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A VARIETY INDEX FOR USE IN CORN BELT SOYBEAN YIELD MODELS*

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ABSTRACT

Regional and state level variety indexes are developed for the five Corn Belt states (Illinois, Indiana, Iowa, Missouri, Ohio). The indices are based on data from Soybean Variety Performance Trials and survey data on variety adoption as a percent of planted acreage. The use of this type of index as an explanatory variable in state level yield models is illustrated. The variety index is shown to provide additional explanatory power over the more conventional time trend specification for technological change. It is not possible, however, to measure quantitatively aggregate state level yield effects due to the variety index as distinct from other technological factors.

Key Words: variety index, technology, soybean yield modeling

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1. INTRODUCTION

Crop yield estimation models typically have two components, one reflecting weather variation and another characterizing the "technology". Weather effects on crop yields are usually modeled using deviations from normal for soil moisture, temperature, precipitation, and other weather related variables. In fact, there is an extensive literature on appropriate characterizations of weather variables in crop yield models. Information on the use and understanding of the technology component of crop yield models is, however, not nearly as well developed. This component is represented in most applied state and regional crop yield models as a simple time trend. Because of this simple characterization of technology, the aggregate yield models contain little information on yield responses to input differences, changes in varieties, and other production practice shifts.

The present analysis has the objective of providing a more systematically developed and responsive technology index for inclusion in state and regional yield models. The variety index is developed for soybeans in the five corn belt states and utilizes a unique data source in combination with variety adoption data. Specifically, data from variety performance trials in Illinois, Indiana, Iowa, Missouri and Ohio for the period 1967 through 1982 are utilized to estimate individual variety yield factors (relative to a standard variety). The variety yield factors are then aggregated using weights developed from variety adoption data to produce a variety index value for each year. After constructing this variety index, it is used as an explanatory variable in estimating average yields at the state level.

Results from using the variety or technology index along with weather data to estimate state level yields for soybeans are encouraging. The variety index is a more responsive measure of technology than the simple time trend and has the potential to characterize the influence of new plant breeding technologies. This approach to technology estimation is particularly attractive for soybean yield estimation, since the crop yield responses to nonland inputs have been less than for many other crops. Still, methods of producing soybeans have changed in recent years. A final portion of the study addresses these changes in production practices and their implications for the use of the variety index in soybean yield estimation.

2. METHODS

Problems and shortcomings of using a simple time trend as a proxy for technological progress in crop yield equations have long been recognized (Shaw, 1964; Heady and Auer, 1965; Perrin, 1968; Linn and Seauer, 1978; Padgitt, 1982; Kestle 1982b). However, attempts to improve the technology components of yield estimation models have been largely unsuccessful for two important reasons. First and most obvious, the operational definition and measurement of crop yield "technology" is not simple or straightforward. Many different proxy variables for technology have been suggested; public and private expenditures on agricultural research (Ruttan, 1979; Miner, 1981), educational attainment of farmers (Mellor, 1966), application rates for nitrogen and other fertilizers (Shaw, 1965), percent of cropland acres treated with herbicides, indices of genetic improvement (Heady and Auer, 1965), and plant population (Miner, 1981). Even though each of these factors is related to technological change, it is also clear that no single one, nor any combination of them, provides a summary measure of the impact of technological change on crop yields.

The second major obstacle to quantifying crop yield technology is that most of the observable technical variables are highly correlated in the available time series data. This means that statistical yield models including these variables have erratic and misleading parameter estimates (Judge et al., 1980). On the other hand, if the statistical yield model includes only one technical variable (e.g., fertilizer application) the estimated coefficient will likely overstate the actual yield effect of that factor. Doll (1974) has shown that the existence of multicollinearity between production inputs for aggregate yield data is not coincidence, but actually follows directly from optimal economic behavior of farmers. Consequently, even if accurate information were available for all technical inputs at the state level, multicollinearity would complicate the unambiguous estimation of their individual effects on crop yields from nonexperimental data.

In spite of these limitations, there are benefits from quantifying technology in crop yield estimation. Changes in the mixture and extent of adoption of production practices and varieties have important consequences for agricultural production levels. Deviations from trend-like behavior in estimated crop yield models can be caused either by innovations in crop production methods and varieties or shifts in relative prices of inputs (El-Shereif, 1981). For example, Griliches (1958) has argued that the large increase in nitrogen fertilizer use after World War II was due primarily to innovations in fertilizer production and a substantial decrease in the relative real price of fertilizer. Thus, a data base that contains reliable information on these various technical factors can be valuable in the timely assessment of crop yield changes as well as for short run forecasting.

3. YIELD MODEL SPECIFICATION

The objective of the yield model specification is to provide a preliminary evaluation of the information content of a variety index for predicting state level crop yields. The model includes weather variables and a variety index as a substitute for the time trend typically used to capture technological effects.

Weather variables. Specification of weather variables for use in crop yield models is a complex and interesting problem (Shaw, 1964; Oury, 1965; LeDuc, 1980; Kestle, 1982b). The primary focus of this study, however, is on the variety index. For this reason, the weather variables suggested by Thompson (1970) are used in the yield model. These weather variables are easily calculated from available monthly data and are representative of standard practices for including weather in crop yield models (Pope and Heady, 1982). These weather variables are:

1) September to June total precipitation,

2) July total precipitation,

3) August total precipitation,

4) June mean temperature,

5) July mean temperature,

6) August mean temperature.

These quantities were computed as departures from normal (mean of 1931-1982) at the Climatic Division level.[1] State level weather data series were computed from district means weighted by harvested soybean acres for each year.

The yield model specification suggested by Thompson also included squared values of each of the weather variables. However, these terms were omitted in the yield model specifications used for this study. Kestle (1982a) found many of the estimated parameters for the squared weather variables to be statistically insignificant. Also, since there were only fourteen or fifteen years (depending on the state) of variety adoption data by state, it was necessary to limit the total number of parameters to be estimated for the yield models.

Variety index. Technology indices to be used in a yield model must use available data. Although the aggregate yield and weather data sets cover fifty years for Illinois and thirty or more years for the other four states, the variety index to be used in reflecting technology can be computed for only twenty-four years for Illinois and

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[1] For Illinois, Indiana, and Iowa the nine Crop Reporting Districts are identical to the Climatic Divisions. In Missouri and Ohio the boundaries of the two regions do not coincide. In these states, county level crop data were aggregated to compute the appropriate Climatic Division production figures.

fourteen to fifteen years for the other states. The variety index is partitioned into a trend component and deviations from trend. The resulting "variety residual" variable can be thought of as a measure of the additional information contained in the variety index over the trend component commonly used in applied models. If both the trend and deviation variables are included in the yield model, the coefficient of the "variety residual" term can be interpreted as reflecting the non-trend technological (through improved varieties) contribution to yield, while the "technological trend" coefficient will reflect effects of non-genetic technology plus the trend component of variety improvements. This approach has the advantage that even in the early years when the variety index is not available, the predicted trend value can be computed and used in yield model development. Setting the variety residual equal to zero in these years allows the use of the full time series to estimate the weather coefficients.

The full yield model is:

$$Y = \beta_0 + \beta_1 TRINDEX + \beta_2 GENTRES + \beta_3 DNPRSP + \beta_4 DNPJUL + \beta_5 DNPAUG + \beta_6 DNTJUN + \beta_7 DNTJLY + \beta_8 DNTAUG + \varepsilon \qquad (1)$$

where

Y = State level soybean yield - bushels per harvested acre

TRINDEX = Trend component of the variety index

GENTRES = residual deviations of the variety index from trend (variety index minus trend fit)

DNPRSP = Departure from normal preseason precipitation (total Sept.-June)--inches

DNPJLY = Departure from normal July total precipitation--inches

DNPAUG = Departure from normal August precipitation--inches

DNTJUN = Departure from normal June mean temperature--degrees Fahrenheit

DNTJLY = Departure from normal July mean temperature--degrees Fahrenheit

DNTAUG = Departure from normal August mean temperature--degrees Fahrenheit

ε = An error term, assumed to be normally distributed with a mean of zero.

4. DATA

The two data bases are used in constructing the variety index. The information from these two sources is well-suited to the goal of constructing a quantitative measure of variety improvement. The variety performance trials are conducted under an experimental design that focuses on differences of yield potential between varieties, while the adoption data provide a measure of the use of the varieties on commercial farms. Together, they can be used to construct a time-series index measure of genetic yield potential changes in adopted varieties.

Variety performance trials. The Agricultural Experiment Stations associated with the land grant universities have conducted annual performance trials for selected crops for a number of years (State

Experiment Station Bulletins, various years). Most Corn Belt states began soybean variety testing programs in the late 1960s or early 1970s. Each state conducts trials at several sites representative of major growing areas. Measured characteristics for each variety generally include plant height, maturity, lodging, and shattering, as well as yield. Experimental plots consist of two to four rows twenty to thirty feet long, with two to four replications for each variety.

The variety trial data set for the five states during the period 1967-1982 contains over 22,000 observations (Table 1). By state, there are about 5,700 observations for Illinois, 3,900 for Indiana, 4,500 for Iowa, 7,300 for Missouri and 1,200 for Ohio. Not all of these observations are used in this study. Specifically, only those varieties which appear in the adoption data (listed in Table 2) are required for the aggregate yield model. The subset of adopted varieties represented 4,872 of the available 22,000 observations.

Table 1 and Figure 1 provide a summary of the number of test sites and the number of varieties tested each year by state. Iowa and Illinois have consistently tested more varieties than the other three states. In the last ten years, the yield performance testing programs have been significantly expanded in all states. The increase in privately developed and patented varieties offered by seed companies is the main reason for the increase in the number of varieties tested (Perrin, Hunnings, and Ihnen, 1984).

Table 2 gives the maturity group and the vintage (year of first appearance in the performance trials) for all varieties that appear in the adoption data. Since the yield trials data begins with 1967, all

Table 1

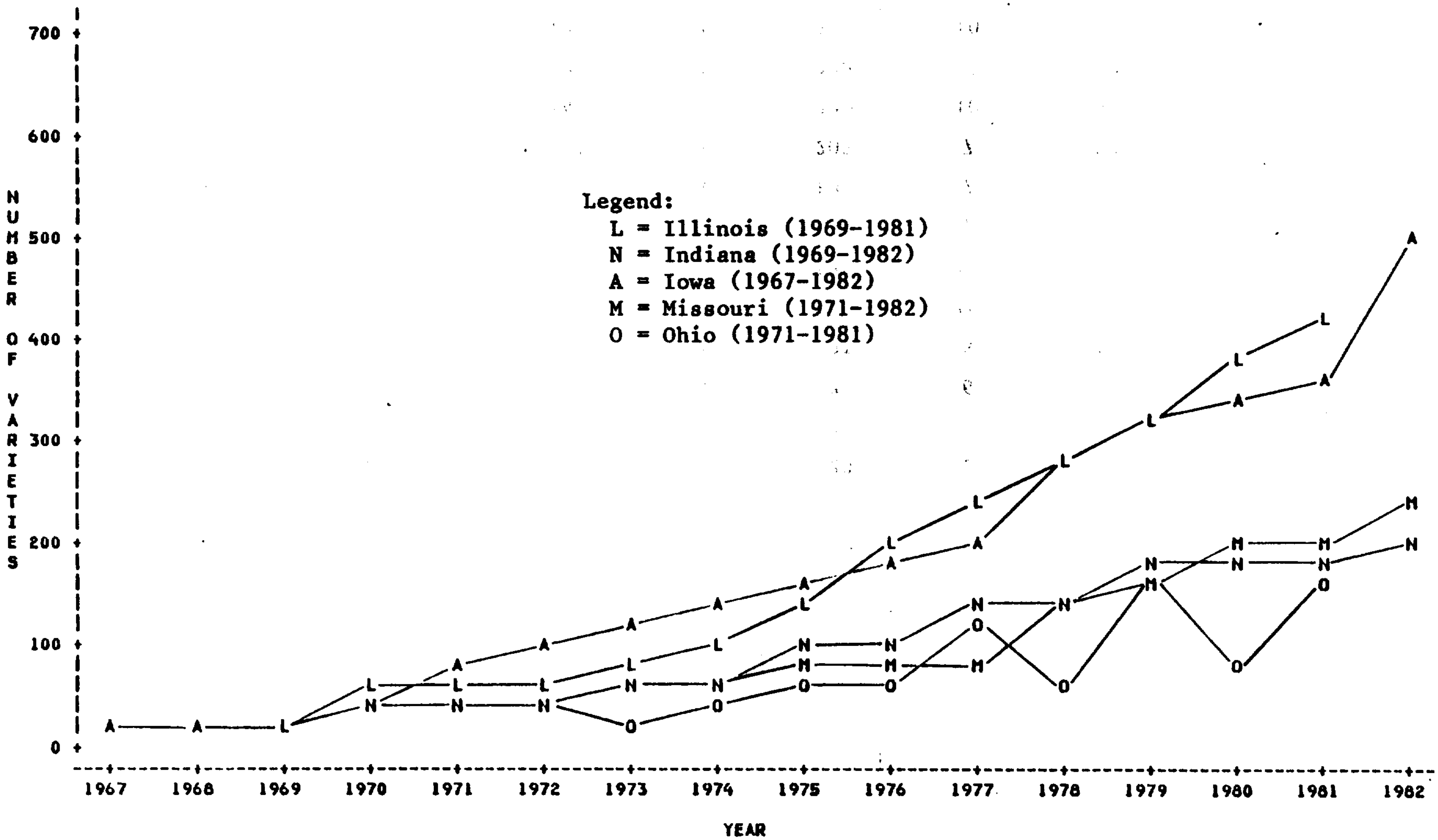
Number of Soybean Varieties in Performance Trials and
Number of Test Sites by State, 1967-1982

Year	Illinois		Indiana		Iowa		Missouri		Ohio	
	Sites	Varieties	Sites	Varieties	Sites[a]	Varieties	Sites	Varieties	Sites	Varieties
1967	.	.	.	.	3	19	.	.	.	.
1968	.	.	.	.	3	20	.	.	.	.
1969	2	16	3	20	3	23	.	.	.	.
1970	3	53	4	34	3	33	.	.	.	.
1971	3	52	4	40	3	72	6	36	2	33
1972	3	54	3	47	3	91	5	48	2	36
1973	5	84	4	58	3	128	10	53	1	22
1974	6	90	4	63	3	138	10	59	1	39
1975	6	134	5	92	3	160	7	71	1	67
1976	7	200	6	103	3	183	7	73	2	59
1977	8	231	5	141	3	203	7	83	2	111
1978	8	270	6	145	3	280	10	134	1	68
1979	8	326	6	178	3	328	11	159	2	155
1980	10	381	6	173	3	345	10	203	2	87
1981	10	419	6	177	4	364	11	204	2	151
1982	.	.	6	197	3	500	10	239	.	.

[a]Iowa actually had nine test sites in most years but results were reported as averages within three regions.

Figure 1

Number of Soybean Varieties in Performance Trials
by State, 1967-1982



NOTE: 14 OBS HAD MISSING VALUES

Table 2

Maturity Group and Vintage of Adopted Soybean Varieties

Variety	Maturity Group	Vintage[a]
Agripro	b	1973
Amsoy	2	1967
Asgrow	b	1974
Bedford	5	1978
Beeson	2	1969
Bonus	4	1971
Calland	3	1968
Clark	3	1967
Corsoy	2	1967
Cumberland	3	1977
Cutler	4	1969
Dare	5	1971
Elf	3	1977
Essex	5	1972
Forrest	5	1972
Franklin	4	1978
Harcor	2	1975
Harosoy	2	1967
Hawkeye	2	1967
Hill	5	1971
Kent	4	1970
Lindarin	2	1967
Mack	5	1971
Mitchell	4	1972
Pickett	6	1971
Shelby	3	1967
Union	4	1976
Wayne	3	1967
Wells	2	1972
Williams	3	1971
Woodworth	3	1973
York	5	1971

[a]Year in which the variety first appeared in the performance trials. Since the data set begins with 1967, all older varieties are assigned this vintage. For the geneology of these varieties, see Luedders, 1977.

[b]These brand names included varieties in groups 1 through 5.

older varieties are assigned this vintage. Luedders (1977) gives the geneology of many of these public varieties of soybeans. This information could be used to establish the actual vintage of varieties already in the adoption data in 1967.

The performance trials are designed to help farmers decide which varieties to plant, not the levels or types of inputs or management practices to apply in the production process. The experimental procedure for the performance trials is designed to measure the relative yielding ability of different varieties when grown under identical and nearly ideal management conditions. This experimental design is consistent with the goal of this study in that it focuses primarily on yield differences between varieties. Data from side by side trials can be used to control for weather effects and other non-genetic technical factors, since these factors are applied uniformly in the performance trials. Soil fertility is maintained at a high level and weed and pest threats are carefully controlled in the trials. Except for a few experiments, the trials are not irrigated. There are also some experiments to measure yield effects of variations in plant population (usually reported as row width).

Variety adoption data. State data on the percent of total soybean acreage planted to the leading varieties are available from the USDA Statistical Reporting Service's Objective Yield Survey (USDA, 1975). In addition to these data, special state surveys conducted in Missouri and Illinois have compiled similar variety adoption information for several years based on non-probability samples. For some of the more recent years these state compiled data are available by Crop Reporting District.

There is a difference in the methodological basis of the special state and USDA objective yield surveys. The annual Objective Yield Survey (USDA) is a probability survey which samples soybean fields in each state proportional to soybean acreage. Since the primary purpose of the survey is to estimate yield rather than acreage, the sample size is generally considered adequate for estimating the percent of planted acreage for only the three or four leading varieties. On the other hand, the Missouri and Illinois state surveys are based on a larger samples and include data for all varieties that are adopted on at least one percent of planted acreage. Because of this greater completeness, in years for which data from both sources were available the special state surveys were used.

Appendix A contains tables and plots of state level variety adoption data. For Illinois this series is for 1957 to 1980. For the other four states the series is for 1967 to 1980, except that for Missouri 1981 is also included. Yearly percentage totals for the major public varieties have declined for all states except Missouri. This reflects the increasing adoption of private varieties. Within the last five years (1975-1980), privately developed and patented soybean varieties have been adopted to a significant extent.

In 1980, public varieties were still planted on approximately half of the soybean acreage in the Corn Belt. Nevertheless, there is a trend toward the adoption of private varieties. As this trend continues, data on acreage by variety may become more fragmented. The private seed companies usually offer several different varieties. However, the surveys generally report only the brand or company name without the specific cultivar designation. These changes in seed supply may impose limitations on the future uses of the variety index as a technology measure.

5. VARIETY ADOPTION AND THE VARIETY INDEX

This section describes the procedure used to calculate the relative yield factor for each adopted variety and the variety index for each state. Generally, the procedure involves a comparison to a reference variety, Clark, for the period of record in the performance trials.

Relative yield factors. The variety performance trials data can be used to estimate a yield factor that expresses the average yield of a particular variety as a proportion of the average yield of a "reference" variety. The criteria for choosing a reference variety were that it be:

1) representative of an "old" genetic technology, and
2) tested over a wide geographic area and
3) extensively represented in the yield trials data base.

To an extent, these criteria were mutually inconsistent since none of the widely tested varieties represented the "old" genetic strains. However, some of the varieties introduced in the early sixties were from genetic parentage only one or two generations removed from the early oriental strains of the 1920's and 1930's (Luedders, 1977).

Because Clark is the most widely grown of these varieties, it was chosen as the reference variety.

The relative yield factor for each adopted variety is based on the average yield difference from the reference variety. This difference may be expressed as a proportion of the average yield of the reference variety to provide an index that equals unity if the mean yield difference is zero. Thus, the procedure for constructing the yield index is straightforward. Specifically:

1) For each variety, compute the mean yield difference from the reference variety in all years and locations where the two varieties were grown together, Y_DIFF.

2) Compute the average yield of the reference variety, YREF. This could be either the average reference variety yield across all years and locations or the average yield in trials with the given variety.[2] The average yield across all observations of the reference variety was used here for simplicity of interpretation.

3) Construct the relative yield factor for each variety, Y_FACTOR = (YREF + Y_DIFF)/YREF. This index equals one if the mean yield difference is zero.

Table 3 lists the results of these calculations for each of the 31 nonreference varieties included in the adoption data for the five states.

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[2]Both possibilities were tried and the results were nearly identical. Correlation coefficients between the two resulting index series were greater than .9990 in all states.

