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Pros and Cons of Pests, Pest Control and Pesticides

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THE peoples of the so-called Free Western Sphere nations enjoy the highest standard of living, including the most abundant and varied food supply ever known to man in all his history. Obviously in the face of ever-rising populations, the mere preservation of the present nutritional status will depend upon further improvement in the already highly efficient standards of food production and conservation. This, of course, implies continued progress in all phases of modern technology, including pest control. Since plant and animal pests rank among the foremost causes of food destruction, food deterioration, and food contamination, the necessity of protecting growing crops and finished products from serious attack by insects, plant diseases, and other pests is recognised as inescapable from the standpoint of the quality as well as the quantity of the food produced.

Man and Pests

Since the average layman is prone to take for granted current standards of living, including a bountiful food supply, a brief review of the nature of these organisms man refers to as pests, as well as a survey of the magnitude and the significance of their activities, becomes an essential prerequisite to any attempt to justify the use of pesticides.

Nature recognises no such categories as pests, beneficial forms, wildlife, domesticated species, or the inalienable rights of man. In nature, every living organism is engaged in relentless competition with every other organism upon which its interest impinge. Man was and, in a sense, still is a part of that environment, but by virtue of a unique attribute called intellect, which enabled him to develop powerful tools capable of changing physical and ecological environments to suit his needs and whims, he has risen to a position of dominance and has set himself apart from other creatures. In his ascent, man selected, protected, and propagated certain plants and animals most desired by him. Other species detrimental to him or to the organisms he has chosen to husband he regards as pests to be suppressed or, if possible, exterminated. Man thus assumed unto himself the role of a manipulator of plant and animal populations without first acquiring a thorough knowledge of all the rules of the game.

Insects the Largest Group

Pests are simply living organisms distinguished from many other forms of life only by the fact that they have acquired the great displeasure of one of their chief competitors, man. Within practically every phylum, if not, indeed, nearly every family of the animal kingdom, can be found one or more species prized by man and one or more species that he regards as pests. Since the phylum Arthropoda is by far the largest group in either the plant or animal kingdom and the single class Hexapoda (insects) alone accounts for over 75% of the known species of animals, and since the writer is by training and experience basically an entomologist, it is only natural this discussion will bear heavily on insects and insect control. However, much of what can be said for and against insect control applies equally to the control of rodents, pestiferous birds, nematodes, starfish and other noxious animals.

Increasing Populations

Man's success as a dominant creature is evidenced by the fact that the world's human population has increased tenfold in the last 1,000 years. In the United States alone the population has risen from less than one million to over 170 million in some fifteen to twenty generations. Now, to clothe and feed this vastly increased population, a higher level of

agricultural production must be attained and maintained. At present a few fortunate areas are blessed, or, as some say, plagued, by over-production, but it must be borne in mind that without the benefits of pest control and other technological advances, there would be no surpluses anywhere. Scarcity would be the universal rule and definite shortages of some products would prevail even in these more fortunate nations. Furthermore, with populations increasing and the area of farm land decreasing, it will be only a matter of a few years until agricultural scientists and farmers throughout the world will have to make ever-increasing use of agricultural technology, including even greater efficiency in pest control, to meet the world's food and fibre requirements.

Notwithstanding Man's temporary and local success, the insects, plant diseases, nematodes, weeds, rodents, and their allies will not give up the battle. Man has annihilated whole armies of his own species, *Homo sapiens*. Civilizations have come and gone. But it is doubtful if man has ever exterminated, except in local areas, a single one of those competing species he calls pests.

Pests, the Common Foe

As civilizations come and go and as nations rise and fall, man, for some unexplainable reason seems so preoccupied with the internal conflicts between nations, races, religions and idealism in general that he has devoted only scant attention and limited resources to the eternal battle between all mankind and the combined forces of pestdom (all classes and species of pests). Historically, in times of war, nations find it possible to suppress internal strife in favour of unity of action against a common foe. What a pity that despite the constant reminders and admonitions of the scientific community, man, a supposedly intelligent being, seems unable or unwilling to recognize and to unite in an all-out effort against a common foe, pests.

After the tragedy of World War II it appeared for a time that such a goal might be attained through the United Nations and related organizations. Such agencies as F.A.O. and W.H.O. made substantial contributions to this end, but, alas, once again the emphasis seems to have turned from pest control to ways and means of self destruction. This is not to imply that individuals and nations should not be prepared to defend themselves against the aggressive acts of fellow human beings, but man's apparent ignorance of or indifference to the aggressive acts of his natural competitors and enemies, the insects, plant diseases, nematodes, weeds, etc., is incomprehensible. Man professes to deplore the ravages of disease and starvation in the

Pest control made major contributions to the military campaigns in the South Pacific where in some areas hardly a man escaped the ravages of the four major jungle diseases—malaria, dengue fever, typhus and dysentery. In malaria-control operations, helicopters were used to spray small or irregular areas where the use of conventional aircraft was impracticable

so-called under-developed or underprivileged nations and at the same time permits pests to spread human and animal diseases and to inhibit crop growth, devour growing crops, and even consume food reserves that could alleviate if not eliminate malnutrition and hunger.

Economically Important Species

Taxonomists have described approximately 1,000,000 species of insects, roughly half of which are phytophagous (feed on plants). Of course, many of these are currently of little interest to man because he has no basic interest in their host plants. At the same time, something in excess of 25,000 species are regarded as pests of crops and, as other plants potentially valuable for food or fibre production are brought under cultivation this number may be materially expanded.

