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Soybean production systems used in West Tennessee, 1976 and 1981

Richard Donald Morris

To the Graduate Council:

I am submitting herewith a thesis written by Richard Donald Morris entitled "Soybean production systems used in West Tennessee, 1976 and 1981." 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 Agricultural Economics.

Charles M. Cuskaden, Major Professor

We have read this thesis and recommend its acceptance:

Keller, Park

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

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

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and recommend its acceptance:

Luther H. Keller

William M. Park

Accepted for the Council:

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Graduate Studies and Research

SOYBEAN PRODUCTION SYSTEMS USED IN WEST TENNESSEE: 1976 AND 1981

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Richard Donald Morris

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ABSTRACT

The objectives of this study were as follows: (1) identify the soybean production systems used by West Tennessee farmers in 1981 and to describe those systems and the farms on which they were used, (2) analyze the changes between 1976 and 1981 in the soybean production systems utilized by West Tennessee farmers, and (3) summarize the advantages and/or disadvantages observed by farmers as a result of changing soybean production systems.

In 1976, the single crop-row crop system was used exclusively by 72.3 percent of the farmers producing soybeans. However, in 1981 that system was used exclusively by only 44.7 percent of the soybean growers. The single crop-grain drill, double crop-grain drill, and double crop-no till production systems were all used by a higher percentage of farmers in 1981 than they had been in 1976.

The average acreage of total land operated by soybean producers increased approximately 20 percent between 1976 and 1981. Soybean acreage per farm was almost 37 percent greater in 1981 than 1976. Only minor changes occurred in tenure patterns between 1976 and 1981.

The advantages of changing production systems listed most frequently by farmers who used the single crop-row crop system in 1976 and some other system in 1981 were: "reduced soil erosion," "decreased labor requirements," and "reduced cost per acre." The

disadvantage of changing production systems cited most frequently by those farmers was "more weed problems."

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CHAPTER I

INTRODUCTION

The production and sales of soybeans in Tennessee has increased almost every year from 1966 to 1981 with few exceptions. The acreage of harvested soybeans was larger than that of corn, cotton, tobacco, or wheat in 1966 (Table 1). Over one million acres of soybeans were harvested in 1967 and by 1971 the soybean enterprise surpassed all other major farm crops in terms of production value.

The value of soybean production in Tennessee was $91,279,000 in 1971 which exceeded the value of the second place crop, cotton, by over $9 million. That same year tobacco, corn, and wheat production were valued at $79,983,000, $46,170,000, and $12,468,000, respectively. Soybeans continued as the first place crop from 1971 to 1981 in terms of production value and by 1981 the value of soybean production in the state had risen to $381,875,000. Soybean value increased by 318 percent during the 1971-1981 period, whereas the value of tobacco, the second leading valued crop since 1972, increased by only 259 percent. This dominance in the production value of soybeans makes this commodity the leading farm crop enterprise in Tennessee.

The farmers of Tennessee harvested about 2.3 million acres of soybeans in 1981. Soybeans comprised 34.8 percent of the cash receipts from marketing farm crops and accounted for 18.9 percent

TABLE 1. Harvested Acreage and Value of Production of Major Tennessee Crops, 1960-1981

	Harvested Acreage (1000 acres)					Value of Production (1000 dollars)				
Year	Soybeans	Corn Grain	Cotton Lint & Seed	All Tobacco	Wheat	Soybeans	Corn Grain	Cotton Lint & Seed	All Tobacco	Wheat
1960	394	1,354	512	74	137	18,085	59,134	101,437	70,044	5,820
1961	463	1,002	538	80	148	23,122	50,411	106,074	89,379	6,734
1962	463	882	538	85	107	24,170	42,671	101,542	84,043	4,701
1963	528	856	504	84	125	28,607	54,442	122,526	88,385	6,405
1964	586	852	502	76	160	34,504	52,185	114,498	86,357	6,891
1965	732	792	499	69	147	41,285	55,884	104,261	85,336	5,721
1966	871	768	365	61	140	59,112	55,112	50,470	80,824	7,078
1967	1,115	783	236	58	294	67,736	53,127	24,085	74,686	12,877
1968	1,150	658	360	59	273	57,719	40,375	45,972	85,101	9,179
1969	1,125	605	400	59	175	62,370	40,729	51,704	78,478	7,219
1970	1,150	569	390	54	187	73,796	39,688	51,987	79,557	8,770
1971	1,219	675	425	52	234	91,279	46,170	81,886	79,983	12,468
1972	1,298	480	485	57	240	116,223	55,776	83,542	93,853	10,982
1973	1,570	533	440	51	144	202,185	95,684	97,686	89,440	12,544
1974	1,520	570	510	57	325	225,674	117,870	76,647	123,202	32,516
1975	1,850	615	315	66	270	213,675	100,737	64,692	138,472	24,106
1976	1,800	715	370	68	300	268,515	152,438	79,140	163,529	33,855
1977	2,220	730	300	68	280	296,326	104,244	67,426	163,085	22,680
1978	2,420	660	230	67	180	382,735	109,296	79,468	179,185	18,270
1979	2,620	620	230	60	250	449,199	150,195	60,929	144,275	32,300
1980	2,550	640	275	65	450	361,692	102,746	85,664	180,221	64,980
1981	2,350	640	305	79	850	381,875	148,608	92,072	286,789	130,900

Sources: Tennessee Agricultural Statistics, Annual Bulletin T-12, Tennessee Crop Reporting Service, Nashville, Tennessee, 1975; Tennessee Agricultural Statistics, Annual Bulletin T-14, Tennessee Crop Reporting Service, Nashville, Tennessee, 1977; Tennessee Agricultural Statistics, Annual Bulletin T-18, Tennessee Crop Reporting Service, Nashville, Tennessee, 1981; and Tennessee Agricultural Statistics, Annual Bulletin T-19, Tennessee Crop Reporting Service, Nashville, Tennessee, 1982.

of the cash receipts from all farm marketing in Tennessee in 1981.[1] Tennessee ranked eleventh among all the states in the United States in the number of bushels of soybeans harvested in 1980. Tennessee produced approximately 2.5 percent of the total soybean production in the United States in 1980 (Table 2).

Soybean acreage in Tennessee increased 496 percent from 1960 to 1981, while over the same period the value of soybean production increased 2,012 percent. The rate of growth in soybean value was a result of both increases in price and yield. Through scientific developments and promotional efforts new uses for soybeans have been created which have lead to an increase in the demand for soybeans. This increased demand for soybeans and the consequent increase in price have prompted farmers to allocate more land for soybean growth.[2,3] Growth in all segments of the soybean market has been impressive. Rising exports of soybeans, soybean meal, and soybean oil attest to the growing importance of world markets.[4] As the largest producer, processor, and exporter of soybeans, the U.S. has also emerged as the largest residual supplier of protein meal and edible oil. Recently, however, South America has begun

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[1] Tennessee Agricultural Statistics, Annual Bulletin T-19, Tennessee Crop Reporting Service, Nashville, Tennessee, 1982.

[2] J. G. Reed, Jr., "Building Markets for U.S. Soybeans," Soybean News, Vol. 30, No. 1 (October, 1978), pp.1-4.

[3] Dale E. Hathaway, "Export Policies for the Eighties," Soybean News, Vol. 32, No. 1 (October, 1980), pp.1-4.

[4] Reed, loc. cit.

TABLE 2. Rank of Top 30 States Producing Soybeans for Beans in 1980

Rank	State	Production (1000 bu.)
1	Iowa	322,530
2	Illinois	309,875
3	Indiana	157,680
4	Minnesota	152,320
5	Missouri	138,250
6	Ohio	135,360
7	Louisiana	70,350
8	Arkansas	69,600
9	Mississippi	61,600
10	Nebraska	53,100
11	Tennessee	48,450
12	Kentucky	36,800
13	North Carolina	35,705
14	Alabama	31,500
15	Michigan	30,400
16	Georgia	25,680
17	Kansas	23,925
18	South Carolina	22,400
19	South Dakota	20,020
20	Texas	13,860
21	Wisconsin	10,890
22	Florida	10,120
23	Maryland	9,360
24	Virginia	9,150
25	Delaware	5,200
26	North Dakota	3,500
27	New Jersey	3,492
28	Oklahoma	3,000
29	Pennsylvania	2,524
30	New York	456
	TOTAL	1,817,097

Source: United States Department of Agriculture, Agricultural Statistics, 1980, United States Government Printing Office, Washington: 1981.

to challenge the United States position. During the 1977 and 1978 crop years, soybean meal exports from Brazil exceeded United States exports and exports of soybean oil by that country almost surpassed exports of the United States. Some analysts are stressing that the United States is now less dominate as the largest meal and oil exporter.[5,6]

The production of soybeans in Tennessee is concentrated in the western counties. Farmers in the six counties of Tennessee Crop Reporting Service (TCRS) District I harvested 822,000 acres of soybeans in 1981. The farmers of TCRS District II harvested 935,000 acres of soybeans in the same period. The 18 counties in these two districts accounted for 74.8 percent of the total soybean acres harvested and 73.6 percent of the total bushels of soybeans produced in Tennessee in 1981 (Table 3).

I. PROBLEM

Farmers of Tennessee and other states are persistently confronted with the problem of choosing from among alternative production systems. A soybean production system is comprised of a mixture of cultural practices; tillage operations; and other inputs such as pesticides, herbicides, and fertilizers. Input prices, resource requirements, yields, and other factors are constantly

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[5]Hathaway, loc. cit.

[6]United States Department of Agriculture, 1980 Handbook of Agricultural Charts, Agriculture Handbook No. 574, p.90.

TABLE 3. Soybean Production in Tennessee by Crop Reporting Service District, 1981

District	Soybean Production				Counties (Number)	
	Acres		Bushels		Total	100 Acres or more
	(000)	%	(000)	%	in District	Soybeans Harvested
I	822.0	35.0	21,712	35.5	6	6
II	935.0	39.8	23,273	38.1	12	12
III	230.0	9.8	6,193	10.1	12	12
IV	193.0	8.2	5,353	8.8	18	18
V	132.5	5.6	3,625	5.9	16	15
VI	37.5	1.6	944	1.5	28	19
State Total	2,350.0	100.0	61,100	99.9[a]	95	85

Source: Tennessee Agricultural Statistics, Annual Bulletin T-19, Tennessee Crop Reporting Service, Nashville, Tennessee, 1982.

[a]Total does not equal 100 due to rounding error.

changing and must be considered by a farmer before he chooses a production system.

The single crop-row crop system of soybean production is used most often by Tennessee farmers.[7] The conventional single crop-row crop system provides an exposed surface for planting. This is accomplished through the plow-disk-harrow sequence which is followed by soybeans being planted in rows wide enough to permit cultivation.

Farmers need current and accurate information about production systems such as: (1) relative costs and returns, (2) resource requirements, and (3) yield variation, in order to make informed management decisions. With such information at his disposal, a farmer can more accurately determine which production system is best suited for his farm situation. Reducing the soil loss which results from the use of the conventional single crop-row crop production system is also of substantial importance to the soybean producer.[8] Recent studies have suggested that the use of minimum tillage production systems can reduce soil erosion,

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[7]William Alan Miller, "Indentification and Economic Analysis of Alternative Soybean Production System," (Unpublished Master's thesis, The University of Tennessee, 1978).

[8]Bob Parkins, et al., "Importance of SOS," Operation SOS, published by the SOS Dyer Facelift Committe, Gibson County, Tennessee, September 15, 1979, p.3.

production costs, and planting time, but yields will remain competitive to those of the single crop-row crop system.[9]

II. OBJECTIVES

The objectives of this study were as follows:

(1) Identify the soybean production systems used by West Tennessee farmers in 1981 and to describe those systems and the farms on which they were used.

(2) Analyze the changes between 1976 and 1981 in the soybean production systems utilized by West Tennessee farmers.

(3) Summarize the advantages and/or disadvantages observed by farmers as a result of changing soybean production systems.

The accomplishment of these objections should provide information which is useful in the evaluation of alternative soybean production systems by farmers, research workers, and extension personnel. For example, information about current implement and practice use in soybean production is vital in updated enterprise budgets to use in decision making.

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[9]Samuel W. Bone, "Reduced Tillage Systems for Soybean Production," Soybean News, Vol. 29, No. 2 (January, 1978), pp.1-2.

