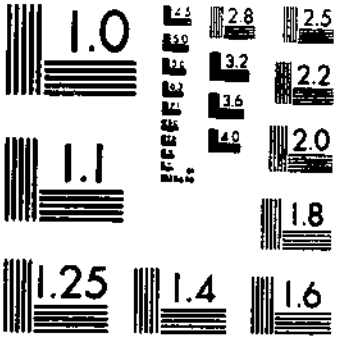
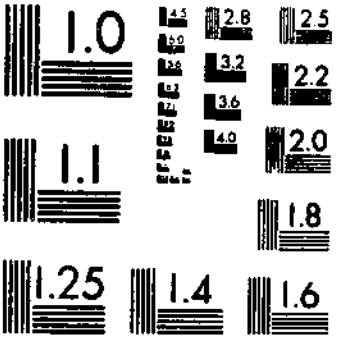
IB 1017 (1950) USDA TECHNICAL BULLETINS UPDATA
VARIABILITY OF AGRONOMIC AND SEED COMPOSITIONAL CHARACTERS IN SOYBEANS.
WEISS, M G. ET AL 1 OF 1

START



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Technical Bulletin No. 1017 • *September 1950*

UNITED STATES
DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

Variability of Agronomic and Seed Compositional Characters in Soybeans, as Influenced by Variety and Time of Planting[1,2]

By MARTIN G. WEISS, *principal agronomist*, C. R. WEBER, *agent*, L. F. WILLIAMS, and A. H. PROBST, *associate agronomists, Division of Forage Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration*[3]

United States Department of Agriculture, Bureau of Plant Industry, Soils, and Agricultural Engineering, in cooperation with the Iowa, Illinois, and Purdue Agricultural Experiment Stations

CONTENTS

INTRODUCTION

Varied dates of planting affect differentially the yielding ability of varieties in many species of plants. In soybeans differential responses are exhibited particularly by varieties that vary appreciably in date of maturity. Performance of varieties differing in earliness is important, not only for making recommendations to growers as to choice of variety but also in comparing and interpreting experimental data from plantings at several dates.

In view of the increase in accuracy of phenotypic determinations afforded by refinement of experimental plot techniques since 1935, and because of the increasing emphasis on composition of soybean seed, a comprehensive experiment was conducted to measure the effect of varied dates of planting on agronomic and seed compositional characters of soybean varieties that differ in earliness.

[1] Submitted for publication April 25, 1950.

[2] This work was performed under an allotment from the Special Research Fund authorized by Title 1 of the Bankhead-Jones Act of June 29, 1935.

[3] The experiments were conducted by the United States Regional Soybean Laboratory, Urbana, Ill., and the agronomy departments of the cooperating agricultural experiment stations. Test 1 was conducted as project 659 of the Iowa Agricultural Experiment Station, and this publication constitutes journal paper No. J-1605 from that station. The authors wish to express their appreciation to J. L. Cartter for his advice during the course of these investigations and to W. G. Cochran and Oscar Kempthorne for guidance in the statistical analyses and interpretation of results.

PREVIOUS INVESTIGATIONS

Varied dates of planting were recognized early by Garner and others (*6*)[4] as a means of altering conditions under which plants mature, thereby permitting a study of the factors affecting seed size and oil content of oil-bearing seed crops. Four varieties of soybeans that differed widely in earliness were planted in West Virginia throughout a 2-month period at intervals of 15 days. In general, the later the seed was planted the greater was the reduction in oil content in the beans harvested. The authors state this trend was not confirmed in other tests. No definite relationship between seed size and date of planting was established. In additional studies the authors found no correlation between seed size and oil content of beans taken from the same plants. They concluded that "heredity is a very important factor, not only with respect to the size and oil content of the seed but also as regards the extent to which these characters respond to change in environment."

The period from germination to blossoming of four varieties of soybeans, grown under summer daylight conditions at Washington, D. C., by Garner and Allard (*5*), ranged from 27 to 105 days. When the daylight was shortened to 12 hours, however, the varieties all became early-maturing and blossomed 21 to 28 days after germination. The blossoming time of the earliest variety was reduced only slightly by the shortened day length, whereas that of the later variety, Biloxi, was radically reduced.

Composition of beans of the Haberlandt variety planted at four different dates in one year and at six different dates the next year in South Africa was reported by Viljoen (*13*). Oil content decreased and protein content increased progressively as the planting date was delayed. Ash content decreased slightly with delayed planting.

Chemical composition of seed of 10 varieties of soybeans grown in 5 States for 5 successive years was studied by Carter and Hopper (*1*). Variance contributed by varieties was appreciably greater than that attributed to locations or years in seed size, protein percentage, oil percentage, and iodine number of oil. In each of the 4 characters varieties interacted with years to a greater extent than with locations.

Yields and maturity dates of several varieties of soybeans planted at different times in Mississippi were reported by Henson and Carr (*7*). Yields of beans from plots planted at several dates prior to early June did not differ significantly, whereas the yield from plantings in late June was appreciably reduced. Varieties matured differentially in relation to various planting dates. When planting was delayed from April 13 to June 4, the maturity of the earliest variety was retarded 26 days, whereas all plantings of a later variety matured within 2 days. A slight decrease in oil content of the beans from later plantings was observed.

Performance of five soybean varieties planted at 20-day intervals in southeastern Missouri was reported by Feaster (*4*). When planted April 20, the earliest and latest varieties in the experiment differed 52 days in date of maturity, whereas the difference in maturity date of the same varieties planted on July 10 was only 14 days. Varieties reacted differentially at the several dates of planting in yield, protein, oil content, and iodine number of oil in the beans. Maximum yields were obtained from late-maturing varieties when planted early, and somewhat later planting

[4] Italic numbers in parentheses refer to Literature Cited, p. 39.

dates gave maximum yields for the early-maturing varieties. Oil content of beans for each variety was highest at the date of planting giving maximum yields. In general, a slight decrease in oil content occurred at the latest dates of planting. Protein content tended to vary inversely with oil content, the lowest protein content occurring at the planting dates giving maximum yields. Iodine number of the oil increased with lateness of planting.

The effect of environment on the composition of flaxseed has been studied extensively. Only studies pertaining to variations induced by delayed planting will be reviewed. In an experiment by Johnson (*8*) oil content of seed of five varieties of flax was found to decrease slightly with delayed planting in one season, whereas in a second season no consistent differences were obtained. Iodine number of oil from one variety in a single season decreased slightly with delayed planting; no significant change resulted in a second variety. The study suggested differences in varietal response to delayed planting.

MATERIALS AND METHODS

The data reported were collected on two separate sets of field plantings, which will be designated as test 1 and test 2. Experimental results from the two tests will be presented simultaneously, as they involve a certain degree of duplication.

Test 1 consisted of five varieties—Richland, Mukden, Mandell, Illini, and Dunfield. Each variety was planted May 1, May 12, May 23, June 3, and June 14.

The 25 combinations of 5 varieties and 5 dates of planting were arranged in a 5 by 5 lattice square design with 3 replications. Five rates of planting were superimposed on this design in a split-plot arrangement, a subplot consisting of a single row 16 feet long and spaced 32 inches from the adjacent subplots. Data reported, however, pertain only to the median rate of planting (approximately 1.5 bushels per acre), the other 4 subplots being considered border rows. All agronomic measurements were made on individual plots, and all compositional determinations were made on representative portions of seed from single plots.

Test 2 consisted of variety × date-of-planting tests conducted uniformly during 1940, 1941, and 1942 at Ames, Iowa, Urbana, Ill., and La Fayette, Ind. Of the 5 varieties selected for test 2, 3 were the same as those used in test 1—Richland, Mukden, and Dunfield. 1 variety was appreciably earlier in maturity (Mandarin) and 1 later in maturity (Boone). The dates of planting were as nearly identical with those of test 1 as climatic conditions allowed. Single plots consisted of 3 rows, 16 feet long and 24 to 32 inches between rows. Data were collected on the center row only. Rate of planting was approximately 1 viable bean per linear inch of row. In each test the 25 treatment combinations were arranged in a 5 by 5 lattice square design with 3 replications.

As test 2 was conducted at widely scattered locations, a summary of pertinent climatological data at each location is presented (*10, 11, 12*). Geographical location and lateness of season, presented as first killing frost, for the three locations are given in table 1, and the monthly averages of mean daily temperatures for May through October are shown in table 2.

TABLE 1.—*Geographical location and lateness of season as indicated by date of killing frost for 3 locations, 1940–42*

Place	Approximate geographical location		First killing frost in autumn			
	Longitude	Latitude	1940	1941	1942	Average date[1]
Ames, Iowa	93°30′ W.	42°00′ N.	Nov. 7	Oct. 28	Sept. 24	Oct. 6
Urbana, Ill.	88°14′ W.	40°05′ N.	do	do	Sept. 28	Oct. 23
La Fayette, Ind.	86°51′ W.	40°26′ N.	Oct. 16	Oct. 29	do	Oct. 12

[1] Means for 62, 37, and 50 years for Iowa, Illinois, and Indiana, respectively.

TABLE 2.—*Monthly averages of mean daily temperatures for 3 locations, May to October, 1940–42*

Place and year	Monthly average temperature for—					
	May	June	July	August	September	October
Ames, Iowa:	°F.	°F.	°F.	°F.	°F.	°F.
1940	57.6	71.1	75.4	69.8	65.0	56.9
1941	65.9	69.3	74.0	74.2	65.2	54.0
1942	59.5	69.4	73.6	71.4	60.8	52.2
Average (62 years)	60.5	69.2	74.1	71.5	64.2	51.9
Urbana, Ill.:						
1940	58.5	72.6	76.0	74.8	66.0	60.0
1941	66.0	72.8	75.1	74.4	69.4	58.6
1942	62.4	71.6	76.3	72.6	65.0	55.8
Average (50 years)	61.5	70.6	75.6	73.3	66.7	54.8
La Fayette, Ind.:						
1940	60.2	73.6	77.0	76.4	66.8	60.6
1941	66.2	73.0	76.8	75.8	71.6	59.8
1942	63.8	72.8	77.0	73.6	65.2	57.2
Average (62 years)	61.8	70.9	75.6	73.4	67.0	55.0

All agronomic data were collected at the three locations in a manner as nearly identical as possible. Seed size, oil percentage, protein percentage, and iodine number of oil were determined by the United States Regional Soybean Industrial Products Laboratory[5] after all samples had been stored in a conditioning chamber (70° F. and 18 percent relative humidity) long enough to attain uniform moisture.

