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Molecules WITH GREEN THUMBS

THE use of chemicals on the farm has culminated in an agricultural revolution of grand dimensions. Chemicals have helped solve two age-old problems of the farm. Supplying basic plant nutrients has required the supplementing of earlier methods with chemical fertilizers. Crop insects, diseases, and weeds were attacked with chemicals long ago, but the "miracle" pesticides have been a recent development.

Chemicals are important to Eighth District crops, especially cotton. Cotton farmers use great quantities of fertilizers, herbicides, and insecticides. Defoliants facilitate both hand and machine picking. And post-harvest use of chemicals strengthens the competitive position of the great natural fiber. These innovations add to the efficiency of district agriculture.

The entire story is not told alone in terms of the impact of chemistry on district agriculture. Industry is likewise affected as manufacturers develop new products, venture capital to produce them, and promote their acceptance by the farmer.

Further use of chemicals on the farm will increase crop production, free farm labor for other employment, and stimulate industrial development, with benefit to the economy of the district.

Federal Reserve Bank

of St. Louis

The use of chemicals on the farm has culminated in an agricultural revolution of grand dimensions.

ON A FAIR SUMMER DAY early-morning drivers through the Mississippi Delta may see small planes skimming the ground to spray a pungent mist over the cotton fields. This spectacle is one of the more dramatic signs of the coming of the chemical age to agriculture. While watching the air circus one may think that the use of chemicals is mainly confined to a few large farms which can afford to use planes or to a few narrow applications such as the control of certain insects. This would be far from the truth; actually, chemicals are used in nearly every type of farming, for hundreds of different purposes, in continuance of processes begun at least sixty-five years ago.

To nourish United States crops, to protect them from diseases, insects, and weeds, and to improve production efficiency, farmers are expending annually about $1.2 billion on commercial fertilizers, $35 million on lime, $300 million on pesticides, and $10 million on chemical defoliants. Some 7,000 airplanes and many thousands of earthbound machines are used to apply these chemicals. Evidently the agricultural chemical revolution has grand dimensions. How did it come about, and what does it mean?

Chemicals have helped solve two age-old problems of the farm.

From the time the first crude furrow was scratched with a pointed stick, man has struggled to coax more food and fiber from the earth. In this struggle he has always faced two basic problems—how to increase the supply of available plant nutrients, and how to protect crops from insects, disease, and weeds. In meeting these problems chemicals have become a powerful aid, supplementing or replacing methods developed long ago.

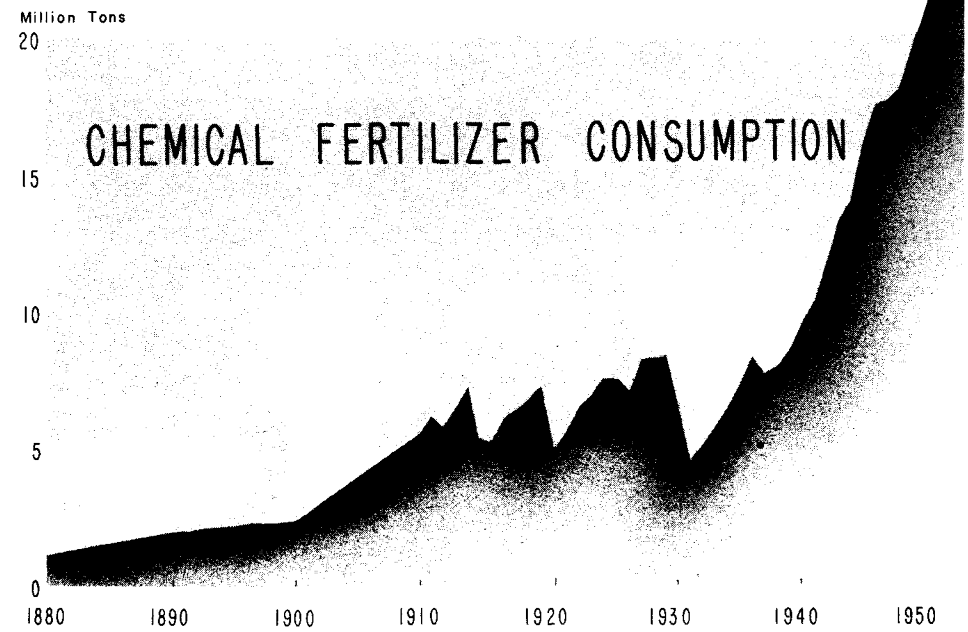
Supplying basic plant nutrients . . .

