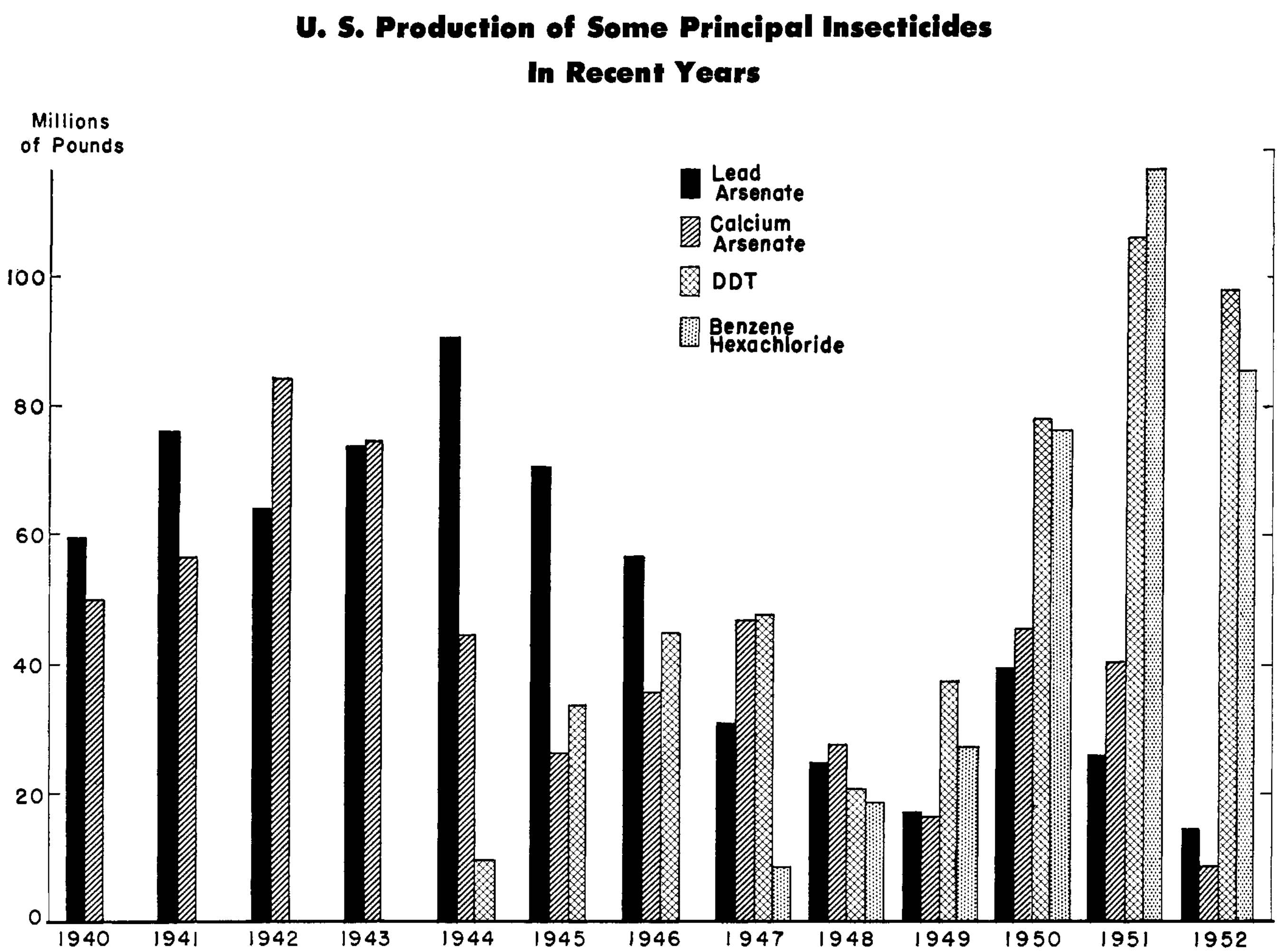

Figure 1. The trend in production of lead arsenate and calcium arsenate has been downward since the introduction of DDT and benzene hexachloride, two major representatives of the newer synthetic organic insecticides

What's the Status of Agricultural Chemicals?

The agricultural chemicals industry, producing insecticides, fungicides, weed killers, rodenticides, and related products, has grown at a remarkable rate since World War II. Such rapid growth, the omnipresent complications of weather, and increasing government regulations produce a very complex situation which can change quickly and is sensitive to a host of conditions. The influence of this industry and its products is felt from one end of the food production chain to the other. Thus, an up-to-date review of the status of the industry is important. From a well-informed view, trends are summarized. The Editors of AG & FOOD, during recent weeks, have gone to leaders of the industry for their views. The current picture is presented against a background of history of the industry and the association which serves it.

Trends in Production and Consumption Of Pesticidal Chemicals

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DURING MOST OF THE 19TH CENTURY, agricultural efficiency in the United States was relatively low. Most people lived and worked on farms and so there was little lack of farm labor. As agricultural machinery was developed, farm efficiency increased. A trend toward fewer workers on farms became evident, coincident with the rapid industrial growth of the country. About 72% of the population in 1820 worked in agriculture, but the proportion in 1950 was only about 15%. Our present standard of living would have been impossible without this development of farm machinery. Within the next few years the use of agricultural chemicals, even now just beginning in many fields, should advance as rapidly as has the use of machines since 1850.

It should be remembered that the present acreage of cultivated land cannot be increased greatly. Our population is growing by more than 2 million persons per year, and production must be increased to feed these additional mouths. While much can be gained by improved fertilization and by better breeds or varieties of crops and animals, spectacular gains in food production and conservation can be made also by the development and adoption of chemicals for many purposes throughout agriculture. This is a real challenge to science and technology.

Pesticides are those agricultural chemicals which are used as insecticides, fungicides, herbicides (weed killers), and rodenticides. Certain other materials, such as crop defoliants and hormone fruit sprays, are usually considered to belong to the same class of materials because of their similarity with respect to chemical properties and methods of application.

Most pesticidal chemicals, especially the newer ones, must be mixed or processed into suitable formulations of different strengths, combinations, and physical characteristics, before they can be applied by farmers for various specific purposes. Undiluted, they could not be applied thinly enough, and their physical properties—because they are usually coarse or sticky solids or viscous liquids—make them unsuited for direct application. The technical chemicals, therefore, have no practical value as pesticides until they have been processed into forms suitable for application.

Vast changes have occurred during the last 10 years or so in the kinds and quantities of chemicals used as pesticides by the farmers of the United States. At the end of World War II those materials in general use were mostly inorganic chemicals, such as lead arsenate, calcium arsenate, and copper compounds, as well as botanical products such as rotenone, pyrethrum, nicotine, and red squill. Beginning about 1945, the pattern of consumption underwent a radical change (Figure 1).

The quantity of pesticidal chemicals, exclusive of accessory materials such as diluents, solvents, and emulsifiers, estimated to have been used in 1935 was somewhat in excess of 215 million pounds. By 1944 the consumption of these chemicals is believed to have grown to about 513 million pounds. During the period from 1944 to the present time, at least 25 major pesticidal compounds not previously available commercially, to say nothing of many lesser ones, were introduced and accepted widely (Table I). The quantity of pesticidal chemicals, including sulfur and copper sulfate, estimated to have been used on farms in 1951 was about 1229 million pounds. Consumption in 1952 was considerably lower than in 1951. It is the consensus of the industry that in 1953 consumption will be appreciably higher than in 1952 although not approaching the 1951 figure.

Harold H. Shepard has been pesticide staff specialist for USDA's Office of Materials and Facilities since 1950 and is greatly responsible for the annual review called "The Pesticide Situation" which is so valuable to the agricultural chemicals industry. Dr. Shepard first came to the Department of Agriculture in 1946 to take charge of the insecticide testing laboratory at Beltsville. Before that he was assistant professor of entomology at the University of Minnesota and later associate professor at Cornell. During the war he put in two years of government service with the War Food Administration.

The actual amount of a material absorbed by the domestic economy within a given past period can be calculated, if suitable data on production, producers' stocks, imports, and exports are all available. Some of such figures, thus calculated from more or less complete data, are shown in Table II under the term of "domestic disappearance." Pesticidal chemicals, however, must pass through numerous processing and merchandising operations carried out by different persons or companies. In any one season, there will be consumed, in addition to current production, some of the material which entered the "pipeline" the previous year. Some supplies unused at the end of the season will remain in the channels of trade until the next year or even longer before being used.

Variation in Pipeline Stocks Not Known

No practical method is known by which to obtain reliable information regarding variations in pipeline stocks. These stocks may be inventories of the basic chemicals in the hands of formulators or of ready-mixed pesticides held by formulators, dealers, or growers. It is believed generally true that growers seldom hold large supplies, and many dealers return their unsold stocks to the wholesaler at the end of the season. Data showing disappearance at the level of the chemical manufacturer, therefore, do not reflect the wide variations in pipeline stocks that often occur. For this reason they should not be considered as a precise measure of actual consumption by growers, though they are extremely useful in such studies.

Data showing actual consumption in the field are scattered and for many areas are entirely lacking. The reliability of estimates by persons in touch with control operations in the field depends largely upon personal interest in such data. Often these persons are official extension specialists whose chief responsibility is in methods of control rather than consumption statistics. The Production and Marketing Administration, U. S. Department of Agriculture, made surveys in 1951 and in 1952 to obtain usage estimates arrived at by a group of field specialists in each state. The results of these surveys in general checked surprisingly well with other information.