Table 3

Mean Yield Difference From Clark for Adopted Soybean Varieties

Variety	Y_DIFF[a]	Y_FACTOR[b]	N_OBS[f]	STD_DEV[g]	T_VALUE[c]	P_VALUE[h]
AGRIPRO[d]	3.9257	1.11453	183	6.0410	8.7909	0.000100
AMSOY[e]	1.4523	1.04237	107	6.9960	2.1474	0.034043
ASGROW[d]	5.9948	1.17490	229	5.9491	15.2488	0.000100
BEDFORD	7.4783	1.21818	23	9.4937	3.7777	0.001052
BEESON[e]	0.8800	1.02567	60	7.6191	0.8947	0.374606
BONUS	1.6706	1.04874	85	4.9247	3.1275	0.002423
CALLAND	3.5718	1.10421	85	4.8320	6.8277	0.000100
CORSOY	1.8829	1.05493	35	8.9908	1.2389	0.223851
CUMBERLAND	5.3316	1.15555	38	4.8672	6.7525	0.000100
CUTLER[e]	2.2701	1.06623	117	4.7370	5.1836	0.000100
DARE	3.7463	1.10930	54	7.1096	3.8722	0.000298
ELF	3.1842	1.09290	38	5.8218	3.3716	0.001764
ESSEX	8.9750	1.26185	48	6.5008	9.5651	0.000100
FORREST	8.5638	1.24985	47	10.1287	5.7964	0.000100
FRANKLIN	0.0875	1.00255	32	4.9583	0.0998	0.921123
HARCOR	-1.0667	0.96888	3	6.9169	-0.2671	0.814411
HAROSOY[e]	-0.9783	0.97146	23	10.2513	-0.4577	0.651685
HAWKEYE[e]	-1.7625	0.94858	8	4.1908	-1.1895	0.273006
HILL	2.2091	1.06445	33	7.6660	1.6554	0.107619
KENT	4.5651	1.13319	43	6.8141	4.3932	0.000100

Table 3--Continued

Variety	Y_DIFF[a]	Y_FACTOR[b]	N_OBS[f]	STD_DEV[g]	T_VALUE[c]	P_VALUE[h]
LINDARIN	3.2500	1.09482	2	2.2749	1.8571	0.314453
MACK	6.7449	1.19678	49	8.2376	5.7315	0.000100
MITCHELL	7.7137	1.22505	51	6.1812	8.9120	0.000100
PICKETT[e]	7.8800	1.22990	30	8.9706	4.8813	0.000100
SHELBY	-2.7250	0.92050	4	1.2842	-4.2439	0.023962
UNION	3.3154	1.09673	65	5.2152	5.1253	0.000100
WAYNE	1.6216	1.04731	88	5.7417	2.6493	0.009578
WELLS[e]	-1.0000	0.97082	18	11.8494	-0.3580	0.724715
WILLIAMS[e]	3.8902	1.11350	205	4.9657	11.2170	0.000100
WOODWORTH	3.1790	1.09275	62	5.6368	4.4408	0.000100
YORK	6.6173	1.19306	52	7.5092	6.3547	0.000100

[a]Mean yield difference from Clark (bushels per acre) in side-by-side performance trials.

[b]Y_FACTOR = (YREF + Y_DIF)/YREF where YREF = 34.28 bu./ac. = mean yield of Clark at all locations, all years.

[c]Value of student's t-statistic for a test of the null hypothesis, H_o: Mean Yield Difference = 0.

[d]Includes all varieties tested under these brand names.

[e]Includes all later derivatives, e.g., Amsoy 71, Beeson 80, etc.

[f]N_OBS is the number of yield observations where both the variety and Clark where included in side by side performance trials.

[g]STD_DEV is the standard deviation in Y_DIFF.

[h]The P_VALUE is the probability level for the significance of the difference.

This method of constructing a comparative yield factor can be misleading when the reference variety and the comparison variety are in different maturity classes. There is no precise way to compare the yielding ability of two varieties of different maturity in a side by side trial, since one of the varieties will necessarily be outside its optimal growing area. Although this problem will arise whenever the compared varieties are in different maturity classes, it is likely to be especially acute when comparing a "determinate" variety to a "indeterminate" variety.

Determinate soybean varieties exhibit a growth pattern in which flowering occurs at all fruiting sites concurrently and vegetative growth stops as flowering begins. In indeterminate varieties, flowering begins near the middle of the plant and moves both directions along the stem while vegetative growth continues. Flowering continues over a three to four week period and plant height approximately doubles during this time. Maturity Groups 0 to III are all indeterminate varieties, Group IV are also mostly indeterminate, with the exception of a few varieties (e.g., Kent) that exhibit some determinate tendencies, while Groups V and VI are all determinate (Helsel, 1983).

This maturity class problem is most prevalent in the Missouri data where several determinate varieties of maturity Groups V and VI (Bedford, Essex, Forrest, Mack, Pickett, York) are grown commercially only in the Bootheel Region. Clark is an indeterminate variety of maturity Group III and is adapted to the central and northern parts of the state. Since the Bootheel varieties are seldom included in trials at northern test sites, most of the side by side observations are from southern trials where Clark is at a disadvantage. This resulted in large positive yield differences for these southern varieties even though aggregate yields in the South were typically lower than in the North. Thus, the numerical value of the mean yield differences should not be interpreted as a flawless quantitative measurement of the comparative yielding ability of any variety relative to Clark except those that are also of maturity Group III.

Fortunately, the construction of the variety index requires only an annual series of values that indicates relative changes over the time period. Provided there have not been large shifts in the proportion of total acreage devoted to each maturity class, the bias in the variety index due to the maturity class problem will remain constant over time. To the extent that increased acreages have been planted to non-Group III varieties, there may be an upward bias in the index over time.

Acreage weighted variety index. By merging the relative yield factor for each variety with the acreage adoption data, a state level acreage weighted mean of the adopted variety yield factors can be calculated for each year. The weighted mean is expressed as

$$\bar{y}_w = \sum_{i=1}^{n} w_i y_i \qquad (2)$$

where the sum of the weights w_i is one, i.e.,

$$\sum_{i=1}^{n} w_i = 1 .$$

In equation (2), $\bar{y}_w$ is the value of the variety index for a particular year, n is the number of adopted varieties reported in that year, y_i is the relative yield factor (Y_FACTOR in Table 3) for a particular variety and the weight, w_i is the adjusted percent of planted acres for that variety in that year. Since the identified varieties reported for each year do not account for 100 percent of the planted acreage, a percent of planted acreage for each variety was divided by the reported total so that the sum of the weights would equal one. That is:

$$w_i = \frac{W_i}{\sum_{i=1}^{n} W_i}$$

where W_i is the reported percent of planted acres (PPLAC in Tables A.1-A.5). This is equivalent to the assumption that unreported acreage is planted to the same variety mix as reported acres. If in fact this acreage were planted to varieties with a higher (lower) average yield than the reported varieties, this would result in a downward (upward) bias in the calculated index value. An associated assumption is that the genetic mix for the harvested crop (that which produces a yield) is the same as for the planted acreage.

The necessary assumption that must be made to justify the use of the variety index as a technology variable in aggregate yield equations is that observed yield differences in the performance trials are proportional to realized changes in aggregate yields as higher yielding varieties are adopted on commercial farms. It is not necessary to assume any fixed relationship between experiment station and farm yield levels, only that if a higher yielding variety replaces a lower yielding one (as measured by the performance trials), a proportional increase in farm yields will result.

6. RESULTS

The Variety Index

Plots of the state and region level variety indexes are shown in Figures 2 through 7. Tabulated values are given in Appendix B. Although Illinois is the only state for which adoption data are available before 1967, a detailed examination of the time series plots of state adoption data (Appendix A) will confirm that the introduction of Amsoy and Wayne in the late sixties was primarily responsible for a relatively rapid increase in the variety index from 1966 to 1970. During the early to mid-seventies there was a plateau, followed by another substantial increase with the introduction of Williams in the late seventies. Although complete data on the adoption of private varieties are lacking, they probably account for an increasingly significant share of acreage, particularly in the highly productive areas of central and northern Iowa. To the extent that this is true, the computed variety index may understate the increase in adopted genetic technology.

Results of fitting a simple time trend to the index series are shown in Appendix C (Tables C.1 through C.6 and Figures C.1 through C.6). The predicted variety index trend component, along with the residual deviations (variety index minus its trend component) are the

Figure 2

State Level Variety Index for Adopted Soybean Varieties in Illinois, Weighted by Percent of Planted Acres

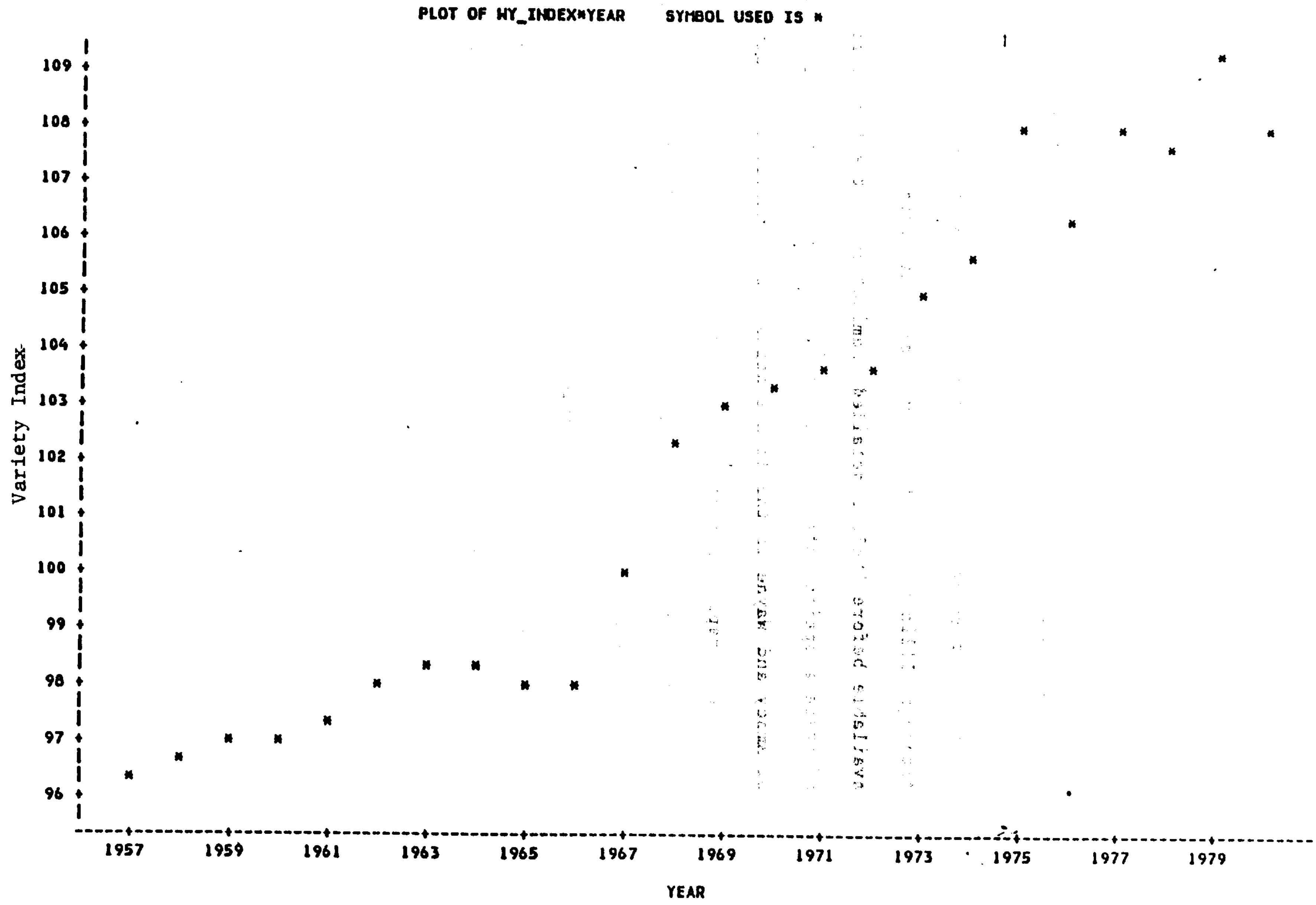


Figure 3

State Level Variety Index for Adopted Soybean Varieties in Indiana, Weighted by Percent of Planted Acres

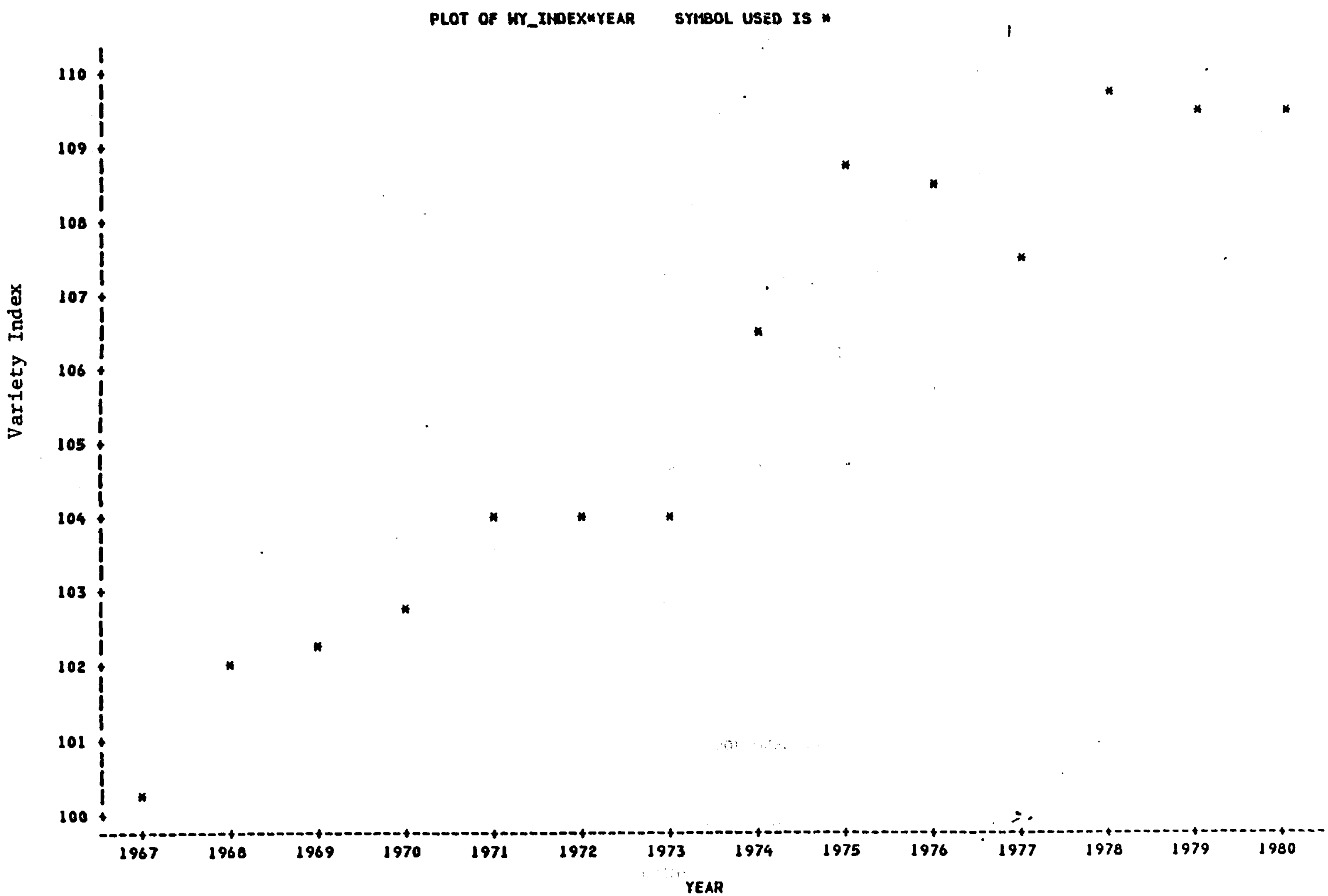


Figure 4

State Level Variety Index for Adopted Soybean Varieties in Iowa, Weighted by Percent of Planted Acres

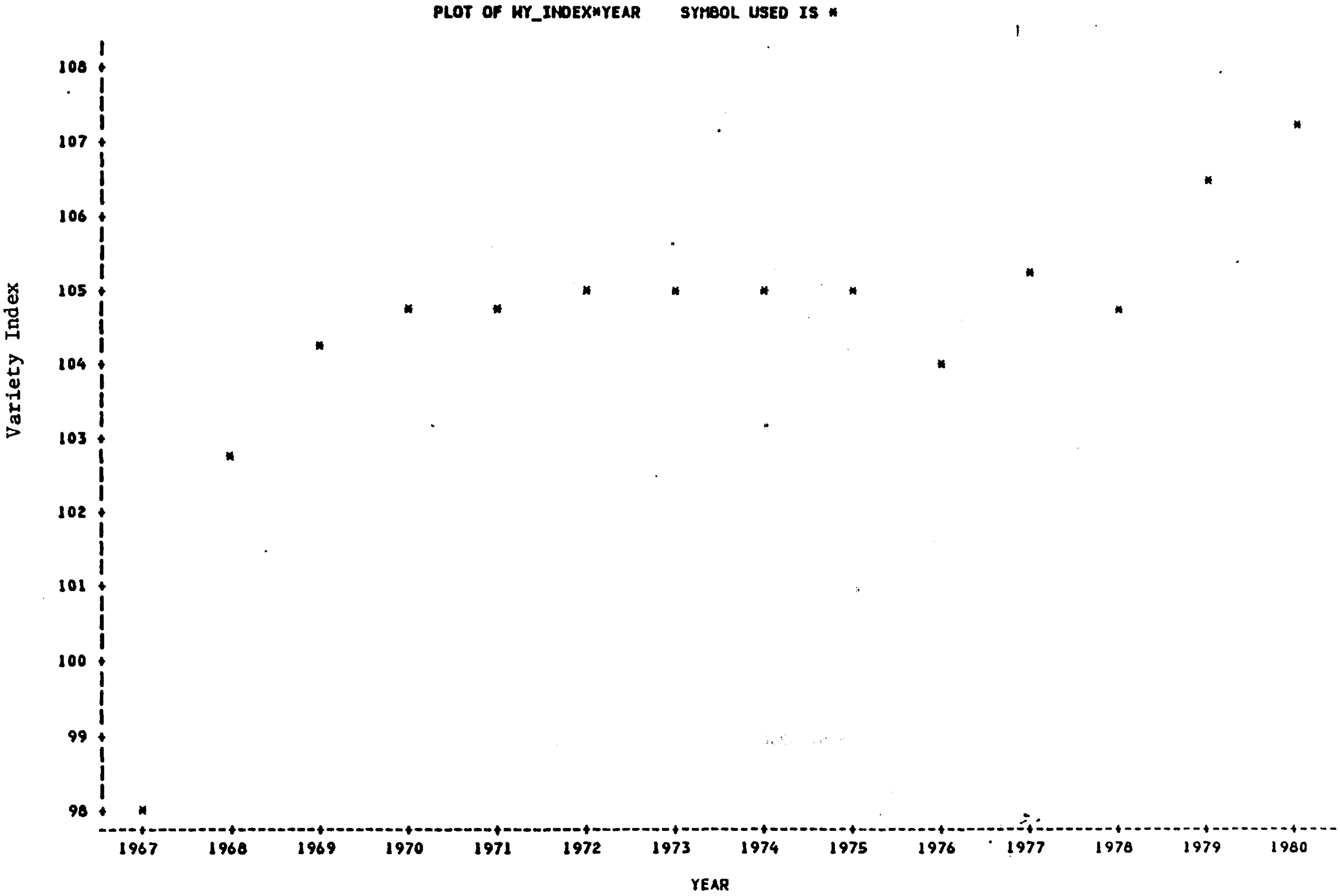


Figure 5

State Level Variety Index for Adopted Soybean Varieties in Missouri, Weighted by Percent of Planted Acres

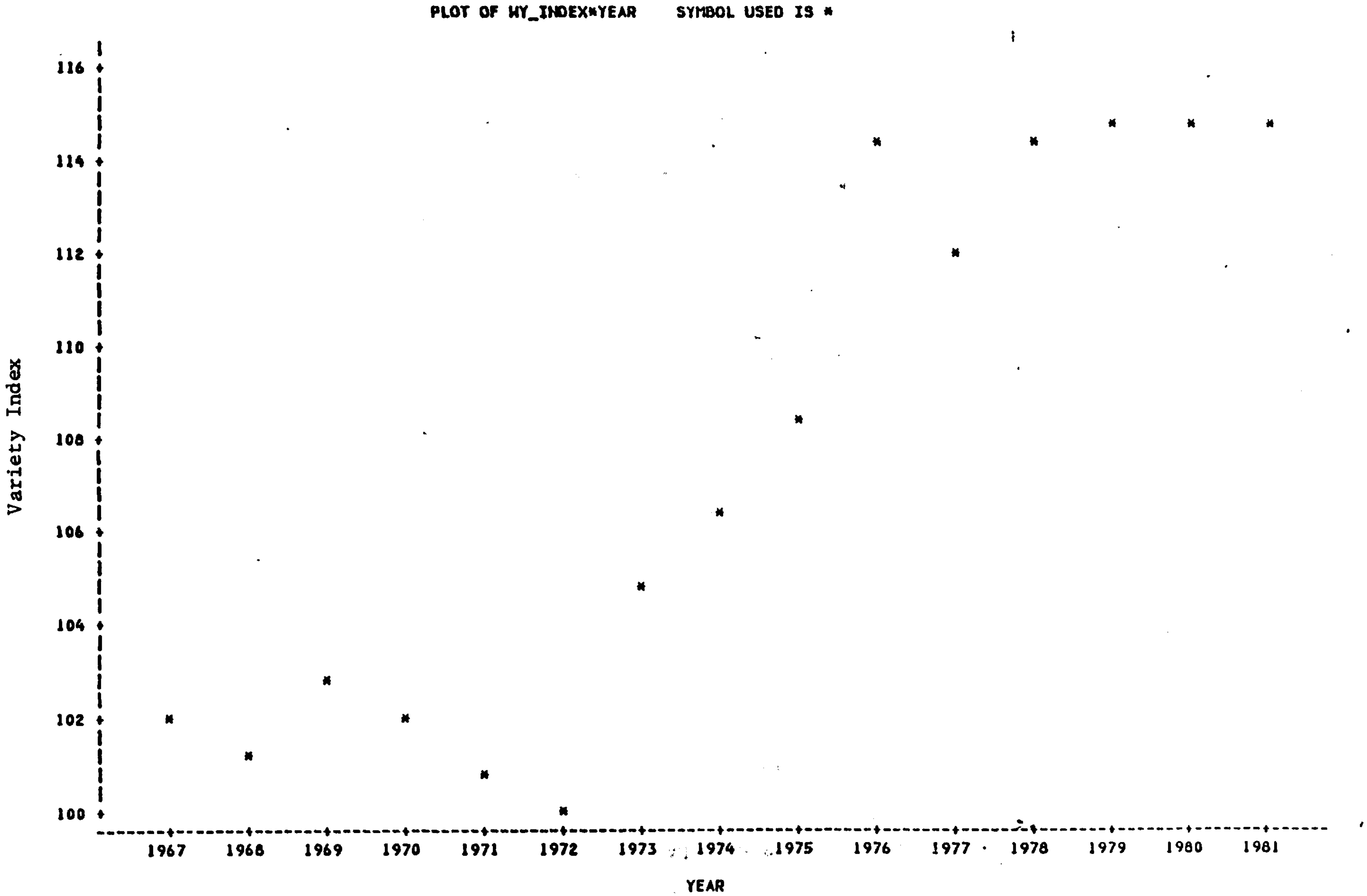


Figure 6

State Level Variety Index for Adopted Soybean Varieties in Ohio,
Weighted by Percent of Planted Acres

