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# Evaluation of a barley-soybean double-cropping system

Larry Neal Peters

To the Graduate Council:

I am submitting herewith a thesis written by Larry Neal Peters entitled "Evaluation of a barley-soybean double-cropping system." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agronomy.

Calvin O. Qualset, Major Professor

We have read this thesis and recommend its acceptance:

Frank F. Bell, Curtis F. Lard

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

May 19, 1967

To the Graduate Council:

I am submitting herewith a thesis written by Larry Neal Peters entitled "Evaluation of a Barley-Soybean Double-Cropping System." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agronomy.

Calvin O. Qualset
Major Professor

We have read this thesis and recommend its acceptance:

Frank F. Bell

Curtis F. Lard

Accepted for the Council:

Hilton A. Smith
Vice President for
Graduate Studies and Research

# EVALUATION OF A BARLEY-SOYBEAN DOUBLE-CROPPING SYSTEM

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A Thesis

Presented to

the Graduate Council of

The University of Tennessee

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In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

Larry Neal Peters

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TABLE OF CONTENTS

LIST OF TABLES

## LIST OF FIGURES

# CHAPTER I

## INTRODUCTION

The expanding population of the world has an ever increasing food requirement and the development of methods to increase production are needed in developed countries as well as in underdeveloped countries. For example, soybeans are a major source of protein, fats, and oils and production has expanded in recent years to meet the increased demand throughout the world.

Many producers are increasing their production and profits by producing two crops each year from the same production area (double-cropping). In the United States soybeans planted after the harvest of small grains is an example of double-cropping which has increased annual income in many soybean-producing regions. Revelle (1966) stated that increased cropping intensity by double-cropping would increase food production in underdeveloped countries such as India and thus establish a better balance between population and food supply.

In the southeastern United States double-cropping soybeans after small grains has been practiced for many years, but only recently has become important in Tennessee. In a double-cropping system soybeans must be planted later than desirable for high production. Yields may be reduced because soil moisture may be limiting for stand establishment and the growing period is reduced. Soybean varieties are sensitive to daylength and varieties suitable for single cropping may not be desirable for the late planting time required for double-cropping. Similarly, small grain varieties differ widely in time of maturity and therefore, may differ in their desirability for use in a double-cropping system. Thus, information is needed on production and management techniques using double-cropping systems. Parks, Bell, and McCutchen (1965) indicated profitable returns from a wheat-soybean double-cropping system in Tennessee.

The present study was conducted (1) to evaluate the feasibility of a barley-soybean double-cropping system; (2) establish objectives for breeding barley and soybean varieties for double-cropping; and (3) to establish points of departure for additional research on double-cropping.

CHAPTER II

# MATERIALS AND METHODS

A two-year barley-soybean variety double-cropping experiment was designed and the results of the first year are presented in this thesis. The crops for this experiment were grown at the Knoxville Plant Science Farm in 1965-1966 on a Sequatchie fine sandy loam.

## Varieties

All possible two-crop sequencies of six varieties each of barley and soybeans were used. This included treatments with one crop per year of both barley and soybeans. The barley and soybean varieties were selected to provide a wide range of time of maturity. The barley and soybean varieties used are listed in Table 1. The barley varieties are all winter types with adequate winter-hardiness for use in Tennessee in most seasons. Hill, Hood, and Lee are important soybean varieties in Tennessee at present, but the other varieties are considered too early for production in Tennessee in a one-crop system.

## Design of Experiment

The experiment consisted of four replications with seven main plots per replication (for six barley varieties and one plot for soybeans only). Each of the main plots consisted of seven sub-plots (for six soybean varieties and one plot for barley only) as illustrated in Figure 1. The size of the main plots was 21 x 90 feet and each sub-plot was 12 x 21 feet. All barley varieties were planted at the

TABLE 1. Origin and relative maturity of the barley and soybean varieties used in the double-cropping experiment at Knoxville, 1966

| Variety | Relative maturity | Origin |
|---|---|---|
| Barley | | |
| Barsoy (Ky. 60-586) | Very early | Kentucky (Finkner, 1965) |
| Dayton | Early | Ohio (Wiebe and Reid, 1961) |
| Harrison | Midseason to late | Indiana (Caldwell *et al.*, 1966) |
| Will | Midseason to late | Oklahoma (Jackson *et al.*, 1964) |
| Hudson | Midseason to late | New York (Jensen, 1964) |
| Tenn. 60-34 | Late | Tennessee |
| Soybeans | | |
| Harosoy 63 | Very early | Illinois (Bernard, 1964) |
| Clark 63 | Early to midseason | Illinois (Williams and Bernard, 1964) |
| Kent | Midseason | Indiana (Probst and Athow, 1964) |
| Hill | Midseason to late | Mississippi (Johnson, 1960) |
| Hood | Late | Mississippi (Johnson, 1960) |
| Lee | Late | North Carolina (Johnson, 1958) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| DAYTON | 6 | 7 | 4 | 2 | 3 | 5 | 7 |
| BARSOY | 3 | 5 | 1 | 7 | 6 | 2 | 4 |
| NO BARLEY | 7 | 4 | 5 | 2 | 1 | 3 | 6 |
| HARRISON | 1 | 7 | 5 | 3 | 6 | 4 | 2 |
| WILL | 4 | 1 | 5 | 7 | 6 | 2 | 3 |
| HUDSON | 6 | 3 | 5 | 1 | 2 | 7 | 4 |
| TENN. 60-34 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

Fig. 1. Field arrangement of one replication of the barley-soybean double-cropping experiment.

Legend

1 = Clark 63
2 = Lee
3 = Kent
4 = No soybeans
5 = Harosoy 63
6 = Hill
7 = Hood

same time in October 1965, and all soybean varieties were to be planted in the sub-plots (Figure 1, page 5) immediately after the harvest of each barley variety. However, a severe wind storm on 28 April resulted in considerable lodging of some varieties and a hail storm on 28 May prevented normal maturity of the barley varieties. Therefore, the soybean varieties were planted at estimated barley maturity dates.

The main plot marked "no barley" in Figure 1, page 5, was reserved for planting soybeans at the proper time and likewise the "no soybean" sub-plot was reserved for planting barley at the proper date in the fall of 1966. The "no barley-no soybean" plot was not planted and was intended to be used to obtain information on soil moisture in the absence of either barley or soybeans.

Experimental Procedures: Barley

All barley varieties were planted on 6 October 1965 with a grain drill with seven-inch spacing between rows. Before planting the barley, 500 lb. per acre of 6-12-12 per acre were incorporated in the soil and on 14 April 1966, 70 lb. per acre of ammonium nitrate per acre were top-dressed.

The characteristics evaluated were the following: heading date, days past 31 March when 50 per cent of the heads had emerged from the flag leaf sheath; lodging percentage, a visual estimate of the proportion of the sub-plot lodged at various times; disease reaction, general notes on leaf rust, powdery mildew, and scald; grain yield, bushels per acre determined from 63 $ft.^2$ of each sub-plot; straw yield, tons per acre from the same area as determined for grain yield; test weight, pounds per bushel; and kernel weight, milligrams per kernel obtained from a 1,000 kernel sample.

Because of the wind and hail damage, grain and straw yield, test weight, and kernel weight were not determined for Hudson and Will.

Experimental Procedures: Soybeans

Before planting soybeans, the barley straw was removed and 200 pounds of 0-20-20 per acre were incorporated in the soil by disking. The soybeans were planted at a rate of twelve seeds per foot of row. The plots were four rows wide with 36 inches between rows. Soybeans were planted in the "no barley" plots on 23 May 1966 but because of hail damage replanting was necessary on 1 June. Planting dates of soybeans after the barley varieties were as follows:

| | |
|---|---|
| Barsoy | 6 June |
| Dayton | 9 June |
| Harrison | 16 June |
| Will | 22 June |
| Hudson | 28 June |
| Tenn. 60-34 | 1 July |

These approximated the normal maturity times of the barley varieties except that the 1 July date for Tenn. 60-34 main plots is about one week later than normal. This resulted in a date of planting experiment with planting dates (barley varieties) as main plots and soybean varieties as sub-plots.

Data were collected on the following characters: stand count, the number of plants per six feet of row; days to first flower, when 50 per cent of the plants began to flower; termination of flowering, the date at which 75 to 100 per cent of the plants ceased to flower at the terminal part of the plant; height in inches at time of first flower and at maturity; time of maturity, days from planting until the leaves had dropped and 95 per cent of the pods were ripe; lodging at maturity was recorded on a scale of one to five where one indicated no lodging and five was severe lodging; grain yield in bushels per acre of air-dried beans, obtained from 18 feet of the two center rows of the four-row plot; seed size, grams per 200 seed; seed quality rating, a visual estimate using a one to five scale where one indicates good quality and five very poor quality; and purple stain rating, a visual estimate recorded on a score of one to five where one indicated no purple staining and five when 20 per cent or more of the seeds had purple stain. Because of an error in planting, data were not collected for Clark 63 on 6 June, 22 June, and 28 June plantings.

## Economic Analysis of Double-cropping

Itemized cost budgets for producing one acre of barley alone, soybeans alone, and barley-soybeans in a two-crop system are given in Table 2. All indicated expenses are based on unpublished data of Keller and Lard (1965). The interest on capital has been considered in all budgets, and custom harvesting was assumed. All of the net income values per acre were adjusted for a hauling cost of three cents per

TABLE 2. Costs for producing one acre of barley alone, soybeans alone, and barley and soybeans in a double-cropping system

| Item | Barley | | Soybeans | | Barley and soybeans | |
|---|---|---|---|---|---|---|
| | Cost per unit | Total cost | Cost per unit | Total cost | Cost per unit | Total cost |
| Seed, bu. barley | $1.40 | $2.80 | | | $1.40 | $2.80 |
| soybeans | | | $4.80 | $4.80 | 4.80 | 4.80 |
| Seedbed preparation and planting, acre | 4.58 | 4.58 | 5.09 | 5.09 | 8.55 | 8.55 |
| Fertilizer, 100 lb. | | | | | | |
| 0 - 20 - 20 | | | 3.04 | 6.12 | 3.04 | 6.12 |
| 6 - 12 - 12 | 2.60 | 13.00 | | | 2.60 | 13.00 |
| 33.5 - 0 - 0 | 3.70 | 2.59 | | | 3.50 | 2.59 |
| Cultivation, acre | | | 3.76 | 11.28 | 3.66 | 10.98 |
| Combining, acre | 6.00 | 6.00 | 6.50 | 6.50 | 12.50 | 12.50 |
| Hauling | 1.00 | 1.00 | a | | 1.00 | 1.00[b] |
| Total expenses | | 29.97 | | 33.79 | | 62.33 |

[a]Hauling cost for soybeans is $.03 per bushel of soybeans produced.