Early settlers in this country had little immediate cause for concern about nutrients removed from the soil by plants. As population increased, farming took more basic plant food elements from the soil and replenishing these elements became necessary.

The restoration of nutrients by rotation of crops and use of manures was begun early. From grammar school days we are familiar with the story of how the Indians taught the Pilgrims to put a fish under each hill of corn. Subsequently a more extensive practice has been the use of legumes for supplying nitrogen.

. . . has required the supplementing of earlier methods with chemical fertilizers.

The use of chemical fertilizers began about 1840, when German agricultural chemists scientifically demonstrated the value of enriching the soil with nitrogen, phosphorus, potash, and lime. In America these chemicals were applied in considerable amounts even before the turn of the century. In 1900 over two million tons of fertilizer were being applied annually. In 1951, for every 100 pounds of nitrogen removed from the soil by crops, 17 pounds were added in the form of chemical fertilizers. The ratios for phosphorus and potash were much higher —99 and 33, respectively. Thus, nearly one-half as much nutrient value is each year placed in the soil in the form of fertilizers as the harvested crops take from the soil. In 1953, about 23 million tons of commercial fertilizer and 20 million tons of lime were applied to United States farms.



Source: USDA, "Agricultural Statistics 1952"; "National Fertilizer Review," April-May-June, 1953, Oct.-Nov.-Dec., 1953; Commodity Stabilization Service, "The Fertilizer Situation for 1953-54," Nov., 1953

Crop insects, diseases, and weeds . . .

The undoing of man's work by insects has been recorded in legend and literature. One of the worst of a series of plagues visited upon Pharaoh was a plague of locusts which left behind ". . . not any green thing in the trees, or in the herbs of the field, through all the land of Egypt." Plant diseases, too, have had considerable influence on the history of the world's people. One outstanding example was the potato blight in Ireland in the 1840's which caused famine and mass emigration.

. . . were attacked with chemicals long ago, . . .

The employment of chemicals in the fight against insects and plant diseases has a long history, ranging back to the early use of pest-averting sulphur, which Homer mentioned (circa 1000 B.C.). About 900 A.D. the Chinese were using arsenic mixed with wine against garden pests. Paris Green, originally a coloring agent containing arsenic, became popular as an insecticide in this country about 1850.

In general, practically anything with an acrid or bitter taste and a pungent odor has been tried as an insecticide at some time or other. In addition to the mineral-based poisons mentioned above, several derived from plants are still in use. Among these are nicotine, which came into use about 1690, and pyrethrum, developed about 1851.

One of the earliest fungicides, and also one of the most interesting examples of accidental discovery, was Bordeaux Mixture, first applied to grapevines growing along the roadsides in France to discourage children and travelers from stealing the grapes. About 1880 Bordeaux Mixture became a staple remedy when it was discovered that vines treated with it resisted the downy mildew.

. . . but the "miracle" pesticides have been a recent development.

