Pesticides' Impact on Food Production and Consumption

JOSEPH A. NOONE, National Agricultural Chemicals Association, Washington, D. C.

THE HIGH QUALITY, variety, and abundance of the American food supply, unequaled in the world, are dependent upon the proper use of pesticides. Without them, many important food crops could not be produced in this country, or, at best, only in very limited quantities and at very high prices to consumers.

That statement is not intended to minimize the importance of such other factors as improved varieties of fruits and vegetables, fertilization, mechanization, good cultural practices, and improved packing and shipping techniques. They are all essential to efficient agricultural production and distribution. However, the contributions of these factors would be largely nullified without the use of pesticides. There would be little net gain in using modern farm machinery to prepare a field and plant it, applying fertilizer in optimum amounts, using an improved crop variety, irrigating it, and then losing it to insects or plant diseases.

The well-established fact of increased agricultural production and efficiency is illustrated in Figs. 1 and 2, which show yield progress for a pair of fairly typical commodities, and also point up the impact of modern pesticides on their production.

The vertical line in each figure corresponds to the year 1945, frequently considered to mark the beginning of a new era of expanded pest control. It was at the end of World War II that many pesticides developed in wartime research became available to the grower. These and other new pest control chemicals which soon came from research laboratories found acceptance and wide usage. At the same time, the prewar products (inorganic, botanical, and organic) continued to find appreciable demand.

Data on many other crops—e.g., celery, cucumbers, snap beans—show striking increases in production per acre similar to that depicted for tomatoes, with a sharp upward break in the curve around 1946. Weight gains in meat animals have been influenced in much the same way as milk production in dairy herds.

It is true that during the period 1936–52 there was an increase in mechanization, fertilization, development and use of improved crop varieties, and employment of good cultural practices on the farm and ranch. Each contributed to increased output and efficiency. However, the benefits from these practices would be expected to show up in the productivity curves in more or less direct ratio to the increases in use of the practices. Official USDA data show generally steady increases in these items over the years 1940–1957, but no sharp upward breaks in the mid-forties.

Hence, these factors cannot be considered primarily responsible for the dramatic increases in crop yields. Only the advent and wide use of the new pesticides, along with the older ones, can explain the sharp upturn after 1945. Certain other crops on which pesticides were not being used to any appreciable extent around that time do not show this greatly increased yield per acre.

In support of the thesis that pest control chemicals were responsible for the acute increases in crop production, Fig. 3 shows what the advent of the new insecticides did to reduce the incidence of malaria, one of several human diseases controlled through control of the insect vectors involved in transmission. Again there is a spectacular and dramatic change in the curve after 1945.

These and other similar data firmly establish the value of pesticides in the control of insects, weeds, plant diseases and other pests. And these data are based upon national averages. Much more spectacular figures are available from experimental plots and local areas in which pesticides have been used extensively.

The importance of pesticides in commercial food production, which ultimately means in the quantity and quality of food available for consumption, can also be established by considering what would happen if no pesticides were used. Although exact statistics are not available, George C. Decker of Illinois has reported on a survey he made among professional entomologists and farmers specializing in certain crops. Their replies indicate the value of pesticides. For example, the entomologists were of the opinion that only 9% of the normal commercial peach crop and 10% of the apple crop could or would be produced without the use of insecticides. The commercial growers gave even lower estimates, namely, 3% and 4%. Entomologists also estimated that only 23% of the commercial cabbage crop and 37% of the potato crop could or would be produced without the use of insecticides. The growers again thought even less. When additional losses due to plant disease and weeds are taken into account, it becomes apparent that the commercial production of many crops would be practically eliminated without pesticides.

At this point, it might be well to take note of the opinion held by some that increased agricultural production is of no benefit or is even undesirable, in view of existing surpluses of agricultural products. This is not so. Actually, surplus production is concentrated in only a very few crops. On the other hand, the production and consumption of many crops generally

