated in a greenhouse experiment that plants receiving a temperature of 85 degrees Fahrenheit during the day for as short a period as one week may produce seeds with oil percentages two or three points higher than plants kept at 70 degrees Fahrenheit. He further concluded that this effect appears to be independent of any effects on yield (17).

The current varieties and experimental lines in the regional testing program in the United States (17) have recently averaged about 21.5 percent oil and the protein has averaged 40 to 42 percent.

MATERIALS AND METHODS

The experiment was conducted for two years, 1961 and 1962, at the American University farm located in the Bekaa plain about 80 km. east of Beirut, under irrigated conditions. The experimental soil was high in clay content and low in organic matter, nitrogen and phosphorus, high in potassium content and is calcareous with a pH of about 8.0.

Three varieties of improved types of soybeans were used in this experiment, namely, Grant, Hawkeye and Clark. Grant is an early variety and matured about fifteen days earlier than the other two varieties. Both the seed and plant size of Grant are smaller than that of Hawkeye and Clark. Hawkeye has large, usually high quality seeds and excellent resistence to lodging. Its protein and oil content averaged about 41.4 percent and 21.0 percent, respectively (3). Clark is a selection from backcross Lincoln x (Lincoln x Richland). It was developed cooperatively by the Illinois Agricultural Experimental Station and the U.S. Regional Soybean Laboratory and has been tested in cooperation with other stations in the north-central regions of U.S. It is resistant to lodging and is a high-yielding variety. Its protein and oil content averaged 40.5 percent and 21.4 percent, respectively (23).

A split-plot field design was used in which the three spacing within rows 2, 3 and 4 cm. were in the main plots, three spacing between rows 25, 50 and 75 cm. were

the sub-plots, and the three varieties were the sub-sub-plots.

Through the experience gathered during the first year it was obvious that a slight modification in the field lay-out was necessary for the 25 cm. row-width spacing to facilitate irrigation, weeding and other cultural practices. In 1962, instead of the 25 cm. rows used in 1961, the soy-beans were planted in two-15 cm. rows leaving 35 cm. between each pair of rows for irrigation.

The test was planted in four replications on the 9th and 10th of May, 1961 (two replicates in each day) and on the 25th of April, 1962. A good seed bed was prepared before the beans were planted. The plots received a uniform fertilizer treatment at the rate of 20 kg. per dunum of P_2O_5 in the form of super-phosphate and 12 kg. per dunum of nitrogen in the form of ammonium sulfo-nitrate. The fertilizer was disked and worked into the soil just before planting. Side-dressing with nitrogen fertilizer in the form of ammonium sulfo-nitrate at the rate of 4 kg. per dunum was done only in the plots showing nitrogen deficiency symptoms.

The whole experimental plot involved an area of 21 x 24 meters. Each main plot covered an area of 7 x 5 meters. Each treatment constituted 3 rows, each 5 meters long. Only 4 meters of the center row of each treatment were harvested to reduce border effects. Hand-weeding was practised regularly to keep the plots free from weeds

until the seedlings were well established; afterwards weeding was done by means of appropriate nursery equipments. The plots were sprayed with Endrin during the early stages of growth to control cutworms. There was some infestation of leaf-hoppers, but as soon as they were detected, the plants were sprayed with meta-systox at the recommended rates.

The plants were harvested when the pods were fully matured and the leaves practically all off the plants. The soybeans were threshed after about 20 days of sun-curing. There was no shattering, only a few plants in the close-spaced plots were lodged because of mechanical injury to the plant during the weeding and other cultural operations.

There were nine different combinations of seed spacings used by varying the area both within the row and between the row as shown in Table 1.

Table 1. Nine combinations of seeding rates are shown by varying the spacing of seeds both between and within rows.

Within-row spacing in cm.	Between-row spacing in cm.					
	25		50		75	
	Number of seeds in 5 meter rows	kg. per dunum	Number of seeds in 5 meter rows	kg. per dunum	Number of seeds in 5 meter rows	kg. per dunum
2	275	35.2	275	17.6	275	11.7
3	184	23.5	184	11.8	184	7.8
4	138	17.7	138	8.9	138	5.9

The seeding rate, kg. per dunum, has been calculated on the basis of average seed weight of 1,000 seeds of the three varieties. In all seeding combinations ten percent of extra seeds was sown as the laboratory tests reveal that germination percentage of all the three varieties was near 90 percent.

For protein and oil determinations in the seed, a representative sample of each row was dried in an oven for 24 hours at a constant temperature of 70° C and then cooled before grinding. Oven dried samples were ground in a Wiley mill with 20 mesh sieve and the ground material was collected and stored in a bottle. Before weighing the ground samples (for the determination of protein and oil), they were put in the oven at 70° C for several hours to remove the moisture, cooled in a dessicator and then weighed on the electrical balance to the nearest tenth of a milligram. Protein determination was made according to the modified Kjeldahl method as specified in Association of Official Agricultural Chemists official methods of Analysis (14) to determine nitrogen percentage. The nitrogen values obtained were multiplied by 6.25 to get the percentage of protein. Results of duplicates differing from the sample mean by six percent or more were rejected and the analyses were repeated.