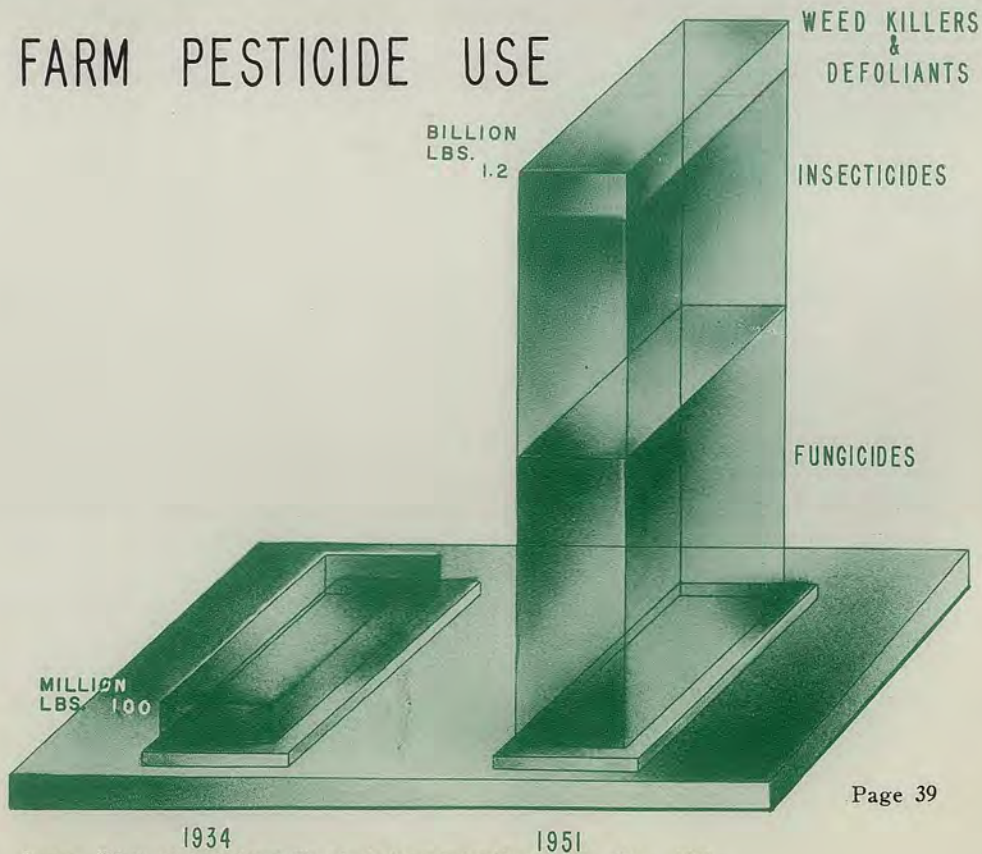
At the onset of World War II there was in common use a wide variety of effective insecticides, including such inorganic materials as calcium arsenate, lead arsenate, sulphur, cryolite, various copper compounds, and several organic poisons derived from plants, such as nicotine, rotenone, and pyrethrum. During the war DDT burst upon the world as a miracle insecticide. This extremely effective product is not the cure-all it at first appeared to be, but its success launched chemists into the exploration of thousands of related organic compounds. From the accelerated war and postwar search has come an array of chlorinated hydrocarbons, organic phosphorus compounds, and others, to give the farmer a better choice of insecticides than he has ever had before. Among the newest weapons are the systemic insecticides which are absorbed by plants, making the plants poisonous to insects for a considerable time.

Chemical weed killers and fungicides also date primarily from the war and post-war period. Newly developed selective weed killers make it possible to destroy grasses among broad-leaf plants and to kill broad-leaf weeds in grasses or grains. Fungicides are useful in seed treatment and for the protection of grains in storage.

Today farmers buy over a billion pounds of pesticides annually, including 600 million pounds of fungicides, 500 million pounds of insecticides, and 120 million pounds of weed killers and defoliants. Hundreds of new compounds are presently in the laboratory or experimental stage, and we have just touched the surface of potential application. Agricultural chemicals during the last decade showed faster production and consumption increases than any other group in the fast-growing chemical products field.

Chemicals are important to Eighth District crops, especially cotton.

The use of farm chemicals has a special significance in this district. Agriculture is a major source of income. In addition, the climate, soils and crops in this area are such that chemical requirements are high, especially in the growing of cotton.