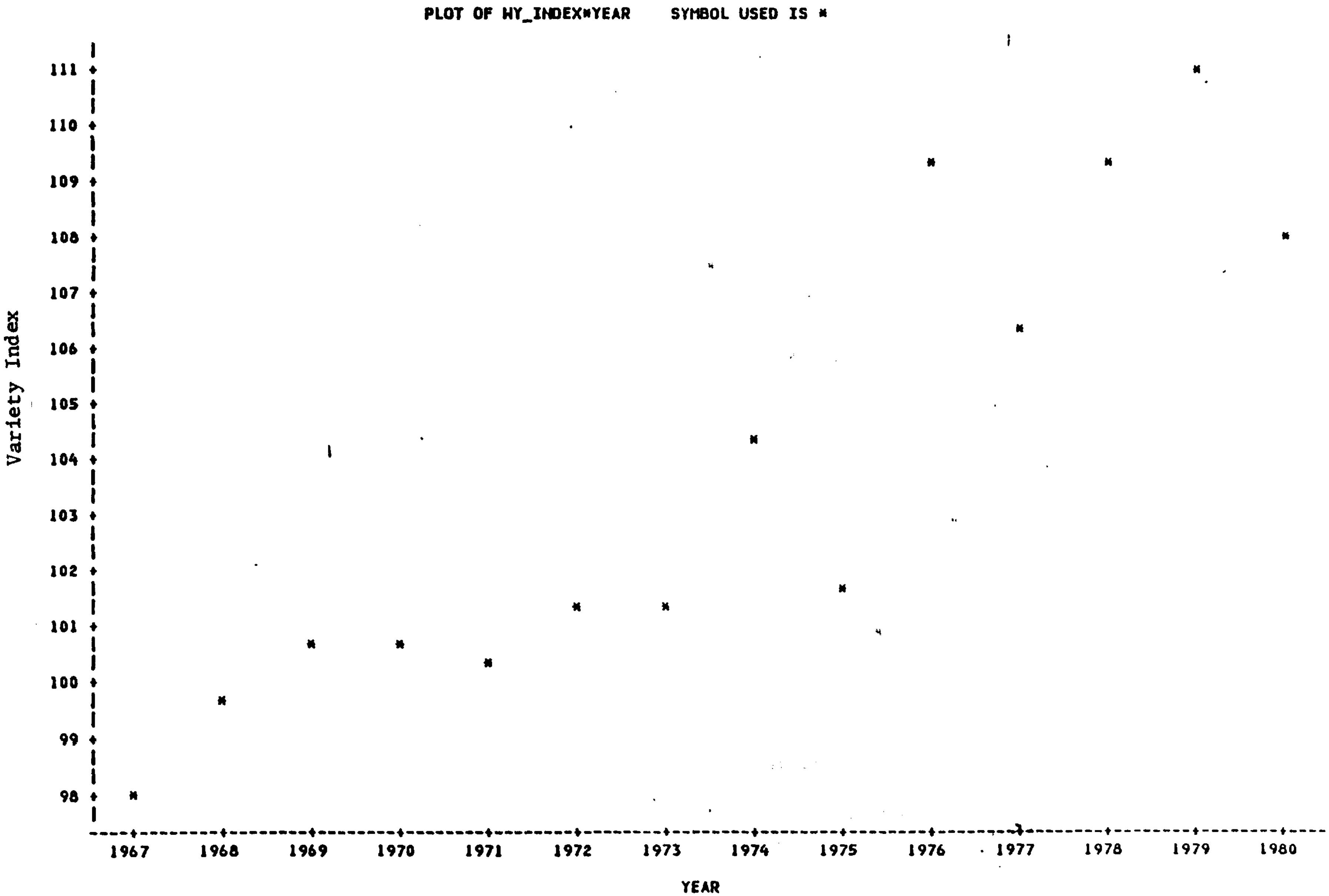
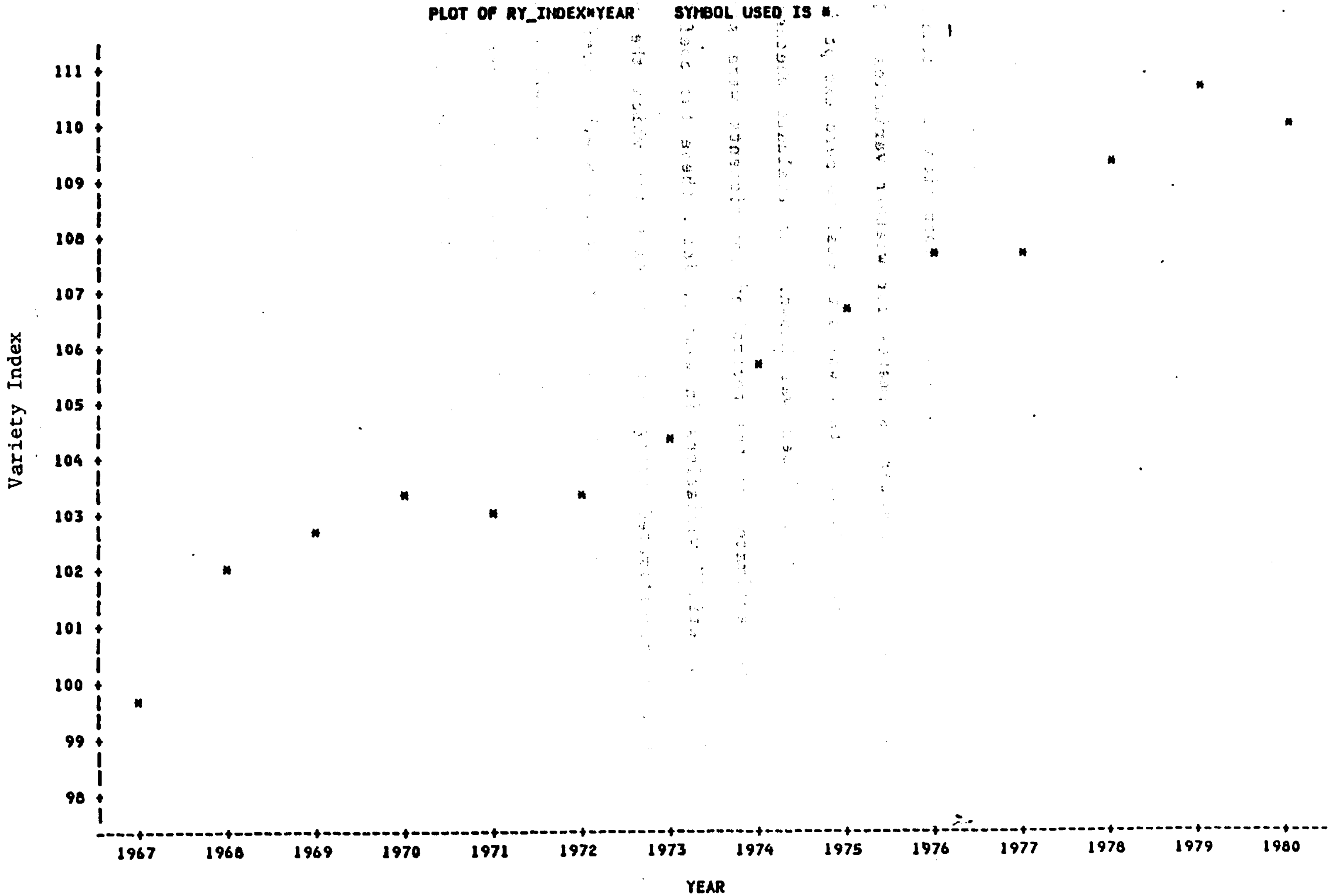


Figure 7

Region Level Variety Index for Adopted Soybean Varieties in Five Corn Belt States, Weighted by Percent of Planted Acres



two technology variables included in the yield model specified in equation (1).

Yield Model Estimation

Technology. Two different techniques are used to estimate the coefficients of the technology terms in the state and regional yield models (Table 4). An ordinary least squares estimate using the full sample period for yield and weather information is desirable to produce reliable parameter estimates for weather variables. In this case the "variety residual" term was set equal to zero except in years for which the variety index was known. To evaluate whether these unrestricted estimates of the technology coefficients were sensitive to "out-of-period" variations in weather data, these two coefficients were then re-estimated using only the years for which the variety index was available, imposing restrictions on the weather coefficients to make them equal to the values obtained for the full period of years. This procedure effectively introduces seven additional degrees of freedom (intercept plus six weather term coefficients) available for estimation of the technology coefficients over the shorter sample period.

By comparing the unrestricted and restricted estimates of the technology coefficients given in Table 4, it is clear that the estimated values of both terms were nearly identical whether or not the restrictions are imposed. This indicates that the estimates are not highly sensitive to weather data variation in the earlier years when the variety index is not known. Appendix D contains both

Table 4

Comparison of Unrestricted and Restricted Estimates of Variety Index Trend and Residual Coefficients for State and Region Level Soybean Yield Models

State	Variety Trend Coefficient		Variety Residual Coefficient		Error Degrees of Freedom	R-Square
	Estimate	p-value	Estimate	p-value		
Illinois						
Unrestricted	.5199	.0001	.2920	.5140	42	.9232
Restricted	.5197	.0001	.2920	.4791	22	.7669
Indiana						
Unrestricted	.5498	.0001	.5716	.3878	37	.9163
Restricted	.5505	.0001	.5716	.4531	12	.6234
Iowa						
Unrestricted	1.437	.0001	.3521	.4605	24	.8946
Restricted	1.438	.0001	.3521	.2683	12	.7825
Missouri						
Unrestricted	.2634	.0001	-.0868	.7263	24	.8454
Restricted	.2626	.0001	-.0868	.7279	13	.6664
Ohio						
Unrestricted	.3630	.0001	.6288	.0783	23	.8458
Restricted	.3671	.0001	.6288	.0854	12	.7412
Region						
Unrestricted	.5472	.0001	.6405	.3581	24	.9232
Restricted	.5488	.0001	.6864	.3561	12	.7301

regression estimates for the full yield model specification, equation (1).

Although the variety trend coefficient has the units of bushels per acre per index unit, it actually represents the combined yield impact of both the trend component of the variety index and associated technology changes. The problem of multicollinearity makes it impossible to decompose this combined effect into the components that are attributable to these factors, individually. Nevertheless, the magnitude of this coefficient gives an indication of the extent to which the yield potential from new varieties has been realized on commercial farms (as aided or retarded by other production changes), i.e., the larger the value the more aggregate yield has increased for each index unit of variety improvement.

A positive sign on the variety or technology residual coefficient is consistent with theory. This means that when the variety index is above the trend value, the impact on yield is positive and when it falls below trend, the yield effect is negative. Alternatively, when improved varieties are being adopted faster than the trend average, yields also tend to increase faster than trend, but when variety adoptions remain on a plateau, yields begin to lag behind the rate of increase implied by the trend. The fact that these estimators do not have high statistical significance levels is neither surprising nor disappointing since they represent only the non-trend component of genetic technology. It is gratifying that the coefficient signs are consistent with expectations for all states except Missouri. In this case, the small negative value is not statistically different from zero.

Weather. Estimated coefficients of the weather variables are given in Table 5. In all states, the two most significant terms are July and August rainfall. Preseason precipitation and August temperature are generally the least consistent in terms of sign and magnitude, and lack statistical significance in all states.

In Iowa, the smaller coefficients on summer rainfall may indicate that normal precipitation is closer to optimal. Thus, a positive departure causes less of an increase in yields. The relatively large and more significant positive coefficient on June temperature is also reasonable for Iowa. The sensitivity of Missouri yields to drought is indicated by the large coefficients on July and August rainfall, as well as the significant negative coefficient value for July temperature.

Comparisons between states. It is instructive to compare estimates from the various state level yield models. Analysis of these differences gives insight into the role of variety effects on yield relative to other technological factors. The comparison also provides guidance for future yield modeling efforts, pinpointing the shortcomings and advantages of different data sources.

Referring to Table 6, the first column is the average annual rate of increase in the variety or technology index. Dimensions of this index are index units per year. Column two is the estimated coefficient of the varietal trend variable, with units of bushels per acre per index unit. It is the average aggregate yield increase

Table 5

Estimated Weather Coefficients for Soybean Yield Models

	Precipitation Variables					
	DNPRSP		DNPJLY		DNPAUG	
State	Estimate	p-value	Estimate	p-value	Estimate	p-value
Illinois	-.0104	.866	1.143	.0001	.8619	.0006
Indiana	.0685	.3339	.9167	.0005	.4497	.1610
Iowa	.0331	.7594	.6917	.0373	.4317	.0751
Missouri	.0701	.3425	1.198	.0001	1.178	.0016
Ohio	-.0943	.3679	.9867	.0085	1.0076	.0075
Region	-.0137	.8565	.9783	.0011	.6967	.0167

	Temperature Variables					
	DNTJUN		DNTJLY		DNTAUG	
State	Estimate	p-value	Estimate	p-value	Estimate	p-value
Illinois	.0335	.7736	-.1019	.4652	-.1034	.4737
Indiana	.0258	.8498	.1120	.5401	-.0753	.6382
Iowa	.2860	.0988	-.0392	.8296	.0186	.9251
Missouri	.1234	.4549	-.4158	.0343	.0644	.7703
Ohio	.1352	.4706	-.0042	.9871	.3658	.1346
Region	.0856	.5146	-.2045	.2349	.0121	.9413

Table 6

State and Region Level Average Annual Increment of Variety Technology Index and Aggregate Yields

State	Average Annual Increment of Variety Index (Units Per Year)	Aggregate Yield Increment per Index Unit (Bu/Acre Per Unit)	Average Annual Increment of Aggregate Yield (Bu/Acre Per Year)	Ratio of Aggregate Yield Increment to Experimental Yield Increment[a]
Illinois	.6117	.5199	.3180	1.517
Indiana	.7483	.5498	.4114	1.604
Iowa	.3624	1.437	.5208	4.192
Missouri	1.234	.2634	.3250	.7684
Ohio	.9355	.3630	.3396	1.059
Region	.7775	.5472	.4254	1.596

[a] 1 Variety Index Unit = 1% of 34.28 Bu/Acre = .3428 Bu/Acre (experiment station).

associated with one index unit of varietal improvement. The average annual yield increment in units of bushels per acre per year (column 3) is obtained by multiplying these two quantities,

$$\frac{\text{Bushels/Acre}}{\text{Index Unit}} \times \frac{\text{Index Units}}{\text{Year}} = \frac{\text{Bushels/Acre}}{\text{Year}} .$$

It is also possible to convert the varietal index to units of bushels per acre. By definition, one index unit equals one percent of the average yield of Clark in the variety trials data (Y_REF = 34.28 bu/ac) or .3428 bushels per acre. It is important to note that this yield is for experiment station variety trial plots, not aggregate level farm yield. Division by this conversion factor expresses the varietal trend coefficient (column 2) as a ratio of aggregate yield increment to experimental yield increment (column 4),

$$\frac{\text{Bushels/Acre (aggregate)}}{\text{Index Unit}} \div \frac{\text{Bushels/Acre (experimental)}}{\text{Index Unit}}$$

$$= \frac{\text{Bushels/Acre (aggregate)}}{\text{Bushels/Acre (experimental)}} .$$

It may seem surprising that the ratio of farm yield increase to experimental yield increase is greater than one for all states except Missouri, since plot yields in the variety trials are usually higher than county or district level farm yields. However, this is a ratio of incremental changes in yields, not of yield levels. The value of the ratio is the average increase in aggregate yield associated with a one bushel per acre increase in the adopted acreage weighted yield difference from Clark in the variety trials.

The magnitude of this ratio can be interpreted as a measure of the extent to which other non-genetic factors have been successful in exploiting the varietal or technological yield potential of adopted varieties. If the ratio is large, it implies that yield increases of the last fifteen years are due to a balanced complementary application of both varietal and non-varietal technologies. In this case, the introduction of improved varieties could easily result in significant additional yield improvements in a relatively short time. Where the ratio is small, the estimate implies that factors other than variety technology are limiting and that the additional genetic potential in current varieties remains to be realized through improved soil fertility, water conservation, irrigation, weed and pest control, etc.

From the differences between states it becomes clear that Iowa and Missouri are at opposite extremes. Iowa had the largest rate of increase in aggregate yield but the smallest increase in the technology index. Missouri had the largest rate of increase in the variety index but the next to smallest increase in aggregate yield. This indicates that in these states non-varietal factors account for most of the difference in the rate of increase in aggregate yields. In Iowa, higher and more uniform land quality, less variable weather patterns, and probably a higher level of mechanization and weed and pest control tended to enhance the full realization of varietal potential. In Missouri, the absence of these advantages tended to prevent or retard this realization.

The rapid increase in the varietal index for Missouri after 1972 is due to two factors. One of these is the previously described upward bias due to maturity differences between Clark and the southern varieties, together with an increase in soybean acreage in the Bootheel Region where the Southern varieties are grown. The other is the widespread adoption of Williams and its derivatives over the rest of the state. Since the variety trials show Williams to have a 3.9 bushel per acre yield advantage over Clark (Table 3), this substitution probably represents a real increase in varietal potential that has yet to be fully exploited.

In addition to the upward bias in the calculated varietal index for Missouri, there is also the likelihood of a downward bias in the index for Iowa. An examination of the variety adoption data for Iowa (Appendix A) shows why the varietal index has increased slowly. The major variety change has been the substitution of Corsoy for Amsoy and Wayne, mostly in the early seventies. Williams came into Iowa to a small extent in the late seventies, but because it is Group III maturity it is limited to the southern part of the state. The total of identified varieties from Iowa varietal soybean surveys has fallen to about forty percent in recent years (Figure A3.2) and this probably reflects the trend toward increasing adoption of private varieties in the northern and central regions (maturity Groups I and II). If this trend exists, and if these private varieties do in fact have a yield advantage over Corsoy, the varietal index calculated will be biased downward. This would be especially true in the late seventies when Corsoy declined from 35% of reported acreage to around 20% but no Group II substitute of this magnitude appears in the data. Consequently, in addition to the real differences between these states, there are probably opposite biases in the technology indices that tend to overstate the actual difference.

Comparison with other studies. If the varietal trend coefficient is expressed in units of bushels per acre per year (Table 6, column 3), it is directly comparable to the usual time trend measure of the rate of technical change. Table 7 compares these values with estimates reported in three other comparable studies. Notice that even though the magnitudes are somewhat different because of differences in the period of years, Iowa has the largest coefficient in all cases, followed by Indiana and Illinois. The relatively small value for Illinois in this study as compared to Pope and Heady is due to the inclusion here of data from the 1931 to 1950 period. Visual inspection of the plot of Illinois aggregate yield (Appendix E) will show that yields increased more slowly in those years. Thompson's region level estimate for 1930 to 1968 is noticeably smaller than our 1950 to 1981 value. Although the question of whether a "yield plateau" is being approached has not been dealt with explicitly, these results does not appear to support such a hypothesis.