III. RELATED LITERATURE

In 1975 a systems approach to soybean production research was undertaken by Johnson and Gebhardt[10] in Missouri utilizing large scale production experiments and engaging a complete line of farm equipment in order to assess the influence of alternative soybean production systems on yields, income, and energy utilization. Small field plot studies and individual "basic laboratory" studies were undertaken to provide supplementary information needed in analyzing the problems and questions that could not be answered with only information from large scale experiments. An analysis was made of alternative soybean production systems consisting of various combinations of tillage practices, row widths, planting dates, and weed controls.

Woolf and Leary[11] selected commonly used soybean production practices from among those reported by producers surveyed in the Macon Ridge area of Louisiana and utilized the selected production practices in developing estimates of costs and returns for high and low yield producers of single crop soybeans. Results of the research indicated that low yield producers could increase their

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[10]David R. Johnson and Maurice R. Gebhardt, "A Systems Approach to Soybean Production," Soybean News, Vol. 27, No. 1 (October, 1975), pp.5-6.

[11]Willard F. Woolf and Patrick D. Leary, Effects of Production Practices on Soybean Yields, Costs, and Returns, Macon Ridge Area, Louisiana, Louisiana State University, Department of Agricultural Economics Research Report 497, Baton Rouge, Louisiana, December, 1975.

yields and net returns by adjusting production practices, e.g., low yield producers could increase yields and net returns with a more complete and intensive weed control program (both pre-emergence and conventional) where weed infestation was a problem.

Woolf, Vidrine, and Martinez[12] used input-output data obtained from a survey of Southwest Louisiana soybean producers for developing estimates of the costs and returns of producing single crop soybeans seeded by either a row crop planter or a grain drill. The level of management of soybean producers was designated as either low or high depending upon the yield per acre of soybeans harvested. Generally, average inputs and outputs were both greater for high yield producers than for low yield producers.

Miller[13] utilized a mail survey to obtain information pertaining to soybean production systems used in 1976 in West Tennessee. Respondents were asked to indicate the production systems they were using and the production implements and cultural practices that were associated with those systems. Information such as row width and yield which is essential in the construction of cost and return budgets for alternative production systems was also collected.

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[12]Willard F. Woolf, Blank J. Vidrine, and Adolf Martinez, Costs and Returns for Soybeans, Southwest Louisiana Rice Area, Projections for 1977, Louisiana State University, Department of Agricultural Economics Research Report 512, Baton Rouge, Louisiana, December, 1976.

[13]William Alan Miller, "Identification and Economic Analysis of Alternative Soybean Production System," (Unpublished Master's thesis, The University of Tennessee, 1978).

In 1976 Miller reported that soybean acreage per farm was approximately 225 acres. About 45 percent of those farms were exclusively owner operated, 12.9 percent of them were renter operated, and 42.6 percent of them were composed of a mixture of both owned and rented land.

A two-step procedure was used by Miller to determine representative production implements and cultural practices for six cropping-planting systems: (1) single crop-row crop, (2) single crop-grain drill, (3) single crop-broadcast, (4) double crop-row crop, (5) double crop-grain drill, and (6) double crop-no till. Miller also developed enterprise budgets for those six production systems which estimated the net return to land and management that was associated with each system. Estimated net returns per acre for the single crop-row crop system were lower than for four other production systems. However, the single crop-row crop production system was actually used by 73.3 percent of all farmers reporting.

Paxton[14] applied the enterprise budgeting technique to estimate soybean production costs and returns and analyzed survey data to determine the influence of cultural practices, input use, and machinery complements on soybean yields in Louisiana. Cost and return estimates based on soybean budgets indicated that the sandy soils of the River Delta areas produced the highest net

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[14]Kenneth W. Paxton, Cotton and Soybean Production Costs and Returns, Estimates for Louisiana for 1978, Louisiana State University, Department of Agricultural Economics Research Report 528, January, 1978.

returns per acre. The lowest net returns per acre were projected to occur on the clay soils of the River Delta areas of the Macon Ridge.

McArthur[15] reported the most common field operations used in 1978 by soybean growers in major production states and their relative production cost. A survey was conducted to collect current information on production inputs, practices, and costs which was not available through other sources. Most farmers utilized a basic set of field operations in soybean production. The usual operations in seedbed preparation included flatbreaking the land with a mold-board plow, disking with a tandem or offset disk, harrowing with a spring-tooth or spike-tooth harrow, broadcasting fertilizer, and applying preplant herbicides.

IV. PROCEDURE

A mail survey instrument was used to collect information about soybean production from farmers located in Districts I and II of the Tennessee Crop Reporting Service. Those districts were selected since soybean production is heavily concentrated in West Tennessee. The information collected was restricted to the 1976 and 1981 crop years.

A random sample of 2,000 farmers was drawn from the Farm Universe list held in file by the Tennessee Crop Reporting Service

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[15]W. C. McArthur, Soybean Production Practices and Costs in the United States, Research Report 360, The University of Georgia, College of Agriculture, Experiment Station, October, 1980, p.10.

in conjunction with the Agricultural Extension Service of The University of Tennessee. The sample represented approximately 10 percent of the estimated total population of farm operators in the sampling districts selected.[16] A total of 132 survey forms were returned by soybean producers who provided information which was complete enough to permit analysis.

Responses from soybean growers were representative of the sample area in that the number of responses from a particular county was positively correlated with the number of soybean growers in that county and the average acreage of soybeans produced by respondents was not greatly different from that produced by all soybean growers in the area (Tables 4 and 5). The correlation coefficient between the number of soybean growers responding to the survey in a county and the total number of soybean growers in that county was 0.8.[17] Soybean acreage per farm in 1981 reported by survey respondents was not significantly different at the 0.01 level from the average acreage of soybeans produced by all soybean growers in the survey area. The hypothesis tested was: Ho: soybean acreage

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[16]This specific estimate of the total population of farm operators in Crop Reporting Service Districts I and II was furnished by the Tennessee Crop Reporting Service and was based on the 1981 Farm Universe List.

[17]The statistical tests discussed here must be interpreted with caution since a 1978 data source was used for the number of soybean growers and soybean acreage by county and information from survey respondents comprises the 1981 data source.

TABLE 4. Distribution of Soybean Producer Responses and Soybean Production in the Sample Area by County

County	Soybean Producer Responses		Soybean Production[b]		
	Number[a]	% Total	Farms Producing Number	% Total	Acres
Carroll	2	1.5	589	6.4	55,123
Chester	2	1.5	300	3.3	27,320
Crockett	3	2.3	441	4.8	59,680
Dyer	11	8.3	642	7.0	178,807
Fayette	4	3.0	433	4.7	109,624
Gibson	21	15.9	1,083	11.9	144.252
Hardeman	7	5.3	336	3.7	72,003
Haywood	6	4.5	464	5.1	112,847
Henderson	11	8.3	456	5.0	41,771
Henry	5	3.8	473	5.2	41,984
Lake	2	1.5	129	1.4	73,058
Lauderdale	5	3.8	532	5.9	125,399
McNairy	10	7.6	537	5.9	51,338
Madison	13	9.8	543	5.9	83,031
Obion	12	9.1	639	7.0	109,403
Shelby	3	2.3	278	3.0	98,855
Tipton	4	3.0	476	5.2	118,748
Weakley	11	8.3	787	8.6	83,175
TOTAL	132	99.8[c]	9,138	100.0	1,586,418

TABLE 4 (continued)

[a]Data from 132 questionnaires were used in this study.

[b]Source: Census of Agriculture 1978, U. S. Department of Commerce, Bureau of Census, Vol. 1, State and County data.

[c]Total does not equal 100 due to rounding error.

[d]The correlation coefficient between the number of soybean growers responding to the survey in a county and the total number of soybean growers in that county was 0.8.

TABLE 5. Total Land Operated and Land in Soybeans on Farms Producing Soybeans in West Tennessee, 1976 and 1981

Acreage Item	Farms Reporting[a]	Total Acreage	Acreage per Farm[b]	Range of Acreage per Farm		t Statistic[c]
				Minimum	Maximum	
Total Land Operated						
1976	157	55,385	352.7	9	3,600	
1981	130	48,035	369.5	1	8,000	
Land in Soybeans						
1976	161	36,195	224.8	3	3,600	1.2
1981	128	39,307	307.1	1	8,000	

[a]Four farmers did not report total land operated in 1976, and two farmers did not report total land operated in 1981. In 1981, four farmers did not report land in soybeans.

[b]Average acreages were rounded to the nearest tenth.

[c]Standard deviation of soybean acreage per farm in 1981 = 779.4. The hypothesis tested was: Ho: Soybean acreage per farm in 1981 = 224.8; Ha: Soybean acreage per farm in 1981 = 224.8. $t_{.10,\ 127} = 1.645$.

produced in 1981 per farmer responding to the survey equals 173.6; Ha: soybean acreage in 1981 per farmer responding does not equal 173.6.[18]

The survey instrument selected for this study was designed to obtain information about the component parts of soybean production systems used by farmers in West Tennessee. Respondents receiving the survey instrument were instructed to specify the production implements and cultural practices which they used to produce each of eight predetermined soybean production systems they utilized. The eight predetermined soybean production systems specified on the questionnaire were selected based on information from farmers and research and extension personnel and on previous research studies.

A production system was defined in this study as either a single or a double crop of soybeans planted by any one of four planting methods. The planting methods were row crop, grain drill, no till, and broadcast. The eight production systems formed by

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[18]Soybean acreage per farm producing soybeans in TCRS Districts I and II was 173.6 in the 1978 Census of Agriculture. $t = 1.9$; $t_{.01,127} = 2.576$; $t_{.10,127} = 1.645$. Average soybean acreage produced in 1981 by survey respondents was, however, significantly different at the 0.10 level from that produced by all growers in the survey area. Therefore, either average soybean acreage on all farms producing soybeans increased between 1978 and 1981 or respondents to the survey conducted for this study tended to have larger soybean acreages than respondents to the 1978 Census of Agriculture. A larger number of responses to the 1982 survey of soybean growers would have been desirable in light of these test results.

combining each of the four planting methods with each of the two crop types were: (1) single crop-row crop, (2) single crop-grain drill, (3) single crop-no till, (4) single crop-broadcast, (5) double crop-row crop, (6) double crop-grain drill, (7) double crop-no till, and (8) double crop-broadcast. The respondents were asked to identify the cropping-planting combinations which they utilized to produce soybeans and to designate the number of times they used specified implements and production practices with their cropping-planting combinations.

Objective one of this study was to identify the soybean production systems used by West Tennessee farmers and representative production operations, production implements, and cultural practices for each of those systems.

The number of times that representative implements and practices were used per soybean field was also determined. Objective one was accomplished by using the following procedure.

A production operation was defined as a process which can be carried out by the use of selected farm implements and cultural practices. The soybean production operations considered in this study were: (1) pre-tillage field preparation, (2) primary tillage, (3) secondary tillage, (4) seedbed conditioning, (5) cultivation, (6) chemical weed control, and (7) chemical disease control. Each implement and cultural practice appearing on the mail questionnaire was assigned to, and could perform, only one specific production operation, e.g., a subsoiler, chisel plow, moldboard plow, or an

offset disk could only be utilized to perform the primary tillage operation. A production operation was chosen as representative of a given soybean production system if over 50 percent of the respondents utilizing that system reported using implements and/or practices which could be used to perform that operation. The implement or practice used most often by soybean growers to perform a representative production operation was chosen as the representative implement or practice to perform that production operation in the cropping-planting combination. The modal number of times that implements and practices were utilized per field in the production of soybeans was also tabulated by production system. The modal number of times a representative implement or practice was used per field by growers using a given system was chosen as representative of the frequency with which that implement or practice was used per field for the system being analyzed.

Objective two of this study was to analyze the changes which occurred between 1976 and 1981 in the soybean production systems used by West Tennessee farmers. The procedure used in determining the 1981 production systems duplicated the procedure employed by Miller in 1976 so that changes occurring in the production systems from 1976 to 1981 could be analyzed.[19] The representative production operations and farm implements and cultural practices were compared in the two crop years to determine if the production systems

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[19]Miller, op. cit.

had changed. Also, the modal number of times that a representative farm implement or cultural practice was used per field for a given system in 1976 was compared with its modal frequency of use in 1981.

