

SOYBEAN PRODUCTION ON SOME MAJOR SOILS IN TENNESSEE

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INTRODUCTION

The acreage and total value of soybeans in Tennessee have increased rapidly over the past 10 years. In 1971, the year this research project was initiated, there were 1.3 million harvested acres of soybeans in Tennessee, having a total value of \$98.2 million [8]. During this same 10-year period the average soybean yield per harvested acre in Tennessee remained essentially constant at the 23- to 24-bushel level.

These statistics caused several questions to be raised in the minds of producers and researchers alike.

Is 24 bushels per acre a true measure of Tennessee's soybean production potential? . . . or,

Could the average yield of soybeans be increased significantly through closer attention to the land selection factor and through the use of improved management practices? . . . and, Would the increased returns resulting from higher yields be enough to outweigh the increased management input costs and result in higher profit for the growers?

OBJECTIVES

In an attempt to find answers to these questions, the soybean research begun in 1971 had two major objectives.

- 1) To measure the soybean production potentials of major soils within the soybean-producing areas of Tennessee, using all production practices recommended by the University of Tennessee Institute of Agriculture.
- 2) To obtain data on costs and returns of producing soybeans on soils representing specific geographic and physiographic regions within the soybean-producing areas of the state, using all production practices recommended by the University of Tennessee Institute of Agriculture

Part I of this publication reports the data obtained under the first of the two objectives during the 3-year duration of the study. The data obtained from the phase of the study defined by the second objective is reported in Part II.

The research was a cooperative effort of the Tennessee Agricultural Experiment Station and the Tennessee Farm Bureau Federation.

PART I

SOYBEAN PRODUCTION POTENTIALS OF SOME MAJOR TENNESSEE SOILS

by George J. Buntley

OBJECTIVE

The objective of this phase of the study was to measure the soybean production potentials of major soils within the soybean-producing areas of Tennessee, using all production practices recommended by the University of Tennessee Institute of Agriculture.

SITE SELECTION AND SOILS

Fourteen off-station locations and six Experiment Station fields were selected as research sites (Figure 1). All sites were on major soil mapping units for the geographical areas in which they occurred.



Figure 1. Location of research sites.

Since both objectives of the research were directly involved with measurements on individual soils, the selection of soils was an important input of the study.

All soils selected for use in the study are identified and briefly described here as background to later comparisons and discussion.

Bowdre: The Bowdre soils are somewhat poorly-drained Mississippi River Delta soils. They have dark grayish-brown, silty clay or clay surface and subsoil horizons about 16 inches thick over a loamy substratum. The Bowdre soils are classified within the clayey over loamy, mixed, thermic family of Aquic Fluventic Hapludolls. The Bowdre site was in Lake County and the mapping unit at the site was Bowdre silty clay, 0 to 2% slopes.

Calloway: The Calloway soils are somewhat poorly-drained upland soils in West Tennessee. These soils have grayish-brown silt loam surface horizons, yellowish-brown silt loam upper subsoils, and grayish-brown silt loam lower subsoils. The lower subsoils are dense fragipans. The Calloway soils are classified within the fine-silty, mixed, thermic family of Glosaquic Fragiudalfs. Calloway soils occurred on two study sites. The mapping unit at the Gibson County site was Calloway silt loam, 0 to 2% slopes, and that on the Experiment Station field at Martin was Calloway silt loam, 2% to 5% slopes.

Collins: The Collins soils are moderately well-drained soils of the bottomlands and drainageways in West Tennessee. They have brown silt loam, surface horizons, and brown mottled with gray silt loam subsoils. The Collins soils are classified within the coarse-silty, mixed, acid family of Aquic Udifluvents. Collins soils occurred on two study sites. The mapping unit at the Gibson County site was Collins loam, 0 to 2% slopes and that on the bottomland field at the Milan Experimental Station was Collins silt loam, 0 to 2% slopes.

Commerce: The Commerce soils are somewhat poorly-drained Mississippi River Delta soils. These soils are characterized by dark grayish-brown silt loam surface horizons and dark grayish-brown silt loam or silty clay loam subsoils. They are classified within the fine-silty, mixed, nonacid, thermic family of Aeris Fluvaquents. The Commerce site was in Lake County and the mapping unit at the site was Commerce silt loam, 0 to 2% slopes.

Dekoven: The Dekoven soils are poorly-drained low upland and terrace soils in West Tennessee. Although considered to be upland soils, they behave more like bottomland soils. They have very dark grayish-brown silt loam surface horizons and very dark gray to dark gray silt loam subsoils. These soils are classified within the fine-silty, mixed, thermic family of Fluventic Haplaquolls. The Dekoven site was in the Houser Valley in Obion County and the mapping unit at the site was Dekoven silt loam, 0 to 2% slopes.

Dickson: The Dickson soils are moderately well-drained upland soils of the Highland Rim area of Middle Tennessee. These soils have brown silt loam surface horizons, yellowish-brown silt loam subsoils, and a fragipan beginning at depths of about 30 inches. They are classified within the fine-silty, siliceous, thermic family of Orchreptic Fragiudults. Dickson soils occurred on two study sites. The mapping unit at the Coffee County site was Dickson silt loam, 2 to 5% slopes, and that in

the Highland Rim Experiment Station field was Dickson silt loam, 5 to 8% slopes, eroded.

Falaya: The Falaya soils are somewhat poorly-drained bottomland soils in West Tennessee. They are characterized by brown silt loam surface horizons, mottled brown silt loam upper subsoils and mottled grayish-brown lower subsoils. These soils are classified within the coarse-silty, mixed, acid, thermic family of Aeric Fluvaquents. Falaya soils occurred on two study sites. The mapping unit at both the Tipton and McNairy County sites was Falaya silt loam, 0 to 2% slopes.

Grenada: The Grenada soils are moderately well-drained upland soils in West Tennessee. These soils have grayish-brown, silt loam surface horizons, yellowish-brown, heavy silt loam upper subsoils overlying dense fragipans beginning at about 24 inches. They are classified within the fine-silty, mixed, thermic family of Glossic Fragiudalfs. The Grenada soils occurred at three study sites. The mapping unit at the Fayette County site was Grenada silt loam, 5 to 8% slopes, eroded, in 1971 and Grenada silt loam, 5 to 8% slopes, severely eroded in 1972-73. The mapping unit in the Martin Experiment Station field was Grenada silt loam, 5 to 8% slopes, eroded, and in the upland field at the Milan Experiment Station was Grenada silt loam, 0 to 2% slopes.

Henry: The Henry soils are poorly-drained soils of upland depressions in West Tennessee. These soils are characterized by brown, silt loam surface horizons; gray, buck-shotty, silt loam upper subsoils which in turn are underlain by gray, silt loam fragipans beginning at about 30 inches. They are classified within the coarse-silty mixed thermic family of Typic Fragi-aqualfs. The Henry site was in the upland field at the Milan Experiment Station and the mapping unit was Henry silt loam, 0 to 2% slopes.

Loring: The Loring soils are moderately well-drained upland soils in West Tennessee. They have brown, silt loam surface horizons; brown, silt loam upper subsoils and fragipans beginning at about 28 inches. The Loring soils are classified within the fine-silty, mixed, thermic family of Typic Fragiudalfs. The Loring site was in Tipton County and the mapping unit at the site was Loring silt loam, 5 to 8% slopes.

Maury: The Maury soils are well-drained upland soils of the Outer Central Basin area of Middle Tennessee. These soils have dark reddish-brown to reddish-brown silt loam surface horizons and yellowish-red, clayey subsoils. They are classified within

the clayey, mixed, mesic family of Typic Paleudults. The Maury site was on the Middle Tennessee Experiment Station and the mapping unit at the site was Maury silt loam, 2 to 5% slopes.

Memphis: The Memphis soils are well-drained upland soils in West Tennessee. These soils have dark grayish-brown, silt loam surface horizons and dark brown, silty clay loam subsoils. They are classified within the fine-silty, mixed, thermic family of Typic Hapludalfs. The Memphis soils occurred at two study sites. The mapping unit at the Fayette County site in 1971 was Memphis silt loam, 2 to 5% slopes, and in 1972-73 was Memphis silt loam, 2 to 5% slopes, severely eroded. The mapping unit at the Ames Plantation field was Memphis silt loam, 0 to 2% slopes.

Mountview: The Mountview soils are well-drained upland soils of the Highland Rim area of Middle Tennessee. They have brown, silt loam surface horizons and strong brown, silt loam and silty clay loam, grading with depth to yellowish-red, cherty silty clay loam or clay loam subsoils. These soils are classified within the fine-silty siliceous, thermic family of Typic Paleudults. The Mountview site was in Coffee County and the mapping unit at the site was Mountview silt loam, 2 to 5% slopes, eroded.

Routon: The Routon soils are poorly-drained soils of depressions and nearly level uplands and terraces in West Tennessee. These soils have dark grayish-brown, silt loam surface horizons and strongly mottled, light brownish-gray silt loam and silty clay loam subsoils. They are classified within the fine-silty, mixed, thermic family of Typic Ochraqualfs. The Routon site was in Obion County and the mapping unit at the site was Routon silt loam, 0 to 2% slopes.

Sango: The Sango soils are moderately well-drained soils of upland flats and depressions in the Highland Rim area of Middle Tennessee. They have pale-brown, silt loam surface horizons, light yellowish-brown, silt loam upper subsoils, and a fragipan beginning at about 28 inches. These soils are classified within the coarse-silty, siliceous, thermic family of Glossic Fragiudalfs. The Sango site was on the Highland Rim Experiment Station field and the mapping unit was Sango silt loam, 0 to 2% slopes.

