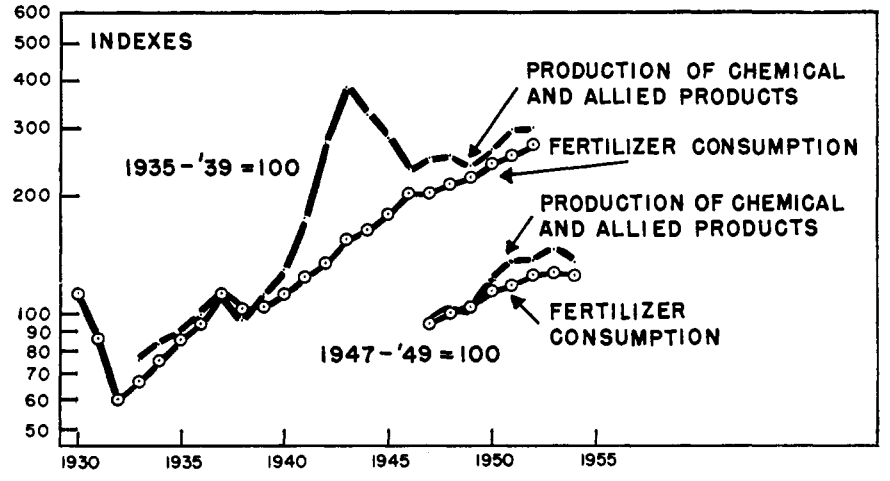

Figure 1. Comparison of trends of fertilizer consumption with chemical and allied industrial production—1930–54

Notes.

1. The base year of the Index of Chemical and Allied Industrial Production was changed from 1935–39 to 1947–49 in recent years. Therefore, to show the trends through 1954 both indexes were used. The Index of Fertilizer Consumption has been computed on a 1935–39 and on a 1947–49 base period.
2. Fertilizer consumption excludes secondary and minor-element fertilizer and liming materials, but includes government-distributed fertilizer from 1936.
3. 1954 data are estimates.

Sources.

1. Federal Reserve System, *Federal Reserve Bulletin*, December 1953, November 1954.
2. National Fertilizer Association, *National Fertilizer Review*, April-May-June 1954.

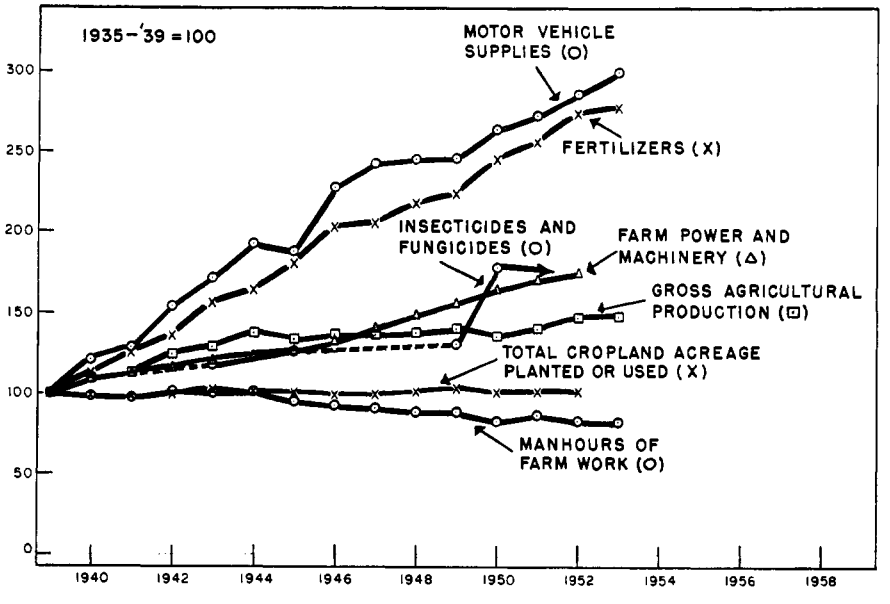

Figure 2. Agricultural production and purchases of chemicals and machinery—index comparison

Notes.

1. No index of insecticides and fungicides has been reported by the Department of Agriculture since 1950. However, the drop from 1951 through 1953 is well substantiated and the arrow shown on the graph is meant to represent this drop. As reported by the Tariff Commission, the consumption of synthetic organic insecticides dropped from about 247 million pounds in 1951 to 198 million pounds in 1953. Acyclic fungicides and seed disinfectants increased in consumption from 13 million pounds in 1951 to 49 million pounds in 1953, while cyclic fungicides and seed disinfectants dropped from 43 to 38 million pounds over the same period. Hence, the total of synthetic organic insecticides and fungicides (including seed disinfectants) consumption fell from 302 million pounds in 1951 to 285 million pounds in 1953. No comparable data are available prior to 1951 from the same source.
2. All purchased goods are expressed in terms of physical volume.
3. "Gross Agricultural Production" includes production for farm consumption and for market sale.
4. "Man-Hours of Farm Work" is total manhours of farm work in terms of the time which would be required by an average adult male worker.

Sources.