Statistical analyses were performed on the following measures for 1976 and 1981 in order to determine if changes had occurred: (1) the soybean acreage per farm, (2) the proportion of farms in three alternative tenure patterns, and (3) the proportion of farmers using only the single crop-row crop system (Tables 5, 6, and 7).

Change in soybean acreage per farm between 1976 and 1981 was analyzed with the use of the t test. The hypothesis tested was: Ho: soybean acreage per farm in 1981 equals 224.8; Ha: soybean acreage per farm in 1981 does not equal 224.8[20]

The chi-square test was used to determine whether or not the proportion of farms in three alternative tenure patterns in 1981 was the same as in 1976. The hypothesis tested was: Ho: the proportion of farms in three tenure patterns in 1976 equals that of 1981; Ha: the proportion of farms in three tenure patterns is not equal in those two years.

The chi-square test was also employed to determine if the proportion of farmers using only the single crop-row crop system in 1981 was the same as in 1976. The hypothesis tested was: Ho: the proportion of farmers using the single crop-row crop system

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[20]Soybean acreage per farm reported by the respondents in 1976 was 224.8 acres (Table 5).

TABLE 6. Land Tenure Patterns on Farms Producing Soybeans in West Tennessee, 1976 and 1981

Tenure Pattern	Farms Producing Soybeans				Chi Square[b] Statistic
	1976		1981		
	No.[a]	%	No.[a]	%	
All Land Owned	69	44.5	53	40.8	1.0
All Land Rented	20	12.9	22	16.9	
Both Owned and Rented	66	42.6	55	42.3	
Total	155	100.0	130	100.0	

[a]Two farmers did not report acreage by tenure class.

[b]$\chi^2_{.05,2} = 5.991$.

TABLE 7. Number and Type of Soybean Cropping-Planting Systems Used by West Tennessee Farmers, 1981

Number of Systems Per Farm	Description of Observed Systems or Systems Combinations on Farms[a]	Farms Producing Soybeans		
		Number Reporting	% of Group Subtotal[b]	% of Total
1	S.C.-R.C.	59	67.8	44.7
	S.C.-G.D.	7	8.0	5.3
	S.C.-N.T.	2	2.3	1.5
	S.C.-B.C.	2	2.3	1.5
	D.C.-R.C.	2	2.3	1.5
	D.C.-G.D.	10	11.5	7.6
	D.C.-N.T.	4	4.6	3.0
	D.C.-B.C.	1	1.1	0.8
	Subtotal	87	99.9	65.9
2	S.C.-R.C.+S.C.-G.D.	1	2.9	0.8
	S.C.-R.C.+S.C.-B.C.	1	2.9	0.8
	S.C.-R.C.+D.C.-R.C.	15	42.9	11.4
	S.C.-R.C.+D.C.-G.D.	4	11.4	3.0
	S.C.-R.C.+D.C.-N.T.	8	22.9	6.1
	S.C.-G.D.+D.C.-G.D.	3	8.6	2.3
	S.C.-G.D.+D.C.-N.T.	2	5.7	1.5
	S.C.-B.C.+D.C.-B.C.	1	2.9	0.8
	Subtotal	35	100.2	26.5[c]

TABLE 7 (Continued)

Number of Systems Per Farm	Description of Observed Systems or Systems Combinations on Farms[a]	Farms Producing Soybeans		
		Number Reporting	% of Group Subtotal[b]	% of Total
3	S.C.-R.C.+S.C.-G.D.+D.C.-R.C.	3	37.5	2.3
	S.C.-R.C.+S.C.-G.D.+D.C.-N.T.	2	25.0	1.5
	S.C.-R.C.+S.C.-N.T.+D.C.-N.T.	2	25.0	1.5
	S.C.-R.C.+D.C.-R.C.+D.C.-N.T.	1	12.5	0.8
	Subtotal	8	100.0	6.1
4	S.C.-R.C.+S.C.-G.D.+D.C.-R.C+ D.C.-G.D.	2	100.0	1.5
	Subtotal	2	100.0	1.5
	Total	132		100.0

[a]Each system consists of one cropping practice combined with one planting method. The codes used to designate cropping practices are: S.C.= single crop, and D.C. = double crop. The codes used to designate planting methods are: R.C. = row crop, G.D. = grain drill, B.C. = broadcast and N.T. = no till. Thus, the code S.C.-R.C. represents a single crop-row crop system of soybean production. A combination of systems indicates that soybeans were produced by two or more different cropping-planting systems on a given farm. Combinations of systems are indicated in the table by the (+) sign.

[b]Some group subtotals do not equal 100% due to rounding error.

[c]Subtotal does not equal the sum of individual category percentages due to rounding error.

exclusively in 1976 equals the proportion employing that system exclusively in 1981; Ha: the proportion of farmers using the single crop-row crop system exclusively in 1976 does not equal the proportion of farmers utilizing that system exclusively in 1981.

A third objective was to analyze the advantages and disadvantages associated with changes in the soybean production systems used by farmers. Farmers were asked to indicate on the survey instrument the production system they used in 1976 and 1981. Growers who had used a different production system(s) in 1976 than they used in 1981 were asked to identify which of the advantages and/or disadvantages on a predetermined list they had experienced as a result of the change.

CHAPTER II

SELECTED CHARACTERISTICS OF FARMS PRODUCING SOYBEANS

The objective of this chapter is to describe the farms on which soybeans were produced in West Tennessee in 1981 and to identify and describe the soybean production systems used on those farms in that year. Changes which occurred between 1976 and 1981 in selected characteristics of farms producing soybeans in West Tennessee are also analyzed. All of the 1976 data which appears in this chapter was collected by Miller.[21] The information from that study was utilized in conjunction with the 1981 data in order to make comparisons between the two crop years. Five kinds of information is presented in this chapter: (1) total farms and soybean acreage, (2) tenure patterns, (3) soybean cropping-planting systems, (4) soybean yields, and (5) row spacings.

I. TOTAL FARM AND SOYBEAN ACREAGE

The average size farm operated by soybean producers in West Tennessee in 1976 was approximately 353 acres. Soybean growers in that area in 1981 operated an average of about 370 acres of land (Table 5). In contrast to the relatively small change in total acres per farm between 1976 and 1981, soybean acreage per farm was almost 37 percent greater in 1981 than in 1976. In 1976,

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[21]Miller, op. cit.

224.8 acres per farm was planted in soybeans as compared to 307.1 acres per farm in soybean production in 1981. Soybean acreage per farm in 1981 was not significantly different from 224.8, however (Table 5). The range in acres of land in soybean production per farm was similar to the range in acres of total land operated per farm in both 1976 and 1981.

II. LAND TENURE PATTERNS

Tenure patterns on the farms operated by soybean producers responding to the survey were analyzed to determine the relative importance of owned and rented land used for soybean production. Information about land tenure patterns in 1976 was obtained from 155 respondents and 130 respondents provided that information for 1981 (Table 6). Each farm operated by soybean growers responding to the survey was categorized into one of the following three tenure patterns: (1) all land owned, (2) all land rented, and (3) a combination of owned and rented land. The proportions of farms in the three tenure patterns in 1976 and 1981 were not significantly different.

III. SOYBEAN CROPPING-PLANTING SYSTEMS

The farmers surveyed in the study were requested to signify which of the eight predetermined cropping-planting systems they used in 1981 to produce soybeans. A total of 132 farmers supplied that information.

Cropping-Planting Systems and Systems Combinations on Farms, 1981

All eight of the predetermined systems were used in 1981 by farmers responding to the survey, although some combinations were listed infrequently (Table 7). The single crop-row crop system was used by more soybean growers in 1981 than was any other system. It was used exclusively by 44.7 percent of the soybean growers responding to the survey. Both the single crop-row crop and the double crop-row crop systems were used by 11.4 percent of all farmers responding and the double crop-grain drill system was cited by 7.6 percent of all farmers. All other systems were reported less frequently.

Cropping-Planting Systems and Systems Combinations on Farms in 1976 and 1981

The single crop-row crop system was employed exclusively by 72.3 percent of all farmers in 1976 (Table 8). In 1981 that system was used exclusively by only 44.7 percent of all farmers. Not only was the proportion of farmers using only the single crop-row crop system smaller in 1981 than it had been in 1976, but the proportions of farmers using only that system were significantly different in those two years (Table 9). The single crop-grain drill system was the sole production method employed in 1981 by 5.6 percent of all farmers, but only 3.0 percent of the farmers reported using only that system in 1976. The double crop-grain drill system was used exclusively by 7.6 percent of all farmers

TABLE 8. Number and Type of Soybean Production Systems Used by West Tennessee Farmers, 1976

Number of Systems Per Farm	Description of Observed Systems or Systems Combinations on Farms[a]	Farms Producing Soybeans		
		Number Reporting	% of Group Subtotal	% of Total
1	S.R.-R.C.	120	89.6	72.3
	S.C.-G.D.	5	3.7	3.0
	S.C.-B.C.	1	.7	.6
	D.C.-R.C.	6	4.5	3.6
	D.C.-N.T.	2	1.5	1.2
	Subtotal	134	100.0	80.7
2	S.C.-R.C.+S.C.-G.D.	4	16.0	2.4
	S.C.-R.C.+S.C.-B.C.	3	12.0	1.8
	S.C.-R.C.+D.C.-R.C.	15	60.0	9.0
	S.C.-R.C.+D.C.-G.D.	1	4.0	.6
	S.C.-R.C.+D.C.-N.T.	1	4.0	.6
	S.C.-G.D.+D.C.-G.D.	1	4.0	.6
	Subtotal	25	100.0	15.1[c]
3	S.C.-R.C.+S.C.-G.D.+D.C.-R.C.	4	66.7	2.4
	S.C.-R.C.+S.C.-G.D.+D.C.-G.D.	1	16.7	.6
	S.C.-R.C.+D.C.-R.C.+D.C.-N.T.	1	16.7	.6
	Subtotal	6	100.1[b]	3.6

TABLE 8 (Continued)

Number of Systems Per Farm	Description of Observed Systems or Systems Combinations on Farms[a]	Farms Producing Soybeans		
		Number Reporting	% of Group Subtotal	% of Total
4	S.C.-R.C.+D.C.-R.C.+S.C.-G.D. +D.C.-G.D.	1	100.0	.6
	Subtotal	1	100.0	.6
	Total	166		100.0

[a]Each system consists of one cropping practice combined with one planting method. The codes used to designate cropping practices are: S.C. = single crop, and D.C. = double crop. The codes used to designate planting methods are: R.C. = row crop, G.D. = grain drill, B.C. = broadcast, and N.T. = no till. Thus, the code S.C.-R.C. represents a single crop-row crop system of soybean production. A combination of systems indicates that soybeans were produced by two or more different cropping-planting systems on a given farm. Combinations of systems are indicated in the table by the (+) sign.

[b]Percentage subtotal does not equal 100.0% due to rounding error.

[c]Percentage subtotal does not equal the sum of individual category percentages due to rounding error.

TABLE 9. Farmers Using Only the Single Crop-Row Crop Soybean Production System and Other Soybean Production Systems and Combinations of Systems, 1976 and 1981

Soybean Production System by Farm[a]	Number of Farmers 1976	1981	Chi Square Statistic
Single crop-row crop only	120	59	23.4[b]
All other systems and combinations of systems	46	73	
Total	166	132	

[a]The information necessary for the formation of these categories was obtained from Tables 7 and 8.

[b]$\chi^2_{.01,\ 1} = 6.635$.

in 1981, but that system was not used in isolation by any farmers responding to the 1976 study.

With respect to those farmers reporting the use of two systems on their farms, the combination of single crop-row crop plus double crop-row crop systems was used by about 10 percent of all farmers in both 1976 and 1981. Few soybean growers reported the use of either three or four systems in combination on an individual farm in either 1976 or 1981.

Incidence of Soybean Cropping-Planting Systems and Soybean Acreage by System in West Tennessee, 1976 and 1981

The foregoing analyses were made in terms of individual farm units. The analyses in the succeeding paragraphs are based on each production system reported by a farm operator in 1976 and 1981 as a unit of observation.

Single crop systems were far more common on farms than double crop systems in both 1976 and 1981 (Table 10). Single crop production systems accounted for 83.0 percent and 66.7 percent, respectively, of all systems reported in 1976 and 1981.