For oil determination dry extraction methods were used. Continuous extraction method very close to that of Soxhlet type were set up. Dry extraction method involves

the removal of the fat soluble substances from thoroughly dried materials by means of an anhydrous solvent-ether. The percentage of oil was calculated on an air-dry basis.

The data for germination percentage both in field and the laboratory, plant height, number of days from planting to flowering, number of seeds per pod (average of 20 pods per row), shattering tendency, lodging characteristics, total weight at maturity (stem, pod and seed), seed yield and 1,000-kernel weight per plot were obtained and recorded.

Statistical methods appropriate to the split-plot design were used to analyze the data (24). Analysis of variance and the 't' test were used to calculate the difference between the treatment combinations.

The data for only the germination percentage and the number of days from planting to flowering are reported for both of the seasons, 1961 and 1962. All other data for the second year or 1962 crop is not presented in this report as the crop was not harvested before the completion of this thesis.

RESULTS AND DISCUSSION

The main objectives of this study were to determine the effects of between and within-row spacings of three varieties of soybean on several plant characteristics. The data for these will be reported in Tables 2 to 9, under the following headings: Seed yield, 1000-kernel weight, total weight at maturity (stem, pod and seed), number of seeds per pod, plant height, number of days from planting to flowering, protein and oil percentage. The result of germination percentage of both laboratory and field will be represented in a histogram in Fig. 1.

At the bottom of each table the LSD figures and mean values are given only for those treatments which were found to be statistically significant. The analysis of variance values are given in Tables 10 to 17. The abbreviations which will be used in Table 2 to 9, are as follows: Q, stands for between-row spacing, P, for within-row spacing and V for variety. The numbers 1, 2, 3, with Q represent row-spacing at 25 cm., 50 cm. and 75 cm., respectively. Numbers with P represent within-row spacing of 2 cm., 3 cm. and 4 cm., respectively. The three different varieties are coded as Grant (V1), Hawkeye (V2) and Clark (V3).

Seed yield

Row-width significantly affected the seed yield in soybeans as shown in Table 10. The highest seed yields were

obtained when the rows were spaced 50 cm. apart and the lowest seed yields were from row spaced of 75 cm. apart. The soybeans planted in 25 cm. rows yielded in between the two treatments. The mean seed yields for the 50, 25 and 75 cm. spaced rows were, 297.9, 273.5 and 250.6 kg. per dunum, respectively (Table 2). A possible explanation for greater seed yield at the narrow-row width than at wider-row width may be that the soybean plant does not tiller very much and therefore does not utilize fully the area in the wider spaced rows. Moreover, narrow-row spacing has the merits of reducing weed population by shading. This is in agreement with the findings of Frans (9), Rouse (29), Haeckleman, Sears and Burlison (11). Wiggins (38), in 1939 concluded that "the nearer the arrangement of plants (soybean) on a given area approaches a uniform distribution, the greater will be the yield. Other things being equal, the narrower the distance between rows until the distance between rows equals the space between plants in the row, the greater the yield."

There were significant differences among the mean yields of the three soybean varieties (Table 2). The variety Clark yielded the highest, 359.8 kg. per dunum, while Grant yielded only 197.3 kg. per dunum. The yield of Hawkeye was in between Clark and Grant. The mean yield differences among the varieties were found to be significant at the 1% level. The low yield of Grant is due to the fact that it is early maturing variety, and matured about

Table 2. Effect of between and within-row spacing on the seed yield of soybeans in kg. per dunum during 1961 at the University farm.

Variety	Within-row spacing in cm.	Between-row spacing in cm. 25(Q1)	50(Q2)	75(Q3)	Average of Variety
Grant (V1)	2	197.0	225.2	192.2	
	3	206.1	178.3	195.4	
	4	184.1	198.6	198.6	197.3
Hawkeye (V2)	2	254.6	262.8	234.9	
	3	244.4	290.3	248.7	
	4	247.3	350.5	250.0	264.8
Clark (V3)	2	396.3	380.0	308.3	
	3	365.5	377.3	324.0	
	4	365.8	413.0	303.1	359.8
Average		273.5	297.9	250.6	

	LSD(5%)	LSD(1%)
Between-row spacing	23.6	32.4
Variety	20.3	26.7
Between-row x Variety	35.9	47.8

Between-row spacing	50 cm.	25 cm.	75 cm.
Mean	297.9	273.5	250.6

Variety	Clark	Hawkeye	Grant
Mean	359.8	264.8	197.3

Between-row x Variety:

Q2V3	Q1V3	Q3V3	Q2V2	Q1V2	Q3V2	Q2V1	Q1V1	Q3V1
390.1	375.9	311.8	301.2	248.8	244.5	200.7	195.7	195.4 /

/ denotes treatment means that did not differ significantly at the 5% level.

fifteen days earlier than the other two varieties.

The seed yields were not affected by the different plant spacing within the rows. That is, soybean seeds planted 2, 3 and 4 cm. apart in the row, had little, if any, influence on the resulting yield (Table 10).

