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The New Research in Pesticides[1]

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Highlight

Agricultural pests cause tremendous losses and they must be controlled. Pesticides are essential but in using them adequate safeguards and operational procedures are necessary to protect against possible adverse effects on man, animals, plants, fish, wildlife, and other values in man's environment. Interim and expanded research is underway to curb the side effects of pesticides. Several new research approaches are being followed in attempts to control a wide range of pests.

Blights, plagues, weeds and insects have always dogged man's attempts to produce food, feed, and fiber. Sometimes he has been able to control the pests. Often when he has not been able to do so, society has suffered and, on occasion, much of it has perished. Take for example the potato late-blight disease in Ireland which in 1845 and 1846 all but destroyed the potato crops. The potato crop was, and still is, a major source of food for the island. At least one million people died from starvation or from disease caused by poor nutrition. Farmers today can prevent such tragic and serious losses from plant disease epidemics.

Year by year, despite an abundance of hand labor, crop plantings are lost in the tropics and other regions of high rainfall because of heavy weed competition. Some crops can no longer be grown in places that have become infested with such perennials as nutsedge, quackgrass, Johnsongrass and field bindweed. Rangelands and other grazing lands are frequently so overrun with brush or poisonous plants that livestock production is no longer profitable. Herbicides, combined with other methods, offer a new tool to push back the invaders that threaten agricultural production in many areas.

Insects ravage food and feed crops. They transmit diseases to plants, animals, and man, and constitute a nuisance in man's environment. Insecticides have made possible the enhancement of the quality and amount of agricultural products and they protect the health of people against such diseases as malaria, typhus, and yellow fever.

History is replete with examples of the ravages of pests. In situations where other methods were ineffective and uneconomical, necessity has forced farmers and ranchers to adopt chemical methods for controlling weeds, insects, nematodes, and plant and animal diseases. Since 1940, more effective pesticides and more knowledgeable use of them have revolutionized American farming methods. This revolution, based on technological progress, has increased farm output by 60%. Today one farmer can feed 26 people, whereas in 1940 almost 8 million more farm workers were needed because of the farming techniques, crop varieties, fertilizers and pesticides available at that time. Pesticides have made a major contribution to this dramatic increase in efficiency.

Pesticides are essential, but in using them we must assure the public of operational regulations to safeguard and assure the wholesomeness of our food, feed, and drinking water, and to keep airborne fumes and pesticide spray from endangering health. I am pleased to report that an interim and expanded research effort is underway to curb the side effects of pesticides.

Pesticide and Pest Control Programs

One important fact should be stressed. Of all the countries in the world, the United States has the most comprehensive law enforcement to insure the safe use of pesticides. Our pesticide safety program has been promulgated at both the Federal and State level, and the cooperative effort of industry and agriculture has made it effective. The program is a good one. It is so based in fact and logic, and so tempered with extra precautions to eliminate or to minimize hazards, that it needs no defense. Yet, we do have to defend it. We have to defend it in reply to those who say it is too cautious as well as those who say it is not cautious enough. Not only is the program being continually strengthened by new findings but its educa-

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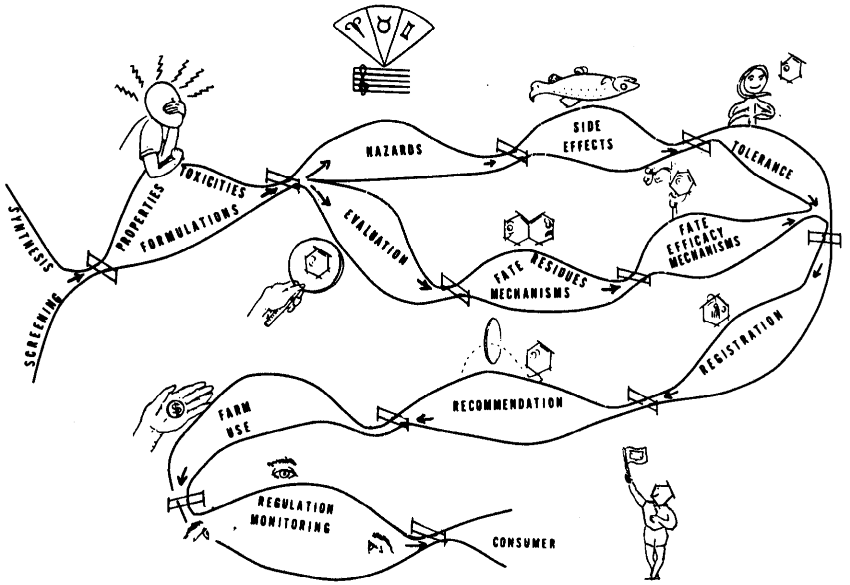