[5] Now known as the United States Regional Soybean Laboratory. Federal agencies cooperating in the former laboratory were the Bureau of Plant Industry and the Bureau of Agricultural Chemistry and Engineering. The research phases conducted by the latter Bureau were later transferred to the Northern Regional Research Laboratory.

Data were collected for each of the following: Maturity date, plant height, lodging score, seed yield, seed size, protein and oil percentages of seed, and iodine number of the oil. The methods used in collecting the data were as follows:

Maturity Date.—Number of days after August 1 when 90 to 100 percent of the pods had ripened, as evidenced by their dry appearance.

Height.—Distance in inches from the ground level to the highest point of the mature plants.

Lodging score.—Determined at maturity by assignment to each plot as follows:

1. All plants nearly erect.
2. All plants leaning slightly or a few plants lodged badly.
3. All plants leaning moderately or approximately 25 percent lodged badly.
4. All plants leaning more than 45° from vertical or more than 50 percent lodged badly.
5. All plants nearly prostrate.

Seed yield.—Air-dried, threshed plot weights converted to bushels per acre.

Seed size.—Weight of 100 seeds, in grams.

Chemical analyses.—Methods of chemical analysis employed by the United States Regional Soybean Industrial Products Laboratory were described by Cartter and Hopper (*1*). Oil content of the seed was determined as percentage of total lipids on a moisture-free basis. Protein content was determined by multiplying percentage of nitrogen by 6.25 and is reported on a moisture-free basis as percentage of crude protein. Iodine number of oil was calculated from the refractive index of the oil according to the equation developed by Majors and Milner (*9*).

Statistical treatment of data consisted of conducting an analysis of variance for each attribute of each experiment with and without recovery of interblock information. When a gain in precision accompanied removal of row and column effects, the analysis with recovery of interblock information was used. However, when no gain in precision resulted from removal of these effects, the randomized block analysis was used. The combined analysis for an attribute was made on treatment totals, which lacked adjustment in those experiments analyzed as randomized blocks but which were adjusted in those experiments in which interblock information was recovered. The correlation between variety-date means introduced by the lattice square method of estimation is sufficiently small to justify the analysis of these totals by ordinary methods. The estimate of experimental error was obtained by determining the mean error mean square of the individual experiments. In experiments in which interblock information was recovered, however, error mean squares were first weighted according to the efficiency factor of the particular experiment. Error degrees of freedom for the combined analyses were obtained by adding those of the separate experiments, an approximation which is deemed reasonable.

As an aid in interpretation of the analyses of variance, estimates of variance components were calculated according to the method described by Crump (*3*). In this procedure, the attribute is regarded as made up of

TABLE 3.—*Mean number of days to maturity after August 1 of 5 varieties of soybeans planted on 5 dates for 2 years (1939–40) at 1 location (test 1); and of 5 varieties planted on 5 dates for 3 years (1940–42) at 3 locations (test 2); and analyses of variance for locations*

MEAN NUMBER OF DAYS TO MATURITY

Location, year, and variety	Number of days to maturity (after Aug. 1) for variety planted—					Mean
	May 1	May 12	May 23	June 3	June 14	
Ames, Iowa (test 1, 1939–40):						
Richland	43.7	46.2	48.7	52.7	57.9	49.8
Mukden	46.9	49.3	52.6	55.3	57.7	52.4
Mandell	48.2	50.4	56.7	57.3	60.6	54.6
Illini	51.7	53.5	56.6	58.7	60.4	56.2
Dunfield	51.6	53.3	57.2	58.8	62.7	56.7
Mean	48.4	50.5	54.4	56.5	59.9	53.9
Ames, Iowa (test 2, 1940–42):						
Mandarin	34.0	35.6	38.7	50.3	53.3	42.4
Richland	47.3	48.7	53.4	60.4	64.6	54.9
Mukden	56.2	57.9	59.9	64.0	70.7	61.7
Dunfield	59.1	64.1	64.6	69.3	77.1	66.8
Boone	75.2	75.5	80.4	83.5	88.2	80.6
Mean	54.4	56.3	59.4	65.5	70.8	61.3
Urbana, Ill. (test 2, 1940–42):						
Mandarin	23.4	28.4	33.2	40.4	45.6	34.2
Richland	43.0	46.1	49.9	52.3	58.2	49.9
Mukden	43.6	46.4	49.3	52.9	59.2	50.3
Dunfield	49.4	51.0	53.8	58.1	61.9	54.8
Boone	65.4	67.0	69.1	73.7	78.0	70.6
Mean	45.0	47.8	51.0	55.5	60.6	52.0

La Fayette, Ind. (test 2, 1940–42):						
Mandarin	31.3	34.8	40.2	55.4	59.0	43.7
Richland	55.7	57.3	60.0	66.3	67.7	61.4
Mukden	54.8	61.0	62.1	67.2	69.5	62.9
Dunfield	65.6	67.9	68.9	70.3	71.8	68.9
Boone	78.0	81.5	86.3	88.6	94.2	85.7
Mean	57.1	60.5	63.5	69.2	72.4	64.5

ANALYSES OF VARIANCE FOR LOCATIONS

Source of variation	Test 1 Iowa			Test 2					
				Iowa		Illinois		Indiana	
	Degrees of freedom	Mean square	Variance component	Degrees of freedom	Mean square	Variance component	Mean square	Variance component	Mean square	Variance component
Varieties	4	242.98	7.17	4	9,008.36	190.46	7,654.83	167.35	10,282.45	225.24
Dates	4	631.84	19.15	4	2,062.11	41.61	1,727.82	34.90	1,761.44	35.45
Years	1	3,374.48	43.97	2	401.18	−2.56	163.17	−1.04	793.84	9.15
Varieties × dates	16	6.52	.38	16	31.04	.33	25.84	1.62	122.37	9.20
Varieties × years	4	25.77	1.43	8	434.56	27.10	109.48	6.55	63.71	1.61
Dates × years	4	55.11	3.39	8	186.56	10.57	142.71	8.76	83.46	2.92
Varieties × dates × years	16	4.27	.82	32	28.08	7.91	11.25	3.10	39.59	11.54
Error	72	1.82	1.82	[1]72	4.36	4.36	1.96	1.96	4.96	4.96
Coefficient of variation (percent)		2.5			3.4		2.7		3.5	

[1] 120 degrees of freedom for Iowa.

contributions from variety, location, year, and so on, and the variance of each contribution is estimated. The method depends on the assumption that variety, location, and year, for example, are randomly chosen members of populations. Without such an assumption general conclusions cannot be drawn. The components of variance measure the relative importance of each possible contribution.

AGRONOMIC RESPONSES

Maturity Date

Varieties in test 1 did not differ greatly in date of maturity. As many characters appear to be associated with earliness of soybean varieties, the varieties in test 2 were chosen to represent the maximum range in genetic maturity that could be utilized commercially in Iowa, Illinois, or Indiana. To facilitate comparisons as to earliness of the varieties in the two tests, mean maturity dates at five dates of planting for tests 1 and 2 at Ames in 1940 are presented. Maturity dates of the two tests are reasonably comparable for the tests, though conducted separately. The varieties were grown in adjacent areas and planted on the same dates.

TEST 1		TEST 2	
Variety:	Maturity date *Mean for 5 plantings*	Variety:	Maturity date *Mean for 5 plantings*
Richland	Sept. 23	Mandarin	Sept. 15
Mukden	Sept. 25	Richland	Sept. 24
Mandell	Sept. 29	Mukden	Sept. 26
Illini	Oct. 1	Dunfield	Sept. 30
Dunfield	Sept. 30	Boone	Oct. 15

Varieties are listed in order of earliness, with the exception of Illini and Dunfield in test 1. Although Illini matured 1 day later than Dunfield in 1940, mean date of maturity of Dunfield for 3 years was slightly later than that of Illini. In test 1 the range of maturity dates of the varieties was 8 days; in test 2 it was 30 days.

Mean number of days to maturity after August 1 for each location of tests 1 and 2 and analyses of variance for locations appear in table 3. Mean number of days to maturity after August 1 for all years and locations of test 2 and analysis of variance appear in table 4.

Delayed dates of planting resulted in progressively later dates of maturity. The mean delay in maturity of the varieties in test 2 at the three locations was consistent; a total delay of 44 days in planting resulted in retarding maturity approximately 16 days at each location. Magnitude of delay in ripening varied in different years. A delay of 44 days in planting retarded maturity 9.3 days in 1940, 18.5 days in 1941, and 19.6 days in 1942. These observations are confirmed in the combined analysis of variance (table 4), as variance attributable to dates × years is of appreciable magnitude, whereas that variance contributed by dates × locations is negligible. Furthermore, at all locations (table 3) components of variance attributable to dates × years interactions were appreciable.