In North America alone cultivated crops are attacked by over 3,000 economically important species of insects, an equal number of plant disease agents, and unestimated numbers of nematodes, rodents, weeds, and other competitors. In 1954 the United States Department of Agriculture estimated that to offset the pest losses in agricultural production, an extra 88 million acres must be cultivated, and that losses subsequent to harvest equal the production of an additional 32 million acres. Estimates of the destruction caused by agricultural pests in the United States made independently by several other agencies range somewhere between 8 and 15 billion dollars annually—a quarter of the nation's annual production—and this despite the widespread use of the best control practices now available. While extrapolations are hazardous and perhaps unwarranted, it would appear that to make a reasonable estimate of pest damage to crops on a worldwide basis the estimates cited would have to be multiplied by a factor of 5, perhaps 10, or even more.

Insect-borne Disease

For centuries the Black Plague, typhus, yellow fever, malaria, sleeping sickness and a host of other insect-borne diseases were dominant factors in retarding the ascendancy of mankind. In most of the great wars of history the casualties attributed to these diseases far exceeded those caused by arrows, bullets, shrapnel bomb fragments and poison gas combined. The full role that diseases spread by mosquitoes, fleas, lice, ticks, mites, flies and other pests have played in world history is still vague, and except for such examples as the death of Socrates, Cleopatra, and the early Christians in the Roman arena, even less is known of the impact of poisonous plants and reptiles, predatory beasts, fungi and other pests.

At the site of old Jamestown in Virginia, the U.S. Park Service has erected a tablet to remind generations yet unborn that in one of its darkest hours the strength of this struggling colony was reduced to six able-bodied men by the ravages of malaria, a mosquito-borne debilitating disease, that held forth in epidemic proportions over much of the world until well into the 1940's and is still rampant in some remote areas.

Damage Caused

Most home owners are well aware that the activity of pest organisms extends far beyond both food production and disease dissemination. Termites, wood rots, and many other organisms invade our dwellings, often causing serious damage necessitating costly repairs. Silverfish, mildew, rodents, and other pests damage and often destroy costly garments, works of art, and all sorts of fabrics.

Damage to forests both in reduced production and actual destruction of standing timber is enormous. Shade trees, ornamental shrubs, and lawns are subject to attack and at times the cost of replacing such plants and turf may exceed the cost of crop protection over large areas. For example, in the state of Florida, U.S.A., it is said that actual expenditures for the protection and the replacement of lawns destroyed by chinch bugs exceed the cost of pest control on all of the state's fruit and vegetable crops combined. Then, too, there are those intangible but nevertheless real and agonizing instances where nuisance pests, flies, pestiferous mosquities, black flies, ants, boxelder bugs and roaches make life miserable and at times preclude man's enjoyment of the great out-of-doors or the splendid recreation facilities made available for his use. Nor can we overlook the hay fever and asthmatic victims who suffer because the air they breathe is filled with obnoxious pollen, insect dust, etc. Understandably, the reader may ask if pests are so important to man's wellbeing, why have we indulged in coexistence all these years? The answer is by no means clear. Perhaps it is partly through ignorance or indifference, or perhaps because over the centuries such pests have been so common people have taken them for granted and accepted them as inevitable.

Centuries ago when the human population was scant and widely dispersed, with agriculture on a subsistence basis and a seemingly endless

supply of land available, farmers raised only feeble objections to share-cropping with insects and other pests. To assume that pests are of recent origin is fallacious, indeed. Many pest species are older than man himself and the writings of the ancients and the Bible are replete with references to locust plagues and the ravages of worms that invade putrified bodies, devoured woollen garments, and consumed the leaves of plants. The latter were frequently referred to as cankerworms, palmer worms, etc.

Factors Contributing to Prevalence

At times primitive man, either through choice or necessity, relied heavily on fishing and hunting to supply his basic food requirements. As the years passed, many factors have contributed to the increased prevalence and destructiveness of insects, weeds, fungi, bacteria, nematodes, viruses, and other pests:

(1) As farmers began to use the same fields over and over, the pests had less and less difficulty finding suitable host plants.

(2) After several generations certain pests which at first rarely attacked cultivated crops developed an appetite for the domesticated plants and as they became better and better adapted to the new environment they became increasingly destructive.

(3) In the breeding of crops for increased yields, uniformity, and many other desirable characteristics, man inadvertently eliminated many genes for pest resistance acquired through centuries of evolution, and at the same time increased the crops, susceptibility to one or more pests.

(4) Many pest species have been carried from one part of the world to areas where they were previously unknown and in the new environment, free of restraint by their natural enemies which were left behind, their ravages were enhanced many fold.

Obviously if all efforts to control pests were to be abandoned, agricultural lands would tend to revert toward their original or natural state in which their production would support no more than a scant human population, e.g. the North American continent which supported a more or less stable human population of about 1,000,000 in 1492, now has a population of over 200,000,000 people. If we were to adopt a policy of "Let nature take its course," as some individuals thoughtlessly advocate, it is possible these would-be experts would find disposing of the 200,000,000 surplus human beings even more perplexing than the disposition of America's current corn, cotton, and wheat surpluses.