Affecting individual state estimates of pesticide consumption is the fact that these are made by different methods according to the amount and quality of the

Table I. Some Pesticidal Chemicals Introduced Commercially Since 1944[a]

Aldrin	Ethyl-*p*-nitrophenylthionobenzene phosphonate (EPN)
Allethrin	Heptachlor
"Aramite"	Isopropylphenylcarbamate (IPC)
Benzene hexachloride, gamma	Malathon
Captan	Methoxychlor
Chlordan	Parathion
Chloroisopropylphenylcarbamate (CIPC)	Piperonyl butoxide
Chlorophenylchlorobenzene sulfone	Schradan
Chlorophenyldimethylurea (CMU)	Sodium 2,4-dichlorophenoxyethyl sulfate
Dichlorodiphenyldichloroethane (TDE)	Sodium trichloroacetate (TCA)
Dichlorodiphenyltrichloroethane (DDT)	Demeton (in Systox)
2,4-Dichlorophenoxyacetic acid (2,4-D)	Tetraethyl pyrophosphate (TEPP)
Dieldrin	Toxaphene
Endrin	2,4,5-Trichlorophenoxyacetic acid (2,4,5-T)
Ethylene dibromide	Warfarin

[a] Other compounds fully as important as some of these have been omitted without prejudice.

information available in the particular state. Furthermore, field experts are often not familiar with the volume of these chemicals used in agricultural processing industries—true of pyrethrum and other materials used in household types of mixtures. Affecting such estimates likewise is the fact that often agricultural pesticides are put also to nonagricultural uses (for example, DDT for the control of disease-carrying insects when used by public health agencies). When the estimates for all the states are combined, individual errors are for the most part cancelled.

Estimates of Usage Shifts Most Valuable

State estimates do not provide merely a check on disappearance data calculated from industry and foreign trade figures. Estimates from the consuming areas often supply information about the volume of chemicals used for which production data cannot be obtained directly. Perhaps most valuable are the state estimates of expected shifts in usage for the approaching growing season—figures which have formed a reliable basis for estimating national agricultural requirements. Also of much value are the patterns of distribution of usage that can be developed from the data furnished by the states.

It can be seen from Figure 1 that the production of either lead arsenate or calcium arsenate prior to 1945 was of the same order of magnitude as present-day production of leading synthetic organic insecticides such as DDT and benzene hexachloride. It will be recalled that the arsenicals must be used at relatively high strength or even undiluted, while such compounds as DDT are so potent that one pound will go as far in killing insects as several pounds of an arsenical. The present consumption of insecticides, therefore, has increased enormously in terms of units of potency. This trend is well shown by the producers' sales value of the basic pesticidal chemicals produced. In 1940, this figure was about $35 million, while by 1951 it had risen to about $195 million. These figures, however, have not been adjusted for changing purchasing power of the dollar.

The volume of materials sold to growers for pest control has been affected greatly by the necessity for the newer chemicals to be processed commercially into forms ready for use. Failure to control insects and other pests would result if farmers were to attempt by themselves to dilute the technical grades of synthetic organic compounds to make dusting powders or emulsion concentrates. The individual farmer cannot cope with the technical difficulties of choosing and obtaining diluents and other additives adapted to usage in specific types of mixtures. He cannot afford the large equipment necessary for grinding and blending the ingredients of the mixtures he must use. In Table III are given data from the U. S. Bureau of Mines showing the growth in usage of some of the more important diluents employed in manufacturing dusting powders for pest control.

The manufacture of emulsion concentrates for use where liquid sprays are needed has increased in much the same way as the preparation of ready-mixed dusts. These concentrates are liquid mixtures containing emulsifying agents so formulated as to mix readily with water. A rough estimate of the quantity of emulsifiers so used is 10 million pounds. Figures for emulsion concentrates, used on cotton in three states where spraying this crop has become most general, are shown in Table IV. These indicate not only the growth of the use of spray emulsions but also the effect of drouth in that area upon insecticide consumption in 1952.

Application of chemicals for pest control on some types of crops is fairly uniform and predictable. This is true particularly of fruit crops where definite spray schedules are planned in advance of the growing season. In contrast is the cotton crop which can support a certain amount of boll weevil infestation without undergoing serious loss and which may suffer severely over large areas only in seasons when weather conditions favor development of this insect. The demand for cotton insecticides, therefore, is extremely variable. This fact is disturbing to the insecticide industry which must be prepared to meet a heavy demand occurring over a period of a few weeks while knowing that an unpredictable dry spell may result in a reduction of those infestations upon which its business depends. Incomplete data indicate that consumption of cotton insecticides, both dusts and sprays expressed in field-strength dust equivalent, was about 550 million pounds in 1950 and 850 million pounds in 1951. Consumption of these materials fell off markedly in 1952 but is expected to rise again moderately in 1953.

At the present time interest in chemicals to control spider mites is active. These tiny creatures, related to spiders and ticks, often develop in increased numbers following the use of organic

Table II. Domestic Disappearance of Some Major Pesticidal Chemicals During Recent Crop Years[a]

Pesticide	*1950 Pounds*	*1951 Pounds*	*1952 Pounds*
Benzene hexachloride, gamma basis	8,549,000	9,600,000	11,100,000
Calcium arsenate	38,842,000	39,588,000	4,735,000
Copper sulfate[b]	124,573,000	122,449,000	110,097,000
2,4-D (acid basis)	17,600,000	23,494,000	25,298,000
DDT	57,638,000	72,688,000	70,074,000
Lead arsenate	27,490,000	30,174,000	17,452,000
Parathion	2,551,000	4,670,000	4,500,000
Sulfur, ground[c]	540,000,000	400,000,000	310,000,000
2,4,5-T (acid basis)	small	2,822,000	2,937,000

[a] The crop year is considered to be the period from Oct. 1 of one calendar year to the following Sept. 30. Production and export figures for a particular month are not available until six weeks to three months later.
[b] All domestic uses, including plant nutrient as well as a wide variety of other small industrial and other uses; 1950 and 1951 figures are on a calendar year basis.
[c] Calendar year basis.

chlorinated compounds such as DDT. Formerly, when lead arsenate spray schedules for apple orchards were followed, spider mite infestations were usually of minor importance. Several synthetic acaricides (miticides) of commercial significance are now on the market and others are being developed. They are generally more effective and may be less injurious to the crop than ground sulfur, formerly the standard miticide. Synthetic miticides, furthermore, can be incorporated in emulsion concentrate formulations, while sulfur cannot.

It is known that certain species of insects and mites are becoming resistant on a wide scale to particular chemicals. Some leading insecticides now in use are gradually losing their value for the control of such pests. This is a factor favoring some types of chemicals and particularly certain methods of application.

A number of synthetic organic fungicides have become available in recent years. Most of these are more effective for certain specific uses than sulfur or copper fungicides and, in some cases, are effective against plant diseases not controlled satisfactorily by any of the older fungicides. The adverse effects of the synthetic organic fungicides upon plant life generally are mild. They are not so damaging as elemental sulfur and the copper fungicides. Another important use of synthetic organic fungicides is in the treatment of seeds and seed beds as a protection against fungi which infect the soil or are carried on the seeds and which destroy the young plant during germination or cause damping-off after the young plant starts to grow.

Chemicals that control weeds and other unwanted plant growths have come into widespread use during recent years. This development has resulted in the reclamation of much idle land which had been rendered practically useless by weeds, and has increased the productivity of many additional acres. Chemical weed killers, being relatively simple to apply, have freed millions of man hours of labor for other productive work. Chemical control of weeds has become a recognized procedure in modern farming.

Sodium chlorate is a highly effective general weed killer for use in situations where it is desired to kill all plant growth. It is also important as a cotton defoliant which does not require dew formation in order to be active. Under normal conditions, approximately two thirds of the total output of sodium chlorate is used for weed killing operations and for defoliation of cotton. Sodium chlorate was in general use as a weed killer for a number of years before the introduction of 2,4-D and other synthetic organic weed killers. The expanding use of the newer weed killers, however, has not affected the trend toward increased use of sodium chlorate.

Table III. Quantities of Some Materials Used in Manufacturing Dusting Powders for Pest Control

Year	Talc, Pyrophyllite and Ground Soapstone (Short tons)	Fuller's Earth (Short Tons)	Kaolin (Short Tons)
1941	10,479	(not available)	(not available)
1944	21,454	" "	" "
1945	37,012	" "	" "
1946	64,954	5,558	19,305
1947	66,952	12,940	11,602
1948	72,700	18,749	15,950
1949	61,100	37,342	14,956
1950	77,000	69,928	41,346
1951	90,418	86,339	40,000
1952		(Figures not yet available)	

Source: U. S. Bureau of Mines, "Minerals Yearbook" series.

The organic herbicide industry has grown rapidly, yet it is a relatively youthful business. Fundamental information is still not available to answer many serious problems in the practical use of these materials on an extensive scale. If these potent chemicals were to be recommended for field application without adequate data, crops grown on the treated land might suffer severe injury.

Defoliant chemicals are now used regularly to remove the leaves from plants, especially from cotton, or to destroy the foliage of potatoes, castor beans, and some other crops. Defoliation with some such compound as calcium cyanamide or sodium chlorate is an accepted practice on about 2 million acres of cotton. In many areas it would be impossible to operate mechanical pickers if the plants were not defoliated. The increased use of such machines will make necessary more extensive use of defoliant chemicals. Defoliation of cotton at the proper stage of maturity is reported to be at least as effective as an application of insecticide in reducing boll weevil infestation by removing much of the opportunity for insect harborage. Compared to the total acreage of cotton which could be profitably defoliated, this practice has hardly scratched the surface with respect to this important crop. Destruction of the foliage of potatoes, castor beans, and certain other crops is necessary to force the crop to mature and otherwise to facilitate harvest operations. The trend on crops other than cotton is not so clearly defined, only a beginning having been made in this field.

