The economics of IPM in processing tomatoes

John M. Antle □ Seong K. Park

In 1984, the University of California introduced an integrated pest management (IPM) program for reducing damage to processing tomatoes by the fruitworm and beet armyworm. To evaluate the entomological and economic viability of the program, investigators tested it on about 2,000 acres in the Sacramento Valley. The program provides growers and their pest management consultants with a probability-based method of sampling fields for fruit damage and lepidopterous caterpillar eggs, and decision rules for insecticide spraying based on the sample results. Cooperating growers and pest management consultants agreed to be trained in the use of the sampling technique and to use it on selected fields.

We conducted an economic analysis of the tomato IPM program based on data collected from growers who participated in the program and other growers in the Sacramento Valley. The data included 56 fields, 21 of which were in the IPM program.

Economics of the program

The economics of the IPM program are easily understood in terms of its various benefits and costs. To the grower these can be categorized as: changes in expected yield and revenues due to effects of the program on average fruit damage; changes in pest management costs, primarily in the number of sprays, the kind of spray materials used, and labor for field monitoring; and changes in production risk related to fruit damage. Fruit damage reduces revenue through lower yields that occur when fruit is rejected in the harvesting process. Revenues are also lower when trailer loads of tomatoes fail to pass the state's 2 percent damage standard and must be re-sorted or not processed at all. Processors may offer growers with good damage histories more attractive processing contracts, or may offer price premiums for deliveries with low damage levels.

Its unpredictability means that fruit damage by fruitworm and armyworm represents an important aspect of the production risk. The tomato IPM program is designed to offer growers a way to increase yields and revenues, as well as to reduce production risk, without using more chemicals. In addition, by spraying less growers may be able to reduce insecticide costs. The program's direct costs to growers involve a possible increase in labor devoted to monitoring the fields systematically. A possible indirect cost could be an increase in production risk if the program were not used correctly or if the design of the program were faulty.

In addition to the benefits and costs to growers, the IPM program could have beneficial effects on pest resistance, biological control, and the environment, if it leads to a reduction in overall pesticide use.

Our economic evaluation of the program thus considered four questions on: (1) what effects the program has on worm damage, expected yield, and revenue; (2) whether or not growers using the program do, on average, spray less frequently and use a smaller total quantity of insecticide than they otherwise would; (3) whether or not labor costs for sampling fields are increased; and (4) whether the IPM program reduces worm damage risk.

Analysis

To investigate the effects of the program on average damage and damage risk, we used a statistical model that related the probability distribution of preharvest worm damage to a number of production-related variables, including irrigation, the amount of insecticides applied, whether or not the field was in the IPM program, and the date the field was planted. The statistical analysis indicated that, holding constant other factors affecting the damage distribution, the fields in the program had 39.5 percent lower average worm damage, a result statistically significant at greater than the 1 percent level. If average yield were 25 tons per acre, the price \$52 per ton, and the damage reduction translated into an equal yield increase, a grower averaging 1.5 percent preharvest damage could increase expected revenue per acre by about \$7.70 by using the program.

In addition to the reduction in average damage, the program fields had a damage distribution whose mass was more concentrated toward the origin, and less dispersed. The "spread" (or variance) of the damage distribution was reduced by 58.5 percent and the asymmetry (or right skew) of the distribution was reduced by 30.3 percent. These findings mean that the program fields showed a significant reduction in damage risk, as indicated by the cumulative probability distributions in figure 1. Figure 1 shows the probability that a field has a damage rate less than or equal to the values indicated on the horizontal axis. For example, it shows that program fields had about a 3-out-of-4 (or 75 percent) chance of having damage less than 1 percent, whereas nonprogram fields had only about a 2-out-of-10 (or 20 percent) chance of having less than 1 percent damage. Figure 1 also implies that a program field was virtually assured of falling below the state's 2 percent damage standard, but that some nonprogram fields could have more than 2 percent damage. Thus the program was successful in more effectively timing sprays to the presence of pests in the field. Growers using the program can expect to have lower average damage and to face less risk of a field having a particularly high damage rate.

