Chapter III

Fifteen-Year Prelection of Agricultural Pest Control in the United States

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Each of the seven regional work groups was asked to project crop protection for their crops based on three assumptions: 1) continuation of current crop protection tactics, 2) no pesticide use, and 3) full implementation of integrated pest management (1PM). An overriding assumption was that any significant new technology that will take place in the field during the next 15 years is in the early developmental stages at this time. For example, the developmental period for a new pesticide is 8 to 10 years before initial registration which is then followed by an additional period of time before it is generally adopted by users. A similar or longer time span is involved in developing and introducing pest-resistant cultivars. Radically new procedures are likely to require even longer periods to be fully validated, demonstrated, and adopted.

The scenarios for the several crops are shown in figures 4 to 16. It must be emphasized that these projections are schematic trends and, because actual trends are not known, they are not quantitatively accurate; rather, they are intended to illustrate our best qualitative estimates of what may occur in the next one and one-half decades.

From these figures it is obvious that great variation exists in the dependence on pesticides to produce each of the crops. Crop losses for wheat, corn, and soybeans would increase significantly without pesticides but could be reduced to a reasonable level after several years by substitution of other tactics. Current yield potential of corn and soybeans would not be maintained, but alternate tactics could reduce pest losses. On the other hand, production of apples, lettuce, cole crops, strawberries, and Northeast potatoes would be disastrously reduced to the level at which commercial production would become impossible. Obviously one cannot generalize on the role of pesticides in production across agricultural crops.

The principal impact of the adoption of 1PM over the present mix of tactics would be a trend towards reduced pesticide use accompanied by more stable control of insects and diseases. Considerable fluctuations in crop losses are anticipated when the use of certain existing chemicals is discontinued because of pest resistance, regulations, economics, or combinations thereof when no effective substitutes are immediately available, For most crops, losses would be consistently less with greater implementation of 1PM than with current practices.

As stated elsewhere, a significant percentage of crop production is lost prior to harvest because of pest activity. This occurs in spite of the extensive use of pesticides. This implies that pesticides are not efficient or effectively used; actually they are reasonably efficient and cost-effective for farmers in most situations. The extensive crop losses that do

Figure 4.—Schematic Projections for Three Crop Protection Scenarios for Wheat in the Great Plains

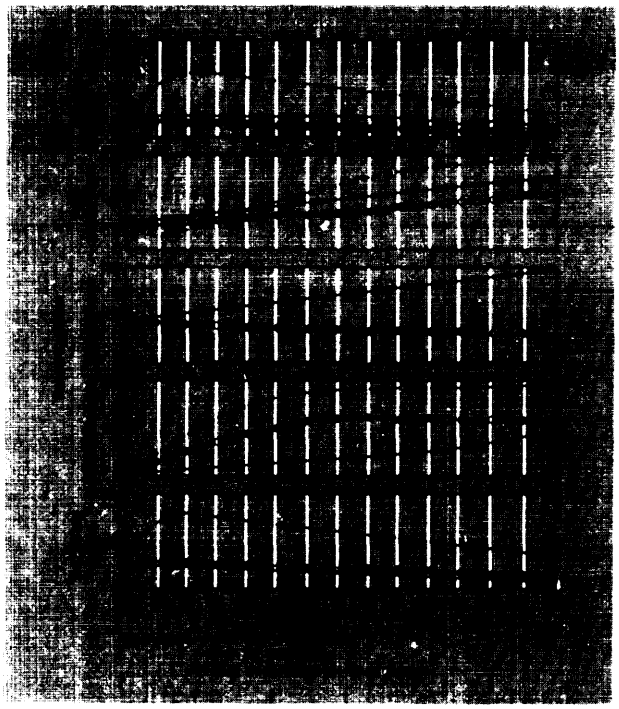


Figure 5.—Schematic Projections for Three Crop Protection Scenarios for Corn in the Corn Belt