1. "Raw Materials in the United States Economy," 1900–1952, Working Paper 1, Preliminary, Bureau of the Census (data for 1919–52).
2. "Major Uses of Land in the United States," Technical Bulletin 1082, Bureau of Agricultural Economics (data for 1919–51).
3. "Farm Income Situation," FIS-149, Agricultural Marketing Service (data for 1940–53).
4. "Farm Cost Situation," FCS-16, Agricultural Research Service (data for 1940–53).
5. "Agricultural Statistics," 1953, U. S. Dept. of Agriculture (data for 1939–52).
6. *National Fertilizer Review*, April-May-June 1954 (data for 1919–53).

ECONOMIC

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THE CHEMICAL INDUSTRY has secured a sizable market in agriculture during the last 30 years and is now selling about 5% of its total output to agriculture as commercial fertilizers. Trends in fertilizer consumption and production of chemicals and allied products are shown in Figure 1. It is of interest to examine some of the factors that have a bearing on the nature and growth of this important market for chemicals.

Growth and Stability of Fertilizer Use

Commercial fertilizers have become an increasingly important factor in agriculture. Fertilizers are indispensable for the maintenance of soil fertility, while farm productivity and income are both clearly dependent on fertilizer use. Fertilizers have grown from a $292 million business in 1929 to nearly $1 billion in 1953.

In 1920, with a total cropland acreage of 402 million acres, about 5 million short tons of fertilizers were used (excluding secondary and minor element fertilizers and liming materials but including Government-distributed fertilizers from 1936). A substantial acreage at that time received no commercial fertilizers. In 1950, with only about 7 million more acres of cropland, fertilizer use was at about 18 million short tons—an increase of 360%, while acreage increased less than 2%. Out of this total cropland area of 409 million acres, a much larger proportion is fertilized now than in 1920, while the rates of application have increased measurably in many areas. The index of farm crop production over this period increased from 95 in 1920 to 178 in 1950—an increase of 87%. Except for the small increase in cropland acreage this increase in crop production is largely a result of increasing crop yields per acre. Many other factors may contribute to rising crop yields, such as irrigation, better drainage, better seed and management, insect control, and mechanization; but

ANALYSIS OF FERTILIZER CONSUMPTION

The fertilizer purchase trend has departed from its historically close relationship to farm income variations. SRI economists point out factors useful in short-run and long-run forecasting and emphasize the importance of regional as well as national data in such forecasts.

the use of commercial fertilizers is probably the most responsible single factor for increased yields per acre. The relationship of farm purchases of machinery, insecticides, fungicides, and fertilizers is shown in Figure 2.

Large amounts of fertilizer will continue to be required to support high yields per acre if the expanding population of the United States is to have adequate food commensurate with a high standard of living. Farmers will continue to use fertilizers to maintain productivity of their farms and especially to compensate for rising costs of production as well as rising costs of commodities and services they purchase. Over the long term, how much fertilizer farmers will use depends on the supply and demand for agricultural products. This is reflected in the price they can expect to receive for crops, restrictions on acreage, labor and other costs, and therefore ultimately on farm income. A farmer can afford to buy as much fertilizer as can be justified economically; that is, the increase in yield afforded by fertilizer use must result in income in excess of the cost of the fertilizer applied to the soil. Determination of these limits is beyond the scope of this paper; however, studies by the staff of the "Chemical Economics Handbook" reveal important relationships that may be useful in evaluating the effect of farm income on fertilizer use.

Trends in U. S. Fertilizer Consumption

Several factors other than farm income, such as acreage under cultivation and total farm output, etc., are related to fertilizer use, but the easiest and most accessible measurable factor is some type of farm income. Two simple types of farm income—cash farm income and farm purchasing power—have been selected for examination here.

The first type of farm income to be considered is cash farm income, which is approximately equivalent to farm sales. This includes marketing receipts from livestock and livestock products, crops,