FIGURE 1. Pesticide Obstacle Course. Many hurdles must be overcome before a pesticide is marketed and used by ranchers and farmers.

tional activities are emphasizing pesticide safety more and more.

Scientists know of no instance of human cancer caused by registered pesticide. Despite widespread use of pesticides, the wildlife population is in many instances increasing. We must make doubly certain that pesticides are not hazards through contaminating our ground water, streams, and lakes, and that residues and degradation products in the environment have no real significance. Research must be continued, to improve pest-control procedures by chemical, biological, cultural, and whatever other methods may be needed to render pest control entirely safe.

To insure the safety and effectiveness of the pesticides used in this country, many painstaking procedures are already followed (Fig. 1). These involve an increasingly difficult obstacle course for pesticides before they reach our farms and ranches. To determine whether a pesticide will pass or not pass the requirements of this obstacle course, many scientists and private and public agencies are making their essential contribution. Each of these obstacles represents an assessment of the usefulness, or the safety, or both, of the chemical to be offered for sale to ranchers, farmers, and others.

The first contribution is made by the chemical industry which synthesizes, screens, and discovers the biological activity of a new compound and determines — sometimes cooperatively with scientists in public institutions— that it has utility for controlling weeds, plant diseases, insects, nematodes, or other pests. Research determines whether it may be acutely toxic to animals, and its chronic effects—whether it is likely to leave residues on food or feed, or to have a harmful effect on fish and wildlife, or their habitat.

Along with the work done by the chemical industry, scientists in public agencies are making an intensive study of the effectiveness of the potential pesticidal compounds for controlling specific pests. They determine the dosages required, as well as the best method of application for maximum effectiveness at the smallest dosage, at the least cost, and minimum least adverse side effects on other values in the environment.

Research is also being conducted on selected pesticides to determine their mechanism of action, their degradation in plants, animals, soil or water; and their beneficial or possibly adverse effects on fish and wildlife. Many agencies are involved in this effort.

There are a number of approaches to the control of pests.

Nonchemical techniques have been employed throughout recorded history. The mechanical control of weeds and insects, crop rotation for the control of a number of pests, cultural and management practices such as plowing, cultivating, reseeding, managed grazing, and the breeding and selection of plants resistant to pests are not new. Natural predators and parasites continually suppress certain pests; considerable emphasis is placed on introducing the natural parasites and predators for some of our more formidable introduced insect and weed pests.

Since 1940, as we have said, chemical pesticides have offered the greatest potential for combating crop and livestock pests. Undoubtedly, pesticides will continue to play an important part in American agriculture.

Progress with chemical control hinges on various principles of selective toxicity. That some substances affect only certain species is paramount in all branches of biological control. It is the basis for synthesis and formulation of effective herbicides that kill weeds and leave the crop unharmed, and of insecticides and fungicides that do not injure the host plants.

Selectivity, in the use of herbicides and pesticides in general, is important not only in relation to the pest and the crop or animal to be protected, but it is absolutely essential to these. From a broad and desirable viewpoint, selectivity amounts to killing the pests without injury to any beneficial forms of life, and man above all. For example, herbicides are selective because they kill some plants without injuring others. This is one kind of essential selectivity. But they should also be required to kill weeds without injuring man, domestic animals, wildlife, and fish.

