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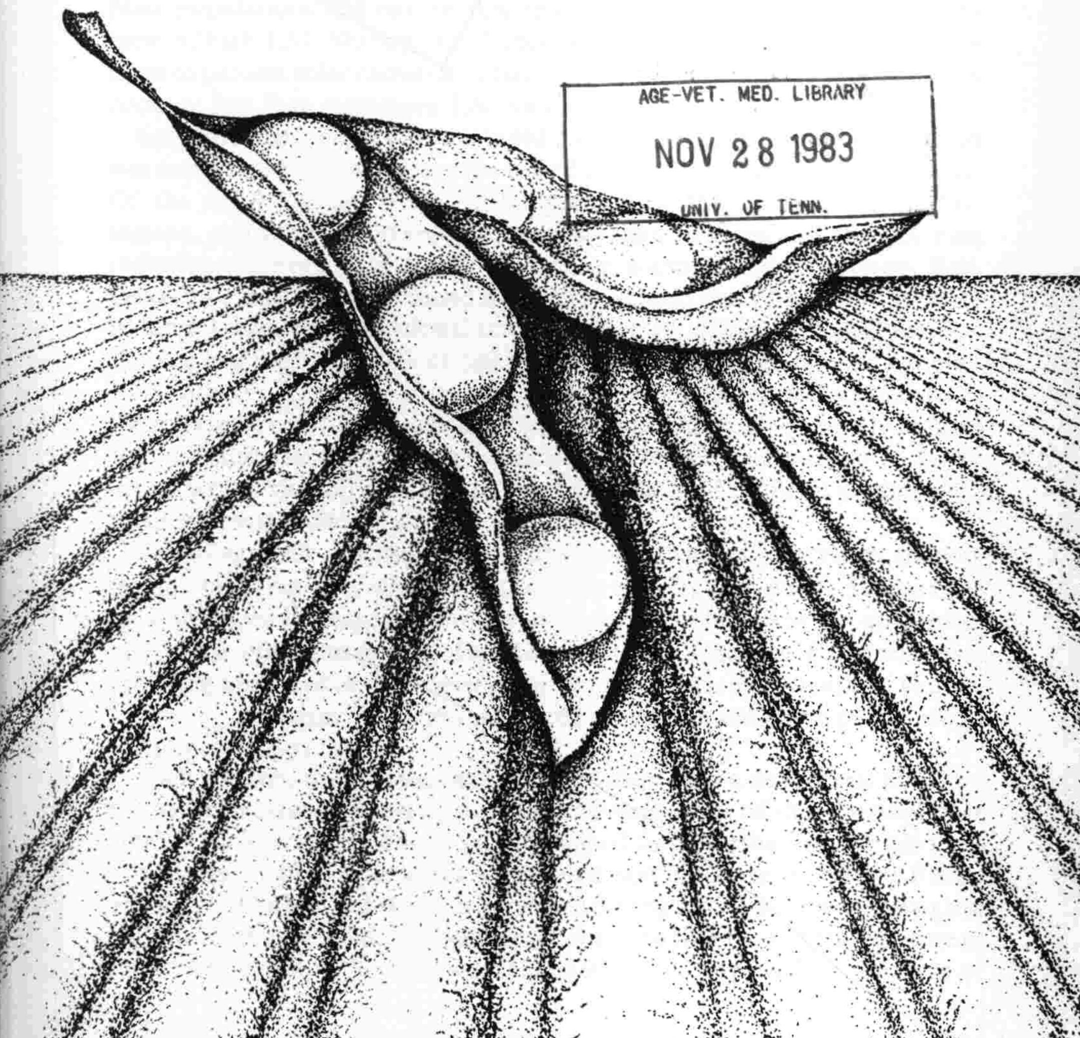

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Soybean Yields As Affected By Row Spacing and Within Row Plant Density

by

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Soybeans are particularly responsive to quality and quantity of sunlight. Light greatly influences the morphological development of the soybean plant as it affects plant height, branching, leaf area, time of flowering, lodging, and maturity. Soybeans are perhaps the most light sensitive of the major farm crops produced in Tennessee.

The rate of dry matter production by the soybean plant has been linearly related to percent radiation interception. Weber, et al. (10) reported that dry weight production was highly correlated to leaf area index (LAI). High plant populations and narrow row spacings are necessary for rapid attainment of high LAI. Shibley and Weber (9) directly related leaf area development to percent solar radiation interception. Maximum seed yields generally occur at less than maximum LAI values.

Sakamoto and Shaw (7) concluded that 90% of the incoming radiation was intercepted by leaves near the top of a fully developed soybean canopy. Of the small amount of radiation penetrating the canopy, Parks, Livingston, and Overton (5) reported that less than 10 percent of the incoming radiation reaches as far as 10 to 12 inches within the plant canopy. Egli, Pendleton, and Peters (2) found the photosynthetic rate of soybean leaves to be almost directly proportional to relative percent of full sunlight intensity. Thus, a leaf receiving 50% of full sunlight intensity would operate at about 50% capacity. Less than 2 percent of the total incoming radiation reaches the soil surface (5). This soybean canopy characteristic alone greatly reduces soil moisture losses through evaporation, thereby permitting a larger percentage of the soil moisture to be utilized through the plant in photosynthetic and metabolic processes.

Increasing plant densities through closer row spacings reduces the proportion of seed that is produced on the bottom parts of a plant. Most of the seed produced in dense narrow row soybean canopies are in the uppermost part of the plant canopy (4). This has an added advantage in that the seeds are being produced at the closest possible point to the photosynthate source. Likewise, the largest soybeans produced on determinate type plants are in the upper canopy.

High temperatures during the growing season have a deleterious effect on the soybean plant. Howell (3) noted the adverse effect of short periods over 100° F on internode elongation and rate of node formation. He also observed that high temperatures aggravated soil moisture problems. Runge and Odell (6) observed that temperatures during mid-season were often too high for optimum yield. Shahandeh (8) observed that the soil temperature at the 2.5 cm depth in 76 cm rows reached 97 °F midway between the rows of

63-day soybeans at 2 p.m. when the standard air temperature was 99 °F. The in-row 2.5 cm depth soil temperature for 76 and 25 cm rows as well as midway between the 25 cm rows were all 84° F at the same time. Davis (1) reported that 25, 51, 76, and 102 cm row soybeans formed a complete canopy at 60 to 65, 70 to 80, 84 to 91, and 93 to 120 days, respectively.

As evidenced by these findings, the distribution intensity of the soybean plants over a unit area of soil alters the micro-climatic environment around the soybean plants. Therefore, planting soybeans to maximize the beneficial effects and minimize the detrimental effects should provide a soybean production planting system that enhances yields.