7. CONCLUSION

This study has demonstrated a procedure for deriving a state-level, time-series index measure of improvements in varietal technology in adopted soybean varieties. The two sources of information used are Experiment Station variety performance trials and survey data on variety adoption as a proportion of planted acreage. The use of information from the performance trials is theoretically

Table 7

Comparison of Estimated Coefficients of Time Trend in Aggregate Soybean Yield Models

Author and Year	Geographic Area	Period of Years	Trend Coefficient Bu/Ac/Yr
Thompson (1970)	Corn Belt Region	1930-1968	.304
Kestle (1982)	Illinois	1932-1979	.372
	Indiana	1937-1979	.432
	Iowa	1950-1979	.503
Pope & Heady (1982)	Illinois	1951-1980	.456
	Indiana	1951-1980	.394
	Iowa	1951-1980	.546
	Missouri	1951-1980	.303
	Ohio	1951-1980	$.598\ t - 3.6 \ln t$[a]
Present study (1983)	Illinois	1931-1982	.318
	Indiana	1937-1982	.411
	Iowa	1950-1982	.521
	Missouri	1949-1981	.325
	Ohio	1950-1981	.340
	Region	1950-1981	.425

[a] t = year - 1950.

appropriate since the experimental design of these tests focuses on varietal differences in yield potential. When combined with variety adoption data, this information provides a measure of the potential yield improvement due to the adoption of improved soybean varieties on commercial farms.

The use of this varietal index in state and regional level soybean yield models has also been demonstrated. It has been shown that the varietal index has the potential to improve the accuracy of weather-yield models. Partitioning the index into a trend component and deviations from trend provides a method of comparing the performance of a yield model specification that includes this index to the more conventional specification which uses a time trend variable as the only proxy for all technological factors.

Although it is still not possible to separate and quantify the yield effects of genetic technology from all other technical inputs, it is possible to make some useful inferences based on observed differences between states. In particular, it is clear that non-varietal factors, including normal weather patterns as well as other technical inputs, are instrumental in the success of Iowa farmers in realizing a relatively large aggregate yield increase for each increment of improvement in genetic technology. The opposite extreme is found in Missouri where vulnerability to drought and poorer land quality result in a relatively low ratio of actual to potential yield improvement.

The two primary disadvantages of this approach are: 1) the use of side-by-side trials with a "reference variety" to compute a relative yield factor is inherently biased when the two varieties are of different maturities, and 2) the increase in private soybean varieties means that the adoption data may become progressively more fragmented in the future. This is the reason that a similar approach will not work for corn. The number of different hybrids is so large that no manageable subset of them accounts for the majority of planted acreage.

Use of the variety technology index in state and regional level soybean models is reported. The use of such an index provides an alternative specification of the technology component based on experimental evidence of genetic improvements in adopted Corn Belt soybean varieties. Although the reported regression coefficients for the variety residual variable in the investigated yield models were generally not significant, this index may have enhanced potential when used in models which incorporate improved specifications of the weather variables.

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APPENDIX A

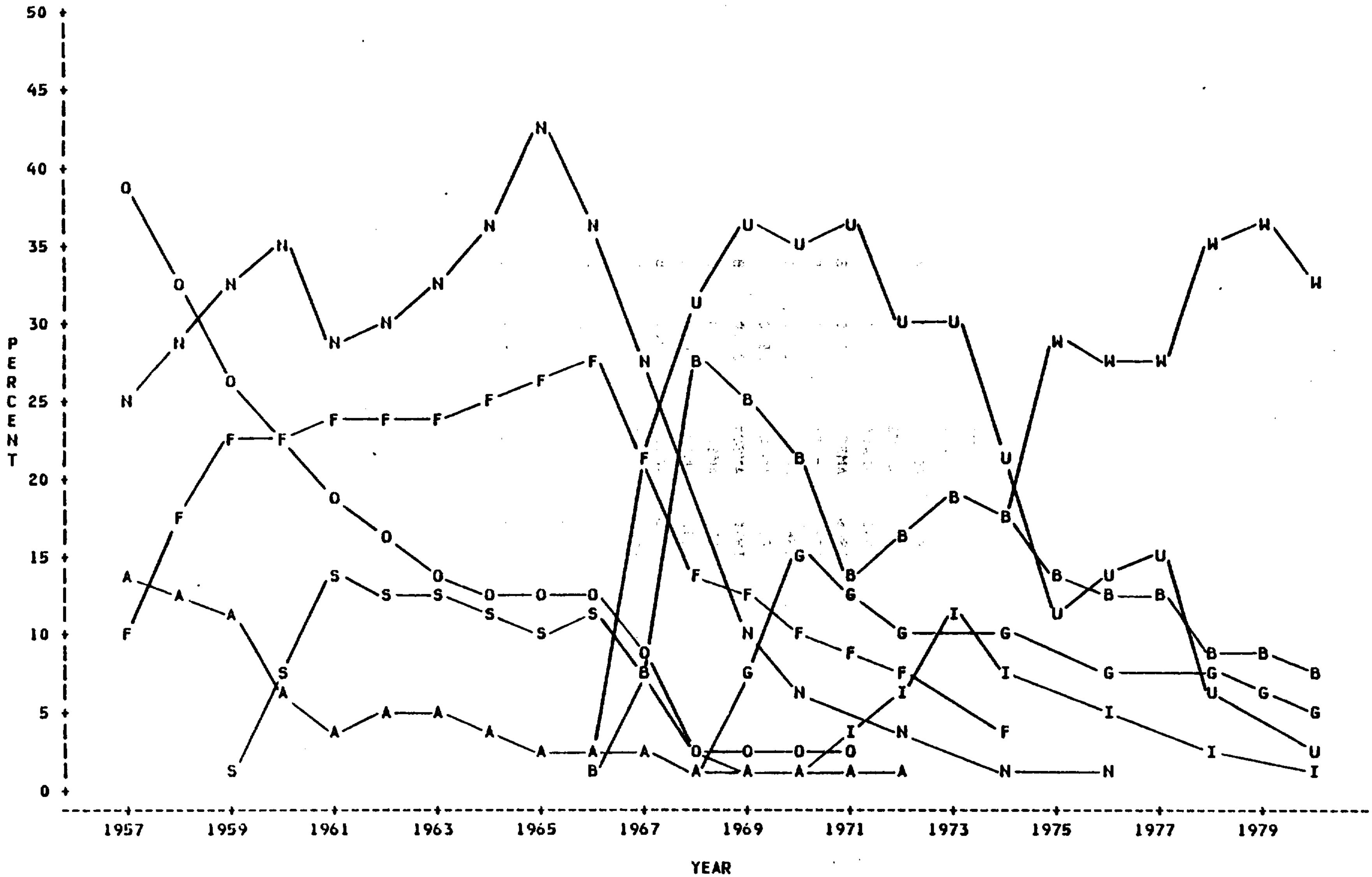
Soybean Variety Adoption Data

Figure A1.1

ADOPTION OF MAJOR SOYBEAN VARIETIES IN ILLINOIS

PERCENT OF PLANTED ACRES

PLOT OF PPLAC*YEAR   SYMBOL IS VALUE OF ID



NOTE: 15 OBS HIDDEN

Table A.1

SOYBEAN VARIETY ADOPTION DATA FOR ILLINOIS
PERCENT OF PLANTED ACRES

YEAR	VARIETY	PPLAC	ID
1957	ADAMS	14.0	A
1958	ADAMS	12.0	A
1959	ADAMS	11.0	A
1960	ADAMS	6.0	A
1961	ADAMS	4.0	A
1962	ADAMS	5.0	A
1963	ADAMS	5.0	A
1964	ADAMS	4.0	A
1965	ADAMS	2.0	A
1966	ADAMS	2.0	A
1967	ADAMS	2.0	A
1968	ADAMS	1.0	A
1969	ADAMS	1.0	A
1970	ADAMS	1.0	A
1971	ADAMS	1.0	A
1972	ADAMS	1.0	A
1966	AMSOY	1.0	B
1967	AMSOY	7.0	B
1968	AMSOY	27.0	B
1969	AMSOY	25.0	B
1970	AMSOY	21.0	B
1971	AMSOY	14.0	B
1972	AMSOY	16.0	B
1973	AMSOY	19.1	B
1974	AMSOY	17.0	B
1975	AMSOY	13.5	B
1976	AMSOY	13.0	B
1977	AMSOY	12.9	B
1978	AMSOY	9.0	B
1979	AMSOY	8.9	B
1980	AMSOY	7.0	B
1970	BEESON	2.0	C
1971	BEESON	6.0	C
1972	BEESON	11.0	C
1974	BEESON	8.0	C
1976	BEESON	5.0	C
1978	BEESON	3.0	C
1980	BEESON	2.0	C
1974	BONUS	2.0	D
1976	BONUS	2.0	D
1978	BONUS	1.0	D
1971	CALLAND	1.0	E
1972	CALLAND	2.0	E
1974	CALLAND	2.0	E
1978	CALLAND	1.0	E
1957	CLARK	10.0	F
1958	CLARK	17.0	F
1959	CLARK	22.0	F

Table A.1--Continued

SOYBEAN VARIETY ADOPTION DATA FOR ILLINOIS
PERCENT OF PLANTED ACRES

YEAR	VARIETY	PPLAC	ID
1960	CLARK	22.0	F
1961	CLARK	24.0	F
1962	CLARK	24.0	F
1963	CLARK	24.0	F
1964	CLARK	25.0	F
1965	CLARK	26.0	F
1966	CLARK	28.0	F
1967	CLARK	21.0	F
1968	CLARK	14.0	F
1969	CLARK	12.0	F
1970	CLARK	10.0	F
1971	CLARK	9.0	F
1972	CLARK	7.0	F
1974	CLARK	4.0	F
1968	CORSOY	1.0	G
1969	CORSOY	7.0	G
1970	CORSOY	15.0	G
1971	CORSOY	12.0	G
1972	CORSOY	10.0	G
1974	CORSOY	10.0	G
1976	CORSOY	7.0	G
1978	CORSOY	7.0	G
1979	CORSOY	5.8	G
1980	CORSOY	5.0	G
1980	CUMBERLAND	2.0	H
1970	CUTLER	1.0	I
1971	CUTLER	4.0	I
1972	CUTLER	6.0	I
1973	CUTLER	11.2	I
1974	CUTLER	8.0	I
1976	CUTLER	5.0	I
1978	CUTLER	2.0	I
1980	CUTLER	1.0	I
1980	ELF	1.0	J
1978	ESSEX	1.0	K
1980	ESSEX	1.0	K
1980	FRANKLIN	1.0	L
1978	HARCOR	1.0	M
1980	HARCOR	2.0	M
1957	HAROSOY	25.0	N
1958	HAROSOY	29.0	N
1959	HAROSOY	33.0	N
1960	HAROSOY	35.0	N
1961	HAROSOY	29.0	N
1962	HAROSOY	30.0	N
1963	HAROSOY	33.0	N
1964	HAROSOY	36.0	N
1965	HAROSOY	42.0	N

Table A.1--Continued

SOYBEAN VARIETY ADOPTION DATA FOR ILLINOIS
PERCENT OF PLANTED ACRES

YEAR	VARIETY	PPLAC	ID
1966	HAROSOY	36	N
1967	HAROSOY	27	N
1968	HAROSOY	14	N
1969	HAROSOY	10	N
1970	HAROSOY	6	N
1971	HAROSOY	4	N
1972	HAROSOY	4	N
1974	HAROSOY	1	N
1976	HAROSOY	1	N
1957	HAWKEYE	39	O
1958	HAWKEYE	32	O
1959	HAWKEYE	26	O
1960	HAWKEYE	23	O
1961	HAWKEYE	19	O
1962	HAWKEYE	16	O
1963	HAWKEYE	14	O
1964	HAWKEYE	13	O
1965	HAWKEYE	12	O
1966	HAWKEYE	12	O
1967	HAWKEYE	9	O
1968	HAWKEYE	3	O
1969	HAWKEYE	2	O
1970	HAWKEYE	2	O
1971	HAWKEYE	2	O
1972	HAWKEYE	1	O
1962	KENT	1	P
1963	KENT	3	P
1964	KENT	2	P
1965	KENT	1	P
1966	KENT	1	P
1967	KENT	1	P
1968	KENT	1	P
1960	LINDARIN	1	Q
1961	LINDARIN	6	Q
1962	LINDARIN	8	Q
1963	LINDARIN	7	Q
1964	LINDARIN	7	Q
1965	LINDARIN	5	Q
1966	LINDARIN	4	Q
1967	LINDARIN	3	Q
1968	LINDARIN	2	Q
1969	LINDARIN	1	Q
1970	LINDARIN	1	Q
1980	OAKLAND	1	R
1959	SHELBY	1	S
1960	SHELBY	7	S
1961	SHELBY	14	S
1962	SHELBY	13	S

Table A.1--Continued

SOYBEAN VARIETY ADOPTION DATA FOR ILLINOIS
PERCENT OF PLANTED ACRES

YEAR	VARIETY	PPLAC	ID
1963	SHELBY	12.0	S
1964	SHELBY	11.0	S
1965	SHELBY	10.0	S
1966	SHELBY	11.0	S
1967	SHELBY	7.0	S
1968	SHELBY	3.0	S
1969	SHELBY	2.0	S
1970	SHELBY	1.0	S
1971	SHELBY	1.0	S
1972	SHELBY	1.0	S
1980	UNION	4.0	T
1966	WAYNE	3.0	U
1967	WAYNE	21.0	U
1968	WAYNE	31.0	U
1969	WAYNE	36.0	U
1970	WAYNE	35.0	U
1971	WAYNE	36.0	U
1972	WAYNE	30.0	U
1973	WAYNE	30.3	U
1974	WAYNE	21.0	U
1975	WAYNE	11.8	U
1976	WAYNE	14.0	U
1977	WAYNE	14.4	U
1978	WAYNE	6.0	U
1980	WAYNE	3.0	U
1974	WELLS	1.0	V
1976	WELLS	6.0	V
1978	WELLS	6.0	V
1980	WELLS	6.0	V
1974	WILLIAMS	17.0	W
1975	WILLIAMS	28.5	W
1976	WILLIAMS	28.0	W
1977	WILLIAMS	26.9	W
1978	WILLIAMS	35.0	W
1979	WILLIAMS	35.9	W
1980	WILLIAMS	32.0	W
1976	WOODWORTH	4.0	X
1978	WOODWORTH	8.0	X
1980	WOODWORTH	7.0	X

Figure A1.2

YEARLY SUM OF REPORTED VARIETY ADOPTIONS

STATE=ILLINOIS

PLOT OF TOPCT*YEAR   SYMBOL USED IS *

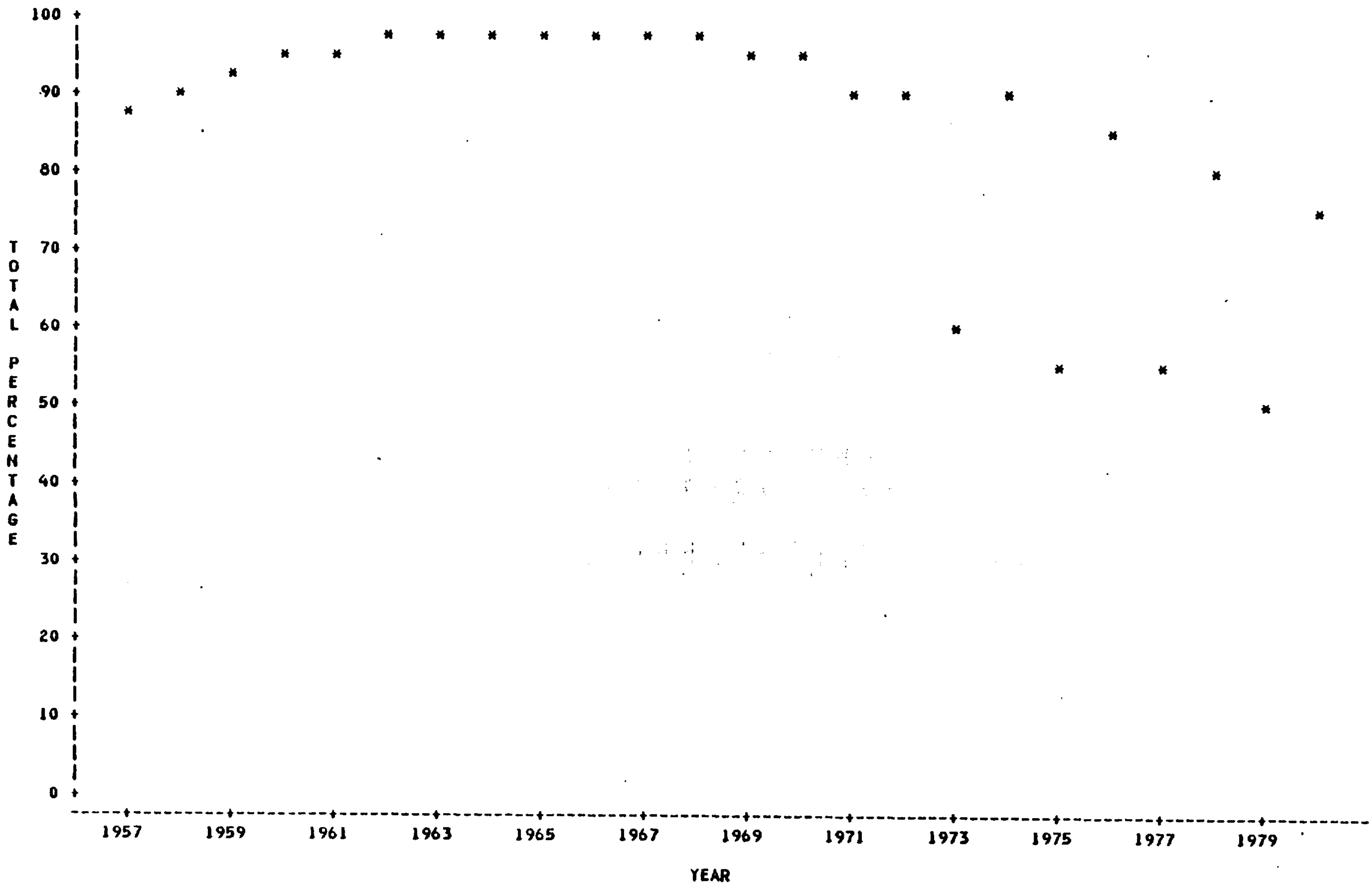
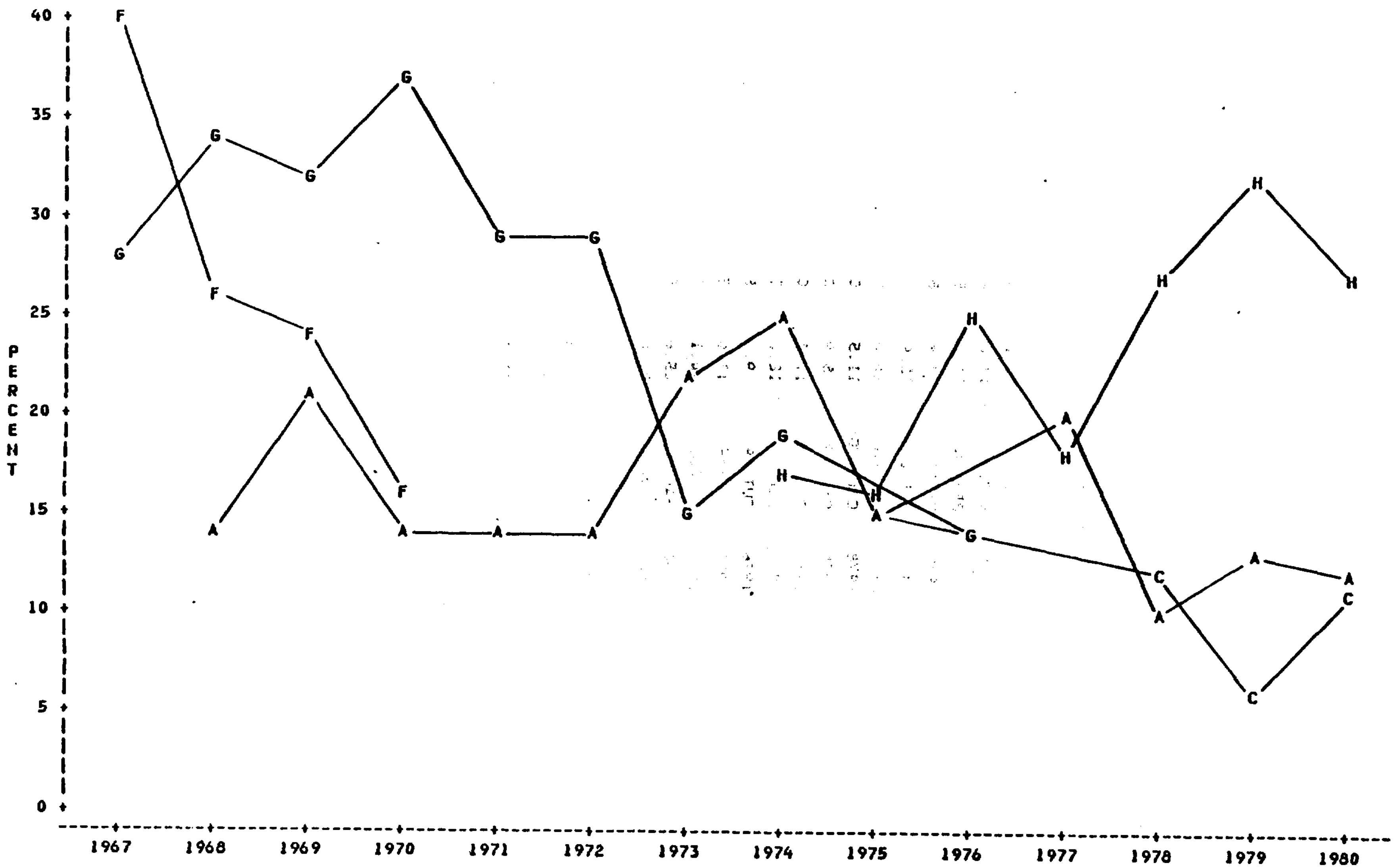


