Leopold Center
FOR SUSTAINABLE AGRICULTURE

COMPETITIVE GRANT REPORT
89-30

Reducing pesticide use through environmental monitoring for pest protection

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Budget
$7,400 for year one
$3,480 for year two
$5,000 for year three

Background and goals

Strict grading standards require that fresh market apples be blemish-free. Consequently, Iowa orchardists are heavy users of synthetic chemical pesticides, typically making more than a dozen pesticide applications each growing season. The environmental and economic costs of this practice are high. Environmental contamination from spray drift and residues in surface and groundwater is an ever-present concern. This concern is critical in orchards located near populated areas. In addition, these pesticide applications represent direct costs to Iowa growers in the form of pesticide, labor, fuel, and equipment.

Growers face increasing pressure to reduce pesticide sprays while maintaining high quality of the fruit. Integrated pest management, or IPM, can help growers to meet both of these demands.

Successful IPM depends on understanding the links between weather and pest behavior, because weather conditions can be closely related to the risk of a pest outbreak. For example, apple scab (see Fig. 1, p. 31), the number one fungal disease problem in Iowa orchards, infects apples during the spring only when leaves or fruit remain wet for a sufficient time period and the temperature is warm enough for fungal growth.

New, automated pest forecasters transmit data from weather sensors to microcomputers that use models to interpret the data and advise growers about the potential for losses to specific disease and/or insect pests. These forecasters also recommend when to apply pesticide sprays. While such forecasting systems facilitate decision making, many growers consider them too expensive.

Other recent research has shown that growers can achieve the same level of pest control by using "low technology" approaches that rely on weather data from strip chart recorders and calculations made from simple reference tables. An even simpler IPM approach to apple scab control does not measure weather at all, but relies on assessment of scab incidence on fruit the previous season and on careful selection of fungicides and spray timing to reduce the number of sprays.

The goals of this project were (1) to evaluate the ability of IPM strategies to reduce the pesticide spray applications in Iowa apple orchards while maintaining pest control, yield, and fruit quality equivalent to standard spray programs, and (2) to compare the cost effectiveness of IPM spray strategies with a standard spray program in Iowa.

Approach and methods

Investigators located the study in a rootstock trial block of five-year-old Red Delicious apple trees at the ISU Horticulture Farm. The experimental design consisted of a randomized complete block with four replications and five treatments. Rootstocks were randomly distributed within treatments. To further minimize heterogeneity in yield potential among the various rootstocks, investigators selected 5 trees from the 10 to 11 in each replication on the basis of the greatest fruit set in 1989. Yield and pest data were averaged from these trees; the others received the same spray treatment but were not used to provide data.

The study focused on apple scab and codling moth. It included the following five treatments:

Treatment 1: Automated electronic devices were used to gather weather data. The device initially used, the "Predictor®," monitored temperature, relative humidity, and duration of periods of leaf wetness. It interprets the data with built-in computer programs and outputs spray advisories for apple scab and degree-day (DD) accumulation. (A degree-day is one degree of departure, on a single day, of the daily mean temperature from a given standard temperature.) Because manufacture of this device ceased after 1989, data were gathered in similar fashion with a datalogger and sensors in subsequent years of the project and downloaded to a computer via phone line. In all years, instruments were read on alternate days throughout the growing season.

Treatment 2: Investigators monitored weather data with a Leaf Wetness Recorder®, a strip chart device that records temperature, relative humidity, and duration of wetness period. Data transcribed from the strip chart were interpreted to make recommendations about timing of fungicide sprays.

Treatment 3: In Treatment 3, standard grower practice was used for application of fungicide and insecticide sprays.

Treatment 4: This IPM strategy for scab control, developed and used in New York State, specified four pre-scheduled fungicide sprays during spring, a pair just before bloom (at tight cluster and pink stages) and a pair just after bloom (at petal fall and first cover stages). Insecticide sprays were scheduled as in Treatment 2.

Treatment5: No fungicides were applied. In order to assure harvestable apples for the rootstock trial evaluation, insecticide sprays were scheduled as in Treatment 2.

Throughout the experiment, populations of male codling moths, which contribute to early abscission, or dropping, of fruit, were monitored with pheromone traps placed in trees. The pheromone-containing rubber cap in each trap was replaced every 4 to 6 weeks during the growing season. The number of codling moths per trap was assessed every other day until the first capture was recorded, then weekly during the remainder of the growing season.