In order to evaluate the effect of planting pattern on soybean growth, development, and yield, experiments utilizing a split plot design with row spacings of 40, 30, 20, and 10 inches as the main plot and 12, 10, 8, 6, 4, and 2 plants per foot of row as the split plots were used with 4 replicates at several locations across the state. Table 1 shows the number of plants per acre for each treatment of the experiment.

Table 1. Plants per acre by row spacing and within row plant density.

Plants per foot of row	Row spacing in inches 40	30	20	10
	Plant population in thousands			
12	156.8	209.1	313.6	627.3
10	130.7	174.2	261.4	522.7
8	104.5	139.4	209.1	418.2
6	78.4	104.5	156.8	313.6
4	52.3	69.7	104.5	209.1
2	26.1	34.8	52.3	104.5

A six-fold plant population spread occurs within each row spacing with several cases of identical plant populations occuring in 1, 2, 3, or 4 of the different row spacings. In order to attain the desired plants per foot of row at each row spacing, 18 to 20 seeds per foot of row were dropped at planting time and when the soybeans had reached the second-to-third trifoliate stage, they were thinned to the desired plant density within each row spacing.

This experiment was grown for 3 years (1979, 1980, 1981) at several locations across the state. These locations were on a Loring soil at Ames Plantation, on a Vicksburg soil at Milan, on a Dickson soil at Springfield, on an Emory soil at Columbia, and on a Sequatchie soil at Knoxville. Essex, Forrest, and Mitchell varieties were used. More than one variety was grown each year at Milan and Knoxville.

The three crop production years tended to constitute a fair sample of the range of climatic conditions generally encountered in the state. 1979 was excessively wet, 1980 was rather dry and drouthy, while 1981 was a good crop production year, being somewhat better than an average year.

The May, June, July, August, September, and October rainfall records for each experimental location are shown in Table 2.

The average yields produced by each treatment at each location for 1979, 1980, and 1981 are shown in Tables 3, 4, and 5. In the wet year of 1979 yields ranged from 36 to 61 bu./A at Ames, from 48 to 62 bu./A at Milan, from 36 to 64 bu./A at Springfield, from 46 to 65 bu./A at Columbia, and from 48 to 79 bu./A at Knoxville.

The plant density within the individual rows had no great effect on the yield except in very few cases. A significant drop in yield is observed where only 2 plants per foot of row occurred.

The average yield for the different row spacings indicates that decreasing the space between rows increased yields in all cases except for the Forrest variety at Knoxville. Generally, the largest yield increase from row spacing occurred when row spacing was changed from 20 to 10 inches. However, for Ames Plantation this large increase occurred when row spacing was changed from 30 to 20 inches.

In the drouthy year of 1980, yields all across the state were reduced considerably except at Knoxville where irrigation was used. Yields ranged from 20 to 27 bu./A at Ames, from 28 to 42 bu./A at Milan, from 20 to 28 bu./A at Springfield, from 31 to 46 bu./A at Columbia and from 20 to 74 bu./A at Knoxville where irrigation was utilized. Only at Milan and Knoxville were significant yield differences due to number of plants per foot of row found. At Milan, the higher number of plants per foot of row (8 and above) significantly reduced yield in the Mitchell variety. At Knoxville, 2 and 4 plants per foot of row resulted in significantly lower yields. Generally, the number of plants per foot of row effect on yield was small and not significant except in the two cases mentioned.

Row spacing resulted in significant yield differences only at Springfield where yields for 40-inch rows were significantly lower than yields for 30-inch rows and for all three varieties at Knoxville where irrigation was used. At Knoxville, the greatest yield increase came when row spacing was changed from 20 inches to 10 inches.

The yield results for the extreme drouthy 1980 crop year revealed one very significant finding. The intensity of the drouth was greatest at Ames Plantation and Springfield. At both of these locations as well as at Milan and Columbia there was no indication that the higher plant populations at any of the row spacings decreased yields during the high moisture stress crop year. In many farm crops, high plant populations depress yields during years of high moisture deficiency. This is particularly true for corn.

The 1981 crop year was a very good one for soybeans all across the state. Rainfall came at the desired time in most cases and there was not as much cloud cover that reduces sunlight intensity as occurred in 1979. The highest yield obtained at each location in 1981 was 57 bu./A at Ames, 88 bu./A at Milan, 69 bu./A at Springfield, 68 bu./A at Columbia, and 93 bu./A at Knoxville.

Plants per foot of row caused a significant yield difference at all locations except Ames in 1981. This was essentially due to the lower number of

Table 2. Rainfall records for May, June, July, August, September, and October for each experimental location.

Location	Month						6-month Total	Long Term Mean
	May	June	July	August	September	October		
1979								
Ames Plantation	8.83	6.48	3.33	6.36	6.63	1.86	33.49	21.76
Milan Exp. Station	10.37	2.06	5.96	2.48	6.59	1.64	29.10	22.57
Highland Rim Exp. Station	6.16	2.65	5.71	8.31	10.13	3.12	36.08	19.87
Middle Tenn. Exp. Station	6.27	1.66	4.47	3.11	9.15	3.68	28.34	21.18
Knoxville Exp. Station	----	----	10.23	4.04	3.75	2.43	20.45	21.99
1980								
Ames Plantation	3.16	2.05	2.18	1.39	3.22	2.98	14.98	21.76
Milan Exp. Station	2.29	7.91	1.15	.98	3.44	3.16	18.93	22.57
Highland Rim Exp. Station	4.63	3.72	2.24	1.65	2.23	1.38	15.85	19.87
Middle Tenn. Exp. Station	10.02	2.35	4.75	2.75	2.57	2.16	24.60	21.18
Knoxville Exp. Station	3.97	1.22	3.83	4.70	2.11	2.11	17.94	21.99
1981								
Ames Plantation	4.58	4.00	5.91	1.77	4.98	3.77	25.01	21.76
Milan Exp. Station	4.53	6.39	5.54	3.82	2.93	6.16	29.37	22.57
Highland Rim Exp. Station	4.34	9.92	5.26	2.51	5.06	4.69	31.78	19.87
Middle Tenn. Exp. Station	----	6.70	7.64	5.60	1.66	3.36	24.96	21.18
Knoxville Exp. Station	3.27	7.43	2.52	3.18	4.14	5.23	25.77	21.99

plants per foot of row producing lower yields. Indications of this effect had occurred in previous years but the differences were not always significant.

Row spacing significantly affected yields at all locations except Columbia in 1981. Yields were highest at Milan for 40, 30, and 20-inch rows and lowest at Ames. Yields for 10-inch rows were highest for all row spacings at all locations and were highest at Milan and Knoxville with 84 and 85 bu./A, respectively. In the average yield for row spacing all across the State, a 3 bu./A increase occurred when row spacing went from 40 to 30 inches. A 2-bushel per acre increase occurred when row spacing went from 30 to 20 inches and a 12 bu./A increase occurred when row spacing went from 20 to 10 inches.

