Integrated pest management (IPM) is an increasingly popular approach to reduce the use of pesticides. These programs should recognize that farmers use pesticides in order to minimize risk of crop loss just like people pay for auto insurance to minimize the economic effects if an accident should occur. IPM programs can be made more effective if this desire by some to avoid risk is taken into account when designing recommended guidelines/rules for producers. Not only will the resulting rules be more acceptable to producers but their effects will be more equitable among producers.

INTEGRATED PEST MANAGEMENT:

It Needs to Recognize Risks, Too

by John M. Antle

Integrated pest management, or IPM, combines ecological and economic principles. It strives to attain control of crop pests with the use of a full spectrum of information and control methods, including chemicals and biological techniques. The ultimate objective of IPM is to achieve economic pest control for farmers while also mitigating the possible adverse effects of pesticides on the environment and society.

Thus, one particular IPM objective is to utilize chemicals as effectively as possible in the hope of reducing total chemical use. For example, an IPM program for processing tomatoes was introduced in California's Sacramento Valley in 1984. It provides growers and their pest management consultants with reliable ways to monitor fruit worm and beet armyworm infestation. In addition, decision rules were designed by IPM specialists. These rules indicate the levels of infestation that are economically acceptable. In turn, growers know when it pays to spray with chemicals.

However, IPM is conventionally considered to be a management activity distinct from other management requirements of the farm. Indeed, the researchers who design IPM programs such as the California tomato program typically are trained in biological sciences, not in farm management. Pest management in general, and integrated pest management in particular, is better thought of as one tool of many used in the management of a farm.

In addition, it is important to recognize that a major element in managing a business enterprise is coping with price and production risks. The risk of pest damage is an important part of the production risks faced by farm managers. Viewing IPM as a part of a farmer's risk management activities, rather than as a means of managing pests per se, provides two important insights into pest management.

- First, at the farm level, IPM methods are essentially a tool for managing risk. This fact needs to be taken into consideration when IPM programs are designed so that they will be consistent with the needs of farm managers. For example, IPM recommendations on pesticide use need to recognize the role of pesticide use in risk management.
- Second, IPM can be an effective feature for public policies aimed at reducing agricultural pesticide use. In particular, IPM can reduce the costs of pesticide restrictions for those farmers most affected by the restrictions. In that sense, IPM is more equitable than simply prohibiting or restricting the use of pesticides.

Conventional IPM Rules

To put pest management into the context of risk management we need to examine the relationship between the conventional IPM approach, the nature of the agricultural production process and the risks associated with the use of pesticides and farming.

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The "economic threshold" concept is used by entomologists and economists trained in conventional IPM methods when designing IPM programs. Conventional IPM wisdom states that farmers should apply pesticides only when a pest population reaches the "threshold" level—the level at which pest damage to the crop is greater than the cost of the chemicals.

In other words, pesticide application results in additional output; if the value of the added output exceeds the cost of the pesticide, then profits will be increased and the pesticide application is justified. By applying pesticides according to this kind of "threshold" decision rule, entomologists believe farmers will use less pesticides, and economists believe farmers will receive higher profits than they would if they try to eradicate all pests or otherwise apply pesticides without regard to the actual pest populations in their fields.

This conventional approach to IPM does not take production risk, as perceived by farm managers, into account. The production process is risky, in part, because farm management decisions must be made before farm managers know for sure the size of pest populations or the damage they will cause. Designers of IPM thresholds have developed statistically reliable methods for farmers to use in sampling pest populations in their fields. But there is still uncertainty about the pest populations and their effects on the crop, even when fields are systematically sampled for pests.

IPM researchers typically ignore the implications of this uncertainty when designing pesticide application thresholds. The important implication is that farmers value an input such as a pesticide for the contribution it makes to reducing production risk, as well as the contribution it makes to actual profit. Consequently, IPM thresholds should be designed taking into account the fact that pesticides serve as an "insurance input."