TABLE 4.—*Mean number of days to maturity after August 1 and analysis of variance of 5 varieties of soybeans planted on 5 dates at 3 locations for 3 years (1940–42) (test 2)*

MEAN NUMBER OF DAYS TO MATURITY

Variety	Number of days to maturity (after Aug. 1) for variety planted—					Mean
	May 1	May 12	May 23	June 3	June 14	
Mandarin	29.57	32.90	37.37	48.00	52.61	40.09
Richland	48.66	50.70	54.41	59.68	63.52	55.39
Mukden	51.56	55.12	57.10	61.36	66.47	58.32
Dunfield	58.06	61.01	62.41	65.89	70.24	63.52
Boone	70.85	74.68	78.61	81.95	86.77	78.97
Mean	52.14	54.88	57.98	63.37	67.92	59.26

ANALYSIS OF VARIANCE

Source of variation	Degrees of freedom	Mean square	Variance component
Varieties	4	26,066.53	195.68
Dates	4	5,516.55	39.01
Years	2	145.61	−2.77
Locations	2	9,573.26	40.44
Varieties × dates	16	120.35	3.30
Varieties × years	8	216.40	.42
Varieties × locations	8	139.55	−1.33
Dates × years	8	233.30	3.15
Dates × locations	8	17.41	−1.69
Years × locations	4	606.29	4.62
Varieties × dates × years	32	27.47	.19
Varieties × dates × locations	32	29.45	.41
Varieties × years × locations	16	195.67	11.33
Dates × years × locations	16	89.71	4.27
Varieties × dates × years × locations	64	25.73	7.32
Error	264	3.76	3.76

In test 2, varieties responded differentially to dates of planting with respect to time of ripening. Although the varietal differential response was consistent among years and among locations, as indicated by low variance components attributable to varieties × dates × years and varieties × dates × locations (table 4), it was of low magnitude when compared with variance contributed by differences among varieties. Delayed date of planting tended to retard maturity of the earliest variety more than that of the latest variety. Means for all locations and all years (table 4) reveal that a delay of 44 days in planting caused the maturity of Mandarin, the earliest variety, to be retarded 23 days; maturity of Dunfield and Boone, the latest varieties, was retarded 12 and 16 days, respectively. Frost hastened ripening of Boone planted at the late date at certain locations, but Dunfield, in general, matured normally.

TABLE 5.—*Mean lodging scores*[1] *for 5 varieties of soybeans planted on 5 dates for 2 years (1939–40) at 1 location (test 1) and 5 varieties planted on 5 dates for 3 years (1940–42) at 3 locations (test 2), and analyses of variance for locations*

MEAN LODGING SCORES

Location, year, and variety	Lodging score for variety planted—					Mean
	May 1	May 12	May 23	June 3	June 14	
Ames, Iowa (test 1, 1939–40):						
Richland	1.6	1.8	1.3	1.6	2.0	1.7
Mukden	2.8	2.8	2.5	2.8	2.8	2.7
Mandell	3.0	2.9	3.2	3.7	3.7	3.3
Illini	3.5	3.8	3.8	4.5	4.7	4.0
Dunfield	3.3	3.3	3.8	4.0	3.9	3.7
Mean	2.9	2.9	2.9	3.3	3.4	3.1
Ames, Iowa (test 2, 1940–42):						
Mandarin	1.9	2.3	2.7	2.2	2.6	2.3
Richland	1.6	1.9	1.7	1.9	2.0	1.8
Mukden	3.1	3.1	2.6	2.3	2.7	2.8
Dunfield	3.6	3.4	3.2	3.6	4.1	3.6
Boone	3.4	3.7	3.8	3.7	4.6	3.8
Mean	2.7	2.9	2.8	2.7	3.2	2.9
Urbana, Ill. (test 2, 1940–42):						
Mandarin	1.8	2.1	1.6	1.7	2.0	1.8
Richland	1.2	1.3	1.1	1.1	1.2	1.2
Mukden	2.3	2.4	2.0	2.1	2.1	2.2
Dunfield	2.2	2.4	2.6	3.1	3.1	2.7
Boone	2.8	3.4	3.4	3.8	3.6	3.4
Mean	2.1	2.4	2.1	2.4	2.4	2.3

La Fayette, Ind. (test 2, 1940–42):						
Mandarin	1.0	1.4	1.2	1.3	1.7	1.3
Richland	1.3	1.6	1.1	1.3	1.1	1.3
Mukden	2.1	2.0	2.3	1.7	2.1	2.0
Dunfield	2.2	2.3	2.3	2.1	2.6	2.3
Boone	2.9	2.9	3.0	2.3	2.1	2.6
Mean	1.9	2.0	2.0	1.8	1.9	1.9

ANALYSES OF VARIANCE FOR LOCATIONS

Source of variation	Test 1—Iowa			Test 2						
					Iowa		Illinois		Indiana	
	Degrees of freedom	Mean square	Variance component	Degrees of freedom	Mean square	Variance component	Mean square	Variance component	Mean square	Variance component
Varieties	4	26.02	0.799	4	32.10	0.697	31.53	0.585	16.15	0.330
Dates	4	2.06	.020	4	1.65	−.040	1.03	−.004	.55	−.011
Years	1	9.57	.088	2	1.23	−.029	30.27	.329	13.96	.165
Varieties × dates	16	.41	.026	16	.79	.004	.64	.020	.63	.014
Varieties × years	4	1.88	.108	8	.71	−.003	5.03	.305	1.18	.045
Dates × years	4	1.31	.070	8	3.43	.178	1.04	.039	.92	.028
Varieties × dates × years	16	.253	.018	32	.756	.180	.459	.063	.506	.113
Error	72	.199	.199	[2] 120	.217	.217	.270	.270	.168	1.68
Coefficient of variation (percent)		14.5			16.3		23.0		21.4	

[1] Lodging scores from 1 (erect) to 5 (prostrate); see p. 12.
[2] 96 degrees of freedom for Iowa.

Lodging

Mean lodging scores for each location of tests 1 and 2 and analyses of variance for locations appear in table 5. Mean lodging scores for all locations and years of test 2 and analysis of variance appear in table 6. A considerable range in lodging was exhibited by the varieties grown in both tests. In general, lodging increased with genetic lateness of variety. Association of lateness with degree of lodging among soybean genotypes was noted by Weiss and coworkers (*14*). Among 248 F_3 and 127 F_4 lines derived from 17 crosses and tested in different years, correlations of date of maturity with degree of lodging were +0.68 and +0.65, respectively. In the present study an exception to this association was found in the varieties Mandarin and Richland of test 2. Although Mandarin matured earlier than Richland, it exhibited a higher degree of lodging in most tests. The exceptional lodging resistance of Richland has, however, been demonstrated over a period of years in many varietal tests.

TABLE 6.—*Mean lodging scores and analysis of variance of 5 varieties of soybeans planted on 5 dates at 8 locations for 3 years (1940–42) (test 2)*

MEAN LODGING SCORES

Variety	Lodging score for variety planted					Mean
	May 1	May 12	May 23	June 3	June 14	
Mandarin	1.6	2.0	1.8	1.7	2.1	1.8
Richland	1.4	1.6	1.3	1.4	1.4	1.4
Mukden	2.5	2.5	2.3	2.0	2.3	2.3
Dunfield	2.7	2.7	2.7	2.9	3.3	2.9
Boone	3.0	3.3	3.4	3.3	3.4	3.3
Mean	2.2	2.4	2.3	2.3	2.5	2.3

ANALYSIS OF VARIANCE

Source of variation	Degrees of freedom	Mean square	Variance component
Varieties	4	76.24	0.535
Dates	4	1.66	−.011
Years	2	17.87	−.003
Locations	2	50.25	.162
Varieties × dates	16	.77	−.007
Varieties × years	8	3.93	.047
Varieties × locations	8	1.76	.002
Dates × years	8	3.49	.050
Dates × locations	8	.79	.007
Years × locations	4	13.79	.158
Varieties × dates × years	32	.78	.034
Varieties × dates × locations	32	.64	.019
Varieties × years × locations	16	1.49	.068
Dates × years × locations	16	.95	.032
Varieties × dates × years × locations	64	4.72	.083
Error	336	.219	.219

Date of planting had no appreciable effect on the degree of lodging of any of the varieties in any of the tests.

Lodging was affected to a greater degree by seasonal variation than by the widely scattered locations in test 2. However, lodging at the locations was not consistent among years, as indicated by the appreciable variance component attributable to years × locations in table 4. The means constituting this interaction were as follows:

Location:	1940	1941	1942
Iowa	2.0	2.7	3.0
Illinois	2.0	3.0	1.8
Indiana	1.4	2.3	2.1

Lodging in Iowa was consistently severe; at the other two locations the season of 1941 was conducive to heavier lodging than the seasons of 1940 and 1942. The consistently higher degree of lodging at the Iowa location has been substantiated by other tests grown uniformly in the three States.

Height

Mean plant heights for each location of tests 1 and 2 and analyses of variance for locations appear in table 7. Mean heights for all locations and years of test 2 and analysis of variance appear in table 8.

Moderate differences in height resulted from varied dates of planting. Although the variance attributable to dates was not large, definite trends were established. Maximum height was attained at the second date of planting (May 12) and diminished successively at later dates. This trend was fairly consistent throughout the locations and years of these tests. Interaction of varieties with dates of planting was appreciable only in test 2 in Iowa. At this location, Mandarin, the earliest variety, exhibited linear increase in height with lateness in planting. In no trial was the height of early varieties reduced as greatly as that of late varieties at the later dates of planting.

Varieties of both tests varied in height. As previously mentioned, varieties are listed in order of earliness in tables 7 and 8, and, with exception of the variety Dunfield in both tests, height varied directly with lateness of varieties. Correlations obtained by Weiss and coworkers (*14*) between maturity date and height in 248 F_3 and 127 F_4 lines of soybeans were +0.55 and +0.58, respectively.

Seed Yield

Mean seed yields for each location of tests 1 and 2 and analyses of variance for locations appear in table 9. Mean yields for all locations and years of test 2 and analysis of variance appear in table 10.