It is evident from the data in Table 2, that there were no benefits in yield by seeding soybeans beyond a certain optimum. The best seeding rate, under the conditions of this experiment, was found to be nine to 18 kg. per dunum (Table 1). Increased planting rates resulted in increased yield only to a certain point beyond which yields remained relatively constant or less even though the planting rate was increased up to 35 kg. per dunum (Table 1). These results are in agreement with the findings of Rouse (29), Caviness and Smith (6).

Interaction between row spacing x variety was found to be significant as shown in Table 10. It will be noted in Table 2 that the higher as well as the lower yielding varieties reacted uniformly in average seed yield when planted in 25, 50 and 75 cm. rows. On the basis of average yield, all three varieties yielded the highest at the 50 cm. row-spacing and the least at the 75 cm. row-width.

Weight of 1000-kernels

The 1000-kernel weights were found to differ significantly due to variations in row-spacings both within and between-row (Table 11). The weight of 1000 seeds was maxi-

Table 3. Effect of between and within-row spacing on the 1000-kernel weight of soybeans in grams during 1961 at the University farm.

Variety	Within-row spacing in cm.	Between-row spacing in cm. 25(Q1)	50(Q2)	75(Q3)	Average of Variety
Grant (V1)	2(P1)	110.3	122.8	120.8	
	3(P2)	105.6	118.0	123.2	
	4(P3)	104.5	117.9	140.2	118.2
Hawkeye (V2)	2(P1)	150.0	178.3	183.6	
	3(P2)	158.7	188.3	187.9	
	4(P3)	163.0	192.9	190.4	177.0
Clark (V3)	2(P1)	158.7	190.5	192.2	
	3(P2)	162.9	191.7	195.5	
	4(P3)	172.5	201.2	196.2	184.6
Average		142.9	166.9	170.0	

	LSD(5%)	LSD(1%)
Between-row spacing	5.54	7.60
Within-row spacing	5.22	7.91
Variety	3.99	5.31
Between-row x Variety	3.43	9.15

Between-row spacing	75 cm.	50 cm.	25 cm.
Mean	170.0	166.9 /	142.9

Within-row spacing	4 cm.	3 cm.	2 cm.
Mean	164.3	159.1	156.4

Variety	Clark	Hawkeye	Grant
Mean	184.6	177.0	118.2

Between-row x Variety:

Q3V3	Q2V3	Q3V2	Q2V2	Q1V3	Q1V2	Q3V1	Q2V1	Q1V1
194.6	194.5	187.3	186.5	164.7	157.2	128.1	119.6	106.8

/ denotes treatment means that did not differ significantly at the 5% level.

mum when the spacings within rows were 4 cm. apart as shown in Table 3. There were no significant differences in seed weight between the 3 cm. and the 2 cm. spaced plantings.

Seed weight was also influenced by the various spacings between the rows (Table 11). The highest seed weight was obtained when the soybeans were planted in 75 cm. rows, however the differences between the 75 and 50 cm. rows are not statistically significant. Soybeans planted in 25 cm. rows produced the smallest seed. These results are in agreement with the work of Lehman and Lambert (18).

Significant differences in seed weight were obtained between the three varieties studied. This was expected as Grant, an early maturing variety, was known to possess smaller seeds. In this study the mean weight of 1000-kernel was 184.6, 177.0 and 118.2 grams for Clark, Hawkeye and Grant, respectively (Table 3).

An interaction between variety x between-row spacing was found to be significant. It will be noted from the data presented in Table 3, that, in all varieties, the mean weight of the seeds were higher when a greater growing space per plant was available, but the seeds were smaller when the plants were thicker on the ground. One of the reasons for the higher seed weight, at the wider spacing of both within and between-rows, may be that at the wider row spacing there was more nutrient and sunlight available for the plants per unit area than at the narrow-spacings.

Total weight at maturity (stem, pod and seed)

Significant differences were found in total weight at maturity of soybean due to between-row spacing (Table 12). The highest total weights were obtained when the row spacing was minimum, i.e., 25 cm. as reported in Table 4. The lowest total weight was derived from the row-spacing of 75 cm. The average total weight at maturity obtained at the 25, 50 and 75 cm. rows were 1784, 1551 and 1137 kg. per dunum, respectively. A possible explanation for greater yield from the narrow-row width plots is probably due to the greater number of plants than in the wider row spaced plots.

The differences in the total weight for the three varieties studied were found to be statistically significant (Table 12). The highest total weight was obtained for the Hawkeye, followed by Clark and Grant.

A statistically significant interaction between-row spacing x variety for total weight was found (Table 12). The highest mean total weight was obtained by the variety Hawkeye when planted with 25 cm. rows. On the other hand Grant produced the least total weight in the 75 cm. plots. The other combinations, involving average total weight x row-width, are in general agreement that varieties of soybeans produced the greater yield when planted in 25 cm. rows than when the rows are spaced further apart.

The plant spacing of 2, 3 and 4 cm. within the rows did not influence the total weight of soybean (stem, pod and seed).

Table 4. Effect of between and within-row spacing on the total weight at maturity of soybeans in kg. per dunum during 1961 at the University farm.