An overall evaluation of the results from the row spacing - plant population experiments was accomplished within each variety of soybeans used in the experiments. Essex, Forrest, and Mitchell varieties were utilitized with Essex being evaluated all 3 years at Milan, Springfield, Columbia, and Knoxville. Forrest was evaluated for all 3 years at Ames and Knoxville, and Mitchell was evaluated for 2 years at Milan and Knoxville.

In this overall evaluation, the yield data from the different row spacing and plant population treatments for each variety-year-location were utilized to develop a soybean yield equation that expressed yield as a function of row spacing and the number of plants per foot of row. These yield functions were used to calculate isoyields for a range of row spacings and plants per foot of row covered by the experiments.

Figure 1 shows the yields found for Essex soybeans when grown at different row spacings and plant populations. It indicates that a 45 bu./A yield occurred in 40-inch rows with 5 plants per foot of row. Increasing the number of plants per foot of row to 8 increased yields to 48 bu./A. However in 38-to-40 inch rows with up to 12 plants per foot of row average yields of 49-to-50 bu./A would be the most expected. Each line within the figure lattice shows the combination of the row spacings and plants per foot of row that produced the bu./A yield the line indicates.

The narrow row side of Figure 1 indicates that a yield of 55 bu./A or more would be expected from a range of row spacings between 10 and 15 inches with a range of 2 to 12 plants per foot of row. Yields above 55 bu./A would be expected in 10-inch rows with 4 to 10 plants per foot of row. Narrow row soybeans generally produced several more bu./A than soybeans planted in wider rows.

The yield equation for Essex for all year-location situations was:

$$\hat{Y}\,(5.2)^{*} = 80.9527 - 3.8927R\,(0.7847)^{**} + 0.1360R^2\,(0.0345)$$
$$- 0.001679R^3\,(0.000459)$$
$$+ 1.3996P\,(0.4924) - 0.1174P^2\,(0.0311) + 0.02779RP\,(0.0081)$$
$$CV = 10.12;\ R^2 = 0.88$$

* Value indicates standard deviation.

** Value indicates standard error of the coefficients.

where Y is soybean yield in bushels per acre, R is row spacing in inches and P is the number of plants per foot of row. Only the significant terms in the analysis of variance were used in developing the yield equations.

Narrow row soybeans do not always mean higher yields as was found with unirrigated soybeans in 1980 when extreme moisture and temperature stress occurred. If the yield data for the droughty 1980 year at Milan, Springfield, and Columbia are omitted from the analyses, then isoyield functions as shown in Figure 2 are obtained. Notice that row spacings near 40 inches yielded 51 bu./A, a one bushel increase over all years-locations, while the 10-inch rows with 5-to-10 plants per foot of row yielded over 64 bu./A, a 9 bu./A increase. Figure 2 clearly shows that yield increased as distance between rows decreased and that the yield increase was greatest between 20 and 10-inch rows. These data also indicate that within a given rowspacing, a range of plants per foot of row produces the same yield.

The yield equation for Essex when 1980 yields from Milan, Springfield, and Columbia were omitted was:

$$\hat{Y}\,(4.8)^{*} = 87.1188 - 4.4905R\,(0.8395)^{**} + 0.1507R^2\,(0.0370) - 0.001803R^3\,(0.000491) + 2.2127P\,(0.5294) - 0.1625P^2\,(0.0334) + 0.02869RP\,(0.00873)$$

$$CV = 8.38;\ R^2 = 0.84$$

Figure 3 shows the isoyields for Forrest soybeans grown at Ames and Knoxville for the three years. Each isoyield line is 1 bu./A above or below adjacent lines. Note here that the maximum yield for the 40-inch row Forrest soybeans was slightly over 44 bu./A with 12 plants per foot of row. Yields increased as row spacing decreased and/or plants per foot of row increased. Yields over 55 bu./A were obtained with 10 to 12 plants per foot of row in 10-inch rows.

The yields equation for Forrest at Ames and Knoxville for three years was:

$$\hat{Y}\,(5.5)^{*} = 59.6938 - 1.0500R\,(0.2346)^{**} + 0.01284R^2\,(0.0046) + 0.5091P\,(0.1352)$$

$$CV = 11.88;\ R^2 = 0.84$$

Omitting the 1980 drouth year at Ames the yield equation becomes

$$\hat{Y}\,(4.1)^{*} = 64.3875 - 1.2113R\,(0.2509)^{**} + 0.0143R^2\,(0.0049) + 0.5752P\,(0.1446)$$

$$CV = 10.56;\ R^2 = 0.71$$

Note that number of significant factors from the ANOV was much less for Forrest soybeans.

* Value indicates standard deviation.

** Value indicates standard error of the coefficients.

If only the data for the one drouthy year (1980) at Ames are dropped from the analyses, isoyields as shown in Figure 4 were obtained. Note that the high yield for 40-inch rows would be 48 bu./A, a 4 bu./A increase over that in Figure 3. However, yields for the 10-inch row spacing would be slightly over 64 bu./A with 8-10 plants per foot of row. The isoyields of Figure 4 are 2 bu./A apart and illustrate the necessity for having a high number of plants per foot of row to increase yields of wide row soybeans. At 9 plants per foot of row, the isoyield curves show that the yield increases one bushel per acre each time the distance between the rows is reduced by 2 inches.

Figure 5 shows the isoyields for Mitchell soybeans grown at Milan and Knoxville at the different row spacings and plant populations within the rows. Each isoyield line is 1 bu./A above or below adjacent isoyield lines. Note that the highest yield in 40-inch rows was 43 bu./A. Yields increased for all row spacings as the number of plants per foot of row increased from 2 to 9. Further increases in plants per foot of row resulted in a lower yield at each row spacing. The results for the Mitchell variety are very similar to those for Forrest soybeans in Figure 4. In the case of Mitchell soybeans, yields increased one bushel per acre each time the row spacing was decreased 2½ inches at 9 plants per foot of row.

The yield equation with Mitchell at Milan and Knoxville for the two year period was:

$$\hat{Y}\ (5.0)^{*} = 46.5548 - 0.3820R\ (0.0461)^{**} + 2.8975P\ (0.7382) - 0.1677P^2\ (0.0516)$$

$$CV = 10.71;\ R^2 = 0.85$$

Omitting the 1980 drouth year at Milan, the equation becomes:

$$\hat{Y}\ (4.2)^{*} = 51.0121 - 0.5057R\ (0.0445)^{**} + 4.1293P\ (0.7129) - 0.2328P^2\ (0.0498)$$

$$CV = 8.08;\ R^2 = 0.85$$

Note that plant population becomes a more important yield component in the Mitchell soybean.