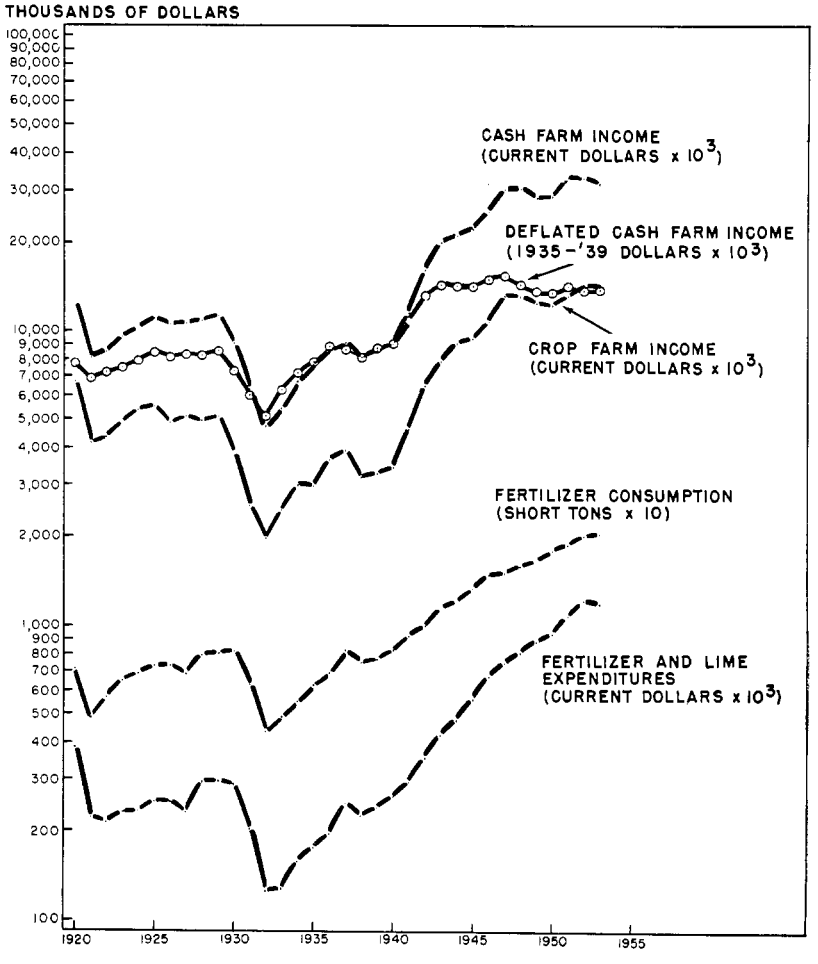


Figure 3. United States fertilizer use compared with farm income—1920–53

Notes.

1. Cash Farm Income includes marketing receipts from crops livestock and livestock products, and government payments.
2. Crop Farm Income includes marketing receipts from crops only.
3. Deflated Cash Farm Income constitutes cash farm income deflated by a price index (1935–39 = 100) of all foods and services used in production. This is a measurement of farm purchasing power.
4. Fertilizer consumption excludes secondary and minor-element fertilizers and liming materials, but it includes government-distributed fertilizers from 1936–53.

Sources.

1. U. S. Dept. of Agriculture, Bureau of Agricultural Economics, "Cash Receipts and Value of Home Consumption by States," 1924–51.
2. U. S. Dept. of Agriculture, Agricultural Marketing Service, "Farm Income Situation," FIS-148, FIS-149, and FIS-150.
3. U. S. Dept. of Agriculture, Bureau of Agricultural Economics, "The Farm Cost Situation," FCS-15.
4. National Fertilizer Association, *National Fertilizer Review*, April-May-June 1954.

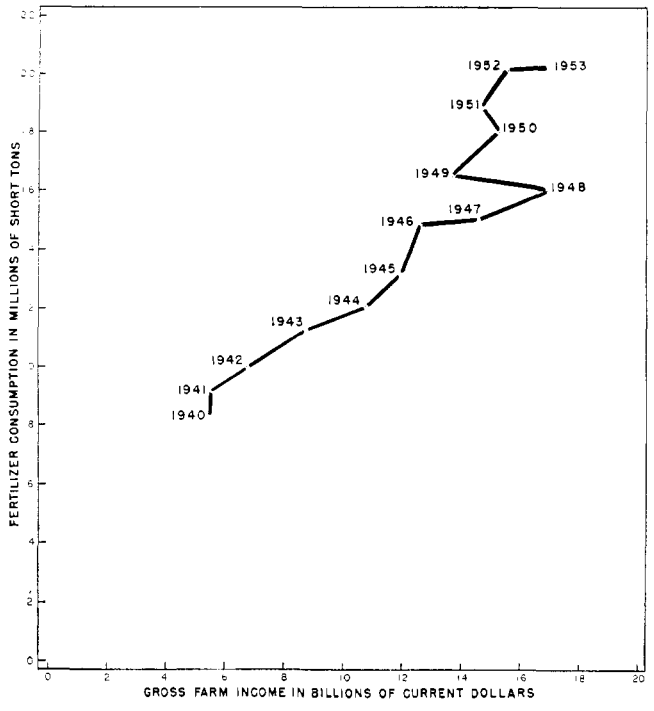


Figure 4. Fertilizer consumption related to gross farm income of the previous year—1940–53

Notes.
1. Gross Farm Income includes marketing receipts from crops, livestock and livestock products, government payments, and value of farm products consumed on farms.
2. Years represent data for the amount of fertilizer consumed in each given year and gross farm income for the previous year.
3. Fertilizer Consumption excludes secondary and minor-element fertilizer and liming materials. It includes government-distributed fertilizers from 1936.