A study of trends of seed yield can possibly best be initiated in table 10. Variety means in test 2 for three locations and 3 years indicated that for all dates of planting, the earliest variety, Mandarin, and the latest, Boone, were lower in yield than the varieties intermediate in earliness. Varieties that utilized the major part of the growing season but did not incur frost damage tended to give maximum yields. Mean yields for all varieties at the first three dates of planting did not vary greatly. Yields at the last two dates were progressively lower. The performance of individual varieties with respect to date of planting, however, was dissimilar. The yield of Mandarin, the earliest variety, varied only slightly at the various dates of planting, whereas the yield of Boone, the latest variety, de-

TABLE 7.—*Mean heights of 5 varieties of soybeans planted on 5 dates for 2 years (1939–40) at 1 location (test 1) and 5 varieties planted on 5 dates for 3 years (1940–42)*[1] *at 3 locations (test 2), and analyses of variance for locations*

MEAN PLANT HEIGHTS

Location, year, and variety	Plant height for variety planted—					Mean
	May 1	May 12	May 23	June 3	June 14	
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Ames, Iowa (test 1, 1939–40):						
Richland	31.6	32.5	31.0	31.2	30.3	**31.3**
Mukden	37.3	38.6	36.6	37.9	34.2	**36.9**
Mandell	38.6	39.1	38.6	36.4	35.0	**37.6**
Illini	39.6	39.9	40.5	38.2	36.5	**39.0**
Dunfield	37.2	38.7	37.4	35.8	34.9	**36.8**
Mean	36.9	37.8	36.8	35.9	34.2	**36.3**
Ames, Iowa (test 2, 1940–42):						
Mandarin	25.7	26.9	29.2	30.4	32.2	**28.9**
Richland	33.6	33.9	33.7	31.9	29.1	**32.4**
Mukden	40.7	43.0	40.6	39.1	36.1	**39.9**
Dunfield	40.7	40.6	40.0	38.1	34.7	**38.8**
Boone	42.7	43.1	41.4	40.4	41.4	**41.8**
Mean	36.7	37.5	37.0	36.0	34.7	**36.4**
Urbana, Ill. (test 2, 1940–41):						
Mandarin	28.8	28.7	30.2	29.2	26.7	**28.7**
Richland	30.3	30.3	30.2	28.2	26.3	**29.1**
Mukden	36.0	38.2	36.7	33.3	30.8	**35.0**
Dunfield	36.0	36.5	35.7	33.5	30.8	**34.5**
Boone	40.3	41.8	41.8	40.5	39.7	**40.8**
Mean	34.3	35.1	34.9	32.9	30.9	**33.6**

La Fayette, Ind. (test 2, 1940–42):						
Mandarin	27.9	28.2	29.1	29.7	27.7	28.5
Richland	30.3	32.0	31.2	29.7	27.8	30.2
Mukden	39.4	40.3	39.4	35.8	34.6	37.9
Dunfield	37.2	38.7	38.1	33.3	32.1	35.9
Boone	46.6	47.1	45.3	43.4	41.1	44.7
Mean	36.3	37.3	36.6	34.4	32.6	35.4

ANALYSES OF VARIANCE FOR LOCATIONS

Source of variation	Test 1—Iowa			Test 2					
				Degrees of freedom	Iowa		Illinois[1]		Indiana	
	Degrees of freedom	Mean square	Variance component		Mean square	Variance component	Mean square	Variance component	Mean square	Variance component
Varieties	4	255.52	8.14	4	1,345.12	28.66	747.38	24.81	1,886.95	41.32
Dates	4	55.11	1.66	4	51.59	.05	92.58	3.07	162.58	3.02
Years	1	526.40	6.85	2	581.00	7.40	1,555.26	20.69	2,216.61	29.01
Varieties × dates	16	3.20	.08	16	43.35	3.93	6.46	−1.05	15.08	−.17
Varieties × years	4	10.86	.54	8	19.99	.80	9.41	−.22	29.06	.83
Dates × years	4	4.77	.14	8	14.12	.41	6.71	−.40	28.35	.78
Varieties × dates × years	16	2.71	−.46	32	7.99	1.52	12.78	3.60	16.60	4.81
Error	48	4.08	4.08	72	3.44	3.44	1.97	1.97	2.17	2.17
Coefficient of variation (percent)		5.6			5.1		4.2		4.2	

[1] For Illinois (test 2), 1940 and 1941 only.

TABLE 8.—*Mean heights and analysis of variance of 5 varieties of soybeans planted on 5 dates at 3 locations for 3 years (1940–42)*[1] *(test 2)*

MEAN PLANT HEIGHTS

Variety	Plant height for variety planted—					Mean
	May 1	May 12	May 23	June 3	June 14	
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Mandarin	27.3	27.8	29.4	29.8	29.1	28.7
Richland	31.5	32.3	31.9	30.1	27.9	30.7
Mukden	39.0	40.8	39.2	36.4	34.2	37.9
Dunfield	38.2	38.8	38.2	35.2	32.8	36.6
Boone	43.5	44.3	43.0	41.6	40.9	42.7
Mean	35.9	36.8	36.3	34.6	33.0	35.4

ANALYSIS OF VARIANCE

Source of variation	Degrees of freedom	Mean square
Varieties	4	3,812.11
Dates	4	287.68
Years	2	2,383.73
Locations	2	341.16
Varieties × dates	16	47.23
Varieties × years	8	50.44
Varieties × locations	8	83.67
Dates × years	8	10.59
Dates × locations	8	9.53
Years × locations	3	794.33
Varieties × dates × years	32	9.01
Varieties × dates × locations	32	8.83
Varieties × years × locations	12	2.21
Dates × years × locations	12	23.49
Varieties × dates × years × locations	48	14.64
Error	192	2.60

[1] For Illinois (test 2), 1940 and 1941 only.

creased appreciably with delayed planting. The sharp decrease in yield of this late variety when planted at the two latest dates was partially attributable to occasional frost damage. The magnitude of decrease in yield with delayed planting for the varieties intermediate in earliness was indirectly proportional to earliness of variety.

Mean seed yields summarized by location in table 9 indicated similar trends with respect to differential response of the varieties differing in earliness. Among locations, the variance attributable to varieties × dates relative to error variance was lowest in Illinois, the most southern location. The low interaction in Illinois was undoubtedly influenced by the relatively high yield of Boone at the latest planting dates. In test 1, although the varieties did not differ so greatly in earliness, the yield of

the earliest variety, Richland, was not reduced as greatly at the last two dates of planting as was the yield of Illini or Dunfield, the latest varieties.

A relatively large variance attributable to the interaction of date of planting effects with years in test 2 (table 10) is of interest. The means for years contributing to this interaction are shown in table 9, each value consisting of the mean of five varieties replicated three times at three locations.

In 1940, considering all varieties and all locations, mean yields were unaffected by date of planting. In 1941 decreases accompanied lateness in planting; in 1942 this trend was more pronounced. Variation introduced by seasonal variations of planting date effects was greater than that contributed by over-all differences in planting dates.

The high variance attributable to varieties × years × locations interaction may be of interest. Returning to the analyses of variance by location in table 9, it may be seen that a considerable portion of this variance was contributed by the high varieties × years interaction at the Iowa location (table 11).

The means by years indicated that the varieties responded much differently in the 1942 season than in the 2 previous years. In 1942, mean yields of early varieties, considering all dates of planting, exceeded those of the 2 previous years: on the contrary, the yield of Boone, the latest variety, was the lowest of the 3 seasons. Seasonal interaction seemed logical, in that killing frosts during the seasons of 1940 and 1941 occurred 32 and 22 days later, respectively, than the long-time average. Therefore, these seasons were favorable for the development of relatively late varieties, even at delayed plantings. Killing frost occurred 12 days earlier than the long-time average in 1942, thereby reducing yields of the relatively late varieties when planted at delayed dates. As a consequence, when all dates of planting were pooled for 1942, the varieties yielded more nearly in order of earliness.

Seed Size

Mean seed sizes, expressed in grams per 100 seeds, for each location of tests 1 and 2 and analyses of variance for locations appear in table 12. Mean seed sizes for all locations and years of test 2 and analysis of variance appear in table 13.

Varieties differed in seed size in both tests. However, varietal differences were not consistent for locations (test 2) or years. The interaction of varieties with locations was largely attributable to relatively larger mean seed sizes of early varieties and smaller mean seed sizes of late varieties when grown at the Iowa location. As a consequence, when grown in Iowa, earliness of varieties seemed correlated with large seed size. This association was not evident, however, at either of the other two locations. Variance attributable to varieties × years was also of appreciable magnitude, but no consistent trend was established by differential seed size of the varieties in different years. Furthermore, in test 2 the differential response of varieties to years was not consistent at the three locations, as evidenced by the magnitude of the variance attributable to varieties × years × locations.