Table IV. Consumption of Emulsifiable Spray Concentrates on Cotton in Texas, Louisiana, and Mississippi

Year	Texas (Gallons)	Louisiana (Gallons)	Mississippi (Gallons)
1949	28,631	27,943	no data
1950	3,091,123	145,370	983,000
1951	8,674,975	435,400	946,363
1952	3,228,142	211,026	683,438

Source: State Agricultural Extension Services.

Growth Regulation No Longer Limited to Weed Control

Plants, like animals, respond to synthetic hormones. Practical regulation of growth by plant hormones, furthermore, is not now limited to weed control by such materials as 2,4-D. A number of chemicals have the ability to change the life processes of plants in economically desirable directions. Certain synthetic plant hormones are used to delay flowering in areas subject to late frosts. Dinitro compounds are applied to thin blossoms of fruit trees which tend to produce too much fruit of poor quality. Fruit sprays containing naphthalene acetic acid are used to prevent abnormal and premature fruit drop. Other chemicals stimulate root formation, and still other compounds, such as maleic hydrazide, delay sprouting of potatoes and onions. The use of such specialty chemicals now results in savings amounting to millions of dollars each year, although we are a long way from applying synthetic plant hormones as generally in agriculture as we doubtless shall within a few years.

Although a significant quantity of chemicals for the control of rodents is sold annually in this country, the amount is relatively smaller than that of insecticides, fungicides, or weed killers. The principal rodenticides on the market today are warfarin, sodium fluoroacetate, red squill, zinc phosphide, and strychnine. A recent trend is the development of new compounds having anticoagulant properties similar to those possessed by warfarin. The use of rodenticides has public health aspects in addition to its economic importance in agriculture and industry.

Industry and Research Leaders See Strong Future Related to Need for Farm Efficiency

Anticipated Cotton Cutbacks, Farmer's Realization of Value Affect Outlook in The West

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President
California-Spray
Chemical Corp.
Richmond, Calif.

In the West it is evident that the pesticide material supply has been out of balance with the current year's demand. Oversupplies have resulted from a season of subnormal pest control problems. Low spring temperatures and other unusual weather conditions have been substantially responsible. Since inventories started high and were increased in contemplation of normal use, the supply has proved more than adequate and there will again be a carryover. Prices have been very low and the volume subnormal so that industry profits have suffered rather severely.

It is doubtful if policies of the new administration have had any marked effect on our industry as yet. Anticipated cutbacks on cotton and other acreage allotments may affect us next year. There will be some compensation if this acreage is planted to other crops. Volume of agricultural pesticide business has not yet shown the effects of a "farm price squeeze," if one exists in the West. Insect and plant disease prevalence has had a much greater effect on the volume of pesticide business than any change in the farmers' economy. Western farmers in general are well aware of the need and value obtained from pesticides. Barring a complete price debacle for a given crop, a grower can be expected to protect his investment from pest destruction.

The outlook for next year or any future year is uncertain. The volume depends on the extent of infestations which are unknown. Inventory carryovers and the cut in cotton acreage are bearish factors for 1954.

Good Selling Practices Can Give a Good Future

We look forward to a good year for agricultural chemicals in 1953–54. Of course, people in this industry always look forward to good years. You might call it chronic optimism. Actually, however, there have been no signs to date that there will be anything but a favorable year ahead.

One possibility is encouraging. The Department of Agriculture may place new limitations on the U. S. acreage devoted to farm crops. The more intensive use of farm land usually results in the increased use of fertilizers, insecticides, and other agricultural chemicals.

Paul Mayfield

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Department
Hercules Powder Co.
Wilmington, Del.

A major problem for the industry today is prices. The prices of many important agricultural chemicals are far too low. They will have to rise. There just isn't enough incentive to sell insecticides and weed killers unless profits can be increased. What manufacturer can make money selling DDT at its present price?

The recent declines in farm prices are bound to affect the agricultural chemicals industry. But what is obviously needed is a more effective, more dynamic program of selling chemicals to farmers. The job hasn't been done. Farmers today would be using substantially more agricultural chemicals if manufacturers made a really concerted selling effort.

Year Good on Tonnage, Poor on Profits

Ernest Hart

Executive
Vice President
Food Machinery and
Chemical Corp.
New York, N. Y.

The year in agricultural chemicals was satisfactory from the standpoint of tonnage consumption, but not so good as far as profits were concerned, due to competition and an unfavorable price structure. Pesticides are on an acreage-cost basis. If one volume leader such as DDT goes down in price, then many others will have to follow because they are competing for the same acre of use.

Overproduction is the basic underlying factor in this unsatisfactory situation. We have erected manufacturing capacity far in excess of any historical use of these materials.

The outlook for the agricultural chemicals industry is promising, notwithstanding, for the long term. The industry, as is well known, is undergoing what might be termed an "organic revolution," where synthetic products are replacing the older inorganics. As a result, some very promising new markets have been developed.

A few of the more interesting are soil fumigants and soil insecticides. Weed killers now include those which eradicate many types of weeds, products which are brush killers and those which eliminate weeds from plant rows, such as cotton, potatoes, carrots, beans, and the like. There are also compounds available for external parasitic control of animals.

Soil conditioners comprise a more recent development among the organics. Others meriting mention are defoliants which pave the way for the mechanical cotton picker or which provide potato maturity by top removal; chemicals for insect control of stored grain; hormones which allow for the chemical thinning of fruits or which enable them to stay on the tree until harvest; and the hormone-type materials which act as growth inhibitors. The better known and more powerful insecticides now provide us with controls against grasshopper and locust, the scourges of ancient civilizations.

The volume production of the farm chemicals in industry, as we can see, is going more and more into diversified fields. And in all this the large chemical companies are certain to figure prominently considering the use that is being made of their products in organic pesticides, and the facilities which they possess for scientific research.

Educational Programs in The Field Offer Important Possibilities for Larger Volume

Each year, as comparisons are made with the previous season, a progressive growth in the usage of synthetic insect toxicants is noted. This progressive

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Regenstein, Jr.

President
Velsicol Corp.
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growth is due to the acknowledgement of well established evidence that the correct usage of agricultural pesticides enables a grower to produce larger yields and better quality crops and, thus, to obtain a higher net return for his efforts. In addition, newly developed chemical products are brought on the commercial market following lengthy research and evaluation programs. The goals of the insecticide industry are in the direction of the development of technological advances which will improve the productivity of the farmer and which will provide the consumer with more nutritious and uncontaminated food stuffs.

We can anticipate increasing population with increasing food and fibre requirements, which will necessitate a better control of destructive insect pests. On the basis of this premise, a continuing growth in the usage of pesticide products is in prospect for the future.

In facing a possible surplus in agricultural crops, planting restrictions may be adopted which in turn will cause farmers to select their best land to obtain the highest possible net return. The currently declining prices of agricultural crops and the fixed costs of farming operations are placing a "cost-price" squeeze on the farmer. A partial solution can be higher crop productivity and prime quality crops which will command a higher market price. The correct use of chemical insecticide control agents will enable the farmer to reach these objectives.

The promotion of these ideas requires an extensive educational program and Velsicol is carrying on such a program through its own field entomologists. By acquainting and instructing the growers in the use of our products, we will enable them to use our pesticides profitably and thus to increase our sales volume.

Fewer Pests, Export Changes, Farm Buying Power Big Factors in Lower Demand

In recent months, there has been a considerable backup in supplies of such major agricultural chemicals as DDT, BHC, and 2,4-D. It's been a case of overproduction and underconsumption. Actually, many agricultural pests, such as the boll weevil and corn borer, haven't been too great a problem this year—with the result that the demand for insecticides in some major applications has fallen off considerably.

At the same time, we have seen the growing use of toxaphene, aldrin, dieldrin, and malathon. These newer materials are cutting into markets once held by DDT, BHC, lindane—particularly since many insects have developed considerable resistance to the older organic insecticides.

In the year immediately ahead, we expect a definite reorientation in the agricultural chemicals industry. Some mergers are likely. We certainly do not look for any real stability in the industry. It's a hectic business, as you know. The demand for agricultural chemicals depends on numerous unpredictables—rainfall, temperatures, insect infestations. A manufacturer may make a year's supply of an insecticide and then be forced to grit his teeth and hold over much of his output until the following year.

Harold Noble

Vice President
S. B. Penick & Co.
New York, N. Y.

Of course, there is a brighter side to the picture too. We see increasing use of agricultural chemicals on forage crops and on grasslands. More and more insecticides are being used in forest areas and in livestock sprays. All these trends are encouraging signs for the industry.

Even if we cannot expect price supports to remain at the same high levels as in the recent past, we can still expect the continuation of price supports. That means that U. S. farmers will definitely have the ability to continue their purchases of needed agricultural chemicals.

In view of the U. S. Government's program to rehabilitate Korea, we can actually expect even greater use of agricultural chemicals there than during the war. In the months ahead, we can look for more exports to Asia—not just to Korea but to Thailand, India, and elsewhere.

Speaking of exports, we have faced increasing difficulty in recent months in selling agricultural chemicals to Europe. Today, new agricultural chemicals plants are springing up in Germany, France, and in other countries. These new facilities are taking care of many of the requirements once met by U. S. manufacturers. Of course, the limited supply of dollars in many European nations is a big factor in this situation.