Vicksburg: The Vicksburg soils are well-drained soils on nearly level bottomlands in West Tennessee. They are characterized by dark grayish-brown, silt loam surface horizons and dark

brown to dark yellowish-brown, silt loam subsoils. These soils are classified within the coarse-silty, mixed, acid, thermic family of Typic Udifluvents. Vicksburg soils occurred at two study sites. The mapping unit at the McNairy County site was Vicksburg loam 0 to 2% slopes, and that in the bottomland field at the Milan Experiment Station was Vicksburg silt loam, 0 to 2% slopes.

METHODS AND PROCEDURES

The off-station sites selected were 1 acre in size and in all cases included only one soil mapping unit. These were divided into two half-acre plots; one was used as the high-level management plot and the other as the cooperator-managed check plot. High-level management was defined as the use of all soybean production practices recommended by the University of Tennessee Institute of Agriculture [9]. This consisted of the preparation of a level, moderately-firm seedbed; the application of lime and fertilizer following soil test recommendations; the use of high-quality seed of a recommended variety (in this study the variety York was used where cyst nematodes were not present and the variety Pickett 71 was used where cyst nematodes were present); the use of inoculant in fields where soybeans had not been grown recently; the adherence to recommended planting dates and seeding rates; and the use of the appropriate combination of preplant, preemergence, and postemergence herbicides at label rates plus timely cultivation for the control of weeds present.

The management level of the check plot at each off-station location consisted of whatever combination of production practices the farmer-cooperator at each particular location used on the rest of his field that year.

In 1971, three 60-foot rows from the high-level management plot and three from the cooperator-managed check plot were hand-harvested at all off-station locations for yield measurements [3]. Rows from the high-management plots were selected to exclude obvious environmental accidents and management skips that would cause yield reductions that were not related to the productivity potential of the soil. Rows harvested from the cooperator-managed check plots also were selected to exclude obvious environmental accidents and management skips that were not representative of the cooperator's overall management level. All off-station half-acre plots were machine-harvested for comparison of management-level yield differences.

In 1972 and 1973 a slightly different sampling and harvesting procedure was used for the off-station plots than that used in 1971

[4]. Six randomly-selected, 60-foot rows were hand-harvested for yield measurement from the high-level management plot and from the cooperator-managed check plot at all off-station locations. The half-acre plots were not machine-harvested in 1972 and 1973 because of inconvenience to the cooperator and difficulties encountered in transporting harvesting equipment from site to site in 1971.

For purposes of comparing the 3-year yield data from the off-station plots, the three selected hand-harvested rows from the 1971 harvest procedure were considered comparable to the three high rows from the six randomly-selected rows harvested in 1972 and 1973. The machine-harvested yields obtained from the half-acre plots in 1971 also were considered to be comparable to the average of the six randomly selected rows harvested in 1972 and 1973.

Research fields at Experiment Stations ranged from 4 to 5 acres in size. Four of the six fields selected had two soil mapping units within the field. The other two fields had only one soil mapping unit per field. High-level management, as previously defined, was applied at all on-station locations. All labor, equipment, materials, and other production inputs were recorded as basic data for the production economics analysis phase of the study. Three selected 60-foot row samples were hand-harvested for yield measurement from each soil mapping unit in the field at all locations each year. The entire fields also were machine-harvested at all locations each year for yield and economic returns.

All yields reported were calculated on a standard basis of 13% moisture and 1% or less foreign material.

RESULTS AND DISCUSSION

Yield by years, yield range within years, yield range among years, and average yield across years of the high-level management plots on the individual soils at all off-station and on-station sites are reported in Tables 1 through 24.

The yields reported in these tables for the off-station sites fall into three categories. The high row yield is that of the highest-yielding 60-foot row sample. The second yield parameter is the average of the three highest-yielding 60-foot row samples. The half-acre field yield on the off-station plots is the actual machine-harvested yield from the half-acre plot in 1971 and is the average of the six randomly-selected 60-foot row samples in 1972 and 1973. Yield parameters reported for the on-station sites are the same as those for the off-station sites except that the yields reported for production fields are the machine-harvested yields from the entire 4- to 5-acre field.

Table 1. Summary of yields from high-level management plot on Bowdre silty clay, 0 to 2% slopes in Lake County, 1971-72

	Bushels per acre				
	1971	1972	1973	Maximum range among years	2-year average
High row	43.2	37.6	*—	5.6	40.4
Average of 3 high rows	38.3	35.8	—	2.5	37.5
Half-acre field	39.3	32.7	—	6.6	36.0
Maximum row sample range	9.0	8.6	—		
Standard deviation among row samples	4.5	3.7			

*Not planted in 1973 because of the extremely wet conditions throughout the planting season.

Table 2. Summary of yields from high-level management plot on Calloway silt loam, 0 to 2% slopes in Gibson County, 1971-73

	Bushels per acre				
	1971	1972	1973	Maximum range among years	3-year average
High row	52.8	51.3	41.0	11.8	48.4
Average of 3 high rows	45.4	43.9	39.9	5.5	43.1
Half-acre field	40.0	39.1	37.7	2.3	38.9
Maximum row sample range	12.8	20.3	9.9		
Standard deviation among row samples	6.6	7.0	3.5		

Table 3. Summary of yields for Calloway silt loam, 2 to 5% slopes in high-level management field at the Martin Experiment Station, 1971-73

	Bushels per acre				
	1971	1972	1973	Maximum range among years	3-year average
High row	49.7	33.3	27.1	22.6	36.7
Average of 3 rows	47.9	30.8	25.0	22.9	34.6
Production field	*—	—	—	—	—
Maximum row sample range	2.7	5.7	6.1		
Standard deviation among row samples	1.6	2.9	3.5		

*Field also included Grenada soils.

Table 4. Summary of yields for Collins silt loam, 0 to 2% slopes in high-level management field at the Milan Experiment Station, 1971-73

	Bushels per acre				
	1971	1972	1973	Maximum range among years	3-year average
High row	55.7	37.5	48.1	18.2	47.1
Average of 3 high rows	52.9	35.8	46.9	17.1	45.2
Production field	—	—	—	—	—
Maximum row sample range	4.5	2.9	2.4		
Standard deviation among row samples	2.4	1.5	1.2		

*Field also included Vicksburg soils.

Table 5. Summary of yields from high-level management plot on Collins loam, 0 to 2% slopes in Gibson County, 1971-73

	Bushels per acre				
	1971	1972	1973	Maximum range among years	3-year average
High row	47.3	38.8	41.9	8.5	42.7
Average of 3 high rows	44.5	37.9	39.7	6.6	40.7
Half-acre field	40.4	36.9	36.8	3.6	38.0
Maximum row sample range	6.9	3.8	11.5		
Standard deviation among row samples	3.6	1.3	4.0		

Table 6. Summary of yields from high-level management plot on Commerce silt loam, 0 to 2% slopes in Lake County, 1971-72

	Bushels per acre				
	1971	1972	1973	Maximum range among years	2-year average
High row	44.4	45.9	*—	1.5	45.2
Average of 3 high rows	43.4	44.7	—	1.3	44.1
Half-acre field	46.8	41.6	—	5.2	44.2
Maximum row sample range	1.9	9.7	—		
Standard deviation among row samples	1.1	3.9	—		

*Not planted in 1973 because of the extremely wet conditions throughout the planting season.

Table 7. Summary of yields from high-level management plot on Dekoven silt loam, 0 to 2% slopes in Obion County, 1971-73

	Bushels per acre				
	1971	1972	1973	Maximum range among years	3-year average
High row	54.3	42.7	46.6	11.6	47.9
Average of 3 high rows	40.7	38.7	44.2	5.5	41.2
Half-acre field	38.5	36.0	41.0	5.0	38.5
Maximum row sample range	23.7	13.4	10.9		
Standard deviation among row samples	12.2	4.3	3.9		

Table 8. Summary of yields from high-level management plot on Dickson silt loam, 2 to 5% slopes in Coffee County, 1971-73

	Bushels per acre				
	1971	1972	1973	Maximum range among years	3-year average
High row	39.5	36.0	29.5	10.0	35.0
Average of 3 high rows	37.2	34.7	28.4	8.8	33.4
Half-acre field	32.8	32.4	27.0	5.8	30.7
Maximum row sample range	5.8	9.8	4.9		
Standard deviation among row samples	3.1	3.5	1.9		

Table 9. Summary of yields for Dickson silt loam, 5 to 8% slopes, eroded in high-level management field at the Highland Rim Experiment Station, 1971-73

	Bushels per acre				
	1971	1972	1973	Maximum range among years	3-year average
High row	42.0	42.7	38.0	4.7	40.9
Average of 3 high rows	41.6	38.6	34.7	6.9	38.3
Production field	—	—	—	—	—
Maximum row sample range	0.7	7.9	5.6		
Standard deviation among row samples	0.3	4.5	2.9		

*Field also included Sango soils.