Variety	Within-row spacing in cm.	Between-row spacing in cm. 25(Q1)	50(Q2)	75(Q3)	Average of Variety
Grant (V1)	2	1168	1016	757	
	3	1090	847	765	
	4	1022	995	799	940
Hawkeye (V2)	2	2430	2045	1495	
	3	2477	1998	1269	
	4	2090	2083	1333	1913
Clark (V3)	2	2115	1710	1366	
	3	1872	1561	1287	
	4	1800	1705	1163	1619
Average		1784	1551	1137	

	LSD(5%)	LSD(1%)
Between-row spacing	213	292
Variety	147	196
Between-row x Variety	295	393

Between-row spacing	25 cm.	50 cm.	75 cm.
Mean	1784	1551	1137

Variety	Hawkeye	Clark	Grant
Mean	1913	1619	940

Between-row x Variety:

Q1V2	Q2V2	Q1V3	Q2V3	Q3V2	Q3V3	Q1V1	Q2V1	Q3V1
2332	2042	1929	1658	1365	1272	1093	953	774

/ denotes treatment means that did not differ significantly at the 5% level.

Number of Seeds Per Pod

The various soybean plant populations, as attained by various row-width and within-row plant spacings, did not influence the number of seeds per pod (Table 13). Although the analysis of variance did not show any significant differences on the number of seeds per pod due to within-row spacing, the LSD figures in Table 5 reveals a significant difference among the three within-row space plantings. The data show that the highest mean number of seeds per pod was obtained when the plants were spaced 3 cm. apart as compared to the other two spacings.

The three varieties used varied in the average number of seeds per pod as shown in Table 5. Grant having the highest number of seeds per pod with 2.9, this was followed by Clark 2.8 and Hawkeye with 2.4 seeds per pod.

Interaction within-row spacing x variety was found to be significant as shown in Table 13. The highest mean seeds per pod was obtained by the variety Grant when spaced 4 cm. apart within the rows. On the other hand Hawkeye produced the lowest number of seeds per pod in the 4 cm. within-row spacing. An inspection of the mean values, in Table 5, of the treatment combinations of within-row spacing x variety shows the lack of consistency in the number of seeds per pod due to the effect of spacing within-row x variety combinations. This shows that within-row spacing had very little influence on the number of seeds per pod. The varietal differences on the number of seeds per pod ac-

Table 5. Effect of between and within-row spacing on the number of seeds per pod of soybeans during 1961 at the University farm.

Variety	Within-row spacing in cm.	Between-row spacing in cm. 25(Q1)	50(Q2)	75(Q3)	Average of Variety
Grant (V1)	2(P1)	2.8	2.8	2.9	
	3(P2)	3.0	2.8	2.8	
	4(P3)	2.9	3.0	2.9	2.9
Hawkeye (V2)	2(P1)	2.3	2.3	2.4	
	3(P2)	2.7	2.4	2.4	
	4(P3)	2.3	2.3	2.2	2.4
Clark (V3)	2(P1)	2.9	2.9	2.9	
	3(P2)	2.7	2.8	2.8	
	4(P3)	2.8	2.9	2.9	2.8
Average		2.8	2.9	2.9	

	LSD(5%)	LSD(1%)
Variety	.01	.01
Within-row spacing	.01	.02
Within-row x Variety	.01	.02

Variety	Grant	Clark	Hawkeye
Mean	2,9	2.8	2.4

Within-row spacing	3 cm.	4 cm.	2 cm.
Mean	2.74	2.68	2.68 /

Within-row x Variety:

P3V1	P1V3	P3V3	P2V1	P1V1	P2V3	P2V2	P1V2	P3V2
2.95	2.87	2.85	2.85	2.82	2.77	2.57	2.35	2.25

/ denotes treatment means that did not differ significantly at the 5% level.

counts for much of the significant interaction.

Plant Height

The height of the soybean plant was influenced very little by planting soybean in various row-widths and in 2, 3 and 4 cm. within the rows as shown in Table 6. However, those planted in 50 cm. row-width were significantly higher than those planted in 25 cm. row spacing. Except in Grant, those planted 4 cm. apart in 50 cm. rows produced the tallest plants (Table 6).

There were significant differences among the mean plant height of three soybean varieties (Table 6). Clark grew the tallest with an average height of 114.9 cm., followed by Hawkeye, 110.5 cm., Grant with 84.5 cm.

Interaction within-row spacing x variety was found to be significant as shown in Table 14. The highest plant height was obtained with Clark when the plants were spaced 4 cm. apart within the row. On the other hand, the lowest height was obtained in Grant in 2, 3 and 4 cm. within row spacing. The other mean plant heights obtained by treatment combination within-row x variety do not differ significantly among themselves.

Number of Days from Planting to Flowering

The analysis of variance reported in Table 15 indicates a significant difference in the number of days from planting to flowering due to the varieties both in 1961 and

Table 6. Effect of between and within-row spacing on the plant height of soybeans in cm. during 1961 at the University farm.