The desired number of plants per foot of row for optimum yield of each variety may be determined by examining the slope of the isoyield line relative to the plants per foot of row axis in Figures 1-5. Where the slope of this line is zero is the best in row plant density for maximum yield of a given row spacing. This observation holds true for all cases except Figure 3 (Forrest soybeans) where yields were continually increasing as the number of plants per foot of row increased.

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* Value indicates standard deviation.

** Value indicates standard error of the coefficients.

The results from the analyses of the combined yield data within each variety indicate clearly that yields were higher with the more narrow rows in all cases. Wide row soybeans have certain yield limitations as indicated in each case. These results indicate that the soybean producer who wishes to make extra high yields must use narrow row soybeans. This does not mean that high yields automatically follow narrow row soybeans. The 1980 crop year indicated this as with the high temperatures and moisture stress, yields of the same magnitude were produced at all row spacings. However, during the good crop year of 1981, the climatic factors necessary for high yields were present and the narrow row soybeans produced yields higher than the yields obtained in soybeans planted in wider row spacings. The proper planting pattern enables a soybean producer to "cash in" on the good crop years.

Days From Planting to Canopy Closure

Canopy closure may be defined as when little or no incoming radiation reaches the soil surface directly or when there are few, if any, sunspots visible on the soil surface around noon on a clear sunny day. Canopy closure occurred for both Forrest and Essex soybeans in 10-inch rows at 70 days in 1979 and at 64 days for most treatments in 1980. The lower in-row plant densities took several days more to form a complete canopy (Table 6).

In 20-inch rows, both varieties had treatments that reached closed canopy in 70 days in 1979. Each variety had one treatment that closed canopy in 64 days in 1980. The canopy closure time was generally less for Forrest than Essex with some of the less dense Essex treatments taking 120 days for canopy closure.

In 30-inch rows, canopy closure occurred between 72 and 90 days for most treatments with the less dense plantings taking longer, up to 100 days for Forrest and 120 days for Essex.

In 40-inch rows, canopy closure occurred for most treatments in 85 days for Forrest in 1979 and in 93 days or less in 1980. Essex formed a closed canopy about 10 to 20 days later than Forrest at this row spacing.

Generally, Forrest and Essex soybeans formed a complete canopy about 67 to 70 days after planting in 10-inch rows. In 20-inch rows Forrest formed a complete canopy in 71 to 73 days while Essex took 78 to 90 days. In 30-inch rows, Forrest reached a complete canopy stage at 81 to 84 days while Essex took 90 to 95 days. In 40-inch rows, Forrest reached complete canopy in 85 to 93 days while Essex took 102 to 106 days.

Thus, wide row soybeans took about a month longer before vegetation completely covered the soil surface than with narrow row soybeans. Forming a complete canopy as soon after planting as possible reduces stress on weed control herbicides, slows or stops weed seed germination, greatly reduces soil water loss through evaporation, stops rainfall impact on soil surface and thus reduces sheet erosion, forces the soybean plant to form pods higher on the stem, and thereby reduces or eliminates losses at harvest, protects nodules from excessive temperature stress, and results in producing a larger seed. All of these factors contribute to the higher yields generally obtained in narrow row soybeans.

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Table 3. Soybean yields as affected by row spacing and within row plant density at Ames, Milan, Columbia, Springfield, and Knoxville in 1979.

	ppf	E Milan	F Ames	E HRES	E MTES	E PSF	F PSF	Average
40"								
156.8	12	52.8	41.7	47.6	49.1	62.9	56.2	51.7
130.7	10	51.8	43.2	46.4	54.7	61.3	57.0	52.4
104.5	8	54.8	42.0	43.0	52.3	59.9	54.2	51.0
78.4	6	48.1	44.6	45.2	56.4	59.1	57.0	51.7
52.3	4	51.9	41.8	41.1	50.9	59.5	50.4	49.3
26.1	2	49.5	35.6	36.0	46.5	48.2	56.2	45.3
30"								
209.1	12	54.3	51.2	53.1	61.1	65.3	54.4	56.6
174.2	10	54.9	46.7	45.8	53.2	62.9	56.4	53.3
139.4	8	53.3	46.2	52.8	53.2	61.1	51.8	53.1
104.5	6	52.4	47.0	49.3	52.3	57.5	58.0	52.8
69.7	4	54.0	45.8	48.0	55.0	58.0	51.4	52.0
34.8	2	49.6	42.9	42.0	54.1	52.8	51.7	48.8
20"								
313.6	12	50.9	53.5	47.6	57.4	63.5	57.6	55.1
261.4	10	54.8	56.2	51.4	54.0	60.7	56.7	55.6
209.1	8	54.6	52.1	53.6	53.0	66.8	53.3	55.6
156.8	6	53.1	60.6	50.7	55.0	64.0	56.6	56.7
104.5	4	54.0	55.5	52.3	51.3	62.0	65.8	56.8
50.3	2	53.7	49.0	45.7	52.3	49.4	53.9	50.7
10"								
627.3	12	59.6	54.6	60.7	53.6	69.4	53.9	58.6
522.7	10	59.5	56.1	63.6	55.7	71.7	49.4	59.3
418.2	8	61.0	58.6	61.1	65.2	77.2	57.2	63.4
313.6	6	61.8	52.9	47.1	48.9	77.0	49.8	56.3
209.1	4	62.1	51.8	58.7	54.3	72.3	57.4	59.4
104.5	2	60.3	61.0	60.9	51.6	79.3	64.7	63.0
			Row Spacing Average					
	40"	51.5	41.5	43.2	51.6	58.5	55.2	50.3
	30"	53.1	46.6	48.5	54.8	59.6	54.0	52.8
	20"	53.5	54.5	50.2	53.8	61.1	57.3	55.1
	10"	60.7	55.8	58.7	54.9	74.5	55.4	60.0
L.S.D.	(5%) =	5.3	5.6	N.S.	N.S.	5.9	N.S.	....
	(1%) =		8.0			8.5		....
			Plant Population Average					
	12	54.4	50.3	52.2	55.3	65.3	55.5	55.5
	10	55.2	50.5	51.8	54.4	64.1	54.9	55.2
	8	55.9	49.7	52.6	55.9	66.3	54.1	55.8
	6	53.8	51.2	48.0	53.1	64.4	55.4	54.3
	4	55.5	48.7	50.0	52.9	63.0	56.2	54.4
	2	53.3	47.1	46.1	51.1	57.4	56.6	51.9
L.S.D.	(5%) =	N.S.	N.S.	N.S.	N.S.	3.8	N.S.	....
	(1%) =					5.1		....