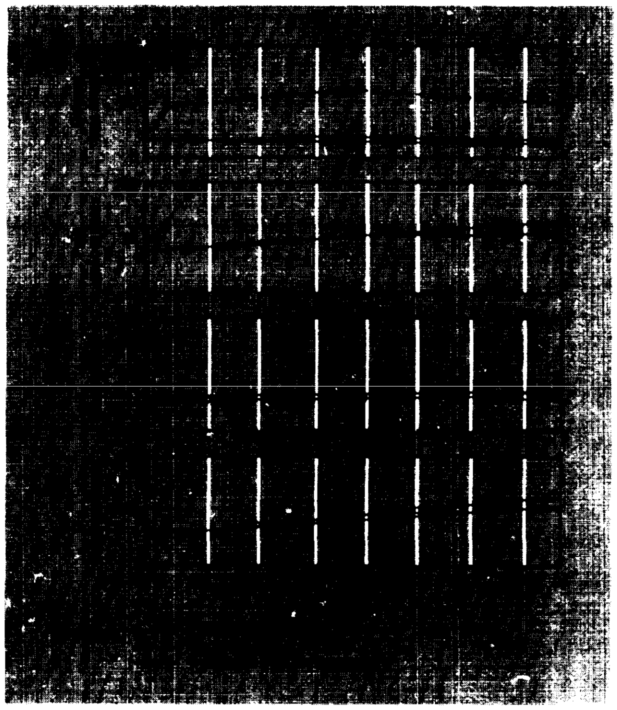


Figure 6.—Schematic Projections for Three Crop Protection Scenarios for Soybeans in the Southeast

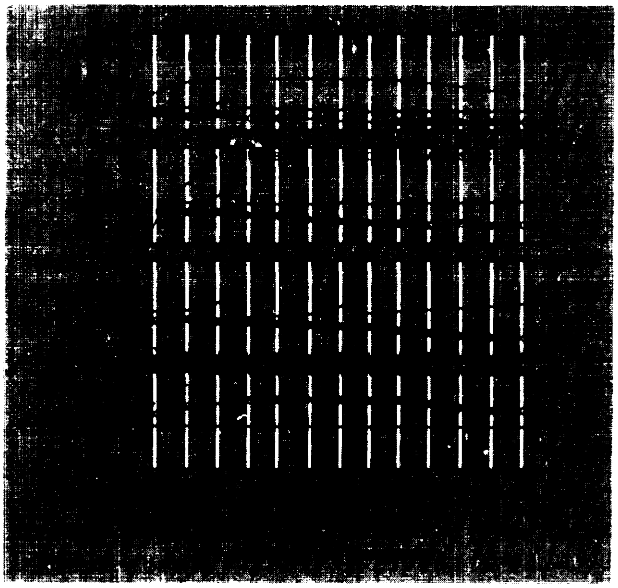


Figure 7.—Schematic Projections for Three Crop Protection Scenarios for Apples in the North

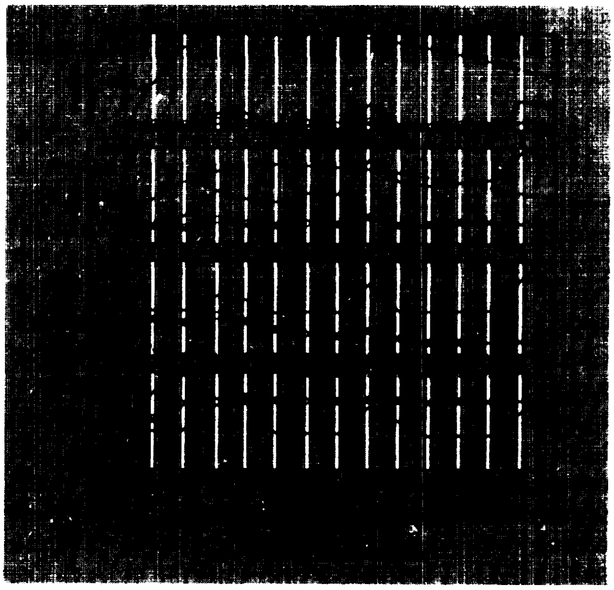


Figure 8.—Schematic Projections for Three Crop Protection Scenarios for Potatoes in the Northeast

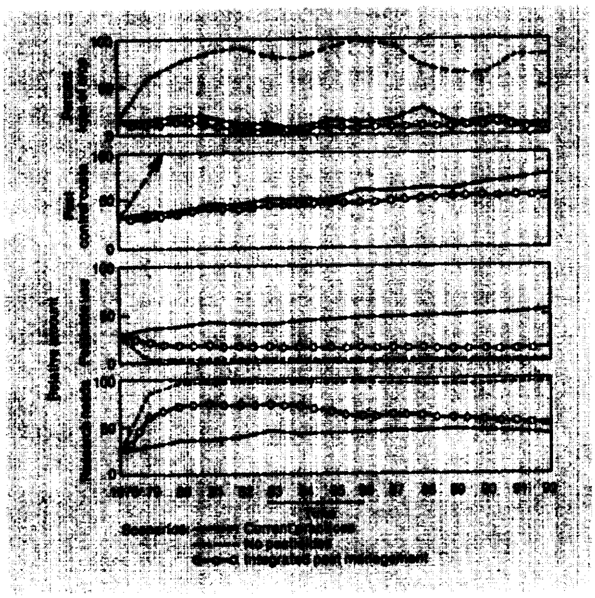


Figure 9.—Schematic Projections for Three Crop Protection Scenarios for Lettuce in California