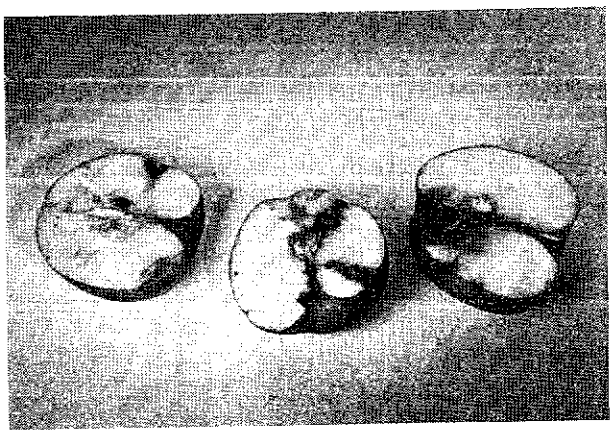
Control by Nature

Although hard pressed at times, farmers of the last and previous centuries had little choice but to rely upon nature to control the pests that were ravaging their crops and livestock. Then, as losses mounted and the standards of perfection demanded by an increasingly more discriminating consuming public rose, farmers generally began to clamour for scientific guidance in the solution of their pest-control problems. The early entomologists, botanists, horticulturists, and other agricultural specialists were essentially naturalists. They preached a gospel of biological and cultural pest control methods and for years such measures dominated all pest-control endeavour, for these early officials had no other course open to them. Diligent efforts were made to control insects, plant diseases, weeds, and other pests by good cultural practices. Even now, insofar at it is practical, farmers utilize cultural practices, observing planting dates that will be most unfavourable for specific pests and planting varieties of crops that are resistant to diseases and insects. The introduction and dissemination of parasites, predators, and disease organisms have proved advantageous in controlling some insects, but such practices have very definite limitations.

Use of Chemicals

As the need for better pest-control grew, it became increasingly apparent that natural and cultural control measures alone were grossly

80% of the fruit produced on this unsprayed tree, all badly infected, lies rotting on the ground. Apples remaining on the tree are fairly sound and edible, but so badly infected that they could not be marketed as sound fruit



Insect- and disease-infected apples usually fall to the ground prematurely

inadequate. In desperation the farmers themselves turned to the use of all sorts of chemical concoctions. The successful control of the Colorado potato beetle by the application of a paint pigment, Paris green, in 1867, and the control of mildew on grapes through the use of Bordeaux mixture in France about 1880 introduced the use of chemical pesticides and scientists reluctantly were forced into the position of following the farmers' lead. Thus, we entered an age of chemical pest-control.

The rise in pesticide usage has been closely associated with and has run parallel to advances in farm mechanization. Thus, in these days of automation and labour-saving devices, many farm managers have come to regard pesticides as chemical tools and they think of them in the same light as mechanical tools.

Effect of Damages by Pests

Many crops have not been successfully produced, at least on a commercial scale, without the use of insecticides since about 1880. It is not known exactly what would happen if the use of pesticides were to be prohibited or abandoned, but it is safe to say most fruits and vegetables either would totally disappear from the market or the price of the meagre quantities produced would soar to levels where they would be classed as luxuries available only to the rich. From valid studies conducted over the years in America, England, and elsewhere it has been observed that apples produced without pesticide protection will be 40 to 80% damaged by codling moth and/or 30 to 80% damaged by apple scab, and that there will be an equal or even greater amount of damage to fruit caused by innumerable other insects and diseases. To this must be added the destruction wrought by wood borers, scale insects and other pests that result in the devitalization and eventual destruction of the trees themselves.

Lowered Yields

Without the benefit of pesticides, the yield of many staple fibre, cereal, and forage crops could be expected to drop by from 10% to as much as 25%. In two separate studies data accumulated by the United States Department of Agriculture over periods of 34 and 20 years showed that the omission of insecticide treatments reduced cotton yields 25.5% and 41.8% respectively. Agronomists have demonstrated that in general, an acre of land is able to produce only a certain amount of dry matter in any given season. Therefore, whatever is wasted in weed production must be subtracted from the potential production of the crop. With weeds partially uncontrolled, crop yields would certainly be reduced, and with weeds completely uncontrolled, yields would be nil.

Farming is Big Business

There are those who say that man should revert to the use of those partially effective control methods used before the advent of pesticides. That is impossible. Farming has risen to the status of big business. Modern agricultural practices demand maximum efficiency. Unlike conditions 20 to 30 years ago, capital investments on farms today are so large farmers can no longer afford even occasional crop failures and still stay in business. With labour costs at current levels, the days of the hoe, hand picking of potato bugs and the maintenance of dusty furrow barriers for the control of chinch bugs and armyworms are gone forever.

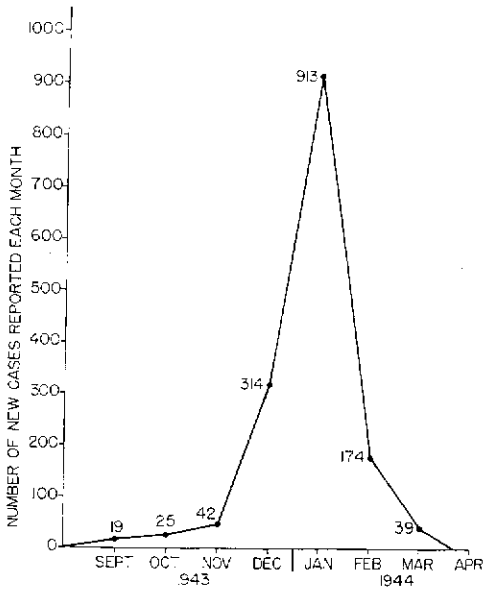
Consumer Benefits from Pesticides

All too often the lay public and some scientists condemn the use of pesticides as an unwarranted practice imposed upon society by selfish industrialists and farmers who seek only personal gains and larger profits. That is not the case. For several reasons it is the consumer who benefits most from the use of pesticides:

(1) With greater efficiency attained through higher production per acre, reduced losses, and reduced labour costs in grading and sorting, the cost of production has been reduced and competition for available markets has forced the price of fruits, vegetables and other agricultural products downward. Today in

America, at least, the consumer spends only about 20% to 25% of his income for food, whereas only a few years ago about 60% to 70% of the worker's weekly pay was required to meet his family's food requirements. This is true despite the fact that there has been an abrupt rise in packaging, transportation, marketing, and distribution costs.