Sources. Same as Figure 3

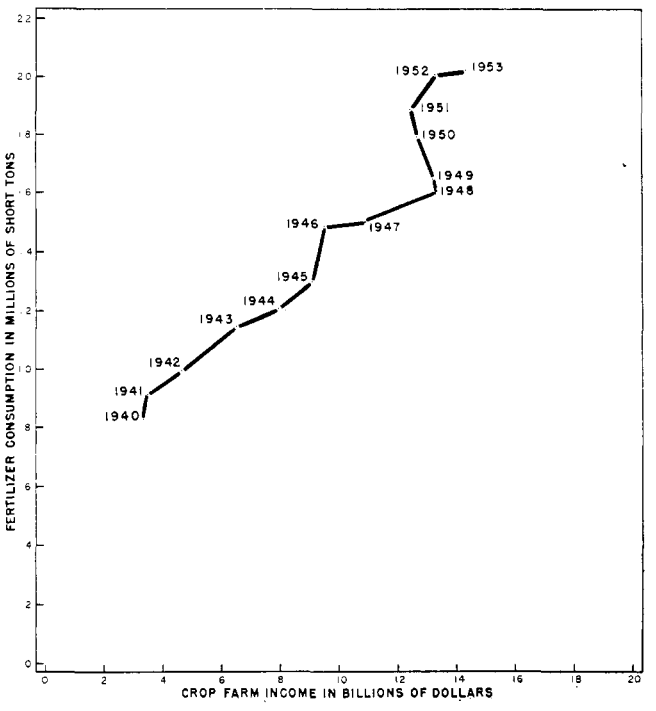


Figure 5. Fertilizer consumption related to crop farm income of the previous year—1940–53

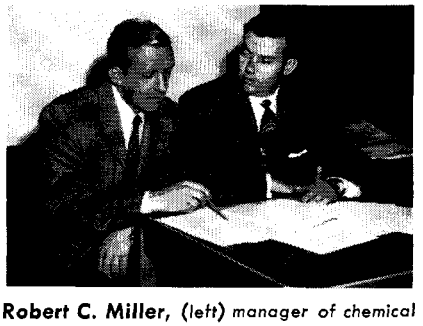
Notes.
1. Crop Farm Income includes marketing receipts from crops only.
2. Years represent data for the amount of fertilizer consumed in each given year and Crop Farm Income for the previous year.
3. Fertilizer Consumption excludes secondary and minor-element fertilizers and liming materials, but includes government-distributed fertilizer from 1936.

and Government payments. Crop farm income includes marketing receipts from crops only.

The second type of income is deflated cash farm income, which consists of cash farm income deflated by a price index of all goods and services used in production, and constitutes a measurement of farmers' purchasing power. In Figure 3 farm income is shown along with fertilizer use (including lime) in terms of short tons and dollar expenditures.

Figure 3 illustrates that the growth rate in fertilizer use and expenditures began to slow down in 1946 and 1947, while cash and crop farm income began to level off from 1947 to 1948, and began to drop from 1948 to 1949. The Korean War gave a boost to farm income, but again from 1952 to 1953, cash and crop farm income began to fall off. An important factor in the lack of greater advance in fertilizer use in the World War II years was restricted use of nitrogen for agriculture due to munitions requirements. Fertilizer use in tons and in dollars continued to increase from 1947 to 1950, but at a decreasing rate. The Korean War also gave fertilizer use a boost until 1953 to 1954, when fertilizer use (in tons) dropped slightly, while dollar expenditures began to drop as early as 1952. There is a clear analogy in trends between declining cash and crop farm income and a declining rate of growth in fertilizer use. Figures 4 and 5 emphasize a deviation after 1948 from an almost straight-line relationship between fertilizer use in tons and cash crop farm income (includes crop and livestock receipts, Government payments, and value of farm products consumed on farms). However, these data and graphs alone cannot support the argument that fertilizer use tended to level off because cash or crop farm income decreased. The root of the argument is to be sought in the general downward trend of farm prices since 1948 (except for the Korean boom) and the continuing upward trend in prices of goods and services bought by farmers for production purposes. This phenomenon, often called "the price-cost squeeze," can be shown to exist by finding a measurement of farmers' purchasing power, which is an indication of the "real" value of cash income. As shown in Figure 3, farmers' purchasing power in 1935–39 dollars began to level off in 1943 and, except for the immediate postwar period of worldwide food shortages from 1945 through 1947 and the Korean War boom, continued to decline through 1954. Farm sales and farmers' purchasing power are two pertinent factors that influence fertilizer use and both must be considered since there is not necessarily an analogy in the short-run direction of their trends.