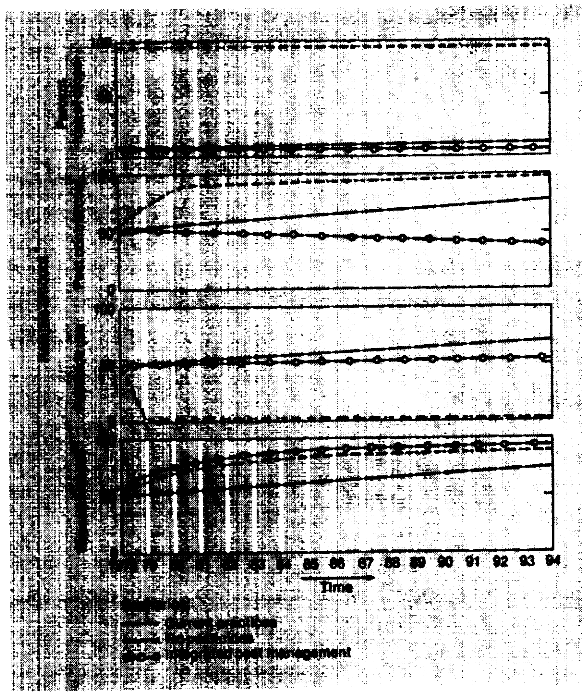


Figure 10.—Schematic Projections for Three Crop Protection Scenarios for Melons in California

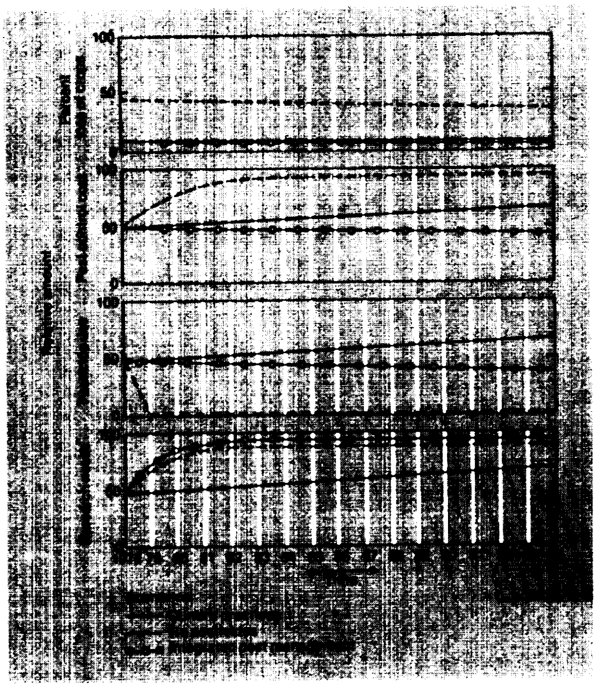


Figure 11 .—Schematic Projections for Three Crop Protection Scenarios for Potatoes in California

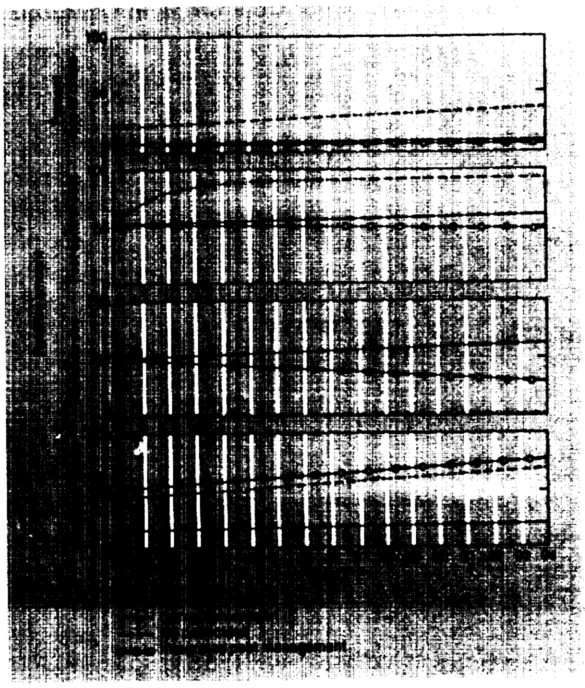


Figure 12.—Schematic Projections for Three Crop Protection Scenarios for Strawberries in California