TABLE 9.—*Mean seed yields per acre of 5 varieties of soybeans planted on 5 dates for 2 years (1939–40) at 1 location (test 1) and 5 varieties planted on 5 dates for 3 years (1940–42) at 3 locations (test 2), and analyses of variance for locations*

MEAN SEED YIELDS

Location, year, and variety	Yield for variety planted—					Mean
	May 1	May 12	May 23	June 3	June 14	
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
Ames, Iowa (test 1, 1939–40):						
Richland	23.1	25.8	27.5	25.6	24.7	25.4
Mukden	23.7	25.8	25.1	25.5	20.8	24.2
Mandell	25.4	26.2	26.8	21.7	22.4	24.5
Illini	27.2	28.9	25.2	23.5	19.9	24.9
Dunfield	26.4	27.4	28.3	22.5	18.7	24.6
Mean	25.2	26.8	26.6	23.8	21.3	24.7
Ames, Iowa (test 2, 1940–42):						
Mandarin	22.5	24.6	25.0	23.7	25.1	24.2
Richland	30.5	30.6	32.2	26.8	23.2	28.7
Mukden	33.6	32.4	31.6	26.2	21.5	29.1
Dunfield	34.3	31.7	32.7	26.5	22.0	29.4
Boone	24.5	21.4	20.7	16.0	11.3	18.8
Mean	29.1	28.1	28.4	23.8	20.6	26.0
Urbana, Ill. (test 2, 1940–42):						
Mandarin	30.1	30.5	28.6	31.2	28.3	29.7
Richland	35.7	34.4	34.1	34.7	35.3	34.9
Mukden	35.4	35.9	30.6	35.3	32.7	34.0
Dunfield	35.9	33.9	35.0	33.7	33.3	34.4
Boone	35.6	32.7	32.7	28.5	24.6	30.8
Mean	34.5	33.5	32.2	32.7	30.8	32.7

La Fayette, Ind. (test 2, 1940–42):						
Mandarin	23.9	24.7	25.1	24.7	24.7	24.6
Richland	30.5	29.4	30.6	30.0	28.3	29.8
Mukden	33.4	33.3	33.4	32.7	30.3	32.6
Dunfield	30.7	33.7	30.1	29.3	27.5	30.3
Boone	30.8	30.0	27.0	22.0	20.1	26.0
Mean	29.8	30.2	29.3	27.7	26.2	28.6
Means for years (test 2):						
1940	25.5	25.5	25.6	25.6	25.0	25.4
1941	30.0	29.9	28.9	28.0	25.7	28.5
1942	38.1	36.3	35.5	30.6	27.0	33.5

ANALYSES OF VARIANCE FOR LOCATIONS

Source of variation	Test 1—Iowa			Test 2					
					Iowa		Illinois		Indiana	
	Degrees of freedom	Mean square	Variance component	Degrees of freedom	Mean square	Variance component	Mean square	Variance component	Mean square	Variance component
Varieties	4	8.26	−1.14	4	939.85	11.25	239.66	4.20	483.08	8.22
Dates	4	155.85	4.26	4	600.45	10.47	86.37	−.79	125.75	.28
Years	1	3,411.98	45.03	2	579.69	1.58	1,592.31	19.72	1,927.80	23.47
Varieties × dates	16	20.83	2.50	16	58.31	4.80	38.32	1.88	37.79	2.30
Varieties × years	4	27.41	1.44	8	390.41	25.02	29.53	.54	92.45	5.02
Dates × years	4	12.91	.47	8	86.01	4.73	105.15	5.58	92.57	5.03
Varieties × dates × years	16	5.82	.15	32	15.11	3.24	21.40	4.06	17.11	4.01
Error	72	5.37	5.37	[1]96	5.40	5.40	9.22	9.22	5.07	5.07
Coefficient of variation (percent)		9.4			8.9		9.3		7.9	

[1] 72 degrees of freedom for Indiana.

TABLE 10.—*Mean seed yields per acre and analysis of variance of 5 varieties of soybeans planted on 5 dates at 3 locations for 3 years (1940–42) (test 2)*

MEAN SEED YIELDS

Variety	Yield for variety planted—					Mean
	May 1	May 12	May 23	June 3	June 14	
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
Mandarin	25.5	26.6	26.2	26.5	26.1	26.2
Richland	32.2	31.5	32.3	30.5	29.0	31.1
Mukden	34.1	33.9	31.9	31.4	28.2	31.9
Dunfield	33.6	35.1	32.6	29.8	27.6	31.3
Boone	30.3	28.0	26.8	22.2	18.7	25.2
Mean	31.2	30.6	30.0	28.1	25.9	29.1

ANALYSIS OF VARIANCE

Source of variation	Degrees of freedom	Mean square	Variance component
Varieties	4	1,368.30	7.98
Dates	4	627.36	2.04
Years	2	3,726.49	14.52
Locations	2	2,580.55	10.37
Varieties × dates	16	89.67	2.30
Varieties × years	8	225.08	1.69
Varieties × locations	8	147.14	−.06
Dates × years	8	226.18	4.27
Dates × locations	8	92.60	1.28
Years × locations	4	186.65	.40
Varieties × dates × years	32	21.39	.59
Varieties × dates × locations	32	22.37	.69
Varieties × years × locations	16	143.66	8.50
Dates × years × locations	16	28.77	.84
Varieties × dates × years × locations	64	16.12	3.18
Error	264	6.57	6.57

In general, delayed planting resulted in decreased seed size in test 1. In test 2, time of planting had little effect on seed size. However, in test 1 and at all locations of test 2 seed size of varieties was affected differentially by time of planting. The differential performance of varieties

was largely attributable to the failure of early varieties to be affected as much by delayed planting as the later varieties. In test 1, seasonal effects on the seed size of the variety Richland were pronounced (table 14). Delayed planting caused progressive decreases in seed size in 1939; it caused progressive increases in 1940. No explanation is proposed for this inconsistency. In test 2, seed-size variation attributable to locations and years was slight.

TABLE 11.—*Mean seed yields per acre of 5 varieties of soybeans planted on 5 dates with 3 replications at Ames, Iowa, 1940–42*

Variety	Year			Mean
	1940	1941	1942	
	Bushels	*Bushels*	*Bushels*	*Bushels*
Mandarin	18.9	19.5	34.2	24.2
Richland	25.8	26.2	34.0	28.7
Mukden	25.3	29.8	32.1	29.1
Dunfield	26.0	31.7	30.5	29.4
Boone	20.1	23.1	13.2	18.8

SEED COMPOSITIONAL RESPONSES

PROTEIN CONTENT

Mean protein content for each location of tests 1 and 2 and analyses of variance for locations appear in table 15. Mean protein content for all locations and years of test 2 and analysis of variance appear in table 16.

Varieties in both tests differed in protein content. Remarkably low variances attributable to dates of planting and the varieties by dates interaction in all tests indicated a virtually complete absence of effect on protein content of single varieties or groups of varieties by date of planting. Protein content varied with years and with locations.

OIL CONTENT

Mean oil content for each location of tests 1 and 2 and analyses of variance for locations appear in table 17. Mean oil content for all locations and years of test 2 and analysis of variance appear in table 18.

TABLE 12.—*Mean seed sizes per 100 seeds of 5 varieties of soybeans planted on 5 dates for 2 years (1939–40) at 1 location (test 1) and 5 varieties planted on 5 dates for 3 years (1940–42) at 3 locations (test 2), and analyses of variance for locations*

MEAN SEED SIZES

Location, year, and variety	Seed size for variety planted—					Mean
	May 1	May 12	May 23	June 3	June 14	
	Grams	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*
Ames, Iowa (test 1, 1939–40):						
Richland	16.69	16.65	16.27	16.39	16.03	16.40
Mukden	16.01	15.37	14.99	13.88	12.91	14.63
Mandell	16.06	16.38	15.94	14.59	13.88	15.37
Illini	15.29	14.49	13.71	12.29	11.08	13.37
Dunfield	16.53	15.78	14.79	13.04	12.13	14.45
Mean	16.12	15.73	15.14	14.04	13.20	14.84
Ames, Iowa (test 2, 1940–42):						
Mandarin	17.02	16.48	15.47	16.29	16.66	16.38
Richland	15.13	15.34	15.90	16.71	16.29	15.87
Mukden	15.61	15.67	15.18	14.82	13.99	15.05
Dunfield	16.12	15.96	15.61	14.27	13.56	15.10
Boone	12.43	12.46	11.84	10.41	9.31	11.29
Mean	15.26	15.18	14.80	14.50	13.96	14.74
Urbana, Ill. (test 2, 1940–42):						
Mandarin	15.58	15.78	15.76	15.36	16.38	15.77
Richland	15.32	16.13	16.21	16.87	17.66	16.44
Mukden	15.22	15.13	15.38	15.99	16.34	15.61
Dunfield	16.26	16.48	16.90	16.82	15.63	16.42
Boone	15.06	14.42	13.82	12.74	11.51	13.51
Mean	15.49	15.59	15.61	15.56	15.50	15.55

La Fayette, Ind. (test 2, 1940–42):						
Mandarin	16.19	15.39	15.38	15.22	16.40	15.72
Richland	15.88	16.42	16.24	17.37	17.53	16.69
Mukden	15.43	15.84	15.53	16.47	15.84	15.82
Dunfield	16.94	16.96	17.33	16.99	14.86	16.62
Boone	13.91	13.24	12.77	11.46	11.01	12.48
Mean	15.67	15.57	15.45	15.50	15.13	15.46

ANALYSES OF VARIANCE FOR LOCATIONS

Source of variation	Test 1—Iowa			Test 2					
					Iowa		Illinois		Indiana	
	Degrees of freedom	Mean square	Variance component	Degrees of freedom	Mean square	Variance component	Mean square	Variance component	Mean square	Variance component
Varieties	4	38.06	1.05	4	181.24	3.33	64.69	1.14	134.30	2.70
Dates	4	43.81	1.21	4	12.80	.10	9.13	.02	1.89	−.13
Years	1	104.33	1.25	2	43.88	.22	2.20	.20	8.93	.02
Varieties × dates	16	2.60	.14	16	6.76	.63	7.67	.77	7.29	.60
Varieties × years	4	5.72	.26	8	25.57	1.63	6.30	.37	7.18	.35
Dates × years	4	6.74	.33	8	2.83	.12	1.17	.03	2.40	.04
Varieties × dates × years	16	1.75	.50	32	1.10	.28	.75	.16	1.87	.53
Error	72	.24	.24	96	.27	.27	.28	.28	.28	.28
Coefficient of variation (percent)		3.3			3.5		3.4		3.4	

TABLE 13.—*Mean seed sizes (in grams per 100 seeds) and analysis of variance of 5 varieties of soybeans planted on 5 dates at 3 locations for 3 years (1940–42) (test 2)*

MEAN SEED SIZES

Variety	Seed size for variety planted—					Mean
	May 1	May 12	May 23	June 3	June 14	
Mandarin	16.26	15.88	15.53	15.62	16.48	15.96
Richland	15.44	15.97	16.12	16.98	17.16	16.33
Mukden	15.42	15.55	15.36	15.76	15.39	15.50
Dunfield	16.44	16.46	16.61	16.03	14.68	16.05
Boone	13.80	13.37	12.81	11.54	10.61	12.43
Mean	15.47	15.45	15.29	15.19	14.86	15.25

ANALYSIS OF VARIANCE

Source of variation	Degrees of freedom	Mean square	Variance component
Varieties	4	348.90	2.22
Dates	4	8.21	−.12
Years	2	52.68	.10
Locations	2	44.45	.10
Varieties × dates	16	18.83	.62
Varieties × years	8	24.20	.36
Varieties × locations	8	15.67	.17
Dates × years	8	4.79	.07
Dates × locations	8	3.31	.05
Years × locations	4	11.05	.05
Varieties × dates × years	32	1.65	.07
Varieties × dates × locations	32	1.45	.05
Varieties × years × locations	16	7.43	.43
Dates × years × locations	16	.80	−.02
Varieties × dates × years × locations	64	1.03	.25
Error	288	.28	.28

Varieties differed significantly in oil content in test 1 and all locations of test 2. At individual locations (table 17), variances attributable to

varietal interaction with years were generally appreciable, but in comparison variances contributed by varietal differences were not of excessive magnitude.