Variety	Within-row spacing in cm.	Between-row spacing in cm. 25(Q1)	50(Q2)	75(Q3)	Average of Variety
Grant (V1)	2(P1)	80.8	84.0	84.0	
	3(P2)	84.3	83.8	88.5	
	4(P3)	85.3	86.8	83.5	84.5
Hawkeye (V2)	2(P1)	108.6	112.1	110.6	
	3(P2)	104.3	113.0	111.6	
	4(P3)	109.0	113.6	111.8	110.5
Clark (V3)	2(P1)	110.1	108.5	109.8	
	3(P2)	109.2	116.7	114.4	
	4(P3)	117.9	130.1	117.9	114.9
Average		101.1	105.4	103.6	

	LSD(5%)	LSD(1%)
Between-row spacing	4.1	5.6
Variety	3.2	4.3
Within-row x Variety	5.4	7.2

Between-row spacing	50 cm.	75 cm.	25 cm.
Mean	105.4	103.6	101.1

Variety	Clark	Hawkeye	Grant
Mean	114.9	110.5	84.5

Within-row spacing x Variety:

P3V3	P2V3	P3V2	P1V2	P2V2	P1V3	P2V1	P3V1	P1V1
122.0	113.4	111.5	110.4	109.6	109.4	85.5	85.2	82.9

≠ denotes treatment means that did not differ significantly at the 5% level.

1962. On inspection of the means in Tables 7a and 7b reveals that the variety Grant flowered earlier than other two varieties in both of the seasons. Varieties were the most important in affecting the period from planting to flowering. Since the three varieties were selected for their difference in maturity it may be assumed that this is a varietal characteristic (2).

There were no significant differences in the number of days from planting to flowering due to the spacing treatments, both between and within-row for the 1961 season. However, in the 1962 season the period from planting to flowering was influenced by the within-row, between-row and an interaction within x between row spacing (Table 15). Even though the means are statistically significant, the differences due to various spacing treatment are so small that they have little practical application. These observations are in agreement with the findings of the U.S. Regional Soybeans Laboratory and the Purdue University agricultural experiment station (25).

Protein Percentage in the Seed

The data reported in Tables 8 and 16 show that the protein content was influenced significantly by planting soybeans in different rows spaced at 25, 50 and 75 cm., but it was not affected by within-row plant spacings. The soybeans produced 37.38, 36.37 and 34.51 percent protein when grown in 50, 75 and 25 cm. rows, respectively. There were

Table 7a. Effect of between and within-row spacing on the number of days from planting to flowering of soybeans during 1961 at the University farm.

Variety	Within-row spacing in cm.	Between-row spacing in cm. 25(Q1)	50(Q2)	75(Q3)	Average of Variety
Grant (V1)	2	47.5	46.8	45.3	
	3	46.0	47.0	44.3	
	4	46.0	46.5	46.5	46.19
Hawkeye (V2)	2	50.3	50.5	50.0	
	3	50.5	50.5	50.0	
	4	50.0	50.3	49.8	50.19
Clark (V3)	2	59.3	60.3	55.8	
	3	56.5	52.8	59.5	
	4	60.3	54.3	52.8	56.81
Average		51.81	50.97	50.42	

	LSD (5%)	LSD(1%)
Variety	1.88	2.51

Variety	Clark	Hawkeye	Grant
Mean	56.81	50.19	46.19

Table 7b. Effect of between and within-row spacing on the number of days from planting to flowering of soybeans during 1962 at the University farm.

Variety	Within-row spacing in cm.	Between-row spacing in cm. 25(Q1)	50(Q2)	75(Q3)	Average of Variety
Grant (V1)	2(P1)	54.00	53.75	53.50	
	3(P2)	53.00	53.50	53.00	
	4(P3)	53.50	53.00	53.50	53.42
Hawkeye (V2)	2(P1)	58.75	59.00	58.25	
	3(P2)	59.00	58.75	57.00	
	4(P3)	57.75	57.50	58.00	58.22
Clark (V3)	2(P1)	70.00	69.25	70.00	
	3(P2)	70.00	67.75	67.00	
	4(P3)	68.25	68.75	68.00	68.78
Average		60.47	60.14	59.81	

	LSD(5%)	LSD(1%)
Within-row spacing	0.51	0.77
Between-row spacing	0.42	0.58
Variety	0.48	0.64
Within-row x between-row	0.73	1.00

Between-row spacing	25 cm.	50 cm.	75 cm.
Mean	60.47	60.14 /	59.81

Within-row spacing	3 cm.	4 cm.	2 cm.
Mean	59.89	59.81 /	60.72

Variety	Clark	Hawkeye	Grant
Mean	68.78	58.22	53.42

Within-row x Between-row:

P1Q1	P1Q2	P2Q1	P1Q3	P2Q2	P3Q1	P3Q3	P3Q2	P2Q3
60.92	60.67	60.67	60.58	60.00	59.83	59.83	59.75	59.00

/ denotes treatment means that did not differ significantly at the 5% level.

no significant differences in protein content between the 50 cm and the 75 cm. row spacings, but these differed significantly from the 25 cm. row spacing.

The analysis of variance reported in Table 16 did not reveal a statistical significant differences in protein percentage among the varieties, but the LSD figure shows that the both Clark and Grant varieties differed significantly from Hawkeye in protein percentage (Table 8).