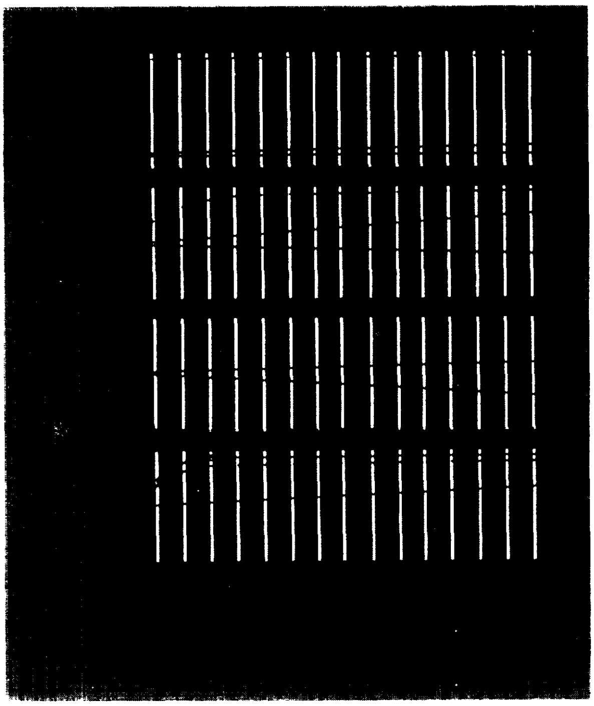


Figure 13.—Schematic Projections for Three Crop Protection Scenarios for Tomatoes in California

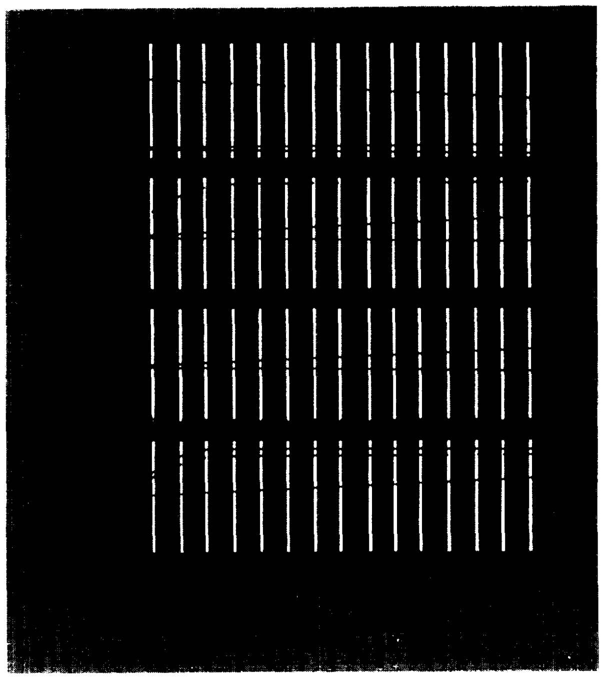


Figure 14.—Schematic Projections for Three Crop Protection Scenarios for Cole Crops in California