Table 10. Summary of yields from high-level management plot on Falaya silt loam, 0 to 2% slopes in McNairy County, 1971-73

	Bushels per acre				
	1971	1972	1973	Maximum range among years	3-year average
High row	55.8	40.1	35.8	20.0	43.9
Average of 3 high rows	51.0	35.9	34.0	17.0	40.3
Half-acre field	47.3	32.3	32.3	15.0	37.3
Maximum row sample range	7.6	10.8	7.1		
Standard deviation among row samples	4.2	5.0	2.4		

Table 11. Summary of yields from high-level management plot on Falaya silt loam, 0 to 2% slopes in Tipton County, 1971-73

	Bushels per acre				
	1971	1972	1973	Maximum range among years	3-year average
High row	38.6	35.3	33.7	4.9	35.9
Average of 3 high rows	38.2	32.9	32.7	5.5	34.6
Half-acre field	35.8	29.2	30.9	6.6	32.0
Maximum row sample range	0.6	11.2	5.9		
Standard deviation among row samples	0.4	4.8	2.3		

Table 12. Summary of yields for Grenada silt loam, 0 to 2% slopes in high-level management field at the Milan Experiment Station, 1971-73

	Bushels per acre				
	1971	1972	1973	Maximum range among years	3-year average
High row	55.3	45.6	50.0	9.7	50.3
Average of 3 high rows	53.7	43.0	46.4	10.7	47.7
Production field	—*	—	—	—	—
Maximum row sample range	3.1	5.3	7.3		
Standard deviation among row samples	1.5	2.6	3.6		

*Field also included Henry soils.

Table 13. Summary of yields for Grenada silt loam, 5 to 8% slopes, eroded in high-level management field at the Martin Experiment Station, 1971-73

	Bushels per acre				
	1971	1972	1973	Maximum range among years	3-year average
High row	44.3	38.3	34.3	10.0	39.0
Average of 3 high rows	42.3	37.3	29.8	12.5	36.5
Production field	—	—	—	—	—
Maximum row sample range	4.2	3.1	9.2		
Standard deviation among row samples	1.9	1.8	4.6		

*Field also included Calloway soils.

Table 14. Summary of yields from high-level management plots on Grenada silt loam, 5 to 8% slopes, eroded (1971) and on Grenada silt loam, 5 to 8% slopes, severely eroded (1972-73) in Fayette County

	Bushels per acre				
	1971	1972	1973	Maximum range among years	2-year average
High row	44.7	*—	—	—	—
Average of 3 high rows	41.2	—	—	—	—
Half-acre field	37.8	—	—	—	—
Maximum row sample range	7.3	—	—	—	—
Standard deviation among row samples	3.7	—	—	—	—
High row	*—	38.3	45.3	7.0	41.8
Average of 3 high rows	—	36.5	41.9	5.4	39.2
Half-acre field	—	32.4	37.6	5.2	35.0
Maximum row sample range	—	13.6	15.1		
Standard deviation among row samples	—	5.3	5.5		

*Plot location was changed between 1971 and 1972 to accommodate cooperators.

Table 15. Summary of yields for Henry silt loam, 0 to 2% slopes in high-level management field at the Milan Experiment Station, 1971-73

	Bushels per acre				
	1971	1972	1973	Maximum range among years	3-year average
High row	61.4	39.7	45.3	24.7	48.8
Average of 3 high rows	56.5	37.6	41.6	18.9	45.2
Production field	—	—	—	—	—
Maximum row sample range	8.7	5.2	7.8		
Standard deviation among row samples	4.4	2.7	3.9		

*Field also included Grenada soils.

Table 16. Summary of yields from high-level management plot on Loring silt loam, 5 to 8% slopes, eroded in Tipton County, 1971-73

	Bushels per acre				
	1971	1972	1973	Maximum range among years	3-year average
High row	48.5	42.1	45.7	6.4	45.4
Average of 3 high rows	47.9	41.8	44.0	6.1	44.6
Half-acre field	42.6	40.8	40.4	2.2	41.3
Maximum row sample range	1.1	2.8	13.7		
Standard deviation among row samples	0.6	1.2	5.0		

Table 17. Summary of yields for Maury silt loam, 2 to 5% slopes in high-level management field at the Middle Tennessee Experiment Station, 1971-73

	Bushels per acre				
	1971	1972	1973	Maximum range among years	3-year average
High row	48.5	43.2	47.6	5.3	46.4
Average of 3 high rows	46.4	42.0	47.0	5.0	45.1
Production field	35.8	36.7	41.2	5.4	37.9
Maximum row sample range	5.3	3.3	1.7		
Standard deviation among row samples	2.3	1.8	1.0		

Table 18. Summary of yields for Memphis silt loam, 0 to 2% slopes in high-level management field at Ames Plantation, 1971-73

	Bushels per acre				
	1971	1972	1973	Maximum range among years	3-year average
High row	56.3	46.4	38.1	18.2	46.9
Average of 3 high rows	53.3	45.7	37.7	15.6	45.6
Production field	27.9	42.5	42.1	14.2	37.5
Maximum row sample range	4.9	1.4	0.8		
Standard deviation among row samples	2.6	0.7	0.4		

Table 19. Summary of yields from high-level management plots on Memphis silt loam, 2 to 5% slopes (1971) and on Memphis silt loam, 2 to 5% slopes, severely eroded (1972-73) in Fayette County

	Bushels per acre				
	1971	1972	1973	Maximum range among years	2-year average
High row	51.9	*—	—	—	—
Average of 3 high rows	49.1	—	—	—	—
Half-acre field	40.8	—	—	—	—
Maximum row sample range	5.1	—	—	—	—
Standard deviation among row samples	2.6	—	—	—	—
High row	*—	44.8	34.8	10.0	39.8
Average of 3 high rows	—	42.1	32.4	9.7	37.3
Half-acre field	—	38.3	29.1	9.2	33.7
Maximum row sample range	—	12.7	10.2		
Standard deviation among row samples	—	4.8	4.3		

*Plot location was changed between 1971 and 1972 to accommodate cooperator.

Table 20. Summary of yields from high-level management plot on Mountview silt loam, 2 to 5% slopes, eroded in Coffee County, 1971-73

	Bushels per acre				
	1971	1972	1973	Maximum range among years	3-year average
High row	37.9	32.3	29.1	8.8	33.1
Average of 3 high rows	35.9	30.6	27.8	8.1	31.4
Half-acre field	32.4	29.8	25.8	6.6	29.3
Maximum row sample range	4.5	3.3	6.8		
Standard deviation among row samples	2.3	1.2	2.8		

Table 21. Summary of yields from high-level management plot on Routon silt loam, 0 to 2% slopes in Obion County, 1971-73

	Bushels per acre				
	1971	1972	1973	Maximum range among years	3-year average
High row	43.2	34.4	36.2	8.8	37.9
Average of 3 high rows	40.9	33.8	34.9	7.1	36.5
Half-acre field	35.9	31.8	32.3	4.1	33.3
Maximum row sample range	3.8	6.8	9.0		
Standard deviation among row samples	2.0	2.7	3.5		

Table 22. Summary of yields for Sango silt loam, 0 to 2% slopes in high-level management field at the Highland Rim Experiment Station, 1971-73

	Bushels per acre				
	1971	1972	1973	Maximum range among years	3-year average
High row	45.9	43.1	47.6	4.5	45.5
Average of 3 high rows	43.7	41.7	42.6	2.1	42.7
Production field	—	—	—	—	—
Maximum row sample range	3.9	3.9	8.6		
Standard deviation among row samples	2.0	2.1	4.4		

*Field also included Dickson soils.

Table 23. Summary of yields from high-level management plot on Vicksburg loam, 0 to 2% slopes in McNairy County, 1971-73

	Bushels per acre				
	1971	1972	1973	Maximum range among years	3-year average
High row	61.5	34.7	35.5	26.8	43.9
Average of 3 high rows	55.5	31.6	33.9	23.9	40.3
Half-acre field	43.1	29.8	31.1	14.3	34.7
Maximum row sample range	11.4	4.9	5.4		
Standard deviation among row samples	5.7	3.0	3.3		

Table 24. Summary of yields for Vicksburg silt loam, 0 to 2% slopes in the high-level management field at the Milan Experiment Station, 1971-73

	Bushels per acre				
	1971	1972	1973	Maximum range among years	3-year average
High row	52.4	40.5	48.4	11.9	47.1
Average of 3 high rows	50.5	39.4	45.9	11.1	45.3
Production field	—	—	—	—	—
Maximum row sample range	5.2	2.8	4.5		
Standard deviation among row samples	2.9	1.5	2.3		

*Field also included Collins soils.

Although the high-row yields comprise an interesting statistic, the average of the three highest row samples probably comes closer to representing an attainable soybean production potential for the soils studies using current varieties and level of technology. As a consequence, the yields cited in the following discussions of the data will be those expressing the average of the three highest rows unless otherwise stated.

Yield ranges among soils on the high-level management plots were quite wide in each of the 3 years of the study. In 1971, yields across all locations averaged 45.8 bushels of soybeans per acre, but varied from a high of 56.5 bushels per acre on the Henry soil at Milan to a low of 35.9 bushels per acre on the Mountview soil in Coffee County. In 1972, yields averaged 38.0 bushels per acre but varied from 45.7 bushels per acre on the Memphis soils at Ames Plantation to 30.6 bushels per acre on the Mountview soil in Coffee County. In 1973, yields averaged 37.8 bushels per acre and ranged from 47.0 bushels per acre on the Maury soil at Spring Hill to 25.0 bushels per acre on the Calloway soil at Martin.

As would have been predicted, yield differences among soil series were not apparent in these data. This is explained primarily by the fact that the soil mapping unit, not the soil series, is the basic unit of soil interpretation. In other words, although the soils of the Memphis series basically have a higher productivity potential than those of the Grenada series, this does not say that a soil mapping unit such as Memphis silty clay loam, 8 to 12% slopes, severely eroded, will produce more soybeans than a mapping unit such as Grenada silt loam, 0 to 2% slopes.