Ample Supplies and Dearth of Pests Slows Activity on West Coast

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Climatic conditions prevailing on the West Coast have had a very definite effect on the needs of agricultural pesticides during the early 1953 season. Heavy rains in the Northwest brought about a greater demand for fungicides, while cooler conditions in the South have not been particularly conducive to the development of the usual pests.

In general throughout the West Coast there have been, with few exceptions, very few major insect problems. Because of this situation, coupled with the conservative approach of the farmer this year, there has been particularly no advance buying of agricultural pesticides. In addition, there has been a tendency on the part of the insecticide formulator to keep his inventory at a minimum, with the result that manufacturers of basic chemicals are carrying heavy inventories. With very few exceptions, all raw materials utilized in the insecticide and fungicide field are in ample supply.

Because of this ample supply and the dearth of pests thus far in 1953 there has been the natural tendency toward price fluctuation, generally downward.

There is little indication that the government policy of the new administration has had any marked effect on the agricultural pesticide industry, since farmers on the Pacific Coast, at least, are fully cognizant of the value of pesticides in the growing of their crops. The use of pesticides has become a general farm practice.

The outlook for 1954 is as unpredictable as usual since this business is dependent on weather conditions which affect both crop and pest development.

One of the major markets for pesticides on the Pacific Coast, particularly in the South, is cotton; with the government policy of reduction in cotton acreage in 1954, it is only natural that there will be a reduction in pesticide tonnages.

Farmers' Business Sense Should Increase Use Of Agricultural Chemicals

A revolution in the agricultural industry during the past 15 years made the

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farmer a seasoned businessman who mechanized for labor efficiency. Next he looked for ways to increase productivity *per acre*. Agricultural chemicals have provided an answer. Fertilizers have increased crop yields, herbicides have intensified planting and simplified cultivation, and insecticides and fungicides have saved crops from biological attack.

Will the farmer change his buying habits because of his uncertainty of future farm prices? There is every indication that he will use a businessman's approach and try still harder to increase efficiency. He will use more concentrated fertilizers and more efficient pesticides if available. He is increasingly cost-conscious, but should not be expected to cut back on agricultural chemicals as these offer his greatest hope of paring production costs and sustaining a high level of profit.

Agricultural fungicides have been overshadowed by insecticides and fertilizers in the past, but current research should produce a succession of fungicides. Research on soil conditioners can also be expected to pay off. Even now, herbicide and insecticide research is producing a healthy flow of new and better products. New techniques of application should also develop to be adopted by the farmer just as he took up the application of anhydrous ammonia to the soil.

This season's demand has been mixed. Sales of DDT were better than in 1952, but still have been below expectations, primarily because the cotton crop has been late and hard hit by drought conditions. Parathion and some of the newer insecticides have been in good demand.

Herbicides generally have enjoyed a good season. The poor wheat crop in the Kansas area hurt the 2,4-D demand and drought conditions in Texas undoubtedly discouraged the mesquite control programs, in which 2,4,5-T had proved so effective. Otherwise, the herbicide picture was healthy.

It is still too early to say how the new administration's farm philosophy will affect the agricultural chemical picture. Reduced farm income, for example, might well hurt sales. On the other hand, acreage limitations, such as now imposed on cotton, might well encourage greater use of chemicals to increase per acre yields. Unless farm policy is changed drastically, weather will probably continue to be the dominant factor in agricultural chemicals.

Long term, the outlook for this industry is good. Our growing population imposes ever higher production goals.

Trend to Balanced Lines Seen in Diversified Products

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In the review of past achievements and the prediction of future objectives, it must be realized that insofar as our industry is concerned, potentials are radically influenced by the fantastic product development and research programs being sponsored by a large number of chemical manufacturers. As the result of these programs, a highly diversified group of chemicals is now available to manufacturers of agricultural insecticides, fungicides, weed killers, soil sterilents, plant hormones, nutrients, defoliants, fertilizers, and rodenticides—and to manufacturers of household sprays and powders, there have been developments which have increased the numbers and types of products beyond any expectation.

For many organizations the current year of 1953 has been regarded as highly successful, while others have complained of extremely poor results as compared to previous years. This contrast in reports can undoubtedly be traced to the emphasis these respective firms placed on specific end-products which historically are affected by numerous factors, including general economic and climatic conditions. While it is recognized that in certain instances firms are engaged in a highly specialized distribution pattern, there is fortunately a rapidly growing trend to expand their line of products in order to balance high volume, low profit products with a group of so-called specialty high profit products. Many manufacturers find that their sales organizations are perfectly capable of handling new products carrying high profit margins, without in the least affecting their efforts in selling their previously established line of commodities.

It is always gratifying to review the history of our industry prior to World War II in comparison with present day standards for this quickly portrays the tremendous expansion of production, distribution, and sales which has occurred in a relatively short period of time. The opportunities for the future are boundless and will be met by our industry, not with the assistance of controls, but in the true American tradition involving improved production techniques, research, development, and distribution.

Not Much Slackening of Demand Anticipated

J. W. Britton

Manager, Agricultural Chemicals, Dow Chemical Co. Midland, Mich.

Field performance of Dow agricultural chemicals in the past year has been very satisfactory but not perfect. Results in general have well justified their use. Volume of sales is up over last year; and in spite of lower prices, dollar volume is higher.

With regard to government policy, we are watching with interest the many areas which affect our business. Some, of course, have not yet become clear. We anticipate the possibility that new regulations and laws may increase research costs, delay development of new materials, and in general require industry to take time to adjust. We believe this will exert a long-term healthy effect on the agricultural chemical industry.

The farmer's changing economic picture seems to us to be making him a more critical buyer. A dollar he invests in production must yield him more than a dollar's return. This is good business sense at any time but many farmers are finding it more urgent now. To the extent that they fit in with this kind of strict farm management, we believe agricultural chemicals will be a good and an increasingly necessary investment. Dow Chemical Co. does not anticipate much slackening of demand.

The General Trend Will Be Upward for a Long Time

William Hall

Sales Manager, Chipman Chemical Co., Bound Brook, N. J.

Unusual weather conditions, such as the widespread droughts, have made 1953 a peculiarly difficult year for the agricultural chemicals industry.

Reductions in both sales and output of

agricultural chemicals can be blamed on the weather. Inventories are relatively low, because the industry is very "demand-conscious," and instances of production outstripping demand by large margins have been rare.

Price levels were disappointingly low because of the bad weather. Some companies tried to stimulate sales by cutting prices drastically. Farmers have held off buying, in hopes that prices would fall still further. Thus, prices were forced to unprofitable levels, especially on cotton pest poisons and to a lesser degree on 2,4-D.

Conditions were not bad all over the country. In the Northeast, the year has been pretty good. The Northwest and the far West have also been encouraging. The defoliation picture, at present, looks pretty good. Raw materials prices were generally down, although certainly not as much as the decline in the finished product prices.

The outlook for 1954 has to be encouraging. We certainly can't expect such unusual weather to continue for another season. True, the farmer's income has declined but so have the prices of many, but not all, of the things he buys. Use of agricultural chemicals is bound to increase as the consumer becomes educated. The general trend in the agricultural chemicals industry is upward and will continue upward for a long time.

Consumer Education and Application Equipment Important Needs

J. A. Field
and
C. D. Fischer

Fine Chemicals
Carbide & Carbon
Chemicals Co.
New York, N. Y.

J. A. Field

CARBIDE & CARBON, this year's agricultural chemicals business exceeded expectations. This was due to the fact that the chemicals supplied by Carbide & Carbon are relatively new and still in the period of initial rapid sales expansion; a damp spring in the Northeast and Northwest, which caused unusual weed growth and serious epidemics of apple scab; and a shortage of farm labor, which encouraged the use of labor saving chemicals. A lack of adequate application equipment and consumer education has retarded the agricultural chemicals market. The relatively insect-free year of 1952 resulted in large inventories of some chlorinated insecticides this year, with 2,4-D prices in particular dropping from 61 cents a pound into the low 30's.

Next year the new products will continue their sharp growth. As farmers realize that chemicals mean greater efficiency, they must convert to their use or be squeezed out by the competition, regardless of crop prices or farm income. Prices of certain herbicides will fall, as new production comes in. Pyrethrins and allethrin will make a strong come-back, because of the growing resistance of some insects to other insecticides. The automatic treadle sprayer should be a strong stimulant to pyrethrins and allethrin. Sales of hormone type weed killers should increase, as new blends are developed to achieve better balanced weed control.

Increasing Fertilizer Use Provides Optimism for Agricultural Chemicals

The pesticides and fertilizer industries are influenced by many similar factors. Here's an authoritative view to complement those from the pesticides field.

Hugo Riemer

President
Nitrogen Division
Allied Chemical &
Dye Corp.
New York, N. Y.

THE 1952-53 season for fertilizer was good. More nitrogen was produced, mixed into complete fertilizer, and applied to the soil in the United States than ever before. New capacity pushed forward by industry made its initial contribution, although a number of new projects are yet to come into run.

The coming year looks equally good, if not better, to extent of completed new capacity, although the ability of the market to absorb all prospective new production has not yet been tested. Industry will undoubtedly continue its extraordinary efforts of the past season to produce as much liquid nitrogen for fertilizer manufacturers as capacity will permit. Farmers will also be assisted toward the greater use of nitrogen recommended by university, state, and federal experts by high analysis 1-1-1 ratio materials.