Source: "National Agricultural Chemicals Association News," Mar.-Apr., 1952

Three factors make cotton, the big cash crop of this district, highly dependent upon chemicals. First, the cotton plant has been lush fare for hordes of insects, including boll weevils, bollworms, aphids, red spider-mites, thrips, and fleahoppers. The boll weevil alone reduces cotton yields from 5 to 30 per cent annually, and other insects gnaw, chew, and suck away another 3 to 4 per cent. Second, mineral requirements of the cotton plant are high, and erosion and leaching have reduced the natural chemical content of cotton-belt soils. Third, weed damage to cotton necessitated expensive control by hand chopping before the introduction of chemical weed killers.

Cotton farmers use great quantities of fertilizers, . . .

Planning for chemical fertilizer applications begins long before spring weather brings cotton planting time. Soil samples are tested chemically to determine nitrogen, phosphorus, and potassium requirements. Largely on the basis of these tests and recommendations of county agents, farmers determine what combinations and amounts of nutrients to apply. Approximately $45 million worth of fertilizer will be applied to district-state cotton acres this spring—and the volume has been increasing over the years.

. . . herbicides, . . .

Chemical weed control starts before the weeds have even raised their heads. In 1952 pre-emergence sprays such as the carbamates and dinitro compounds were used on 300,000 acres, primarily in the Mississippi Delta from Southeas Missouri to the Gulf of Mexico. Yet as late as 1947 only 5,000 acres were so treated. Nor is pre-emergence chemical treatment the whole story of chemical weed control in cotton. Post-emergence herbicides make some weeds literally grow themselves to death.

. . . and insecticides.

The chemicals used to control weeds are supplemented by other chemical weapons in the struggle against insects and diseases. Insect losses cost district-state cotton farmers from $40 to $190 million annually, the primary culprit being the boll weevil, which as late as 1950 reduced district yields by 20 per cent. And even today the plaintive *Boll Weevil Song* can be heard in the South lamenting the destruction and hardship caused by prolific, persistent, tough, and voracious Mr. Boll Weevil.

In former one-crop days, when cotton grew right up to the porches of the farmers' cabins, a boll weevil invasion was as much of a disaster as a plague of locusts. When the cotton was lost, all was lost. Diversification and insect-control measures have reduced risk, but the sight of Mr. Boll Weevil investigating a tender young plant can still send chills down a planter's spine. And justifiably so—insect and disease losses in 1950 exceeded 1952 drouth damage to cotton by 60 per cent.

For some notion of the amount of ammunition used in the battle, consider these figures. In 1951, the nation's cotton crop, 30 per cent of which was grown in district states, required 20 per cent of the DDT used in that year, as well as 66 per cent of the BHC, 69 per cent of the calcium arsenate, 32 per cent of the parathion, 30 per cent of the TEPP, and 94 per cent of the combined use of aldrin, chlordane, dieldrin, heptachlor, and toxaphene.

Defoliants facilitate both hand and machine picking.

Having chemically nurtured his crop to maturity, the modern cotton farmer does not yet put aside the products of the test tube. Before picking cotton it is desirable to get the leaves out of the way. Chemicals in the form of defoliation applications, offered by at least a dozen manufacturers, facilitate hand-picking and are a practical necessity for mechanical cotton harvesting. In addition, use of defoliants reduces infestation by boll weevils, aphids, and leafworms. Defoliation chemicals were applied to 10 to 15 per cent of the 1953 cotton acreage.

And post-harvest use of chemicals strengthens the competitive position of the great natnral fiber.

The use of chemicals in the production of the cotton fiber does not cease even upon harvesting. Extensive research is being conducted in the use of chemical processes for making cotton fabrics rot-proof, fire-proof and more durable, and for giving them other qualities which will help cotton in the competition with synthetic fibers.