Figure A2.1

ADOPTION OF MAJOR SOYBEAN VARIETIES IN INDIANA

PERCENT OF PLANTED ACRES

PLOT OF PPLAC*YEAR   SYMBOL IS VALUE OF ID



NOTE: 1 OBS HIDDEN

Table A.2

SOYBEAN VARIETY ADOPTION DATA FOR INDIANA
PERCENT OF PLANTED ACRES

YEAR	VARIETY	PPLAC	ID
1968	AMSOY	13.7	A
1969	AMSOY	20.9	A
1970	AMSOY	14.0	A
1971	AMSOY	14.0	A
1972	AMSOY	14.3	A
1973	AMSOY	21.7	A
1974	AMSOY	25.2	A
1975	AMSOY	14.5	A
1977	AMSOY	19.7	A
1978	AMSOY	10.2	A
1979	AMSOY	13.2	A
1980	AMSOY	11.8	A
1971	BEESON	18.0	B
1972	BEESON	18.4	B
1973	BEESON	15.4	B
1975	CALLAND	15.3	C
1978	CALLAND	11.5	C
1979	CALLAND	5.9	C
1980	CALLAND	11.3	C
1967	CLARK	12.2	D
1976	CUTLER	9.7	E
1977	CUTLER	11.0	E
1967	HAROSOY	40.1	F
1968	HAROSOY	25.8	F
1969	HAROSOY	23.8	F
1970	HAROSOY	16.0	F
1967	WAYNE	27.9	G
1968	WAYNE	34.3	G
1969	WAYNE	32.0	G
1970	WAYNE	36.8	G
1971	WAYNE	29.2	G
1972	WAYNE	28.9	G
1973	WAYNE	14.6	G
1974	WAYNE	19.2	G
1976	WAYNE	13.7	G
1974	WILLIAMS	17.3	H
1975	WILLIAMS	16.5	H
1976	WILLIAMS	25.0	H
1977	WILLIAMS	17.9	H
1978	WILLIAMS	27.5	H
1979	WILLIAMS	31.8	H
1980	WILLIAMS	27.3	H

Figure A2.2

YEARLY SUM OF REPORTED VARIETY ADOPTIONS

STATE=INDIANA

PLOT OF TOPCT*YEAR   SYMBOL USED IS *

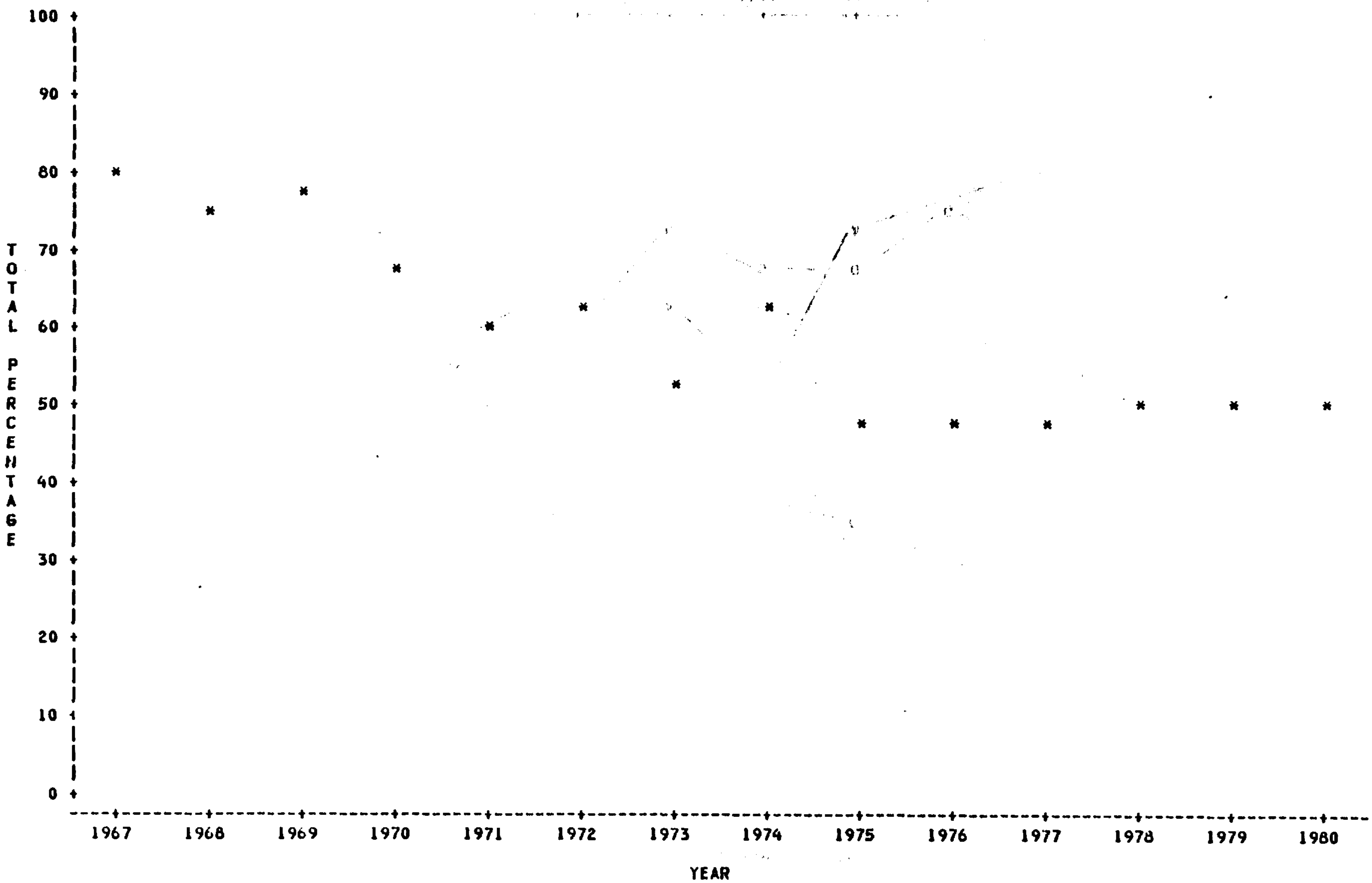


Figure A3.1

ADOPTION OF MAJOR SOYBEAN VARIETIES IN IOWA

PERCENT OF PLANTED ACRES

PLOT OF PPLAC*YEAR   SYMBOL IS VALUE OF ID

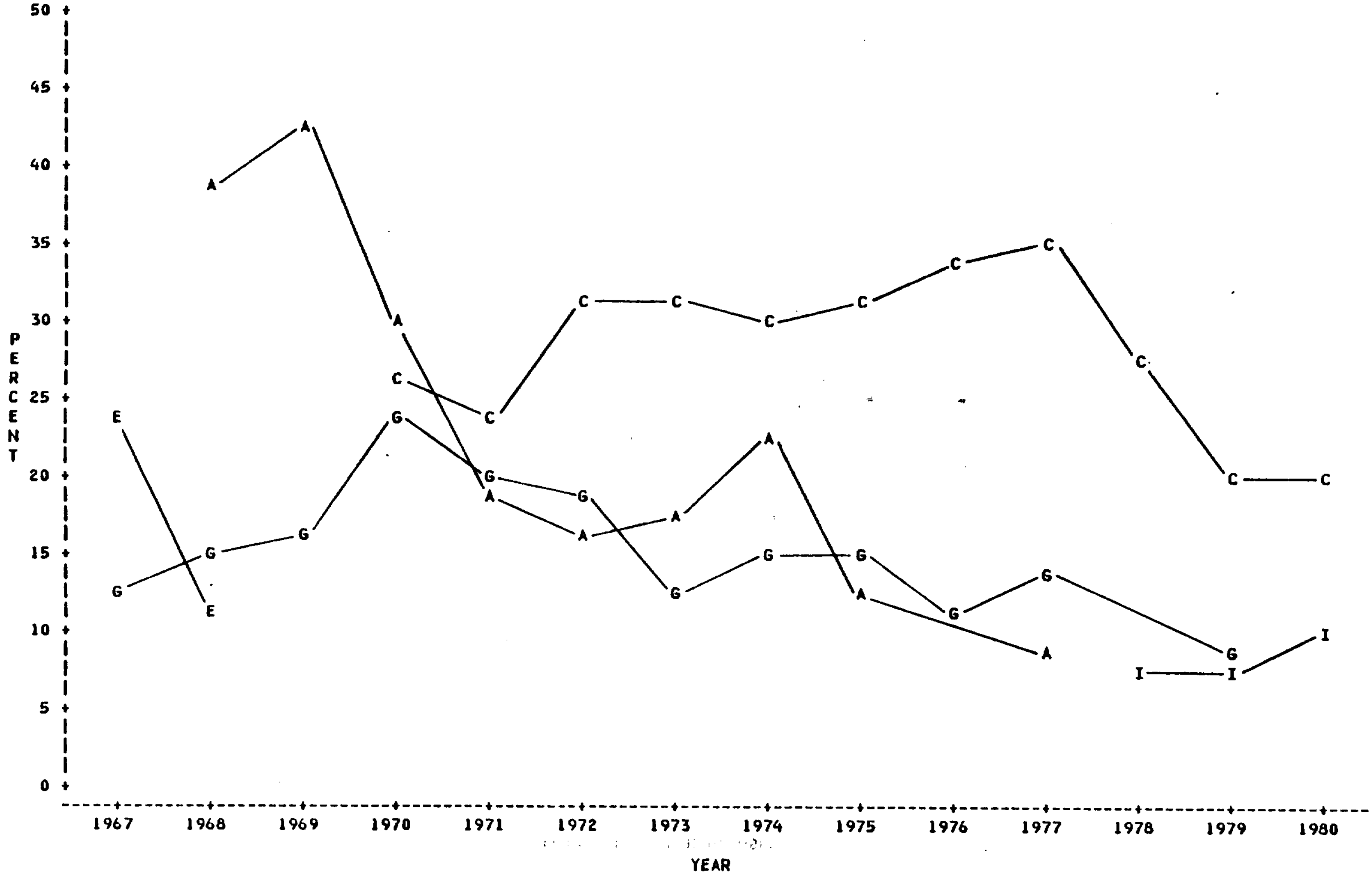


Table A.3

SOYBEAN VARIETY ADOPTION DATA FOR IOWA
PERCENT OF PLANTED ACRES

YEAR	VARIETY	PPLAC	ID
1968	AMSOY	39.0	A
1969	AMSOY	42.4	A
1970	AMSOY	30.6	A
1971	AMSOY	19.0	A
1972	AMSOY	16.2	A
1973	AMSOY	17.9	A
1974	AMSOY	22.4	A
1975	AMSOY	12.6	A
1977	AMSOY	8.3	A
1969	CHIPPEWA	7.6	B
1970	CORSOY	26.5	C
1971	CORSOY	23.5	C
1972	CORSOY	30.7	C
1973	CORSOY	31.4	C
1974	CORSOY	30.5	C
1975	CORSOY	30.8	C
1976	CORSOY	34.2	C
1977	CORSOY	34.6	C
1978	CORSOY	27.0	C
1979	CORSOY	19.9	C
1980	CORSOY	20.5	C
1967	HAROSOY	12.8	D
1967	HAWKEYE	23.2	E
1968	HAWKEYE	11.8	E
1980	OTHER	9.7	F
1967	WAYNE	12.9	G
1968	WAYNE	15.4	G
1969	WAYNE	16.1	G
1970	WAYNE	24.1	G
1971	WAYNE	20.4	G
1972	WAYNE	19.0	G
1973	WAYNE	12.8	G
1974	WAYNE	14.6	G
1975	WAYNE	14.7	G
1976	WAYNE	10.8	G
1977	WAYNE	13.5	G
1979	WAYNE	8.9	G
1976	WELLS	8.2	H
1978	WELLS	8.2	H
1978	WILLIAMS	7.1	I
1979	WILLIAMS	7.2	I
1980	WILLIAMS	9.4	I

Figure A3.2

YEARLY SUM OF REPORTED VARIETY ADOPTIONS

STATE=IOWA

PLOT OF TOPCT*YEAR   SYMBOL USED IS *

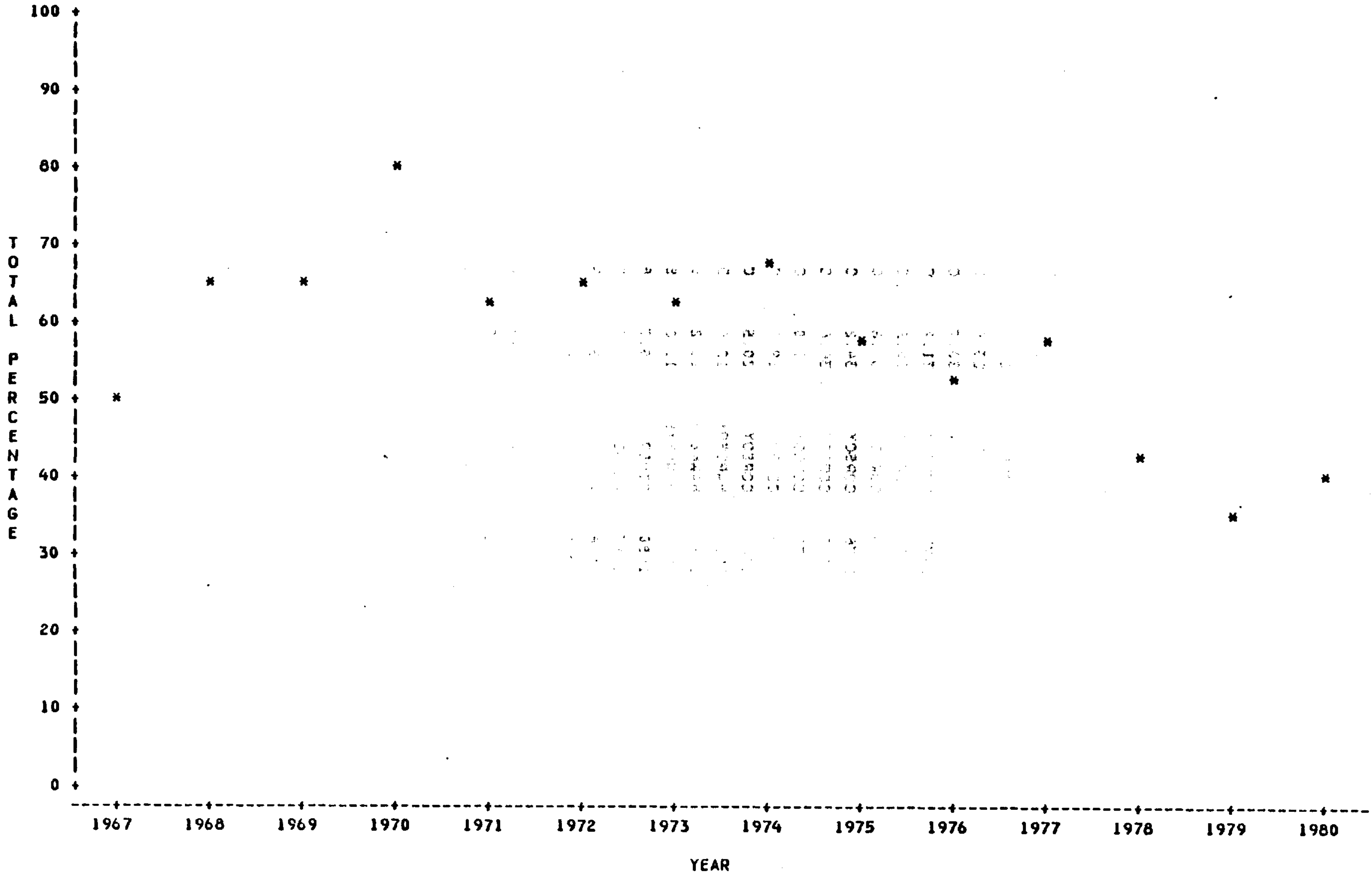
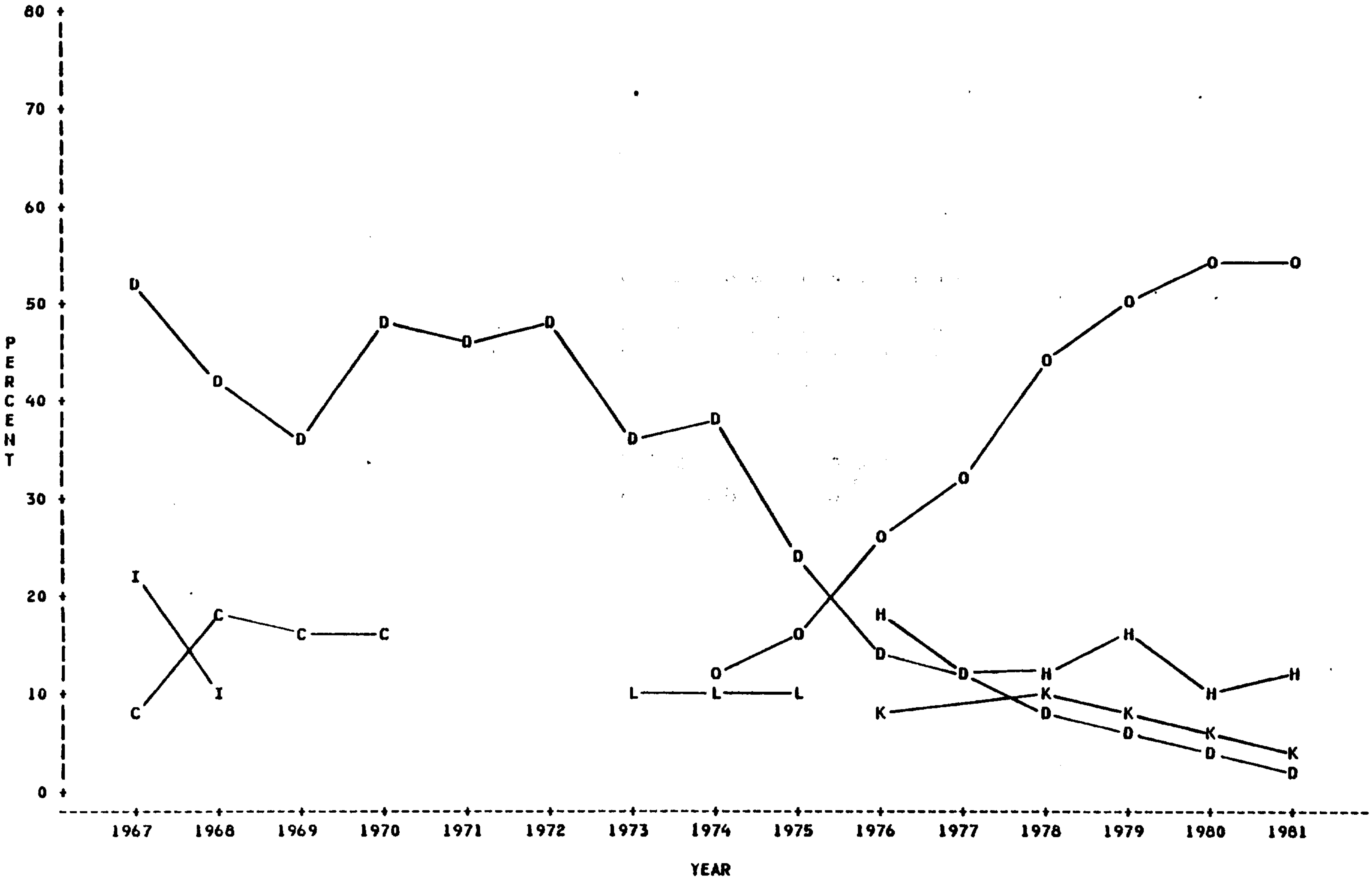