Under the conditions of the present trial the protein content of the varieties are somewhat lower than what the varieties averaged in the United States (3, 23). The high oil percentage found in all of the three varieties might account for the low protein percentage (Table 9), as a negative association between the attributes (oil and protein) would be a reasonable expectation. A variety with high oil and high protein content would be virtually impossible.

Oil Percentage

The planting of soybeans in various row-widths and in different spacings within the rows, did not change the oil content of the three soybean varieties studied. The varieties varied significantly in their percentage of oil. The analysis revealed an oil percentage of 24.24, 23.56 and 22.33 for the varieties Hawkeye, Grant and Clark respectively.

Under the conditions of this experiment the oil per-

Table 8. Effect of between and within-row spacing on the percentage of protein of soybeans during 1961 at the University farm.

Variety	Within-row spacing in cm.	Between-row spacing in cm. 25(Q1)	50(Q2)	75(Q3)	Average of Variety
Grant (V1)	2	38.10	38.54	35.23	
	3	34.86	37.23	34.41	
	4	35.98	36.08	36.70	36.35
Haekeye (V2)	2	32.34	36.79	36.26	
	3	34.16	37.21	34.27	
	4	33.32	37.36	36.59	35.36
Clark (V3)	2	33.87	39.41	36.94	
	3	32.56	36.44	38.42	
	4	35.39	37.35	38.48	36.54
Average		34.51	37.38	36.37	

	LSD(5%)	LSD(1%)
Between-row spacing	1.08	1.48
Variety	0.94	1.24

Between-row spacing	50 cm.	75 cm.	25 cm.
Mean	37.38	36.37 /	34.51

Variety	Clark	Grant	Hawkeye
Mean	36.54	36.35	35.36

/ denotes treatment means that did not differ significantly at the 5% level.

centage in the three varieties were found to be fairly high, as these varieties averaged from 21.0 to 21.8 percent oil in United States (3, 23).

The mean maximum temperature during the pod forming stage is particularly important with regard to oil. Keirstead, according to Howell and Cartter (15), observed that an increase of one degree Fahrenheit in temperature during this period was associated with an increase in oil contents of 0.41 to 0.47 percent. Howell (17) demonstrated in a greenhouse experiment that plants exposed to a temperature of 85° F, during pod forming stage, for as short a period as one week, may produce seeds with oil content two to three points higher than plants kept at 70° F.

The temperature at the University farm in the Bekaa at the pod forming stage i.e., during the end of June to middle of July (maximum, from 81.0° F to 95.0° F; minimum, from 50.7° F to 66.0° F) was higher than the temperature that prevailed during the pre-pod forming stage, starting from the beginning of May to 7th of June (maximum 60.3° F to 92.3° F; minimum, 36.0° F to 66.6° F) and this temperature may account for increase in the oil content.

Germination of Seed

The use of viable seed is essential to reliable field experiment. It will be noted from Fig. 1 that the germination percentage of the soybean used in the experiment was high even though it varied in the two years. The

Table 9. Effect of between and within-row spacing on the oil percentage in soybeans during 1961 at the University farm.

Variety	Within-row spacing in cm.	Between-row spacing in cm. 25(Q1)	50(Q2)	75(Q3)	Average of Variety
Grant (V1)	2	23.55	23.95	23.73	
	3	23.93	23.55	23.38	
	4	23.25	23.43	23.28	23.56
Hawkeye (V2)	2	24.08	24.28	23.98	
	3	24.33	24.28	24.33	
	4	24.38	24.30	24.25	24.24
Clark (V3)	2	22.70	22.25	22.50	
	3	22.23	22.40	22.28	
	4	22.18	22.18	22.30	22.33
Average		23.40	23.40	23.33	

	LSD(5%)	LSD(1%)
Variety	0.19	0.26

Variety	Hawkeye	Grant	Clark
Mean	24.24	23.56	22.33

germination, both in laboratory and in field, in the 1962 season was higher than that in 1961. A possible explanation for the lower germination is the fact that there appeared a greater amount of seed coat injury in the 1961 seed. The seeds used for the 1962 planting were hand threshed and showed no seed coat injury or damage.