For example, farmers may apply insecticides on a scheduled basis before they observe a pest infestation, in order to insure" against pest damage. These pesticide applications provide a service to farmers even if the pest population would not have turned out to be large enough to cause economic damage, just as auto insurance provides a service whether or not the car is ever damaged in an accident.

This logic also helps us understand why farm managers value the information about pest populations that they obtain from field sampling. The more they know about the pests and the degree to which these pests are likely to cause damage, the less is the uncertainty in the farmer's mind about the state of the crop and the appropriate management decisions to take.

IPM and Risks

The valuation of risk is subjective and varies from one individual to another. Economists define the value of risk reduction as the risk premium, that is, as the maximum amount an individual is willing to pay to avoid risk. A risk averse individual is willing to pay up to the amount of his risk premium to insure against risk.

The conventional IPM decision rules for pesticide use can be modified to take risk management into account. The usual IPM guideline is, "apply pesticides only when the expected profit from applying them is positive." Taking risk management into account, the rule would be "apply pesticides only when the expected profit and the value to the farmer from risk reduction combined is positive." Note that this rule takes into account both expected profits and the value to the individual farmer of risk reduction. In other words, this generalized threshold says the farmer should apply pesticides when their expected profitability *plus* their value in reducing risk is positive.

This generalized formulation of the threshold concept shows why it can be important to view pest management as part of an overall risk management strategy for farm managers. Suppose, for example, a situation in which the expected benefit of applying pesticides to tomatoes is less than the cost of the

Pesticide application results in additional output.

pesticides—the expected average effect on profit is negative. The conventional threshold rule would say to the farmer "do not use pesticides in this case." But the farmer knows that there is a chance that pesticide damage may be greater than expected even though, on average, the expectation is correct.

Suppose further that the farmer wants to avoid this possibility of greater damage and is willing to pay something to avoid the possibility. For example, expected profitability could be a negative \$10 per acre, but if the farmer valued the risk-reducing effect at \$15 per acre, the farmer would perceive a net gain of \$5 per acre from pesticide use. If a pest management consultant recommended that the farmer not use pesticides in this situation, the farmer would be likely do so anyway in order to avoid the risks associated with not using the pesticides.

This example helps explain why IPM consultants and other specialists sometimes believe that farmers "overuse" pesticides in spite of expert recommendations to use less. The reality is that farm managers who view pest management as a way to avoid risk will tend to err on the side of caution and may choose to spray a crop for pests when the conventional IPM rule says do not spray.

Pesticide Regulations Involve Equity

The preceding analysis of pest management decisions and risk demonstrates that the degree to which an individual reacts to risk depends on the individual's subjective perception of and attitudes toward risk. This means that each individual may respond differently to each particular risky situation. This aspect of risk-responsive behavior has important implications when we evaluate the effects that pesticide regulations have on agricultural producers.

Suppose that the use of a pesticide is prohibited. The loss to a farmer who uses the pesticide equals the sum of (1) the effects the prohibition has on expected profitability, and (2) the value (cost) to the particular farmer of the increase in the risk that he now confronts. In contrast, a farmer who does not use the pesticide does not experience any loss. Losses to farmers who use the pesticide are also greater the more risk averse they are. If two farmers, Jones and Smith, use a pesticide with the same expected profitability, but farmer Jones is more risk averse and values risk reduction more than farmer Smith, the elimination of the pesticide would harm farmer Jones more than farmer Smith.

Now consider the introduction of an IPM technology rather than a prohibition such as the California tomato IPM program. This program makes it possible for farmers to apply pesticides in a more timely manner and thus to reduce their use of pesticides without increasing the risk of pest damage. If the IPM technology provided all farmers with the same expected profitability from its use, those farmers who are more risk averse would gain commensurately more from the IPM technology than those who are not risk averse.