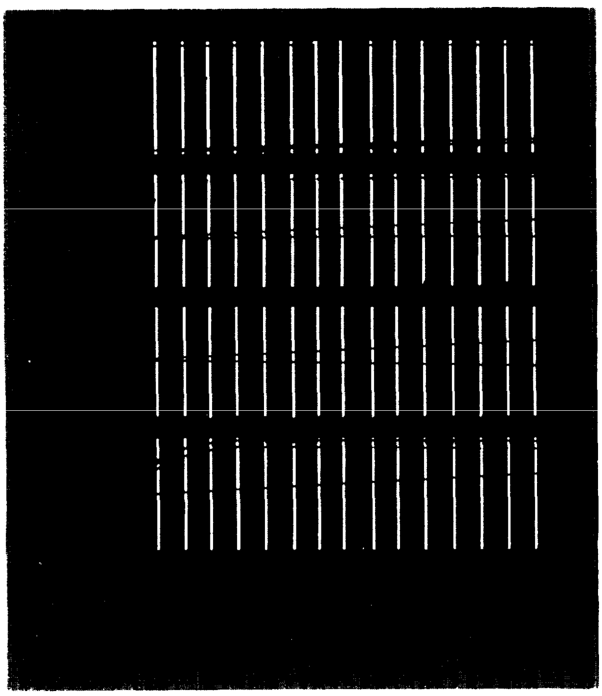


Figure 15.—Schematic Projections for Three Crop Protection Scenarios for Cotton in Texas

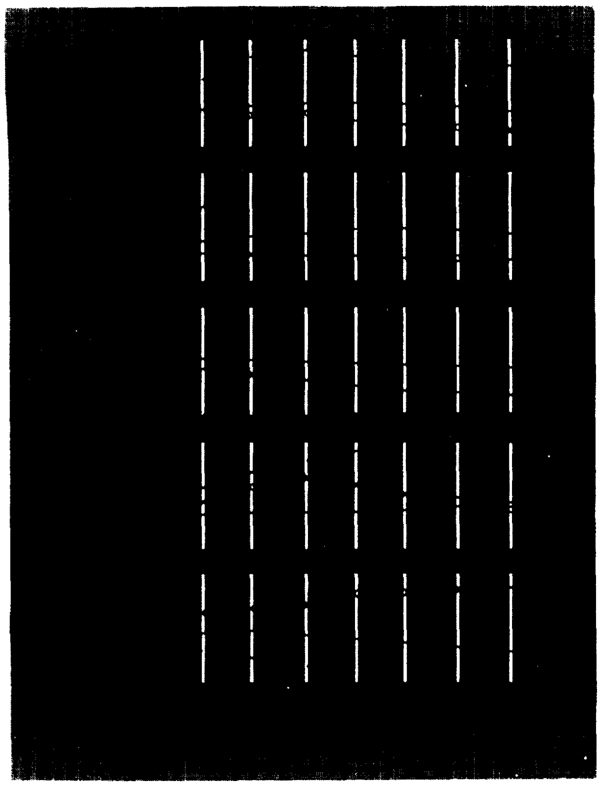
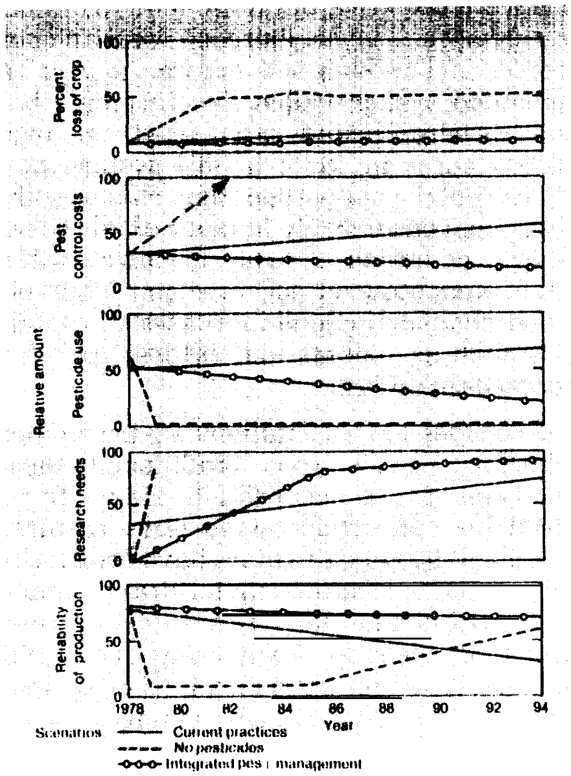


Figure 16.—Schematic Projections for Three Crop Protection Scenarios for Sorghum in Texas



occur are caused by pests against which pesticides are not generally used and for which there are no other known feasible control tactics. The development of other control tactics, such as host resistance, cultural controls, and biological controls and their implementation in 1PM systems will significantly reduce pest losses. It has been estimated that current losses can be reduced up to 50 percent or more on a number of crops.

Production costs for pest control on most crops are expected to be much higher without pesticides than with either current practices or 1PM. The need for increased cultivation, hand weeding, and insect picking would add greatly to production costs. 1PM is expected over time to reduce production costs somewhat, but the reduction will probably be minimal even on high pesticide use crops such as cotton and apple. The reliability of crop production is much improved on many crops by the use of pesticides and is further improved by the use of 1PM programs.