[b]Hauling cost of soybeans is not included.

bushel for soybeans and a fixed cost of $1.00 per acre was used for barley produced. The price per bushel of soybeans and barley was determined by taking the 1965 price per bushel plus twice the 1966 price and dividing the total by three which gives $2.70 per bushel for soybeans and $1.00 for barley.

Net income was obtained on a sub-plot basis. With soybeans cropped alone, the yield of each sub-plot was multiplied by $2.70 and subtracted from this value was a hauling cost of 3 cents per bushel and a production cost of $33.79. In the two-crop system, Barsoy income ($37.70 per acre) was added to the soybean income per acre of each sub-plot and a hauling cost of 3 cents per bushel of soybeans and a double-cropping production cost of $62.33 subtracted from each sub-plot. The net return from the sub-plots was taken for each variety to determine the average net income.

# CHAPTER III

# RESULTS AND DISCUSSION

## Barley

When barley is grown on highly productive soils suitable for soybean production, lodging resistance is important because barley would usually grow taller. All varieties used in this experiment had good winter survival, but they differed in lodging resistance. Lodging was severe for Will, Dayton, and Hudson (Figure 2) after 1 May. Harrison had outstanding lodging resistance and Barsoy was only about 20 per cent lodged before the first storm of 28 May. Lodging data were not taken after 20 May because a hail storm caused all varieties to lodge severely.

The varieties reacted differently to the diseases leaf rust, powdery mildew, and scald. All varieties were susceptible to leaf rust but only Will and Tenn. 60-34 were affected severely. Hudson was the only variety with powdery mildew infection and Will, Harrison, and Barsoy were susceptible to scald.

A summary of the other characters evaluated on barley are given in Table 3. Barsoy, having the earliest heading date, headed on 20 April and Dayton headed on 25 April. All other varieties headed on approximately 28 April.

Grain yields were highest for Barsoy and Harrison with Barsoy yielding approximately 38 bushels per acre and Harrison about 28 bushels (Table 3). All grain yields, however, were reduced by

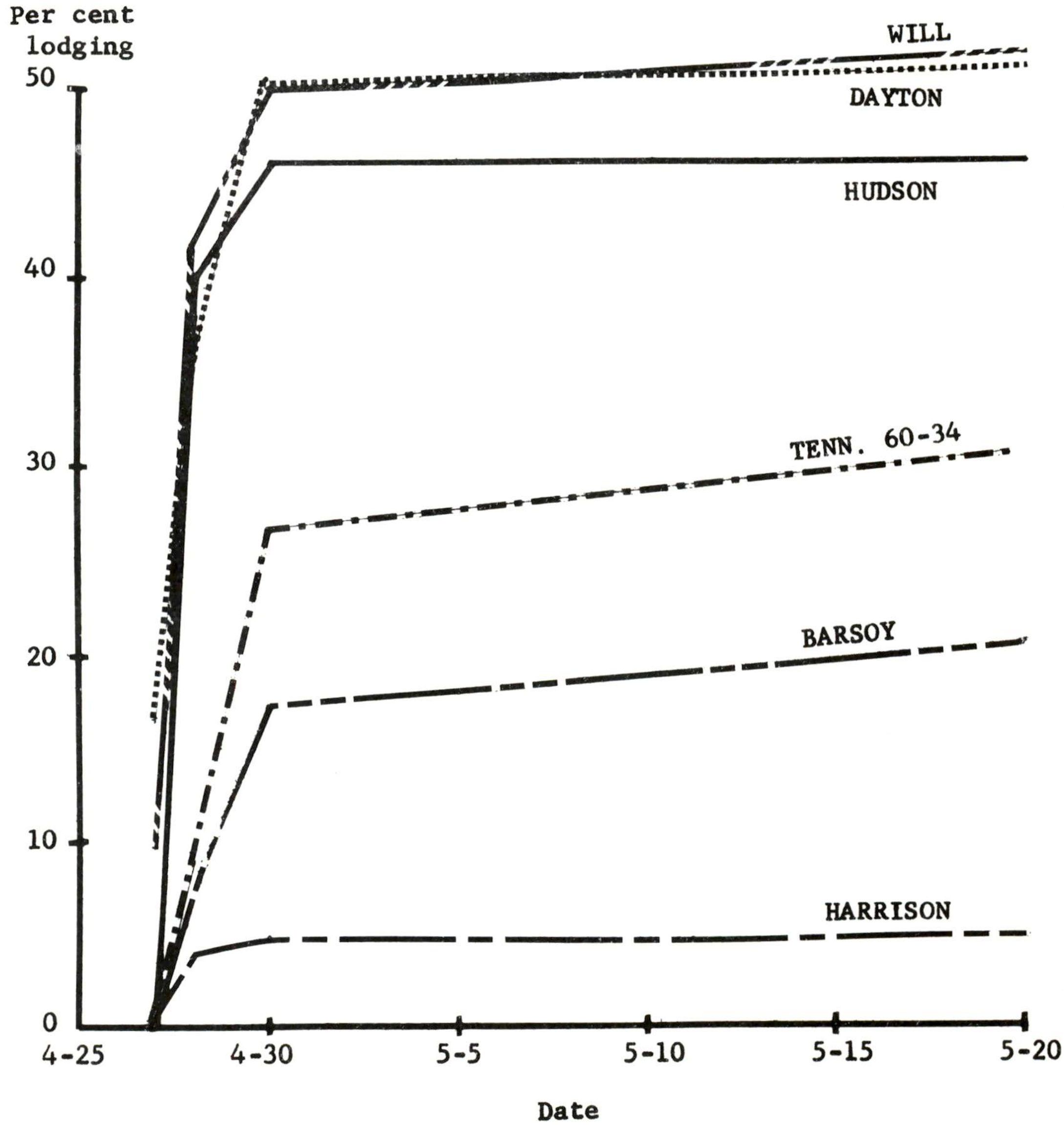


Fig. 2. Lodging percentage at various times for six barley varieties.

TABLE 3. Performance of six barley varieties at Knoxville, 1966

| Variety | Grain yield, bu./acre | Straw yield, tons/acre | Test weight, lbs./bu. | Kernel weight, mg. | Heading date, days past 31 March | Per cent lodging, 20 May |
|---|---|---|---|---|---|---|
| Barsoy | 37.7 | 3.49 | 42.6 | 22.8 | 21.0 | 20.4 |
| Dayton | 15.1 | 2.73 | 37.0 | 23.1 | 25.0 | 50.2 |
| Harrison | 27.7 | 3.02 | 44.1 | 30.1 | 29.2 | 4.9 |
| Tenn. 60-34 | 10.6 | 2.93 | 38.4 | 28.0 | 28.0 | 30.5 |
| Will | | | | | 29.5 | 51.7 |
| Hudson | | | | | 28.8 | 45.7 |
| L.S.D. (.05) | 5.4 | N.S. | 2.5 | 1.8 | 1.6 | 9.0 |

wind and hail damage. Barsoy was nearly mature at the time of the hail, and counts of fallen kernels indicated that shatter losses were about 9.5 bushels per acre. Straw yields were high for all varieties but did not differ significantly among varieties (Table 3, page 13). Because of the wind and hail damage, kernel development was not normal resulting in lower test weight and kernel weight than anticipated (Table 3, page 13).

All of the barley varieties were planted on the same date, 6 October, since this was the first year of the experiment; however, barley would be planted at different dates at the beginning of the second year of the experiment because of the various maturity dates of the soybeans. Plantings prior to 15 October in Tennessee usually insure good establishment before winter and the plants develop rapidly in the early spring. The planting date of barley is an important factor in a barley-soybean cropping system because soybean varieties maturing after 15 October make planting of barley later than desirable.

Barsoy and Harrison were the most suitable varieties in this experiment for double-cropping with soybeans. Harrison has greater disease resistance than Barsoy, but Barsoy matures 7 to 10 days earlier which is an important factor with double-cropping of barley with soybeans. Dayton, Will, and Hudson lodged excessively, and therefore, these varieties would not be desirable for double-cropping on highly productive soils such as the Sequatchie used in this experiment. Harrison had the least lodging of all varieties and lodging of Barsoy was not severe. Tenn. 60-34 has good scald and powdery mildew resistance, but its time of maturity is somewhat late for a double-cropping system.

Soybeans

The 1966 growing season was excellent for soybean production. Temperatures were exceptionally favorable and the rainfall distribution was conducive to good soybean growth. Stands were excellent because of sufficient moisture for germination after each time of planting.

Mean squares and significance levels from the analyses of variance for characters evaluated on soybeans are given in Table 4. Most of the results are presented in graphs, and the complete data for each variety and planting date for all characteristics are presented in Table 5. As indicated in Table 4, differences among varieties were highly significant for all characters which might have been expected since they were chosen because of differences in time of maturity. It is important to note that the interaction of varieties with planting date was significant for all characters except stand count and lodging score. This indicates that the six soybean varieties used in this experiment responded differently to planting dates, and the importance of this interaction to a double-cropping system will be discussed in later sections.