E = Essex F = Forrest M = Mitchell

Table 4. Soybean yields as affected by row spacing and within row plant density at Ames, Milan, Columbia, Springfield, and Knoxville in 1980.

	ppf	M Milan	E Milan	F Ames	E HRES	E MTES	F PSF	E PSF	M PSF	Average
40"										
156.8	12	28.3	38.4	26.0	23.6	37.1	46.2	50.2	39.9	36.2
130.7	10	28.4	36.1	27.0	22.5	39.8	45.6	49.4	40.4	36.2
104.5	8	29.1	39.0	23.6	20.3	36.9	41.1	51.9	39.7	35.2
78.4	6	30.8	39.9	25.2	19.7	39.8	41.2	51.1	40.5	36.0
52.3	4	30.8	35.8	25.6	20.6	37.7	37.0	40.9	33.9	32.8
26.1	2	33.5	36.3	21.5	19.8	34.3	37.3	31.6	20.4	29.3
30"										
209.1	12	31.3	39.5	26.7	23.1	43.7	50.6	54.5	45.7	39.4
174.2	10	31.8	36.2	24.6	24.0	46.6	51.8	49.7	45.2	38.7
139.4	8	32.5	37.5	24.0	23.8	46.1	48.8	55.9	47.0	39.5
104.5	6	33.9	39.1	21.4	25.6	41.2	47.8	53.2	47.5	38.7
69.7	4	35.4	40.2	23.1	24.4	42.4	44.5	44.6	43.1	37.2
34.8	2	36.6	34.5	22.3	22.7	45.4	33.8	38.4	32.6	33.3
20"										
313.6	12	30.9	38.1	25.3	23.0	36.0	51.0	54.6	52.4	38.9
261.4	10	33.7	41.4	22.0	24.2	38.1	55.6	65.6	54.4	41.9
209.1	8	29.7	40.4	22.3	23.9	31.4	52.7	60.5	48.5	38.7
156.8	6	33.7	37.7	21.8	26.1	32.8	51.9	52.1	51.5	38.5
104.5	4	35.0	40.0	24.5	24.7	36.6	52.3	47.1	44.9	38.1
50.3	2	33.7	38.0	20.2	24.3	46.1	43.9	53.6	30.6	36.3
10"										
627.3	12	30.7	39.1	23.6	22.2	38.2	67.2	54.8	58.1	41.7
522.7	10	28.0	37.2	18.7	21.8	31.0	72.5	70.7	60.3	42.5
418.2	8	30.7	41.3	26.6	25.4	35.0	67.3	69.6	52.9	43.6
313.6	6	30.6	40.3	25.6	25.4	43.2	61.1	64.7	54.7	43.2
209.1	4	32.8	41.8	22.1	28.4	39.4	62.0	74.0	57.6	44.8
104.5	2	31.9	41.2	26.3	24.3	44.6	59.6	59.4	36.9	40.5
				Row Spacing Average						
	40"	30.1	37.6	24.8	21.1	37.6	41.4	45.8	35.8	34.3
	30"	33.6	37.8	23.7	23.9	44.2	46.2	49.4	43.5	37.8
	20"	32.8	39.3	22.7	24.4	36.8	51.2	55.6	47.1	38.7
	10"	30.8	40.1	23.8	24.6	38.6	64.9	65.5	53.4	42.7
L.S.D.	(5%) =	N.S.	N.S.	N.S.	2.0	N.S.	6.8	5.9	7.0	....
	(1%) =						9.7	8.5	10.1	....
				Plant Population Average						
	12	30.3	38.8	25.4	23.0	38.8	53.8	53.5	49.0	39.1
	10	30.5	37.7	23.1	23.1	38.9	56.4	58.8	50.1	39.8
	8	30.5	39.5	24.1	23.3	37.3	52.5	59.5	47.0	39.2
	6	32.2	39.2	23.5	24.2	39.2	50.5	55.2	48.5	39.1
	4	33.5	39.4	23.8	24.5	39.0	48.9	51.6	44.9	38.2
	2	33.9	37.5	22.6	22.8	42.6	43.6	45.7	30.1	34.9
L.S.D.	(5%) =	2.0	N.S.	N.S.	N.S.	N.S.	2.8	5.8	3.7	....
	(1%) =	2.7					3.7	7.7	4.9	....

E = Essex, F = Forrest, M = Mitchell.

Table 5. Soybean yields as affected by row spacing and within row plant density at Ames, Milan, Columbia, Springfield, and Knoxville in 1981.