(2) There is much less waste in the home kitchen where in years past culling and trimming food damaged by insects, mould, and rot accounted for losses ranging up to one-third or even one-half of the food purchased. Then, too, under existing laws in the United States and many other countries, it would be impossible for the consumer to buy most of the foods displayed daily in the supermarkets and other food stores if pesticides had not been used in their production. Section 402 of the U.S. Food, Drug, and Cosmetic Act clearly indicates that food contaminants may be either biological or chemical in nature. Each year the Food and Drug Administration seizes thousands of tons of food as unfit for human consumption, and roughly three-fourths of all these seizures are attributable to "filth or decomposition," which, of course, includes the presence of insects, insect fragments, mould, rot organisms, etc.



Course of the Naples typhus epidemic 1943-44. Use of DDT began about 1 January, 1944. The population was treated at the rate of 50,000 to 100,000 individuals a day until well over 2 million persons had been deloused

Eliminating the Corn Borer

At this point it might be well to cite an instance in which the elimination of biological contamination necessitated the use of chemicals. When the European corn borer was inadvertently introduced into the United States about 1908, emtomologists went to work in an attempt to find some weak point in its biotic requirements that would suggest possible means of controlling the pest, and each lead developed was pursued by other scientists (agronomists, agricultural engineers, botanists, bacteriologists, chemists, geneticists, etc.). For over 20 years their efforts were devoted to the investigation of cultural control practices—the search for resistant varieties of corn, the evaluation of different planting dates, the introduction of parasites, and other non-chemical methods of insect control.

Combinations of the more promising practices were helpful in reducing damage, but were totally inadequate to provide the desired degree of corn borer control. When it became impossible for sweet corn canners in the midwest to process corn without permitting a few borers to get into cans, the Food and Drug Administration seized quantities of canned corn which contained borers or borer fragments as adulterated (contaminated) and unfit for human consumption. It was then and only then that insecticides came into the picture.

This example could be multiplied a hundredfold, e.g., fruit flies in cherries, blue berries, or tomatoes, insects or insect fragments in fruit products, including cider, insects in grain, insect fragments or rodent hairs in flour and other cereal products. Actually, the mere presence of flies, roaches, rodents, or other vermin in flour mills, canneries, bakeries, or milk processing plants may subject such plants to punitive action by one or more regulatory agencies.

Value of Insecticides

Perhaps the benefits derived from the use of insecticides have been most spectacular in the public health field, where through the control of lice, mosquitoes, fleas and other vectors, the reduction in the incidence of typhus, malaria, and many other insect-borne diseases has been phenomenal and irrefutable.

One can only speculate as to the ultimate course of the typhus epidemic raging in Naples in the winter of 1943-44, had it not been for the timely development of DDT which was used generally to dust the bodies and treat the clothing

of the entire civilian population and the military personnel.

Recall also that in Greece and Italy as late as the early 1940's the number of cases of malaria exceeded a half million and the number of deaths ran into the thousands annually. The concerted use of DDT for spraying homes and to some extent for larvicidal purposes practically eliminated the incidence of malaria, and the death rate from this disease became negligible within a very few years, e.g. in Greece the death rate dropped from about 4,000 in 1944 to 7 in 1951.

While all of the credit cannot be attributed to DDT alone, it is well to recall that prior to the advent of DDT, malaria ran rampant despite the use of water-level control and of predaceous fish, oil and Paris green for larval control. Reliance should not, of course, and in some cases cannot be on pesticides alone to solve pest-control problems, e.g. in the case of fly control; in the absence of good sanitation flies are produced faster than they can be knocked down with chemicals. Likewise, a few years ago in some newly developed suburban areas clover mites invaded new homes by the billions and became a source of extreme annoyance to housewives. It was found that the elimination of grass, clover, and weeds next to the foundation of the house so as to leave a strip of bare soil 18 inches wide reduced invading populations by 95% to 98% and the use of appropriate acaricides on the vegetation also reduced the number of invaders to a comparable degree. Neither method alone provided the desired degree of mite control but a combination of both procedures turned the trick. This trend toward integrated chemical, biological, and cultural practices is gaining in popularity in many areas of pest control.

Public Health and Pesticides

When DDT and at least a dozen other new chemicals became available for general use, a number of competent and distinguished scientists expressed concern that the widespread use of these materials might create a public-health problem. Immediately a number of publicity seekers and misguided individuals seized upon the idea that the public was being poisoned and their apprehension precipitated an amazing flood of scare stories. Then, as the general public began to show some concern, a *bona fide* witch hunt got underway in earnest. As absurd charges and countercharges were hurled back and forth in legislative halls and in the press, the scientists settled down to a detailed analysis and factual study of the problem.

