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Can Productivity Growth in Agriculture be Continued?*

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There is growing uncertainty about the future course of productivity growth in U.S. agriculture.

In a widely publicized report issued in 1975, a committee of the National Academy of Sciences pointed out that productivity indicators such as output per acre, output per worker, and output per unit of total inputs (including land, labor, capital, and operating expenses) appeared to be declining. The committee suggested that part of this decline was due to a slowing of support for agricultural research.

There was disagreement over the academy committee's conclusions. Agricultural production and productivity rose rapidly again for a few years. But the real level of support for agricultural research, after accounting for inflation, has tended to stagnate. This was particularly true of U.S. Department of Agriculture (USDA) support for its own research programs and for research at the state experiment stations (figure 1). The total number of agricultural research workers has remained quite static, with a decline at USDA stations slightly more than offset by increases at state stations.

By 1979 it was obvious that productivity growth—whether measured by partial productivity indicators such as output per acre or worker or by total productivity measures—had begun to fall off (table 1). Oklahoma State University projections suggest that if support for agricultural research continues to stagnate, total productivity growth might decline from the 2.2 percent per year level achieved during 1950-1965 to something like a 1.0 to 1.5 percent range during the next several decades. If the rate of productivity growth declines, the rate of production growth can be maintained only by an increase in the rate of use of purchased inputs—at higher costs of production.

Productivity growth is important both to farmers and consumers for it helps slow the increase in production costs. If some of these cost reductions are passed on to consumers, it helps slow food cost increases. When productivity growth stagnates, farmers can improve their incomes only by passing higher costs on to consumers in the form of higher prices. When productivity growth stagnates, consumers can protect their cost of living only at

Figure 1. Purchasing power of federal appropriations and nonfederal support of agricultural research programs in the U.S. for fiscal years 1960-1978. (After Bernard J. Liska and Joseph Havlicek, Jr., "Statement on Experiment Station Committee on Organization and Policy, Fiscal Year 1981 Budget Recommendations," USDA Science and Education Administration, Washington, D. C., September 27, 1979.)