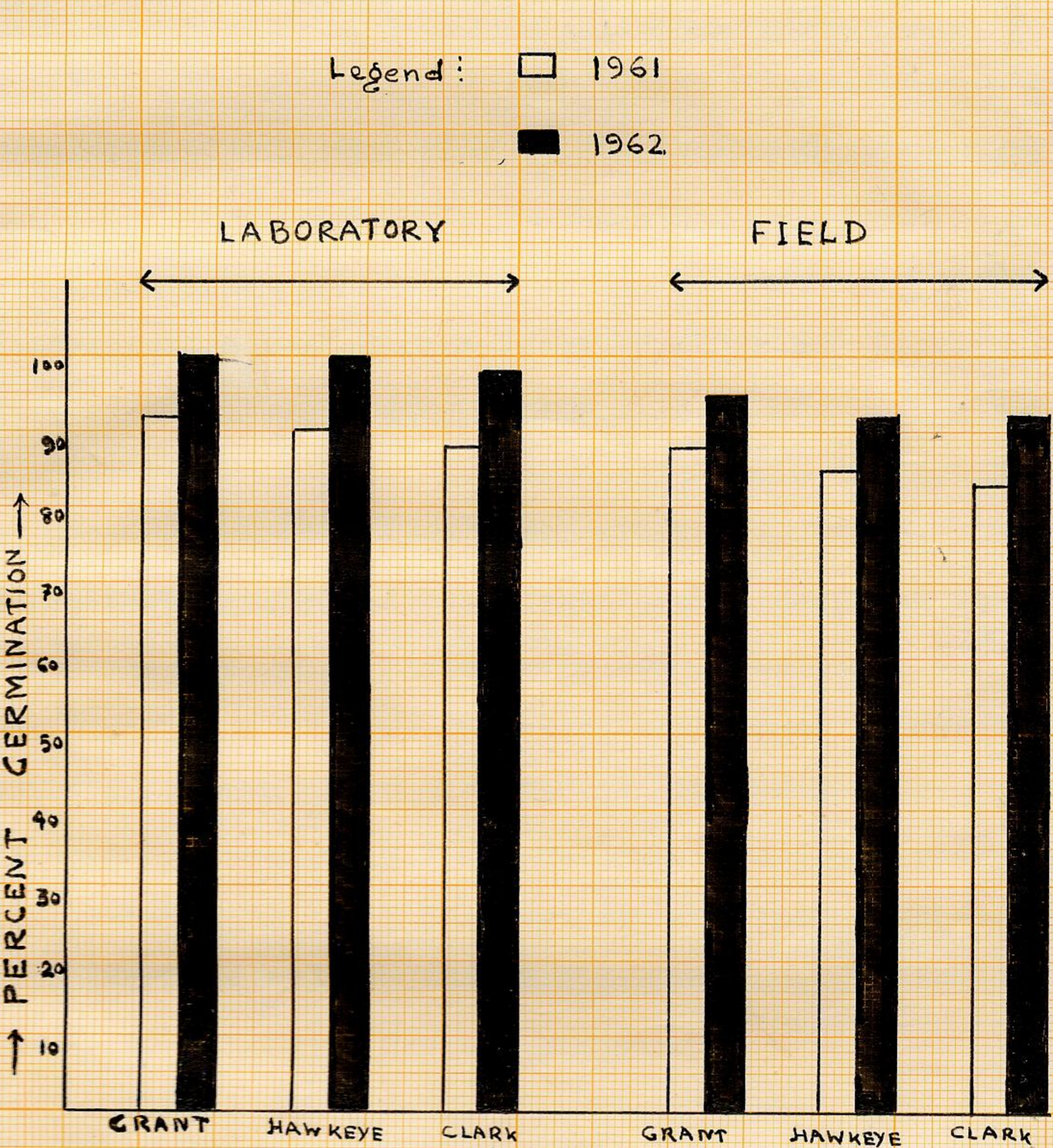

Fig. 1. Field and laboratory germination of three soybean varieties.

SUMMARY AND CONCLUSIONS

This study deals with the evaluation of the effect of three plant spacings within the rows, three row-width spacings, and three soybean varieties on the seed yield, 1000-kernel weight, total weight at maturity (stem, pod and seed), number of seeds per pod, plant height, number of days from planting to flowering, protein and oil percentage in the seed. The plants were spaced within the rows at 2, 3 and 4 cm. apart in rows 25, 50 and 75 cm., respectively. The varieties tested were Grant, Hawkeye and Clark.

The highest seed yields were obtained from soybeans planted in rows spaced 50 cm. apart, while the lowest yields were derived from those planted in 75 cm. rows. The variety Clark yielded the highest, when compared to Hawkeye and Grant. The seed yields were not affected by the different seeding rates i.e., planting soybean at different spacings within the row.

The seed weight was maximum when the soybean plants were grown under wide spacings of both within and between row. The size of the seed of Clark variety was found to be larger than that of Hawkeye and Grant.

The total weights at maturity were found to be the least at the wider row-spacing, while the highest yields were attained for the narrow row spacings of 25 cm. Among the three varieties tested, Hawkeye produced the highest and Grant produced the lowest total weight at maturity.

The number of seeds per pod was not affected significantly by planting soybeans in 2, 3 and 4 cm. apart in rows 25, 50 and 75 cm. Varieties were found to be different in the number of seeds per pod with Grant having the highest and Hawkeye having the lowest number.

The plant height of soybeans grown in 50 cm. and 75 cm. rows were significantly higher than those in 25 cm. rows. The plants of the variety Clark grew the tallest, while those of Grant were found to be the smallest.

During both of the years, 1961 and 1962, the variety Grant flowered earlier than the other two varieties. Only in the 1962 season variations in within and between row spacings influenced the flowering date. In this season, the varieties had a tendency to flower slightly earlier when the plants were spaced wider apart within and between rows.

The percentage of protein was significantly influenced by planting soybeans in different row-widths. Soybean planted in 50 cm. and 75 cm. rows gave higher protein percentage than soybean planted in 25 cm. rows. The variety Clark had the highest protein percentage, while Grant had the lowest protein content.

The different plant spacings of both within and between the rows, did not change the oil content of the three soybean varieties studied. On the other hand, the varieties differed significantly in their oil percentage with Hawkeye having the highest oil content followed by Grant and Clark.