The public-health aspects of pesticide usage were reviewed by several scientific bodies, notably the World Health Organization, the U.S. Public Health Service, the Ministries of Agriculture and Fisheries, Health and Food in Great Britain, and the Food Protection Committee of the National Research Council in the United States. The general conclusions drawn in each instance were: (*a*) the large-scale usage of pesticides in the manner recommended by manufacturers or competent authorities and consistent with the rules and regulations promulgated under existing laws would not be inconsistent with sound public-health programmes, and (*b*) although the careless or unauthorized use of pesticidal chemicals might pose potential hazards requiring further consideration and study, there was no cause for alarm.

Misuse of Insects

These encouraging conclusions notwithstanding, the fact that insecticides may be misused remains a matter of concern to a considerable segment of world opinion. This is true particularly of certain groups of food faddists and conservationists—the latter quite justifiably so, because admittedly many forms of wildlife are subjected to certain potential hazards not shared by man and his domestic animals.

Before attempting to enumerate or evaluate the various real and imaginary hazards inherent in the use of insecticides, a few more or less axiomatic principles must be recognised and rather thoroughly understood. In the first place, practically all insecticides have toxic properties and are at least to some extent toxic to warm-blooded animals, including man. If they did not have these properties, they probably would not control insects and therefore would not be used as insecticides. The fact that most insecticides are toxic to man and animals does not necessarily mean that they cannot be used safely. If a proper respect for the toxic properties of a substance is developed it may frequently be used with greater safety than a much less toxic substance which is apt to be handled carelessly.

Hazard and Toxicity

A careful distinction must be drawn between the terms hazard and toxicity. As the Food Protection Committee of the National Research Council (U.S.A.) has repeatedly pointed out: "Toxicity is the capacity of a substance to produce injury; hazard is the probability that

injury will result from the use of the substance in the quantity and in the manner proposed." To be reliable, any estimate of the hazard involved in the use of a particular substance must be based not only upon a knowledge of its inherent toxicity, but upon the details of its proposed use as well. If confusion is to be avoided, it is necessary also to distinguish between use or operational hazards and residue or food contamination hazards. In other words, the hazards associated with residues and food contamination may not be related to and should not be confused with the occupational hazards associated with manufacturing or application practices.

In general, use or occupational hazards are related to and may be measured in terms of the acute toxicity (response to a single exposure or dose) of the pesticide and the degree of exposure to it. There is also the possibility or probability that men engaged in the manufacture, processing, or application of a pesticide or pesticidal chemical will be injured or seriously affected by the substance, either through normal use or accidents and carelessness in handling the material, e.g. many organo-phosphate insecticides pose hazards to the user, but residues may be negligible. Some other aspects of operational and related hazards will be discussed later.

Insecticide Residues

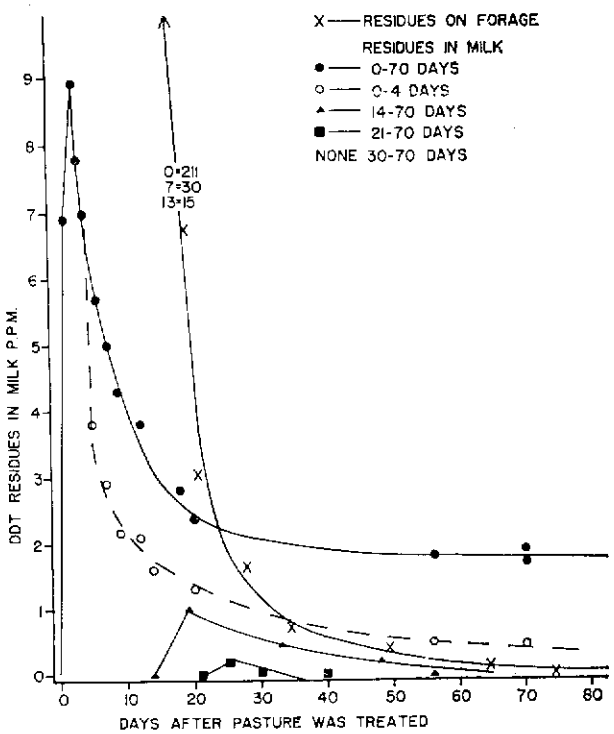
Insecticide residue or food contamination hazards are, in general, closely related to and may be measured in terms of the chronic toxicity (response to continued or prolonged exposure or intake) of the chemical and the amount of the residue appearing on or in the food as it reaches the consumer. The inherent toxicity of an insecticide or an insecticidal chemical to warm-blooded animals may have little or no direct bearing on the final food contamination hazards. Very often the most toxic materials can be and are applied at a time or in a manner that would not endanger foods and, as a rule, such chemicals are applied in proportionately smaller amounts than are less toxic materials. Also some of the most toxic compounds are short-lived—in other words, they are quickly destroyed through chemical change or lost through evaporation. Most countries now have laws or voluntary imposed regulations that are more than adequate to protect food supplies against the possibility of contamination to a point where it might become a hazard to the health of the consumer. In the United States the Federal Food, Drug and Cosmetic Act of 1938, as amended by the Miller Bill, provides for pre-testing and the establishment of safe tolerances before a new pesticide intended for use on food crops can be placed on the market.