Figure A4.1

ADOPTION OF MAJOR SOYBEAN VARIETIES IN MISSOURI

PERCENT OF PLANTED ACRES

PLOT OF PPLAC*YEAR   SYMBOL IS VALUE OF ID



NOTE: 1 OBS HIDDEN

Table A.4

SOYBEAN VARIETY ADOPTION DATA FOR MISSOURI
PERCENT OF PLANTED ACRES

YEAR	VARIETY	PPLAC	ID
1981	ASGROW	3.0	A
1979	BEDFORD	2.0	B
1980	BEDFORD	6.0	B
1981	BEDFORD	4.0	B
1967	CHIPPEWA	7.4	C
1968	CHIPPEWA	17.6	C
1969	CHIPPEWA	16.5	C
1970	CHIPPEWA	15.3	C
1967	CLARK	52.0	D
1968	CLARK	42.6	D
1969	CLARK	35.7	D
1970	CLARK	47.1	D
1971	CLARK	46.3	D
1972	CLARK	48.8	D
1973	CLARK	36.9	D
1974	CLARK	37.3	D
1975	CLARK	24.3	D
1976	CLARK	14.0	D
1977	CLARK	12.8	D
1978	CLARK	7.0	D
1979	CLARK	6.0	D
1980	CLARK	3.0	D
1981	CLARK	2.0	D
1978	CUTLER	2.0	E
1979	CUTLER	2.0	E
1969	DARE	12.7	F
1970	DARE	10.6	F
1978	DARE	2.0	F
1978	ESSEX	2.0	G
1979	ESSEX	2.0	G
1980	ESSEX	3.0	G
1981	ESSEX	3.0	G
1976	FORREST	17.0	H
1977	FORREST	12.8	H
1978	FORREST	12.0	H
1979	FORREST	15.0	H
1980	FORREST	10.0	H
1981	FORREST	11.0	H
1967	HILL	22.1	I
1968	HILL	10.6	I
1976	MACK	5.0	J
1978	MACK	5.0	J
1979	MACK	6.0	J
1980	MACK	4.0	J
1981	MACK	3.0	J
1976	MITCHELL	8.0	K
1978	MITCHELL	9.0	K
1979	MITCHELL	7.0	K

SOYBEAN VARIETY ADOPTION DATA FOR MISSOURI
PERCENT OF PLANTED ACRES

YEAR	VARIETY	PPLAC	ID
1980	MITCHELL	6.0	K
1981	MITCHELL	3.0	K
1973	PICKETT	9.3	L
1974	PICKETT	10.4	L
1975	PICKETT	10.0	L
1980	UNION	2.0	M
1981	UNION	3.0	M
1971	WAYNE	8.6	N
1973	WAYNE	16.9	N
1974	WILLIAMS	11.2	O
1975	WILLIAMS	16.8	O
1976	WILLIAMS	26.0	O
1977	WILLIAMS	31.4	O
1978	WILLIAMS	43.0	O
1979	WILLIAMS	49.0	O
1980	WILLIAMS	54.0	O
1981	WILLIAMS	54.0	O
1978	WOODWORTH	2.0	P
1979	YORK	2.0	Q
1980	YORK	2.0	Q

Figure A4.2

YEARLY SUM OF REPORTED VARIETY ADOPTIONS

STATE=MISSOURI

PLOT OF TOPCT*YEAR   SYMBOL USED IS *

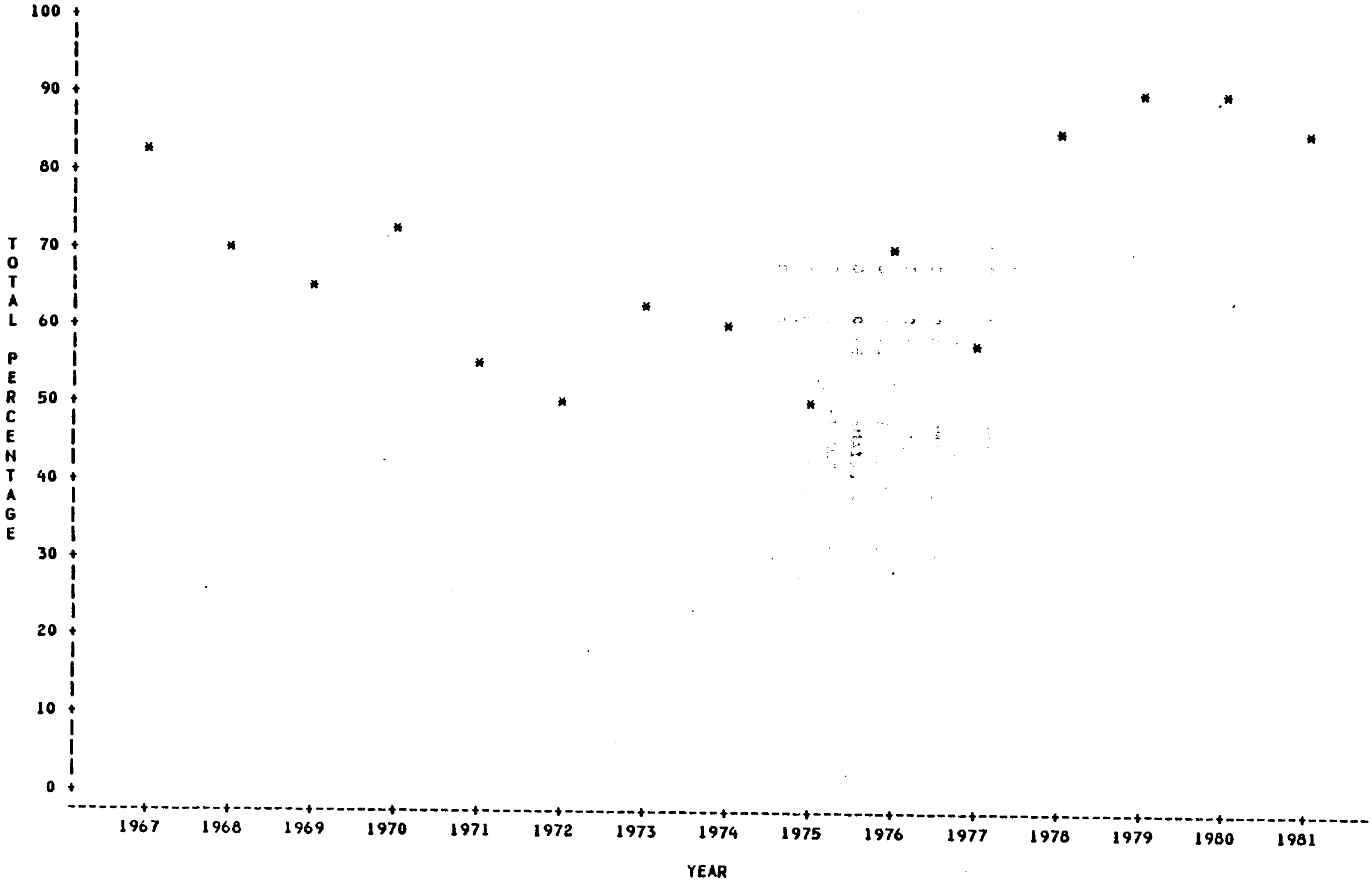
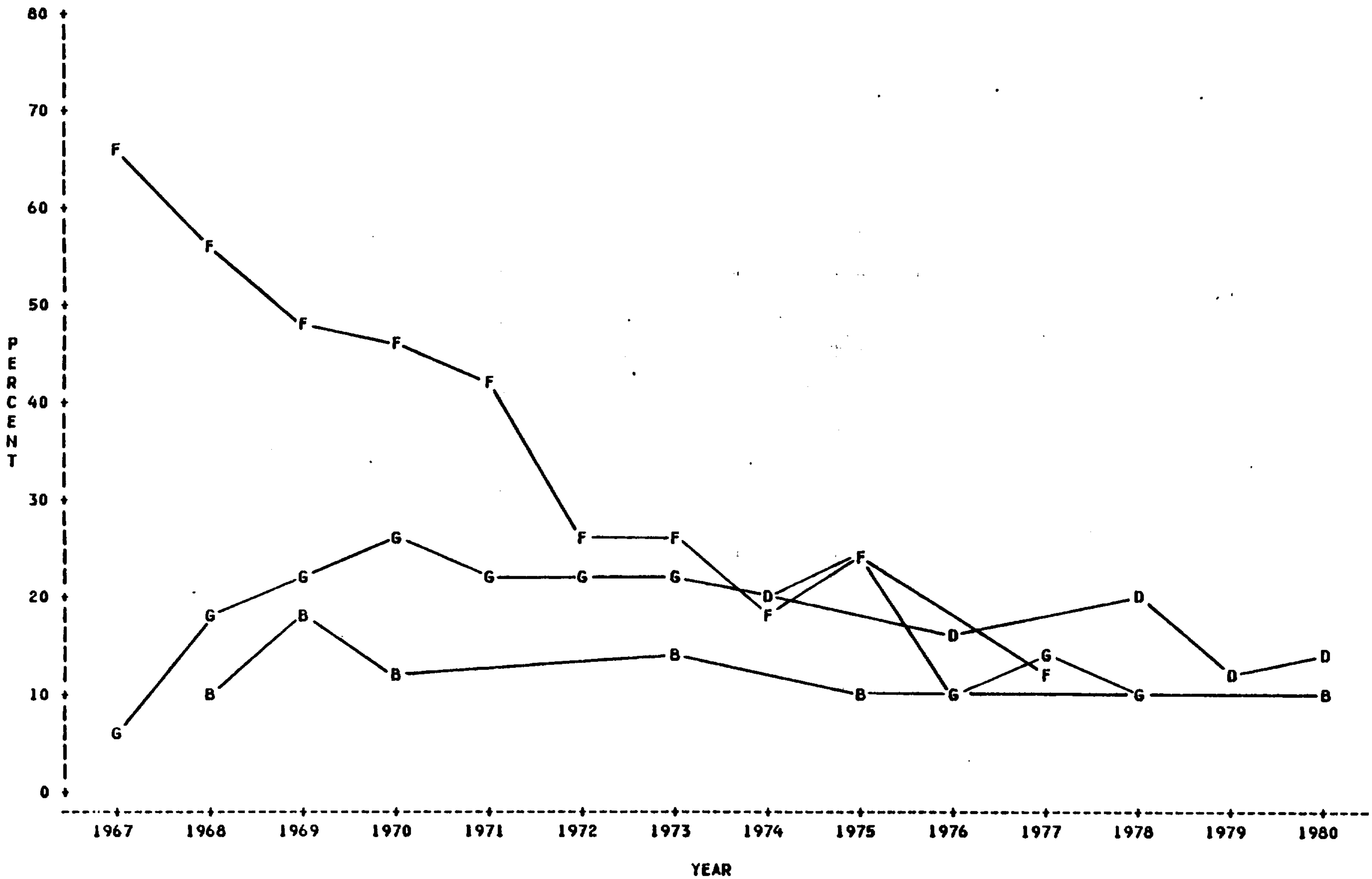


Figure A5.1

ADOPTION OF MAJOR SOYBEAN VARIETIES IN OHIO

PERCENT OF PLANTED ACRES

PLOT OF PPLAC*YEAR   SYMBOL IS VALUE OF ID



NOTE: 2 OBS HIDDEN

Table A.5

SOYBEAN VARIETY ADOPTION DATA FOR OHIO
PERCENT OF PLANTED ACRES

YEAR	VARIETY	PPLAC	ID
1979	AGRIPRO	8.4	A
1968	AMSOY	9.4	B
1969	AMSOY	17.4	B
1970	AMSOY	11.1	B
1973	AMSOY	13.8	B
1975	AMSOY	10.9	B
1980	AMSOY	9.0	B
1971	BEESON	15.7	C
1972	BEESON	20.4	C
1980	BEESON	9.0	C
1974	CALLAND	19.4	D
1976	CALLAND	15.5	D
1978	CALLAND	19.6	D
1979	CALLAND	12.6	D
1980	CALLAND	13.5	D
1967	CLARK	6.0	E
1967	HAROSOY	65.7	F
1968	HAROSOY	55.7	F
1969	HAROSOY	47.5	F
1970	HAROSOY	45.4	F
1971	HAROSOY	41.8	F
1972	HAROSOY	26.4	F
1973	HAROSOY	26.8	F
1974	HAROSOY	18.3	F
1975	HAROSOY	23.8	F
1977	HAROSOY	11.4	F
1967	WAYNE	6.7	G
1968	WAYNE	18.9	G
1969	WAYNE	22.3	G
1970	WAYNE	26.9	G
1971	WAYNE	22.8	G
1972	WAYNE	22.0	G
1973	WAYNE	21.5	G
1974	WAYNE	18.7	G
1975	WAYNE	24.3	G
1976	WAYNE	9.5	G
1977	WAYNE	13.2	G
1978	WAYNE	10.7	G
1976	WILLIAMS	13.8	H
1977	WILLIAMS	25.0	H
1978	WILLIAMS	16.5	H
1979	WILLIAMS	28.2	H
1980	WILLIAMS	14.3	H

Figure A5.2

YEARLY SUM OF REPORTED VARIETY ADOPTIONS

STATE=OHIO

PLOT OF TOPCT*YEAR   SYMBOL USED IS *

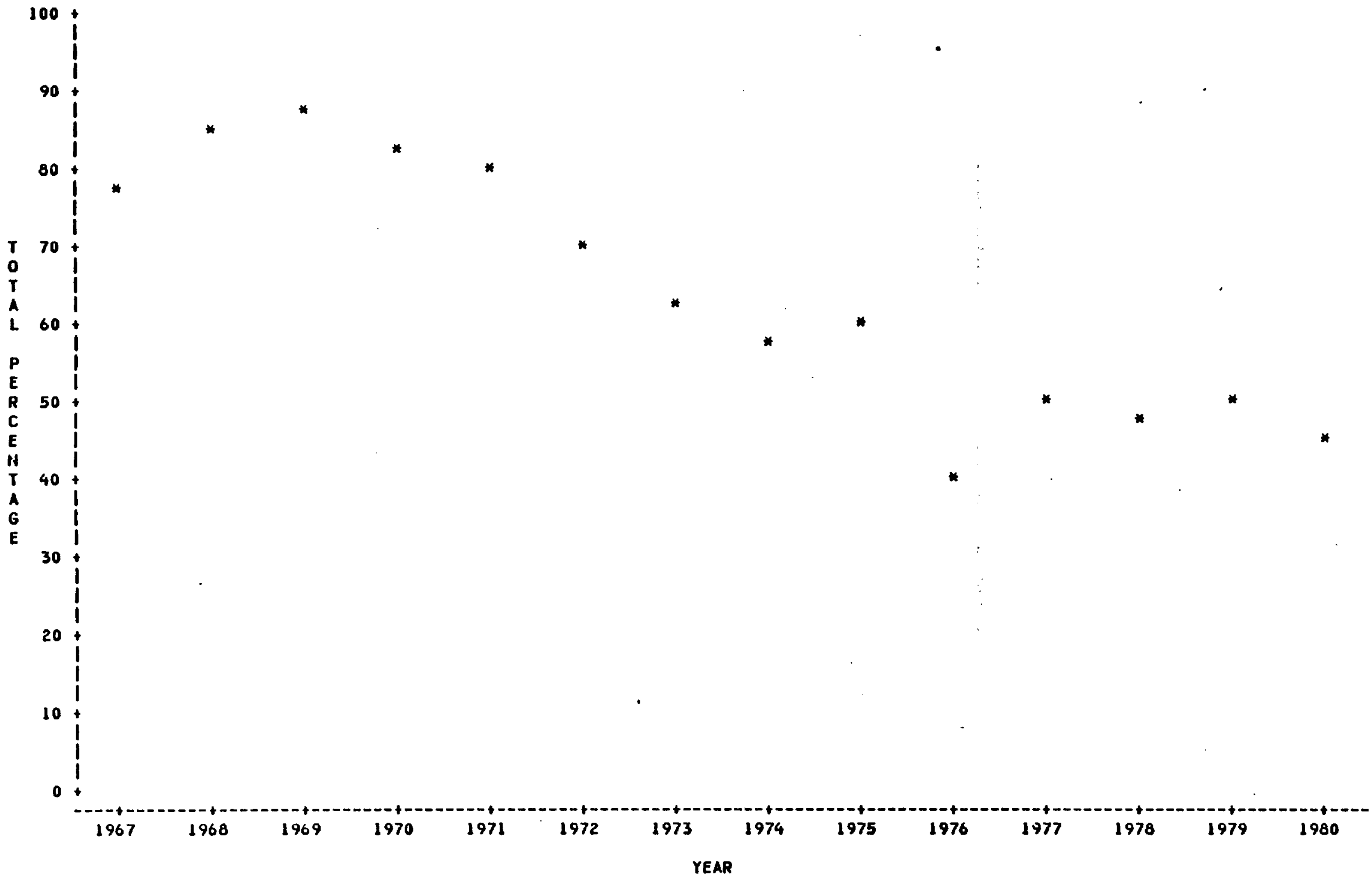


TABLE B.1

STATE LEVEL

VARIETY INDEX

---------------- STATE=ILLINOIS ----------------

YEAR	TREND	INDEX	TRINDEX	GENTRES
1957	28	96.326	95.023	1.3026
1958	29	96.829	95.635	1.1939
1959	30	97.124	96.247	0.8772
1960	31	96.996	96.859	0.1375
1961	32	97.447	97.470	-0.0232
1962	33	98.021	98.082	-0.0610
1963	34	98.331	98.694	-0.3627
1964	35	98.255	99.305	-1.0504
1965	36	97.913	99.917	-2.0041
1966	37	98.102	100.529	-2.4268
1967	38	99.914	101.141	-1.2265
1968	39	102.288	101.752	0.5358
1969	40	102.836	102.364	0.4721
1970	41	103.435	102.976	0.4593
1971	42	103.576	103.587	-0.0114
1972	43	103.738	104.199	-0.4611
1973	44	104.925	104.811	0.1142
1974	45	105.688	105.423	0.2655
1975	46	108.113	106.034	2.0788
1976	47	106.471	106.646	-0.1749
1977	48	107.898	107.258	0.6404
1978	49	107.728	107.869	-0.1413
1979	50	109.427	108.481	0.9459
1980	51	108.013	109.093	-1.0798

---------------- STATE=INDIANA ----------------

YEAR	TREND	INDEX	TRINDEX	GENTRES
1967	38	100.219	100.761	-0.5422
1968	39	101.988	101.510	0.4785
1969	40	102.243	102.258	-0.0148
1970	41	102.811	103.006	-0.1950
1971	42	103.982	103.754	0.2277
1972	43	103.970	104.503	-0.5326
1973	44	103.879	105.251	-1.3719
1974	45	106.385	105.999	0.3859
1975	46	108.815	106.747	2.0676
1976	47	108.529	107.496	1.0333
1977	48	107.397	108.244	-0.8470
1978	49	109.658	108.992	0.6658
1979	50	109.398	109.740	-0.3425
1980	51	109.476	110.489	-1.0128

---------------- STATE=IOWA ----------------

YEAR	TREND	INDEX	TRINDEX	GENTRES
1967	38	98.061	102.107	-4.0462
1968	39	102.680	102.470	0.2104
1969	40	104.373	102.832	1.5410
1970	41	104.794	103.194	1.5997
1971	42	104.867	103.557	1.3103
1972	43	104.965	103.919	1.0459
1973	44	104.974	104.282	0.6925
1974	45	104.912	104.644	0.2681
1975	46	105.028	105.006	0.0217
1976	47	104.042	105.369	-1.3267
1977	48	105.126	105.731	-0.6051
1978	49	104.846	106.093	-1.2475
1979	50	106.476	106.456	0.0201
1980	51	107.334	106.818	0.5157

TABLE B.1 CONTINUED

STATE LEVEL

VARIETY INDEX

---------------- STATE=MISSOURI ----------------

YEAR	TREND	INDEX	TRINDEX	GENTRES
1967	38	101.922	98.879	3.0429
1968	39	101.284	100.113	1.1709
1969	40	102.868	101.347	1.5208
1970	41	102.008	102.581	-0.5732
1971	42	100.741	103.815	-3.0742
1972	43	100.000	105.049	-5.0492
1973	44	104.655	106.283	-1.6282
1974	45	106.218	107.517	-1.2993
1975	46	108.230	108.751	-0.5213
1976	47	114.261	109.985	4.2757
1977	48	111.863	111.219	0.6437
1978	49	114.224	112.453	1.7706
1979	50	114.883	113.687	1.1956
1980	51	114.932	114.921	0.0106
1981	52	114.670	116.155	-1.4854

------------------ STATE=OHIO ------------------

YEAR	TREND	INDEX	TRINDEX	GENTRES
1967	38	98.013	97.605	0.4077
1968	39	99.646	98.541	1.1052
1969	40	100.501	99.476	1.0248
1970	41	100.536	100.412	0.1243
1971	42	100.360	101.347	-0.9871
1972	43	101.179	102.283	-1.1036
1973	44	101.348	103.218	-1.8701
1974	45	104.227	104.154	0.0735
1975	46	101.580	105.089	-3.5090
1976	47	109.358	106.024	3.3336
1977	48	106.324	106.960	-0.6359
1978	49	109.447	107.895	1.5517
1979	50	111.130	108.831	2.2992
1980	51	107.952	109.766	-1.8143

REGIONAL LEVEL

VARIETY INDEX

YEAR	TREND	INDEX	TRINDEX	GENTRES
1967	38	99.762	100.357	-0.59526
1968	39	101.898	101.135	0.76316
1969	40	102.735	101.912	0.82257
1970	41	103.197	102.690	0.50698
1971	42	103.131	103.468	-0.33660
1972	43	103.314	104.245	-0.93119
1973	44	104.311	105.023	-0.71178
1974	45	105.515	105.800	-0.28536
1975	46	106.510	106.578	-0.06795
1976	47	107.829	107.356	0.47346
1977	48	107.618	108.133	-0.51513
1978	49	109.177	108.911	0.26629
1979	50	110.783	109.688	1.09470
1980	51	109.982	110.466	-0.48389