Second, the influence on yields of variations in such things as the amount and distribution of rainfall that occurs from location to location within years and between years usually cannot be subdued over a short duration study to the degree necessary to show the effects of soil differences on yields.

An array of all the soil mapping units studied from highest to lowest average yield is shown in Table 25. In general, the highest-yielding soils were the nearly level upland soils and the better-drained bottomland soils. These relationships are shown more clearly by the breakdown of yield data in Tables 26 and 27.

As reported in Table 26, yields on West Tennessee upland soils on 0 to 2% slopes averaged about 5 bushels per acre higher than those on soils on 2 to 5 and 5 to 8% slopes over the 3-year study. The influence of slope on yield was more pronounced in 1971 when row samples from upland soils on 0 to 2% slopes averaged 52.2 bushels per acre; those from soils on 2 to 5% slopes averaged 48.5 bushels; and those from soils on 5 to 8% slopes averaged 43.7 bushels per acre. These slope-yield relationships were predictable

and are a reflection of the higher runoff and lower water-supplying capacity of the soils on steeper slopes.

Yield differences among row samples within years were not greatly different among slopes although they were slightly higher on 5 to 8% slopes than on the lesser slopes. The year to year variations in yield were greatest on the soils on more nearly level slopes

Table 25. Soils arrayed in order of highest to lowest average soy-bean yields¹

Soil mapping unit	Avg. yield bu/A		Years
Grenada silt loam, 0 to 2% slopes	47.7	² U	1971,72,73
Memphis silt loam, 0 to 2% slopes	45.6	U	1971,72,73
Vicksburg silt loam, 0 to 2% slopes	45.3	³ B	1971,72,73
Collins silt loam, 0 to 2% slopes	45.2	B	1971,72,73
Henry silt loam, 0 to 2% slopes	45.2	U	1971,72,73
Maury silt loam, 2 to 5% slopes	45.1	U	1971,72,73
Loring silt loam, 5 to 8% slopes	44.6	U	1971,72,73
Commerce silt loam, 0 to 2% slopes	44.1	B	1971,72
Calloway silt loam, 0 to 2% slopes	43.1	U	1971,72,73
Sango silt loam, 0 to 2% slopes	42.7	U	1971,72,73
Dekoven silt loam, 0 to 2% slopes	41.2	U	1971,72,73
Collins loam, 0 to 2% slopes	40.7	B	1971,72,73
Falaya silt loam, 0 to 2% slopes	40.3	B	1971,72,73
Vicksburg loam, 0 to 2% slopes	40.3	B	1971,72,73
Grenada silt loam, 5 to 8% slopes, severely eroded	39.2	U	1972,73
Dickson silt loam, 5 to 8% slopes, eroded	38.3	U	1971,72,73
Bowdre silty clay, 0 to 2% slopes	37.5	B	1971,72
Memphis silt loam, 2 to 5% slopes, severely eroded	37.3	U	1972,73
Grenada silt loam, 5 to 8% slopes, eroded	36.5	U	1971,72,73
Routon silt loam, 0 to 2% slopes	36.5	U	1971,72,73
Calloway silt loam, 2 to 5% slopes	34.6	U	1971,72,73
Falaya silt loam, 0 to 2% slopes	34.6	B	1971,72,73
Dickson silt loam, 2 to 5% slopes	33.4	U	1971,72,73
Mountview silt loam, 2 to 5% slopes, eroded	31.4	U	1971,72,73

¹Soils for which there was only 1 year's data are not included in the array.

²Upland

³Bottomland

Table 26. Yields on West Tennessee upland soils as stratified by the slope class of the soil, 1971-73

	3-year average	Average row sample range within years	Maximum yield range among years
Bushels per acre			
Soils on 0 to 2 percent slopes	45.4	7.3	12.7
Soils on 2 to 5 percent slopes	40.3	7.3	16.3
Soils on 5 to 8 percent slopes	40.4	8.2	8.0

having higher productivity potentials. Overton and Bell [10] reported this same relationship in corn yield studies on the West Tennessee Experiment Station at Jackson.

As shown in Table 27, yields on bottomland soils generally appeared to be stratified according to the drainage class of the soil. The yield on well- and moderately-drained soils averaged about 5 bushels per acre higher than those on somewhat poorly- and poorly-drained soils over the 3-year period. The effect of the drainage class of the soil on yield was most strongly expressed in 1971, a wetter than normal year. In 1971 row sample yields from well-drained bottomland soils averaged 53.6 bushels per acre; those from moderately well-drained soils averaged 48.7 bushels; those from somewhat poorly-drained soils averaged 42.7 bushels; and those from poorly-drained soils averaged 40.7 bushels. This also was a predictable yield sequence and seems to support the concept that in wetter than average years, excess water in the soil can be a yield-limiting factor on the more poorly-drained bottomland soils.

Yield differences among row samples within years were smallest on the well- and moderately-drained soils and largest on the poorly-drained soils. Again however, the year to year variations in yield were greatest on the better-drained soils having higher productivity potentials.

The relationship between the water-supplying capacity of the soil and its yielding potential is evident throughout these data, but is especially well illustrated by the differences in the 3-year average yields between the silt loam and loam types for the Vicksburg and Collins soils. Vicksburg silt loam, 0 to 2% slopes and Collins silt loam, 0 to 2% slopes, averaged 45.3 and 45.2 bushels per acre, respectively. On the other hand, Vicksburg loam, 0 to 2% slopes, and Collins loam, 0 to 2% slopes, averaged 40.3 and 40.7 bushels per acre respectively. The silt loam surface soils hold approximately .25 inch of available water per inch of soil material, or 3.00 inches of available water in the upper foot of the soil. The loam surface soils hold about .18 inch of available water per inch of soil material, or 2.16 inches of available water in the upper foot

Table 27. Yields on West Tennessee bottomland soils as stratified by the drainage class of the soils, 1971-73

	3-year average	Average row sample range within years	Maximum yield range among years
	Bushels per acre		
Well-drained soils	42.8	5.7	17.5
Moderately well-drained soils	44.6	5.2	11.8
Somewhat poorly-drained soils	39.1	7.2	6.6
Poorly-drained soils	38.8	11.2	6.3

of the soil. The additional capacity to hold .84 of an inch of available water in the silt loam types resulted in an average production of 5 or more bushels of soybeans per acre on the silt loam types than on the loam types of both series.

Although the available water holding capacity of the soil is an important factor of yield, so also is the distribution of rainfall during the growing season.

In Tennessee, the evapotranspiration—the amount of water used by an actively-growing plant plus the water lost from the soil surface by evaporation—often exceeds the amount of water that falls as rain for some period or periods during the soybean growing season. Although moisture stored in the soil tends to compensate in part for this lack of rainfall, the crop often undergoes variable intensities of moisture stress during these periods.

Soybeans have a high water requirement which is especially critical during flowering and early pod-filling. Since it is during these stages that the number of pods, number of seeds per pod, and relative size of seeds are determined, any moisture stress that occurs during these growth stages could be expected to reduce yields.

The data utilized in this aspect of the study were gathered from several sources. The yields used were taken from the yields reported in Table 28 which are the machine-harvested yields from the high-level management economic study fields on the stations. Daily rainfall records kept at each experimental field throughout the growing season as a data input of the parent study furnished the monthly precipitation figures. Data on number of days after

Table 28. Machine-harvested soybean yields from economic study fields on Experiment Stations, 1971-73

Location	Soils	Yield—bushels per acre			Avg.
		1971	1972	1973	
Milan Experiment Station	Grenada-Henry	48.2	34.5	36.2	39.6
Milan Experiment Station	Vicksburg-Collins	44.7	32.4	43.7	43.7
Martin Experiment Station	Grenada-Calloway	43.8	29.4	27.7	33.6
Ames Plantation	Memphis	27.9	42.5	42.1	37.5
Middle Tennessee Experiment Station	Maury	35.8	36.7	41.2	37.9
Highland Rim Experiment Station	Dickson-Sango	34.8	35.2	31.7	33.9
Yearly averages		39.2	35.1	37.1	
Three-year average					37.1

planting to first flower, last flower, and first full pod by varieties and locations are after Graves *et al* [7]. The average monthly potential evapotranspiration figures follow the Penman method and the values used for locations are as previously published for Tennessee [12].

The relationship for rainfall distribution and potential evapotranspiration during flowering and pod-filling to the yield of soybeans from two fields at Milan and one at Spring Hill for 1971 and 1972, the years of highest and lowest yields, respectively, during the 3-year study are presented in Figures 2 through 7 [5].

York soybeans were planted on the bottomland Vicksburg-Collins field at Milan on May 10 in 1971 (figure 2). Potential evapotranspiration losses exceeded rainfall during the first third of the flowering period. About July 17 this relationship changed and for the remainder of the flowering period and throughout the pod-filling period, the moisture received as rainfall greatly exceeded the moisture losses from evapotranspiration. Moisture stress did not appear to be a problem during most of the moisture-critical flowering and pod-filling stages and the beans grew off well, yielding 44.7 bushels per acre.