Establishing Tolerances

In establishing tolerances it is generally conceded that safety factors ranging from 10- to 100-fold have been included in the overall evaluation of data on performance, residue persistence, and toxicity. At times such factors have been superimposed one upon another to such an extent that the possibility that an actual hazard may exist is fantastically remote. Insofar as the safety of food supplies is concerned the

Insecticide residues (p.p.m.) immediately and 2 weeks after spraying at normally recommended rates and residues (p.p.m.) in feeds animals have consumed for weeks (indicated) without showing any serious ill effects

Insecticide		*Methoxychlor*	*DDT*	*Dieldrin*	*Aldrin*	*Heptachlor*
Rate used, pounds per acre ...		2	1½	1/4	1/4	1/4
Initial residues, p.p.m.		125	100	20	10	10
Residues, 2 weeks, p.p.m. ...		15	10	1	1	1
Animals	*Weeks*			*Rates Fed, p.p.m.*		
Cows	18	7,000	200	75	40	200
Steers	16	—	100	25	25	25
Chicks	7	—	250	50	25	25
Rats	26	—	400	50	50	50



DDT residues on forage and in milk of cows turned into a treated pasture at intervals of 0, 7, 14 and 30 days after treatment. (see page 17)

record speaks for itself. There have been no authenticated cases of illness, let alone deaths, attributable to residues on foods when pesticides have been used according to directions. Furthermore the number of cases of poisoning presumably resulting from the consumption of foods grossly contaminated by entirely improper applications of pesticides have been remarkably few and far between, e.g. 11 persons were made ill after eating mustard greens having an average residue of 100 p.p.m. of pesticide x (a compound in use for 50 years) which had a tolerance of 2 p.p.m. In another case the members of two families became ill after eating greens bearing residues of 3,200 p.p.m. of a common chlorinated hydrocarbon insecticide which had a tolerance of 7 p.p.m. No deaths or permanent afflictions occurred in either case.

Thus, it is evident that residues many times larger than the established tolerance, while illegal, do not necessarily mean or even imply that dire consequences would follow the consumption of such produce.

Unfortunately there have been a number of regrettable instances involving serious illness and some deaths resulting from the direct gross contamination of foods in instances where cooks or their helpers mistook unlabelled pesticides for food ingredients, but here again the amount of the pesticide in the food might better be recorded in terms of percentage than in parts per million.

Reliable Instances of Toxicity

Some of the confusion which prevails arises as a result of possible errors inherent in the conversion of data from one category to another. Inherently the most reliable indices of toxicity are stated as mg./kg. of bodyweight for the test animal, but pesticide residues and much of the data on rates of toxicant intake are stated in terms of parts per million of chemical on the product or in the diet. In attempting to extrapolate data from one species to another, or even from young to mature specimens of the same species, writers often fail to note that the rate of food intake in terms of bodyweight varies greatly with the size and rate of growth both within and between species. Thus, if insects, mice, rats, sheep and steers all received a diet containing 1 p.p.m. of a toxicant, in terms of mg./kg. their rates of intake would be in the order of 1.0, 0.15, 0.05, 0.04 and 0.03 respectively. Assuming they were equally susceptible to the toxicant and 1 p.p.m. was the amount required to kill the insect, it would take 7, 20, 25 and 33 p.p.m. respectively, to kill the other species. In some cases the range might be even greater depending upon the age, sex, and physical condition of the individual concerned.

Pesticide manufacturers and users frequently are accused of using the human race as guinea pigs, which is by no means true. They do, however, rightly contend that since tolerances are based on chronic toxicity studies involving life-span or at least long-time feeding studies, the occasional ingestion of some one item in the diet bearing a residue slightly above or possibly well above the established tolerance will not endanger the life or health of an individual. True, such products are illegal and should not be condoned, but occasional incidents do not pose a public-health problem. Be that as it may, one wonders if present-day pesticide residues can possibly do as much damage to human health and well-being as does the state of hysteria that has been created through ill-advised publicity and sensational journalism. Why are we not concerned about hypertension as a factor in nervous disorders and heart ailments, malnutrition resulting from failure to eat certain foods, or faulty digestion and assimilation attributable to apprehension and an ever-present fear that poison abounds in every morsel of food placed on the table?

Number of accidental deaths in the United States, 1956

Cause	*Number*	*Percentage*
Miscellaneous	52,517	55.38
Motor vehicles	39,628	41.77
Poisonous substances	2,635	2.78
Pesticides	152	0.15
Total	94,780	100.00

Accidental deaths in the United States (1956) attributed to pesticides in groups indicated.

Pesticide	*Number of deaths*	*Percentage of total*
Arsenic compounds	54	36
Other pre-DDT compounds ...	40	26
Miscellaneous and unnamed ...	30	20
Organo-phosphate compounds ...	16	10
Chlorinated hydrocarbon compounds	12	8
Total	152	100

Laws and Regulations

Returning again to the question of operational and related hazards, it is found that in addition to laws and regulations pertaining to residues in foods, many countries have laws and/or regulations governing pesticide labelling comparable to those prevailing in the United States. The U.S. Federal Insectidice, Fungicide and Rodenticide Act of 1947 provides that no pesticide may move in interstate commerce until it has been granted label approval and registered by the U.S. Dept. of Agriculture. To attain registration, the applicant must supply data adequate to convince the Secretary of Agriculture that, when used according to instructions, the pesticide will perform as claimed and that it will not injure man or living organisms other than those it is intended to control. If and when it is deemed necessary, the Department of Agriculture will insist on the inclusion of appropriate precautionary statements. Thus, before a new pesticide can be placed on the market in the United States, the manufacturer must spend approximately one million dollars on the research that is required to establish its practical value and safety.