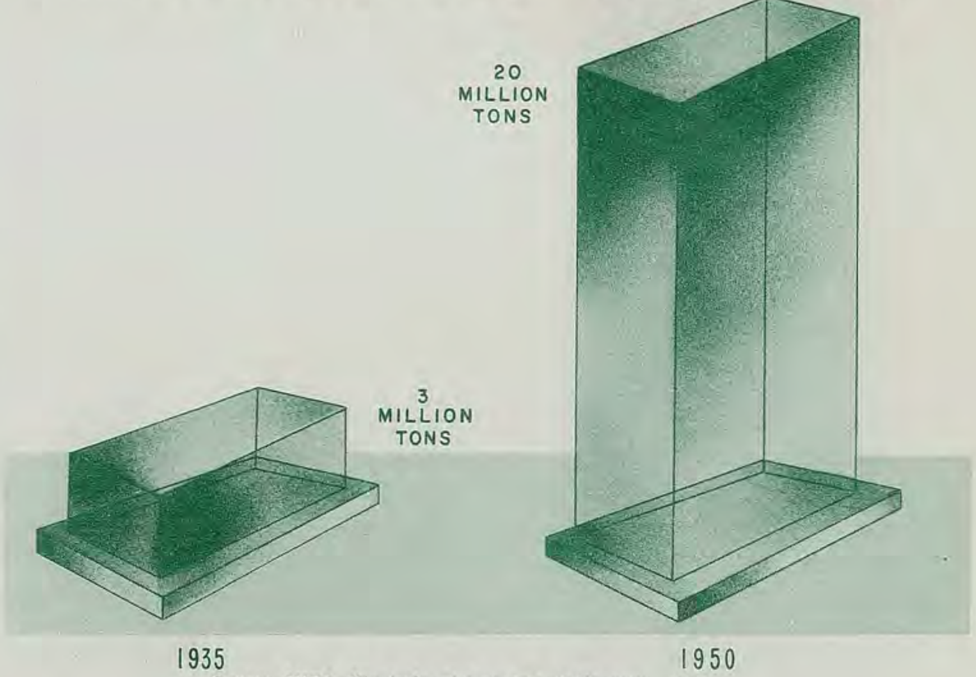
These innovations add to the efficiency of district agriculture.

Insect and disease control, plus additional fertilizer applications, could more than double cotton yields on individual farms and do it with less labor.

In our district we thus have an example of a farm crop, the efficient production of which is highly dependent on the ability of industry and farmers to work together in the application of chemicals to agriculture. The ability of the two to work step-by-step together is complicated by the rapid growth in use of chemicals, by the variety of existing compounds presently available, and by the fact that still other chemicals are coming out of laboratories at a staggering rate.

AGRICULTURAL LIME CONSUMPTION

AGRICULTURAL lime is essential to efficient crop production in areas where the soil is "sour." The application of lime to farm land has increased at a rapid rate in the last two decades. From a rate of one million tons during the low income year of 1933, lime consumption for agricultural purposes increased to three million tons in 1935. Later, war-time demand for increased food production created pressure for greater lime outturn. As a result, production quadrupled from 1938-39 to 1947. By mid-century 20 million tons were being applied annually to farm land in the United States.



Source: USDA, "Agricultural Statistics 1937"; ibid., 1952

The entire story is not told alone in terms of the impact of chemistry on district agriculture. Industry is likewise affected . . .

On the industrial side of the agricultural chemicals revolution most all of the major chemical companies are active, and many of them have facilities in this district. Petroleum refiners and rubber companies too are represented. These manufacturers combine a relatively small number of basic building blocks, such as air, water, natural gas, sulphur, salt, and other minerals, to produce part of virtually every commodity consumed in this country. The agricultural market for chemicals has influenced the selection of products offered by the chemical industry and has been a major inducement for industry expansion. In turn, the industry has done much to shape the market by finding new uses for chemicals on the farm. These cross-effects provide a good example of the interdependence of the sectors of our economy.

. . . as manufacturers develop new products, . . .