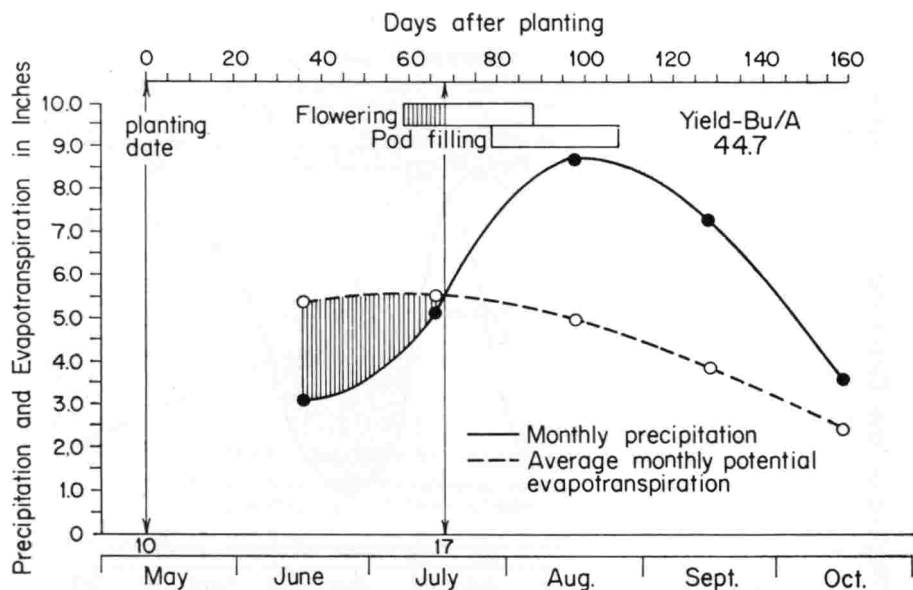


Figure 2. Relationship of rainfall distribution and potential evapotranspiration during flowering and pod-filling to the yield of York soybeans on Vicksburg-Collins soil at Milan in 1971.

York soybeans were planted in this same field on May 16 in 1972 (Figure 3). Moisture received as rainfall exceeded the moisture losses from evapotranspiration during the first half of the flowering period. Around July 30, this relationship reversed and for the last half of the flowering period and throughout the pod-filling period, the moisture losses from evapotranspiration exceeded the moisture received as rainfall. Moisture stress was apparent during much of the moisture-critical flowering and pod-filling stages. This moisture deficit was reflected in the yield of 32.4 bushels per acre which was 12.4 bushels per acre lower than the 1971 yield.

The relationship of rainfall distribution and potential evapotranspiration during flowering and pod-filling to the yield of soybeans on the upland Grenada-Henry field at Milan for 1971 and 1972 was essentially the same as on the Vicksburg-Collins field for the same years. In 1971 (Figure 4), rainfall exceeded evapotranspiration during most of the flowering and pod-filling period and the field yielded 48.2 bushels per acre. In 1972 (Figure 5) the moisture losses from evapotranspiration were greater than the rainfall during much of the flowering and pod-filling period. As a consequence, yields were limited to 34.5 bushels per acre in 1972, or 13.7 bushels per acre under the 1971 yields.

Although the 1972 yield levels at both Milan locations were

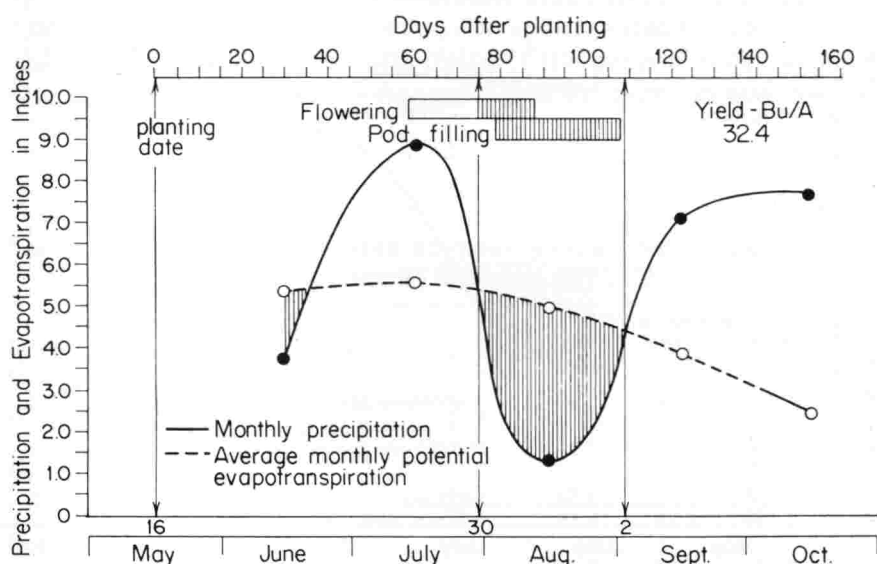


Figure 3. Relationship of rainfall distribution and potential evapotranspiration during flowering and pod-filling to the yield of York soybeans on Vicksburg-Collins soils at Milan in 1972.

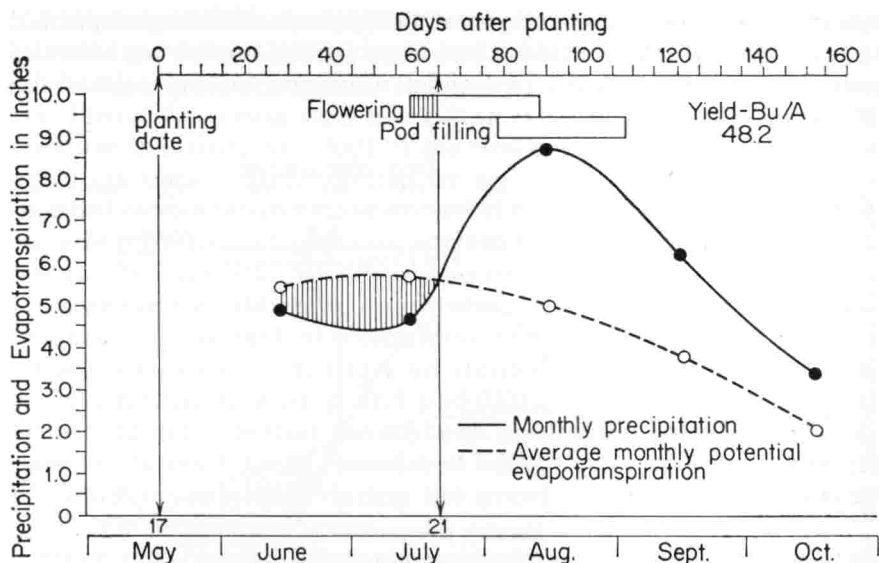


Figure 4. Relationship of rainfall distribution and potential evapotranspiration during flowering and pod-filling to the yield of York soybeans on Grenada-Henry soils at Milan in 1971.

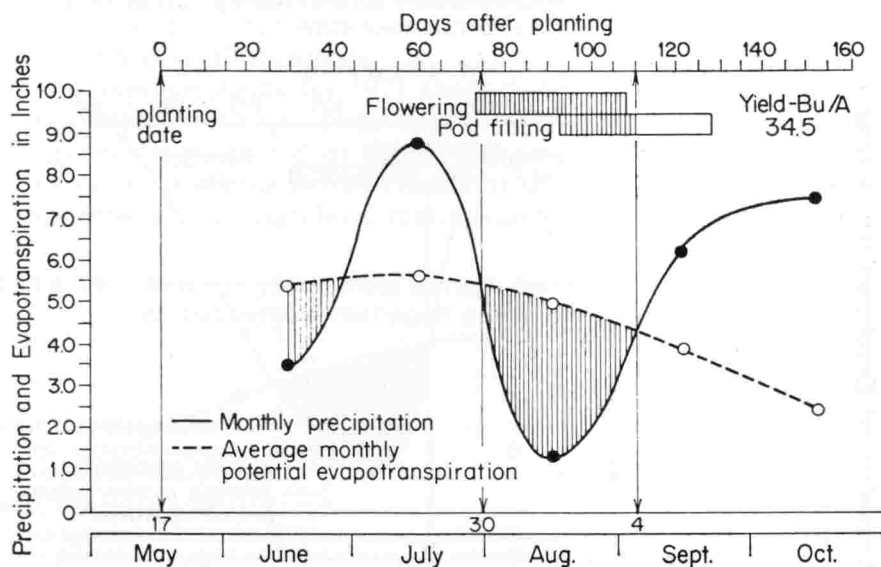


Figure 5. Relationship of rainfall distribution and potential evapotranspiration during flowering and pod-filling to the yield of Pickett soybeans on Grenada-Henry soils at Milan in 1972.

considerably lower than those of 1971, these differentials would have been even greater had it not been for the modifying effect of available moisture stored in the soil during the early part of the 1972 growing season.