The sufficiency of presently existing and building nitrogen capacity to meet the full demands of the market lies in part at the farm and fertilizer works themselves. Capital requirements for nitrogen production are so high—upwards of two dollars per dollar of annual sales volume—as to make entirely uneconomic the building of enough plants to satisfy seasonal peaks from current production. Large storages in the off-season are necessary, for which fertilizer manufacturers, dealers, and farmers must share responsibility if adequate supplies of nitrogen are to be available when needed.

Decreases in farm income should not adversely affect fertilizer sales. Intelligent farmers have learned, first, that fertilizer prices are low compared to other things they buy and, second, that proper use of fertilizers lowers unit cost and bolsters income—that they get their fertilizer money back several times over depending on rate of use, soil, and crop.

Need for Farming Efficiency Demands More Agricultural Chemicals

Wallace E. Gordon

Assistant
Director of Sales
Grasselli Chemicals
Department
E. I. du Pont de
Nemours & Co.
Wilmington, Del.

AGRICULTURAL CHEMICALS sales during the 1952-53 season maintained reasonably good volume but pricewise, for the manufacturer at least, left much to be desired. Extreme price competition prevailed in large-volume insecticides, such as DDT and BHC products, whose success two years ago had encouraged installation of manufacturing facilities more than adequate to meet current demand. The market for hormone weed killers, such as 2,4-D and 2,4,5-T, followed a similar pattern.

The season showed a trend, likely to grow in the future, of specialty products increasing their proportionate share of the market. These are products which do a superior job in specific applications, such as CMU, for pre-emergence weed control in sugar cane and pineapple fields, and methoxychlor, for control of forage crop insects and Colorado potato beetles, which have developed resistance to DDT.

Declining farm prices present a sales challenge to the manufacturer but actually increase the need for agricultural chemicals. With a smaller margin of profit, the farmer must concentrate on producing efficiently. Also, in times of farm surpluses, buyers become increasingly quality conscious, and the proper use of chemicals is quality insurance.

Over the long haul, demand for farm chemicals is bound to increase because of the need for more foodstuffs. Population of the United States passed 160 million on Aug. 10 and the Census Bureau looks forward to a population of 175 million by 1960. We will have to produce more food more efficiently.

Sulfur Consumption Changes Compensate To Give a Stable Result

Sherman W. Clark

Manager, Agricultural Department, Texas Gulf Sulphur Co., Houston, Tex.

SULFUR CONSUMPTION in the production of insecticides is expected to remain at its present level during 1953. This is explained by several interdependent factors. Increased use of fertilizers, judicious use of water, and more effective insecticides have boosted cotton yields considerably in recent years. The general upward trend of insecticide sales has provided a compensating market for losses sustained to competing organic compounds. Indirect consumption of sulfur as sulfuric acid in the preparation of many new insecticides has also provided additional outlets. The proportionate use of sulfur as a direct applicant, however, has declined.

Organic insecticides, in some instances, have disturbed nature's balance by destroying harmful insects which eat mites. This situation has increased the demand for sulfur as a miticide. In some cases, mixtures of sulfur and organic compounds have proved to be more effective than organic compounds alone.

Many of the citrus orchards were destroyed in Texas by the heavy freeze of 1950. Even though they are being rehabilitated, new orchards require about five years before they become producers. This condition, in relation to sulfur consumption, was greatly offset by the sudden increase in cotton acreage planted to supplement incomes during the rehabilitation period. In general, the long range trend of direct sulfur application to orchards has been slightly downward.

Although sulfur has been tight in the past, increased production facilities, including production from natural sour gas and oil refinery gases, have made possible the meeting of current demands. Recent price rises in crude sulfur have not been completely reflected in the price of finished products because of large inventories in the hands of formulators.

Texas, Arkansas, Oklahoma, Louisiana, New Mexico, Arizona, and California continue to be the largest consuming states.

Drought and Irrigation Are Major Influences in Southwest

A. J. Garon, Jr.

District Manager, Julius Hyman and Co., Division Shell Chemical Corp., Houston, Tex.

DROUGHT HURTS the insecticide producer more than the farmer. This year in Texas insecticides are being sold almost at cost. Formulators are making a gross profit of only about half the amount considered a reasonable margin.

By normal standards, Texas, with roughly three dry years to each wet year, is considered a dry state. In spite of this, Texas leads the nation in cotton production with an estimated cultivation of 9.6 million acres in 1953. Totals for the U.S, on July 1 were reported by the USDA at 24.6 million. Cotton yields in Texas can be doubled in some localities during a wet year, which means a 50% increase in the average production throughout the state. This points out the value of federal or state irrigation projects to the farmer.

Assuming that increased irrigation is in sight for the future—what is in store for the insecticide manufacturer? Increased volume of sales is the answer.

Here is the paradox—both farmer and insecticide producer benefit simultaneously from conditions which produce boll weevils. During a drought the farmer suffers lower yields. June heat kills boll weevils. The insecticide manufacturer is left with only the boll worm to kill. This limits his market severely. On the other hand, a mild winter and June showers (or irrigation) give good cotton yields and plenty of boll weevils with regularity. Other than being at a psychological disadvantage, the farmer is better off under the latter conditions. His profit is greater after insecticide expenses because of the increased yield. Mutual prosperity and a consistent volume of business for both parties will be closely tied to future expansion of irrigation projects.

Increasing Demand for Insecticides in Cotton Belt Will Continue Next Year

H. G. Johnston

Head
Research Development
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National Cotton Council
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THE DEMAND for insecticides in the cotton belt has increased tremendously during the last five years and all evidence indicates an increasing demand for the future. Mechanized cotton production means a greatly increased investment per farm unit and to be economically successful the cost of production must be reduced to a minimum. Maximum potential yields must be protected from destructive insect pests.

The development of new organic chemicals has made possible insecticide combinations that are effective for the control of all major cotton pests throughout the season. The use of spray formulations of such insecticides combined with the rapid development of low pressure, low volume sprayers has made possible a more rigid schedule of applications which is essential for effective pest control. With these improvements, increased yields of one-half bale per acre or more may often result from a properly conducted insect control program.

Despite the tremendous progress made in improved methods of control, losses from cotton insect pests are still high. In the "boll weevil belt" cotton insects were extremely abundant in 1950 and caused a reduction from full yield of 26.9%. This was the second greatest loss on record, exceeded only in 1922 when the reduction from full yield amounted to 35.5%. Due to excessive dry weather and more effective use of insecticides since 1950, the insect population has been greatly reduced. The reduction from full yield was only 6.7% in 1952, very near the lowest on record. Such wide variation in the abundance of cotton pests, due primarily to variable weather conditions, causes a corresponding fluctuation in the demand for insecticides. Despite this wide variation, the demand for insecticides in recent years has increased rapidly.

Cotton insect pests were abnormally abundant during 1950 throughout most of the boll weevil belt. The total amount of insecticides used, 464.1 million pounds of field strength dust equivalent, was sufficient for only 2.7 applications at 10 pounds per acre for the total cotton acreage harvested in 1950. Reliable evidence indicates that an average of no less than six applications per acre, or a total of approximately 950 million pounds of insecticides, would have been needed for adequate insect control under conditions existing in 1950. It is evident that when conditions are favorable for normal or above normal insect populations to develop, adequate control will require much greater quantities of insecticides than have been used previously.

Progress in Insect Control Calls for Care and Skill

J. J. Davis

Chief in Entomology, Agricultural Experiment Station, Purdue University, Lafayette, Ind.

As is generally realized, more progress in insect control with chemicals has been made in the past 12 years than in all previous time. However, instead of simplifying controls, the many new organic insecticides developed, because of their specificity, have complicated controls and required a better understanding on the part of users. Development of resistance by some insects to certain of these chemicals has further complicated the problem. On the other hand, the reduced costs per acre and the increasing use of low pressure-type sprayers and airplanes has increased the practicablity of chemicals for extensively cultivated crops such as corn and legumes.

What of the future? We must strike a balance between the use of chemicals on the one hand and on the other the use of good farm and home practices, which are *preventive* and inexpensive. The two methods of insect control must go hand in hand. Chemical control is always more effective when used in conjunction with sanitary practices and other preventive measures, which reduce the build-up of insect populations. Therefore, along with chemicals we must emphasize good farm practices, i.e., *preventive* practices, providing conditions unfavorable to the insects, which also are usually the best practices for crop and animal production, regardless of the presence or absence of insects.

The tremendous development of new chemicals will continue. More research in perfecting applicators for various purposes is essential to keep up with the chemical development. At present, with the exception of orchardists, gardeners, and greenhouse men, at least 70% of the insecticides on the market are wasted because users do not read directions and do not heed them. Therefore, we will

Scenes such as this grasshopper infestation of sweet clover are evidence of a need which should make the future of the agricultural chemicals industry a solid one

see greater demand for service operators, both in urban and rural areas, although more farms will be equipped with low volume-type sprayers and will perform their own services. This is logical because such service operators have the equipment and know how to get the best results. We in experiment stations are receiving more inquiries—who can we get to do the job?"—rather than "how can I do it?"

We are reaching our goal in food production through use of fertilizers and hybrids, and to increase production further we must turn to greater efficiency in insect control to reduce losses.

Basic Research Needed to Speed Fungicide Progress

George L. McNew

Managing Director
Boyce Thompson
Institute for
Plant Research
Yonkers, N. Y.