The single crop-row crop system comprised 73.3 percent of all production systems reported in 1976, whereas in 1981 that system accounted for only 51.9 percent of the reported production systems. The decrease in the relative frequency with which the single crop-row crop system was reported between 1976 and 1981 indicates that soybean growers shifted to other systems during that period. Part

TABLE 10. Incidence of Soybean Cropping-Planting Systems and Soybean Acreage Planted by Cropping-Planting System in West Tennessee, 1976 and 1981

Cropping-Planting System	Incidence of Systems: No. of Observations[a] 1976	1981	Incidence of Systems: % of Observations 1976	1981	Soybean Acreage Planted: No. of Acres 1976	1981	Soybean Acreage Planted: % of Total Acres 1976	1981
Single Crop								
Row Crop	151	98	73.3	51.9	29,776	26,275	79.5	66.8
Grain Drill	16	20	7.8	10.6	4,929	2,325	13.2	5.9
No Till	0	4	0	2.1	0	422	0	1.1
Broadcast	4	4	1.9	2.1	87	133	0.2	.3
Subtotal	171	126	83.0	66.7	34,792	29,155	92.9	74.2[c]
Double Crop								
Row Crop	27	23	13.1	12.2	2,070	3,948	5.5	10.0
Grain Drill	4	19	1.9	10.1	207	1,993	.6	5.1
No Till	4	19	1.9	10.1	364	4,171	1.0	10.6
Broadcast	0	2	0	1.1	0	40	0	0.1
Subtotal	35	63	17.0[c]	33.3[c]	2,641	10,152	7.1	25.8
Total	206	189	100.0	100.0	37,433[b]	39,307	100.0	100.0

[a]The number of observations exceeds the number of farmers responding to the survey instrument because several farmers indicated the use of more than one cropping-planting combination.

TABLE 10 (continued)

[b]The 1976 acreage data in this table were corrected for missing observations by assuming that missing soybean acreage observations for any cropping-planting system were equal to the average of available soybean acreage data for that cropping-planting system.

[c]Percentage subtotal does not equal the sum of individual category percentage due to rounding error.

of that shift was to the single crop-grain drill system which comprised 7.8 percent of the production systems reported in 1976 and 10.6 percent of them in 1981. However, most of the shift away from the single crop-row crop system was to double crop production systems.

The double crop-row crop system accounted for 13.1 percent and 12.2 percent, respectively, of all production systems reported in 1976 and 1981. The shift away from the use of the single crop-row crop system was not, therefore, associated with that system. It was related to two other systems: the double crop-grain drill and double crop-no till systems. Both of those systems were reported more frequently by soybean growers in 1981 than in 1976.

Total soybean production is influenced by factors in addition to the production system chosen and the resulting yield per acre. The acreage planted to a given production system also influences total output. A considerable portion of soybean acreage in both 1976 and 1981 was planted using the single crop-row crop system (Table 10). That system accounted for 79.5 percent of the total soybean acreage reported in 1976 and for 66.8 percent of that acreage in 1981.

The single crop-grain drill combination accounted for 13.2 percent of all soybean acreage in 1976, whereas only 5.9 percent of the total soybean acreage in 1981 was planted using that system. The remaining systems of single crop soybean production, no till and broadcast, were each used to plant only a very small percentage of total acreage in either 1976 or 1981.

In 1976, the double crop-row crop, double crop-grain drill, and double crop-no till systems accounted for 5.5 percent, 0.6 percent, and 1.0 percent, respectively, of the total soybean acreage. In 1981, the double crop-row crop, double crop-grain drill, and double crop-no till systems accounted for 10.0 percent, 5.1 percent, and 10.6 percent, respectively, of the total soybean acreage. Double crop methods were used to produce 25.8 percent of the reported soybean acreage in 1981, but only 7.1 percent of that acreage in 1976. Soybean producers in West Tennessee used double cropping practices more extensively in 1981 than in 1976, however the single crop-row crop system was still the principal method used to produce soybeans in that area in 1981.

IV. YIELDS AND ROW SPACINGS BY CROPPING-PLANTING SYSTEM

An analysis of soybean yields per acre for eight predetermined cropping-planting systems and the incidence of reported row spacings growers used in planting soybeans is presented in this section. Soybean yields per acre reported by growers using the selected systems on owned land are compared with those on rented land. Both yields and row spacings reported in 1981 are compared with those reported in 1976.

The number of farmers reporting soybean yield information for the various cropping-planting systems varied considerably. The single crop-no till, single crop-broadcast, double crop-grain drill, double crop-no till, and double crop-broadcast production

systems were all employed infrequently by soybean producers in one or both reporting years. Therefore, the average yields reported for those systems should be viewed with reservations.

Yields

For a particular cropping-planting system, average yields were similar on owned and rented land in a given year. And with the exception of the double crop-no till system, yields on a given land tenure class did not change substantially between 1976 and 1981 (Table 11).

Within the owned land category, the most pronounced yield changes between 1976 and 1981 occurred in the single crop-grain drill and double crop-no till systems. The average yield of the single crop-grain drill system was 3.5 bushels per acre, or 11.7 percent, less in 1981 than in 1976. However, the average yield of the double crop-no till system was 2.7 bushels per acre, or 12.1 percent, greater in 1981 than in 1976.

The most incisive yield changes between 1976 and 1981 on rented land were reported for the single crop-row crop and double crop-no till systems. Growers using the single crop-row crop system on rented land reported yields which averaged 3.3 bushels per acre, or 12.9 percent, more in 1981 than in 1976. Growers using the double crop-no till system on rented land reported yields of 5.6 average bushels per acre, or 28.0 percent, more in 1981 than 1976.

An analysis of total land in soybean production indicated that the greatest change in average yields between 1976 and 1981

TABLE 11. Soybean Yields Per Acre on Owned, Rented, and Total Land in Soybeans by Cropping-Planting System, 1976 and 1981

Cropping-Planting System	Year	Owned Land: No. of Observations	Owned Land: Yield (Bu./A.) Min.	Owned Land: Yield (Bu./A.) Max.	Owned Land: Yield (Bu./A.) Avg.	Owned Land: % Change Avg. Yield 1976-1981	Rented Land: No. of Observations	Rented Land: Yield (Bu./A.) Min.	Rented Land: Yield (Bu./A.) Max.	Rented Land: Yield (Bu./A.) Avg.	Rented Land: % Change Avg. Yield 1976-1981	Total Land in Soybeans: No. of Observations[a]	Total Land in Soybeans: Avg. Yield (Bu./A.)	Total Land in Soybeans: % Change Avg. Yield 1976-1981
Single Crop														
Row Crop	1976	117	10	46	26.8	+9.7	69	10	43	25.5	+12.9	147	26.3	+10.3
	1981	67	18	46	29.4		57	10	41	28.8		98	29.0	
Grain Drill	1976	9	25	42	29.9	-11.7	8	15	40	26.3	+6.4	13	28.6	-3.8
	1981	12	12	40	26.4		11	22	33	28.0		20	27.5	
No Till	1976	No	No	No	No	NA	No	No	No	No	NA	No	No	NA
	1981	2	32	35	33.5		3	22	40	31.3		4	31.5	
Broadcast	1976	2	11	30	20.5	+2.4	2	15	38	26.5	NA	3	23.5	-10.6
	1981	3	12	30	21.0		No	No	No	No		3	21.0	
Double Crop														
Row Crop	1976	19	10	50	29.5	+6.4	9	20	50	29.3	+2.0	22	29.4	+3.4
	1981	12	25	47	31.4		16	23	37	29.9		23	30.4	
Grain Drill	1976	No	No	No	No	NA	2	18	30	24.0	0.0	2	24.0	+2.9
	1981	11	20	30	25.7		11	19	30	24.0	0.0	19	24.7	
No Till	1976	3	10	32	22.3	+12.1	1	No	No	20.0	+28.0	4	21.8	+16.5
	1981	9	18	30	25.0		17	8	40	25.6		19	25.4	
Broadcast	1976	No	No	No	No	NA	No	No	No	No	NA	No	No	NA
	1981	No	No	No	No		1[b]	20	20	20.0		1[b]	20.0	

[a]Total number of observations on owned and rented land does not equal total observations on total land in soybeans because a farmer can be accounted for twice in the analysis of owned and rented land and only once on total land in soybeans. NA: Not applicable.

[b]Only one of the two respondents reported yields for the double crop-broadcast system. No: No observations.

was for the double crop-no till production system. Farmers using that production system reported yields which averaged 3.6 bushels per acre, or 16.5 percent, more in 1981 than in 1976. The second greatest change in average yields was for the single crop-broadcast system. Producers using that system reported yields which averaged 2.5 bushels per acre, or 10.6 percent, less in 1981 than in 1976. The smallest difference in the average yields reported by producers in 1976 and 1981 was for the double crop-grain drill system. Yields reported for that system averaged 2.9 percent higher in 1981 than in 1976.

Row Spacing

A total of 179 incidences of row spacing were reported in 1981 for the six cropping-planting methods for which spacing was applicable (Tables 12 and 13). Soybean producers using the single crop-row crop method utilized row spacings ranging from 20 to 42 inches in 1981. Fifty-seven of the 98 respondents who used that system signified 38 inches as the row spacing which they used while 24 reported using 36 inch rows. Eleven of the 23 respondents using the double crop-row crop system in 1981 specified using 38 inch row spacing, but reported row spacings ranged from 30 to 39 inches for that system.

The bulk of row spacings reported for the single crop-grain drill and the double crop-grain drill planting methods were either 7 or 8 inches in 1981. The range extended from 7 to 14 inches

TABLE 12. Single Crop Soybean Row Spacing by Cropping-Planting System, 1976 and 1981

Row Spacing (inches)	Row Crop		Grain Drill		No Till	
	1976	1981	1976	1981	1976[a]	1981
	- - - - - - - - Number of Observations - - - - - - - -					
6			2			
7			5*	5		
8			2	8*		
9			1	1		
10			1	1		
12						1
14				2		
18						1
19						1
20		4				1
27		1				
30		6				
32	1	2				
34		1				
35		1				
36	25	24				
38	93*	57*				
39	1					
40	8	1				
42		1				
Total	128	98	11	17		4

[a]Use of the no till system was not reported by any growers in 1976.

*Mode.

TABLE 13. Double Crop Soybean Row Spacing by Cropping-Planting System, 1976 and 1981

Row Spacing (inches)	Row Crop		Grain Drill		No Till	
	1976	1981	1976	1981	1976[a]	1981
	- - - - - - - - Number of Observations - - - - - - - -					
6			1			
7				9*		
8				5		
9			1			
10				1		1
11						1
12						2
14				1		1
15						2
16				1		
18						3
19					1	3
20				1	1	6*
22					1	
30		3				
32	1					
34	1	1				
36	7	6			1	
37		1				
38	14*	11*				
39		1				
40	1					
Total	24	23	2	18	4	19

*Mode.

of row spacing for the single crop-grain drill method and the modal row width was 8 inches. The range was from 7 to 20 inches of row spacing for the double crop-grain drill method and the modal space was 7 inches. Growers using the single crop-no till system in 1981 indicated using row spacings ranging from 12 to 20 inches. Three of the four respondents using that system reported row spacings ranging from 18 to 20 inches. Double crop-no till soybeans were planted in 20 inch rows in 1981 by 6 of 19 growers who responded and 18 and 19 inch spacings were each reported by three growers in that year. Row spacings reported for that system extended from 10 to 20 inches in 1981.

A study of data collected for 1976 revealed row spacing distributions for that year were strikingly similar to the row spacing data collected for 1981. The modal row spacing for the single crop-row crop planting method was 38 inches in both 1976 and 1981. The second most frequently reported row spacing for that system was 36 inches in both years. The modal row spacing for the double crop-row crop system in both 1976 and 1981 was also 38 inches and the second most frequently reported row spacing for that system in both of those years was also 36 inches.

The only other system for which enough observations were available in both years to provide a meaningful comparison was the single crop-grain drill systems. Modal row spacings for that system were 7 inches in 1976 and 8 inches in 1981.