Delayed planting usually had little effect on oil content. A slight tendency for lower oil content to be associated with delayed planting seemed evident. Differential performance of the varieties at varied dates of planting was noticeable. Oil content of relatively late varieties, particularly of the Boone variety, tended to be decreased more severely by delayed planting than that of early varieties, especially in plantings made after May 12.

Variances attributable to years and locations in test 2 were large, and are particulariy significant in view of the small interaction of years × locations. Mean oil contents at the Illinois location were consistently higher than at the other 2 locations, and mean oil contents in 1940 were consistently lower than in the other 2 years.

TABLE 14.—*Mean seed size (in grams per 100 seeds) of Richland in test 1, 1939-40*

Year	Mean seed size for Richland planted					Mean
	May 1	May 12	May 24	June 8	June 14	
1939	17.1	16.7	16.0	15.4	13.9	15.7
1940	16.1	16.6	16.6	17.7	18.2	17.4
Mean	16.7	16.7	16.3	16.4	16.0	

IODINE NUMBER OF OIL

Mean iodine numbers of oil for each location of tests 1 and 2 and analyses of variance for locations appear in table 19. Mean iodine numbers for all locations and years of test 2 and analysis of variance appear in table 20.

Iodine number of oil of the varieties differed significantly in all tests. Varietal differences, however, were not consistent among years at any of the locations, as evidenced by consistently high variances associated with varieties × years interactions.

TABLE 15.—*Mean protein content of 5 varieties of soybeans planted on 5 dates for 2 years (1939–40) at 1 location (test 1) and 5 varieties planted on 5 dates for 3 years (1940–42) at 3 locations (test 2), and analyses of variance for locations*

MEAN PROTEIN CONTENT

Location, year, and variety	Protein content for variety planted—					Mean
	May 1	May 12	May 23	June 3	June 14	
Ames, Iowa (test 1, 1939–40):						
Richland	43.29	43.40	42.46	42.78	43.79	43.14
Mukden	46.08	45.81	45.40	45.70	45.56	45.71
Mandell	46.70	46.67	46.56	46.75	46.61	46.66
Illini	42.88	42.99	43.20	42.86	43.53	43.09
Dunfield	40.91	41.41	42.30	42.77	42.80	42.04
Mean	43.97	44.05	43.98	44.17	44.46	44.13
Ames, Iowa (test 2, 40–42):						
Mandarin	47.07	46.81	45.82	45.90	46.09	46.34
Richland	41.91	41.84	41.92	41.59	41.40	41.74
Mukden	45.16	45.07	44.89	45.70	45.64	45.29
Dunfield	40.06	40.54	40.63	40.75	41.47	40.69
Boone	42.24	42.14	42.79	42.57	42.69	42.49
Mean	43.29	43.28	43.21	43.30	43.46	43.31
Urbana, Ill. (test 2, 1940–42):						
Mandarin	43.87	44.27	43.32	42.57	42.99	43.40
Richland	40.03	40.52	41.44	40.42	41.32	40.75
Mukden	43.03	42.64	42.20	42.34	42.72	42.59
Dunfield	39.26	39.31	39.73	38.58	39.80	39.34
Boone	41.00	40.52	40.66	40.61	41.05	40.77
Mean	41.44	41.45	41.47	40.90	41.58	41.37

La Fayette, Ind. (test 2, 1940–42):						
Mandarin	46.74	45.49	45.37	44.43	45.58	45.52
Richland	41.50	41.67	41.21	42.03	41.70	41.62
Mukden	46.37	45.44	45.97	45.62	45.66	45.81
Dunfield	41.39	40.88	41.17	41.70	40.82	41.19
Boone	42.13	41.28	41.49	40.94	41.04	41.38
Mean	43.63	42.95	43.04	42.95	42.96	43.10

ANALYSES OF VARIANCE FOR LOCATIONS

Source of variation	Test 1—Iowa			Test 2					
					Iowa		Illinois		Indiana	
	Degrees of freedom	Mean square	Variance component	Degrees of freedom	Mean square	Variance component	Mean square	Variance component	Mean square	Variance component
Varieties	4	114.85	3.62	4	260.09	5.59	118.18	2.53	247.62	5.27
Dates	4	1.23	−.53	4	.37	−.12	3.15	−.14	3.89	.04
Years	1	151.48	1.72	2	139.96	1.70	141.34	1.72	161.88	2.01
Varieties × dates	16	1.41	−.05	16	1.80	−.02	1.99	−.04	1.85	.02
Varieties × years	4	6.67	.33	8	8.63	.45	4.83	.17	10.48	.59
Dates × years	4	17.57	1.06	8	6.00	.27	9.94	.51	2.09	.03
Varieties × dates × years	16	1.72	.28	32	1.95	.36	2.32	.40	1.64	.34
Error	96	.87	.87	[1]96	.86	.86	1.12	1.12	.63	.63
Coefficient of variation (percent)		2.1			2.1		2.4		1.8	

[1] 72 degrees of freedom for Iowa, 120 for Illinois.

Delayed dates of planting resulted in a substantial increase in iodine number at all locations of test 2; in test 1 no differences in iodine number were attributable to dates of planting. Varied dates of planting resulted

TABLE 16.—*Mean protein content and analysis of variance of 5 varieties of soybeans planted on 5 dates at 3 locations for 3 years (1940–42) (test 2)*

MEAN PROTEIN CONTENT

Variety	Protein percentage for variety planted—					Mean
	May 1	May 12	May 25	June 3	June 14	
Mandarin	45.89	45.52	44.84	44.30	44.89	45.09
Richland	41.15	41.34	41.53	41.35	41.47	41.37
Mukden	44.85	44.39	44.35	44.56	44.67	44.56
Dunfield	40.23	40.24	40.51	40.34	40.70	40.41
Boone	41.79	41.31	41.64	41.37	41.59	41.54
Mean	42.78	42.56	42.57	42.38	42.66	42.59

ANALYSIS OF VARIANCE

Source of variation	Degrees of freedom	Mean square	Variance component
Varieties	4	590.35	4.19
Dates	4	2.92	−.03
Years	2	346.00	1.28
Locations	2	255.69	.88
Varieties × dates	16	2.87	.03
Varieties × years	8	12.00	.12
Varieties × locations	8	17.77	.27
Dates × years	8	8.83	.08
Dates × locations	8	2.25	−.04
Years × locations	4	48.59	.53
Varieties × dates × years	32	2.42	.07
Varieties × dates × locations	32	1.38	−.04
Varieties × years × locations	16	5.97	.28
Dates × years × locations	16	4.60	.19
Varieties × dates × years × locations	64	1.75	.29
Error	288	.87	.87

in consistent differences in iodine number at the three locations of test 2. Throughout years, however, variances due to date of planting were not consistant in test 1 or at the Illinois location of test 2. This interaction is thought to be attributable to differential mean temperatures occurring during the soybean developmental period throughout the years of the tests at these locations.

Interaction of varieties with dates, in general, was of low order magnitude at each of the locations of test 2. In test 1, however, varieties interacted considerably with dates of planting. Iodine number of the earliest variety, Richland, decreased with lateness of planting. Varieties intermediate in maturity, Mukden and Mandell, showed little change in iodine number, whereas the latest varieties, Illini and Dunfield, exhibited little change throughout the first four dates of planting and even a small increase at the latest date.

Among the locations of test 2 relatively high iodine numbers were obtained at the Iowa location, and among years higher iodine numbers resulted in 1942 than in the two previous seasons. Deviations from these trends, however, are indicated by appreciable variance attributable to the interaction of years with locations.

ACCURACY OF LATTICE SQUARE DESIGNS RELATIVE TO RANDOMIZED BLOCKS

Relative to randomized blocks, quasi-factorial types of experimental designs have been shown by numerous workers to facilitate accuracy in comparison of treatment means when variation within replications due to environmental factors is of appreciable magnitude. The higher degree of accuracy in quasi-factorial designs is usually accomplished by reducing the size of the experimental units among which variance attributable to environmental factors may be eliminated. In lattice square designs, as used in these experiments, an estimate of the variance among columns and rows of the square or replication is possible. The accuracy of the experiment relative to randomized blocks can be estimated ($\mathcal{E}$) by comparing the effective error mean square per plot (with recovery of interblock information) with the error variance obtained when the design is analyzed as a randomized block design; that is, the squares are treated as randomized replications.