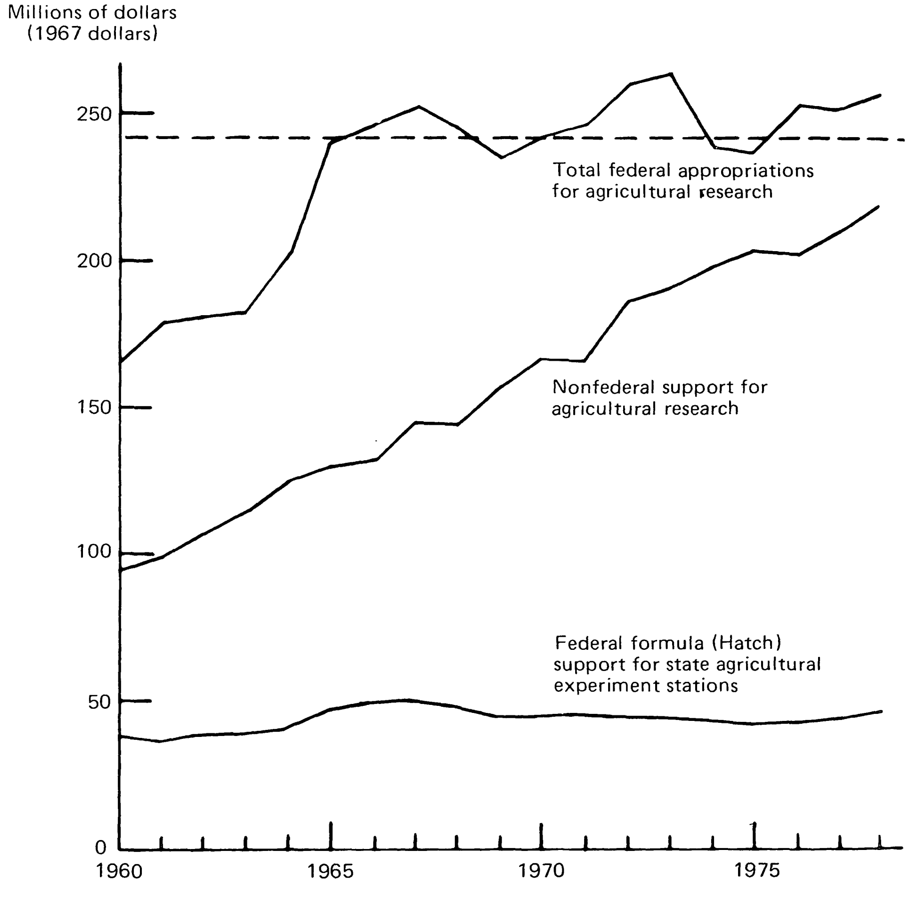

Table 1. Annual rates of change (percent per year) in total output, inputs, and productivity in U.S. agriculture, 1950-1979

Subjects	1950-65	1965-79
	— — percent	— —
Farm output	1.7	2.1
Total inputs	-0.4	0.3
Total productivity	2.2	1.8
Labor inputs	-4.8	-3.8
Labor productivity	6.6	6.0
Land inputs	-0.9	0.9
Land productivity	2.6	1.2

Source: USDA, *Changes in Farm Production and Efficiency,* Washington, D.C., 1979. (1979 data are preliminary.)

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the expense of producers—by export restrictions, for example.

Since 1950, increases in productivity have enabled the U.S. to shift from a net importer of agricultural commodities to a dominant position in world agricultural export markets. Both producers and consumers have shared in the growth dividends from higher productivity.

Agricultural research has been a highly profitable social investment for state and federal governments. A large number of studies indicates a social rate of return to public investment in agricultural research in the 50-100 percent range (table 2). The estimates presented in table 2 are referred to as social rates of return because they are diffused throughout the economy—to farmers, food processors, workers in the food industries, and consumers—rather than being captured by one group.

Agricultural research is clearly a "good buy." One would think that such high rates of return in agricultural research would lead to a greater investment in it rather than stagnation. State governments have recognized that agricultural research pays off in terms of state economic growth so state support has expanded even while federal government support has not.

But how long can this continue? The data presented in table 2 indicate that a substantial share of the benefits from the research conducted in one state "spills over" into nearby states. The federal formula support for state experiment stations can be viewed as compensation to the states for their contribution to productivity growth in the rest of the nation. If the federal share continues to decline, will this affect the willingness of the states to continue to expand their support?

The uncertain support for agricultural research means that it is important to continuously monitor the effectiveness of the agricultural research system. Failure to maintain productivity growth would weaken the economic base of both the state and the national economy. In 1979, the Minnesota Agricultural Experiment Station initiated a project designed to determine if the rate of technical change, measured by productivity growth, is beginning to slow. An initial report of work conducted under the project is presented in the next article in this issue.

Table 2. Estimated impacts of research and extension investments in U.S. agriculture

Period and subject	Annual rate of return	Productivity change realized in the state undertaking the research
	— — — — — — — percent	— — — — — — —
1868-1926		
All agricultural research	65	not estimated
1927-1950		
Agricultural research		
Technology-oriented	95	55
Science-oriented	110	33
1948-1971		
Agricultural research		
Technology-oriented		
South	130	67
North	93	43
West	95	67
Science-oriented	45	32
Farm management and agricultural extension	110	100

Source: Robert E. Evenson, Paul E. Wagonner, and Vernon W. Ruttan, "Economic Benefits from Research: An Example from Agriculture." *Science* 205 (September 14, 1979), p. 110.

Some Selected References for Further Reading on Agricultural Research and Productivity

Committee on Agricultural Production Efficiency. *Agricultural Production Efficiency.* Washington: National Academy of Sciences, 1975.

Evenson, Robert E.; Waggoner, Paul E.; and Ruttan, Vernon W. "Economic Benefits from Research: An Example from Agriculture." *Science,* 205 (September 14, 1979), pp. 1101-1107.

Lu, Yao-chi, and Quance, Leroy. *Agricultural Productivity: Expanding the Limits.* Washington: U.S. Department of Agriculture, ESCS/AI 431, August 1979.

U.S. Department of Agriculture. Science and Education Administration. *Report of the National Agricultural Research and Extension Users Advisory Board,* October 1979.

Soybean Yield Trends in Minnesota*

Vernon W. Ruttan, George W. Norton, and Randy R. Schoeneck**

Expansion of soybean production has been based more on rapid increase in acreage planted than on increase in yield. In the future, however, it seems likely that production growth will depend primarily on increases in yield.