Stand establishment. Stand establishment in soybeans is one of the critical factors in a double-cropping system because soil moisture at planting time may often be deficient. Late planting, which is necessary for soybeans in double-cropping, may be hazardous from the

TABLE 4. Mean squares from the analysis of variance for planting dates, varieties, varieties x planting dates, and error term for 12 characters evaluated on soybeans at Knoxville, 1966

| Character | Planting dates | Varieties | Varieties x planting dates | Error | |
|---|---|---|---|---|---|
| | | | | Main-plot | Sub-plot |
| Stand count | 444.59 | 239.37 | 104.78 | 300.97 | 72.04 |
| Date to first flower | 356.13** | 3,793.10** | 19.91** | 1.63 | 1.82 |
| Flowering period | 182.25** | 894.32** | 25.26** | 3.87 | 3.26 |
| First flower to maturity | 61.82** | 3,360.79** | 11.17** | 2.71 | 2.53 |
| Height at first flower | 69.84** | 1,894.06** | 8.11* | 6.83 | 3.96 |
| Height at maturity | 4.31 | 158.50** | 6.46** | 2.68 | 2.36 |
| Days from planting to maturity | 939.11** | 8,872.91** | 28.89** | 1.15 | 1.51 |
| Lodging score | 5.90** | 9.56** | 0.67 | 0.57 | 0.40 |
| Seed yield | 320.68** | 954.10** | 66.22** | 34.60 | 11.60 |
| Seed size | 1.39 | 451.04** | 5.62** | 3.31 | 2.34 |
| Seed quality | 0.84* | 4.99** | 0.39* | 0.31 | 0.19 |
| Purple stain score | 0.59** | 2.95** | 0.74** | 0.13 | 0.05 |

* $.01 < P < .05$.

**$P < .01$.

TABLE 5. Agronomic performance of soybean varieties for various planting dates at Knoxville, 1966.

| Character | Variety | Planting date | | | | | | | Mean | L.S.D. (.05)[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 June | 6 June | 9 June | 16 June | 22 June | 28 June | 1 July | | |
| Stand count, no. plants per 6 ft. | Harosoy 63 | 52.0 | 60.0 | 63.0 | 48.8 | 48.0 | 58.5 | 56.2 | 55.2 | D = 10.5 |
| | Clark 63 | 55.8 | -- | 62.0 | 75.8 | -- | -- | 60.5 | 63.5 | V = 4.5 |
| | Kent | 54.5 | 72.8 | 59.8 | 64.0 | 59.2 | 62.0 | 69.0 | 63.0 | $V_D$ = 11.9 |
| | Hill | 58.8 | 65.0 | 62.2 | 64.5 | 50.0 | 56.5 | 64.5 | 60.2 | $D_V$ = 26.1 |
| | Hood | 48.5 | 47.8 | 52.6 | 45.7 | 44.6 | 44.4 | 39.2 | 46.1 | |
| | Lee | 49.5 | 39.1 | 44.0 | 39.4 | 42.0 | 39.7 | 39.2 | 41.8 | |
| | Mean | 53.2 | 56.9 | 57.3 | 56.4 | 48.8 | 52.2 | 54.8 | 55.0 | |
| Days from planting to first flower | Harosoy 63 | 40.0 | 35.0 | 32.0 | 30.5 | 28.5 | 28.0 | 28.0 | 31.7 | D = 0.8 |
| | Clark 63 | 42.0 | -- | 41.5 | 34.0 | -- | -- | 34.0 | 37.9 | V = 0.8 |
| | Kent | 44.0 | 41.5 | 41.8 | 39.0 | 39.0 | 35.0 | 38.3 | 39.8 | $V_D$ = 1.9 |
| | Hill | 58.5 | 56.0 | 55.0 | 56.0 | 51.3 | 50.5 | 50.0 | 53.9 | $D_V$ = 2.0 |
| | Hood | 58.5 | 56.0 | 55.0 | 56.0 | 51.3 | 50.5 | 50.0 | 53.9 | |
| | Lee | 69.5 | 66.3 | 64.3 | 60.0 | 57.8 | 54.0 | 51.3 | 60.5 | |
| | Mean | 52.7 | 50.4 | 49.3 | 46.2 | 46.4 | 44.0 | 42.2 | 46.9 | |

TABLE 5 (continued)

| Character | Variety | Planting date | | | | | | | Mean | L.S.D. (.05) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 June | 6 June | 9 June | 16 June | 22 June | 28 June | 1 July | | |
| Days from first flower to termination of flowering | Harosoy 63 | 21.3 | 22.0 | 24.0 | 34.0 | 30.0 | 22.8 | 23.3 | 25.3 | D = 1.2 |
| | Clark 63 | 34.0 | -- | 31.3 | 32.0 | -- | -- | 25.5 | 30.7 | V = 1.0 |
| | Kent | 32.5 | 32.3 | 31.0 | 28.3 | 25.5 | 23.8 | 23.3 | 28.1 | $V_D$ = 2.5 |
| | Hill | 22.5 | 23.0 | 20.3 | 18.3 | 17.3 | 15.8 | 17.0 | 19.2 | $D_V$ = 3.6 |
| | Hood | 24.0 | 17.8 | 18.8 | 20.3 | 15.0 | 12.5 | 13.0 | 17.3 | |
| | Lee | 19.5 | 18.3 | 17.3 | 15.0 | 13.3 | 12.0 | 14.5 | 15.7 | |
| | Mean | 25.6 | 22.7 | 23.8 | 24.6 | 20.2 | 17.4 | 19.4 | 22.7 | |
| Days from termination of flowering to maturity | Harosoy 63 | 39.0 | 39.0 | 30.0 | 37.5 | 39.5 | 42.4 | 44.0 | 40.1 | D = 1.0 |
| | Clark 63 | 45.0 | -- | 47.0 | 51.8 | -- | -- | 49.8 | 48.4 | V = 0.8 |
| | Kent | 54.8 | 60.5 | 59.0 | 60.3 | 60.0 | 61.0 | 58.5 | 59.1 | $V_D$ = 2.2 |
| | Hill | 57.0 | 55.8 | 62.2 | 60.2 | 60.2 | 59.0 | 57.5 | 58.8 | $D_V$ = 3.1 |
| | Hood | 67.2 | 67.8 | 67.2 | 66.2 | 69.5 | 69.0 | 75.0 | 68.3 | |
| | Lee | 68.0 | 68.2 | 69.0 | 67.8 | 67.8 | 70.2 | 68.8 | 68.5 | |
| | Mean | 55.2 | 58.3 | 57.2 | 57.3 | 58.6 | 60.3 | 58.9 | 50.5 | |

TABLE 5 (continued)

| Character | Variety | Planting date: 1 June | 6 June | 9 June | 16 June | 22 June | 28 June | 1 July | Mean | L.S.D. (.05) |
|---|---|---|---|---|---|---|---|---|---|---|
| Height at first flower, in. | Harosoy 63 | 18.8 | 13.5 | 11.3 | 9.0 | 11.3 | 8.5 | 8.8 | 10.2 | D = 1.6 |
| | Clark 63 | 16.8 | -- | 15.8 | 10.8 | -- | -- | 13.0 | 14.1 | V = 1.0 |
| | Kent | 18.0 | 17.8 | 17.3 | 12.0 | 17.3 | 15.8 | 18.3 | 16.6 | $V_D$ = 2.8 |
| | Hill | 27.5 | 28.5 | 26.0 | 28.3 | 25.5 | 28.5 | 27.5 | 27.4 | $D_V$ = 4.4 |
| | Hood | 25.0 | 28.5 | 28.3 | 27.5 | 26.0 | 26.3 | 25.5 | 26.7 | |
| | Lee | 35.2 | 35.0 | 34.0 | 30.0 | 31.8 | 30.3 | 28.8 | 32.2 | |
| | Mean | 23.6 | 24.7 | 22.1 | 19.6 | 22.4 | 21.8 | 20.3 | 21.2 | |
| Height at maturity, in. | Harosoy 63 | 29.0 | 31.0 | 28.5 | 27.2 | 31.8 | 32.0 | 31.8 | 30.2 | D = 1.0 |
| | Clark 63 | 36.8 | -- | 36.2 | 35.8 | -- | -- | 35.2 | 36.0 | V = 0.8 |
| | Kent | 36.0 | 37.0 | 36.8 | 36.8 | 38.0 | 36.2 | 35.8 | 36.7 | $V_D$ = 2.2 |
| | Hill | 32.2 | 33.8 | 32.5 | 34.5 | 32.5 | 34.5 | 34.2 | 33.5 | $D_V$ = 3.0 |
| | Hood | 33.8 | 35.8 | 34.2 | 34.2 | 34.5 | 36.0 | 34.2 | 34.7 | |
| | Lee | 37.8 | 37.8 | 36.8 | 34.8 | 36.0 | 36.2 | 33.8 | 36.2 | |
| | Mean | 34.3 | 35.1 | 34.2 | 33.9 | 34.6 | 35.0 | 34.2 | 29.6 | |

TABLE 5 (continued)

| Character | Variety | Planting date | | | | | | | Mean | L.S.D. (.05) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 June | 6 June | 9 June | 16 June | 22 June | 28 June | 1 July | | |
| Days from planting to maturity | Harosoy 63 | 100.3 | 96.0 | 95.0 | 102.0 | 98.0 | 93.3 | 95.3 | 97.1 | D = 0.7 |
| | Clark 63 | 121.0 | -- | 119.8 | 117.8 | -- | -- | 109.2 | 117.0 | V = 0.7 |
| | Kent | 131.2 | 134.2 | 131.8 | 127.6 | 124.5 | 119.8 | 120.1 | 127.0 | $V_D$ = 1.7 |
| | Hill | 138.0 | 134.8 | 137.6 | 134.6 | 128.8 | 125.3 | 124.5 | 131.9 | $D_V$ = 2.4 |
| | Hood | 153.2 | 148.8 | 147.0 | 144.0 | 135.8 | 133.8 | 139.8 | 143.2 | |
| | Lee | 157.0 | 152.8 | 150.6 | 142.8 | 138.8 | 136.2 | 134.6 | 44.7 | |
| | Mean | 133.4 | 133.3 | 130.3 | 128.1 | 125.2 | 121.7 | 120.6 | 126.8 | |
| Lodging score | Harosoy 63 | 2.0 | 2.8 | 2.2 | 1.5 | 2.0 | 3.0 | 3.0 | 2.4 | D = 0.5 |
| | Clark 63 | 3.0 | -- | 3.0 | 2.5 | -- | -- | 3.8 | 3.1 | V = 0.3 |
| | Kent | 3.0 | 3.2 | 2.5 | 2.0 | 3.2 | 3.5 | 3.2 | 2.9 | $V_D$ = 0.9 |
| | Hill | 3.5 | 2.8 | 2.5 | 1.8 | 2.5 | 3.5 | 3.8 | 2.9 | $D_V$ = 1.3 |
| | Hood | 2.8 | 2.8 | 3.2 | 3.8 | 3.8 | 4.0 | 4.5 | 3.6 | |
| | Lee | 3.2 | 4.5 | 4.0 | 3.8 | 5.0 | 4.5 | 4.8 | 4.3 | |
| | Mean | 2.9 | 3.2 | 2.9 | 2.6 | 3.3 | 3.7 | 3.8 | 3.2 | |