Figure 1

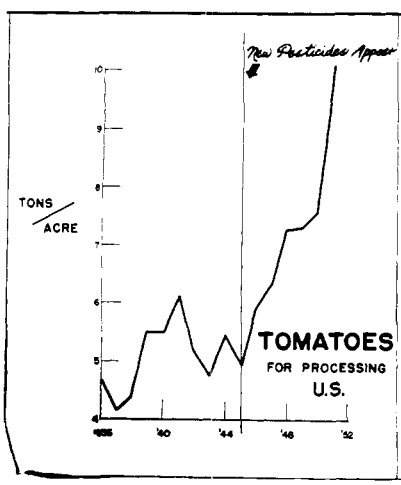


Figure 2

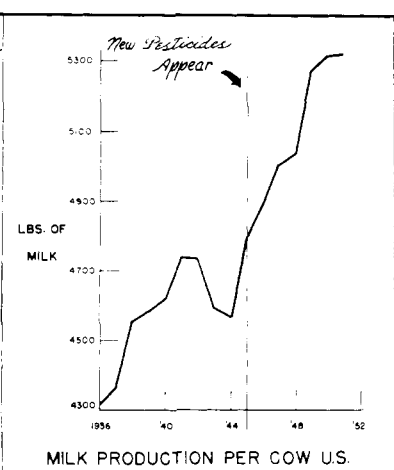
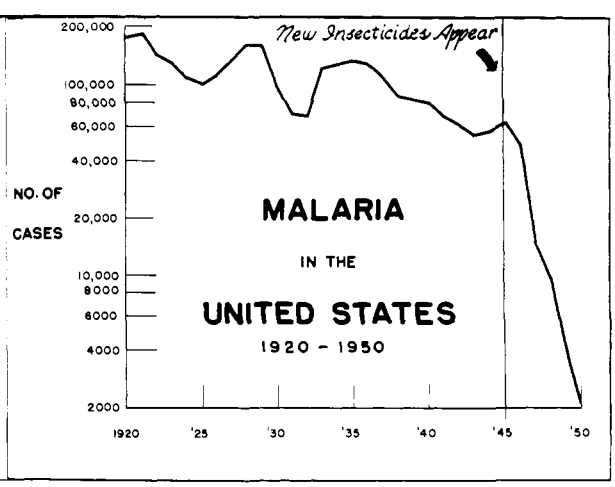


Figure 3



Crop and Unit	Pests Controlled	Yield Per Acre (Untreated)	Yield Per Acre (Treated)	Increase in Yield Per Acre	Cost of Treatment Per Acre	Net Gain Per Acre	Source
Corn (bu.)	Sand Wireworm	0–10	25–50	25	$1.50	$31	S. C. Extension Service
Pea Seed (lb.)	Fungi	456	610	154	70c (seed treatment)	$21.25	Boyce-Thompson Institute
Potatoes (bu.)	Insects and Diseases	200	700	500	$58.60	$441.40	W.Va. Agricultural Experiment Station
Sugar Beet (ton)	Root Maggot	11.8	14.5	2.7	$2.25	$32.20	N. D. Agricultural Experiment Station
Spring Wheat (bu.)	Canada Thistle	40.5	51.5	11		$22 (gross gain)	Mont. Agricultural Experiment Station

Table I. Yield, Cost of Treatment, and Cash Returns of Crops Raised with and without Pesticides

considered necessary for the maintenance of good health are below desired levels.

To provide more people with an adequate diet, it will be necessary to increase the volume of production and reduce the cost of production and distribution of various foods. Pesticides offer one of the best means to achieve that end. Table I shows how increasing production through the use of pest control chemicals means greater net gain per acre to the grower. Greater net gain means lower production costs per unit of salable commodity, and ultimately lower cost to the consumer.

The contributions of pesticides in protecting our food supply against losses from various pests are not restricted to the production phase. They are also of great value in protecting foods during storage and distribution. Insecticides and rodenticides are widely used to protect stored grain. Post-harvest fungicides make it possible to have on a year-around basis many fresh fruits which would otherwise be available only on a short, seasonal basis. One such chemical reduces by 75% spoilage of citrus due to blue mold and stem end rot while in storage and transportation.

In any discussion of pesticides and food, the question of residues inevitably arises. Under the Miller Amendment, any pesticide residue on a raw agricultural commodity is illegal unless it is within the exemption or tolerance established for that residue. In order to obtain a tolerance or exemption, comprehensive toxicity and residue data must be submitted to the Pesticide Regulation Section, U. S. Department of Agriculture, and the Food and Drug Administration, Department of Health, Education, and Welfare, to establish both the anticipated residue level and the safety of that level.

That the Miller Amendment has been effective in assuring the public of a safe food supply is attested to by many who are intimately acquainted with its operation. For example, A. L. Miller, a doctor of medicine and congressman from Nebraska, who authored the Miller bill, has stated that passage of the bill "gives complete assurance that our food is safe insofar as agricultural chemicals are concerned.