APPENDIX C

Variety Index Trend Component

TABLE C.1

VARIETY INDEX TREND

COMPONENT ESTIMATION

STATE=ILLINOIS

MODEL: MODEL01	SSE	24.419545	F RATIO	387.68	
	DFE	22	PROB>F	0.0001	
DEP VAR: INDEX	MSE	1.109979	R-SQUARE	0.9463	

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|	VARIABLE LABEL
INTERCEPT	1	77.895452	1.245874	62.5227	0.0001	
TREND	1	0.611712	0.031068	19.6897	0.0001	

FIGURE C.1

VARIETY INDEX (G) AND VARIETY INDEX

TREND COMPONENT (T), 1957-1980

STATE=ILLINOIS

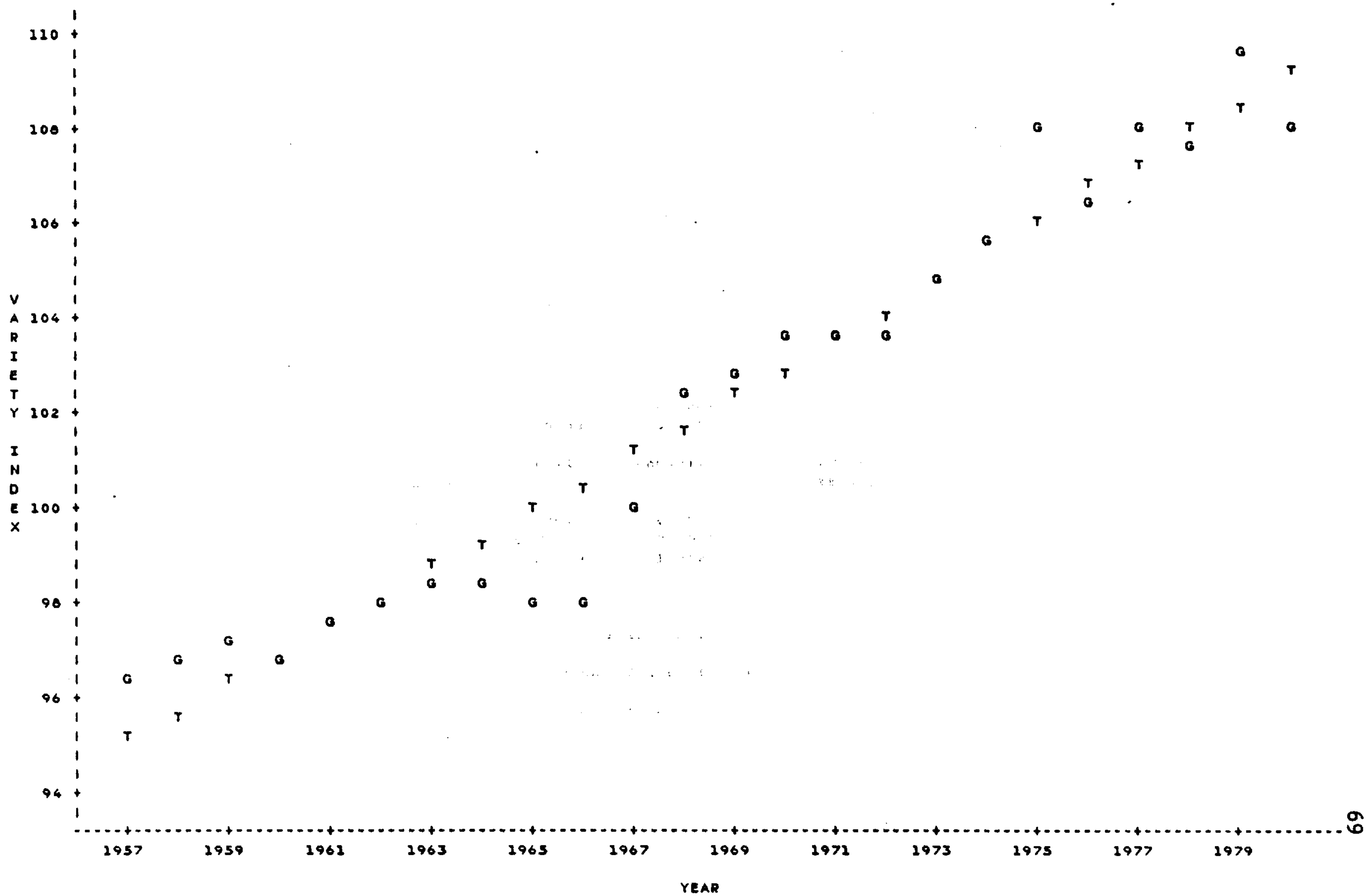


TABLE C.2

VARIETY INDEX TREND

COMPONENT ESTIMATION

STATE=INDIANA

MODEL: MODEL01	SSE	10.573905	F RATIO	144.56	
	DFE	12	PROB>F	0.0001	
DEP VAR: INDEX	MSE	0.881159	R-SQUARE	0.9234	

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|	VARIABLE LABEL
INTERCEPT	1	72.326873	2.780808	26.0093	0.0001	
TREND	1	0.748273	0.062235	12.0233	0.0001	

FIGURE C.2

VARIETY INDEX (G) AND VARIETY INDEX

TREND COMPONENT (T), 1967-1980

STATE=INDIANA

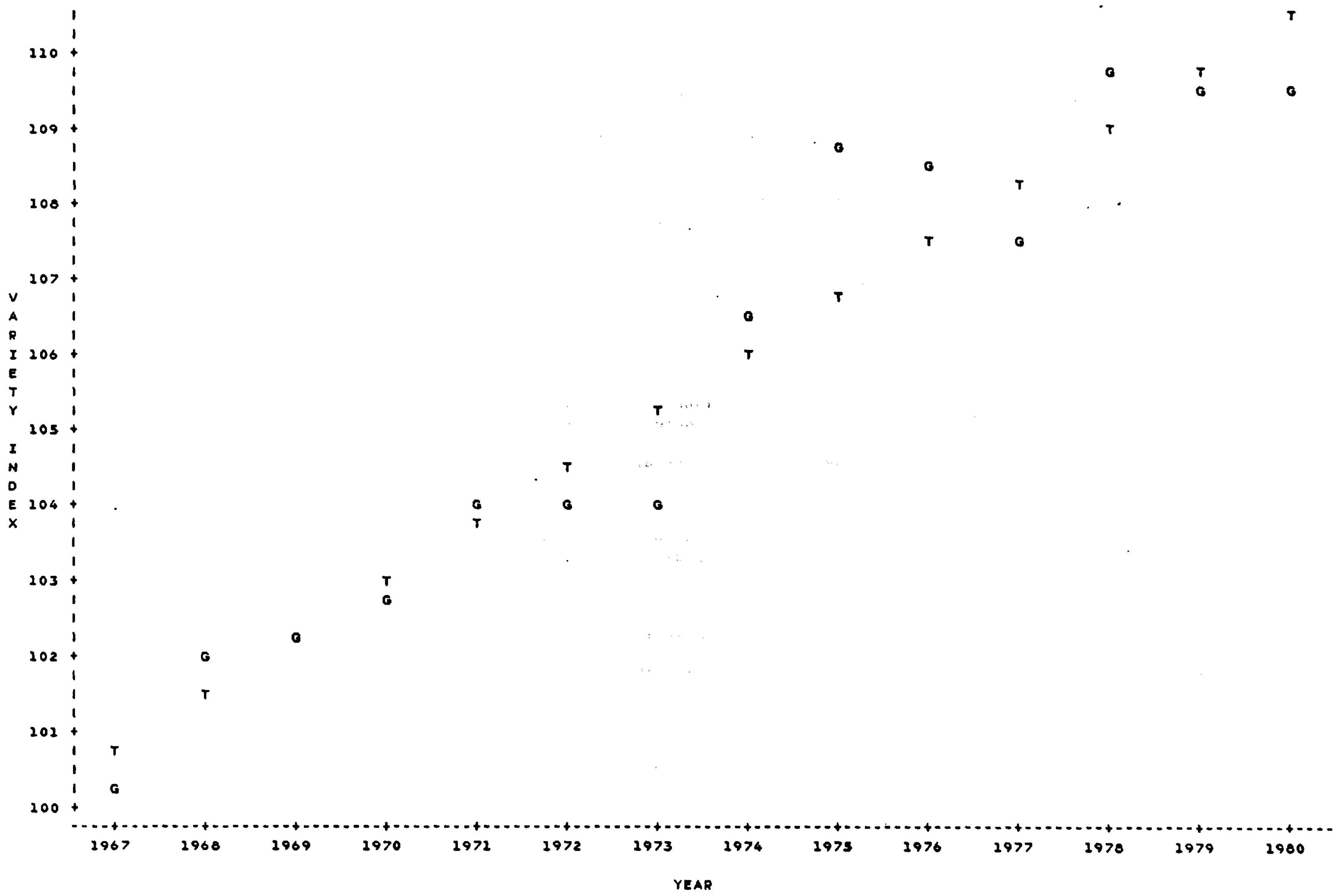


TABLE C.3

VARIETY INDEX TREND

COMPONENT ESTIMATION

STATE=IOWA

MODEL: MODEL01	SSE	28.660848	F RATIO	12.51	
	DFE	12	PROB>F	0.0041	
DEP VAR: INDEX	MSE	2.388404	R-SQUARE	0.5104	

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|	VARIABLE LABEL
INTERCEPT	1	88.336305	4.578233	19.2948	0.0001	
TREND	1	0.362391	0.102462	3.5368	0.0041	

FIGURE C.3

VARIETY INDEX (G) AND VARIETY INDEX

TREND COMPONENT (T), 1967-1980

STATE=IOWA

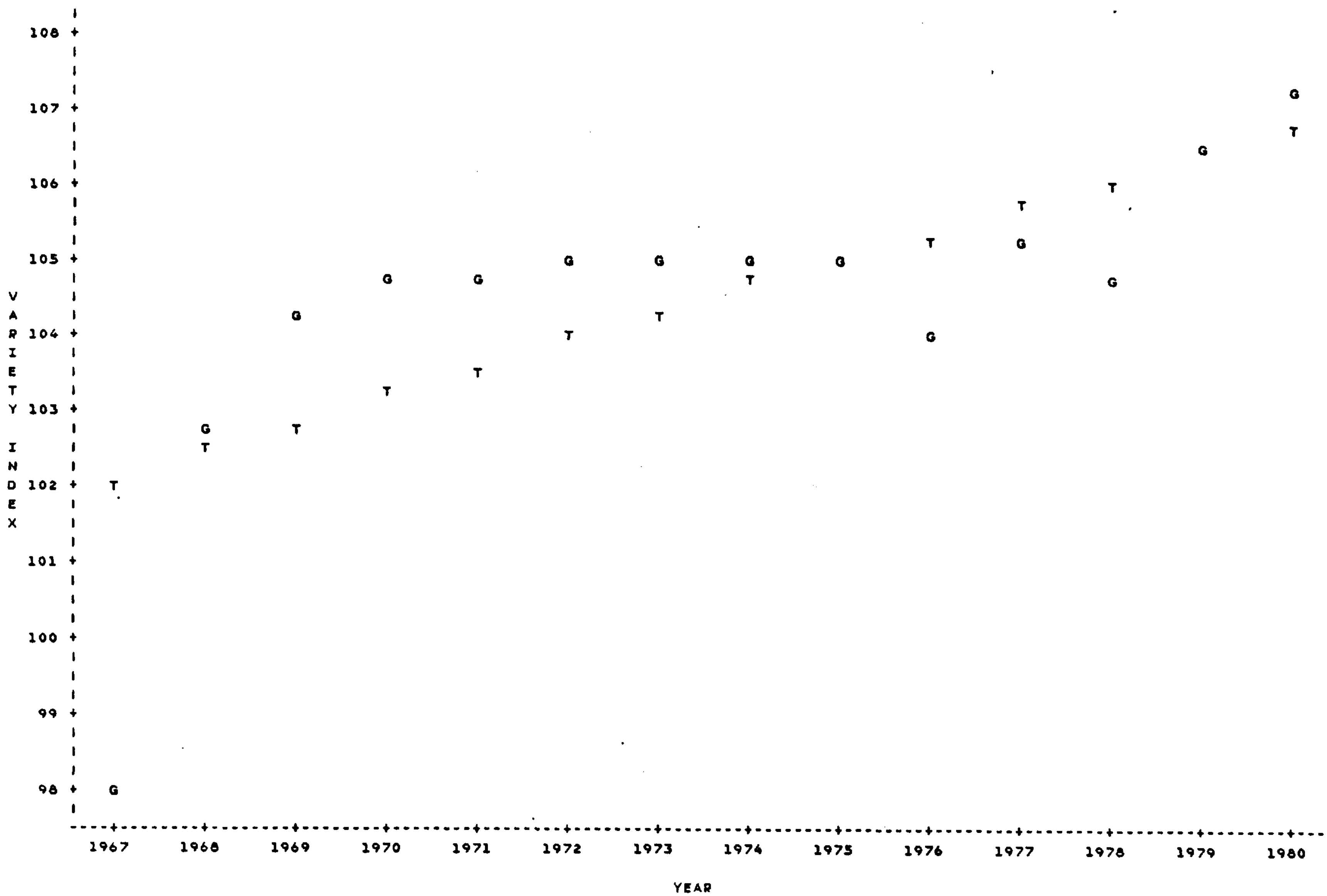


TABLE C.4

VARIETY INDEX TREND

COMPONENT ESTIMATION

STATE=MISSOURI

MODEL: MODEL01		SSE	78.295077	F RATIO	70.80	
		DFE	13	PROB>F	0.0001	
DEP VAR: INDEX		MSE	6.022698	R-SQUARE	0.8449	

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|	VARIABLE LABEL
INTERCEPT	1	51.986302	6.630123	7.8409	0.0001	
TREND	1	1.234021	0.146662	8.4141	0.0001	

FIGURE C.4

VARIETY INDEX (G) AND VARIETY INDEX

TREND COMPONENT (T), 1967-1981

STATE=MISSOURI

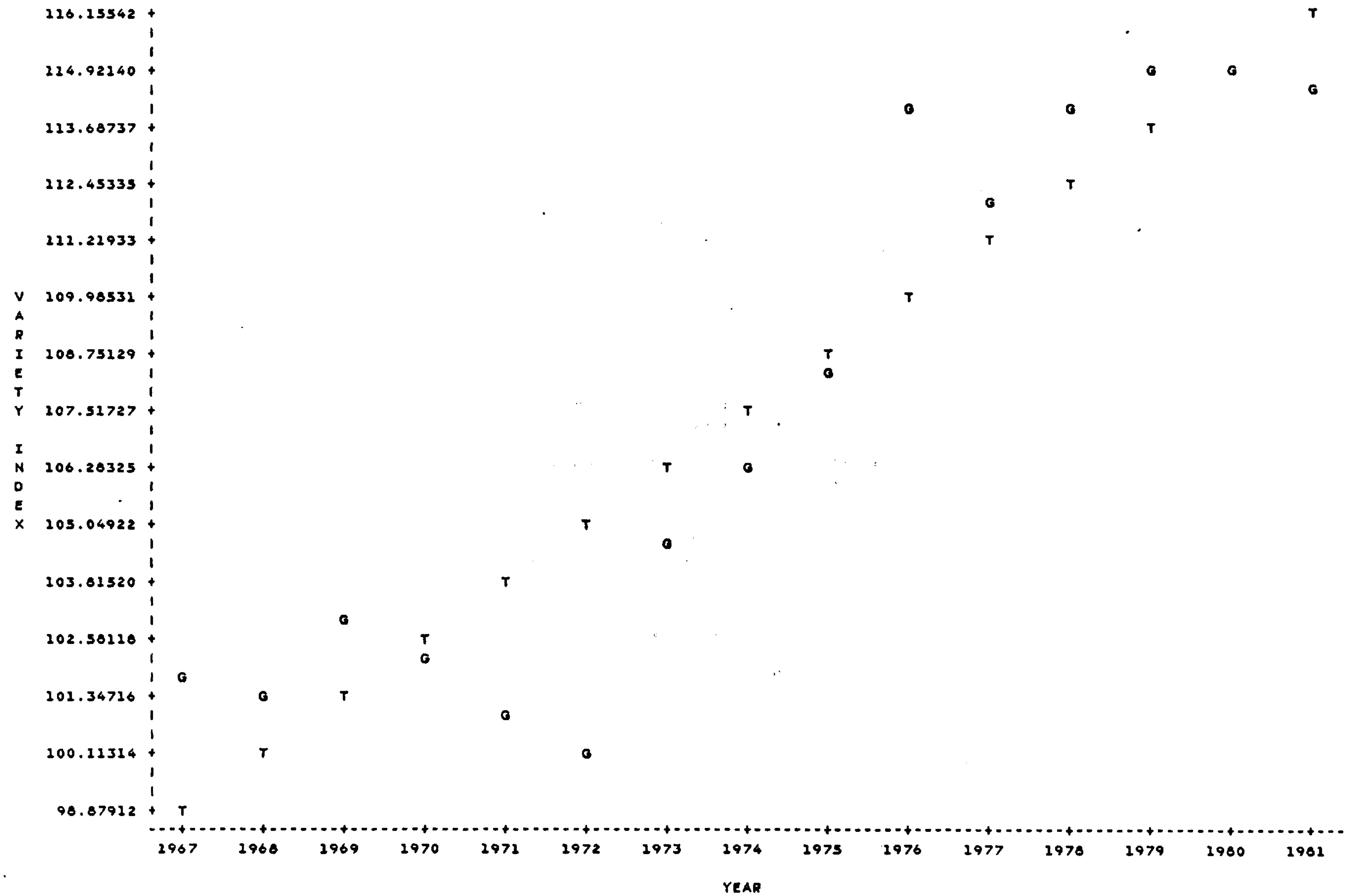


TABLE C.5

VARIETY INDEX TREND

COMPONENT ESTIMATION

STATE=OHIO

MODEL:	MODEL01		SSE	42.963665	F RATIO	55.60	
			DFE	12	PROB>F	0.0001	
DEP VAR: INDEX			MSE	3.580305	R-SQUARE	0.8225	

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|	VARIABLE LABEL
INTERCEPT	1	62.037943	5.605366	11.0712	0.0001	
TREND	1	0.935457	0.125450	7.4568	0.0001	