New fungicides discovered since 1937 among the dithiocarbamates, quinones, imidazolines, quaternary ammonium compounds, hydroxyquinolines, naphthenates, phenols, phthalimidines, pyrazoles, triazines, and other classes of organic compounds have revealed the potentialities of this field of endeavor. More plant diseases are being controlled better with less hazard to the crop, spray operator, and consumer than ever before.

In spite of past attainments, there is still need for better fungicides, so the search should go on. Empirical testing by trial and error methods of every chemical in sight will probably become less popular. In order to prevent the inefficiency of such methods from destroying the interest of risk capital, better research methods will have to be developed.

The biologist and biochemist must provide the organic chemist with basic information so he can visualize what sort of compounds should be synthesized. Assembling and classifying the voluminous data on the relationship of chemical structure to fungitoxicity will provide basic principles for orienting future research. Information must be obtained on the exact role of given substituents. Their effect on the molecule's ability to penetrate the fungus body, react with vital cell metabolites and enzymes, resist detoxifying mechanisms inside and outside the spore, and to be stable and persistent in protective films will have to be investigated.

Recent studies have shown that very few of the new organic fungicides are specific in their action on cell constituents; they are inefficient, massive dosages being needed to destroy spores. Some may be detoxified by spore secretions. They do, however, possess unique ability to penetrate spores. The role of lipoid-solubilizing and polar groups in promoting such penetration is only imperfectly understood and justifies extensive investigation. The differential sorption of fungicides by fungus spores and the cuticle of foliage and fruit will determine the margin of safety for many compounds in agricultural uses.

Special attention is being paid to the type of enzymes and cell metabolites immobilized by fungicides. After the common fungicides have been classified according to ability to destroy certain enzymes by reaction with sulfhydryl, amino, and carboxyl groups or metallic coenzymes, it should be possible to predict with more certainty what classes of chemicals are likely to be fungitoxic and what substituents will influence their activity. The ideal of a tailor-made fungicide that fits certain specifications is coming nearer to reality with every discovery on basic principles.

Herbicides Have Enjoyed Great Growth in 10 Years

Although chemical weed control is not new, a much greater emphasis has been placed on this field since the discovery of 2,4-D less than 10 years ago. Since that time we have seen the phenoxy compounds reach a 30 million pound annual business, including 2,4-D, 2,4,5-T and MCP. Approximately 1 million acres of mesquite have been sprayed in Texas with 2,4,5-T since 1951. Other big increases have been in the use of herbicides in cotton in the Southeast, and for weed control in utility and railroad rights-of-way.

Roy L. Lovvorn
Head
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U. S. Department of Agriculture
Beltsville, Md.

In the phenoxy group of compounds, MCP is increasing in usage on flax and to some extent on other grains, including oats and rice, primarily because it is less injurious to these grain crops. 4-Chlorophenoxy acetic acid has looked good on certain crops; 3,4-Dichlorophenoxy acetic acid has looked promising experimentally; and other phenoxy compounds are being evaluated for specific purposes, especially low vapor activity.

Information developed during the past 12 months shows that the variable results sometimes obtained with the dinitro compounds may be due to vapor activity which is closely associated with temperature and the type of formulation.

The substituted *N*-phenyl carbamates have exhibited a high degree of selectivity, leading potentially to wide use as postemergence sprays for the control of grasses in legume crops and more recently for pre-emergence weed control in cotton and other crops. Preliminary evaluations suggest that other carbamates have important herbicidal properties. Recent studies have also indicated that some of the carbamates evaporate rapidly. Less volatile carbamates of high activity are greatly needed.

CMU [3-(*p*-chlorophenyl)-1,1-dimethylurea] looks very good as a nonselective herbicide on nonagricultural land and most promising as a pre-emergence material at low rates. More recently, phenyldimethylurea has also exhibited similarly interesting properties. It is of significance that these compounds are the first group of organic chemicals having sufficient residual effect in the soil to be used as soil sterilants. This group needs further study.

The Outlook for Systemic Insecticides Is Very Promising

Robert L. Metcalf
Chairman, Entomology Department, University of California Citrus Experiment Station
Riverside, Calif.

THE DEVELOPMENT of systemic insecticides continues to be one of the most intriguing fields of entomological research and is receiving intensive study by industrial and governmental laboratories. The commercial employment of Systox and OMPA on nursery stocks and on large acreages of cotton for the control of mites and aphids has emphasized the promise shown by these materials on a variety of food crops. Protection from insect damage at phenomenally low dosages, ranging from 1 to 8 ounces of technical material per acre, and with considerably reduced rates of spray application reflect the interesting properties of rapid plant absorption and translocation which greatly extend the residual life of the treatment, reduce the necessity for thorough spray coverage, protect new growth formed after treatment, and decrease the hazards to beneficial insects.

Research has satisfactorily demonstrated the usefulness of the materials in insect control and the major efforts are now being devoted to the determinations of residues in foodstuffs and to the elucidation of the biochemical transformations occurring on absorption in plant tissues. These two problems are virtually inseparable as it is clearly impossible to carry out intelligent evaluation of the magnitude of plant residues until the nature and properties of the ultimate toxicants and their breakdown products are known. This work is especially important since it has been demonstrated with most of the systemic compounds that the toxic activity is not due to the material applied to the plant but to secondary compounds derived from these by enzymatic transformations. Solutions to these problems are in sight.

Residues of systemic insecticides in most food crops have proved to be of insignificant or trace amounts, because of the very low rates of application necessary for insect control, the fugitive nature of some of the toxic metabolites, the generally poor translocation downward into root crops such as potatoes and beets, and the lack of penetration through hull and rind into crops such as walnuts and citrus. These facts, along with the generally low chronic toxicity and lack of accumulation in animal tissues characteristic of the organic phosphorus toxicants, result in an optimistic picture for the successful employment of these insecticides on food crops.

Currently many additional systemic compounds are being studied. Their development is likely to be slow because of the difficulties already mentioned. However, certain of these materials possess advantages of greater safety to the applicator, more specific or broader insecticidal effectiveness, and physical and chemical properties which may permit their use with even less chance of residue problems. Thus the future of this new class of insecticides seems well assured.

Synthesis of Insecticides with Low Toxicity to Man Will Keep Chemists Busy

THE INTRODUCTION OF DDT into this country in 1942 stimulated the preparation of numerous other chlorinated organic compounds for testing for pesticidal value, and the discovery that parathion is toxic to many kinds of arthropods quickly led to the synthesis of other organic phosphorus compounds. However, in developing these new synthetics it was soon discovered that with a few exceptions increased toxicity to insects meant increased toxicity to man. The hazards in handling these pesticides and the possible danger to the health of man from continued ingestion of minute amounts of their spray residues in foods emphasizes the need for insecticides of low mammalian toxicity. A noteworthy achievement in supplying this need is the synthesis of allethrin.

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Bureau of Entomology and Plant Quarantine
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Allethrin is highly toxic to insects and of very low toxicity to warm-blooded animals. It has a structure closely related to that of the pyrethrins, the active principles of pyrethrum flowers, and it was synthesized using the known structure of the pyrethrins as a model. It is more toxic than the pyrethrins to the house fly and is the chief active ingredient in 20 million of the aerosol bombs that will be produced in 1953. Allethrin has shown promise in protecting grain, flour, and other cereal products in bags and cartons against attack by weevils and other stored product pests. This finding opens up an enormous potential market for the use of synthetic insecticides of low mammalian toxicity on foodstuffs.

Another significant development is the finding of new synergists for pyrethrins and allethrin. Recently in Beltsville several new compounds have been synthesized which give promise of outperforming any of the commercial synergists when mixed with allethrin.

The synthesis of new insecticides and of synergists for them to make formulations highly toxic to insects and mites but nontoxic to man will engage the attention of the organic chemist to an increasing extent in the next few years.

Pesticides Development History Shows Accelerating Tempo with National Agricultural Chemicals Association Closely Interwoven

Man's contest against insects is probably as old as his history, but, relatively, the organized scientific fight is very new. The application of knowledge of economic entomology is less than two centuries old. The use of chemical action appears to go back at least to the time of Homer, as the great poet mentions the use of sulfur fumes against insects. According to Cato, in 200 B.C., sulfur-asphalt fumes were employed to kill tree-infesting insects. The Romans used false hellebore as rodenticide and insecticide. Some time in the past the Chinese discovered the insecticidal value of derris. The earliest record of recommendation of the application of arsenicals as insecticides, according to R. H. Carter, is dated 1681. The older history of the Borgia's indicates that in the Middle Ages man's battle against neighbors, friends, and associates was given more thought than was the insect problem.

As early as 1795, scientists in the young United States recorded their studies of the insect problem. A paper by Peck, on the cankerworm, appears to have been the first or among the first of papers on economic entomology. This does not mean that scientific knowledge had become the basis of activities. In 1862, published recommendations for action against fire blight of apples suggested placing around the trees such materials as sulfur, sulfuric acid, refuse gas lime, coal ashes and pitch, and vinegar, manure, and urine.

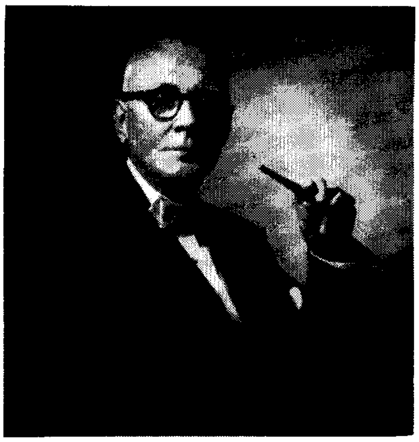
Synthetic chemical materials are not so new to insecticidal practices as many may think. About a hundred years ago, carbon disulfide was in use as a fumigant in France and it was tested against wireworms in the U. S. in 1891. Organic chemicals also are not new; naphthalene probably has the earliest record of replacement by a synthetic organic competitor, the use of *p*-dichlorobenzene in its stead against moths having been reported from Germany in 1911.