New Research Approaches

Research on pesticides has recently been intensified to develop application methods that completely prevent or drastically reduce the chances of contaminating environment.

I would like to cite examples of research now underway and on which progress is being made.

Reduction of Spray Drift.—The drift of sprays and dusts of pesticides from target areas has long been recognized as a problem. When 2,4-D was first used commercially almost 20 years ago, the drifting of sprays and dusts to cotton fields and vineyards was a critical problem. Difficulty is still encountered in using this compound, but generally speaking, guidelines have been established to permit its safe use to control weeds without harming susceptible crops in the vicinity. Similarly, the drifting of insecticides to non-target crops and pastures has sometimes produced residue problems.

Research is being conducted by both private and public agencies to devise principles, formulations, and equipment for the distribution of pesticides which eliminate or minimize contamination of bordering non-target areas. For example, a 100-ft boom sprayer at Woodward, Oklahoma, permits spraying about 250 acres per 10-hour day of rangeland for brush and weed control. Spray drift is markedly reduced as compared to that of aerial application.

Special applicators have been devised for helicopters and other aircraft to deliver invert emulsions of sufficient droplet size and uniformity to reduce drift.

Granules of pesticides have been developed with sufficient specific gravity that target areas can be hit, but without drifting to adjacent areas.

A more recent development is the use of a finely-ground water-swellable polymer that absorbs water solutions of particular pesticides and can be sprayed as discrete pre-sized particles that do not drift appreciably.

Reducing Dosage and Minimizing Residues.—Where treatment of the soil rather than plant foliage is the objective, use of granular formulations promises to reduce residue problems. Granular formulations are available which do not adhere to the foliage but which roll off to be deposited on the surface of the soil in sufficient concentration as to prevent the growth of small annual weeds and germinating weed seeds. Granular formulations may also be used to control insects that inhabit or crawl on the soil.

Surfactants, solvents, and various other spray additives are being studied in relation to pesticide selectivity and dosage reduction.

Some of these substances increase toxicity of a herbicide several-fold. In other instances toxicity is unaffected. Under some conditions, toxicity of one herbicide may be increased by a given surfactant, whereas the activity of another herbicide may be reduced by the same surfactant. These effects of formulating agents can be exploited to achieve the desired pest control, yet reduce hazards to other values in the environment.

Residual toxicity of herbicides and other pesticides in the soil can be markedly affected by solvents and formulating agents. For example, the solvent and carrier of the herbicide EPTC affect the persistence of the herbicide in the soil. EPTC persists for a much shorter period where kerosene rather than xylene, acetone, and other carriers are used. The differential effects of formulating substances on the behavior of herbicides and other pesticides can be exploited to develop methods for selective control of pests and to minimize residues of pesticides in the soil.

The use of a surfactant with diuron for the post-emergence control of weeds in cotton has made possible the lowering of herbicide dosage from 1 to ½ pound per acre. Costs to the grower and soil residue problems are both reduced.

Reducing Volatilization, and Dosages, and Increasing Effectiveness of Pesticides.—Techniques and principles of applying pesticides are being developed to prevent loss of pesticides to the air by volatilization, and to reduce the amounts required for pest control.

For example, volatile herbicides may be applied with precision in subsurface layers to obtain weed control at lower dosage, and without volatilization to the atmosphere. The technique is illustrated as follows. The row of the crop is divided into 3 bands: (A) the drill or point where the crop seeds are planted; and (B) and (C) the left and right shoulders of the row, respectively. Successful use of this technique involves the subsurface application of the herbicide EPTC on each side of the drill of cotton and a preemergence surface application of diuron over the planted cotton seeds. These treatments can be made with special applicators mounted on a tractor that prepares the seedbed; applies the EPTC subsurface; packs the seedbed; plants the cotton seed; repacks the seedbed; and applies diuron to the soil surface directly over the planted seed. Good control of the perennial, nutsedge, and annual weeds is achieved.