TABLE 17.—*Mean oil contents of 5 varieties of soybeans planted on 5 dates for 2 years (1939–40) at 1 location (test 1) and 5 varieties planted on 5 dates for 3 years (1940–42) at 3 locations (test 2), and analyses of variance for locations*

MEAN OIL CONTENTS

Location, year, and variety	Oil content for variety planted—					Mean
	May 1	May 12	May 23	June 3	June 14	
Ames, Iowa (test 1, 1939–40):						
Richland	19.58	19.68	19.74	19.87	19.23	19.62
Mukden	19.38	19.14	18.94	18.56	18.21	18.85
Mandell	18.46	18.40	18.26	17.72	17.69	18.10
Illini	19.62	19.33	19.21	19.31	18.72	19.24
Dunfield	20.39	20.38	20.14	19.71	19.53	20.03
Mean	19.49	19.39	19.26	19.03	18.67	19.17
Ames, Iowa (test 2, 1940–42):						
Mandarin	19.34	18.57	18.17	17.72	17.41	18.24
Richland	20.19	20.28	19.89	20.10	20.13	20.12
Mukden	19.10	19.09	18.98	19.02	19.21	19.08
Dunfield	21.22	21.09	21.26	20.96	20.38	20.98
Boone	20.98	20.76	20.06	19.38	18.79	19.99
Mean	20.17	19.96	19.67	19.44	19.18	19.68
Urbana, Ill. (test 2, 1940–42):						
Mandarin	19.80	19.76	19.80	19.82	19.73	19.78
Richland	21.21	21.21	21.63	21.38	21.21	21.33
Mukden	20.78	20.84	21.17	21.08	20.93	20.96
Dunfield	22.54	22.36	22.22	22.39	22.20	22.34
Boone	21.98	21.82	21.70	20.88	20.12	21.30
Mean	21.26	21.20	21.30	21.11	20.84	21.14

La Fayette, Ind. (test 2, 1940–42):						
Mandarin	18.66	18.79	18.48	18.44	18.16	18.50
Richland	20.58	20.68	20.42	20.48	20.53	20.54
Mukden	18.94	19.39	19.14	19.32	19.43	19.24
Dunfield	20.86	21.17	20.86	20.64	21.03	20.91
Boone	20.91	20.90	20.40	19.51	18.79	20.10
Mean	19.99	20.18	19.86	19.68	19.59	19.86

ANALYSES OF VARIANCE FOR LOCATIONS

Source of variation	Test 1—Iowa			Test 2						
				Iowa			Illinois		Indiana	
	Degrees of freedom	Mean square	Variance component	Degrees of freedom	Mean square	Variance component	Mean square	Variance component	Mean square	Variance component
Varieties	4	16.38	0.35	4	49.56	1.02	38.05	0.80	43.16	0.87
Dates	4	3.13	−.16	4	6.96	.08	1.53	.00	2.56	−.05
Years	1	.23	−.05	2	47.19	.57	79.97	1.04	60.75	.73
Varieties × dates	16	4.96	.76	16	1.80	.09	1.18	.11	1.63	.11
Varieties × years	4	1.21	.05	8	2.85	.13	1.25	.07	3.08	.17
Dates × years	4	3.31	.19	8	2.72	.12	.75	.04	3.66	.20
Varieties × dates × years	16	.42	.09	32	.97	.28	.21	.03	.60	.16
Error	48	.14	.14	96	.13	.13	.13	.13	.11	.11
Coefficient of variation (percent)		1.9			1.8		1.7		1.7	

Owing to the additional computations accompanying the refinement of the quasi-factorial designs, it is customary to remove block effects in only those attributes—yield, for example—that are critical and in which

TABLE 18.—*Mean oil contents and analysis of variance of 5 varieties of soybeans planted on 5 dates at 3 locations for 3 years (1940–42) (test 2)*

MEAN OIL CONTENTS

Variety	Oil content for variety planted—					Mean
	May 1	May 12	May 23	June 3	June 14	
Mandarin	19.27	19.04	18.81	18.67	18.43	18.84
Richland	20.66	20.72	20.65	20.65	20.63	20.66
Mukden	19.61	19.77	19.76	19.81	19.86	19.76
Dunfield	21.54	21.54	21.44	21.33	21.20	21.41
Boone	21.29	21.16	20.72	19.92	19.23	20.46
Mean	20.47	20.45	20.28	20.08	19.87	20.23

ANALYSIS OF VARIANCE

Source of variation	Degrees of freedom	Mean square	Variance component
Varieties	4	127.54	0.90
Dates	4	8.80	.03
Years	2	185.10	.81
Locations	2	142.83	.63
Varieties × dates	16	3.84	.12
Varieties × years	8	2.85	.01
Varieties × locations	8	1.62	−.01
Dates × years	8	1.72	.01
Dates × locations	8	1.13	.00
Years × locations	4	1.41	−.02
Varieties × dates × years	32	.75	.03
Varieties × dates × locations	32	.39	−.01
Varieties × years × locations	16	2.16	.11
Dates × years × locations	16	1.06	.04
Varieties × dates × years × locations	64	.52	.13
Error	288	.122	.12

variability due to environmental factors is considered to be appreciable. In other attributes, such as maturity date and lodging, variability conditioned by the environment is considered of such low magnitude that frequently measurements are made in only one replication. In composition analyses, determinations on bulked samples from the replicates are frequently considered to give sufficient accuracy. When individual plot data have been collected for such attributes and it seems desirable to learn the significance of differences among treatment means, quasi-factorial designs are frequently analyzed as randomized blocks.

As all data in the experiments reported were collected on individual plots, comparison of the attributes as to precision when analyzed as lattice squares relative to randomized blocks was considered of interest. The accuracies of the experiments, when analyzed as lattice squares relative to when analyzed as randomized blocks, appear in table 21.

It is important to note that the mean relative accuracies are considerably lower than usually reported. In practice, when accuracies of lattice square experiments by random chance are lower than when analyzed as randomized blocks, row and column effects are pooled with error variance. When such a system is practiced no experiment can have a relative accuracy less than 100 percent. In order to indicate the true relative accuracy of the lattice square designs, the "practical" mean accuracies are presented in the bottom line of table 21. In determination of these means all accuracies less than that of randomized blocks were considered to be 100 percent. An analysis of variance of the relative accuracies is shown in table 22.

As correlations have been established among certain of the attributes, use of analysis of variance in an examination of the mean accuracies might well be questioned. As the experiments × attributes interaction would be biased downward by such correlations, however, it is of interest to note that mean accuracies of attributes did not tend to differ significantly when compared with this interaction.

Of further interest is the appreciable relative accuracy of oil and protein contents, variables upon which environment is considered to have little effect as compared with that of yield, a character known to be materially influenced by environment. Analysis as lattice squares relative to analysis as randomized blocks contributed perceptibl to the accuracy of certain experiments in all attributes studied. Considering all attributes, relative accuracies tended to vary more by years than by locations.

TABLE 19.—*Mean iodine numbers of oil of 5 varieties of soybeans planted on 5 dates for 2 years (1939–40) at 1 location (test 1) and 5 varieties planted on 5 dates for 3 years (1940–42) at 3 locations (test 2), and analyses of variance for locations*

MEAN IODINE NUMBERS OF OIL

Location, year, and variety	Iodine number for variety planted—					Mean
	May 1	May 12	May 23	June 3	June 14	
Ames, Iowa (test 1, 1939–40):						
Richland	127.0	126.4	125.4	123.6	122.9	125.0
Mukden	127.4	127.3	126.8	126.6	126.9	127.0
Mandell	132.8	132.4	130.9	130.4	131.0	131.5
Illini	131.0	130.4	131.1	131.2	132.1	131.2
Dunfield	124.3	123.8	124.0	124.5	127.1	124.8
Mean	128.5	128.1	127.6	127.3	128.0	127.9
Ames, Iowa (test 2, 1940–42):						
Mandarin	130.2	130.8	132.7	133.8	134.4	132.4
Richland	127.4	127.8	129.0	128.5	128.8	128.3
Mukden	129.3	129.9	130.1	131.0	131.0	130.4
Dunfield	127.7	128.0	128.5	130.5	130.3	129.0
Boone	133.9	133.4	133.9	134.8	135.5	134.3
Mean	129.7	130.0	131.0	131.7	132.0	130.9
Urbana, Ill. (test 2, 1940–42):						
Mandarin	128.5	128.2	128.8	130.9	132.1	129.7
Richland	125.8	125.4	124.9	124.9	126.3	125.5
Mukden	125.4	126.1	127.2	127.2	128.5	126.9
Dunfield	124.0	124.3	124.1	126.2	127.8	125.3
Boone	129.5	129.7	130.3	131.6	132.5	130.7
Mean	126.7	126.8	127.1	128.2	129.4	127.6

La Fayette, Ind. (test 2, 1940–42):						
Mandarin	126.9	127.9	129.7	130.7	132.9	**129.6**
Richland	125.8	124.7	124.8	126.3	127.7	**125.9**
Mukden	127.7	127.6	128.3	128.1	129.6	**128.3**
Dunfield	125.1	125.6	125.8	127.7	130.1	**126.9**
Boone	131.3	131.7	132.1	133.9	135.7	**132.9**
Mean	127.4	127.5	128.1	129.4	131.2	**128.7**

ANALYSES OF VARIANCE FOR LOCATIONS

Source of variation	Test 1—Iowa			Test 2					
				Degrees of freedom	Iowa		Illinois		Indiana	
	Degrees of freedom	Mean square	Variance component		Mean square	Variance component	Mean square	Variance component	Mean square	Variance component
Varieties	4	317.45	9.93	4	272.90	5.31	277.11	5.23	344.15	**6.08**
Dates	4	6.50	−1.04	4	46.78	.99	62.60	1.13	114.93	**2.49**
Years	1	308.70	3.53	2	235.29	2.67	187.64	1.88	657.62	**7.84**
Varieties × dates	16	7.88	.90	16	3.57	−.27	4.69	.20	5.89	**−.30**
Varieties × years	4	14.02	.77	8	36.56	2.04	39.87	2.46	73.04	**4.30**
Dates × years	4	32.29	1.99	8	4.46	−.10	9.80	.46	5.37	**−.21**
Varieties × dates × years	16	2.48	.69	32	5.98	1.73	2.91	.77	8.56	**2.66**
Error	48	.41	.41	[1]120	.79	.79	.59	.59	.59	**.59**
Coefficient of variation (percent)		.54			.68		.60		.60	

[1] 96 degrees of freedom for Iowa.