FIGURE C.5

VARIETY INDEX (G) AND VARIETY INDEX

TREND COMPONENT (T), 1967-1980

STATE=OHIO

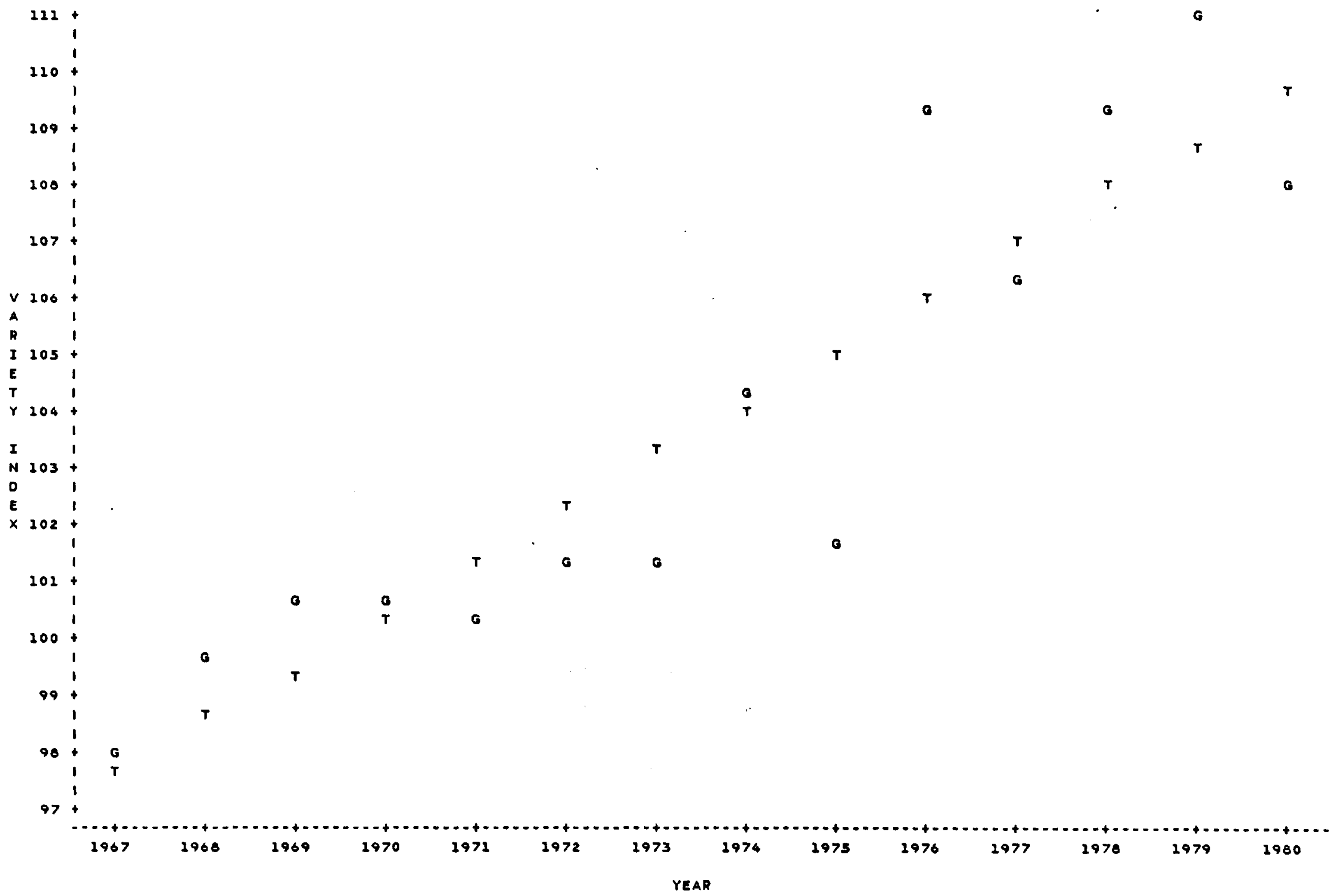


TABLE C.6

REGIONAL VARIETY INDEX

TREND COMPONENT ESTIMATION

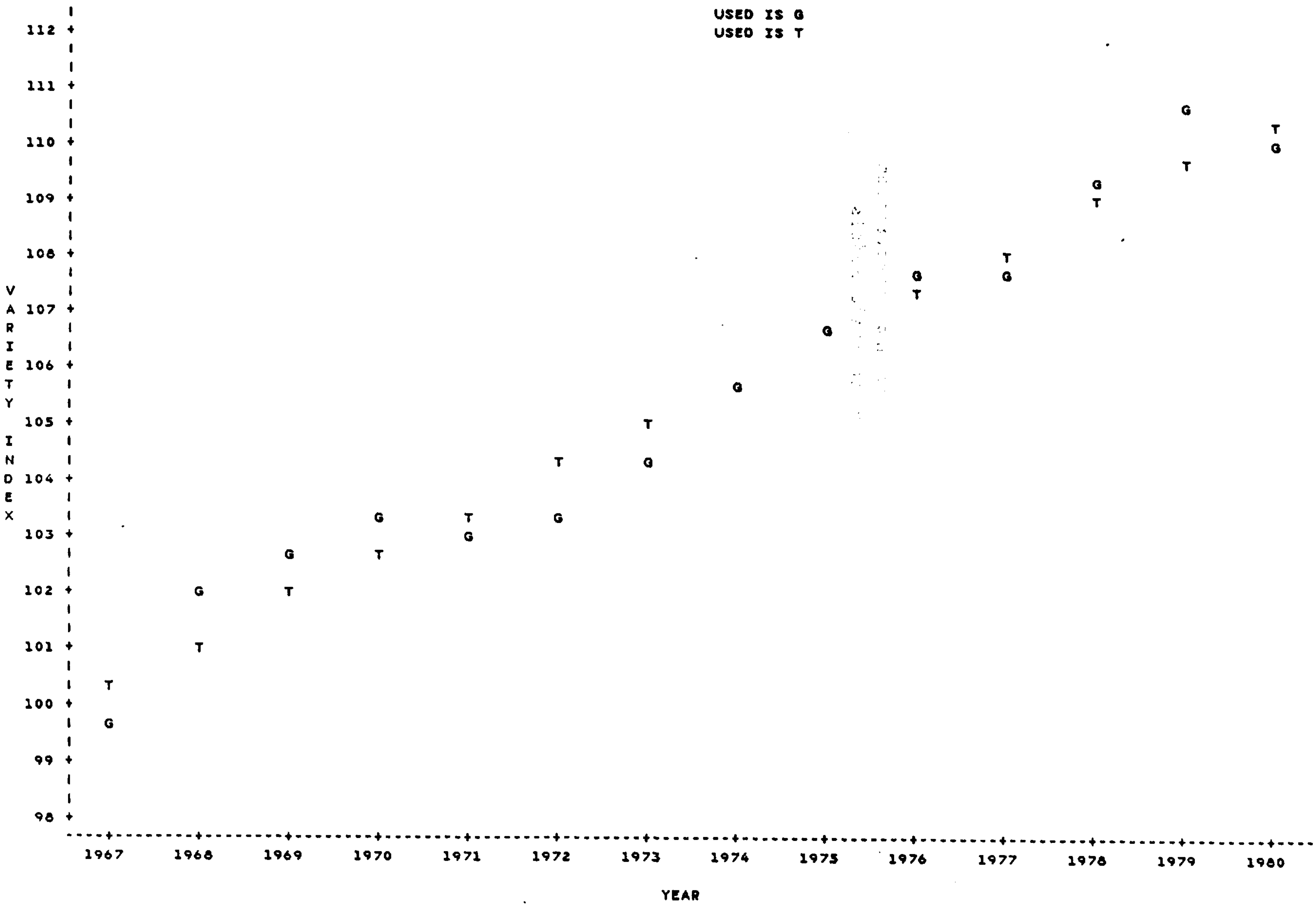
MODEL: MODEL01	SSE	5.436433	F RATIO	303.63	
	DFE	12	PROB>F	0.0001	
DEP VAR: INDEX	MSE	0.453036	R-SQUARE	0.9620	

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|	VARIABLE LABEL
INTERCEPT	1	70.808958	1.993932	35.5122	0.0001	
TREND	1	0.777587	0.044625	17.4250	0.0001	

FIGURE C.6

REGION LEVEL VARIETY INDEX (G) AND VARIETY

INDEX TREND COMPONENT (T), 1967-1980



APPENDIX D

Restricted and Unrestricted Soybean Yield Models

Table D1.1

STATE LEVEL SOYBEAN YIELD MODEL

STATE=ILLINOIS

MODEL:	MODEL01	SSE	151.455485	F RATIO	63.07
		DFE	42	PROB>F	0.0001
DEP VAR:	SYLD	MSE	3.606083	R-SQUARE	0.9232
	BUSHELS PER ACRE				

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|	VARIABLE LABEL
INTERCEPT	1	-22.870880	3.493820	-6.5461	0.0001	
TRINDEX	1	0.519870	0.036635	14.1905	0.0001	PREDICTED
GENTRES	1	0.291958	0.443582	0.6582	0.5140	RESIDUALS
DNPRSP	1	-0.010397	0.061227	-0.1698	0.8660	MEAN OF DNPRSP
DNPJLY	1	1.143044	0.222737	5.1318	0.0001	MEAN OF DNPJLY
DNPAUG	1	0.861924	0.231308	3.7263	0.0006	MEAN OF DNPAUG
DNTJUN	1	0.033502	0.115739	0.2895	0.7736	MEAN OF DNTJUN
DNTJLY	1	-0.101867	0.138207	-0.7371	0.4652	MEAN OF DNTJLY
DNTAUG	1	-0.103357	0.142973	-0.7229	0.4737	MEAN OF DNTAUG

Table 1.2

ILLINOIS STATE LEVEL RESTRICTED ESTIMATES OF

GENETIC TREND AND GENETIC RESIDUAL COEFFICIENTS

MODEL:	MODEL01	SSE	88.331893	F RATIO	72.39
		DFE	22	PROB>F	0.0001
DEP VAR:	SYLD	MSE	4.015086	R-SQUARE	0.7669
	MEAN OF SYLD				

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|	VARIABLE LABEL
INTERCEPT	1	-22.870900	1.19434E-07	-99999.0000	0.0001	
TRINDEX	1	0.519663	0.004004246	129.7780	0.0001	GENETIC TREND
GENTRES	1	0.291978	0.405474	0.7201	0.4791	GENETIC RESIDUAL
DNPRSP	1	-0.010400	1.23435E-09	-99999.0000	0.0001	MEAN OF DNPRSP
DNPJLY	1	1.143000	1.86615E-09	99999.0000	0.0001	MEAN OF DNPJLY
DNPAUG	1	0.861900	3.23227E-09	99999.0000	0.0001	MEAN OF DNPAUG
DNTJUN	1	0.033500	2.63914E-09	99999.0000	0.0001	MEAN OF DNTJUN
DNTJLY	1	-0.101900	0			MEAN OF DNTJLY
DNTAUG	1	-0.103360	0			MEAN OF DNTAUG
RESTRICTION	-1	-0.758822	0.406940	-1.8647	0.0756	
RESTRICTION	-1	-44.916385	47.284290	-0.9499	0.3525	
RESTRICTION	-1	-4.588062	13.470769	-0.3406	0.7366	
RESTRICTION	-1	2.753918	13.240522	0.2080	0.8371	
RESTRICTION	-1	32.013064	18.312644	1.7481	0.0944	
RESTRICTION	-1	-2.307494	17.160705	-0.1345	0.8943	
RESTRICTION	-1	-5.651866	17.094578	-0.3306	0.7441	

Table D2.1

STATE LEVEL SOYBEAN YIELD MODEL

STATE=INDIANA

MODEL:	MODEL01	SSE	151.506571	F RATIO	50.63
		DFE	37	PROB>F	0.0001
DEP VAR:	SYLD	MSE	4.094772	R-SQUARE	0.9163
	BUSHELS PER ACRE				

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|	VARIABLE LABEL
INTERCEPT	1	-26.513651	3.809214	-6.9604	0.0001	
TRINDEX	1	0.549835	0.040165	13.6894	0.0001	PREDICTED
GENTRES	1	0.571594	0.654070	0.8739	0.3878	RESIDUALS
DNPRSP	1	0.068504	0.069974	0.9790	0.3339	MEAN OF DNPRSP
DNPJLY	1	0.916656	0.240013	3.8192	0.0005	MEAN OF DNPJLY
DNPAUG	1	0.449696	0.314387	1.4304	0.1610	MEAN OF DNPAUG
DNTJUN	1	0.025774	0.135125	0.1907	0.8498	MEAN OF DNTJUN
DNTJLY	1	0.112018	0.181155	0.6184	0.5401	MEAN OF DNTJLY
DNTAUG	1	-0.075252	0.158732	-0.4741	0.6382	MEAN OF DNTAUG

Table D2.2

INDIANA STATE LEVEL RESTRICTED ESTIMATES OF

GENETIC TREND AND GENETIC RESIDUAL COEFFICIENTS

MODEL:	MODEL01	SSE	68.957797	F RATIO	19.86
		DFE	12	PROB>F	0.0008
DEP VAR:	SYLD	MSE	5.746483	R-SQUARE	0.6234
	MEAN OF SYLD				

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|	VARIABLE LABEL
INTERCEPT	1	-26.513700	2.85766E-07	-99999.0000	0.0001	
TRINDEX	1	0.550540	0.006063083	90.8019	0.0001	GENETIC TREND
GENTRES	1	0.571601	0.737182	0.7754	0.4531	GENETIC RESIDUAL
DNPRSP	1	0.068500	2.23255E-09	99999.0000	0.0001	MEAN OF DNPRSP
DNPJLY	1	0.916660	3.86689E-09	99999.0000	0.0001	MEAN OF DNPJLY
DNPAUG	1	0.449700	5.46861E-09	99999.0000	0.0001	MEAN OF DNPAUG
DNTJUN	1	0.025770	3.15730E-09	99999.0000	0.0001	MEAN OF DNTJUN
DNTJLY	1	0.112020	6.31461E-09	99999.0000	0.0001	MEAN OF DNTJLY
DNTAUG	1	-0.075250	0			MEAN OF DNTAUG
RESTRICTION	-1	-0.019509	0.256048	-0.0762	0.9405	
RESTRICTION	-1	-60.233920	34.136505	-1.7645	0.1031	
RESTRICTION	-1	11.625498	12.944461	0.8981	0.3868	
RESTRICTION	-1	-0.950690	14.197033	-0.0670	0.9477	
RESTRICTION	-1	16.191999	18.386306	0.8807	0.3958	
RESTRICTION	-1	12.221181	14.567332	0.8389	0.4179	
RESTRICTION	-1	9.980248	16.991685	0.5874	0.5678	

Table D3.1

STATE LEVEL SOYBEAN YIELD MODEL

STATE=IOWA

MODEL: MODEL01	SSE	107.106216	F RATIO	25.47
	DFE	24	PROB>F	0.0001
DEP VAR: SYLD	MSE	4.462759	R-SQUARE	0.8946
BUSHELS PER ACRE				

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|	VARIABLE LABEL
INTERCEPT	1	-116.765550	11.422974	-10.2220	0.0001	
TRINDEX	1	1.437019	0.112208	12.8068	0.0001	PREDICTED
GENTRES	1	0.352123	0.469449	0.7501	0.4605	RESIDUALS
DNPRSP	1	0.033083	0.106784	0.3098	0.7594	MEAN OF DNPRSP
DNPJLY	1	0.691719	0.313706	2.2050	0.0373	MEAN OF DNPJLY
DNPAUG	1	0.431717	0.232023	1.8607	0.0751	MEAN OF DNPAUG
DNTJUN	1	0.285984	0.166554	1.7171	0.0988	MEAN OF DNTJUN
DNTJLY	1	-0.039212	0.180191	-0.2176	0.8296	MEAN OF DNTJLY
DNTAUG	1	0.018578	0.195440	0.0951	0.9251	MEAN OF DNTAUG

Table D3.2

IOWA STATE LEVEL RESTRICTED ESTIMATES OF

GENETIC TREND AND GENETIC RESIDUAL COEFFICIENTS

MODEL:	MODEL01	SSE	31.642632	F RATIO	43.18
		DFE	12	PROB>F	0.0001
DEP VAR:	SYLD	MSE	2.636886	R-SQUARE	0.7825
	MEAN OF SYLD				

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|	VARIABLE LABEL
INTERCEPT	1	-116.765600	3.87156E-07	-99999.0000	0.0001	
TRINDEX	1	1.437622	0.00415411	346.0723	0.0001	GENETIC TREND
GENTRES	1	0.352123	0.303344	1.1608	0.2683	GENETIC RESIDUAL
DNPRSP	1	0.033080	0			MEAN OF DNPRSP
DNPJLY	1	0.691720	4.27751E-09	99999.0000	0.0001	MEAN OF DNPJLY
DNPAUG	1	0.431720	2.61943E-09	99999.0000	0.0001	MEAN OF DNPAUG
DNTJUN	1	0.285980	1.51233E-09	99999.0000	0.0001	MEAN OF DNTJUN
DNTJLY	1	-0.039210	1.51233E-09	-99999.0000	0.0001	MEAN OF DNTJLY
DNTAUG	1	0.010580	3.02465E-09	99999.0000	0.0001	MEAN OF DNTAUG
RESTRICTION	-1	0.071469	0.084960	0.8412	0.4167	
RESTRICTION	-1	-26.771866	26.304437	-1.0178	0.3289	
RESTRICTION	-1	8.542307	9.079401	0.9408	0.3653	
RESTRICTION	-1	-3.897142	12.544488	-0.3107	0.7614	
RESTRICTION	-1	1.455029	13.666459	0.1065	0.9170	
RESTRICTION	-1	-24.372720	12.623951	-1.9307	0.0775	
RESTRICTION	-1	18.593239	9.107328	2.0416	0.0638	

Table D4.1

STATE LEVEL SOYBEAN YIELD MODEL

STATE=MISSOURI

MODEL:	MODEL01	SSE	96.629591	F RATIO	16.40
		DFE	24	PROB>F	0.0001
DEP VAR:	SYLD	MSE	4.026233	R-SQUARE	0.8454
	BUSHELS PER ACRE				

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|	VARIABLE LABEL
INTERCEPT	1	-2.149262	2.983354	-0.7204	0.4782	
TRINDEX	1	0.263353	0.030782	8.5555	0.0001	PREDICTED
GENTRES	1	-0.086765	0.244960	-0.3542	0.7263	RESIDUALS
DNPRSP	1	0.070062	0.072341	0.9685	0.3425	MEAN OF DNPRSP
DNPJLY	1	1.198289	0.249284	4.8069	0.0001	MEAN OF DNPJLY
DNPAUG	1	1.173044	0.331400	3.5548	0.0016	MEAN OF DNPAUG
DNTJUN	1	0.123449	0.162528	0.7596	0.4549	MEAN OF DNTJUN
DNTJLY	1	-0.415758	0.185254	-2.2443	0.0343	MEAN OF DNTJLY
DNTAUG	1	0.064372	0.217953	0.2953	0.7703	MEAN OF DNTAUG

Table D4.2

MISSOURI STATE LEVEL RESTRICTED ESTIMATES OF

GENETIC TREND AND GENETIC RESIDUAL COEFFICIENTS

MODEL: MODEL01	SSE	60.627050	F RATIO	25.97
	DFE	13	PROB>F	0.0002
DEP VAR: SYLD	MSE	4.663619	R-SQUARE	0.6664
MEAN OF SYLD				

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|	VARIABLE LABEL
INTERCEPT	1	-2.149260	1.28719E-07	-99999.0000	0.0001	
TRINDEX	1	0.262635	0.005179694	50.7047	0.0001	GENETIC TREND
GENTRES	1	-0.086764	0.244055	-0.3555	0.7279	GENETIC RESIDUAL
DNPRSP	1	0.070060	1.23162E-09	99999.0000	0.0001	MEAN OF DNPRSP
DNPJLY	1	1.198300	5.68862E-09	99999.0000	0.0001	MEAN OF DNPJLY
DNPAUG	1	1.178040	4.92649E-09	99999.0000	0.0001	MEAN OF DNPAUG
DNTJUN	1	0.123450	2.01123E-09	99999.0000	0.0001	MEAN OF DNTJUN
DNTJLY	1	-0.415760	2.01123E-09	-99999.0000	0.0001	MEAN OF DNTJLY
DNTAUG	1	0.064370	0			MEAN OF DNTAUG
RESTRICTION	-1	0.270469	0.414238	0.6529	0.5252	
RESTRICTION	-1	-47.790294	50.271155	-0.9507	0.3591	
RESTRICTION	-1	1.457086	14.662307	0.0994	0.9224	
RESTRICTION	-1	4.457218	11.620869	0.3836	0.7075	
RESTRICTION	-1	24.881070	14.187553	1.7537	0.1030	
RESTRICTION	-1	-3.463084	19.481723	-0.1778	0.8617	
RESTRICTION	-1	17.420421	16.553453	1.0524	0.3118	

Table D5.1

STATE LEVEL SOYBEAN YIELD MODEL

STATE=OHIO

MODEL:	MODEL01	SSE	97.545128	F RATIO	15.77
		DFE	23	PROB>F	0.0001
DEP VAR:	SYLD BUSHELS PER ACRE	MSE	4.241093	R-SQUARE	0.8458

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|	VARIABLE LABEL
INTERCEPT	1	-8.063190	4.682319	-1.7221	0.0985	
TRINDEX	1	0.362951	0.049066	7.3971	0.0001	PREDICTED
GENTRES	1	0.628833	0.341316	1.8424	0.0783	RESIDUALS
DNPRSP	1	-0.094345	0.102730	-0.9184	0.3679	MEAN OF DNPRSP
DNPJLY	1	0.986670	0.342680	2.8793	0.0085	MEAN OF DNPJLY
DNPAUG	1	1.007590	0.343331	2.9347	0.0075	MEAN OF DNPAUG
DNTJUN	1	0.135208	0.184298	0.7336	0.4706	MEAN OF DNTJUN
DNTJLY	1	-0.00415633	0.253565	-0.0164	0.9871	MEAN OF DNTJLY
DNTAUG	1	0.365765	0.235842	1.5509	0.1346	MEAN OF DNTAUG

Table D5.2

OHIO STATE LEVEL RESTRICTED ESTIMATES OF

GENETIC TREND AND GENETIC RESIDUAL COEFFICIENTS

MODEL:	MODEL01	SSE	58.035611	F RATIO	34.36
		DFE	12	PROB>F	0.0001
DEP VAR:	SYLD	MSE	4.836301	R-SQUARE	0.7412
	MEAN OF SYLD				

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|	VARIABLE LABEL
INTERCEPT	1	-8.063200	5.07671E-07	-99999.0000	0.0001	
TRINDEX	1	0.367085	0.005664827	64.8008	0.0001	GENETIC TREND
GENTRES	1	0.628836	0.335516	1.8742	0.0854	GENETIC RESIDUAL
DNPRSP	1	-0.094350	2.04813E-09	-99999.0000	0.0001	MEAN OF DNPRSP
DNPJLY	1	0.986670	8.19251E-09	99999.0000	0.0001	MEAN OF DNPJLY
DNPAUG	1	1.007600	4.09625E-09	99999.0000	0.0001	MEAN OF DNPAUG
DNTJUN	1	0.135210	2.04813E-09	99999.0000	0.0001	MEAN OF DNTJUN
DNTJLY	1	-0.004156	3.54746E-09	-99999.0000	0.0001	MEAN OF DNTJLY
DNTAUG	1	0.365770	4.09625E-09	99999.0000	0.0001	MEAN OF DNTAUG
RESTRICTION	-1	-0.120147	0.299073	-0.4017	0.6949	
RESTRICTION	-1	-61.566457	26.110691	-2.3579	0.0362	
RESTRICTION	-1	3.145685	9.057959	0.3473	0.7344	
RESTRICTION	-1	-1.054774	12.222712	-0.0863	0.9327	
RESTRICTION	-1	6.619077	18.214979	0.3634	0.7226	
RESTRICTION	-1	3.529903	10.469970	0.3371	0.7418	
RESTRICTION	-1	2.234891	12.409338	0.1801	0.8601	