During 1989, the DD model for IPM (Treatments 1, and 2, and 4), as well as for Treatment 5 was based on a model that accumulates DD's from March 1 using a base temperature of 50° F. Insecticide sprays were applied at pink and petal-fall stages; subsequent sprays were applied at 550 DD's and 1550 DD's only if an average of two or more codling moths per trap per week were captured at these times. In 1990 and 1991, new criteria for codling moth spray timing were used. Insecticide sprays were again applied at pink and petal-fall, but DD accumulation began on the date when the first codling moths were captured in pheromone traps in the orchard. Insecticide sprays were applied at petal-fall and at 250 and 1260 DD after this date. Additional sprays at 2- and 4-week intervals after 250 and 1260 DD were made only if an average of two codling moths per trap were caught in each of the two preceding weeks.

Pesticides were applied with a high-pressure hydraulic sprayer. Care was taken to minimize off-target drift. When feasible, insecticides and fungicides were tank mixed in order to minimize the number of spray trips. Because of drought in 1988 and 1989, few trees had infected leaves in fall 1989. To provide overwintering inoculum for scab in 1990, several hundred pounds of scab-infected apple leaves were obtained from orchards in other states. In December 1989, the leaves were scattered evenly on the plot between tree rows and chopped with a flail to minimize removal by wind.

In mid-October, apples were harvested separately from each tree, and each tree's harvest was separately graded and sorted by size. Workers recorded weights and further classified the fruit into marketable (blemish-free) grades and culls (used for cider). Workers inspected culled apples to identify the probable cause of blemishes, whether by apple scab, codling moth, apple maggot, or mechanical injury. Apples that had dropped prior to harvest were also weighed and inspected to identify probable source of injury, if any.

A partial budget technique was used to compare data from all treatments. The analysis encompassed all direct costs of pesticide applications and pest monitoring, including equipment, chemicals, machinery, and labor. The analysis did not include pesticide applications uniformly made to all treatments (e.g., springtime sprays for control of several insects). Revenue was calculated as the estimated market value of marketable and cull grades. Return was calculated by subtracting cost of scab and codling moth control from total revenue. In addition, investigators projected the estimated differences among treatments over orchard sizes of 5, 10, 20, and 40 acres.

In 1991, investigators cooperated with Jerald Deal, owner of Deal's Orchard near Jefferson, Iowa, in an on-farm demonstration involving Red Delicious and Jonathan apple trees. Three acres were sprayed for codling moth and apple scab according to IPM strategies outlined in Treatment 2 above. A Leaf Wetness Recorder® and two pheromone traps for codling moths were installed in the middle of the test block. Deal monitored weather data every two days during the spring and timed his fungicide sprays for scab accordingly. An ISU scout monitored codling moth captures weekly and assisted Deal in determining when to apply insect sprays. The IPM strategy used for codling moth was as described above for Treatment 2. At harvest, workers picked 50 apples per tree from each of five randomly selected trees in the IPM and control blocks and examined the apples for symptoms of scab and codling moth injury.

Findings

The IPM treatments (1,2, and 4) saved approximately three fungicide and two insecticide sprays per season, reducing pesticide use for scab and codling moth by about 35% compared to standard grower practice.

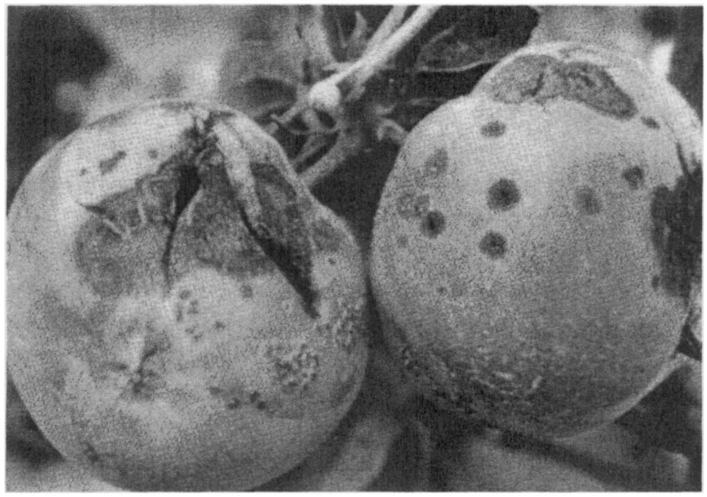

Fig. 1. Investigators plan to field-test several scab-immune cultivars for winter hardiness, yield, fruit quality, and other characteristics.