With increased IPM, pesticide use is projected to decrease on all the crops considered; however, the amount of reduction is speculative and may not be as significant as is often assumed by some persons. It is more certain that the pesticides that are applied will be used more efficiently and effectively.

One final projection observed in figures 4 through **16** is the amount of research required for the three scenarios. If pesticides were not available, much additional research would be needed to improve crop protection by other tactics and strategies. Even with an all-out effort, the results obtained for most crops are not expected to be equal to the judicious use of pesticides during the next 15 years. Also evident is the estimate that more research effort is required to develop and implement pest management strategies than to continue with the present mix of tactics. This reflects the greater complexity of the 1PM approach over the use of single tactics and the time and effort required to develop and implement such methods.

A review of the seven regional reports, as well as other reports and the literature, provides little evidence that there will be any revolutionary new technological developments in insect, mite, disease, nematode, and vertebrate control over the next 10 to 15 years. The new synthetic pyrethroids and certain other insecticides are most promising but are likely to be used in place of. and in a manner similar to, existing products. The same situation exists for fungicides, nematicides, rodenticides, and avicides. On the other hand, projections for the use of existing and new herbicides indicate that their use will increase dramatically over the next 10 to 15 years. In fact these materials are creating a revolution in the production of certain agricultural crops in the United States, particularly in wheat and corn, as discussed later in this chapter.

In spite of the great need for improved pesticide application technology. there are few new developments underway that promise to have significant impacts on pesticide use during the next 15 years. Recent research at the University of Georgia has produced a breakthrough in the use of electrostatically charged dusts and sprays. Evidence shows that application rates can be halved using this method without loss of insect control on row crops. Several prototype sprayers are being evaluated on row crops, and research is planned to adapt the principle to tree crops. This development can significantly improve the efficiency of pesticide applications and reduce the quantities used. Another development, resulting from joint research efforts of weed scientists and engineers, is the recirculating sprayer. It can be used effectively for weed control in some situations with greatly reduced rates of herbicide application and lower costs to farmers, The full potential and impact of these and other new developments have yet to be determined. A need still remains for much greater efficiency in aerial application to improve the target-to-draft ratio.

Much of past and even present agricultural production practice has been dictated by disease, insect, nematode, and, especially, weed problems. The development and use of an array of herbicides with various combinations of selectivity, short- and long-residual action in the soil, systemic and contact activity, etc., now provide farmers with the capability of controlling weeds without the usual plowing, fitting, transplanting, and frequent cultivations that have been required for thousands of years. The practice of no-till corn is being widely adopted, particularly in rolling land where soil erosion is severe. Here, weeds are killed by a contact herbicide and seed sown in unplowed soil. The dead surface vegetation remains in place where it prevents erosion by as much as 50 percent depending on slope, rainfall, and soil type.

A similar development is underway in the dry-land Great Plains wheat production area where herbicides are also replacing plowing and cultivation. To conserve moisture, the land is left fallow (not cropped) for varying periods of time. Because weeds remove moisture from the soil during fallow they must be controlled. Until recently frequent cultivations were required, but these tend to dry out the surface soil layer, increase wind and soil erosion, and reduce soil organic matter. A production system called "ecofarming" has been developed and was used on over 100,000 acres in 1978. In this system, herbicides replace cultivation, thus changing the ecosystem considerably in favor of increased soil organic matter, greater moisture conservation, and reduced soil erosion. Other observed changes include increases in certain pests such as rodents and rattlesnakes, but decreases in others.

Herbicides are also influencing production technology for row crops. Traditionally these have been spaced according to the width required for cultivation—wide rows required for animal-drawn cultivators have been modified to accommodate tractor-drawn implements. Herbicides now can eliminate most cultivation needs for many crops and permit spacings based on considerations other than weed control, Again, such changes in the microenvironment favor some pest organisms and reduce others.

The ultimate potential for changes in agricultural production methods created by herbicides has yet to be determined. Similarly, the secondary impacts on crop protection problems are not fully known or understood. Obviously, much more interdisciplinary crop protection research is required.

A similar but unknown potential for changing cultural production systems exist in tropical agroecosystems, even rather primitive forms (see chapter VII).