"The American food supply, undoubtedly, is the safest in the world."

Dr. Bernard E. Conley, Secretary, Committee on Pesticides, American Medical Association, has said: "Pesticides play an important role in providing the nation's food supply and protecting the public health. Thanks to the Miller Amendment to the Federal Food and Drug Act the consumer is assured of an unparalleled degree of protection."

Use of pesticides has from time to time raised questions as to whether or not they affect the actual composition of crops. The literature indicates that comparatively few pesticides directly modify the metabolism or composition of the crops to which they are applied. There are, of course, a few exceptions, particularly among the herbicides. But since most pesticides remain on the surface of the treated crop and do not enter into the plant itself, no appreciable effect on the metabolism or composition would be anticipated. While higher quality produce normally results from application of pesticides, improvement is due to elimination of pests which reduce plant vigor or otherwise interfere with desired crop development, rather than to direct effect on plant metabolism. Effects of some herbicides on crop composition are considered to be due to a somewhat similar action, namely, elimination of the weeds which compete for plant nutrients and moisture in the soil, thus allowing a higher uptake by the valuable plant.

As noted, some herbicides have been found to affect plant metabolism in the crops to which they are applied, as well as in the weeds which they control. In many instances, these effects are noted only at comparatively high rates of application, far above those used commercially. Meade has reported that CIPC causes an increase in reducing sugars, invert sugars, and total sugars of corn plants, and also the amounts of reducing and nonreducing sugars in soybean plants. Cooke has reported that experimental application of 2,4-D to foliage of bean plants resulted in an initial increase in uptake of minerals from the soil but that after a period of time 2,4-D treatment resulted in inhibition of mineral uptake. He believes that this is related to rate of plant respiration. Menges and Aldrich found that application of 2,4,5-trichlorophenoxyethyl sulfate to tomato plants had no effect on the total nitrogen and acids at lower rates of application but that there was a tendency for nitrogen to be increased and total acids decreased at higher rates. They further found that phosphorus was decreased and sodium increased at all application rates studied but that the chemical had no appreciable effect on total carbohydrates, potassium, or dry matter of the tomato. Wort has compiled a comprehensive listing of the effects of 2,4-D on plant enzymes and vitamins when applied to various crops. He notes that the effect differs from plant to plant and also in the various organs of a given plant.

There have been many reports of 2,4-D's increasing the protein content of grain. In reviewing them, Willard, who has done some of the investigations himself, has stated, "In general, these effects seem physiologically to be like the increased protein content obtained in a dry season; that is, the protein elements in the grain are laid down first, and if the grain does not "fill" well, it will be higher in protein than one that does fill. Usually, at least, the protein per acre has not been increased by spraying."

Some other agricultural chemicals, which are not pesticides within the usual meaning of that term, have been found to affect plant metabolism and thereby the composition of the produce obtained from the plant. A few are being used commercially while others are being further investigated. As examples, lead arsenate is used on

grapefruit to retard the development of acid; potassium gibberellate has been found to increase juice content 9% and vitamin C content 13% when applied to Thompson navel oranges. The latter treatment was found to cause no differences in sugar content, total acids, puffiness, size, weight, or tendency to drop. Certain other chemicals such as 2,4-D are used to prevent premature drop of various fruits, thus allowing full and mature development of the fruit.

There is no question that the use of pesticide chemicals has substantially influenced the American diet and contributed to the health and welfare of the consumer. There can only be a question as to the exact extent of their contribution and influence.

On this point, Hazel K. Stiebling, Director, Home Economics Research, Agricultural Research Service, USDA, has written: "We have in this country today a food supply characterized by variety and abundance. Our markets offer generous supplies of foods in sanitary condition, of good nutritive value, of high table quality, and at prices that are reasonable in relation to income.

"According to Dr. H. L. Haller, U. S. Department of Agriculture, the judicious use of pesticide chemicals is essential in giving us this safe and abundant food supply. These materials help to give us an opportunity unparalleled in history to choose the kind, the quantity, and the form in which we want our food and to select diets that are nutritionally adequate to safeguard health."