Obviously, the information given on pesticide labels represents the end result of very extensive research carried on by the manufacturer and others. The recommendations have been carefully scrutinized for safety and effectiveness and have been approved by the appropriate government regulatory agencies, and since a large margin of safety is incorporated into recommendations and tolerances, it is safe to say that, when properly used in full accord with label directions, pesticides not only present no threat to the safety of the consumer of treated crops and produce but they involve few if any hazards to the user. Therefore, in the field of operational hazards, as in the case of food contamination, there have been no cases of death and few if any cases of illness in either man or his domestic animals traceable to pesticides *used in accord with label instructions*. On the other hand, considering the toxic nature of many of the compounds it is not surprising that there have been numerous cases of illness and even death involving both man and animals attributable to accidents, carelessness, and/or the outright misuse of pesticides.

Accidental Poisoning

Even so, in any attempt to evaluate the toxicological problems associated with pesticide usage, it seems only fair that such hazards as may exist should be placed in a proper perspective with regard to other comparable problems and hazards. Pesticides as chemical tools have a better accident and fatality record than the mechanical tools used on the same farms. Even within the chemical field, pesticides have a much lower accident rate than drugs, household chemicals, solvents, and miscellaneous poisons. It is also interesting to note that in the United States between the years 1949 and 1955, 84% of the accidental deaths attributed to insecticides were induced by materials in common use prior to the advent of DDT, and only 16% of such deaths were attributed to all of the newer chlorinated hydrocarbon and organic phosphate insecticides combined, and yet it is these latter materials that are most severely criticized and most condemned in scare stories. Arsenicals, the oldest of the insecticidal chemicals, were charged with 299 of the 518 such deaths compared with only 79 charged to all of the insecticides introduced since 1946. Furthermore, the latter were far exceeded by the 218 accidental deaths attributed to three rodenticides in common use for many years.

The real hazards—irresponsibility, careless-

ness, ignorance, delusion, and scepticism—involve mental reactions and human judgments and are not toxicological in nature. Perhaps such problems can best be approached and resolved through education rather than through further legislation and regulation.

Although it would seem axiomatic that pesticides, like all other toxic substances, should be stored where they are inaccessible to children and irresponsible individuals, carelessness in storage poses the greatest of all hazards. Data compiled by the U.S. Public Health Service reveal that in 1956, of the 152 accidental deaths attributed to pesticides, 94 (62%) involved children under 10 years of age and 78 of these were children under 4 years. Also, as noted earlier, the careless storage of household pesticides in pantries and cupboards represented the principal cause of serious illness and deaths due to food contamination.

Careless Handling

Most of the remaining fatalities and cases of serious illness involved individuals subject to extensive exposure who had carelessly or inadvertently ignored the prescribed precautions to be observed in the handling and use of highly toxic pesticides. Data developed in California (U.S.A.) (1951-1954) would seem to indicate that whereas the organic phosphates represented only about 10% of the insecticides used, because of the greater operational hazards associated with their use they accounted for over 75% of the cases of accidental poisoning (occupational diseases) attributed to pesticides. While the operational hazards associated with the use of highly toxic pesticides pose serious problems, the safety records established in manufacturing and processing plants bear ample testimony that they can be overcome by the observance of proper precautions.

There are, of course, still other misuses of pesticides that should not be overlooked. At times individuals through carelessness or ignorance fail to use the correct material to do a particular job, in which case the user usually pays the penalty, e.g. (1) the use of benzene hexachloride on certain crops or applied at the wrong time may result in off-flavour that will render the crop unsaleable; (2) some chemicals safe for use on most plants may be highly phytotoxic on others and their misuse may result in injury to or even the loss of susceptible crops or plants, e.g., DDT safe on some varieties of privet will defoliate plants of the Amur River

Toxicity and other characteristics of some common insecticidal chemicals related to safety and hazards

Pesticide	*Acute toxicity Approx. range, LD/50, Mg./Kg.*		*Relative rates of application DDT=100*	*Persistence 1–Brief 5–Long*	*Character of Hazard: Ing.–Ingestion Oper.–Operational*
	Oral	*Dermal*			
Botanical					
Rotenone	60–3,000	900–3,000	20–60	1	Remote
Pyrethrins	500–1,500	> 1,880	10–50	1	Remote
Nicotine	10–30	40–50	20–60	1	Ing. and Oper.
Inorganic					
Lead arsenate	50–500	Slight	200–400	5	Ing.
Calcium arsenate	35–100	Slight	200–400	5	Ing.
White arsenic	5–100	Slight	In baits	5	Ing.
Sodium arsenite	10–50	35–100	In baits	5	Ing. and Oper.
Chlor. Hydrocarbons					
Methoxychlor	5,000–7,000	>2,820–7,000	150–200	4	Remote
Chlordane	200–750	700–2,000	50–100	3	Ing.
DDT	110–250	2,500–3,000	100	4	Ing.
Lindane	85–200	50–1,000	10–50	2	Ing.
Toxaphene	60–90	80–2,300	160–200	4	Ing.
Dieldrin	40–65	60–90	10–50	3	Ing. and Oper.
Aldrin	40–50	50–100	10–50	2	Ing. and Oper.
Organo-phosphates					
TEPP	1–3	5–15	20–40	1	Oper. and ing.
Parathion	3–15	10–15	20–60	2	Oper. and ing.
Phosdrin	4–17	5–10	20–40	1	Oper. and ing.
Demeton	2–20	7–15	20–50	2	Oper. and ing.
Guthion	10–15	100–250	20–60	2	Oper.
Methyl parathion	10–35	50–100	20–100	2	Oper.
Malathion	480–1,400	4,000–5,000	75–100	2	Remote

variety; (3) there have been cases where users mistake 2-4-D for DDT, in which case, while they may have attained insect control, they do so only through destruction of the host.