A trend observed in California toward strawberry production in nearly sterile soil is likely to continue and may expand to other high-value crops. For example, California farmers are finding that yields of other crops are significantly higher when planted in land fumigated the preceding year for strawberry production. For many years fruit growers have had replant problems caused by nematodes and other pests that are now controlled by soil fumigation. Some form of soil fumigation is routine practice in greenhouses. The use of sterilized soil is possible only if a satisfactory soil fumigant or other method of accomplishing the same end is available. Because the current cost of such treatments is high [$450 to $!500 per acre for strawberries), the cost/benefit ratio is favorable only for high-value crops. If an inexpensive safe material or method were available, soil sterilization would expand and spread widely. No such material or method is now available, and all commonly used liquid soil fumigants are on the current RPAR (rebuttable presumption against registration) or pre-RPAR lists (April 1979). Research data on microwave soil sterilization shows that this method can be used to kill weed seed and some microorganisms but is not yet proven technologically nor is it considered to be feasible economically.

Chemical pest control includes the use of hormones for control of insects and weeds. Insect juvenile hormones or mimics do not appear promising except for control of certain species such as mosquitoes and house flies, which are a problem as adults but can be controlled as immatures. The recently discovered anti juvenile hormones appear much more promising, but none are available yet with a satisfactory spectrum of activity. A hormone that either inhibits or induces seed germination would have a potential use in weed control, but such chemicals are not yet available for practical use. As promising as these approaches appear to be, widespread success seems unlikely in the next 10 to 15 years.

Projecting the use of other control tactics is more difficult than for pesticides. We have already commented on changes in cultivation procedures now taking place and mentioned their potential impact on pest populations. Cultural controls including plowing and cultivation have been recommended and used for generations for the suppression of pests other than weeds. Some of these are being reexamined and may have potential in 1PM systems. Modern equipment permits the timely, efficient execution of operations that were once difficult or even impossible. Certain changes no doubt will be made for pest suppression purposes; however, no radical changes are likely. The use of rotations, time of planting, trap crops, and habitat diversification are based on economic and managerial considerations. These practices are not expected to change appreciably within the next 10 to 15 years. With the potential for increased costs of irrigation water and fertilizers during the projection period, increased manipulation of these tactics for managing pests is unlikely; in fact, decreased use of water and fertilizer for control will become less attractive economically.

Although biological control is of only limited use in the control of agricultural pests; insects, mites, and many minor arthropod pests would be major problems in the absence of the biological control provided by parasites, predators, and pathogens. The sudden elevation of secondary insect and mite pests to major importance following applications of certain insecticides provides ample evidence of the role of biological agents. Other major weed, plant pathogen, vertebrate, and nematode pests are controlled less effectively by biological agents.

It is entirely possible that at least some currently important arthropod pests will be effectively controlled biologically during the next few years. An excellent example is the use of a small wasp parasite from India that has effectively provided season-long control of the Mexican bean beetle when released early in the season.

Based on experience over the past few years, the projection for the increased use of host-plant resistance is not encouraging. Much of the breeding work to incorporate resistance into commercially available cultivars has been discontinued in State experiment stations and Federal laboratories on the basis that this work is more appropriately done by commercial seed firms. The latter have not been effective in recent years either because of a lack of incentive or a lack of suitable resistant germ plasm and the genetic information required to combine resistance with desirable agronomic qualities. Experience indicates that the use of resistant cultivars is likely to decrease rather than increase over the next decade unless strong publicly supported efforts in host-plant resistance programs are implemented.

Autocidal (sterile male release) control of insects has been effective against certain species, especially the screwworm and the fruit flies, and has been demonstrated to be effective against low populations of codling moth and onion maggots but is not now economically competitive with other control methods, The autocidal method has not been effective or practical against moderate-to-high insect populations or where heavy migration is common. Technical problems and the expense of mass rearing and sterilization have limited the range of uses for this innovative and ecologically sound method of insect control. No large increases in its use are anticipated over the next 15 years except possibly in conjunction with eradication projects where costs are not the prime consideration.

The use of insect pheromones for control has been demonstrated successfully using two approaches. The use of pheromone-baited traps to control insects by eliminating males and reducing mating is subject to the same limitations as the sterile male release method. Although the use of these pheromones for control by "male confusion'" has been successful (Gossyplure H,F. is registered and being used by some cotton farmers in Arizona and California), there have been enough failures in experimental testing to suggest that there are still some unsolved problems. However, it is expected that these materials will be used commercially for direct control of some insects within the next few years.