The changes in the American diet and the contributions of pesticides toward its upgrading were well summarized by Congressman A. L. Miller, who, as former Director of Public Health for Nebraska, and sponsor of the Pesticide Residue Amendment, has been particularly interested in the safety and quality of our food supply. He has stated: "The average person's diet now contains 15% more calcium, 25% more riboflavin, 20% more thiamine and niacin, 15% more iron, about 5% more protein and 5% more of vitamins A and C, than it did 25 years ago.

"The American diet is better because we eat more milk products, meat, poultry, eggs, vegetables and fruits, but it is still not the best possible.

"As I have pointed out, we now have 5% more vitamin A and C in our average diet. However, dieticians feel that this should be increased considerably. These vitamins are found in leafy green and yellow vegetables and citrus fruits. These crops could never be produced in sufficient quantity without the use of agricultural chemicals, for these specialty crops are highly susceptible to infestation and complete destruction by various pests. Of the more than 80,000 kinds of pests in the U. S., about 7,000 are injurious to crops. Over 80 high vitamin crops could never be produced without the use of agricultural chemicals."

Now for a brief look at the future.

We believe that the use of pesticides in agriculture will expand, not at a uniform rate but with a definite upward trend. The increased population predicted for the future makes this an absolute necessity since more food must be produced to feed more people.

While there are studies under way on the possibilities of utilizing algae or other aquatically grown plants as foods, of synthesizing foods chemically, or converting cellulose and other materials into food, these do not appear to be the immediate answer to the increased food supply problem. Rather, the nation is faced with a choice between producing more food per acre or putting more acres into production.

Most authorities agree that there is little hope of increasing the total number of acres for food production. While some new land may be put into agriculture each year by reclamation, clearance, or irrigation, an equal or greater amount is lost to homesites, highways, airports, factories, and other nonagricultural purposes. Without going into all the factors which may be responsible, the fact remains that the acreage of land used in 1957 was the lowest since before 1920.

Since significant amounts of additional cropland are not available, increased food production must be obtained from present acreage. This can be done only if pesticides are more widely used. While pesticides have reduced agricultural losses and increased yields considerably to date, there is still much that can be done in this regard. Authorities still estimate losses due to pests to be as high as $13 billion annually.

An interesting report covering both phases of this matter was issued recently by the Colorado Experiment Station. It pointed out that for each dollar spent by Colorado farmers for insect control in 1957 they realized a return of $23.00. Growers of potatoes, tomatoes, wheat, lettuce, corn, and beans spent a total of $1,084,000 to prevent insect damage and by so doing gained an estimated $23,368,000 in value of undamaged crops. The report further points out, however, that insects caused losses exceeding $7 million to unsprayed crops.

In addition to the over-all increase in the use of pesticides, we anticipate a further increase in the use of systemics, pesticides which are absorbed into the plant or animal circulatory system and protect against various pests, internal and external.

We expect an increased use of other agricultural chemicals, such as defoliants, desiccants, and plant regulators. The first two will permit harvesting at the desired time, allow mechanization, reduce harvesting costs, obtain greater yields, reduce insect damage, and generally increase production efficiency. Plant regulators will be used to promote fruit set, thin blossoms, prevent premature fruit drop, affect dormancy, delay or promote maturity, influence harvest time, and otherwise alter the normal physiological processes of plants toward the ends of increased yields, higher quality, lower costs, and increased operating efficiencies.

We believe that there will be increased attention to the control of soil insects and nematodes. The losses which these pests cause have only been recognized within the last comparatively few years. Pesticides for the control of these organisms offer new opportunities to reduce losses and increase yields.

We look for an increased trend toward use of combination products containing pesticides along with other farm chemicals, such as fertilizers. Under proper conditions, such products can contribute toward increased operating efficiency.

We also anticipate an expansion in the use of post-harvest pesticides to protect agricultural products during storage, transportation, and marketing.

Pesticides and other agricultural chemicals have already had a great impact on food production and consumption, and have greatly influenced the American diet. We believe that these chemicals will be used to an even greater extent in the future, and will make even greater contributions toward improvement of agricultural efficiency and upgrading of the American diet.

Based on a paper delivered before the 134th meeting of the ACS on Sept. 8.

JOSEPH A. NOONE, technical adviser to NAC began his career as a chemist with Pennsalt, advancing to chief chemist and supervisor of regulatory and consumer safety phases of marketing. A chemical graduate of St. Joseph's College, in Philadelphia (his home town), Noone studied chemical engineering at Drexel Institute and law at George Washington University. He joined the NAC staff in 1949.