Row Spacing	PPFR	E Milan	M Milan	F Ames	E HRES	E MTES	E PSF	F PSF	M PSF	Average
PPAx1000										
40"										
156.8	12	72.8	58.5	41.2	43.5	43.6	53.2	56.8	42.0	51.4
130.7	10	71.2	58.5	36.7	45.7	48.3	57.2	50.3	45.4	51.7
104.5	8	68.7	57.1	35.7	43.2	41.1	53.5	49.3	45.5	49.3
78.4	6	73.3	57.8	36.2	41.4	42.8	52.3	56.2	49.4	51.2
52.3	4	64.2	55.3	29.7	40.7	39.9	55.2	52.1	42.2	47.4
26.1	2	60.6	48.7	30.3	27.8	*	44.1	44.6	29.7	40.8
30"										
209.1	12	75.2	60.4	41.5	49.4	50.0	59.7	61.3	48.6	55.8
174.2	10	79.4	60.2	42.6	47.5	52.0	61.6	57.7	51.5	56.6
139.4	8	76.0	59.4	39.9	48.1	50.8	62.4	57.9	51.1	55.7
104.5	6	74.2	59.8	37.0	47.8	48.5	60.4	54.9	55.5	54.8
69.7	4	69.1	59.6	40.5	47.0	44.8	60.1	54.7	41.4	52.2
34.8	2	58.8	54.9	25.8	35.5	*	53.8	48.4	36.2	44.8
20"										
313.6	12	74.2	64.2	44.6	54.2	50.6	62.6	51.9	49.2	56.4
261.4	10	75.1	63.1	39.9	52.0	50.5	64.2	52.8	52.7	56.3
209.1	8	74.9	63.0	41.8	50.6	48.0	63.8	57.0	48.9	56.0
156.8	6	77.4	66.0	40.8	48.9	51.5	61.8	58.9	51.9	57.2
104.5	4	72.9	65.9	47.3	48.5	49.5	67.8	51.1	51.7	56.8
50.3	2	66.7	62.7	39.0	37.3	*	50.0	42.2	47.2	49.3
10"										
627.3	12	79.2	65.1	56.6	68.8	58.3	81.5	75.7	63.5	68.6
522.7	10	81.0	63.3	56.1	64.0	56.0	87.1	75.5	67.5	68.8
418.2	8	83.5	69.2	53.3	62.6	50.1	92.8	73.2	64.7	68.7
313.6	6	87.0	65.3	50.0	54.0	59.6	85.6	81.2	59.2	67.7
209.1	4	87.9	67.0	47.3	56.6	68.5	85.2	70.9	52.3	67.0
104.5	2	83.1	67.5	54.8	46.6	*	77.3	59.3	60.2	64.1
				Row Spacing Average						
	40"	68.5	56.0	34.9	40.4	43.1	52.6	51.5	42.4	48.7
	30"	72.1	59.0	37.9	45.9	49.2	59.7	55.8	47.4	53.4
	20"	73.5	64.1	42.2	48.6	49.9	61.7	52.3	50.3	55.3
	10"	83.6	66.2	53.0	58.8	58.5	84.9	72.6	61.2	67.4
L.S.D.	(.05)	6.5	4.8	5.3	3.9	N.S.	4.9	6.9	8.8	
	(.01)	9.3	6.9	7.6	5.6	N.S.	7.1	9.9	N.S.	
				Plant Population Average						
	12	75.3	62.0	46.0	53.9	50.6	64.2	61.4	50.8	58.0
	10	76.6	61.3	43.8	52.3	51.6	67.5	59.1	54.3	58.3
	8	75.8	62.2	42.7	51.1	47.5	68.1	59.3	52.5	57.4
	6	78.0	62.2	41.0	48.0	50.6	65.0	62.8	54.0	57.7
	4	73.5	61.9	41.2	48.2	50.7	67.0	57.2	46.9	55.8
	2	67.3	58.4	37.5	36.8	*	56.3	48.6	43.3	49.7
L.S.D.	(.05)	6.3	2.2	N.S.	2.5	2.2	4.8	3.3	3.7	
	(.01)	8.4	3.0	N.S.	3.4	2.9	6.3	4.4	4.9	

E = Essex, F = Forrest, M = Mitchell.

Table 6. Number of days from planting to canopy closure for Forrest and Essex soybeans planted in 4-row spacings and 6 within row plant densities at Knoxville in 1979 and 1980.

Row spacing Inches	Plants per foot of row	Forrest Days to closure 1979	Forrest Days to closure 1980	Essex Days to closure 1979	Essex Days to closure 1980
40	12	85	86	98	100
	10	85	86	98	100
	8	85	93	98	79
	6	85	93	105	93
	4	85	93	120	120
	2	88	107	120	120
	Av.	85	93	106	102
30	12	77	72	84	93
	10	77	79	84	79
	8	77	79	91	79
	6	85	79	91	79
	4	85	93	91	120
	2	88	100	98	120
	Av.	81	84	90	95
20	12	70	72	77	64
	10	70	72	77	72
	8	70	72	70	79
	6	70	64	70	86
	4	70	79	84	120
	2	77	79	91	120
	Av.	71	73	78	90
10	12	70	64	70	64
	10	70	64	70	64
	8	70	64	70	64
	6	70	64	70	64
	4	70	72	70	64
	2	70	72	70	79
	Av.	70	67	70	67

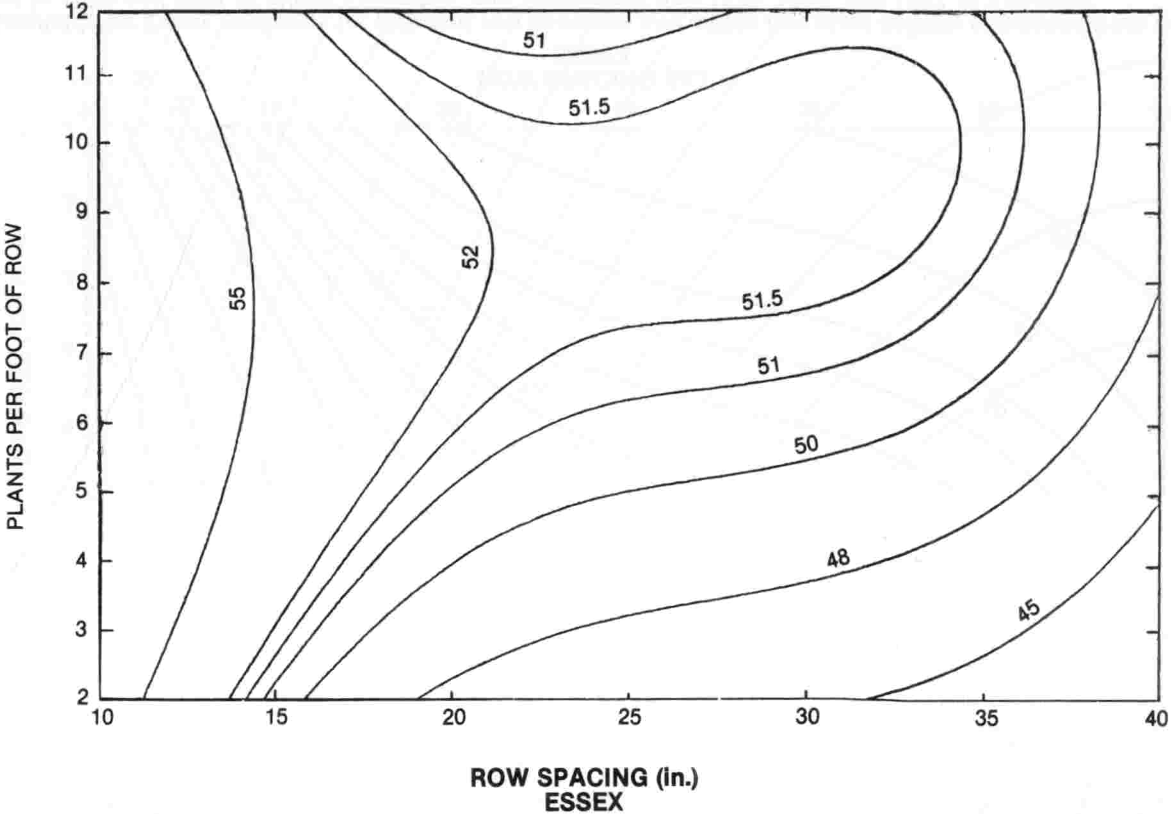

Figure 1. Isoyields for Essex soybeans for different row spacings and within row plant density computed from yields obtained in 1979, 1980, and 1981 at Milan, Columbia, Springfield, and Knoxville.