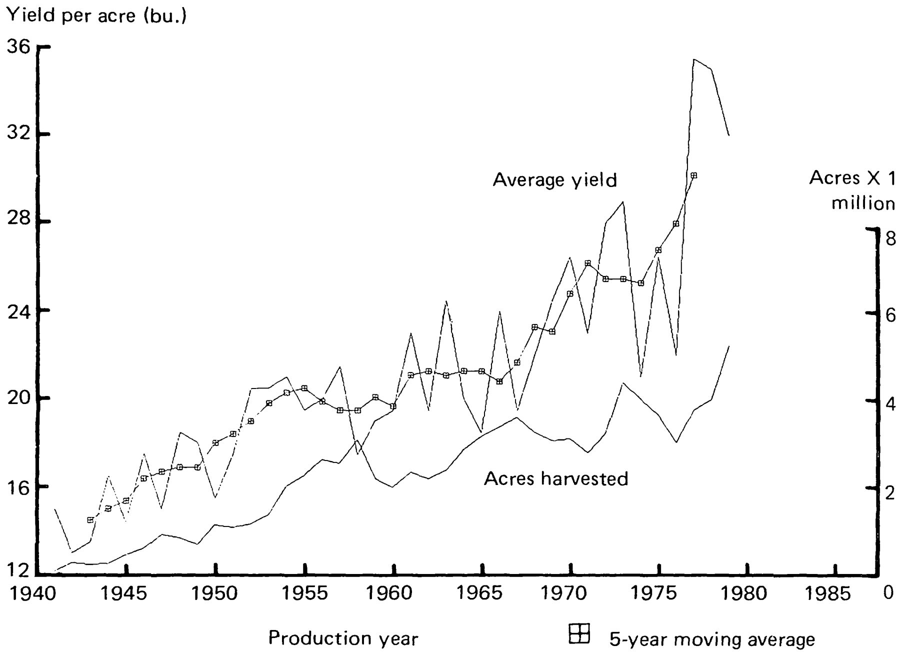
This article examines the history of soybean acreage and yield in Minnesota and what is happening to the gap between farm level and experimental yields. This gap may be a clue to future yield growth.

Acreage, Yield, and Varieties

Soybean acreage in Minnesota has increased from less than 200,000 acres in 1940 to more than 5 million acres in 1979 (figure 1). In 1979 soybeans accounted for 24 percent (5.2 out of 21.9 million acres) of the cropland harvested in Minnesota. In 1940 only four counties in southeastern Minnesota (Dodge, Fillmore, Mower, and Olmsted) devoted over 5 percent of their cropland to soybeans. Today, soybeans are a major crop in almost every county below a line running southeastward from Crookston to Pine City.

Soybean yields have risen substantially. In the early 1940s an average Minnesota yield was about 15 bushels per acre. In the late 1970s soybean yields averaged almost 35 bushels per acre (figure 1). The average gain in yield over this period was 2.3 percent per year. Much of the yield gain was concentrated in two periods: between 1948 and 1954, and between 1966 and 1978. During this latter period, soybean yields increased by 4.3 percent per year—more rapidly than corn and wheat yields and at approximately the same rate as sunflower yields.

Figure 1. Minnesota average yield and acres harvested—soybeans, 1941-1979



The yield gains in the early 1950s were regarded by soybean researchers as due primarily to the introduction of a series of higher yielding varieties suited to southern Minnesota: Hawkeye, 1947; Blackhawk, 1949; Harosoy, 1951; Renville, 1952; and Chippewa, 1954. Because soybeans were typically grown in rotation with corn, the rapid rise in fertilizer applications on corn probably increased soybean yields.

The rate of introduction of new soybean varieties slowed between the mid-1950s and the mid-1960s.[1] Chippewa remained a dominant variety in many areas for over a decade (table 1). Average yields showed little increase between the mid-1950s and the mid-1960s.

The yield gains of the late 1960s and the 1970s are believed to reflect the effects of the rapid introduction of improved varieties and a number of improvements in cultural practices. The important new varieties that were introduced include Hark, 1966; Corsoy, 1967; Clay, 1968; Swift, 1972; Evans, 1974; Hodgson, 1974; and Harcor, 1975. Each occupied a substantial acreage shortly after introduction (table 1). The use of herbicides to achieve more effective weed control was probably the most important cultural practice. Closer row spacing and earlier planting also contributed to higher yields.