TABLE 5 (continued)

| Character | Variety | Planting date 1 June | 6 June | 9 June | 16 June | 22 June | 28 June | 1 July | Mean | L.S.D. (.05) |
|---|---|---|---|---|---|---|---|---|---|---|
| Grain yield, bu. per acre | Harosoy 63 | 37.5 | 37.2 | 37.0 | 32.9 | 41.9 | 42.0 | 41.3 | 38.5 | D = 3.6 |
| | Clark 63 | 54.2 | -- | 55.6 | 48.0 | -- | -- | 47.5 | 51.3 | V = 1.8 |
| | Kent | 64.6 | 61.5 | 58.0 | 54.4 | 54.8 | 46.8 | 46.0 | 55.2 | $V_D$ = 2.9 |
| | Hill | 56.2 | 54.9 | 50.4 | 49.8 | 48.1 | 42.8 | 37.1 | 48.5 | $D_V$ = 2.9 |
| | Hood | 48.5 | 47.8 | 52.6 | 45.7 | 44.6 | 44.4 | 39.2 | 46.1 | |
| | Lee | 49.0 | 39.1 | 44.0 | 39.4 | 42.0 | 39.7 | 39.2 | 41.8 | |
| | Mean | 51.7 | 48.1 | 49.6 | 45.0 | 46.3 | 43.1 | 41.7 | 46.9 | |
| Seed size, g. per 200 seeds | Harosoy 63 | 28.8 | 30.4 | 29.7 | 31.0 | 31.8 | 34.0 | 32.8 | 31.2 | D = 1.1 |
| | Clark 63 | 35.9 | -- | 34.6 | 33.6 | -- | -- | 32.3 | 34.1 | V = 0.8 |
| | Kent | 38.3 | 40.9 | 39.6 | 40.0 | 40.5 | 39.0 | 38.1 | 39.5 | $V_D$ = 2.2 |
| | Hill | 28.0 | 28.4 | 28.4 | 28.0 | 27.8 | 28.3 | 26.8 | 25.1 | $D_V$ = 3.2 |
| | Hood | 32.8 | 32.1 | 32.6 | 32.3 | 30.8 | 32.0 | 32.0 | 32.1 | |
| | Lee | 31.0 | 29.8 | 29.8 | 29.3 | 29.7 | 29.3 | 29.5 | 29.8 | |
| | Mean | 32.5 | 32.3 | 32.4 | 32.4 | 32.1 | 32.5 | 31.9 | 32.0 | |

TABLE 5 (continued)

| Character | Variety | Planting date 1 June | 6 June | 9 June | 16 June | 22 June | 28 June | 1 July | Mean | L.S.D. (.05) |
|---|---|---|---|---|---|---|---|---|---|---|
| Seed quality score[c] | Harosoy 63 | 3.0 | 2.5 | 2.0 | 1.8 | 1.8 | 2.0 | 1.2 | 2.0 | $D = 0.4$ |
| | Clark 63 | 2.8 | -- | 2.2 | 2.8 | -- | -- | 2.0 | 2.4 | $V = 0.3$ |
| | Kent | 4.2 | 2.2 | 2.0 | 1.8 | 2.0 | 1.5 | 2.8 | 2.4 | $V_D = 0.6$ |
| | Hill | 1.5 | 1.0 | 1.2 | 1.2 | 1.5 | 1.2 | 1.0 | 1.2 | $D_V = 0.9$ |
| | Hood | 1.0 | 1.2 | 1.5 | 1.0 | 1.0 | 1.2 | 1.2 | 1.2 | |
| | Lee | 1.5 | 1.8 | 1.8 | 2.0 | 1.5 | 1.8 | 2.5 | 1.8 | |
| | Mean | 2.3 | 1.7 | 1.8 | 1.8 | 1.6 | 1.5 | 1.8 | 1.8 | |
| Purple stain score[c] | Harosoy 63 | 1.0 | 1.2 | 2.0 | 2.2 | 2.0 | 2.0 | 1.0 | 1.6 | $D = 0.2$ |
| | Clark 63 | 3.8 | -- | 2.0 | 1.0 | -- | -- | 1.0 | 1.7 | $V = 0.1$ |
| | Kent | 1.8 | 1.8 | 1.2 | 1.5 | 1.0 | 1.0 | 1.0 | 1.0 | $V_D = 0.3$ |
| | Hill | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | $D_V = 0.6$ |
| | Hood | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | |
| | Lee | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | |
| | Mean | 1.6 | 1.2 | 1.4 | 1.3 | 1.2 | 1.2 | 1.0 | 1.3 | |

[a]Least significant difference at the .05 probability level. D = difference among planting dates, V = difference among varieties, $V_D$ = difference among varieties at the same planting date, $D_V$ = difference among planting dates for the same variety.

[b]1 = no lodging, 5 = completely lodged.

[c]1 = desirable, 5 = undesirable.

standpoint of obtaining stands. In this experiment an attempt was made to establish 10 plants per foot of row and results in Table 5, page 17, show that even though fewer plants were present, adequate stands were obtained at all planting dates. Other experiments in the southeastern U. S. have shown that variation in the number of plants per foot of row does not affect yield if at least two to three per foot are present [Leffel and Barber (1961), Caviness and Taylor (1964)].

Time and duration of flowering and time of maturity. The period from planting to maturity was subdivided into three intervals: (1) planting to first flowering; (2) flowering period; and (3) termination of flowering to maturity. A delay in time of planting caused a reduction in the time interval from planting to first flower (Figure 3). This was also the case with the flowering period, but Harosoy 63 had a markedly prolonged flowering period when planted on 16 and 22 June. The time from planting to first flowering was greater for the late varieties than early varieties in contrast to the flowering period which was longer for earlier varieties than late varieties. The period from termination of flowering to maturity was not affected by planting date for all varieties (Figure 3). Similar results have been reported by Brown and Owen (1961), Garner and Allard (1920), Hartwig (1954) and Johnson *et al*. (1960). Leffel (1961) found, however, that in Maryland all three phases of development were shortened as a consequence of delay in planting.

Figure 4 indicates that the date of maturity of all varieties was later as a result of a delay in planting. The later maturing

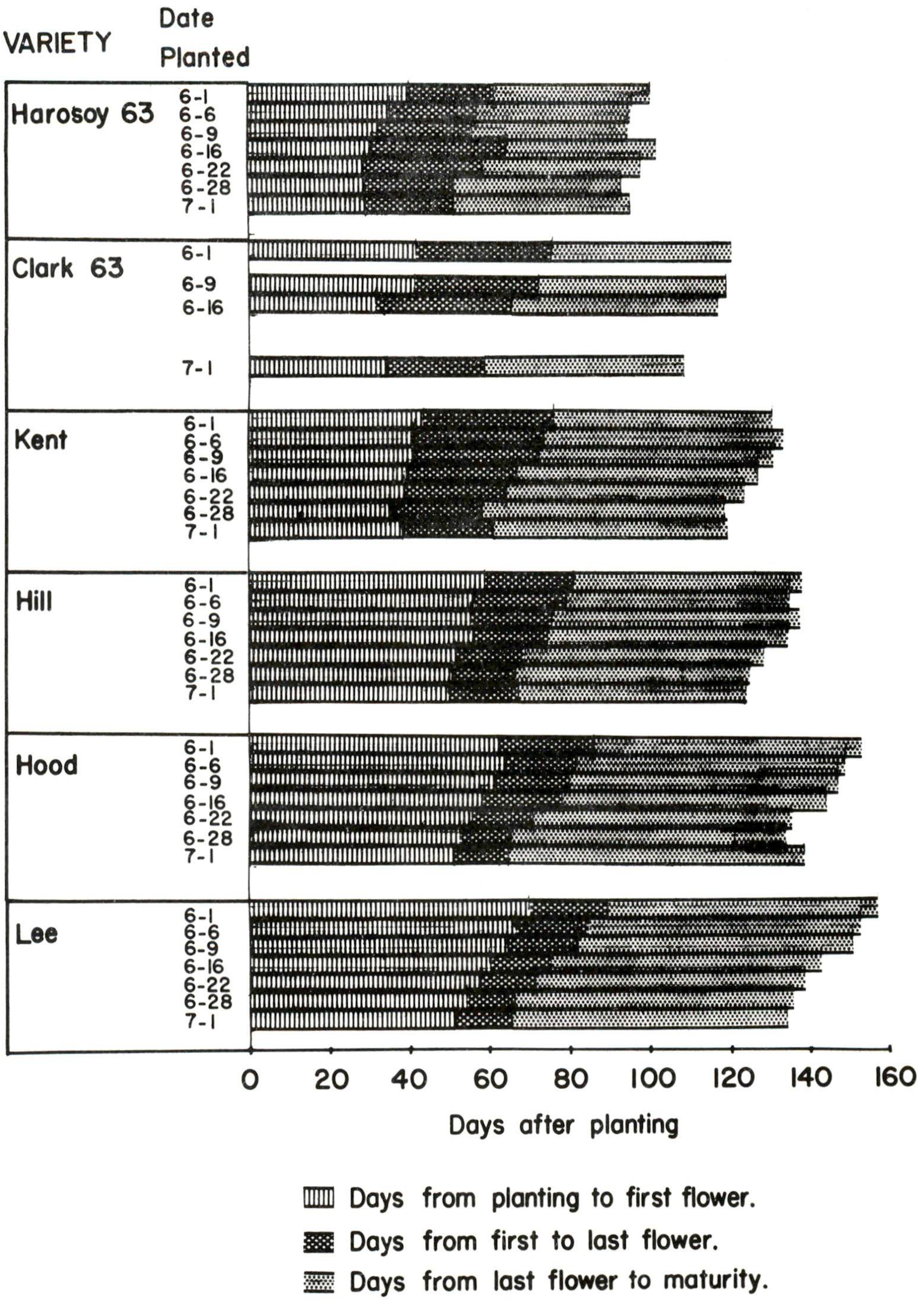


Fig. 3. The periods from planting to first flower, first flower to last flower, and last flower to maturity for six soybean varieties at various planting dates.