New Products Found Rather than Developed

The early organics were not produced as a result of the discovery of their insecticidal powers. They were available materials adapted to use because they were effective against insects. The organic products used in greatest quantity previous to World War II, petroleum sprays, had a similar history. Kerosene apparently was the first used. In 1887, A. J. Cook of Michigan State College

Milestones in the Development of the Agricultural Chemicals Industry

1681	First known record of recommendation of arsenicals for use as insecticides.
1795	Approximate beginning of appearance of papers on economic entomology in U. S. ("The Description and History of the Cankerworm," by William D. Peck, 1795, was among the first).
ca.1850	The first synthetic compound used against insects, carbon disulfide, used in France as a fumigant at least this early.
1854	First official appointment of a state entomologist (Asa Fitch, New York).
1860	Paris green first used as an insecticide.
1882	Bordeaux mixture discovered by Millardet in France.
1887	Kerosene, apparently first petroleum product used against insect pests, applied as a soap emulsion.
1887	Hatch Act established state experiment stations throughout U. S.
1908	Nicotine insecticide first appeared on market.
1910	Federal Insecticides Act passed.
1921	First highly successful dusting of insecticides by plane, Ohio.
1924	Agricultural Insecticides and Fungicides Manufacturers Association organized (later absorbed by Manufacturing Chemists' Association).
1933	Manufacturing Chemists' Association insecticide committee formed Agricultural Insecticide and Fungicide Association which received charter of incorporation following year.
1938	First synthetic insecticide synergist, *N*-isobutylhendecenamide, prepared.
1939	Muller's work leads to discovery of insecticidal powers of DDT.
1942	First reports published on 2,4-D as a weed killer.
1949	Agricultural Insecticide and Fungicide Association becomes National Agricultural Chemicals Association.



Ernest Trigg, of Philadelphia, was the sparkplug of the movement which organized the Agricultural Insecticides and Fungicides Manufacturers Association, predecessor of AIFA and NAC and the first trade association devoted to the agricultural pesticides industry

introduced a kerosene-soap emulsion to combat aphids and scale insects.

William Volck and C. W. Woodworth of the University of California took up work on spray oils about 1902 and moved toward sprays which would fit given needs. It was this work which produced "summer oils," "quick breaking" emulsions and many other products which aided the use of petroleum products in controlling insects.

Early Inorganics

In 1860, George Lidell of Fairplay, Wis., wrote to the *Galena Gazette* that he had sifted Paris green and flour through cheesecloth onto potato plants and thus had killed Colorado potato beetles. Lidell's action led to the making of a dye pigment into one of the leading insecticides of the late nineteenth and early twentieth centuries.

Only about 10 years later, an Ohio fruit grower, named Flagg, having heard of the use of sulfur to control mildew in France, went there to learn what was done. He brought back information and some use was made of it in this country, but 40 years passed before lime-sulfur came into use.

The French apparently were alert to any likely means of protecting their beloved and valuable fruit crop. The power of Bordeaux mixture was discovered there by Millardet about 1882 and within three years it had become a standard fungicide. The secretary of the American Horticultural Society wrote to Millardet for help and received a long set of directions for preparing the material and applying it with a brush. The mixture was zealously put to use with the result that the disease was checked, but much fruit was injured. The U. S. Department of Agriculture came to the rescue with recommendations and further developments came from France, but it was many years before spraying techniques, weather effects, and the need for conditions varying with crops and parasites were understood satisfactorily.

A History of Cut and Try

During the last third of the eighteenth century the history of the struggle against pests was by no means blank, but it certainly was a story of progress made the hard way. The first state entomologist, Asa Fitch, was appointed by New York in 1854. Economic entomology gained recognition to the extent that courses were taught for the first time in 1867 at Michigan and Kansas State Agricultural Colleges. Connecticut established the first state experimental station in 1875. Societies had begun to offer prizes for ideas on the control of pests. The techniques were so elementary that one award went for a suggestion for hand-picking of insects.

A very important step forward came in 1887 in the passage of the Hatch Act which resulted in the establishment of state experiment stations throughout the nation. The fighting of insects was dignified by its first state control law in 1890; the state of Louisiana enacted a regulation over the purity of Paris green in that year.

One insect after another appeared, to the concern of agriculturists who tried known and suggested remedies and sometimes gave up the growing of a crop, as was the case with the onslaught of plum curculio in the '70's. Late in the century Paris green became the victor in the 10-year argument comparing its value with that of London purple. Hellebore and pyrethrum were recognized as valuable agents. A force pump, geared to the wheel of the wagon on which it was mounted, appeared to replace the old technique employing dipper and barrel.

The concensus seems to be that nothing that could be called an industry existed before 1900. Up to that point insecticide and fungicide manufacture was mostly an offshot of other industries, such as dyestuffs, drugs and botanicals, paints and colors, and other chemicals.

A major addition to the family of commercial insecticides came about 1908 when nicotine came on the market. It was not new, its insecticidal powers having been employed at least as early as 1690, but it had not been developed commercially.

Adolescence of an Industry

Calcium arsenate appears to have been the first insecticide with a development based on an approach planned to produce a commercial insecticide. One of the pioneers was William C. Piver, a graduate of the University of North Carolina, who was convinced that there could be insecticides cheaper than any being used. Young Piver's avocation was home laboratory work at night. His landlady apparently was no idolizer of science; Piver was forced to keep his laboratory equipment under the bed when he was away from the room and to work during the dark hours. Eventually he produced laboratory batches of calcium arsenate. The next step toward the goal of that work was achieved in 1912 when the first lot of commercial calcium arsenate insecticide was shipped to a dealer in Houston, Tex.

As late as 1918 an order for 40 tons of calcium arsenate almost overwhelmed the manufacturer, as it was one third greater than his total production of his best previous year.

In 1913 Idaho appointed the first state extension entomologist. Large-scale dusting seemed so attractive that the use of airplanes was being tried. As early as 1918 attempts were made to spread insecticides by dumping from planes. In 1921, a specially equipped airplane, operating under the supervision of C. R. Niellie and J. S. Houser, proved its effectiveness in controlling catalpa sphinx with lead arsenate dust near Dayton, Ohio. The next year, B. R. Coad of the USDA borrowed two planes from

Lea S. Hitchner, the first president of the Agricultural Insecticide and Fungicide Association. His present position as executive secretary of the National Agricultural Chemicals Association is only one part of an active career of a man who has long been a key figure in his industry. He entered the industry with the Kiltone Company, of which he became president. He continued in that position through the company's absorption by John Lucas and Company and when Sherwin-Williams purchased Lucas Kiltone again he was retained as president. He was appointed chairman of the insecticide committee of the Manufacturing Chemists' Association in October 1932 and was influential in the organization of the AIFA a year later

the U. S. Air Service to demonstrate to the cotton farmers near Tallulah, La., that this method was 100 times as fast as the best mule-drawn machine. The commercial aircraft dusting industry was born the next year with the formation of Huff-Daland Dusters, Inc.

The First Industry Association

Developments were coming along at an increasing rate. The use of insecticides and fungicides had become great enough to support an industry devoted to that purpose with companies specializing in products for that field. A need was seen for organized cooperation to stabilize the industry, develop markets, support public education, and cultivate cooperation between producers and dealers. The lead in meeting this need was taken by Ernest Trigg, president of John Lucas and Co., of Philadelphia. Trigg proved to be an effective sparkplug. Heading a committee composed of R. N. Chipman, president of Chipman Chemical, W. H. Simpson, president of Riches Piver, W. H. Rose, president of Interstate Chemical, and W. B. Cragin, head of the insecticides division of General Chemical, Trigg stimulated the planning of an industry association and called a meeting of interested manufacturers in New York, July 15, 1924. The result was the formation of an association named the Agricultural Insecticides and Fungicides Manufacturer's Association. Trigg was elected president.

The AIFMA functioned for several years in the interests of the industry, but it was handicapped by the lack of offices and a paid, full-time staff. The crash in 1929 added to its troubles, and by 1930, the AIFMA's operations had virtually starved to a halt. The Manufacturing Chemists' Association took an interest and in 1932 merger was completed, with what had been the AIFMA becoming the basis for an MCA committee dealing with agricultural and insecticide matters.

The first chairman of the new MCA committee was Lea S. Hitchner of John Lucas and Co. The committee was quite active in the interests of the industry. Under its leadership some 41 industry representatives met in Atlantic City, N. J., in August 1933, with members of the National Recovery Administration, to establish a code authority under which the industry could act. At that same meeting definite steps were taken toward the formation of an association to represent the pesticides industry.

The AIFA Is Born

Interest in the new association flourished and within a few months the Agricultural Insecticide and Fungicide Association was formed. A charter of incorporation was signed Jan. 18, 1934, by Howard Mansfield, George Riches, Joseph Cary, R. N. Chipman, and Lea Hitchner. Incorporation was officially recognized at Dover, Del., Feb. 28, 1934.

CHARTER COMPANIES

American Nicotine Co.
Chipman Chemical Co.
Latimer-Goodwin Co.
National Sulphur Co.
Sherwin-Williams Co.
Pittsburgh Plate Glass Co.
John Powell & Co.
Bowker Chemical Co.
Grasselli Chemical Co.
Mechling Bros. Chemical Co.
New York Insecticide Co.
Tobacco By-Products Co.
California Spray-Chemical Co.
Dow Chemical Co.