Equipment has also been developed which will apply a soil fungicide only to a spot over seed planted in hills. Soil borne disease organisms can be controlled, yet unnecessary treatment of other soil in the field can be avoided.

Mechanism of Action and Metabolism of Pesticides. — Increased attention is being given to gaining an understanding of how pesticides work to kill pests. Their fate in plants, soils, animals and insects is also being explored. For example, the ARS has recently initiated a program of research on the metabolism of pesticides in plants, animals, and insects in a new $2 million facility at Fargo, North Dakota. Publicly-supported basic research along this line is being conducted at a number of other institutions.

An example of the progress already made towards selective toxicity is based on differential biochemical processes in plants. For example, some plants will convert within the plant, by beta oxidation, the herbicidally inactive 4-(2,4-DB) to the active 2,4-D and thereby be killed. Other plants that do not possess this ability are not killed. Other compounds may be detoxified by certain plants and not by others. For example, corn plants detoxify the herbicide, simazine, to a non-phytotoxic compound but most weeds are not capable of biochemically detoxifying simazine and are killed. Such understanding of how herbicides act to kill or not to kill plants provides bases for the development of highly specific chemicals to control pests without adverse side effects.

Degradation of Pesticides in Soil and Water.—Increased research is seeking to determine the behavior and fate of pesticides in soils and in water—how long different pesticides persist in different soils; how they move in soils; how they are broken down; and the nature of degradation products. Specific soil organisms that break down pesticides are being studied and pesticide effects on organisms determined.

Table 1. Number projects on file at Science Information Exchange, Smithsonian Institution, dealing with pesticides, October 1964.

Nature of Project	No.
Effects or fate of pesticides	
Domestic animals	9
Fish	12
Man	4
Plants	200
Soil	76
Water	22
Wildlife	28
Develop chemical control of—	
Insects	116
Nematodes	56
Plant Diseases	229
Weeds	205
Other pests	52

Monitoring programs are soon to determine the levels of pesticides already in agricultural soils and the changes that occur after application, whether by farmers or custom applicators. They will also determine the amounts present in waters that may adjoin areas subject to heavy pesticide treatment. Non-agricultural agencies are involved in monitoring pesticide levels in foods, in potable water supplies, in streams, and in man and wildlife.

The magnitude of the research effort to determine the effects of pesticides is illustrated by the number of projects receiving Federal support now on file with the Science Information Exchange at the Smithsonian Institution in Washington, D.C. (Table 1). The number of USDA research projects dealing with toxic or residual effects of pesticides also gives a measure of this effort (Table 2). The relative research emphasis given different pesticides in the USDA program is shown in Table 3.

Many new projects not reflected in the tables are being initiated in 1965.

Table 2. Federal projects dealing with toxic or residual effects of pesticides, January 1965.

Effects on:	Number
Man	23
Animals	38
Animal Products	19
Wildlife	6
Fish	2
Beneficial Insects	7
Cereals	16
Oilseeds	2
Feeds & Forage	19
Fibers	7
Foods	6
Forest & Trees	10
Fruits	23
Nuts	2
Sugar Crops	5
Tobacco	7
Vegetables	15
Other Plants	19
Soils	21
Water	2
TOTAL	249

Table 3. Federal projects dealing with effects and fate of pesticides.

Pesticides	Number
Air Pollutants	14
Bactericides	84
Defoliants	18
Fungicides	111
Hormones & Growth Regulators	125
Herbicides	125
Insecticides	380
Nematocides	30
Other	9

The use of pesticides presents great challenges and opportunities. All avenues of controlling pests must be united and exploited with vigor. Entirely new principles and approaches need to be discovered and developed. Our procedures must be continually sharpened, to regulate sales and to insure the safe, effective use of pesticides. I am confident that the challenge will be met.