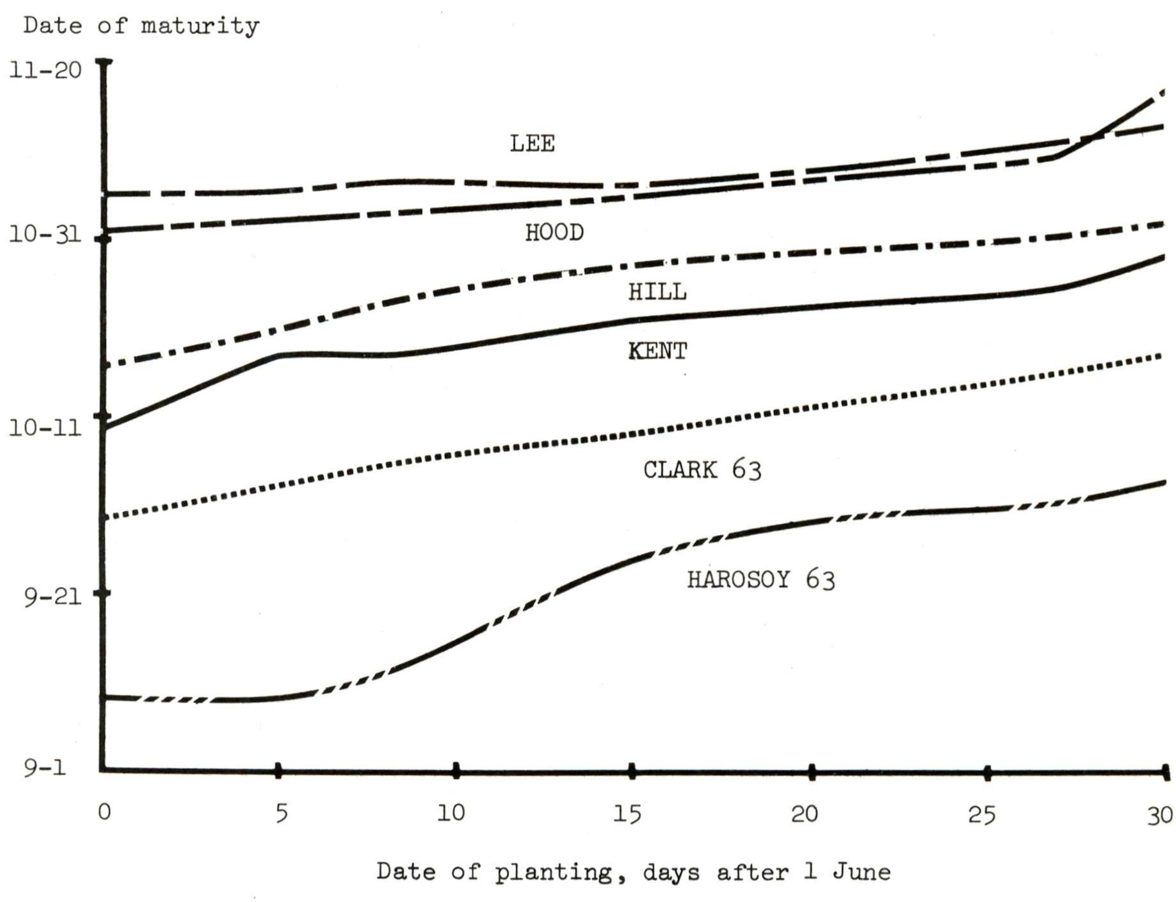


Fig. 4. The relationship of time of maturity to planting date for six soybean varieties.

varieties were affected less by a delay in planting than were the genetically earlier varieties. Regression coefficients in Table 6 indicate that for each day delay in planting after 1 June, the maturity of Lee was delayed approximately one-fourth day; Kent, Hood, and Hill about one-half day, and Clark 63 and Harosoy 63 from three-fourths to one day. Lee matured later than the other varieities at all planting dates except for 1 July where Hood was latest. Fall freezing hastened maturity of Lee and Hood. Osler and Cartter (1954), Weiss _et al._ (1950), Torrie and Briggs (1955), Leffel (1961), and Hartwig (1954) also found that time of maturity was affected more for early varieties than for late varieties. However, Henson and Carr (1946) found that in Mississippi later planting times had less effect on earlier varieties than later varieties.

The soybeans must mature sufficiently early for barley to be planted in the fall if double-cropping of barley and soybeans is to be successful. Double-cropping is not expected to reduce barley yields if the barley is planted early enough in the fall. Since planting after 15 October might result in an unsuccessful barley crop, Lee and Hood (Figure 4, page 25) would be too late for double-cropping purposes.

_Plant height_. Date of planting did not affect plant height at the first flower appreciably for the six varieties used in this experiment (Figure 5). The later varieties (Lee, Hill, and Hood) were considerably taller when flowering initiated than the earlier varieties

TABLE 6. Regression of maturity and yield on planting time for six soybean varieties at Knoxville, 1966

| Variety | Maturity[a] | Yield[b] |
|---|---|---|
| Harosoy 63 | .94 | .18 |
| Clark 63 | .70 | -.38 |
| Kent | .51 | -.68 |
| Hill | .50 | -.56 |
| Hood | .44 | -.50 |
| Lee | .25 | -.22 |

[a]Days delay in maturity per day delay in planting after 1 June.

[b]Bushels per acre per day delay in planting after 1 June.

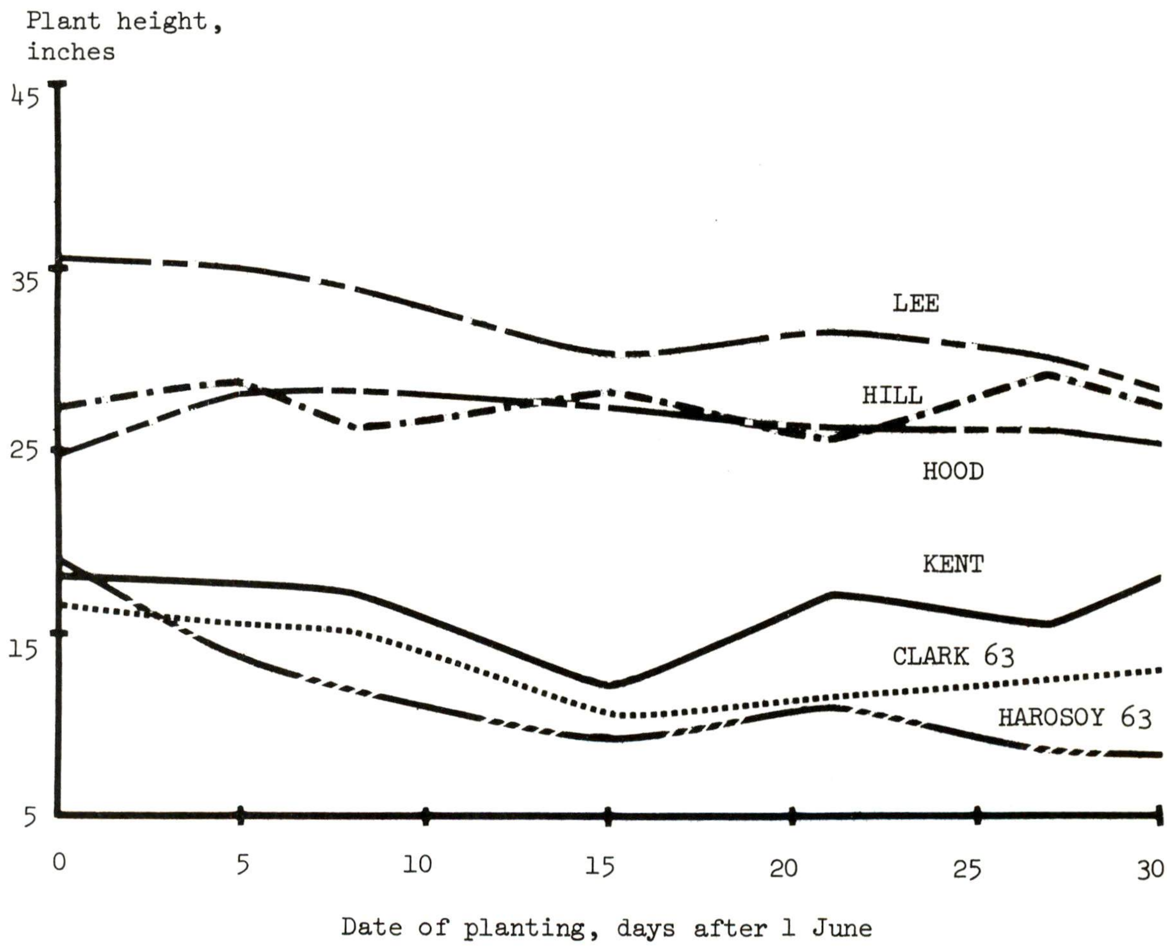


Fig. 5. Plant height at the time of first flower for six soybean varieties at various planting dates.