The first meeting of the new association was held March 5, 1934. Hitchner was elected president, Chipman, chairman of the board, and R. K. Vickery, of the California Spray-Chemical Corp., treasurer. Offices were established in New York City. Fourteen companies constituted the original membership.

Interest in AIFA is attested by the fact that within two years its membership had risen to 34. This group consisted almost entirely of manufacturers of basic chemicals and did not include formulators, remixers, or other branches of the chemical industry serving pesticides manufacturers.

Synthetic Organics Begin

In 1935 there appeared on the horizon of the insecticides world a cloud no bigger than a man's hand. It was phenothiazine, one of the first synthetic organic compounds which gained its primary significance because of its insecticidal power. Although the compound is still used to a limited extent against codling moth and is used extensively for internal medication of livestock, it never held a position of prominence as an organic insecticide. It did herald things to come, as it was probably the first of many compounds to be uncovered or synthesized as a result of a campaign to make use of synthetic organic chemistry against agricultural pests.

Another milestone in organic chemistry of the pesticides field followed three years later with the development of the first synthetic synergist for pyrethrum, *N*-isobutylhendecenamide. At this stage the potential that lay in synthetic chemistry both for making insecticides and for enhancing their strength had begun to show.

DDT—The Great Turning Point

The climax of a development which probably had a greater influence than any other on the direction of progress of the modern agricultural chemicals industry took place in Switzerland about 1939. Its roots can be traced to Germany.

In 1915 the Bayer Company, in Germany, undertook an intensive search for chemicals effective in making wool mothproof. This search was influenced to some extent by an idea which existed among some people in Germany that clothes dyed green were not attacked by moths. While the general idea was disproved, it was discovered that Martius yellow, which had been added to some green dyes to overcome a bluish shade, was effective against moths. From martius yellow, which was 2,4-dinitro-1-naphthol, testing led to many other compounds with the eventual development of one group of products named "eulans." The commercial availability of these products interested the Geigy firm, in Switzerland, and research on the matter was started there. Studies on mothproofing agents led to the testing of organic compounds against other insects. As a result, 1,1,1-trichloro-2,2-bis-(*p*-chlorophenyl)ethane, which first was described in 1874 by Zeidler, of the University of Strasbourg, was found to be a very powerful insecticide. For this work Paul Muller received the Nobel Prize. A short name DDT has been applied to the dichlorodiphenyl-trichloroethanes.

Some of the new DDT product was brought to the United States by the Geigy Company in August 1942. Shortly thereafter, research reports also arrived, reporting that DDT was both a stomach and contact poison. H. L. Haller of the USDA determined the structure of the compound and synthesized it at about the same time that further information, reporting its chemical composition, arrived from Switzerland. By June 1943, DDT was being manufactured for the armed forces.

Organic Herbicides

Chemical means of killing weeds received less attention than did the insect fight previous to World War II. Weeds were removed mostly by cutting or plowing. In some areas, where all vegetation could be removed, as along highways or railroads, petroleum sprays have a long history of use as weed killers. Some inorganic compounds, including chlorates, arsenicals, and borates were in use. Dinitro compounds and thiocyanates found some use and ammonium sulfamate was perhaps the most important organic herbicide before 1942.

Plant growth hormones had been the subject of study for some time, but an almost sensational point was reached in 1942 when the substituted phenoxy and benzoic acids were brought out. Within two years 2,4-D was shown to be a potent selective herbicide. At about the same time 2-methyl-4-chlorophenoxyacetic acid came into use in England. The 2,4-dimethyl compound seems to have found greater use and it may properly be said that the discovery of 2,4-D was a great turning point in the history of weed control.

Rodenticides

Control of animal pests by poison is a very old technique. Perhaps the oldest product for that use is red squill, which was known to the ancient Egyptians. Arsenicals, phosphorus, barium carbonate, and strychnine appear to have been in use since the middle of the nineteenth century.

About 1920 a campaign was begun in the U. S. Squill was brought in for the first time and thallium sulfate was imported from Germany. Also zinc sulfide came into study in the U. S. for the first time.

It was not until World War II began that an aggressive search was made. That program was begun by the Office of Scientific Research and Development and the U. S. Fish and Wildlife Service and continued after the war with the support of the Quartermaster Corps. Three major new products have been evaluated and have gained commercial status. Of these, α-naphthylthiourea, ANTU, is effective against some species, but useless against others, particularly field rodents.

Sodium fluoroacetate, compound 1080, is generally effective, but is too highly poisonous for public use. Warfarin, 3-α-acetonylbenzyl-4-hydroxycoumarin was found by K. P. Link, University of Wisconsin, during a study of drugs to reduce blood clotting. It causes death of the animals by internal hemorrhages and severe anemia.

Wartime

Some important growth in the agricultural chemicals industry came at a time when the outlook was blackest—World War II. In 1940–41 the chemicals supply was not adequate for both civilian and military needs. Only direct defense activities had the rating necessary to get deliveries of pesticides. Fortunately both the Surgeon General and the Quartermaster General Offices were interested in pesticides.

Lea Hitchner, executive secretary of AIFA, convinced P. H. Groggins, chief of the Agricultural Chemicals Division of National Defense Advisory Commission of the importance of prompt attention to pesticides. Groggins, who already had been a leader in action, overcame the industry's distrust of "government men," carried the matter to D. P. Morgan, of the War Production Board, with the result that Preference Rating Order P-87, issued Dec. 13, 1941, gave pesticides manufacturers defense status.

As a result of this status it was possible to push directly against the problem of increasing production.

Copper and arsenic derivatives had to be increased, arrangements were made to encourage increased production of pyrethrum and rotenone in other countries, subsidization of deliveries of low grade tobacco for nicotine sulfate was effected, and shipping and international negotiations got close attention.

Excerpts from the agenda of a meeting of the Agricultural Economic Poisons Committee of the War Food Administration for Oct. 7, 1943, gives an idea of top problems in the industry at the time:

Authority for and responsibilities and functions of war food industry advisory committees
Discussion
Determination of insecticides needed for control programs
Outlook for pyrethrum and rotenone from the other Americas
Pyrethrum insecticides
Nicotine insecticides
Cryolite
Arsenical insecticides
Copper fungicides
Small package program

Evidence of the dramatic change taking place in insecticides is found in comparing with the 1943 agenda that for Jan. 16, 1945, which was devoted entirely to various aspects of the DDT situation, a topic not even mentioned 15 months earlier.

AIFA to NAC

Only a few years after its formation, the AIFA saw the need for modifying its organizational and operational system to keep up with the needs it should meet. Originally, the president was the only paid officer. In 1940, in order to give more flexibility to the system, the chief full-time, paid officer was given the title executive secretary and the president and board of directors were elected from industry. Hitchner then assumed the executive secretary's position, and Warren Moyer, vice president of Chipman Chemical, was elected NAC president.

The revolutionary developments in organic chemicals for the pesticide industry expanded, activated, and changed the industry greatly. It became apparent to the AIFA that its activities no longer served the industry fully. Membership eligibility was extended in 1949 to include not only manufacturers of basic chemicals, but also formulators, remixers, suppliers of diluents, clays, surface active agents, and other affiliate companies serving the pesticides industry. The name was changed to National Agricultural Chemicals Association and the central office was moved from New York to Washington, D. C., in recognition that the seat of information important to the industry would be there.

At the present time, members of the NAC association produce more than 85% of the basic pesticide chemicals and more than 65% of the formulated products.

NAC committees serve the industry in virtually any matter concerned with its interests. Committees include finance, foreign trade, information advisory, legal, legislative, membership, southern regional, technical advisory, and traffic. Members of these committees are selected from the staffs of member companies, of which there are now 140. Association staff members serve in a liaison capacity in committee work. Continuous study of legislation, both state and federal, and related problems and the broad industry problem of educating the public and agriculturalists concerning the use of pesticides are the activities which occupy the greatest share of the time of the paid staff and committees.

The Industry Today

From the discovery of the powers of DDT and 2,4-D, the interest in organic chemical pesticides has grown remarkably. To discuss the great number of new products which have been developed would require a separate article which quite possibly would fall behind developments while being published.

The American farmer now is spending at the rate of about $300 million annually for pesticides, or about 1 % of farm income. He buys 60,000 to 100,000 power machines each year to apply these materials. The estimate of annual research expenditures is eight million dollars and the cost of finding, testing, developing, and establishing a going market for a new pesticide is considered to be about $1.25 million. Yet the race for better compounds continues so rapidly that a manufacturer must consider the risk that a new product may be out of date almost before his investment has been returned.

Great savings are reported along with improvements in yields and efficiency in farming. But estimates of the loss to pests which could be prevented by the effective application of existing knowledge are generally in the vicinity of $13 billion or 40% of the potential salable portion of the farmer's crop each year.

The manufacturer of pesticides faces the always uncertain but vital problem of weather influences. Government regulations, both state and federal, are becoming increasingly complicated, adding to the complexity of marketing new products. Research is moving so rapidly as to add to the risks of entering the market. Yet on the other hand, the farmer is under increasing pressure to increase the efficiency of his operations and there is a great deal to be done before agricultural pests are under control. These reasons make clear the likelihood that the agricultural chemicals industry has only begun to find its place and demonstrate its potential. It promises to be one of the most rapidly developing segments of the expanding chemical industry.