TABLE 20.—*Mean iodine numbers of oil and analysis of variance of 5 varieties of soybeans planted on 5 dates at 3 locations for 3 years (1940–42) (test 2)*

MEAN IODINE NUMBERS

Variety	Iodine number for variety planted					Mean
	May 1	May 12	May 23	June 3	June 14	
Mandarin	128.5	129.0	130.4	131.8	133.1	130.6
Richland	126.3	126.0	126.2	126.6	127.6	126.5
Mukden	127.5	127.9	128.7	128.8	129.7	128.5
Dunfield	125.6	126.0	126.1	128.1	129.4	127.0
Boone	131.6	131.6	132.1	133.4	134.6	132.7
Mean	127.9	128.1	128.7	129.7	130.9	129.1

ANALYSIS OF VARIANCE

Source of variation	Degrees of freedom	Mean square	Variance component
Varieties	4	874.05	6.58
Dates	4	208.21	1.49
Years	2	597.32	1.73
Locations	2	613.99	1.86
Varieties × dates	16	10.40	.06
Varieties × years	8	32.95	−.72
Varieties × locations	8	10.06	−1.03
Dates × years	8	5.24	−.20
Dates × locations	8	8.05	.06
Years × locations	4	241.61	2.40
Varieties × dates × years	32	10.44	.77
Varieties × dates × locations	32	1.87	−.18
Varieties × years × locations	16	58.26	3.65
Dates × years × locations	16	7.19	.25
Varieties × dates × years × locations	64	3.51	.95
Error	360	.653	.65

TABLE 21.—*Accuracies of experiments when analyzed as lattice square designs relative to randomized blocks*

Experiment	Accuracy of —								
	Lodging score	Height	Maturity date	Yield	Seed size	Oil percentage	Protein percentage	Iodine number	Mean
Test I									
Iowa	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
1939	93.2	118.8	109.4	92.9	90.8	108.3	104.8	122.6	105.1
1940	198.9	136.2	96.3	104.3	124.3	105.1	159.8	108.6	129.2
Test II									
Iowa									
1940	92.2	105.6	105.1	129.2	186.9	120.2	106.8	98.5	118.1
1941	103.9	101.9	85.5	134.7	102.1	87.6	103.7	81.4	100.1
1942	107.2	109.5	66.8	93.1	86.3	131.1	133.0	117.0	105.5
Illinois									
1940	92.2	141.8	117.9	100.2	121.5	136.8	147.9	95.5	119.2
1941	105.6	103.3	105.1	90.5	96.6	102.4	75.9	90.6	96.3
1942	79.7	[1]129.6	106.9	109.0	110.9	105.3	94.4	179.9	114.5
Indiana									
1940	89.6	241.7	96.7	110.9	84.9	134.9	108.7	58.3	115.7
1941	127.7	118.2	104.1	116.9	103.7	56.6	94.8	95.6	102.2
1942	80.5	119.1	99.8	117.9	138.3	150.9	167.1	112.5	123.3
Mean	106.4	129.6	99.4	109.1	113.3	112.7	117.9	105.5	111.7
"Practical" mean[2]	113.0	129.6	104.4	111.2	117.1	117.7	121.1	112.8	115.9

[1]Supplied with missing plot technique.

[2]Accuracies less than 100 percent considered to be 100 percent.

TABLE 22.—*Analysis of variance of relative accuracies of experiments when analyzed as lattice square designs relative to randomized blocks*

Source of variation	Degrees of freedom	Mean square
Among experiments	10	884.38
Test 1 versus test 2	1	573.01
Between years, test 1	1	2,520.83
Among locations, test 2	2	210.04
Among years, test 2	2	2,245.78
Locations × years, test 2	4	259.57
Among attributes	7	922.29
Experiments × attributes	69	808.00

SUMMARY

Two experiments are reported in a study of agronomic and seed compositional characters of soybean varieties planted at different dates. The first test was made on the varieties Richland, Mukden, Mandell, Illini, and Dunfield, planted on May 1 and on four succeeding dates, 11 days apart, during 2 years at Ames, Iowa. The second test was made on Mandarin, Richland, Mukden, Dunfield, and Boone planted on the same dates as the first test at three locations—Ames, Iowa, Urbana, Ill., and La Fayette, Ind.—for 3 successive years. The following attributes were studied: Maturity date, lodging, height, seed yield, seed size, protein percentage, oil percentage, and iodine number of oil.

Maturity date was retarded approximately 1 day for each 3 days' delay in planting, but the degree of retardation fluctuated with years. Maturity of genetically early varieties was retarded more than that of late varieties.

Lodging was not appreciably affected by date of planting, and there was little differential response of varieties to date of planting in this respect.

Maximum height was attained at the second date of planting and diminished with successively later dates of planting. Height of late varieties was decreased relatively more than that of early varieties at the later planting dates.

Highest seed yields, considering all dates of planting, were attained by the varieties that had the proper genetic maturity to utilize the entire growing season without incurring frost damage. Considering all varieties, progressively lower yields were obtained at dates of planting subsequent to May 1. However, varieties responded differentially to time of planting in that the yield of the earliest variety did not differ significantly at the various planting dates, whereas yields of the latest variety decreased progressively with delayed planting. Seasonal differences also conditioned the effect of planting date on yield.

Protein content of the seed was not affected by date of planting. Although the varieties differed appreciably in protein content, they failed to respond differentially to varied dates of planting.

Oil content of the seed, considering all varieties, was decreased slightly by delayed planting, although such decrease was not consistent among varieties. Oil content of relatively late varieties was decreased more

severely by delayed planting than was that of the earlier varieties. Oil content varied perceptibly with years and with locations.

Iodine number of the oil of all varieties was materially increased by delayed planting, with little differential response by the varieties.

The accuracies of lattice square designs 5 by 5 relative to randomized blocks were examined with respect to the 5 agronomic and 3 compositional attributes studied. Little difference in relative accuracy was evident among attributes, analysis as lattice squares contributing appreciably to the accuracy of certain experiments in all attributes studied.

LITERATURE CITED

(1) CARTER, J. L., and HOPPER, T. H.
1942. INFLUENCE OF VARIETY, ENVIRONMENT, AND FERTILITY LEVEL ON THE CHEMICAL COMPOSITION OF SOYBEAN SEED. U. S. Dept. Agr. Tech. Bul. 787, 66 pp., illus.

(2) COCHRAN, W. B.
1941. AN EXAMINATION OF THE ACCURACY OF LATTICE AND LATTICE SQUARE EXPERIMENTS ON CORN. Iowa Agr. Expt. Sta. Res. Bul. 289, pp. 395, 415.

(3) CRUMP, S. L.
1946. THE ESTIMATION OF VARIANCE COMPONENTS IN ANALYSIS OF VARIANCE. Amer. Statis. Assoc. Biometrics Bul. 2 (1): 7-11.

(4) FEASTER, C. V.
1949. INFLUENCE OF PLANTING DATE ON YIELD AND OTHER CHARACTERISTICS OF SOYBEANS GROWN IN SOUTHEAST MISSOURI. Amer. Soc. Agron. Jour. 41: 57-62, illus.

(5) GARNER, W. W., and ALLARD, H. A.
1920. EFFECT OF THE RELATIVE LENGTH OF DAY AND NIGHT AND OTHER FACTORS OF THE ENVIRONMENT ON GROWTH AND REPRODUCTION IN PLANTS. Jour. Agr. Res. 18: 553-606, illus.

(6) ALLARD, H. A., and GARNER, W. W.
1914. OIL CONTENT OF SEEDS AS AFFECTED BY THE NUTRITION OF THE PLANT. Jour. Agr. Res. 3: 227-240.

(7) HENSON, P. R., and CARR, R. S.
1946. SOYBEAN VARIETIES AND DATES OF PLANTING IN THE YAZOO-MISSISSIPPI DELTA. Miss. Agr. Expt. Sta. Bul. 428, 12 pp.

(8) JOHNSON, I. J.
1932. THE RELATION OF AGRONOMIC PRACTICE TO THE QUANTITY AND QUALITY OF THE OIL IN FLAXSEED. Jour. Agr. Res. 45: 239-255, illus.

(9) MAJORS, K. R., and MILNER, R. T.
1939. RELATION BETWEEN THE IODINE NUMBER AND REFRACTIVE INDEX OF CRUDE SOYBEAN OIL. Oil and Soap 16: 228-230.

(10) UNITED STATES WEATHER BUREAU.
1940-42. CLIMATOLOGICAL DATA: ILLINOIS SECTION. U. S. Weather Bur. Climatol. Data (by sections), v. 27-29, No. 13. Ill. Sect. 45-47 (9): (61) 66; (73)-80; (75)-80; illus.

(11) ———
1940-42. CLIMATOLOGICAL DATA: INDIANA SECTION. U. S. Weather Bur. Climatol. Data (by sections), v. 27-29, No. 13. Ind. Sect. 45-47 (10): (49)-52.

(12) ———
1940-42. CLIMATOLOGICAL DATA: IOWA SECTION. U. S. Weather Bur. Climatol. Data (by sections), v. 27-29, No. 13. Iowa Sect. 51-53 (11): (107)-126; (125)-140; (129)-144; illus.

(13) VILJOEN, N. J.
1937. AN INVESTIGATION INTO THE COMPOSITION OF THE SOYBEAN IN SOUTH AFRICA. So. African Dept. Agr. and Forestry, Sci. Bul. 169, 68 pp.

(14) WEISS, M. G., WEBER, C. R., and KALTON, R. R.
1947. EARLY GENERATION TESTING IN SOYBEANS. Amer. Soc. Agron. Jour. 39: 791-811.

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price 15 cents

☆ U. S. GOVERNMENT PRINTING OFFICE: 1950 889516

END