Some idea of the complexity of the job of product development may be gained from considering one of the new insecticides, chlordane, a chlorinated hydrocarbon formed by treating hydrocarbons—in this case derived from coal tar—with chlorine. If this process sounds simple, try reading the full chemical name of the compound, 1, 2, 4, 5, 6, 7, 8, 8—octachloro—2, 3, 3a, 4, 7, 7a—hexahydro—4, 7—methanoindene. This complicated compound is one of the few commercially successful products brought to market out of thousands of similar ones synthesized and tested in the laboratories. A promising compound is put through years of tests in laboratory, plant, and field to find out what its properties are, how it can be produced, and how it should be used. To bring a single new insecticide to market may cost a million dollars or more.

. . . venture capital to produce them, . . .

The chemical industry has been making large investments in capacity to produce chemicals for the farm. The expansion in synthetic ammonia capacity provides a good illustration. Approximately three-quarters of the ammonia produced is used in agriculture to supply nitrogen. Ammonia production in the United States has increased from 480,000 tons in 1939 to an estimated 2,523,000 tons in 1953, and further expansion is under way.[1] *The Oil and Gas Journal* estimates that construction of ammonia plants based upon natural gas or petroleum by-product hydrogen will cost about $250 million in 1953-54, of which over $40 million will be spent in Eighth District states.[2]

. . . and promote their acceptance by the farmer.

Costs of research and promotion, and the large investment in plants and equipment required for large-scale production, limit much of the agricultural chemicals business to large firms, but there is a vital place for small firms as formulators. A formulator buys active ingredients of farm chemicals from a large producer and mixes them with

[1] "The Big Squeeze," *Chemical Week*, December 19, 1953.
[2] John C. Reidel "A Look at Round 2 of NH_3 Expansion," *The Oil and Gas Journal*, March 8, 1954.

dusts, solvents, or emulsifiers to put them in the form the farmer needs. Such processing is complicated because each of the chemicals can be applied in a variety of ways, each suitable under a certain set of conditions. The formulator knows the peculiarities of the crops and soils of his territory and can prepare exactly the right combinations. In practice he becomes a combination manufacturer, wholesaler, and retailer, providing essential services for the original manufacturers and the farmer.

Further use of chemicals on the farm will increase crop production, . . .

Largely through increased use of chemicals, the potential growth in agricultural production is tremendous. It has been estimated by a cooperative committee from Land Grant Colleges and the United States Department of Agriculture that, under certain assumptions, including a parity ratio as favorable as that of 1951, farmers would increase total farm output about 20 per cent within five years.[3] A 70 per cent increase in fertilizer application would play the major role in such a growth. The 40 per cent increase in United States agricultural production between 1935-39 and 1951 was brought about with only slightly more crop acreage, 14 per cent less labor, 70 per cent more power and machinery, and 230 per cent more fertilizer.

The greatest increase in production would likely take place in the South, where both recent research and farm testing indicate large increases in output from such improved practices as heavy nitrogen fertilization of corn and pasture improvement for year-round grazing. Total farm output in the South would be more than one-fourth greater, compared with a 16 per cent increase in the North Central states.

Even the production increases just suggested do not indicate maximum yields that could result from full adoption of known improvement practices. The per acre yields of major district crops could be increased two to five times more than the twenty per cent estimated above.

Weed control is a familiar problem to anyone who has been on the business end of a hoe. Today weed control can be done chemically with one per cent as much labor as was formerly required by hand methods. Pre-emergence and post-emergence weed control is being introduced as a replacement for the tedious, even though mechanized, process of slowly and carefully cultivating young corn plants. Thus, the devastation from weeds which, together with that of insects and fungi, reduces corn production from 100 to 400 million bushels per year can be largely prevented by the application of modern chemical practices.

It is thus reasonable to expect a 50 per cent increase in corn yields by elimination of losses caused by weeds, insects, and fungi. Chiefly by increased use of chemicals, yields of pastures in rotation could be nearly doubled, soybean yields increased 41 per cent, and those of tobacco 24 per cent, and hay 56 per cent. As evidence of rapid progress in farm mechanization over the past quarter century becomes more apparent on district farms, "chemicalization," another phenomenal development in food and fiber production, takes the spotlight position.

. . . free farm labor for other employment, . . .