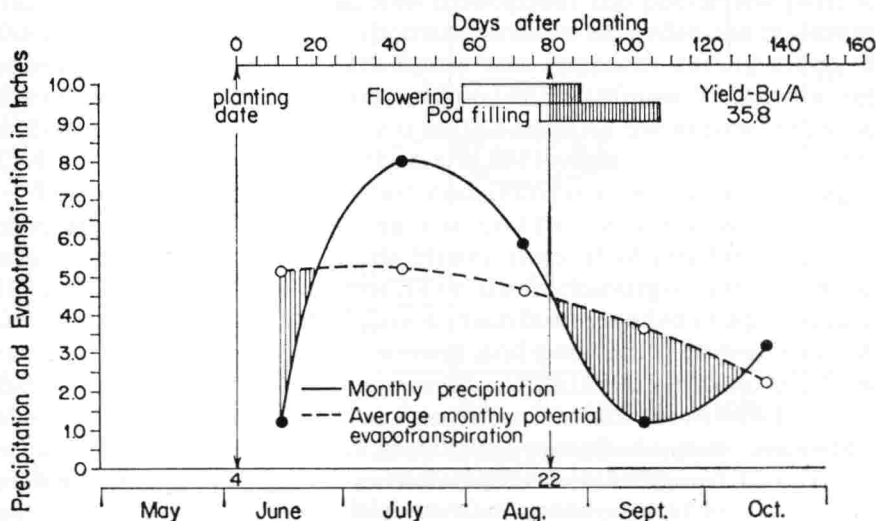


Figure 6. Relationship of rainfall distribution and potential evapotranspiration during flowering and pod-filling to the yield of York soybeans on Maury soils at Spring Hill in 1971.

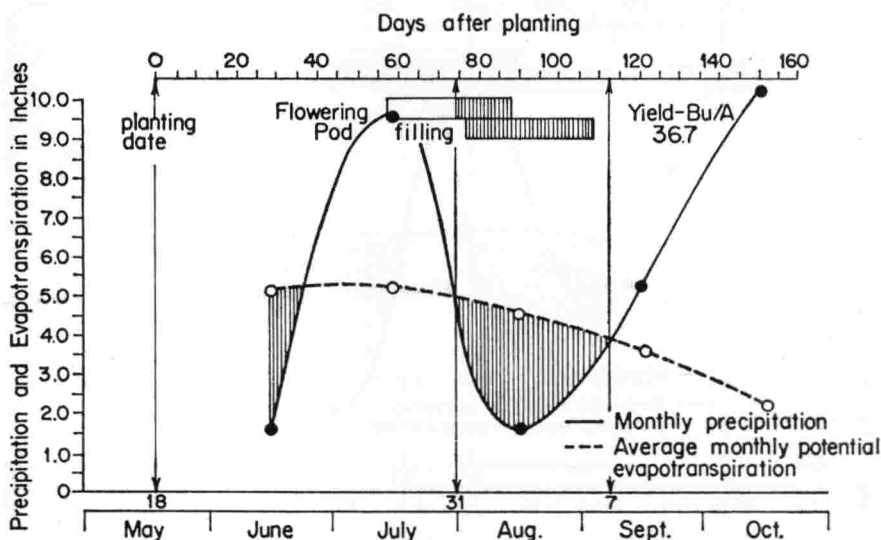


Figure 7. Relationship of rainfall distribution and potential evapotranspiration during flowering and pod-filling to the yield of York soybeans on Maury soils at Spring Hill in 1972.

At Spring Hill, York soybeans were planted on the upland Maury soils on June 4 in 1971 (Figure 6) and on May 18 in 1972 (Figure 7). The relationship between rainfall distribution and evapotranspiration during flowering and pod-filling was very similar for the 2 years—with a third to a half of the flowering period and all of the pod-filling period characterized by an environment in which the potential evapotranspiration exceeded the rainfall. This similarity also was reflected in the yields, with the 1971 and 1972 yields being 35.8 and 36.7 bushels per acre respectively.

These data would seem to indicate that even on soils like Vicksburg and Collins, both of which have high water-supplying capacities, soybean yields sometimes are limited by poor rainfall distribution during the flowering and pod-filling growth stages. This in turn would indicate that the soybean production potentials of Tennessee soils need to be considered within the context of rainfall deficiency probabilities during the growing season for the areas within which the soils occur.

Since moisture so often proves to be a limiting factor to the soybean production potentials of Tennessee soils, it is important that good management practices be used so that the available moisture can be used to best advantage.

Average yields from all high-level management research plots and all cooperator-managed check plots for the 3 years of the study are presented in Table 29. These data illustrate actual average yield differentials that were associated with different levels of management across all locations.

The average yields for 1971 through 1973 from the high-level management plots and from the cooperator-managed plots with which they were paired at the off-station locations are presented in Table 30. A simple paired-t analysis indicated that yield differences between the high-level management plots and the coopera-

Table 29. Average yields from all high-level management plots and all cooperator-managed check plots for 1971-73

	1971		1972		1973	
	n	Bu/A	n	Bu/A	n	Bu/A
West Tennessee upland soils						
High-level management plots	8	48.6	8	39.9	8	37.6
Cooperator-managed plots	2	40.8	3	36.0	3	33.4
West Tennessee bottomland soils						
High-level management plots	10	45.6	10	36.7	8	39.0
Cooperator-managed plots	8	37.8	7	33.4	4	38.7
Middle Tennessee upland soils						
High-level management plots	5	41.0	5	37.5	5	36.1
Cooperator-managed check plots	2	30.8	2	27.5	2	27.5
Tennessee state average		26.0		22.0		23.5

Table 30. Average yields from high-level management plots (HLM) paired with cooperator-managed check plots (CM) for 1971-73

Soil	Bushels per acre					
	1971		1972		1973	
	HLM	CM	HLM	CM	HLM	CM
Bowdre	38.3	43.0	35.8	41.2	—	—
Calloway	45.4	39.5	43.9	37.7	39.9 ¹	—
Collins	44.5	35.3	37.9	33.0	39.7 ¹	—
Commerce	43.4	45.8	44.7	40.4	—	—
Dekoven	40.7	38.5	38.7	28.1	44.2	40.9
Dickson	37.2	28.5	34.7	28.6	28.4	25.3
Falaya	51.0	46.0	35.9	39.5	34.0	42.0
Falaya	38.2	33.4	32.9	29.5	32.7	33.4
Grenada	—	—	36.5	26.4	41.9	34.1
Grenada	41.2 ¹	—	—	—	—	—
Loring	47.9	44.2	41.8	38.6	44.0	32.5
Memphis	49.1	43.2	—	—	—	—
Memphis	—	—	42.1	35.5	32.4	27.3
Mountview	35.9	33.0	30.6	26.3	36.5	38.4
Vicksburg	55.5	29.7	31.6 ¹	—	33.9 ¹	—
³ Mean difference	5.56		4.32		2.04	
DF	12		12		8	
t values	2.82 ²		3.43 ²		1.05 n.s.	

¹Not used in analysis.

²Significant at 5% level of probability.

tor-managed plots were significant at the 5% level of probability in 1971 and 1972, but not in 1973.

The fact that the yields from the high-level management plots were not significantly higher in 1973 than those from the cooperator-managed plots could have been the result of several factors. First, the amount and distribution of rainfall during the growing season was somewhat atypical in 1973; as a result, the earlier-planted beans on the high-level management plots were exposed to an abnormal period of moisture stress at a critical growth stage while the later-planted cooperator-managed beans had not yet reached that critical stage of growth at the time of the moisture stress. Second, the wet weather during the planting season not only delayed the cooperator's date of planting in most cases but in some instances fields remained too wet to plant at all at some locations. This reduced the number of paired observations available for use in the analysis in 1973.

These data indicate that high-level management is a positive yield factor. It also would appear from these data that yield differences resulting from management-level differences are greater in years when moisture is less of a yield-limiting factor, as was the case in 1971. Also apparent is the fact that the farmer-cooperators

in this study were above-average managers as evidenced by the differentials between their yields and the state averages for the same years.

Inadequate weed control proved to be the most yield-limiting management element during the 3 years of the study. The data in Table 31 illustrate the effect of weed competition on soybean yields at four locations in 1971. Yields reported for weed-free rows are from the high-level management research plots while yields reported for weedy rows are from an adjacent area of the field. As shown by these data, weeds drastically cut yields, even in a year when very favorable soil moisture conditions existed throughout the growing season. Cockleburs appeared to cause greater reductions in yield than did johnsongrass.

Table 31. Effect of weed competition on soybean yields at four locations in 1971

A. Maury silt loam, MTES	Bu./A
Avg. of 3 weed-free 60-foot rows	46.4
7 mature johnsongrass plants per 60 feet of row	33.2
17 mature johnsongrass plants per 60 feet of row	32.9
29 mature johnsongrass plants per 60 feet of row	24.1
B. Memphis silt loam, Ames Plantation	Bu./A
Avg. of 3 weed-free 60-foot rows	53.3
446 individual stalks of johnsongrass per 60 feet of row	35.9
45 cockleburs and 38 individual stalks of johnsongrass per 60 feet of row	18.9
C. Routon silt loam, Obion County	Bu./A
Avg. of 3 weed-free 60-foot rows	40.9
Avg. of 3 weedy 60-foot rows, avg. of 24 weeds of mixed species per 60 feet of row	27.3
D. Vicksburg loam, McNairy County	Bu./A
Avg. of 3 weed-free 60-foot rows	55.5
6 cockleburs—104 individual stalks of johnsongrass— 2 pigweeds per 60 feet of row	34.4
21 cockleburs per 60 feet of row	27.9

CONCLUSIONS

The fact that the 3-year average yield on the high-level management research plots across all study locations was 42.0 bushels of soybeans per acre would indicate:

- That the state average of about 24 bushels per harvested acre over the past 10 years is not a true measurement of Tennessee's soybean production potential.
- That the average yield of soybeans in Tennessee could be raised significantly through closer attention to the land selection factor and through the use of recommended management practices.