(Kent, Clark 63, and Harosoy 63). The early variety Harosoy 63 had a plant height of 19 inches at the first flower for the 1 June planting date and a height of approximately 9 inches for 1 July planting date and was affected more by date of planting than the other varieties.

Plant height at maturity was relatively constant for all varieties in spite of a 30-day range in time of planting (Figure 6). Hill and Harosoy 63 showed a slight increase in plant height as a result of later planting, but all varieties were approximately the same height when planted 1 July. Harosoy 63 was shorter than other varieties. Most experiments have indicated a reduction in plant height at maturity as a result of a delay in planting [Leffel (1961), Osler and Cartter (1954), and Torrie and Briggs (1955)]. Leffel (1961) found that the decrease in plant height with a delay in planting was greater for late maturing varieties than for early varieties. Smith _et al_. (1961) and Hartwig (1954) indicated that plant height at maturity was reduced by late planting, but that midseason plantings tend to produce taller plants than for earlier or later seeding dates.

Plant height is an important factor in soybean production, particularly as it is related to lodging. Lodging becomes more likely with tall plants resulting in harvesting difficulties and poor seed quality. Hartwig (1954) indicated, in addition to a reduction in plant height from late plantings, there is a tendency for pods to be formed so close to the soil surface that they are left in the field after combining.

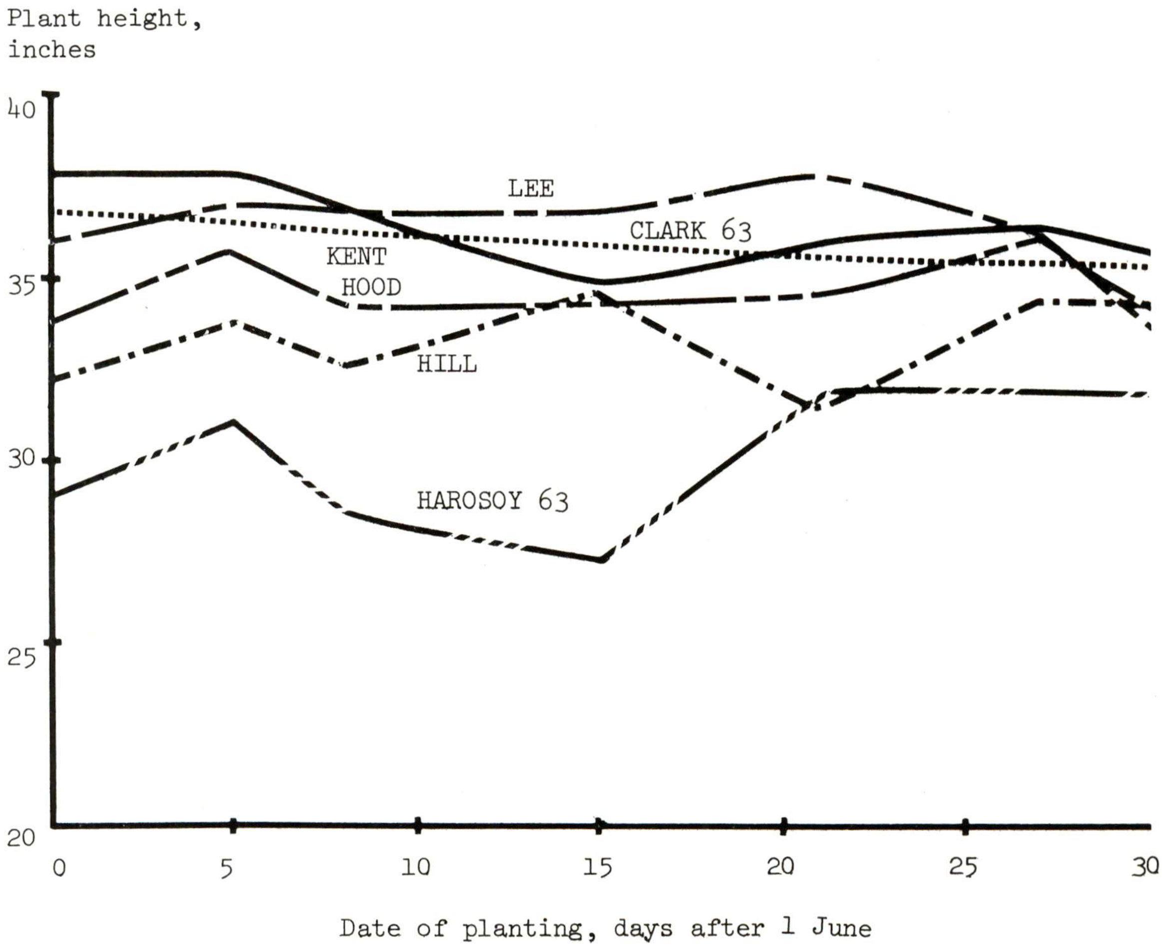


Fig. 6. Plant height at maturity for six soybean varieties at various planting dates.

Lodging. The interaction of varieties with planting dates for lodging was non-significant, but differences among varieties were found (Table 4, page 16). As indicated by Table 5, page 17, Clark 63, Hood, and Lee lodged greater than Harosoy 63, Hill, or Kent. It can also be noted from Table 5, page 17, that there was a greater degree of lodging as time of planting was delayed, which corresponds to the findings of Osler and Cartter (1954), Caviness and Smith (1959), and Nelson and Roberts (1962). Leffel (1961) stated that in Maryland maximum lodging occurred when plantings were made from 30 May to 30 June. Smith et al. (1961) reported that earlier varieties lodged less than late maturing varieties at late dates of planting. Most experiments, therefore, indicated a greater degree of lodging with lateness of planting.

Grain yield. Yield of each variety is depicted in Table 5, page 17, and Figure 7. Kent produced the highest yield for all planting dates except 1 July where Clark 63 was highest. There was a general decrease in yields with delay in time of planting. The yields of both Lee and Hood were greater when planted on 9 June than 6 June but yields were reduced at subsequent planting dates. Regression coefficients in Table 6, page 27, indicate that for each day delay in planting after 1 June the yields of Hood and Hill were decreased about one-half bushel per acre. The grain yield of Kent, the variety with the highest yield in this experiment, was reduced more by late planting than the other varieties. In spite of a reduction of 0.68 bushel per acre each day

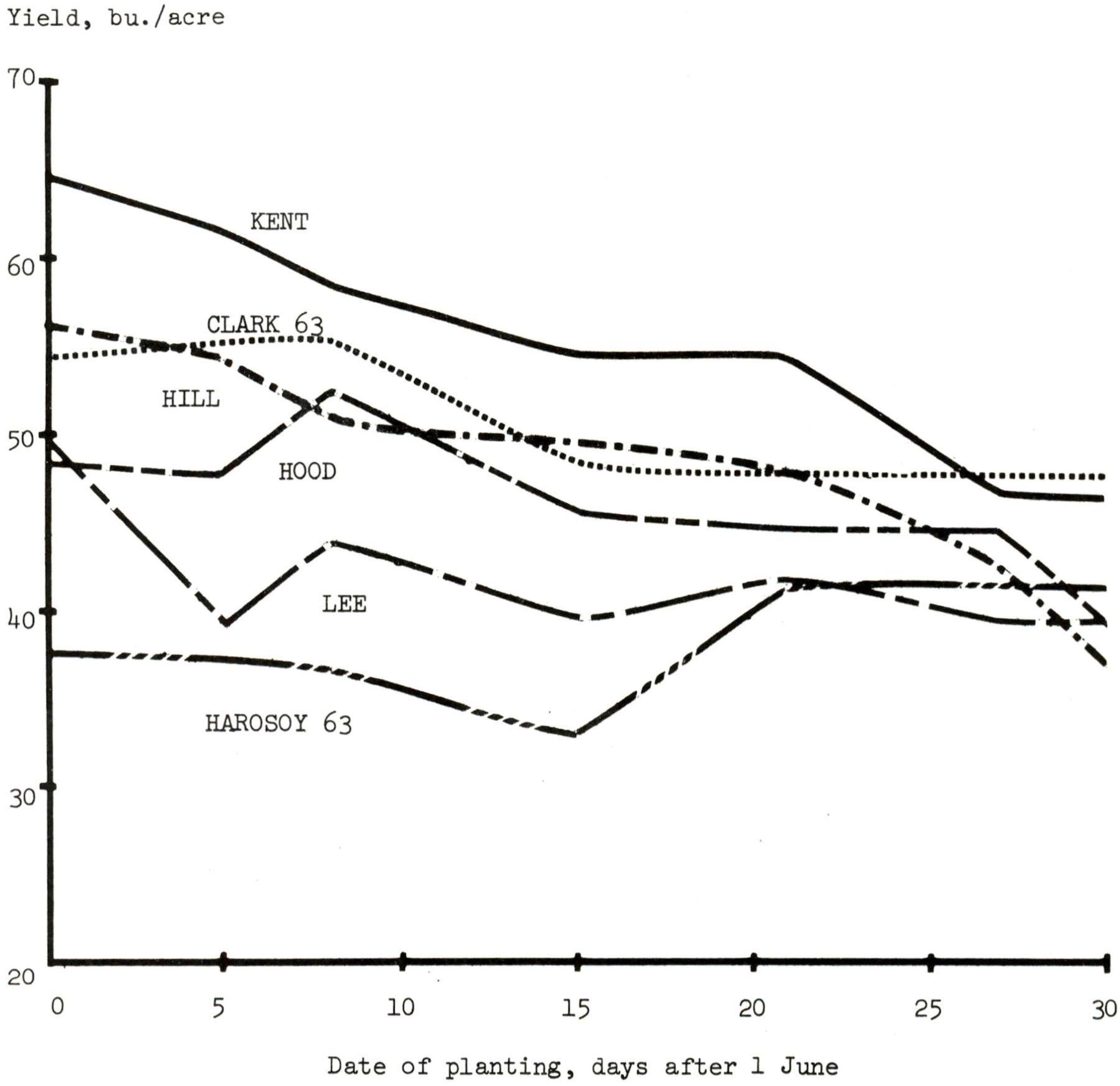


Fig. 7. Grain yield of six soybean varieties at various planting dates.

that planting was delayed after 1 June, Kent was a high yielding variety at all planting dates. The yields of Lee and Clark 63 were decreased 0.22 and 0.38 bushel per acre per day delay in planting, respectively. Harosoy 63, the very early maturing variety, generally produced the lowest grain yield in the experiment, but showed an increase in yield (0.18 bu. per acre per day) as a result of later planting.