Presumably everyone is or should be aware that under favourable conditions a fraction of the pesticide may drift from the point of its release onto adjacent areas. The amount and extent of such drift is determined by the method of application and particle size, as well as wind direction and velocity. This is particularly significant in the case of some herbicides where even a minute amount of the chemical drifting onto a highly susceptible crop may cause serious damage. Then, too, excess drift of some pesticides may result in residues in excess of the legal tolerance and thereby render such crops unsaleable.

Balance of Nature

Pesticides are frequently accused of upsetting the balance of nature, when in reality it would be more accurate to say that pesticides are used to suppress organisms already out of balance.

Many pesticides are admittedly highly toxic to a wide variety of plants and animals and under certain conditions of use they can and do cause some damage to certain species of wildlife. While there have been numerous minor incidents involving carelessness, misuse, and accidents, such incidents have been amazingly few and far between.

In general, agricultural lands present simplified ecosystems with minimal wildlife populations. Pesticide dosage rates used thereon are relatively low, and residue dissipation is often so rapid as to necessitate frequent retreatment in order to hold even highly susceptible pests in check. Thus, despite the use of billions of pounds of pesticides on millions of acres of cropland, damage to wildlife attributable to these treatments has been relatively insignificant and in the vast majority of cases undetectable.

Unpredictable Side Effects

When one considers the vast number of organisms and combinations of ecological conditions encountered in the diverse exosystems of any one continent, country, state, or even local community, it becomes apparent that man cannot logically expect to anticipate all of the possible adverse side effects that may be inherent in the extensive use of chemical pesticides. Hence, it is only natural that from time to time such unpredictable side effects will appear.

Such incidents in themselves are by no means catastrophic mistakes. However, it is important that all interested parties be alert to detect such incidents and correct them quickly. There is no great sin in making an innocent mistake, but failure to recognize and correct such errors may be unpardonable.

Actually, an impartial review of the literature reveals that most of the significant wildlife losses recorded to date have involved eradication programmes, excessive rates of pesticide application in aquatic and other sensitive wildlife habitats, or outright experimentation.

DDT in Milk

At times individuals are apt to question the necessity for observing certain label restrictions such as "Do not harvest," "Do not feed," or "Do not pasture for x number of days." Certain fat-soluble pesticides may be stored in body fat or excreted in milk and unless there is a legally established tolerance adequate to cover the residues found, such products are subject to legal action by the designated government agencies and cannot legally be sold. This may not involve the question of a real public-health problem but one of legal status only. Here again it may be well to illustrate a very important point. When a grass-clover pasture was sprayed with 3 lb. of DDT per acre, there was an initial residue of 211 p.p.m. which dropped to 3 p.p.m. in 21 days (page 14). When cows were placed in this pasture at once, 8.9 p.p.m. DDT was found in their milk 3 days later, but with the declining daily DDT intake, the DDT content of their milk dropped to 2.4 p.p.m. in 20 days. Other cows put in the pasture at the same time also stored comparable quantities of DDT in their fat, and although they were removed from the contaminated pasture in 4 days they still had 1.3 p.p.m. DDT in their milk on the 20th day. On the other hand, cows placed in the pasture 14 days after treatment showed a peak of 1.1 p.p.m. DDT in their milk in 3 days and then declined. Cows put in the pasture on the 21st day showed a peak of 0.2 p.p.m. DDT in their milk four days later. Cows put in the pasture on or after the 30th day failed to show DDT in their milk. Thus, it behoves the enthusiast to overcome his scepticism and assume that all label restrictions are realistic and should be observed. If the label says "Do not pasture for 30 days," it means just that.

Not Always to Blame

It seems obvious that pesticides are not responsible for all of the incidents attributed to them. There have been numerous instances

where pesticide users, or more often their neighbours, in attempts to shift responsibility or collect damages, have knowingly or inadvertently but nevertheless wrongly charged pesticides with a whole host of afflictions to both man and his livestock which have no basis in science, logic or fact.

Science has developed valid research data to establish the magnitude of the pesticide residues that will result from a particular pesticidal usage, the rate at which such residues are dissipated, and the approximate tolerance of most domestic animal species for the pesticides in common use today. Many animals are known to tolerate, over long periods of time, quantities of a given pesticide far in excess of normal initial deposits resulting from the proper use of that pesticide. Thus, when these animals are reportedly killed by the drift of some of the material onto an adjacent pasture, competent authorities are well aware and even the alert layman should realize that these reports obviously represent cases of delusion, deliberate or otherwise.

Science is continually opening new doors and it is always possible that important new procedures for the nonchemical control of pests may be imminent. However, until such significant breakthroughs become proven and practical substitutes, man has no choice but to continue the use of pesticides.

Since large segments of the public are apprehensive and many individuals are waiting and ready to exploit any mistakes that are made, it is important that every individual in any way associated with pesticide usage understands the basic facts about residues and their implications so that he can help avoid embarrassing incidents and counteract false propaganda.