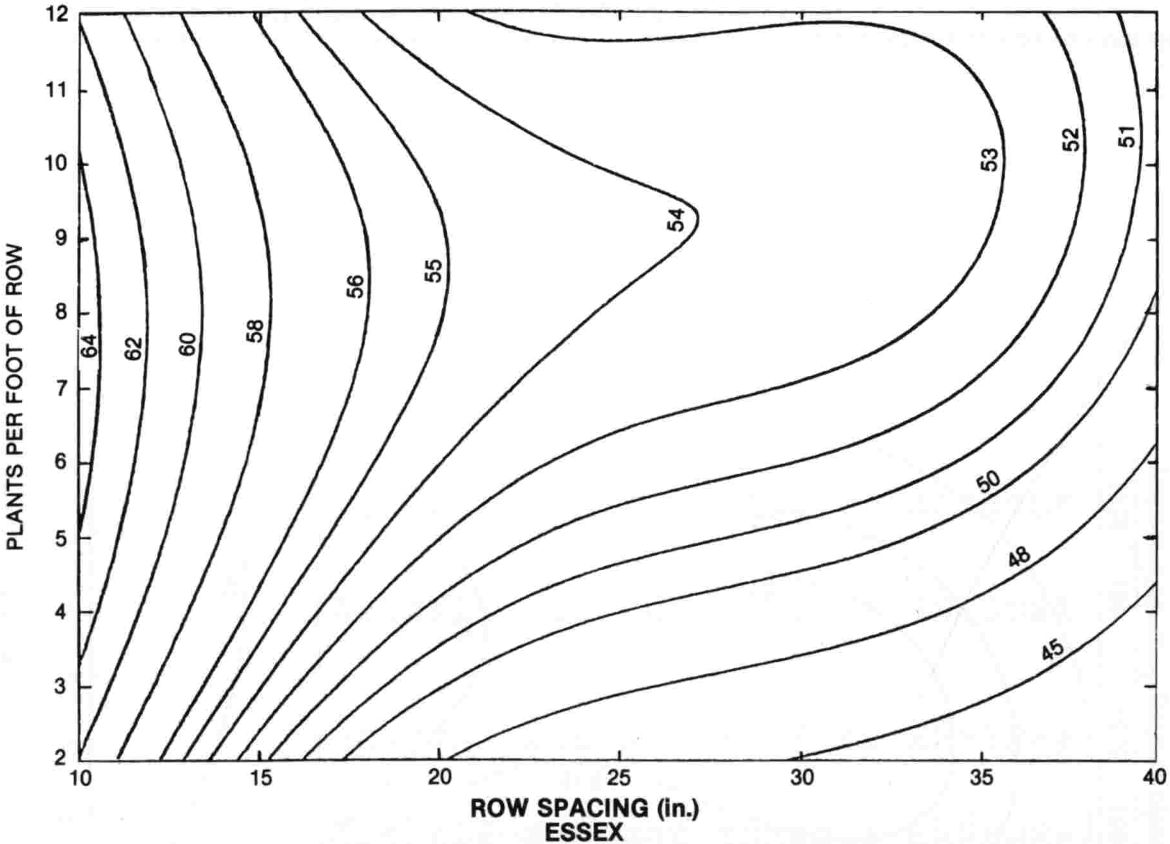

Figure 2. Isoyields for Essex soybeans for different row spacings and within row plant density computed from yields obtained in 1979 and 1981 at Milan, Columbia, and Springfield and 1979, 1980, and 1981 at Knoxville.

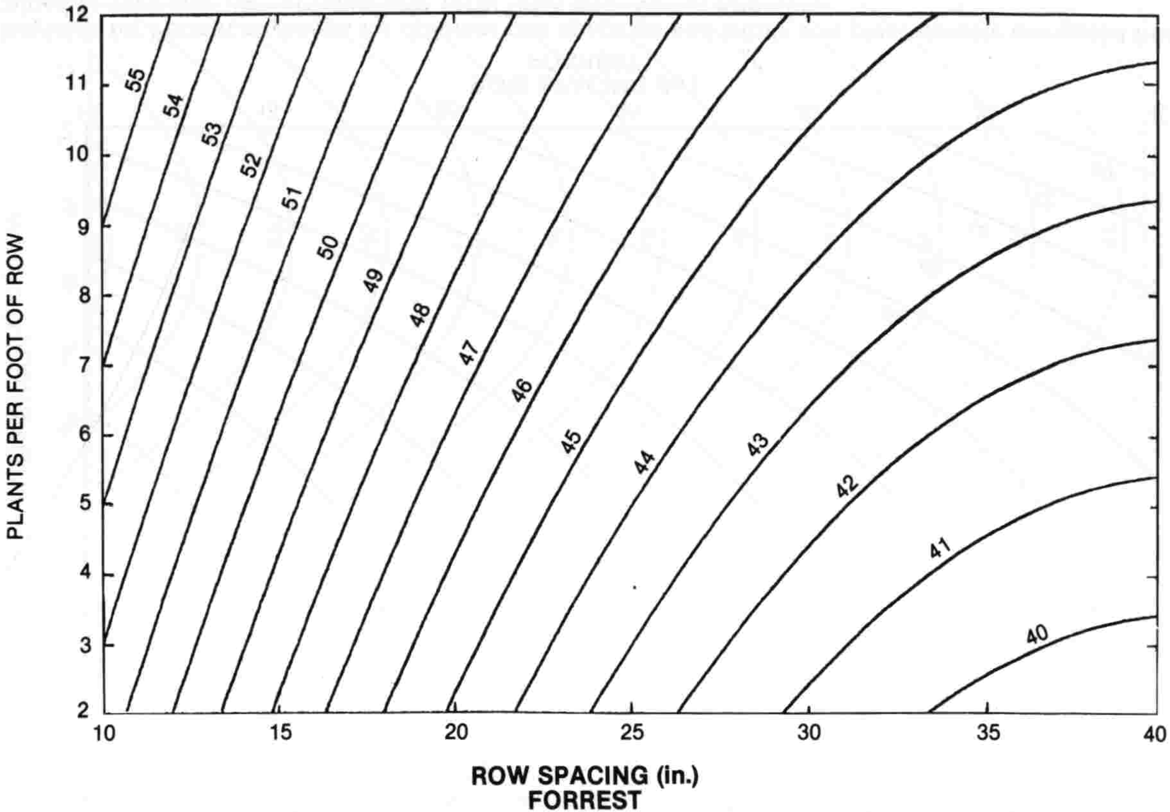

Figure 3. Isoyields for Forrest soybeans for different row spacings and within row plant density computed from yields obtained in 1979, 1980, and 1981 at Ames and Knoxville.