PART 2

COSTS AND RETURNS OF SOYBEANS ON TENNESSEE EXPERIMENT STATIONS

by Larry L. Bauer

OBJECTIVE

The objective of this portion of the study was to obtain data on costs and returns of producing soybeans on soils representing specific geographic and physiographic regions within the soybean producing areas of the state, using all the appropriate production practices recommended by the Institute of Agriculture. The research was carried out on six fields, each about 5 acres in size, located at the University of Tennessee at Martin, the Highland Rim and Middle Tennessee Experiment Stations, Ames Plantation Field Station, and two at the Milan Field Station (Figure 1).

These plots were intended as demonstrations, and since they are on experiment stations they cannot be considered as typical farm situations. Therefore care should be exercised when drawing inferences from the results presented from this part of the study.

METHODS AND PROCEDURE IN CALCULATING COSTS AND RETURNS

The returns in each case were calculated using the price actually received. The yields and prices are on the basis of the beans having 13% moisture and less than 1% foreign matter.

When lime was applied, its cost was allocated over 3 years, or one-third of the total charged each year.

Power and machinery costs were the most difficult to estimate since this was not a typical farm situation. On an actual farm, fixed costs can be allocated on the basis of the proportion of total use spent on soybeans. Since the costs could not be reliably calculated in this manner, they were calculated based on machinery cost estimates per hour of use developed by Glover [6]. Actual hours of use of particular machines were reported by the field supervisor. Variable costs—those based on time a machine is used, such as fuel, lubricants, and repairs—were inflated from the 1965 level reported by Glover to the appropriate current level by a prices paid for motor supplies index [13]. The fixed costs, those that remain the

same regardless of how much the equipment is used—such as depreciation, insurance, taxes, housing, etc.—were estimated by taking Glover's hourly rates for "high" level of use and inflating from the 1965 level to the appropriate current level by a prices paid for farm machinery index [13]. The cost figures for a combine and truck were obtained from the *Farm Planning Manual* [11].

The labor costs for 1971 and 1972 are based on an hourly rate of \$1.60 per hour and for 1973 they are based on \$2.25 per hour for everything except hoeing which is \$1.40 per hour. These are actual rates that were paid at the experiment stations. A land charge of 6% of the value of the land plus \$2 per acre for taxes was used to reflect the opportunity cost or income that could be received if the capital invested in land were invested elsewhere. The land values used for 1971, 1972, and 1973, respectively, were \$450, \$535.50, and \$668 per acre at Martin, Ames Plantation, and the Milan Field Station; \$400, \$476, and \$594 on the Highland Rim Experiment Station; and \$350, \$416.50, and \$520 on the Middle Tennessee Station.¹

In the following tables in which costs and returns are presented, the direct costs are those items that would have to be paid each year in all farm situations. These costs include a charge for all production items except land, labor, and the fixed cost of power and machinery which does not have to be paid each year but does have to be paid at some point in time and is prorated.

The difference between total direct costs and gross returns is "return above direct costs" which is the income available to the farm family that owns its land and equipment and performs the production operations with family labor. In other words, this is a return above out-of-pocket expenses for any 1 year.

The "return above all costs" is the return after charges are made for the items land, labor, and machinery and would represent a return over a longer period of time when land and machinery had to be purchased.

One additional point about the tables: PPI herbicides (preplant incorporated) are included in the tables along with preemergence herbicides.

¹These values are based on those used in 1971 and obtained in a survey carried out by Dr. Luther H. Keller of the Department of Agricultural Economics and Rural Sociology, University of Tennessee. The estimates on the three West Tennessee stations were provided by the supervisor of appraisers of the Federal Land Bank for that portion of the State. The values for the Middle Tennessee and Highland Rim Stations were estimated by the Federal Land Bank Agent in those respective counties. The values used for 1971 were inflated to 1972 value on the basis of a state index in "Farm Real Estate Market Developments," ERS, USDA, Supplement No. 3 to CD 77, June 1973. The values for 1973 were inflated using the similar figure from the June 1974 publication.

COSTS AND RETURNS

The costs and returns will be discussed by location of the field, that is, all 3 years' costs and returns data will be presented for each field separately.

The costs and returns for 1971 and 1972 were previously reported in *Tennessee Farm and Home Science* [1,2]. The power and equipment figures reported here and in the previous publication differ somewhat due to a difference in the procedure of calculation.

A general statement about weather before the figures are presented: Of the 3 years, 1971 was the best crop year, and the distribution of moisture through the crop year was good. The 1972 crop year was probably the poorest, with excess moisture at planting time, then dry conditions during critical segments of the growing season, and finally extreme wet conditions at harvest time. The 1973 crop year was similar to that of 1972 except that it was not as wet at harvest time. These conditions are reflected in the state average yields, as reported by the Tennessee Crop Reporting Service, which were 26, 22, and 23.5 bushels per acre for 1971, 1972, and 1973 respectively.

Martin Station

The costs and returns for the field of soybeans at the Martin Station are presented in Table 32.

The fertilizer applications for the 3 years were 200 pounds of 0-20-20 per acre in 1971, 100 pounds of 0-20-40 per acre in 1972, and 200 pounds of 0-20-20 per acre again in 1973. Two tons of lime were applied per acre in 1971 and again in 1973, so the 1971 expense was prorated one half each in 1971 and 1972 while one-third of the 1973 application was included as an expense that year.

Dyanap preemergence herbicide at the rate of 1.5 gallons per acre was used all 3 years. Tenoran postemergence herbicide at the rate of 1 pound per acre was used in 1971. Hand hoeing was necessary only in 1971.

The field yield was quite high in 1971, the best weather year, but fell substantially in 1972, and further in 1973. The decrease in yield the latter 2 years can, of course, be partly attributed to weather, but the decrease the last year was most likely due to a build-up of Race-4 nematodes for which there is no resistant variety.

The return above direct cost for 1971 was quite favorable, but due to lower yields the next 2 years, the returns decreased to a level that was, generally speaking, lower than the other fields in the experiment. The direct costs on this field were high relative to most of the other fields, apparently because of higher fertilizer and power and equipment expense. The power and equipment cost was higher because of more necessary seedbed preparation and cultivation.

Table 32. Costs and returns from soybean experiment, Martin Station, 1971-73

Item	Year		
	1971	1972	1973
Acres in experiment	4.1	4.9	5.1
Bushels per acre	43.8	29.5	27.7
Price received per bushel	\$ 2.92	\$ 3.64	\$ 5.05
Gross return per acre	\$127.90	\$107.38	\$139.89
Direct input costs per acre			
Seed and inoculant	6.16	5.51	6.67
Lime	5.51	5.51	4.45
Fertilizer	6.00	4.27	6.90
Pre-herbicide	8.40	7.92	6.62
Post-herbicide	2.25	0.00	0.00
Power and equipment	11.51	11.75	11.62
Total direct cost per acre	39.83	34.96	36.26
Return above direct costs	\$ 88.07	\$ 72.42	\$103.63
Labor cost per acre	14.08	13.55	8.38
Land cost per acre	29.00	34.13	42.08
Power and equipment (fixed)	14.14	14.49	14.88
Return above all costs (except management)	\$ 30.85	\$ 10.25	\$ 38.29

Ames Plantation

The costs and returns for the Ames Plantation field are presented in Table 33.

No lime was necessary during the 3 years. Twenty pounds of potassium per acre was applied in 1971 and 100 pounds of 0-20-20 per acre was applied in 1973.

Johnsongrass presented a serious problem on the Ames Plantation field in 1971. To control weeds that year, 10 pounds per acre of Dowpon preplant, 1½ pints per acre of Treflan PPI, 1½ gallons of Dyanap preemergence, and a total of 10¼ gallons of Glytac spot postemergence were used on the 5-acre field. This concerted effort to control weeds in 1971 had carry-over effect into the other 2 years. In 1972, 3 pints per acre of Treflan, 1½ gallons per acre of Dyanap, and some hand hoeing made up the weed control program. In 1973 no hand hoeing was necessary, but the Dyanap and Treflan were used. Although significant amounts of preemergence herbicides were used in 1972 and 1973, the overall expense for weed control was reduced substantially.

The weed problem in 1971 is reflected in the low yield, the large expense for pre- and post-herbicides, and for labor used for hand hoeing.

After the low yield and very high direct cost figure for 1971, the latter years show soybean yields in excess of 40 bushels per

Table 33. Costs and returns from soybean experiment, Ames Plantation, 1971-73

Item	Year		
	1971	1972	1973
Acres in experiment	5.0	5.0	5.0
Bushels per acre	27.9	42.5	42.1
Price received per bushel	\$ 2.95	\$ 3.32	\$ 5.05
Gross return per acre	\$ 82.31	\$141.10	\$212.61
Direct input costs per acre			
Seed and inoculant	6.19	6.19	8.40
Lime	0.00	0.00	0.00
Fertilizer	1.03	0.00	2.70
Pre-herbicide	18.83	13.76	11.77
Post-herbicide	17.34	0.00	0.00
Power and equipment	13.31	7.96	8.16
Total direct cost per acre	56.70	27.91	31.03
Return above direct costs	\$ 25.61	\$113.19	\$181.58
Labor cost per acre	29.46	13.40	5.07
Land cost per acre	29.00	34.13	42.08
Power and equipment (fixed)	16.20	10.87	11.23
Return above all costs (except management)	\$ 49.11	\$ 54.79	\$123.20

acre, direct expenses that compare favorably with the other fields, and returns above direct costs that are very high relative to the other fields.

Milan (Bottomland)

There were two fields of soybeans at the Milan Station, one on bottomland and one on upland soils. The costs and returns for the bottomland field are presented in Table 34.