The tendency of fertilizer use to be in-

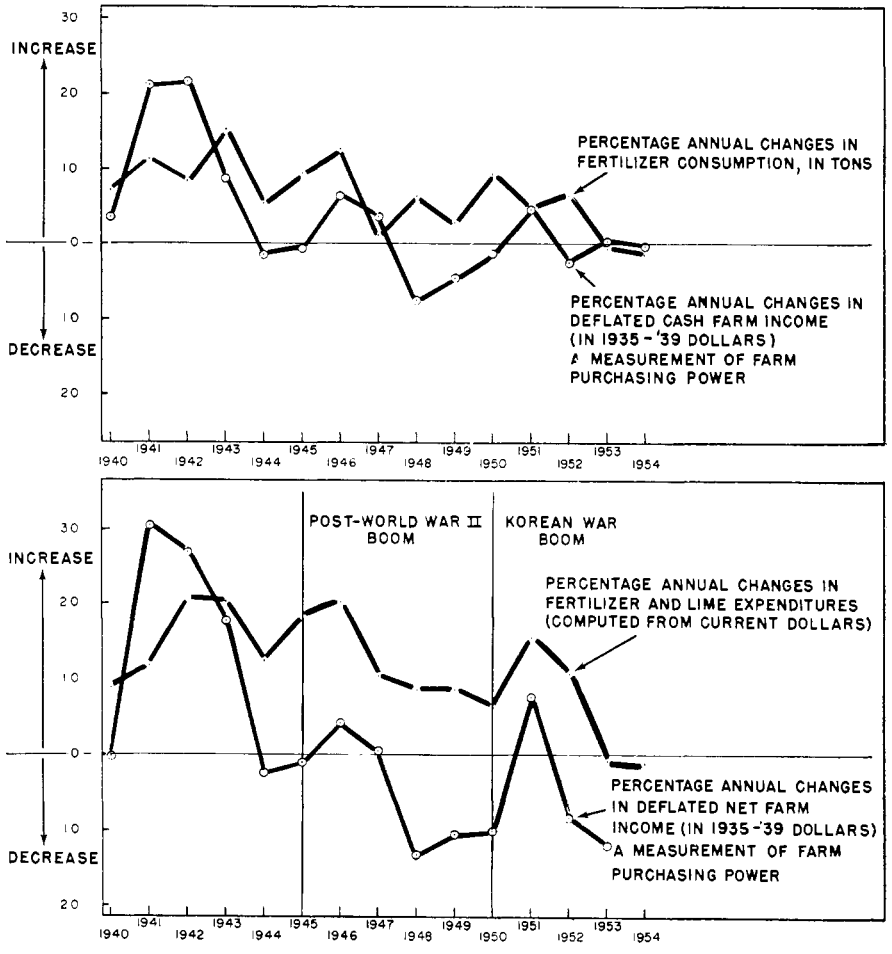


Robert C. Miller, *(left) manager of chemical* economic research at SRI, compiles and analyzes chemical economics data for publication in "Chemical Economics Handbook." A native of Nebraska, he took his degree in chemistry ot the University of Nebraska, did graduate work in chemistry and business administration at Stanford, and studied economics at the New School in New York. Discharged from the Army in 1946 as a captain (he entered in 1940 as a technical sergeant), Miller spent five years in sales and economic research for Shell Chemical in New York and San Francisco. He joined SRI in 1952.

A. Gerlof Homan came to this country in 1947, after receiving a diploma from the State College of Agriculture in The Netherlands. In 1945, he received an A. B. from Bethel College and in 1952 an M. S. in agricultural economics from Kansas State. He has been on the staff of the Food Research Institute at Stanford and is now completing predoctoral work in agricultural economics research, becoming a staff member of SRI in 1953.

fluenced partially by a persistent decline in farmers' purchasing power is shown in Figures 6 and 7. Two measurements have been calculated in terms of percentage annual changes from one year to the next. Percentage annual changes in deflated cash farm income and deflated net farm income (cash farm income minus production expenses) are used, and both are shown with percentage annual changes in fertilizer use in tons, and fertilizer and lime dollar expenditures. Except for the boom following World War II and the Korean War, the trends in this form also suggest the existence of a close relationship between fertilizer use and farmers' purchasing power. Figure 7, showing probably the best measurement of purchasing power in terms of deflated net farm income (net farm income is deflated by a price index of prices paid by farmers for family living items), most clearly indicates the analogy of the trends.

If this close relationship is true, then some sort of evaluation can be made for 1955 fertilizer use, given certain assumptions. Assuming that no armed conflict breaks out in 1955, farm income will probably drop slightly due to somewhat lower Government price supports of some important commodities. Farmers' purchasing power will probably change little in 1955, since a small drop in the general level of prices received by farmers may be offset by a small drop in prices paid by farmers for items used in production. If these conditions prevail through 1955, fertilizer use will probably also remain near the same level as in 1954 or perhaps decline slightly, assuming that prices of fertilizers remain basically unchanged from 1954 level. (Fertilizer prices have increased less than 60% since 1940 which is extremely moderate compared with prices of other farm supplies. See Figure 11.) If farmers do become "squeezed" tighter between prices received and costs of production than here anticipated, farmers' capital expenditures (items like heavy machinery, tractors, and buildings), may be expected to be postponed before any substantial cut in commercial fertilizer use is made. It is worthwhile noting that plant food nutrients per ton of fertilizer, taking an over-all average of nitrogenous, phosphorous, and potash fertilizers, have increased about 8 to 10% in the last 35 years. Thus a slight percentage decline in tonnage use does not necessarily reflect an absolute decrease in total plant food applied.



Figures 6 and 7. Farm purchasing power related to fertilizer consumption (in tons), and fertilizer and lime expenditures (in percentage annual changes)

Notes.
1. Figures 6 and 7 should be read as follows: Deflated Net Farm Income in 1950 was 10% less than in 1949, and in 1951 about 8% more than in 1950.
2. Deflated Cash Farm Income constitutes marketing receipts of livestock and livestock products and crops plus government payments deflated by a price index of all foods and services used in production.
3. Deflated Net Farm Income constitutes gross farm income minus all production expenses deflated by a price index of prices paid by farmers for family living items.
4. Fertilizer data exclude secondary and minor-element fertilizer and liming materials, but include government-distributed fertilizer from 1936.