Most other experiments indicated a decline in grain yields as a result of delayed time of planting [Caviness and Smith (1959), Nelson and Roberts (1962), Hartwig (1954), Leffel (1961), and Smith et al. (1961)]. There is discrepancy, however, among experiments concerning the relative reduction in yield among varieties of different maturity groups. Weiss et al. (1950) and Torrie and Briggs (1955) indicated that the yield of early varieties in Iowa and Wisconsin, respectively, did not differ significantly for various planting dates while yield of later varieties decreased progressively with dates after 1 May. In contrast, Hartwig (1954) and Caviness and Smith (1959) working in Mississippi and Arkansas, respectively, reported a greater reduction for early varieties than for medium and medium-late maturing varieties from late planting.

In the present experiment, there was no clear relationship between yield reduction and maturity as affected by planting date (Table 6, page 27).

In a barley-soybean double-cropping system, a high yielding soybean variety is desirable, but it must mature in sufficient time (prior to about 15 October ) to plant barley. As previously mentioned (see Figure 4, page 25), the late maturity of Hood and Lee decrease their desirability for double-cropping with barley. Hill, planted after 16 June, also matured later than desirable for barley planting, but would probably be satisfactory in most years. The yield of Harosoy 63 was low; however, it is likely that the yield of Harosoy 63 could be increased by closer row spacings because with its determinate type of growth the 36-inch inter-row areas were not completely shaded. Kent and Clark 63 produced good grain yields and would be easy to manage in a two-crop system with barley because both of them mature relatively early which would give sufficient time to plant the barley.

Seed size. Seed size was not affected by delaying planting time (Table 5, page 17). Harosoy 63 showed a slight increase in seed size in the later plantings. Kent had the largest seeds at all planting dates, approximately 40 grams per 200 seeds, while Hill was the smallest with about 28 grams per 200 seeds (Figure 8). Osler and Cartter (1954) also found that seed size was not appreciably affected by a delay in planting, whereas Smith et al. (1961) and Leffel (1961) have indicated a decrease in seed size with a delay in time of planting.

Seed quality. Seed quality and purple stain scores were low for all varieties in this experiment at all planting dates (Table 5, page 17). Seed quality was better for late maturing varieties than for early varieties; however, the quality of seed of earlier maturing varieties was better in the later plantings than in the earlier plantings.

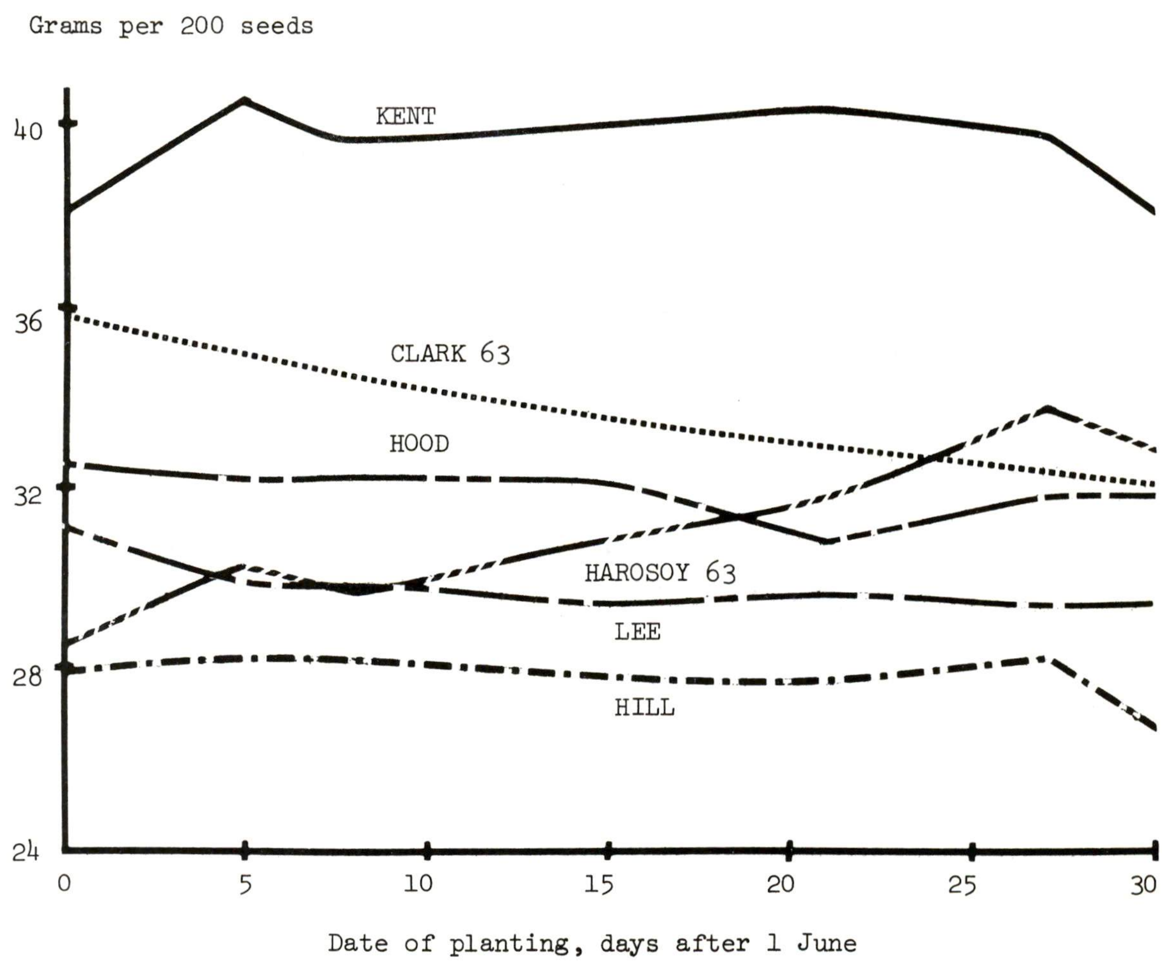


Fig. 8. Seed size for six soybean varieties at various planting dates.

Leffel (1961) found similar results, but indicated that in some instances both early and late planted early varieties had poor quality seed. Other experiments have indicated better seed quality with a delay in time of planting [Torrie and Briggs (1955), Smith *et al.* (1961), Abel (1961), and Green *et al.* (1965)]. Hartwig (1954) and Smith *et al.* (1961) reported better seed quality with late varieties with little effect of dates of planting. Caviness and Smith (1959) obtained superior quality seed with mid-season varieties.

## Economic Evaluation of Double-Cropping System

Net income to land, labor, and management per acre of soybeans single-cropped and in a two-crop system with Barsoy is presented in Table 7. Barsoy was considered in the economic evaluation of the double-cropping system. The other barley varieties, since they produced less than Barsoy, were not evaluated. Net income for soybeans planted after the Barsoy harvest date (6 June) was also computed which gives an evaluation of double-cropping if the time of soybean planting was delayed after barley harvest. In combination with various soybean varieties at different planting dates, net income of barley and soybeans was not significantly greater than that of the corresponding soybean variety alone. Variety means indicate, however, that the net income among varieties differed significantly. In the double-cropping system, Barsoy and Kent produced the greatest net income for all planting dates, except 1 July where Barsoy and

TABLE 7. Net income per acre from grain yield for six soybean varieties, single- and double-cropped with Barsoy barley at various soybean planting dates

| Variety | Soybeans only 1 June | Barsoy barley + soybeans 6 June | 9 June | 16 June | 22 June | 28 June | 1 July | Mean | L.S.D. (.05)[a] |
|---|---|---|---|---|---|---|---|---|---|
| Harosoy 63 | $ 66.40 | $ 74.80 | $74.10 | $63.20 | $87.20 | $87.40 | $85.70 | $ 76.90 | D = $8.60 |
| | | | | | | | | | V = 5.90 |
| Clark 63 | 111.00 | -- | 123.80 | 103.20 | -- | -- | 102.20 | 110.10 | $V_D$ = 15.60 |
| Kent | 138.80 | 139.50 | 130.40 | 120.60 | 121.70 | 100.20 | 97.80 | 121.30 | $D_V$ = 25.20 |
| Hill | 116.20 | 121.90 | 110.10 | 108.00 | 103.70 | 89.60 | 74.30 | 103.40 | |
| Hood | 94.40 | 102.90 | 115.40 | 97.10 | 94.40 | 94.00 | 80.30 | 97.00 | |
| Lee | 98.40 | 109.30 | 92.70 | 80.60 | 87.60 | 81.40 | 80.20 | 90.10 | |
| Mean | 104.20 | 109.70 | 107.80 | 95.60 | 98.90 | 90.50 | 86.60 | 99.00 | |

[a]Least significant difference at the .05 probability. D = difference among planting dates, V = differences among varieties, $V_D$ = difference among varieties at the same planting date, $D_V$ = difference among planting dates for the same variety.

Clark 63 were the greatest. Barsoy and Hill also produced profitable net incomes. Relatively high net incomes were obtained from double-cropping Barsoy with either Hood or Lee at most planting dates, but Hood and Lee mature too late to be used in a barley-soybean cropping system where barley is to be planted after the soybeans are harvested. Hood and Lee might be more favorable in a wheat-soybean system since wheat can usually be planted later than barley. However, most wheat varieties mature later than barley varieties so that the net income for soybeans planted after 16 June should be considered. Values in Table 7, page 37, show no significant advantage for Hood or Lee over Hill or Kent for planting dates after 16 June.