CHAPTER III

SOYBEAN PRODUCTION PRACTICES

Implements and practices used in soybean production by West Tennessee farm operators in 1981 are presented and analyzed in this chapter. The purpose of this chapter is: (1) to identify representative production operations used by West Tennessee soybean growers in selected soybean production systems, (2) to select representative farm implements and cultural practices for those cropping-planting systems, (3) to determine the modal number of times those representative implements and practices were normally used on individual soybean fields, and (4) to compare the representative production operations, representative implements and practices, and modal implement and practice used per field in 1981 with those in 1976.[22]

Miller developed resource requirements necessary to construct cost and return budgets for each of six identified soybean production systems. If changes occurred between 1976 and 1981 in the production operations, the types of implements or practices used to perform those operations, or the modal number of times implements or practices were used by soybean growers; adjustments should be made in the enterprise budgets developed by Miller to make them representative of soybean production methods currently in use.

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[22]Miller, op. cit.

I. PRODUCTION OPERATIONS AND IMPLEMENTS AND PRACTICES USED IN 1981

The selection of representative implements and practices used by West Tennessee farmers to produce soybeans in 1981 consisted of two steps. The production operations used in each soybean cropping-planting system were determined first. Seven types of production operations were identified: (1) pre-tillage field preparation, (2) primary tillage, (3) secondary tillage, (4) seedbed conditioning, (5) cultivation, (6) herbicide use, and (7) pesticide use. Each implement or practice listed on the survey instrument was assigned to one of the above seven types of soybean production operations. If more than 50 percent of the farmers utilizing a specified cropping-planting system indicated the use of implements or practices assigned to a given type of production operation, that operation was included as an integral part of that cropping-planting system.

Specific implements and practices were chose as representative of those used by West Tennessee farmers to produce soybeans in 1981 by each cropping-planting system subsequent to the identification of the representative production operations for each system. The implement or practice used most often by soybean producers to perform a given representative production operation in a cropping-planting system was selected as representative of that cropping-planting system.

Pre-Tillage Field Preparation

Pre-tillage field preparation practices were applicable for seven of the eight cropping-planting combinations (Table 14). With the exception of the single crop-broadcast system, fewer than half of the growers producing soybeans by any of the single crop-planting methods used pre-tillage implements and practices. However, the pre-tillage operation was reported by the double crop-row crop and double crop-grain drill production operators over 50 percent of the time. All growers using those systems who reported pre-tillage field preparation practices did so by either burning or bailing straw.

Primary Tillage

Except for the single crop-no till system, over one-half of the producers of each single crop-planting system reported using primary tillage implements (Table 15). The double crop-row crop system was the only double crop system in which more than 50 percent of the producers reported using primary tillage implements. Producers reporting that system utilized both the chisel plow and the offset disk with equal frequency for primary tillage. The producers of the single crop-row crop, single crop-grain drill, and single crop-broadcast combinations used the chisel plow most often for primary tillage.

TABLE 14. Pre-Tillage Field Preparation Practices Used by West Tennessee Farmers for Soybean Production by Cropping-Planting System, 1981[a]

Item	Single Crop								Double Crop							
	Row Crop		Grain Drill		No Till		Broadcast		Row Crop		Grain Drill		No Till		Broadcast	
	Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Implement and Practice Use	98	100.0	20	100.0	4	100.0	4	100.0	23	100.0	19	100.0	19	100.0	2	100.0
Pre-Tillage Field Preparation Practices	4	4.1	3	15.0	NA		2	50.0	18	78.3	11	57.9	1	5.3	1	50.0
Stalk Cutter or Rotary Mower	4	4.1	2	10.0	NA		2	50.0	0	0	0	0	NA		0	0
Burn or Bale Straw	0	0	2	10.0	NA		1	25.0	18	78.3	11	57.9	1	5.3	1	50.0

[a]The sum of the percentages of producers who reported using various types of pre-tillage field preparation practices does not always equal the percentage who reported the use of pre-tillage field preparation because some producers reported using more than one type of pre-tillage field preparation practice. NA: Not applicable.

TABLE 15. Primary Tillage Implements Used by West Tennessee Farmers for Soybean Production by Cropping-Planting System, 1981[a]

Item	Single Crop								Double Crop							
	Row Crop		Grain Drill		No Till		Broadcast		Row Crop		Grain Drill		No Till		Broadcast	
	Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting	
	No.	%	No	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Implement and Practice Used	98	100.0	20	100.0	4	100.0	4	100.0	23	100.0	19	100.0	19	100.0	2	100.0
Primary Tillage Implements	86	87.8	15	75.0	NA		4	100.0	13	56.5	9	47.4	NA		1	50.0
Subsoiler	8	8.2	3	15.0	NA		0	0	2	8,7	1	5.3	NA		0	0
Chisel Plow	61	62.2	12	60.0	NA		3	75.0	8	34.8	5	26.3	NA		1	50.0
Moldboard Plow	33	33.7	1	5.0	NA		0	0	5	21.7	2	10.5	NA		1	50.0
Offset Disk	9	9.2	2	10.0	NA		2	50.0	8	34.8	2	10.5	NA		0	0

[a]The sum of the percentages of producers who reported using various types of primary tillage implements does not always equal the percentage who reported the use of primary tillage because some producers reported using more than one type of primary tillage implement. NA: Not applicable.

Secondary Tillage

Secondary tillage was employed in the production of soybeans by at least 82.6 percent of the producers of each cropping-planting combination for which it was applicable (Table 16). The tandem disk, which was the implement used most often for secondary tillage in all systems for which it was applicable, was selected for use by 76.5, 80.0, and 75.0 percent, respectively, of the producers of single crop-row crop, single crop-grain drill and single crop-broadcast combinations. The tandem disk was utilized by 73.9, 84.2, and 100.0 percent, respectively, of the producers double cropping in conjunction with the row crop, grain drill, and broadcast systems.

Seedbed Conditioning

Implements designed for the purpose of seedbed conditioning were used by more than half of the producers of the single crop-row crop, single crop-grain drill, single crop-broadcast, double crop-row crop, and double crop-grain drill combinations (Table 17). A do all implement was used most prevalently for seedbed conditioning by producers of all the aforementioned cropping-planting combinations.

Cultivation

Approximately 68 percent of the single crop-row crop producers used cultivation implements as compared to 73.9 percent of the producers of double crop-row crop soybeans (Table 18).

TABLE 16. Secondary Tillage Implements Used by West Tennessee Farmers for Soybean Production by Cropping-Planting Systems, 1981[a]

Item	Single Crop								Double Crop							
	Row Crop		Grain Drill		No Till		Broadcast		Row Crop		Grain Drill		No Till		Broadcast	
	Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Implement and Practice Use	98	100.0	20	100.0	4	100.0	4	100.0	23	100.0	19	100.0	19	100.0	2	100.0
Secondary Tillage	87	88.8	18	90.0	NA		3	75.0	19	82.6	18	94.7	NA		2	100.0
Tandem Disk	75	76.5	16	80.0	NA		3	75.0	17	73.9	16	84.2	NA		2	100.0
Field Cultivator	36	36.7	3	15.0	NA		0	0	6	26.1	2	10.5	NA		0	0

[a]The sum of the percentages of producers who reported using various types of secondary tillage implements does not always equal the percentage who reported the use of secondary tillage because some producers reported using more than one type of secondary tillage implement.
NA: Not applicable.

TABLE 17. Seedbed Conditioning Implements Used by West Tennessee Farmers for Soybean Production by Cropping-Planting Systems, 1981[a]

Item	Single Crop								Double Crop							
	Row Crop		Grain Drill		No Till		Broadcast		Row Crop		Grain Drill		No Till		Broadcast	
	Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Implement and Practice Use	98	100.0	20	100.0	4	100.0	4	100.0	23	100.0	19	100.0	19	100.0	2	100.0
Seedbed Conditioning Implements	81	82.7	14	70.0	NA		4	100.0	22	95.7	18	94.7	NA		1	50.0
Spring or Spike Tooth Harrow	19	19.4	1	5.0	NA		1	25.0	1	4.3	2	10.5	NA		0	0
Cultipacker	1	1.0	1	5.0	NA		0	0	0	0	0	0	NA		0	0
Cultimulcher or Roller Harrow	29	29.6	6	30.0	NA		0	0	8	34.8	6	31.6	NA		0	0
Do All	45	45.9	9	45.0	NA		3	75.0	15	65.2	11	57.9	NA		1	50.0

[a]The sum of the percentages of producers who reported using various types of seedbed conditioning implements does not always equal the percentage who reported the use of seedbed conditioning because some producers reported using more than one type of seedbed conditioning implement. NA: Not applicable.

TABLE 18. Cultivation Implements Used by West Tennessee Farmers for Soybean Production by Cropping-Planting Systems, 1981[a]

Item	Single Crop								Double Crop							
	Row Crop		Grain Drill		No Till		Broadcast		Row Crop		Grain Drill		No Till		Broadcast	
	Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Implement and Practice Use	98	100.0	20	100.0	4	100.0	4	100.0	23	100.0	19	100.0	19	100.0	2	100.0
Cultivation Implements	67	68.4	0	0	NA		NA		17	73.9	0	0	NA		NA	
Row Crop Cultivator	65	66.3	NA		NA		NA		17	73.9	NA		NA		NA	
Rotary Hoe	5	5.1	0	0	NA		NA		1	4.3	0	0	NA		NA	

[a]The sum of the percentages of producers who reported using each type of cultivation implement does not always equal the percentage who reported using cultivation because some producers reported using more than one cultivation implement. NA: Not applicable.

Approximately 66 percent of the producers of single crop-row crop soybeans reported using the row crop cultivator while 73.9 percent of the producers of double crop-row crop soybeans reported the use of that implement.

Types of Herbicides

Over 50 percent of the producers of all cropping-planting systems indicated using some type of herbicide (Table 19). The single crop-row crop, single crop-grain drill, and double crop-broadcast producers reported the broadcast herbicide-fertilizer combination as the type of herbicide practice used most often. A post-emergence herbicide was used most often by single crop-no till, double crop-row crop, and double crop-grain drill soybean producers. A pre-emergence herbicide was employed most frequently in conjunction with the double crop-no till combination. The single crop-broadcast producers reported using a post-emergence herbicide and a broadcast herbicide-fertilizer mixture with equal frequency.

Types of Pesticides

Soybean producers were asked to report the use of three major types of pesticides in 1981 (Table 20). Those pesticides were nematicide, insecticide, and fungicide. Producers did not frequently utilize any pesticide for soybean production for any of the systems analyzed. Pesticide use was not a representative production operation for any of the production systems analyzed.

TABLE 19. Types of Herbicides Used by West Tennessee Farmers for Soybean Production by Cropping-Planting Systems, 1981[a]

Item	Single Crop								Double Crop							
	Row Crop		Grain Drill		No Till		Broadcast		Row Crop		Grain Drill		No Till		Broadcast	
	Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Implement and Practice Use	98	100.0	20	100.0	4	100.0	4	100.0	23	100.0	19	100.0	19	100.0	2	100.0
Types of Herbicides	82	83.6	16	80.0	4	100.0	3	75.0	22	95.7	19	100.0	17	89.5	2	100.0
Preplant Incorporate	52	53.1	8	40.0	NA		2	50.0	12	52.2	13	68.4	NA		0	0
Pre-emergence	36	36.7	8	40.0	2	50.0	2	50.0	7	30.4	5	26.3	14	73.7	1	50.0
Post-emergency	53	54.1	11	55.0	3	75.00	3	75.00	18	78.3	17	89.5	12	63.2	1	50.0
Preplant-Burndown	NA		NA		0	0	0	0	NA		NA		12	63.2	0	0
Broadcast herbicide fertilizer combination	64	65.3	14	70.0	NA		3	75.0	14	60.9	8	42.1	NA		2	100.0

[a]The sum of the percentages of producers who reported using various types of herbicides does not always equal the percentage who reported the use of herbicides because some producers used more than one type of herbicide. NA: Not applicable.

TABLE 20. Types of Pesticides Used by West Tennessee Farmers for Soybean Production by Cropping-Planting Systems, 1981[a]

Item	Single Crop								Double Crop							
	Row Crop		Grain Drill		No Till		Broadcase		Row Crop		Grain Drill		No Till		Broadcast	
	Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting		Producers Reporting	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Implement and Practical Use	98	100.0	20	100.0	4	100.0	4	100.0	23	100.0	19	100.0	19	100.0	2	100.0
Types of Pesticides	19	19.4	6	30.0	0	0	2	50.0	2	8.7	2	10.5	3	15.8	0	0
Nematicide	8	8.2	0	0	0	0	1	25.0	0	0	0	0	1	5.3	0	0
Insecticide	6	6.1	2	10.0	0	0	0	0	0	0	0	0	1	5.3	0	0
Fungicide	10	10.2	5	25.0	0	0	1	25.0	2	8.7	2	10.5	3	15.8	0	0

[a]The sum of the percentages of producers who reported using various chemical disease control practices does not always equal the percentage of producers who reported the use of pesticides because some producers reported using more than one pesticide.