Two steps were used to investigate the question of whether program fields were sprayed with less insecticide than other fields. First, we calculated the average active ingredient applied to both program and nonprogram fields. Overall, program fields used about 22 percent less insecticide than other fields. All of the program fields were planted in mid-season or late season. The reduction in insecticide use was only 12 percent on mid-season fields but over 40 percent on late-season fields. However, this simple comparison of average applications does not take into consideration other factors that were different on the various fields; most notably, it fails to account for price and quality differences in the kinds of materials that were applied. An analysis of quality differences showed that significantly higher price and higher quality materials were applied to IPM fields than to the average nonprogram field, where high quality referred to a lower required application rate per

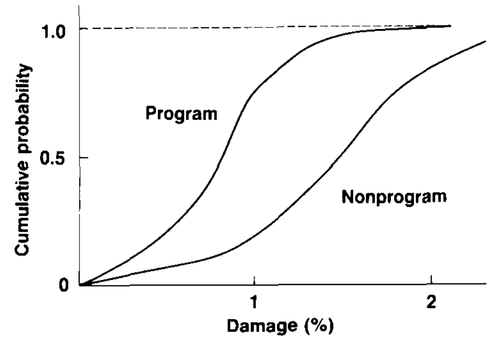

Fig. 1. The cumulative probability distribution shows a significantly greater likelihood of preharvest worm damage in nonprogram fields than in those in which the IPM program is followed.

Agricultural Experiment Station
UNIVERSITY OF CALIFORNIA
Berkeley, California 94720
Lowell N. Lewis, Director

Publication
PENALTY FOR PRIVATE USE, $300

BULK RATE
POSTAGE & FEES PAID
USDA
PERMIT No. G269

spray. As a result, the program fields were found not to differ significantly from nonprogram fields in insecticide cost per acre. The average cost was $22 per acre on fields planted in mid-season and $32 per acre on the late-season fields. Moreover, the program fields were sprayed wtih only slightly less frequency (1.5 times on average) than the nonprogram fields (1.7 times on average), again showing that the reduction in active ingredient applied to program fields had to come from an increase in quality.

The analysis of labor used for sampling fields for pest populations showed that about 38 percent more labor time was used for pest monitoring on program fields than on other fields. However, since only about seven minutes per acre per season of monitoring labor was used on an average field, this represents a cost increase of only about 58 cents per acre at a wage rate of $5 per hour. The evidence thus suggests that the labor cost increase is very small and probably not important.

Before concluding, we report one other finding with implications for the design of pest management programs. The statistical analysis showed that, as more insecticide was applied, damage risk decreased. Thus the data supported the common perception that insecticide performs the role of "insurance." This finding implies that, for programs to be beneficial to growers, they must provide a substitute for the risk-reducing effects of pesticides. The analysis of the tomato IPM program shows that this program does indeed provide a means of reducing pest damage risk without increasing the reliance on chemicals.

IPM reduces the risk of damage to California processing tomatoes with lower use of insecticides.

Conclusion

Our economic analysis of an IPM program for reducing fruit damage due to fruitworm and armyworm on processing tomatoes led to the following conclusions: mean worm damage and damage risk were reduced significantly on program fields; monitoring labor costs were increased slightly; pounds of active insecticide ingredient applied were reduced, but because of quality differences of the materials used, the total cost of the insecticides applied was not significantly different on program and nonprogram fields. Ignoring the value of risk reduction, growers can expect to increase net returns about $7.10 per acre by using the program. The significant reduction in damage risk associated with the program should increase the economic benefits to growers to the extent that they value risk reduction. The program appears to provide growers with an effective way to reduce worm damage risk without increasing their reliance on chemicals.

A final observation is in order on the effectiveness of this IPM program in reducing insecticide use. In terms of pounds of active ingredient, the program fields had, on average, 22 percent less insecticide applied per acre, but this reduction came largely from the use of higher price, higher quality materials. This reduction in total pounds of active ingredient applied may benefit the environment, reduce resistance to pesticides, and enhance biological control. Before this conclusion can be reached, however, it will be necessary to determine the relative effects of the different types of materials being used.

John M. Antle is Associate Professor, Department of Agricultural Economics, University of California, Davis, and Seong K. Park is Economist, Korea Rural Economics Institute, Seoul, Korea.

The authors gratefully acknowledge the advice and assistance of Gene Miyao, Farm Advisor, Yolo County; Craig Weakley, Area Farm Advisor, Sutter-Yuba Counties; Mary Louise Flint, Director, IPM Manuals Group, UC Davis; Karen Klonsky, Farm Management Extension Specialist, UC Davis; and Frank Zalom, IPM Extension Specialist, UC Davis. The authors also thank the 35 Sacramento Valley tomato growers who provided the information on which this study was based.