A higher net income would be obtained for the Barsoy-Kent double-cropping system if the grain loss due to shattering from hail damage and straw yield is considered (Table 8). Considering only the 6 June planting, the net income would be increased $9.20 per acre if an estimated shatter loss of 9.5 bushels per acre is added to the 37.7 bu. per acre yield for Barsoy, making the net income for the two-crop system $148.70. In areas where straw is marketable, an increase in net income may be obtained by the sale of straw. Straw yield of 3.5 tons per acre at $15 per ton would increase net income $24.50 per acre when baling, hauling, and storage costs are considered (Keller and Lard, 1965). Thus, the total net income to land, labor, and management of the Barsoy-Kent double-cropping system would be $173.20, giving a

TABLE 8. Net income per acre for soybeans single-cropped, and for soybeans double-cropped with Barsoy when the barley grain yields were adjusted for shatter loss and income from straw was included

| Variety | Soybeans only | Barsoy barley + soybeans | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 June | 6 June | 9 June | 16 June | 22 June | 28 June | 1 July | Mean | L.S.D. (.05)[a] |
| Harosoy 63 | \$ 66.40 | \$108.50 | \$107.80 | \$ 96.90 | \$110.90 | \$111.10 | \$119.40 | \$105.79 | D = \$8.60 |
| Clark 63 | 111.00 | --- | 157.50 | 136.90 | --- | --- | 135.90 | 138.99 | V = 5.90 |
| Kent | 138.80 | 173.20 | 164.10 | 154.30 | 155.40 | 133.90 | 131.50 | 140.19 | $V_D$ = 15.60 |
| Hill | 116.20 | 155.60 | 143.80 | 141.70 | 137.40 | 123.30 | 108.00 | 132.29 | $D_V$ = 25.20 |
| Hood | 94.40 | 136.60 | 149.10 | 130.80 | 128.10 | 127.70 | 114.00 | 125.89 | |
| Lee | 98.40 | 143.00 | 126.40 | 114.30 | 121.30 | 115.10 | 113.00 | 118.99 | |
| Mean | 104.20 | 143.40 | 141.50 | 129.30 | 132.60 | 124.20 | 120.30 | 127.89 | |

[a]Least significant difference at the .05 probability level. D = difference among planting dates, V = difference among varieties, $V_D$ = differences among varieties at the same planting date, $D_V$ = difference among planting dates for the same variety.

significant increase of $34.40 for the double-cropping system as compared to Kent cropped alone. Therefore, double-cropping is advantageous with Barsoy and Kent being the best combination of varieties. Hill and Clark 63 also would be suitable in a double-cropping system with Barsoy. Expected net income from Barsoy and other soybean varieties planted at different dates with the adjusted grain yield and the value of the straw considered are given in Table 8, page 39.

# CHAPTER IV

## SUMMARY AND CONCLUSIONS

A one-year double-cropping experiment using barley and soybeans was conducted at the Knoxville Plant Science Farm on a Sequatchie soil. Six varieties each of barley and soybeans differing in time of maturity were used. Barley was planted in the fall and soybeans planted immediately after the harvest of each barley variety. Due to wind and hail damage, normal maturity of barley was prevented, thus planting dates of soybeans were based on estimates of time of maturity of the barley varieties. The range in planting dates of soybeans was from 1 June to 1 July.

Barley test and kernel weight and grain yield were lower than normally expected while straw yield was high for the varieties harvested. Barsoy and Harrison produced the highest grain yields and had sufficient lodging resistance to be favorable varieties for a double-cropping system with soybeans. Because of its early maturity, Barsoy was best suited for double-cropping. Will, Dayton, and Hudson lodged severely and Tenn. 60-34 matures rather late for soybeans to be planted after the barley harvest.

Significant soybean variety x date of planting interactions were found for most characters. Delay in time of planting had more effect on maturity date and yield than it did on plant height and seed size, quality, or purple stain.

Maturity of all soybean varieties was delayed with lateness of planting and the delay in maturity was greater for the earlier varieties than late varieties. Early varieties flowered at a lower height than later varieties, but plant height was approximately the same for all varieties at plant maturity.

There was a general reduction in soybean yields of an average of .36 bu. per acre for each day delay in planting after 1 June. However, Harosoy 63 increased in yield at later plantings. Kent produced the highest yield but was affected more by delayed planting while Lee was affected least. Kent, Clark 63, and Hill were the most suitable soybean varieties for a double-cropping system.

For double-cropping purposes, Barsoy barley and Kent soybeans was the best combination of varieties. Because the barley grain yields were reduced by wind and hail damage, the net income per acre obtained from grain production of both crops was not significantly greater than that of soybeans cropped alone. However, if the grain loss due to hail damage and straw yield was included, then Barsoy-Kent double-cropping would return $34.40 per acre more than soybeans single-cropped. This is an expected increase in net income of 24.8 per cent. Since yield of soybeans decreased with lateness of planting, double-cropping would have less advantage at later planting dates, hence an early maturing barley variety, such as Barsoy, would be advantageous.

For the most favorable barley-soybean double-cropping system for conditions similar to those of this experiment, the barley variety should have a high yield potential, mature before 10 June, and have good winterhardiness and lodging resistance. The most suitable soybean variety should have a high yield potential, begin flowering within 40 days after planting, have a flowering period of approximately 30 days, and mature about 120 days after planting. Of the varieties used in this experiment, Barsoy barley and Kent soybeans most nearly met these requirements.

Other considerations increase the advantage of double-cropping over single-cropping. In this study the use of the same machinery for both crops was considered and custom harvesting was assumed, but because of the increased usage it might be economical for a grower to own his own harvestor. There may also be advantages to having a crop such as barley on the soil during the winter months.

# LITERATURE CITED

LITERATURE CITED

Abel, G. H., Jr. 1961. Response of soybeans to dates of planting in the Imperial Valley of California. Agron. J. 53:95-98.

Bernard, R. L. 1964. Hawkeye 63, Harosoy 63, and Chippewa 64 soybeans. Crop Sci. 4:663.

Brown, D. M., and Owen, C. W. 1961. Effect of photoperiod on soybean development. Soybean Dig. 21(7):14-16.

Caldwell, R. M., Compton, L. E., Patterson, F. L., and Schafer, J. F. 1966. Registration of Harrison barley. Crop Sci. 6:387.

Caviness, C. E., and Smith, P. E. 1959. Effect of different dates and rates of planting soybeans. Ark. Agric. Exp. Sta. Rep. Series 88.

________, and Taylor, M. 1964. Row spacings and soybean seeding dates. Ark. Farm Res. 13(2):12.

Finkner, V. C. 1965. Proposed release of winter barley variety, K. 60-586, C.I. 11904. Mimeo. Univ. of Kentucky, Lexington, Ky.

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. J. Agric. Res. 18:553-606.

Green, D. E., Pinnell, E. L., Cavannah, L. E., and Williams, L. F. 1965. Effect of planting date and maturity date on soybean seed quality. Agron. J. 57:165-168.

Hartwig, E. E. 1954. Factors affecting time of planting soybeans in southern states. U. S. Dept. Agric. Cir. No. 943.

Henson, P. R., and Carr, R. S. 1946. Soybean varieties and dates of planting in the Yazoo-Mississippi Delta. Miss. Agric. Exp. Sta. Bul. 428.

Jackson, B. R., Schlehuber, A. M., Oswalt, R. M., Wood, E. A., and Peck, R. A. 1964. Will winter barley. Okla. Exp. Sta. Bul. B-631.

Jenson, N. F. 1964. Registration of Hudson barley. Crop Sci. 4:238.

Johnson, H. W. 1958. Registration of soybean varieties. VI. Agron. J. 50:690-691.

_______. 1960. Registration of soybean varieties. VII. Agron. J. 52:659-660.

_______, Borthwick, H. A., and Leffel, R. C. 1960. Effects of photoperiod and time of planting on rates of development of the soybean in various stages of the life cycle. Bot. Gaz. 122:77-95.

Keller, L. H., and Lard, C. F. 1965. Production requirements, estimated costs and returns from selected crop and livestock enterprises in Tennessee. Unpublished manuscript. Univ. of Tenn.

Leffel, R. C. 1961. Planting date and varietal effects on agronomic and seed compositional characters in soybeans. Maryland Agric. Exp. Sta. Bul. A-117.

_______, and Barber, G. W., Jr. 1961. Row widths and seeding dates in soybeans. Maryland Agric. Exp. Sta. Bul. 470.

Nelson, C. E., and Roberts, S. 1962. Effect of plant spacing and planting date on six varieties of soybeans. Wash. Agric. Exp. Sta. Bul. 639.

Osler, R. D., and Cartter, J. L. 1954. Effect of planting date on chemical composition and growth characteristics of soybeans. Agron. J. 46:267-269.

Parks, W. L., Bell, F. F., and McCutchen, T. 1965. Unpublished results. Tenn. Agr. Exp. Sta.

Probst, A. H., and Athow, K. L. 1964. Registration of Kent soybeans. Crop Sci. 4:240.

Revelle, Roger. 1966. Population and food supplies: The edge of the knife. Proc. Nat. Acad. Sci. 56:328-351.

Smith, T. J., Camper, H. M., Carter, M. T., Jones, G. D., and Alexander, M. W. 1961. Soybean performance in Virginia as affected by variety and planting date. Va. Agr. Exp. Sta. Bul. 526.

Torrie, J. H., and Briggs, G. M. 1955. Effect of planting date on yield and other characteristics of soybeans. Agron. J. 47: 210-212.

Weiss, M. G., Weber, C. R., Williams, L. F., and Probst, A. H. 1950. Variability of agronomic and seed compositional characters in soybeans, as influenced by variety and time of planting. U. S. Dept. Agric. Tech. Bul. 1017.

Wiebe, G. A., and Reid, D. A. 1961. Classification of barley varieties grown in the United States and Canada in 1958. U. S. Dept. Agric. Tech. Bul. 1224.

Williams, L. F., and Bernard, R. L. 1964. Clark 63 soybeans. Crop Sci. 4:663.