Those farmers who face a higher risk of pest damage and who are most risk averse, would stand to lose the most from restrictions on pesticide use. But they stand to gain the most from the availability of an IPM technology which substitutes for the risk-reducing effects of pesticides. Therefore we can conclude that IPM technologies that are designed as effective risk management tools reduce the adverse distributional effects of regulation and provide an equitable alternative to pesticide regulation.

An Example

A recent case study of the California IPM program for processing tomatoes illustrates the role of IPM in risk management, on the one hand, and the role that IPM could play in policy design, on the other hand.

The cost to farmers of pesticide restrictions can be evaluated in terms of the effects of reduced pesticide use on profits and the risk premium. The first column of the accopanying Table shows the per acre costs of a hypothetical 22 percent reduction in pesticide use that could be the effect of pesticide use restrictions imposed by a governmental agency. Four degrees of risk aversion, ranging from very low to very high, are considered. The table shows that the per acre cost is quite low for producers with a low degree of risk aversion, but rises to over \$100 per acre for more risk averse growers. This is because the "insurance" effect of the pesticide is valued the

The risk of pest damage in orchards has been limited with the use of pesticides. *Photos by Tim McCabe, courtesy Soil Conservation Service.*

most by the most risk averse grower.

The Table also shows the per acre value of IPM adoption and breaks out the value into its two components—expected profits and risk reduction. For a grower with a low degree of risk aversion, the IPM program's benefits are $24 per acre. Only one-third ($8) of these benefits are due to risk reduction. In contrast, for a highly risk averse grower, the value of the program's benefits are about $60 per acre, with three-fourths attributable to risk reduction.

Costs of pesticide regulation and value of IPM adoption for Sacramento Valley processing tomato growers

Degree of risk ***aversion***	*Total cost to farmers of pesticide regulation (expected profit* ***plus risk effect)***	*Value of IPM to farmers'* ***program in terms of:*** *Expected* ***profit***	*Risk reduction*	***Total***
Low	$ -17	$16	$ 8	$24
Medium low	-36	16	16	32
Medium-high	-75	16	31	47
High	-113	16	44	60

Note: all figures are 1984 dollars per acre.

Source: *Pesticide Policy, Production Risk, and Producer Behavior* (Resources for the Future, Washington, DC, 1988).

Comparing the regulation's costs to the value of IPM adoption indicates how growers would be affected by alternative approaches to pesticide policy. Consider three possible scenarios. First, suppose a 22 percent reduction in pesticide use is mandated and there are no substitutes for pesticides. Farmers would then bear the regulation costs according to their need for the pesticides and their degree of risk aversion.

A second possibility is combining an IPM program with pesticide restrictions. If the IPM program made it possible for growers to reduce pesticide use by 22 percent or more and obtain the same yields, growers would be better off by the amounts indicated in the "Total" column of theTable.

A third possibility is also a combined IPM program with pesticide restrictions. However, suppose that the IPM program reduces pesticide use by less than 22 percent. In this case, individual farmers' gains or losses would depend on which effect—regulation cost or IPM benefit—were larger. But in all of these cases, the net costs of regulation to farmers, if any, would be more equally distributed among farmers if the IPM program were available to them.

Conclusion

Pest management can be viewed as part of farmers' overall risk management strategies. IPM researchers need to consider the risk dimension of pest management in order to design pesticide application thresholds that are consistent with farmers' management goals. As shown by the case study of the IPM program introduced in the California processing tomato industry, IPM programs can also be an effective tool for the design of equitable pesticide policies. To the extent that IPM programs substitute for the risk-reducing effects of pesticides, it is possible for pesticide use to be reduced without imposing disproportionately high costs on producers who face the highest risk of pests. C

For More Information

See "Pesticide Policy, Production Risk, and Producer Welfare: An Econometric Approach to Applied Welfare Economics" by John Antle for an expanded discussion about IPM. It is available from Publications Department, Resources for the Future, 1616 P Street, NW, Washington, D.C. 20036. Its cost is $12.95.