Eradication of pest organisms is perhaps the ideal solution for introduced species if it can be accomplished without incurring unacceptable costs and risks to human health and the environment, Experience indicates that eradication is not feasible for established species, For example, the barberry eradication program is being terminated in 1979 after 61 years of unsuccessful effort. The reduction in numbers of barberry, the alternate host of stem rust of wheat in the Great Plains area, may have helped to reduce the threat of this severe disease, but the goal of eradication is now deemed unattainable by any acceptable means. The fire ant eradication program has also failed. Success seems attainable only with newly introduced species before the infestations become widespread and well-established. Some organisms such as nematodes simply cannot be eradicated. Any proposed eradication program must be carefully examined in terms of probability of meeting objectives, Political pressures for eradication are considerable but must be tempered by the reality of experience. A second experiment to evaluate the feasibility of boll weevil eradication is now underway. Many knowledgeable people are convinced that eradication of this pest is not feasible with present technology at any reasonable cost and risk to the environment. Certainly eradication will not be an important part of agricultural pest control except where new pests may be introduced.

Quarantine efforts to prevent the introduction of new pests are partially successful and judged to be cost-effective but are inadequate with present transportation facilities and practices for people, animals, and goods. Modifications and improvements are needed to adapt outdated quarantine methods to today's conditions.

Organic farming, as defined in this report, is crop production without using synthetic fertilizers, pesticides, antibiotics, and other agricultural chemicals. In considering organic farming as it affects crop protection against pests, we assume that acceptable pesticides are only those derived from plants, such as rotenone, nicotine, and pyrethrum. However, others suggest that organic farming can involve a minimum, or minor, use of synthetic pesticides, If that were the case, the distinction between organic and conventional farming is obscured and organic farming approaches the 1PM concept regarding pesticide use. Unfortunately, most of the arguments for and against organic farming are qualitative in nature; there are scant quantitative comparative data on the value of organic versus conventional farming for crop protection.

The opportunities for successful use of organic farming methods vary greatly with crop susceptibility to pests, climate, availability of labor, season, and regulations regarding undamaged produce in the marketplace. Certain fruit and vegetable crops are almost completely destroyed by a variety of pests if not properly protected with appropriate pesticides. In other cases, the amount of hand labor involved in weeding is prohibitive for large-scale commercial agriculture. However, some crops that are less severely attacked and for which nonpesticidal controls are known can be produced successfully on a commercial scale without the use of synthetic pesticides, although yields may be lower than with conventional methods. These include several field and forage crops such as alfalfa and field corn. At present, very few commercial farmers within the seven cropping regions of this report are using organic methods of crop production. The estimated 10,000 to 15,000 organic farms in the United States are relatively small operations for which organic farming is most applicable.

Because of the considerable interest in organic farming and the increasing demand for organically grown foods, research is needed in this area. At present, those interested in producing organic foods cannot obtain from county agents or agricultural experiment stations much, if any, information on how to manage pests without pesticides. Research is needed to evaluate the value of methods now being proposed, such as companion plantings, and to develop new' techniques, Much of present research on developing 1PM systems involves approaches that may be useful to organic producers. The tactics of genetic host-plant resistance, encouraging biological control organisms, and cultural controls, along with other tactics, must be improved and incorporated into demonstrated production systems to make this approach more widely attractive in commercial agriculture.

A careful study of pest control in the seven regions indicates that there is now' much more 1PM being practiced than is generally recognized. This is particularly true for wheat in the Great Plains States where extensive use has been made of cultural, host-plant resistance, and chemical controls for weeds, insects, diseases, and vertebrates, and where extensive disease-monitoring systems are used. Pest management systems have been integrated into wheat production practices with due consideration of environmental factors. The impetus for 1PM development and implementation has been economics (wheat is a low-value crop) and the lack of appropriate single-control tactics. The present level of 1PM, however, is still far from its potential on this crop. Various levels of 1PM are used on the other crops.

We project that the implementation of 1PM in crop production in the United States will proceed slowly over the next 15 years unless much greater inputs are made at the National and State levels. The major obstacle to faster adoption is lack of demonstrated feasible 1PM systems. This is due to a number of factors, but lack of information on the basic biology of pests and crops, lack of established economic thresholds, cost/benefit analyses of 1PM programs, and the primitive state of predictive modeling and agroecosystems analyses are the most important.

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