II. FREQUENCY OF IMPLEMENT AND PRACTICE USE PER FIELD

Information on the number of times producers reported using each implement and production practice on their soybean fields in 1981 was analyzed by determining the most common number of times (the mode) specific implements and practices were employed in each cropping-planting system (Tables 21 and 22). The mode for the number of times each implement or practice was used per soybean field in 1981 was one except where the tandem disk was involved. A bimodal use per soybean field was recorded for the tandem disk in conjunction with the double crop-grain drill system.

III. COMPARISON OF REPRESENTATIVE OF IMPLEMENTS AND PRACTICES USED IN 1976 AND 1981

The implements and practices selected as representative of those used by growers to produce single crop soybeans in 1976 and 1981 are reported in Tables 23 and 24, respectively. Representative implements and practices used by producers of double crop soybeans in the two years analyzed are reported in Tables 25 and 26.

Single Crop Production Systems

Producers using the single crop-row crop system in 1981 reported only the chisel plow over 50 percent of the time for primary tillage, whereas producers using that cropping-planting

TABLE 21. Modal Implement and Practice Use Per Field by West Tennessee Farmers for Single Crop Soybean Production by Planting Method, 1981

Item	Row Crop			Grain Drill			No Till			Broadcast		
	Modal[a] Times Used Per Field	Farmers Reporting Mode	Total[b] Farmers Reporting	Modal Times Used Per Field	Farmers Reporting Mode	Total Farmers Reporting	Modal Times Used Per Field	Farmers Reporting Mode	Total Farmers Reporting	Modal Times Used Per Field	Farmers Reporting Mode	Total Farmers Reporting
Implement or Practice			98			20			4			4
Pre-Tillage Field[c] Preparation												
Stalk Cutter or Rotary Mower	1	4	4	1	2	2		NA		1	2	2
Primary Tillage												
Subsoiler	1	8	8	1	3	3		NA		0	0	0
Chisel Plow	1	60	61	1	11	12		NA		1	3	3
Moldboard Plow	1	33	33	1	1	1		NA		0	0	0
Offset Disk	1	6	0	1	2	2		NA		1	2	2
Secondary Tillage												
Tandem Disk	1	51	75	1	11	16		NA		1	3	3
Field Cultivator	1	32	36	1	3	3		NA		0	0	0
Seedbed Conditioning												
Spring or Spiketooth Harrow	1	18	19	1	1	1		NA		1	1	1
Cultipacker	1	1	1	1	1	1		NA		0	0	0
Cultimulcher or Roller Harrow	1	29	29	1	6	6		NA		0	0	0
Do All	1	41	45	1	9	9		NA		1	3	3
Cultivation												
Row Crop Cultivator	1	42	65		NA			NA			NA	
Rotary Hoe	1	5	5	0	0	0		NA			NA	
Types of Herbicides												
Preplant-Incorporate	1	51	52	1	8	8		NA		1	2	2
Pre-emergency	1	36	36	1	8	8	1	1	2	1	2	2
Post-emergence	1	49	53	1	9	11	1	2	3	1	3	3
Preplant-Burndown Broadcast		NA			NA		0	0	0	0	0	0
Herbicide-Fertilizer Combination	1	61	64	1	14	14		NA		1	3	3
Types of Pesticides												
Nematicide	1	8	8	0	0	0	0	0	0	1	1	1
Insecticide	1	6	6	1	2	2	0	0	0	0	0	0
Fungicide	1	10	10	1	4	5	0	0	0	1	1	1

[a]The Mode is the most frequent (or most common) value reported by producers for the number of times specified implements and production practices where used per soybean field.

[b]The total number of producers reporting varied by implement or practice as well as by cropping-planting system. The number of observations for a particular implement or practice used with a particular system was never greater than the total number of observations for that system. However, because more than one implement or practice was often used to perform a given type of production operation by some of the producers who utilized that operation in a given system, the total number of observations for each type of operation may exceed the total number of observations for each system.

[c]Producers were not asked to report the number of times the pre-tillage field preparation practices of burning and bailing were used per soybean field, since these practices would normally be used only once per field.

NA: Not applicable.

TABLE 22. Modal Implement and Practice Use Per Field by West Tennessee Farmers for Double Crop Soybean Production by Planting Method, 1981

Item	Row Crop			Grain Drill			No Till			Broadcast		
	Modal[a] Times Used Per Field	Farmers Reporting Mode	Total[b] Farmers Reporting	Modal Times Used Per Field	Farmers Reporting Mode	Total Farmers Reporting	Modal Times Used Per Field	Farmers Reporting Mode	Total Farmers Reporting	Modal Times Used Per Field	Farmers Reporting Mode	Total Farmers Reporting
Implement or Practice			23			19			19			2
Pre-Tillage Field[c] Preparation												
Stalk Cutter or Rotary Mower	0	0	0	0	0	0		NA		0	0	0
Primary Tillage												
Subsoiler	1	2	2	1	1	1		NA		0	0	0
Chisel Plow	1	8	8	1	5	5		NA		1	1	1
Moldboard Plow	1	5	5	1	2	2		NA		1	1	1
Offset Disk	1	7	8	1	2	2		NA		0	0	0
Secondary Tillage												
Tandem Disk	1	11	17	1.2[d]	7	16		NA		1	2	2
Field Cultivator	1	6	6	1	2	2		NA		0	0	0
Seedbed Conditions												
Spring or Spiketooth Harrow	1	1	1	1	2	2		NA		0	0	0
Cultipacker	0	0	0	0	0	0		NA		0	0	0
Cultimulcher or Roller Harrow	1	8	8	1	6	6		NA		0	0	0
Do All	1	11	15	1	11	11		NA		1	1	1
Cultivation												
Row Crop Cultivator	1	8	17		NA			NA			NA	
Rotary Hoe	1	1	1	0	0	0		NA			NA	
Types of Herbicides												
Preplant-Incorporate	1	12	12	1	13	13		NA		0	0	0
Pre-emergence	1	7	7	1	5	5	1	14	14	1	1	1
Post-emergence	1	17	18	1	17	17	1	10	12	1	1	1
Preplant-Burndown		NA			NA		1	12	12	0	0	0
Broadcast Herbicide-Fertilizer Combination	1	14	14	1	8	8		NA		1	2	2
Types of Pesticides												
Nematicide	0	0	0	0	0	0	1	1	1	0	0	0
Insecticide	0	0	0	0	0	0	1	1	1	0	0	0
Fungicide	1	2	2	1	2	2	1	3	3	0	0	0

[a]The mode is the most frequent (or most common) value reported by producers for the number of times specified implements and production practices were used per soybean field.

[b]The total number of producers reporting varied by implement or practice as well as by cropping-planting system. The number of observations for a particular implement or practice used with a particular system was never greater than the total number of observations for that system. However, because more than one implement or practice was often used to perform a given type of production operation by some of the producers who utilized that operation in a given system, the total number of observations for each type of operation may exceed the total number of observations for each system.

[c]Producers were not asked to report the number of times the pre-tillage field preparation practices of burning and bailing were used per soybean field, since these practices would normally be used only once per field.

[d]There were two modes for use of the tandem disk with the double crop-grain drill system and each was reported by seven producers.

NA: Not applicable.

TABLE 23. Representative Implements and Practices Used by West Tennessee Farmers for Single Crop Soybean Production by Planting Method, 1981

Type of Operation	Row Crop		Grain Drill		No Till		Broadcast	
	Implement or Practice	Times Used Per Field	Implement or Practice	Times Used Per Field	Implement or Practice	Times Used Per Field	Implement or Practice	Times Used Per Field
Pre-Tillage Field[a] Preparation	●	●	●	●	NA		●	●
Primary Tillage	Chisel Plow	1	Chisel Plow	1	NA		Chisel Plow	1
Secondary Tillage	Tandem Disk	1	Tandem Disk	1	NA		Tandem Disk	1
Seedbed Conditioning	Do All	1	Do All	1	NA		Do All	1
Cultivation	Row Crop Cultivator	1	NA		NA		NA	
Herbicides	Broadcast herbicide fertilizer combination	1	Broadcast herbicide fertilizer combination	1	Post-emergency Herbicide	1	Post-emergence Herbicide[b] Broadcast herbicide fertilizer combination	1
Pesticides	●	●	●	●	●	●	●	●

[a]Less than half of the producers who reported the implements and practices they used to produce soybeans by each single crop system used pre-tillage field preparation practices. Therefore, the pre-tillage field preparation operation was not included as a component of any of these three cropping-planting systems. This same reasoning applied when other production operations were not included for a given planting method.

[b]Two types of herbicides, Post-emergence and Broadcast herbicide fertilizer, were each reported 75 percent of the time in conjunction with the Broadcast planting method.

NA: Not applicable.

TABLE 24. Representative Implements and Practices Used by West Tennessee Farmers for Single Crop Soybean Production by Planting Method, 1976

Type of Operation	Row Crop		Grain Drill		Broadcast	
	Implement or Practice	Times Used Per Field	Implement or Practice	Times Used Per Field	Implement or Practice	Times Used Per Field
Pre-Tillage Field[a] Preparation	•	•	•	•	•	•
Primary Tillage	Moldboard Plow[b] or Chisel Plow	1	Chisel Plow	1	Moldboard Plow[b] or Chisel Plow	1
Secondary Tillage	Tandem Disk	2	Tandem Disk	3	Tandem Disk	2
Seedbed Conditioning	Do All	1	Do All	1	Do All	1
Cultivation	Row Crop Cultivator	2	NA		NA	
Herbicides	Broadcast Sprayer+ Preplant Herbicide	1	Broadcast Sprayer+ Pre-emergence herbicide	1	Broadcast Spreader + Preplant herbicide	1
Pesticides	•	•	•	•	•	•

[a]Less than half of the producers who reported the implements and practices they used to produce soybeans by each single crop system used pre-tillage field preparation practices. Therefore, the pre-tillage field preparation operation was not included as a component as any of these three cropping-planting systems. This same reasoning applied when other production operations were not included for a given planting method.

[b]The same number of producers reported utilizing each of these two implements with each of the two systems in question.

NA: Not applicable.

TABLE 25. Representative Implements and Practices Used by West Tennessee Farmers for Double Crop Soybean Production by Planting Method, 1981

Type of Operation	Row Crop		Grain Drill		No Till		Broadcast	
	Implement or Practice	Times Used Per Field	Implement or Practice	Times Used Per Field	Implement or Practice	Times Used Per Field	Implement or Practice	Times Used Per Field
Pre-Tillage Field Preparation[a]	Burn or Bale Straw	1	Burn or Bale Strat	1.	●	●	●	●
Primary Tillage	Chisel Plow or Offset disk[b]	1	●	●	NA		●	●
Secondary Tillage	Tandem Disk	1	Tandem Disk	1.2[c]	NA		Tandem Disk	1
Seedbed Conditioning	Do All	1	Do All	1	NA		●	●
Cultivation	Row Crop Cultivator	1	NA		NA		NA	
Herbicides	Post-emergence Herbicide	1	Post-emergence Herbicides	1	Post-emergence Herbicides	1	Broadcast herbicide fertilizer combination	1
Pesticides	●	●	●	●	●	●	●	●

[a]Less than half of the producers who reported implements and practices they used to produce soybeans with the drouble crop-no till and double crop-broadcast systems used pre-tillage field preparation practices. Therefore, the pre-tillage field preparation operation was not included as a component of that cropping-planting system. This same reasoning applied when other production operations were not included for a given planting method.

[b]The chisel plow was used for primary tillage by the same number of farmers as used the offset disk for that operation.

[c]The tandem disk received a bimodal response from soybean producers. This implement was used one time per field by the same number of farmers as used it two times per field.

Na: Not applicable.

TABLE 26. Representative Implements and Practices Used by West Tennessee Farmers for Double Crop Soybean Production by Planting Method, 1976.