By reducing the amount of labor required, mechanization has been steadily improving the efficiency of cotton production, and it presently appears that use of chemicals will assure a continuation of the trend. It has been estimated that improvements in cotton production practices will reduce United States farm labor requirements by 450,000 workers during the next decade, more than one-fourth of the estimated reduction to take place in district states.[4] Thus approximately one-third of the total farm reduction of 1.5 million is expected to occur in the cotton states and district states may expect to share substantially in the migration from farms.

. . . and stimulate industrial development. . . .

The movement of people released from farm employment by the increasing use of chemicals and other changes in farm technology will be at the same time a problem and an opportunity. The problem will be to ease the transfer of these people to other occupations with a minimum of unemployment and under-employment. Opportunity will lie in expanding district industrial employment with the aid of these new hands. The ability to supply labor for industrial expansion when and where needed is one of the important locational advantages of the district.

In addition to increasing the supply of labor for general industrial growth, the agricultural chemical revolution will have a special impact on district chemical manufacturing. A direct impact will be an expansion of farm chemical manufacturing to supply the expanding farm market. An indirect impact will be the growth of other chemical plants which can supply the agricultural chemical plants or use some of their products.

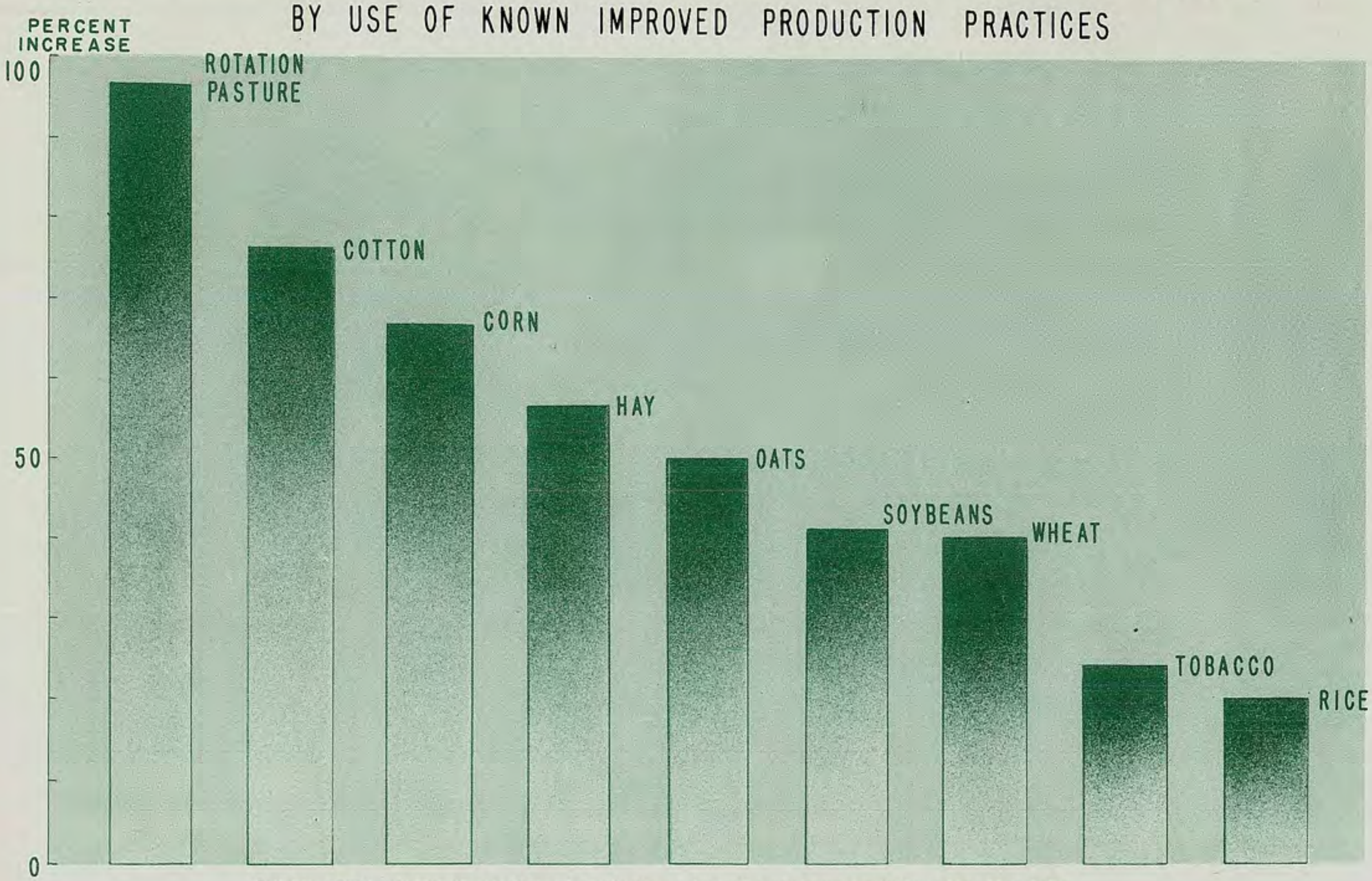
The farm market for chemicals is capable of great growth. Between 1940-44 and 1950 the farm