A statistical analysis was conducted in an attempt to separate the effects of year-to-year variations in weather from the longrun effects of varieties and practices. Variations in July rainfall had a modest effect on yield. A week's delay, after August 15, in the date of

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[1]The number of soybean varieties in the maturity groups suited to Minnesota (00, 0, I, II) during each 5-year period since the mid-1940s follows:

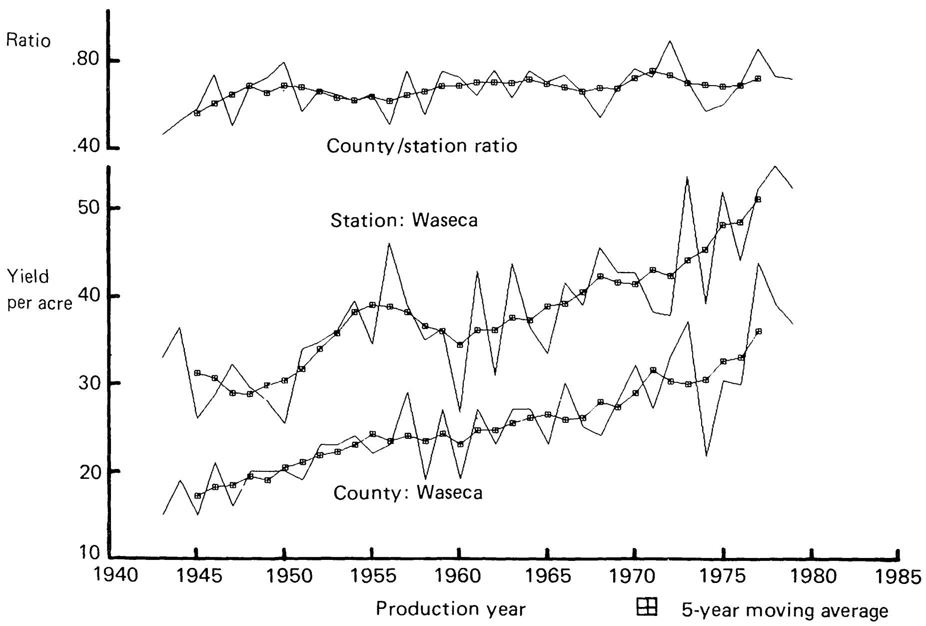
1945-49	7	1955-59	6	1965-69	17
1950-54	8	1960-65	7	1970-74	11

Table 1. Percentage of soybean acreage accounted for by leading varieties in three regions of Minnesota, 1956-1979

Soybean variety	1956	1961	1965	1971	1977	1979
			percent			
Region 1 (Northwest)						
Capital	54	----	----	----	----	----
Flambeau	25	27	4	----	----	----
Grant	----	26	6	----	----	----
Merit	----	----	75	72	----	----
Clay	----	----	----	18	----	----
Evans	----	----	----	----	65	75
Swift	----	----	----	----	5	----
Region 4 (West Central)						
Capital	55	----	----	----	----	----
Blackhawk	14	----	----	----	----	----
Ottawa Mandarin	13	----	----	----	----	----
Chippewa*	4	67	68	53	4	----
Merit	----	----	19	15	4	1
Clay	----	----	----	16	----	----
Corsoy	----	----	----	3	13	11
Hodgson	----	----	----	----	30	29
Swift	----	----	----	----	26	20
Evans	----	----	----	----	10	20
Region 8 (South Central)						
Capital	13	----	----	----	----	----
Blackhawk	38	4	1	----	----	----
Hawkeye	12	6	1	----	----	----
Chippewa*	6	69	74	31	3	1
Harosoy	----	12	8	----	----	----
Corsoy	----	----	----	48	67	54
Hark	----	----	----	10	----	----
Hodgson	----	----	----	----	12	12
Harcor	----	----	----	----	----	8
Coles	----	----	----	----	----	2

*Includes Chippewa 64 after 1964.
Source: *Minnesota Soybean Varieties: 1979,* Minnesota Department of Agriculture, St. Paul, Minn., Sept. 7, 1979 (and earlier releases).