Yield in the IPM treatments was not significantly different from standard grower practice. Mean yield for Treatment 4, while not significantly different from Treatments 1 through 3, was substantially lower than these treatments. Additional years of comparative field trials will be needed to determine whether this disparity is a result of random variability or an inherent treatment effect. Treatment 5, which received no fungicides, had significantly lower yield than the other treatments.

Incidence of apple scab symptoms on harvested fruit in the IPM treatments was not significantly different than for standard grower practice, nor were differences significant among these four treatments in any year of the study. A significantly higher incidence of scab occurred in Treatment 5, however. This means that the IPM treatments controlled scab as well as the standard grower practice and much better than a no-spray treatment. In 1991, however, scab incidence in Treatments 1 through 4 was substantially higher than a commercial grower would consider acceptable. This occurrence was attributed to large amounts of overwintered inoculum, extremely wet weather in spring 1991, and inadequate spray coverage by the hand-held hydraulic sprayer.

Investigators noted codling moth injury only in 1989. Incidence was somewhat higher in dropped fruit than in harvested fruit. Even when dropped fruit were included, incidence of codling moth injury was less than 1.4% in 1989, and differences among treatments were insignificant. As with scab, the IPM treatments gave control of codling moth equivalent to that of the standard grower practice. The absence of fruit injury in 1990 and 1991 despite higher codling moth populations may be attributable to a more stringent (possibly too stringent) IPM spray program in these years than in 1989.

Comparative estimated annual costs of the treatments varied with orchard size. For example, in Treatments 1 and 2, the IPM treatments using weather-measurement instruments were more expensive than Treatment 3 (standard grower practice) for orchard sizes of 5 and 10 acres, nearly equivalent at 20 acres, and less expensive at 40 acres. This is because a single Predictor® or Leaf Wetness Recorder® suffices for an area up to at least 40 acres. Treatment 4 was less expensive than Treatments 1 through 3 at all orchard sizes. This treatment is lower in cost because no weather-monitoring equipment is needed, little labor goes into monitoring, and fewer sprays are applied than in standard grower practice (Treatment 3). The lower cost of Treatment 4 suggests that, in small (5- to 20-acre) orchards, this program may be more cost effective than more equipment-dependent IPM treatments.

Estimated revenues and returns were highest for Treatment 1, closely equivalent for Treatments 2 and 3, somewhat lower for Treatment 4, and by far the lowest for Treatment 5. This pattern parallels the ranking of marketable yield among treatments. However, because differences in yield among Treatments 1 through 4 are not significant, differences in revenue and return among these treatments may be due to random variability rather than treatment effects. More replications and additional years of field trials would allow clearer comparisons.

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Because of abnormally wet weather during spring 1991, the IPM treatment at Deal's Orchard required the same number of fungicide sprays as Jerald Deal's standard spray program. One fewer insecticide spray was applied in the IPM block, however. No damage from scab or codling moth was detected on harvested apples in either treatment.

Implications

This study provided convincing evidence that an Iowa apple grower can save a substantial number of pesticide applications by using IPM methods to control scab and codling moth. Reducing the number of sprays increases the amount of time that can be devoted to other farm management tasks. Fewer chemical pesticide sprays also mean reduced exposure for humans, non-target plants, and animals, and less risk of surface and groundwater pollution.

When compared to traditional pesticide spray schedules in terms of cost, the IPM methods are competitive with standard grower practice, although these relationships depend on orchard size.

The activities and results of this project were presented at three summer field days for apple growers. The project also served as the basis for additional work that resulted in production of a videotape entitled, "IPM for Midwest Apple Growers," for use by apple growers, consultants, and extension specialists across the Midwest. This project also laid the groundwork for later cooperative efforts between researchers and Iowa's commercial fruit and vegetable growers.

The 1991 outbreak of scab in this project emphasizes the need for further field research on scab incidence in the year preceding an outbreak. One key question is whether scab incidence on fruit is a reliable index of scab incidence on leaves, because scab on leaves, not fruit, is the source of subsequent epidemics. The investigators are currently evaluating the suitability of about a dozen "scab-immune" cultivars for Iowa conditions.