Sources. Same as Figure 3

Factors Underlying Regional Growth in Fertilizer Use

A much-discussed and pertinent aspect of fertilizer use that is not revealed in studying national trends is the great diversity of regional and state consumption patterns. The levels of fertilizer use reflect in part the total fertilized acreage in the regions, and in part, rates of application. Figure 9 clearly demonstrates diversity in growth rates. On both Figures 8 and 9 the ratios show the average of the proportions in which the three principal nutrients have been consumed over the period 1947 through 1951.

The growth rates in fertilizer use among states differ because of a great variety of factors. The diversity in soils and climate explains in part the wide difference in the ratios. But it is more pertinent to examine closely some of the other factors that have significantly influenced the growth rates and with what assurance their effects can be expected to continue. California has been selected for evaluating such factors since this state contains many features pertinent to fertilizer use that are also applicable to other states. In evaluating fertilizer growth rates in other states the presence or absence of features characteristic of California must, of course, be taken into consideration.

In California, agriculture contributes about 13% of the state's real disposable income (marketing receipts only in constant 1952 dollars as a percentage of real disposable income payments). California's cash farm income consists of two main types: that from crops and that from livestock and livestock products. In 1952 and 1953 crop farm income contributed an average of 62.6%, and livestock and livestock products 37.4% of cash farm income. Tables I and II point out the great diversity of the make-up of farm income and the agricultural production pattern.

Some pertinent basic characteristics of California's agricultural production pattern are described below.

1. A wide range of agricultural commodities can be produced. Rice and barley are respectively semitropical and temperate-zone crops. In addition,

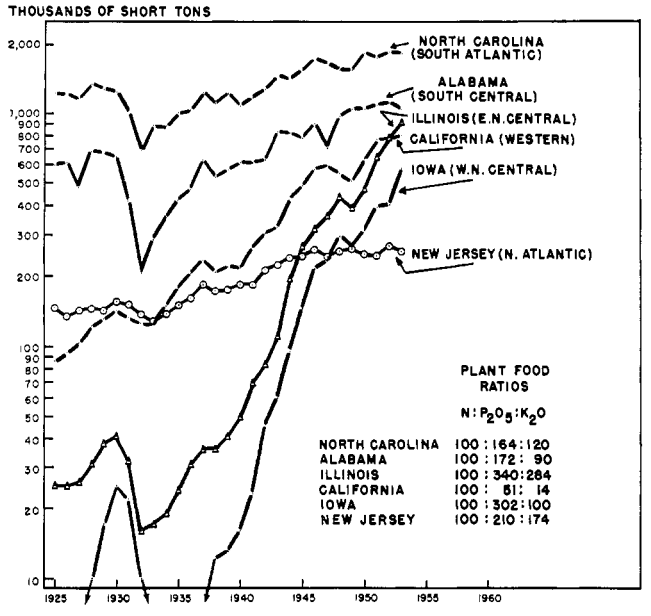


Figure 8. Total United States and regional fertilizer consumption and plant food ratios—1925–53

Notes.
1. Fertilizer excludes secondary and minor-element fertilizers and liming materials, but includes government-distributed fertilizers from 1936.
2. Plant Food Ratios constitute a five-year average 1947–51.

Sources. (Figs. 8 and 9).
1. U. S. Dept. of Agriculture, "Agricultural Statistics," Annual.
2. National Fertilizer Association, *National Fertilizer Review*, April-May-June 1954.

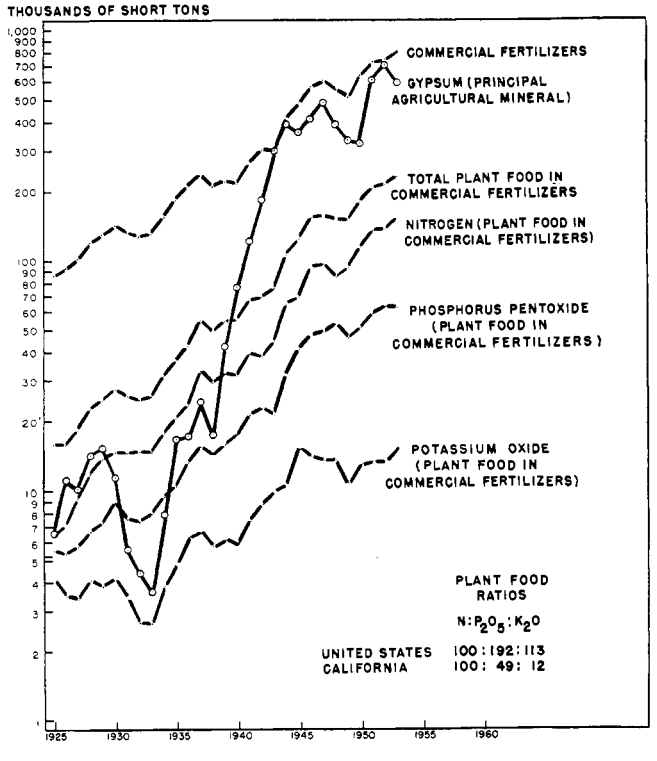


Figure 10. Trends of fertilizer use in California, and plant food ratios in California and the United States—1925–53

Notes.
1. Commercial Fertilizers for California include materials containing 5% or more of nitrogen, phosphorus pentoxide, or potassium oxide, as defined by the Bureau of Chemistry, State of California Dept. of Agriculture, "Fertilizing Materials," 1953.
2. Plant Food Ratios constitute 5-year average 1947–51.
3. Gypsum has been included to emphasize importance of agricultural minerals in California.