Figure 2. Relationship between Southern experiment station, Waseca, and Waseca County farm yield of soybeans—1943-1979



the first frost increased yields, on the average, by approximately one bushel per acre in Waseca and Stevens counties and by about two-thirds bushel in Polk County.

New varieties, and associated practices such as spacing and time of planting, accounted for about half of the increase in yield since 1940. And half of that effect occurred during the last 10 years. We have not yet been able to adequately isolate the effects of weed control and fertility practices.

Experiment Station and Farm Yields

In recent years, there have been increasing expressions of concern about the future of productivity growth in agriculture. Will American farmers be able to continue to increase yields as rapidly during the last two decades of the 20th century as during the 1950s, 1960s, and 1970s?

One way to begin to answer this question is to compare the best yields obtained by experiment stations and the average yields obtained by farmers in the same area. Figures 2-4 show the results of such comparisons for three locations in Minnesota: Waseca County and the Southern Experiment Station at Waseca; Stevens County and the West Central Experiment Station at Morris; and Polk County and the Northwest Experiment Station at Crookston. To smooth out the effects of weather, 5-year moving averages as well as actual yields are shown for each year. The trend in the ratio of the county average yield to the experiment station yield is also shown.

Waseca County in *southern Minnesota,* is one of the state's leading soybean counties. Average farm yields typically run one-third higher than the state average. Yields at the Waseca station are also high: increased from the 30 bushel per acre range in the early 1940s to above 50 bushels per acre in the late 1970s. Part of the increase in station yields during the 1970s, in addition to the effect of varieties and cultural practices, was the result of improvements in the drainage resulting from retiling.

Farm-average yields in Waseca County have increased somewhat more rapidly than station yields. In the early 1940s, farm-average yields were only half as high as the best station yields. By the late 1970s, farm-average yields were 70 to 75 percent as high as the best station yields. There is still, however, a very substantial lag between the best station and average farm yields. Today's average yields in Waseca County farms were being achieved by the Waseca station some 25 years ago.

Figure 3. Relationship between West Central experiment station, Morris, and Stevens County farm yield of soybeans—1944-1979

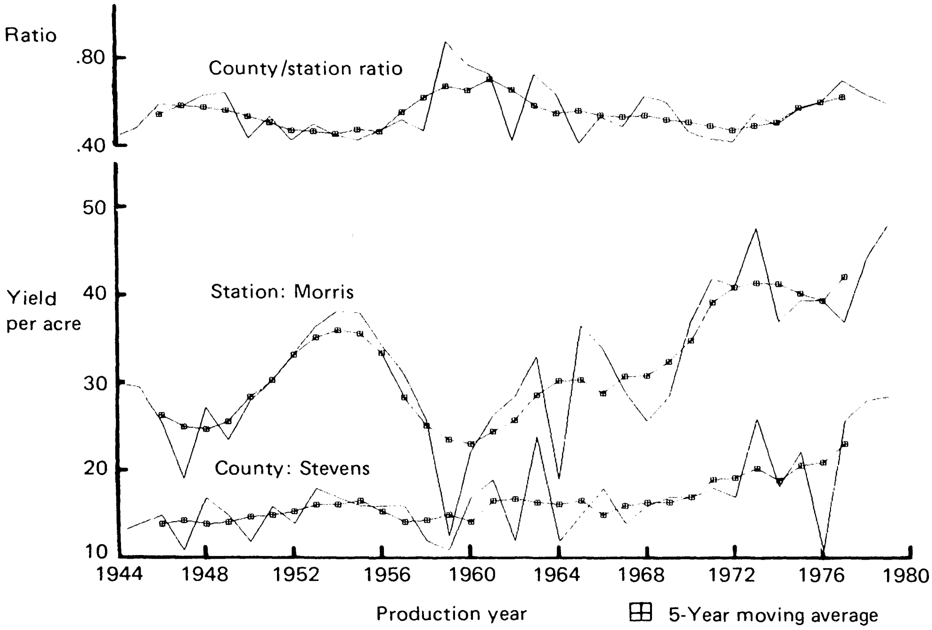
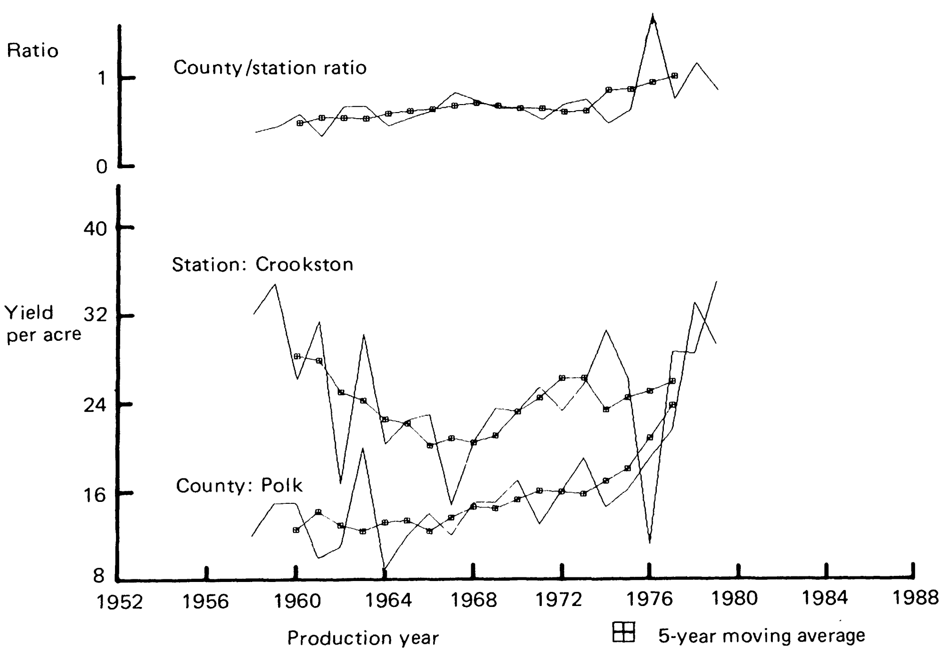