Soil tests indicated no lime was necessary during the 3 years and that 100 pounds per acre of 0-20-20 were required each of the 3 years.

Weed control presented no special problem on this field. During 1971, 1½ gallons per acre of Dyanap preemergence and 1½ pints per acre of Treflan PPI were used. In 1972 and 1973, ½ gallon per acre of Dyanap was used.

The yield from this field was good all 3 years, in excess of 40 bushels in 1971 and 1973, and the yield of 32.4 in 1972 was good in view of the weather conditions during that year.

The direct costs on this field were kept relatively low because no lime was required, a relatively small amount of fertilizer was needed, and expenditures for weed control were low, especially in 1972 and 1973. The labor costs were also low, especially compared to the other fields.

The return above direct costs were quite good, especially in 1971 and 1973, the years that yield exceeded 40 bushels per acre.

Table 34. Costs and returns from soybean experiment on bottom-land soils, Milan Station, 1971-73

Item	Year		
	1971	1972	1973
Acres in experiment	5.0	5.0	4.8
Bushels per acre	44.7	32.4	43.7
Price received per bushel	\$ 2.70	\$ 3.14	\$ 4.95
Gross return per acre	\$120.69	\$101.74	\$216.32
Direct input costs per acre			
Seed and inoculant	5.29	4.47	7.07
Lime	0.00	0.00	0.00
Fertilizer	2.65	2.45	2.70
Pre-herbicide	12.20	2.62	2.73
Post-herbicide	0.00	0.00	0.00
Power and equipment	7.66	7.11	7.62
Total direct cost per acre	27.80	16.65	20.12
Return above direct costs	\$ 92.89	\$ 85.09	\$196.20
Labor cost per acre	6.00	3.79	5.78
Land cost per acre	29.00	34.13	42.08
Power and equipment (fixed)	10.76	9.93	10.58
Return above all costs (except management)	\$ 47.13	\$ 37.24	\$137.76

Table 35. Costs and returns from soybean experiment on upland soils, Milan Station, 1971-73

Item	Year		
	1971	1972	1973
Acres in experiment	5.0	5.0	5.0
Bushels per acre	48.2	34.5	36.2
Price received per bushel	\$ 2.80	\$ 3.25	\$ 5.00
Gross return per acre	\$134.96	\$112.13	\$181.00
Direct input costs per acre			
Seed and inoculant	3.98	4.91	7.07
Lime	3.67	3.67	3.67
Fertilizer	7.95	2.45	2.70
Pre-herbicide	2.24	1.84	2.24
Post-herbicide	0.00	0.00	0.00
Power and equipment	7.27	7.23	7.17
Total direct cost per acre	25.11	20.10	22.85
Return above direct costs	\$109.85	\$ 92.03	\$158.15
Labor cost per acre	6.50	4.50	8.39
Land cost per acre	29.00	34.13	42.08
Power and equipment (fixed)	10.11	10.00	10.00
Return above all costs (except management)	\$ 64.24	\$ 43.40	\$ 97.68

Milan (Upland)

The costs and returns for the upland soils field at Milan are presented in Table 35.

Two tons of lime were applied in 1971, the cost of which was allocated over 3 years. In 1971, 300 pounds per acre of 0-20-20 were applied and in the other 2 years, 100 pounds per acre.

The yield of 48.2 bushels per acre in 1971 is the highest production on any of the fields during the 3-year experiment. The yield decreased to the middle thirties during the next 2 years, presumably due to weather conditions, but was still considerably above the state average. The return above direct costs are quite favorable for all 3 years, especially 1971 when the yield was highest. The direct costs on this field were low relative to the others, the reasons being lower expenditures for chemical weed control and lower power and equipment expense. Labor cost was also lower on this field than the others, generally speaking.

Middle Tennessee Station

The costs and returns for the Middle Tennessee Station field are presented in Table 36.

Two tons of lime were applied in 1972. One third of the cost was included in 1972 and 1973. No fertilizer was necessary during any of the 3 years. Treflan PPI herbicide was used at the rate of 1½ pounds per acre for weed control.

Table 36. Costs and returns from soybean experiment, Middle Tennessee Station, Spring Hill, 1971-73

Item	Year		
	1971	1972	1973
Acres in experiment	5.1	5.1	5.1
Bushels per acre	35.8	36.7	41.2
Price received per bushel	\$ 2.82	\$ 3.49	\$ 5.10
Gross return per acre	\$100.96	\$128.08	\$210.12
Direct input costs per acre			
Seed and inoculant	7.21	6.63	8.61
Lime	0.00	2.50	2.50
Fertilizer	0.00	0.00	0.00
Pre-herbicide	4.10	8.09	8.24
Post-herbicide	0.00	0.00	0.00
Power and equipment	8.92	9.59	9.63
Total direct cost per acre	20.23	26.81	28.98
Return above direct costs	\$ 80.73	\$101.27	\$181.14
Labor cost per acre	11.33	13.33	4.68
Land cost per acre	23.00	26.99	33.20
Power and equipment (fixed)	12.22	12.22	12.54
Return above all costs (except management)	\$ 34.18	\$ 48.73	\$130.72

The field produced good yields, almost 36 bushels of soybeans per acre in 1971, almost 37 in 1972, and more than 41 bushels per acre in 1973. The returns above direct costs for the 3 years were favorable. Of course, the highest returns relatively speaking were in 1973 when the yield exceeded 40 bushels per acre.

Highland Rim Station

The costs and returns for the Highland Rim field are presented in Table 37.

Two tons of lime were applied in 1971 and the cost was allocated equally over the 3 years. Fertilizer applications included 100 pounds per acre of 0-20-20 in 1971 and 1973 and 200 pounds per acre in 1972.

The only chemical weed control necessary was Treflan PPI applied at the rate of 2½ pints per acre in 1971, 2¼ pints per acre in 1972, and 1¾ pints per acre in 1973.

The yield in 1971 was almost 35 bushels per acre and in 1973 it was about 32 bushels per acre, substantially above the state averages of 26 and 23.5 for those years respectively. The return above direct costs was favorable both years but particularly in 1973 when the price was \$5.05 per bushel.

The situation for 1972 was somewhat different on the Highland Rim field. The excessive rainfall of the fall and winter prevented harvesting until March 1973. Weather problems also necessitated

Table 37. Costs and returns from soybean experiment, Highland Rim Station, Springfield, 1971-73

Item	Year		
	1971	1972	1973
Acres in experiment	4.5	4.5	4.5
Bushels per acre	34.8	13.9	31.7
Price received per bushel	\$ 2.84	\$ 5.87	\$ 5.05
Gross return per acre	\$ 98.83	\$ 81.59	\$160.09
Direct input costs per acre			
Seed and inoculant	7.03	6.87	10.12
Lime	2.75	2.75	2.75
Fertilizer	2.95	8.44	3.00
Pre-herbicide	8.75	8.71	4.33
Post-herbicide	0.00	0.00	0.00
Power and equipment	8.68	8.20	9.14
Total direct cost per acre	30.16	34.97	29.34
Return above direct costs	\$ 68.67	\$ 46.62	\$130.75
Labor cost per acre	7.67	32.38	16.55
Land cost per acre	26.00	30.56	37.64
Power and equipment (fixed)	11.17	11.50	12.10
Return above all costs (except management)	\$ 23.83	\$-27.82	\$ 64.46

a large amount of hand hoeing; this is reflected in the labor cost. This would be an unrealistic alternative in an actual farm situation. Even though only 13.9 bushels per acre were harvested, the return above direct costs was still \$46.62 per acre due to bean price increases through the winter to \$5.87 per bushel.

Hand-harvested estimates of yields were obtained in November and December. Table 38 presents estimates of costs and returns given these estimated yields.

The price used is the average price received for soybeans in Tennessee during a 5-day period in that respective month [10].

As Table 37 shows, had it been possible to harvest the beans in November, the return above direct costs would have been \$97.36. If the December harvest had been possible, the return would have been \$67.52, a decrease of \$29.84. For the March harvest they were \$46.62, a decrease of \$50.74 per acre from November. The rise in price was not sufficient to offset the loss of yield during the period.

Table 38. Costs and returns from soybeans, Highland Rim Station, November and December, 1972

Item	November 1972	December 1972
Bushels per acre	40.1	27.7
Price per bushel	\$ 3.30	\$ 3.70
Gross return per acre	\$132.33	\$102.49
Direct input costs per acre		
Seed and inoculant	6.87	6.87
Lime	2.75	2.75
Fertilizer	8.44	8.44
Pre-herbicide	8.71	8.71
Post-herbicide	0.00	0.00
Power and equipment	8.20	8.20
Total direct cost per acre	34.97	34.97
Return above direct costs	\$ 97.36	\$ 67.52
Labor cost per acre	32.38	32.38
Land cost per acre	30.56	30.56
Power and equipment (fixed)	11.50	11.50
Return above all costs (except management)	\$ 22.92	\$ -6.92

CONCLUSION

A primary purpose of this program was to demonstrate that with a high level of management and high soybean yields, returns to land and labor can be improved. In 1971 when the state average yield was 26 bushels per acre, the average from the six fields discussed here was 39.2 bushels per acre, a difference of 13.2 bushels per acre and enough to make a substantial difference in gross returns; with good management to hold down costs, net returns would be favorable. In 1972, the state average was 22 bushels and the average from these six fields was 31.6 bushels per acre, a difference of 9.6. In 1973, the state average was 23.5 and the average from these six fields was 37.1, a difference of 13.6 bushels per acre.

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