Sources.
1. State of California Dept. of Agriculture, Bureau of Chemistry, "Fertilizing Materials," 1953.
2. U. S. Dept. of Agriculture, "Agricultural Statistics," Annual.

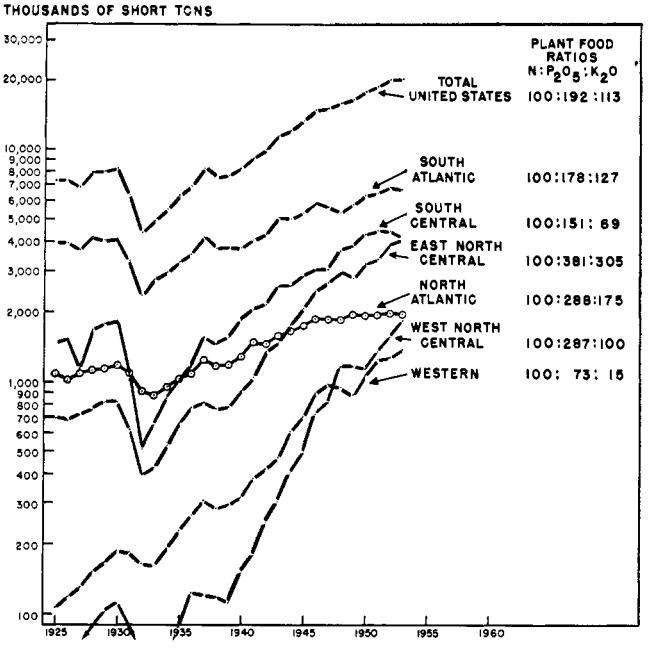


Figure 9. Fertilizer consumption and plant food ratios by states in the six state regions—1925–53

Notes.
1. States selected are from the regions given on Figure 7.
2. Fertilizer excludes secondary and minor-element fertilizers and liming materials, but includes government-distributed fertilizers from 1936.
3. Plant Food Ratios constitute a 5-year average 1947–51.

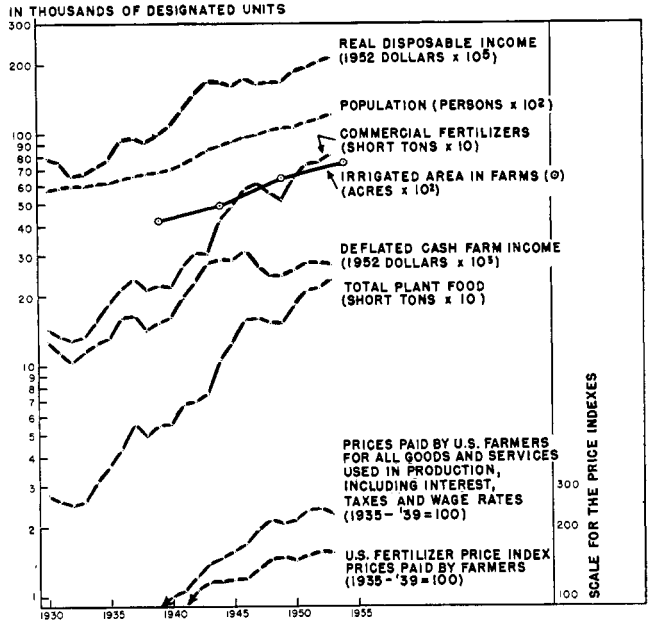


Figure 11. California: fertilizer consumption and selected related factors—1930–53

Notes.
1. Commercial Fertilizers for California include materials containing 5% or more of nitrogen, phosphorus pentoxide, or potassium oxide, as defined by the Bureau of Chemistry, State of California Dept. of Agriculture "Fertilizing Materials," 1953.
2. Deflated Cash Farm Income constitutes marketing receipts from livestock and livestock products and crops and government payments deflated by a United States price index of all goods and services used in production.
3. United States Fertilizer Price Index is shown to emphasize the very moderate price increases of fertilizers since 1940.

Sources.
1. Real Disposable Income computed by Stanford Research Institute from data of the U. S. Dept. of Commerce and U. S. Dept. of the Treasury.
2. Population data were obtained from State of California Dept. of Finance, Division of Budgets and Accounts.
3. State of California Dept. of Agriculture, Bureau of Chemistry, "Fertilizing Materials," 1953.
Sources 1,2,3, Figure 3; Source 2, Figure 2.