Figure 4. Relationship between Northwest experiment station, Crookston, and Polk County farm yield of soybeans—1958-1979



Source for figures 1-4: (1) County data are from *Minnesota Agricultural Statistics* (USDA-Minnesota Department of Agriculture, St. Paul, annual issues). (2) Station data are from *Results of Cooperative Uniform Soybean Tests,* Northern States (USDA Regional Soybean Laboratory, Urbana, Illinois, annual issues). Yield data are averages for five varieties with highest yield in specific group trials.

Stevens County and the Morris station in *west central Minnesota* is a much less favorable environment for soybean production because of weather variations. Yields in Stevens County run well below the state average but have gradually risen from the 10 bushel per acre range in the early 1940s to the 20 bushel per acre range in the late 1970s. While Stevens County yields have risen rather steadily, yields at the Morris station have fluctuated. The sharp decline in yields on that station in the late 1950s was apparently due in part to a shift in the location of the soybean plots. For a few years it was necessary to move the trial plots off the station. Rapid gains were achieved during the 1960s and early 1970s; however, these gains were not maintained after the mid-1970s.

The gap between average Stevens County farm yields and the best Morris station yields has remained wider—except in the early 1960s—than the gap between Waseca County and the Waseca station. In the late 1970s county average yields were only 50 to 60 percent that of station yields.

Polk County, in *northwestern Minnesota,* site of the Crookston station, is on the extreme northern margin for soybean production in Minnesota. Soybean production is concentrated in southern Polk County. Farm level yields there run about the same range as in Stevens County. The Crookston station is located beyond the northern perimeter of successful soybean technology in Minnesota. The station is now devoting considerable effort to understanding the cultural requirements for soybeans in the heavy clay soils of the northern part of the Red River Valley.

Soybean acreage is declining along the northern range of the crop's adaptability area in Minnesota. Between 1953-57 and 1963-68 soybean acreage in northwest Minnesota increased from 63,000 to 119,000 acres.[2] By 1973-77 soybean acreage had declined to 47,000 acres. In northwestern Minnesota, soybeans appear to be less competitive with other crops, particularly wheat and sunflowers, than 10 years ago.

Are Higher Yields Feasible?

Two factors account for the gap between farm and experiment station yields. One factor is that the yield level at which profits are highest is always lower than the maximum possible yield. The second is that there is always a delay between the availability and the adoption of even highly profitable technologies. The importance of these two factors in accounting for the yield gaps in figures 2-4 is not yet measured.