The germination percentage of the soybean varieties, both in laboratory and in the field were higher in the 1962 season than in the 1961 season.

This study reveals that under the conditions prevailing during 1961 in the Bekaa, soybean grown in 50 cm. rows produced higher seed yields with the highest protein percentage, than those grown in 25 and 75 cm. row. However, further studies conducted for several years are needed to come to any definite conclusions.

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APPENDIX

Table 10. Analysis of variance for seed yield of soybeans

Source	D.F.	M.S.
Block	3	9739.32 /
Within-row spacing	2	708.47
Error (a)	6	1842.84
Between-row spacing	2	20161.34 //
Within-row x Between-row	4	2652.00
Error (b)	18	2278.19
Variety	2	240012.44 //
Within-row x Variety	4	1509.00
Between-row x Variety	4	6706.77 //
Within-row x Between-row x Variety	8	1307.62
Error (c)	54	1925.50

/ denotes F values significant at the 5% level.

// denote F values significant at the 1% level.

Table 11. Analysis of variance for 1000-kernel weight of soybeans

Source	D.F.	M.S.
Block	3	262.09
Within-row spacing	2	588.77 ++
Error (a)	6	81.85
Between-row spacing	2	7888.16 ++
Within-row x Between-row	4	10.45
Error (b)	18	124.86
Variety	2	47622.66 ++
Within-row x Variety	4	93.54
Between-row x Variety	4	281.50 +
Within-row x Between-row x Variety	8	129.11
Error (c)	54	71.24

6666

\+ denotes F values significant at the 5% level.

++ denote F values significant at the 1% level.

Table 12. Analysis of variance for total weight at maturity of soybeans.

Source	D.F.	M.S.
Block	3	581292.8
Within-row spacing	2	158542.0
Error (a)	6	128796.7
Between-row spacing	2	3870866.6 ++
Within-row x Between-row	4	83220.1
Error (b)	18	165281.6
Variety	2	8980387.8 ++
Within-row x Variety	4	21365.6
Between-row x Variety	4	347574.8 ++
Within-row x Between-row x Variety	8	27245.3
Error (c)	54	86843.5

\+ denotes F values significant at the 5% level.

++ denote F values significant at the 1% level.

Table 13. Analysis of variance for the number of seeds per pod of three varieties of soybeans.

Source	D.F.	M.S.
Block	3	0.10
Within-row spacing	2	0.0015
Error (a)	6	0.038
Between-row spacing	2	-----
Within-row x Between-row	4	0.055
Error (b)	18	0.03
Variety	2	2.88 ++
Within-row x Variety	4	0.38 ++
Between-row x Variety	4	0.02
Within-row x Between-row x Variety	8	0.02
Error (c)	54	0.028

++ denote F values significant at the 1% level.

Table 14. Analysis of variance for plant height of soybeans.

Source	D.F.	M.S.	
Block	3	338.3	
Within-row spacing	2	254.9	
Error (a)	6	127.1	
Between-row spacing	2	171.5	
Within-row x Between-row	4	48.3	
Error (b)	18	68.2	
Variety	2	9719.2	++
Within-row x Variety	4	134.8	+
Between-row x Variety	4	114.2	
Within-row x Between-row x Variety	8	26.6	
Error (c)	54	44.1	

\+ denotes F values significant at the 5% level.

++ denote F values significant at the 1% level.

Table 15. Analysis of variance for number of days from planting to flowering in soybeans.

Source	D.F.	M.S. 1961	M.S. 1962
Block	3	13.59	1.00
Within-row spacing	2	11.74	9.25 ++
Error (a)	6	10.61	0.78
Between-row spacing	2	17.61	4.00 +
Within-row x Between-row	4	11.53	2.43 +
Error (b)	18	14.07	0.72
Variety	2	1033.82 ++	2222.85 ++
Within-row x Variety	4	7.30	1.45
Between-row x Variety	4	10.70	1.00
Within-row x Between-row x Variety	8	20.80	1.69
Error (c)	54	15.89	1.02

\+ denotes F values significant at the 5% level.

++ denote F values significant at the 1% level.

Table 16. Analysis of variance for percentage of protein of soybeans.

Source	D.F.	M.S.
Block	3	20.22 /
Within-row spacing	2	4.07
Error (a)	6	3.02
Between-row spacing	2	71.25 //
Within-row x Between-row spacing	4	7.16
Error (b)	18	4.76
Variety	2	9.27
Within-row x Variety	4	8.60
Between-row x Variety	4	22.64
Within-row x Between-row x Variety	8	5.51
Error (c)	54	3.90

/ denotes F values significant at the 5% level.

// denote F values significant at the 1% level.

Table 17. Analysis of variance for percentage of oil in soybeans.

Source	D.F.	M.S.
Block	3	0.1
Within-row spacing	2	0.25
Error (a)	6	0.13
Between-row spacing	2	0.05
Within-row spacing	4	0.05
Error (b)	18	0.1
Variety	2	33.7 ++
Within-row x Variety	4	0.35
Between-row x Variety	4	0.075
Within-row x Between-row x Variety	8	0.15
Error (c)	54	0.17

++ denote F values significant at the 1% level.