Table I. California Incomes From Principal Crops as Percentages of Crop Farm Income[a]

(1952–53 Average)

Fieldcrops	%	Fruits and Nuts	%	Other Products	%
Cotton	18.3	Grapes	6.4	Greenhouse and nursery	3.7
Hay	5.0	Oranges	4.5		
Lettuce	4.7	Peaches	2.9		
Tomatoes	4.4	Lemons	2.8		
Potatoes	4.2	Plums and prunes	2.7		
Barley	4.0				
Rice	3.8				
Cottonseed	2.6				
Dry edible beans	2.3				
Sugar beets	2.3				
Total	51.6	Total	19.3	Total	3.7
		Total principal crops	74.6		
		Other crops	25.4		
		Total all products	100.0		

[a] The average for 1952 and 1953 of marketing receipts only. From USDA Agricultural Marketing Service. "The Farm Income Situation," FIS-148.

Table II. California Incomes From Principal Livestock and Livestock Products as Percentages of Livestock Income

(1952–53 Average)

Livestock	%	Livestock Products	%
Cattle and calves	31.4	Dairy products	32.3
Turkeys	6.3	Eggs	14.6
Broilers	4.8		
Total	42.5	Total	46.9
Total principal livestock and livestock products			89.4
Other			10.6
Total all livestock and products			100.0

physical conditions permit a high degree of substitution among crops.

2. Although agricultural production is vulnerable to weather conditions, this is much less the case in California than in most other states because of the high percentage of farm land that is irrigated. Irrigated land is generally capable of producing higher yields with less risk than is nonirrigated land. Irrigated land also usually receives more fertilizer per acre than nonirrigated land. Irrigation projects under construction and those being planned suggest a continued rapid expansion of irrigated land in farms.

3. Rising per capita real incomes in the United States have induced people to demand more high-quality food products, especially meats, eggs, fancy fruits and nuts, and vegetables. California has, in addition to one of the fastest rising per capital real incomes in the United States, a rapidly increasing population. Thus both inside and outside this state one may expect an expanding market for many of the agricultural products grown in the state. If per capita real incomes in California as well as elsewhere in the country continue to rise, a uniquely favorable farm income position may be expected for the long run.

4. A continuing rise in per capita real income in California is dependent upon two factors—population growth and rate of industrialization. Population growth in California may be expected to continue at a relatively high level. A relatively rapid rate of industrialization in California can be expected to continue if national economic activity remains at high levels. Past trends seem to indicate that industrialization and development in California will tend to remain abreast of population growth and hence provide rising per capita real income.

With this broad view of California's economy and agriculture in mind, consider Figures 10 and 11, showing respectively the trends in fertilizer use in California, and the aforementioned factors related to fertilizer use. Of particular interest is the breakdown of commercial fertilizers shown on Figure 10. Since 1945, potash (potassium oxide) seems to have leveled off. Nitrogen and phosphates (phosphorous pentoxide) show a remarkable growth as well as a steady ratio in their use.

The factors that are closely associated with fertilizer use have been discussed above. Figure 11 shows some of these factors on the basis of which estimates can be made of the future use of fertilizers. For example, a statistical forecast could be made by means of a multiple correlation type of analysis, using some of these basic factors like real disposable income, deflated cash farm income, population, etc.

State data do not show the specific breakdown of commercial fertilizers included in the state totals. However, the general plant food data reveal some basic features in the composition of fertilizer use as shown in Figure 10. Every state or region also has very distinct features in this respect.

Table I shows a breakdown of the principal agricultural products in terms of marketing receipts. Table III ranks in decreasing order the principal fertilizer-using crops in terms of total consumption of the three main nutrients for California.

Several of the products listed in Table I appear again in Table III, indicating that some crops which loom big in terms of marketing receipts are also important fertilizer consumers. Maps showing the areas within the state where the principal fertilizer-consuming crops are grown may yield additional valuable information. In California, the main fertilizer-consuming areas are located in the irrigation districts. Where irrigation is expected to be brought in, fertilizer use may be expected to grow fast. Areas of high cash-yielding crops on irrigated land are usually excellent markets for fertilizers. The point is that every state or region has a unique pattern of economic growth, and the special characteristics must be brought out and examined in order to evaluate properly the strength of those factors that influence fertilizer use.

Table III. Ranking[a] of the Principal Plant Food–Consuming Crops, 1950[b] in California

	Nitrogen	Phosphorous Pentoxide	Potassium Oxide
1.	Oranges	Alfalfa hay	Lettuce
2.	Cotton	Irrigated pasture	Apricots
3.	Sugar beets	Lettuce	Oranges
4.	Barley	Sugar beets	Pears
5.	Potatoes	Cotton	Grapes
6.	Lemons	Oranges	Prunes
7.	Lettuce	Barley	Potatoes
8.	Grapes	Potatoes	Sugar beets

[a] The positions of the individual crops as they are ranked are not stable. This table emphasizes the recurrence of several crops in two or three of the columns. Such crops are significant consumers in terms of total tonnage as well as in one or more of the three principal nutrients.

[b] Martin, William E., *Plant Food Journal*, 7, 2, adapted from USDA, *Production and Marketing Administration Estimates for California, 1950.*