3 *Agriculture's Capacity to Produce,* Agriculture Information Bulletin No. 88, United States Department of Agriculture, 1952.

4 *Manpower, Chemistry and Agriculture,* Committee on Labor and Public Welfare, United States Senate, Washington D. C., 1952.

POTENTIAL DISTRICT CROP YIELD INCREASES

BY USE OF KNOWN IMPROVED PRODUCTION PRACTICES



Source: USDA, "Agriculture's Capacity to Produce, Agriculture Information Bulletin No. 88," 1952

use of nitrogen in district states quadrupled, phosphorus use doubled, and the consumption of potash increased roughly three and one-half times. Since application of these chemicals is still well below the optimum, it is safe to assume that their use should increase sharply in the future. The attraction of such a market is obvious.

Expansion of the markets for other farm chemicals may be expected, too. For example, defoliant chemicals were applied to from 10 to 15 per cent of the 1953 cotton acreage. Assuming an application of 25 pounds per acre, there is a potential market for over 100 million pounds of chemical defoliants for cotton in district states, to say nothing of the potential market provided by about 8 million soybean acres.

Any expansion in district production of agricultural chemicals may well attract plants which manufacture other chemicals, because chemical plants have a tendency to link together in complex networks in order to utilize each other's products. Ammonia, for example, is primarily used for fertilizer, but it also has many non-farm uses. The 28 per cent of national production in 1953 which was not used on farms went into military uses, industrial explosives, chemicals, plastics, textiles, and other uses. District-state ammonia producers, who had about 18 per cent of the nation's capacity in place or under construction at the end of 1953, will probably attract some non-farm customers as they grow or develop some nonagricultural uses for part of the ammonia themselves.

Chlorine is another example of a chemical with a great number of agricultural and industrial uses. Some district chlorine producers are primarily manufacturers of heavy chemicals who process some of their chlorine into insecticides, or sell some of it to insecticide makers. Others are primarily insecticide manufacturers who produce chlorine as a step in making their principal product. The byproducts, hydrogen and caustic soda, flow into industrial use. For example, hydrogen is piped by one Memphis insecticide plant directly to nearby manufacturers of shortening products, and caustic soda is used in alumina refining, a major industrial operation near Benton—Bauxite, Arkansas, and East St. Louis, Illinois.

with benefit to the economy of the district.

Production and use of farm chemicals thus help to knit together the agricultural and industrial sectors of our district economy. Continuation of the agricultural chemical revolution will further increase efficiency and productivity in agriculture, and industrial development will be facilitated by the growth in the market for agricultural chemicals as well as by the freeing of resources from farms. Both these avenues of progress will contribute to the growth and welfare of the Eighth District and of the nation.

LAWRENCE E. KREIDER
A. JAMES MEIGS