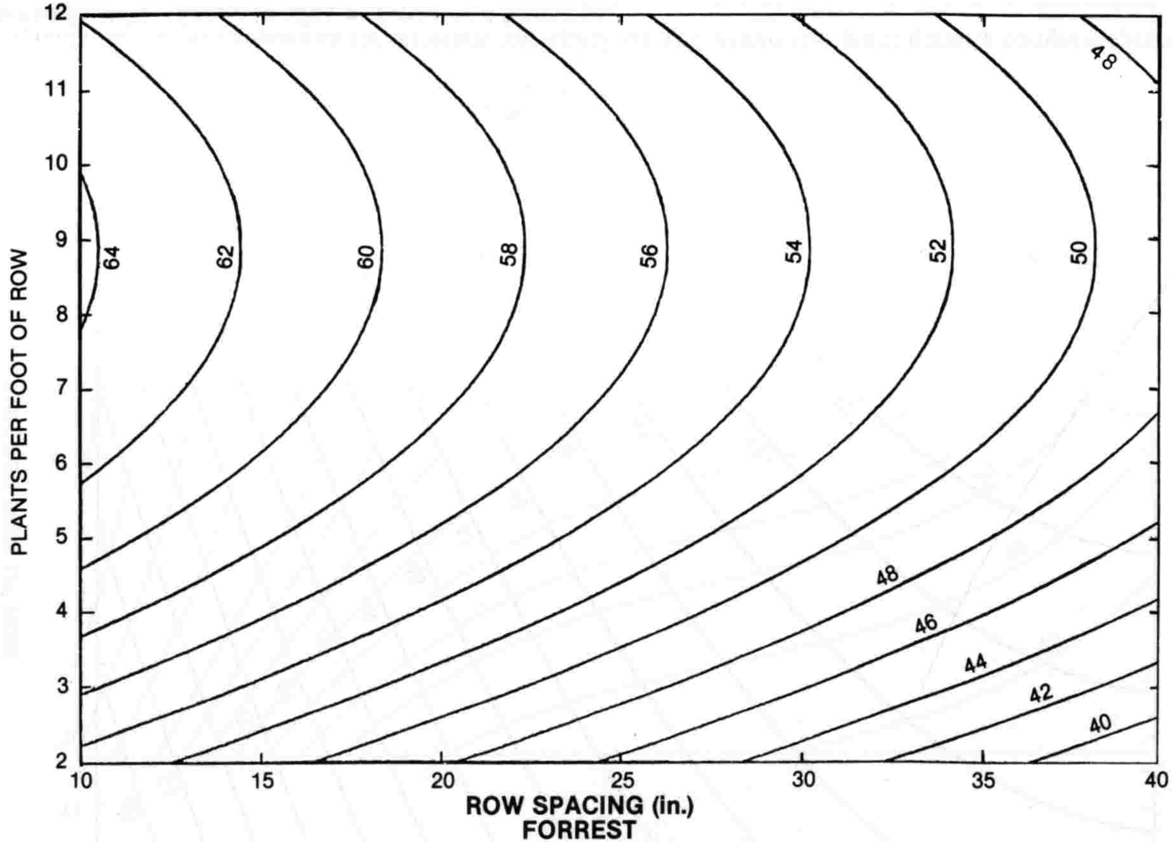

Figure 4. **Isoyields for Forrest soybeans for different row spacings and within row plant density computed from yields obtained in 1979 and 1981 at Ames and 1979, 1980, and 1981 at Knoxville.**

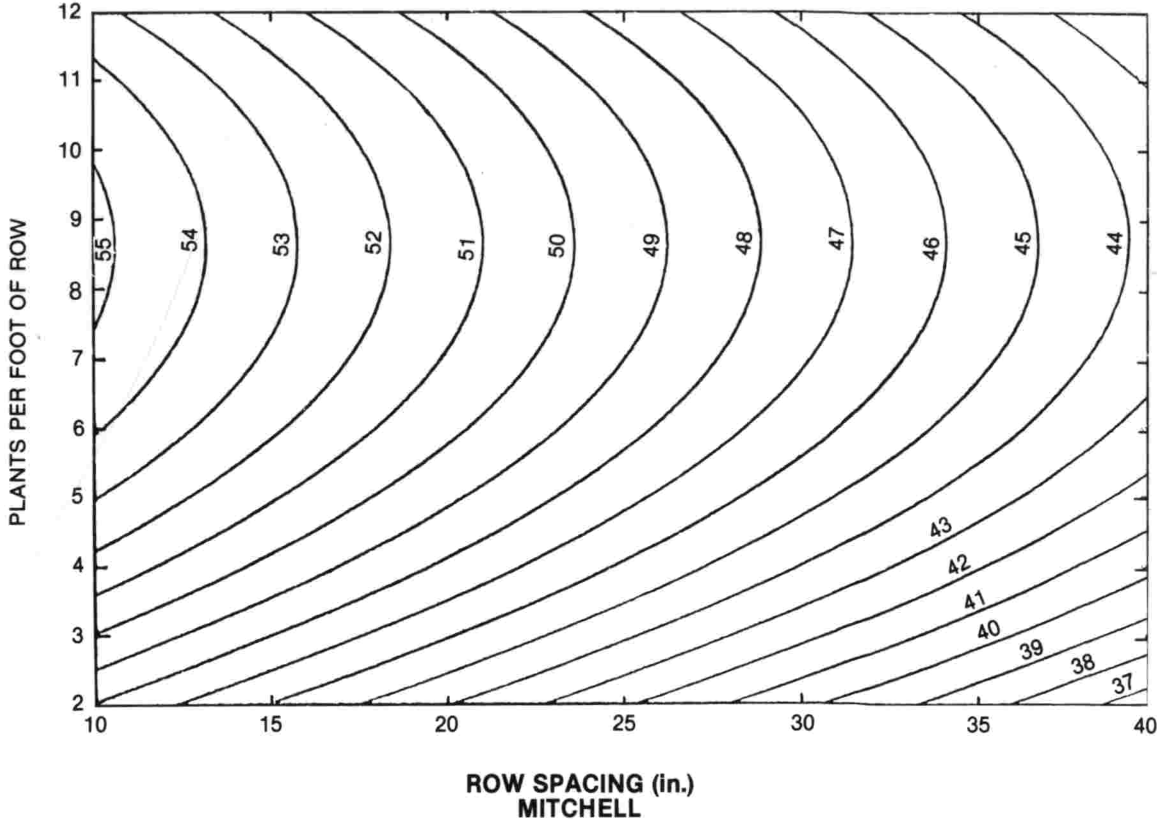

Figure 5. **Isoyields for Mitchell soybeans for different row spacings and within row plant density computed from yields obtained in 1980 and 1981 at Milan and Knoxville.**