Type of Operation	Row Crop		Grain Drill		No Till	
	Implement or Practice	Times Used Per Field	Implement or Practice	Times Used Per Field	Implement or Practice	Times Used Per Field
Pre-Tillage Field[a] Preparation	Burn Straw	1	Burn Straw	1	●	●
Primary Tillage	Moldboard Plow	1				
Secondary Tillage	Tandem Disk	2	Tandem Disk	2		
Seedbed Conditioning	Cultimulcher	1		●	NA	
Cultivation	Row Crop Cultivator	2	NA		NA	
Herbicides	Broadcast Sprayer[b] Preplant Herbicide	1	Broadcast Sprayer+ Preplant Herbicide	1	Broadcast Sprayer+ Burndown Herbicide	1
	Cultivator Mounted Directed Sprayer Post-emergence Herbicide					
Pesticides	●	●	●	●	●	●

[a]Less than half of the producers who reported the implements and practices they used to produce soybeans by each single crop system used pre-tillage field preparation practices. Therefore, the pre-tillage field preparation operation was not included as a component of any of these three cropping-planting systems. The same reasoning applied when other production operations were not included for a given planting method.

[b]This system was unique in that over half of the producers who used heribicides with this system used more than one type.

NA: Not applicable.

combination in 1976 used both the moldboard plow and the chisel plow with equal frequency for primary tillage. The producers who used the single crop-row crop system in 1981 reported a broadcast herbicide-fertilizer combination most often in lieu of a preplant herbicide which had been used more often in 1976. Both the tandem disk and row crop cultivator were most commonly used twice per field in 1976 by single crop-row crop producers as compared to a modal use of only once per field in 1981 by producers who used that system.

The implements and practices selected in 1981 as representative of the single crop-grain drill system were much the same as those selected in 1976. However, the pre-emergence herbicide selected for weed control in 1976 was replaced by a broadcast herbicide-fertilizer mixture in 1981. Producers of the single crop-grain drill system reported using the tandem disk three times per field for secondary tillage most frequently in 1976, but in 1981 they most frequently reported using that implement only once per field.

The moldboard plow and chisel plow were each used for primary tillage by an equal number of producers of single crop-broadcast soybeans in 1976, but in 1981 the chisel plow was the representative primary tillage implement for that system. The preplant herbicide practice which was representative of the single crop-broadcast system for 1976 was supplanted by the use of both a post-emergence herbicide-fertilizer and a broadcast herbicide-fertilizer combination

as the representative herbicide practice in 1981. The tandem disk was most frequently used only once for secondary tillage by producers of the single crop-broadcast system in 1981 as compared to a modal use of two times in 1976.

Use of the single crop-no till system was not reported by any growers responding to the 1976 survey. Therefore, a comparison of representative implements and practices used in 1976 and 1981 could not be made for that system.

Double Crop Production Systems

The use of the double crop-broadcast system was not reported in 1976. Some differences were detected between the two study years in the representative implements and practices for the three cropping-planting systems which could be compared (Tables 25 and 26). The moldboard plow, the cultimulcher, and preplant herbicide were selected as representative of the double crop-row crop system in 1976, but they were not representative implements and practices for that system in 1981. The moldboard plow was selected as the representative implement for primary tillage in 1976 in conjunction with the double crop-row crop system, however the chisel plow and the offset disk were each used by an equal number of growers to perform that operation in 1981. In 1976, the cultimulcher was selected as the representative implement for seedbed conditioning in conjunction with the double crop-row crop system, but in 1981 the do-all was the representative implement for seedbed conditioning.

Both preplant and post-emergence herbicides were selected as representative practices for herbicide application on double crop-row crop soybeans in 1976, but in 1981 only post-emergence herbicide application was representative of that system. The tandem disk was chosen as the representative secondary tillage implement in conjunction with the double crop-row crop system in both 1976 and 1981. The tanden disk was most frequently used twice per field by double crop-row crop soybean producers in 1976, but in 1981 its modal use was only once per field. The row crop cultivator was selected as the representative implement for cultivation in conjunction with the double crop-row crop system in both 1976 and 1981. The modal use of the row crop cultivator was twice per field in 1976 and once per field in 1981.

The use of a preplant herbicide was a representative practice for the double crop-grain drill system in 1976, whereas in 1981 that practice was replaced by the use of a post-emergence herbicide. The tandem disk was the representative implement used by double crop-grain drill farmers for secondary tillage in 1976. This implement was used a modal number of two times per soybean field in 1976. The tandem disk was also the representative implement used for secondary tillage of the double crop-grain drill system in 1981. However, the frequency with which growers using that system reported using the tandem disk per field in 1981 was bimodal: either once or twice. The do all was the representative implement for seedbed conditioning in conjunction with the double crop-grain

drill system in 1981, but seedbed conditioning was not a representative production practice in 1976.

Changes in representative herbicides were observed for the double crop-no till system between the 1976 and 1981 crop years. In 1976, preplant-burn down herbicide was reported most often, however in 1981 the producers opted to use pre-emergence most frequently.

CHAPTER IV

AN EVALUATION OF SOYBEAN PRODUCTION SYSTEM CHANGES: 1976-1981

The choice of a specific production system is of substantial importance to the soybean producer. Soybean production systems vary in resource requirements and economic returns. Changes in economic conditions, e.g., the relative prices of inputs, and new technological developments may result in a change in the optimum soybean production system for a given farm. Knowledge of potential advantages and/or disadvantages of a given production system compared to an alternative system should benefit both soybean growers faced with choosing which production system(s) to utilize and agricultural researchers evaluating alternative production systems.

The farmers surveyed who produced soybeans in 1981 were asked to indicate which of the eight specified soybean production systems they had used in 1976 in order to assess the extent of changes they had made in production practices during that period. Additionally, growers who changed soybean production systems were asked to indicate any advantages and/or disadvantages which they had experienced as a result of the change.

The same soybean production system(s) was used in both 1976 and 1981 by 39.4 percent of the producers responding. Approximately 35 percent of the producers reported using different systems in the

two crop years and 25.8 percent of them did not produce soybeans in 1976 (Table 27).

I. CHANGES IN PRODUCTION SYSTEMS

The majority of soybean producers who changed production systems instituted only one production system change from 1976 to 1981 (Table 28). Among the 46 farmers reporting production system changes, 76.1 percent changed from one system in 1976 to another system in 1981, eight changed from one system in 1976 to two other systems in 1981, two changed from two systems in 1976 to one system in 1981, and one changed from one system in 1976 to three systems in 1981.

One System to Another System

A change from the single crop-row crop system in 1976 to some other system in 1981 was the most common one reported by soybean growers. Over 54 percent of the farmers reporting production system changes between 1976 and 1981 made such a change. More farmers changed from the single crop-row crop to the double crop-no till system than from any other one production system to another. That change was made by 17.4 percent of all farmers reporting changing production systems between 1976 and 1981.

One System to Two Other Systems

The largest number of farmers who changed from one system of soybean production in 1976 to two other systems in 1981 were those

TABLE 27. Soybean Production System Changes in West Tennessee, 1976-1981

Soybean Producers in 1981	Number Responding	Percent of Total
Using same system(s) as in 1976	52	39.4
Using different system(s) than in 1976	46	34.8
Not producing soybeans in 1976	34	25.8
Total	132	100.0

TABLE 28. Changes in Soybean Production Systems Reported by West Tennessee Farmers Using Different Systems in 1976 and 1981

Production System Changes	Production System Used[a] 1976	1981	Farmers Responding	Percent of Total
One System to Another System	SC-RC	SC-GD	5	10.9
	SC-RC	DC-RC	6	13.0
	SC-RC	DC-GD	6	13.0
	SC-RC	DC-NT	8	17.4
	SC-GD	SC-RC	2	4.3
	DC-GD	SC-RC	2	4.3
	SC-BC	SC-RC	1	2.2
	DC-NT	SC-RC	1	2.2
	SC-BC	DC-BC	1	2.2
	SC-GD	DC-GC	1	2.2
	DC-RC	DC-GD	1	2.2
	SC-GD	DC-NT	1	2.2
		Subtotal	35	76.1
One System to Two Other Systems	SC-RC	SC-GD + DC-NT	2	4.3
	SC-RC	DC-RC + DC-NT	2	4.3
	SC-RC	SC-GD + DC-RC	1	2.2
	SC-RC	SC-GD + DC-GD	1	2.2
	SC-RC	SC-NT + DC-NT	1	2.2
	DC-RC	SC-NT + DC-NT	1	2.2
		Subtotal	8	17.4

TABLE 28 (Continued)

Production System Changes	Production System Used[a] 1976	1981		Farmers Responding	Percent of Total
Two Systems to One System	SC-RC + DC-RC	SC-GD		1	2.2
	SC-RC + DC-RC	DC-GD		1	2.2
			Subtotal	2	4.3[b]
One System to Three Other Systems	SC-RC	SC-GD + DC-RC + DC-GD		1	2.2
			Subtotal	1	2.2
Total				46	100.0

[a]Each combination consists of one cropping practice and one planting method. The codes for designating cropping practices are: S.C. = single crop; D.C. = double crop. The codes for designating planting methods are R.C. = row crop; G.D. = grain drill; B.C. = broadcast; N.T. = no till. Thus, the code S.C.-R.C. represents a single crop-row crop system.

[b]Subtotal percentage does not equal the sum of individual percentages in this category due to rounding.

who changed from the single crop-row crop production system to either: (1) both the single crop-grain drill system and the double crop-no till system, or (2) both the double crop-row crop system and the double crop-no till system. Those two categories of change accounted for 8.6 percent of the farmers reporting changes in soybean production systems. Four other farmers made changes from one system in 1976 to two other systems in 1981, but no two of those four farmers reported the same system changes.

Two Systems to One System

Two farmers who reported changes in soybean production systems made a change from two systems in 1976 to one system in 1981. Both of those farmers had used the single crop-row crop system plus the double crop-row crop system in 1976, but in 1981 one of them used only the single crop-grain drill system and the other used only the double crop-grain drill system.

One System to Three Systems

Only one farmer reported a change involving more than two systems of soybean production. The single crop-row crop system was utilized by that operator in 1976, but in 1981 he used three soybean production systems: the single crop-grain drill, the double crop-row crop, and the double crop-grain drill.

II. ADVANTAGES AND DISADVANTAGES OF SOYBEAN PRODUCTION SYSTEM CHANGES REPORTED BY FARM OPERATORS

Advantages and disadvantages of soybean production system changes reported by farm operators were analyzed only for a change from the single crop-row crop system to another production system. The analysis of advantages and disadvantages of changing production systems was restricted to only that one type of change in order to directly link producer responses to a specific change in production systems. In addition, production system changes from the traditional single crop-row crop system to the single crop-grain drill, double crop-row crop, double crop-grain drill, or double crop-no till systems were the most prominent changes reported by producers (Table 28). Those aforementioned production system changes were reported by 10.9, 13.0, 13.0, and 17.4 percent, respectively, of all farmers reporting a production system change. No other production system change was reported by more than two farmers.

Single Crop-Row Crop to Single Crop-Grain Drill

The most frequently cited advantages of changing from the single crop-row crop to a single crop-grain drill production system were "reduced soil erosion" and "decreased labor requirements" (Table 29). Both "fewer weed problems" and "reduced capital investment" were also cited as advantages of changing to the single crop-grain drill system by over 50 percent of the farmers reporting that change.

TABLE 29. Advantages of Changing from Single Crop-Row Crop Production System in 1976 to Another Soybean Production System in 1981 Reported by West Tennessee Farmers

Farmers Responses	System Used Following Change[a]			
	SC-GD	DC-RC	DC-GD	DC-NT
	- - - - - - Number - - - - - - -			
Reporting Change in System	5	6	6	8
Reporting Advantages of Change				
Reduced Cost/Acre	2	3	3	3
Increased Yield	2	2	2	3
Reduced Soil Erosion	4	4	4	4
Fewer Weed Problems	3	0	3	2
Decreased Labor	4	1	3	5
Less Yield Variability	0	1	0	1
Reduced Captial Invest.	3	2	3	2
Other	0	3	0	1

[a]Each combination consists of the cropping practice and one planting method. The codes for designating cropping practices are: S.C. = single crop; D.C. = double crop. The codes for designating planting methods are: R.C. = row crop; G.D. = grain drill; B.C. = broadcast, N.T. = no till. Thus, the code S.C.-G.D. represents a single crop-grain drill system.