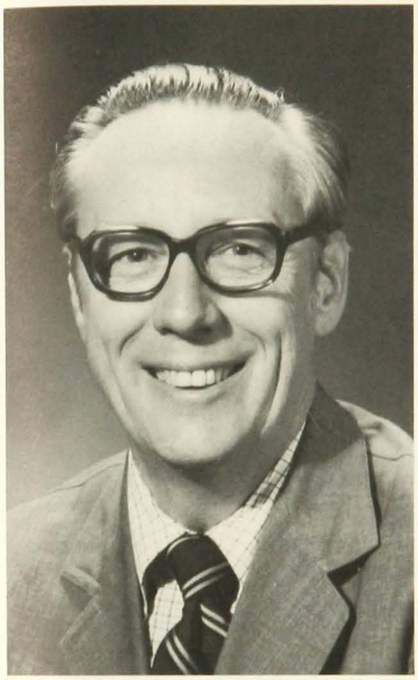
The data plotted in the three figures do imply considerable optimism regard-

[2]Philip M. Raup, "The Northward Movement of Corn and Soybeans," *Minnesota Farm Business Notes* 477 (December 1962) pp. 2 and 3, and *1969 U.S. Census of Agriculture.*

ing future yield levels. Clearly there remains a very substantial gap between average farm yields and the yields obtained from the best varieties at the Waseca and Morris stations. The Waseca County average farm yields are running approximately 25 years behind the best station yields. In Stevens County, farm yields are running roughly 30 years behind station yields. Furthermore, station yields, particularly at Waseca, are currently rising at a more rapid rate than in earlier years.

The high yields obtained by individual farmers is a second reason for optimism. In the 1978 and 1979 Minnesota Soybean Growers Yield contest, substantial numbers of soybean growers experienced yields above 50 bushels per acre and several achieved yields above 60 bushels per acre. Corsoy was the variety that dominated the high yields in 1978. However, a number of newer varieties was among those with the highest yields in 1979. Although 30-inch row width dominated, an increasing number of high yields was obtained with rows in the 6- to 15-inch range.

Even if station yields should begin to slow again in the 1980s in a repeat of the period from the mid-1950s to the mid-1960s, it is not unreasonable to expect that county and state average yields could continue upward for some time.



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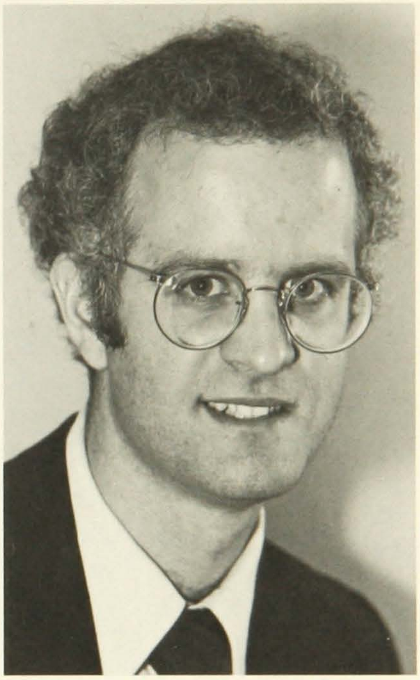

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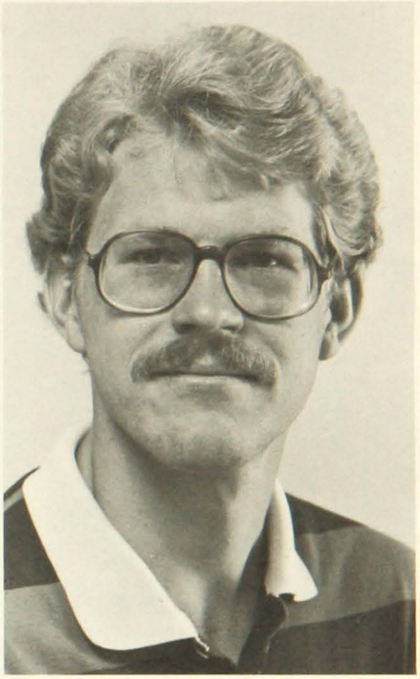

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