Farmers who had changed from the single crop-row crop system to the single crop-grain drill system reported experiencing far fewer disadvantages than advantages as a result of the change. The most frequently cited disadvantage of that change in production systems was "more weed problems" (Table 30). The fact that some farmers cited "fewer weed problems" as an advantage of changing from the single crop-row crop to the single crop-grain drill system while other farmers felt this change resulted in "more weed problems" which was a disadvantage indicates that uniform results with respect to weed problems should not be expected from this change.

Single Crop-Row Crop to Double Crop-Row Crop

The leading advantage cited by soybean producers making a change from a single crop-row crop to a double crop-row crop production system was "reduced soil erosion." "Reduced cost" was also cited by 50 percent of the producers involved in this type of production system change. The most frequent disadvantage reported in conjunction with this system change was "increased capital investment."

Single Crop-Row Crop to Double Crop-Grain Drill

"Reduced soil erosion" was the leading advantage reported by operators making a change from a single crop-row crop to a double crop-grain drill system. Other advantages reported by at least 50 percent of those farmers instituting that change were "reduced cost per acre," "fewer weed problems," "decreased labor," and

TABLE 30. Disadvantages of Changing from Single Crop-Row Crop Production System in 1976 to Another Soybean Production System in 1981 Reported by West Tennessee Farmers

Farmers Responses	System Used Following Change[a]			
	SC-GD	DC-RC	DC-GD	DC-NT
	- - - - - - Number - - - - - - -			
Reporting Change in System	5	6	6	8
Reporting Disadvantages of Change				
Increased Cost/Acre	0	1	1	1
Decreased Yield	1	1	0	1
Increased Soil Erosion	0	0	0	0
More Weed Problems	2	1	3	3
Increased Labor	0	1	1	0
More Yield Variability	0	0	1	0
Increased Capital Invest.	0	2	1	0
Other	0	0	0	0

[a]Each combination consists of one cropping practice and one planting method. The codes for designating cropping practices are: S.C. = single crop, D.C. = double crop. The codes for designating planting methods are R.C. = row crop, G.D. = grain drill, B.C. = broadcast, N.T. = no till. Thus, the code S.C.-G.D. represents a single crop-grain drill system.

"reduced capital investment." The disadvantage farmers most frequently associated with that change was "more weed problems." Contradictory results were recorded with respect to "weed problems" from farmers making this production system change.

Single Crop-Row Crop to Double Crop-No Till

Operators changing from a single crop-row crop to a double crop-no till production system reported the advantage of "decreased labor" most frequently. "Reduced soil erosion" was the second leading advantage experienced by farmers making that change. The disadvantage cited most frequently by farmers instituting a change to the double crop-no till system was "more weed problems."

CHAPTER V

SUMMARY AND CONCLUSIONS

I. SUMMARY

Soybean production has been the leading crop enterprise in Tennessee with respect to acreage harvested since 1966 and in terms of value of production since 1971. Soybeans comprised about 34.8 percent of the cash receipts from marketing farm crops and accounted for almost 18.9 percent of the cash receipts from all farm marketings in Tennessee in 1981. Tennessee ranked eleventh among the states in the United States in the number of bushels of soybeans harvested in 1980.

The purpose of this study was to provide current information which would be useful to farm operators, agricultural researchers and extension personnel in evaluating alternative soybean production systems. The objectives of this study were: (1) to identify the soybean production systems used by West Tennessee farmers in 1981 and to describe those systems and the farms on which they were used, (2) to analyze the change between 1976 and 1981 in the soybean production systems utilized by West Tennessee farmers, and (3) to summarize the advantages and/or disadvantages observed by farmers as a result of changing soybean production systems.

Two principal sources of data were used in this study. A mail survey conducted in 1982 of a random sample of soybean producers

in Tennessee Crop Reporting Service Districts I and II was one of those sources. Data for the 1981 crop year were collected in that survey. A similar survery administered by Miller[23] in which data for the 1976 crop year were collected was the other. Respondents to both surveys were asked to provide the following information:

(1) Indicate each of the eight predetermined soybean production systems listed below which they used: (a) single crop-row crop, (b) single crop-grain drill, (c) single crop-no till, (d) single crop-broadcast, (e) double crop-row crop, (f) double crop-grain drill, (g) double crop-no till, and (h) double crop-broadcast.

(2) Identify the production implements and/or cultural practices used with each production system and the number of times each implement and/or practice was used per field.

(3) The yield and row spacing of soybeans by system.

Respondents to the 1982 survey were also asked to provide information about the soybean production system(s) they had used in 1976. If the respondents made a change in production systems between 1976 and 1981, they were asked to identify the advantages and/or disadvantages they experienced as a result of the change.

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[23]Miller, op. cit.

Data from the 1982 survey were used to select production operations, production implements and/or cultural practices which were representative of those used by West Tennessee farmers to produce soybeans in 1981 by eight different production systems. The method used for selecting representative operations, implements and/or practices for 1981 was the same as the one used earlier by Miller. The number of times a production operation was used in conjunction with a given production system was determined. If the production operation was utilized over 50 percent of the time by soybean producers using a given production system, that production operation was chosen as representative of that system. The production implements and cultural practices which could be used to perform a representative production operation were then noted to determine how frequently each was used with a given production system. The implement or practice used most often by soybean producers using a given system to perform a representative production operation was chosen as the representative implement or practice to perform that production operation in that production system. The modal number of times that a representative implement or practice was utilized per field in the production of soybeans by a given system was selected as representative of its frequency of use in that production system.

Farmers in West Tennessee reported about 37 percent more soybean acreage per farm in 1981 than in 1976. However, soybean acreage per farm in 1981 was not significantly different from 224.8 which was the acreage of soybeans per farm in 1976. The proportions

of farms in three tenure classes were not significantly different in those two years either. Yields and row spacing reported by farmers in 1976 resembled those reported in 1981. Also, there was little variation in yields reported among the production systems in 1976 and 1981.

All eight of the predetermined cropping-planting systems were used in 1981, although some were used by only a few farmers. The single crop-row crop system was the only method of soybean production used in 1981 by 44.7 percent of the farmers reporting. In 1976, 72.3 percent of the farmers reporting used only that system.

Soybean producers in the sample area used double crop systems more widely in 1981 than they had in 1976, but the single crop-row crop system was the most important production method in both years. The preponderance of soybean acreage in both 1976 and 1981 was produced by the single crop-row crop system, but the percentage of total soybean acreage produced by that system decreased from 79.5 percent in 1976 to 66.8 percent in 1981.

Several changes occurred between 1976 and 1981 in the implements and practices which were representative of those used by farmers producing soybeans by the eight systems analyzed to perform various production operations. And the modal number of times the representative implements and practices were used per field declined between 1976 and 1981. However, the production operations performed by growers utilizing a given soybean production system were almost identical in the two years analyzed.

Both the moldboard plow and the chisel plow were representative primary tillage implements in conjunction with both the single crop-row crop and single crop-broadcast production systems in 1976. However, the chisel plow was the only representative primary tillage implement used in association with those two systems in 1981. In 1976, preplant and pre-emergence herbicides applied by a sprayer were representative chemicals used for weed control with the single crop-row crop and single crop-grain drill production systems, respectively. In 1981, broadcasting a herbicide-fertilizer combination was a representative practice for both of those systems. The single crop-broadcast producers utilized preplant herbicide most often for weed control in 1976, but both a post-emergence herbicide and a broadcast herbicide-fertilizer combination were used with equal frequency by growers using that system in 1981.

In 1976, the moldboard plow was used most often by double crop-row crop producers for primary tillage, whereas the chisel plow and offset disk were utilized with equal frequency for primary tillage by farmers using that system in 1981. The cultimulcher was the representative implement used for seedbed conditioning with the double crop-row crop system in 1976. In 1981, the do all implement replaced the cultimulcher as the most popular implement used by double crop-row crop producers for seedbed conditioning. Seedbed conditioning was not a representative production operation in 1976 for the double crop-grain drill system. However, seedbed conditioning was a representative production operation

for that system in 1981 and the do all implement was most frequently used to perform that operation. Preplant and post-emergence herbicides were used for weed control by an equal number of farmers who used the double crop-row crop production system in 1976. However, only post-emergence herbicides were representative of the chemicals used for weed control with that system in 1981. The double crop-grain drill operators used preplant herbicides most often in 1976; however, they used post-emergence herbicides most often in 1981. A burn-down herbicide was the representative chemical used for weed control with the double crop-no till system in 1976, but it was replaced by a pre-emergence herbicide in 1981. In 1976, some production implements and cultural practices used to perform production operations were typically used as many as three times per soybean field. However, in 1981 implements and practices were typically used only once per soybean field with the exception of the tandem disk which was often used one and two times per field.

Approximately 35 percent of the soybean operators surveyed in 1981 had changed soybean production systems between 1976 and 1981. The majority of those changes were from the single crop-row crop system in 1976 to one of four other systems in 1981: single crop-grain drill, double crop-row crop, double crop-grain drill, and double crop-no till. The advantages reported most frequently by farmers making one of those four changes were: "reduced soil erosion," "decreased labor," "reduced cost per acre," and "reduced capital investment." The most frequent disadvantage reported by

growers changing from a single crop-row crop system to one of the other four systems was "more weed problems."

II. CONCLUSIONS

Farmers may increase their net income by: (1) increasing farm size, (2) adjusting combinations of farm enterprises, and (3) adjusting combinations of inputs used in production. A soybean producer may increase his net income by controlling more resources such as land and machinery. Or he may increase his net income by changing enterprise combinations to one in which land is utilized more intensively, e.g., converting pastureland to soybean production. A soybean producer may also increase his net income by changing the combination of inputs used in production. He may use less of one input in order to reduce cost, e.g., eliminate a production operation or reduce the number of times an implement or practice is used per field. Or he may use more of one input in order to increase output, e.g., increase yields by applying more fertilizer.

Soybean growers in West Tennessee have recently made adjustments in production systems which should result in increased net returns. Farms producing soybeans in West Tennessee are becoming larger and a greater percentage of the land on those farms is being planted to soybeans. The traditional single crop-row crop production system has been, and still is today, the most prevalent production system used to produce soybeans. However, alternative production systems such as the double crop-grain drill and double crop-no till

systems are becoming more widely used. Such systems require fewer production operations, e.g., primary tillage and cultivation are not normally utilized with the double crop-grain drill and double crop-no till systems. Therefore, both the cost of production and the labor required per acre to produce soybeans with those systems should be reduced.

Soybean growers have also reduced the number of times they use an implement or practice per field which should reduce production costs. "Decreased labor" and "reduced cost per acre" being cited by growers as advantages of changing soybean production systems is additional evidence that soybean producers have made attempts to reduce the quantity of inputs used in production. However, relatively stable average soybean yields in recent years suggest that growers either have not attempted to adjust inputs in order to increase yields or have been unsuccessful at doing so.

Soybean growers apparently consider long run benefits and costs as well as short run net returns when choosing a production system because they cited "reduced soil erosion" more frequently than any other advantage of changing production systems. Growers responses also suggest that currently available technology may not be well-suited for use with nontraditional soybean production systems. Growers frequently cited "more weed problems" as a disadvantage of changing from the traditional single crop-row crop to some alternative system.

Farmers in West Tennessee are changing the methods they use to produce soybeans. Current economic conditions have encouraged soybean growers to use land more intensively and adopt practices designed to reduce production costs. However, soil conservation is apparently still important in their system of values.

Agricultural researchers should expand their efforts to develop technology for nontraditional soybean production systems which will enable growers to adjust to changing economic conditions more readily. Seed varieties which are better suited for double crop systems, herbicides which are more effective for no till systems, and machinery which allows farmers to utilize labor more efficiently and/or to reduce soil erosion are examples of research areas which should benefit soybean producers.

Actual production levels achieved under field conditions by soybean growers using traditional systems remain far below potential levels and have changed little in recent years. Therefore, current research efforts designed to improve traditional soybean production systems should not be abandoned. And agricultural extension personnel should continue their programs designed to give all soybean growers access to current information on production technology.

An alternative soybean production system or a new production technique may not be profitable on all farms. Research and extension personnel in Agricultural Economics should continually update information designed for soybean growers to use in evaluating

production alternatives. For example, enterprise budgets used in farm planning should reflect systems currently used by growers as well as alternative systems incorporating new technology which they could use. Cost and return coefficients in such budgets should reflect the production operations performed, the machine used to perform each operation, and the number of times a machine is used per field to perform a given operation.

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