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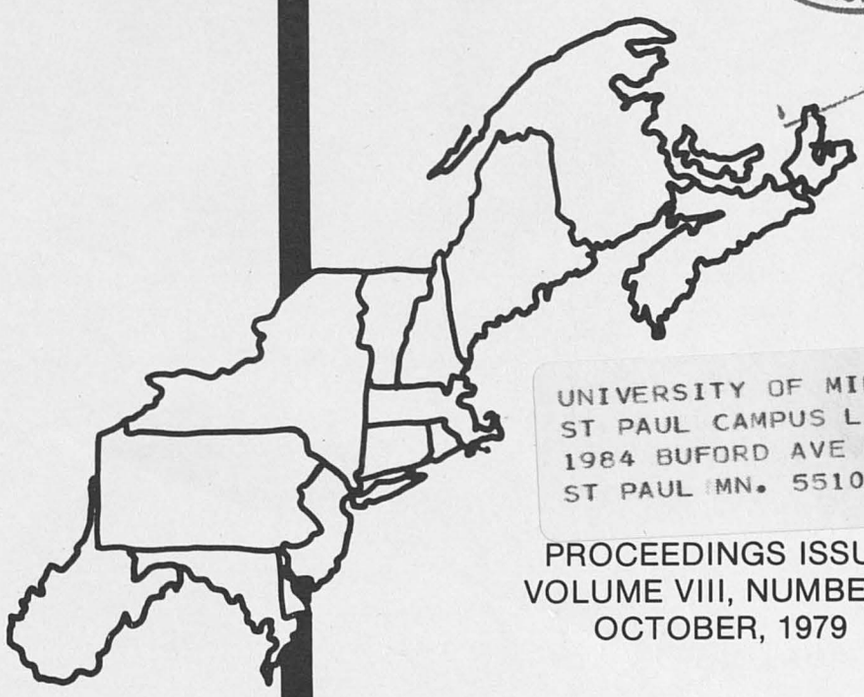

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IMPACT ON COSTS AND ENERGY REQUIREMENTS OF ADOPTING ALTERNATE MIDDLE SPRAY TECHNIQUES IN APPLE ORCHARDS

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One of the factors contributing to the substantial increases in crop yields experienced during the last fifty years was the development and use of synthetic chemical pesticides. In the past decade, however, increasing evidence has shown that use of these materials poses significant negative external effects on human health, wildlife, and the environment. Hall has stated the economic trade-off problem as follows:

> "The compromise of reducing both pesticide use and food production may be a better alternative than either cnacellation or continuing pesticide use at the present greater than the social optimum quantity. Even more attractive would be the alternative of reducing pesticide use while maintaining current levels of production (and) profit by growers."

The concept of "integrated pest management" (IPM) was originally formulated in the late 1950's [Stern]. Integrated pest management is a strategy which seeks to achieve pest control through an optimal selection of a set of available actions. Such actions include the use of pesticides but the employment of these pesticides is in conjunction with other methods and only when needed. To accomplish this objective requires a broad knowledge base of biological, agronomic and climatological information including the various interactions. Economics enters into the design of strategies in three interrelated ways: (1) the pest management goals of farmers are largely economic, (2) as a science of resource allocation, economics can aid in selecting opitmal quantities and combinations of pest management inputs, and (3) the economist's understanding of the incentives underlying farmers' behavior and the effect on these incentives of alternative social institutions can speed the adopiton of new pest management practices [Norgaard].

In 1978 a grant was received by Dr. Ronald Prokopy of the Department of Entomology at the University of Massachusetts for the development of an integrated management program for apple pests. The stated overall objective of the proposal was "to achieve a reduction in pesticide usage in Massachusetts apple orchards while maintaining high yields of high quality fruit" [Prokopy]. It is significant that economic analysis was explicitly in-

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corporated in the project.

The purpose of this paper is to describe one pest management strategy which would significantly reduce the amount of pesticides used while, it was hypothesized, having no significant effect on yields or fruit quality. This strategy involves a technique referred to as "alternate middle" spraying. The method of economic analysis employed was partial budgeting. Only direct costs and returns were considered. That is, no attempt was made to assess the social or environmental benefits resulting from reduced use of pesticides. Similarly, no assessment was made of the loss in consumer satisfaction from the potentially increased risk of biting into a wormy apple!

Description of Experiment

Over the 1976 and 1977 crop years, researchers in the Department of Entomology at the University of Massachusetts studied the effectiveness of alternate versus every middle spray treatments on 4-acre experimental blocks in three commerical apple orchards. In 1978, four orchards were included in the experiment. The data obtained permit preliminary analysis of net economic impact and reductions in energy use.

The alternate middle treatment involves spraying alternate halves of each tree on alternate spray dates instead of both halves (every middle) on all spray dates. For example, in applying the first cover spray, the sprayer would be driven between tree rows A and B and return between tree rows C and D, skipping the middle between B and C. For the second cover spray, the sprayer would be driven between tree rows B and C, D and E, and so forth. If this pattern is followed with every spray application, the practice should save 50 percent of spray materials, as well as reducing other operating costs.

The objective of the economic analysis was to determine the cost reductions associated with this insect and disease control regime and assess the extent of fruit damage and resultant impact on net revenues. A secondary objective was to estimate the resulting impact on energy use; both direct in terms of fuel requirements in application and indirect in terms of reduced pesticides used. It should be emphasized that the analysis presented here is based on limited data.

Direct Cost Effects

This analysis utilized partial budgeting to assess economic impact. The primary variables were: (1) reductions in spray materials cost, (2) reduction in labor cost, (3) reduction in fuel and other equipment related variable costs, and (4) value of fruit loss due to insect and disease injury. No impact on fixed costs was assumed although it could be argued that equipment would have a somewhat longer life due to reduced annual use.

The data from the parial budget are presented below:

Table 1

Partial Budget of Alternate Middle Spray Program[a/]

Cost Source	Cost Reduction Per Acre
Spray Materials Cost	$ 95.78
Labor (@ $3.50/hour)	6.12
Fuel, Oil, Filters, etc.	2.75
Total Cost Reduction	$104.65
Value of Fruit Loss (1978 prices and 3-year average on furit damage)	14.63
Net Cost Reduction (Increased Net Returns)	$ 90.02

a/ Based on analysis for 1978 crop year.

Since the value of fruit loss through insect or disease damage is of particular importance to the above cost analysis, the following data are presented from the experimental results.

Table 2

Damage Measurements from Experimental Blocks[a/]
[Hauschild, et al.]

Treatment	Percentage of Fruit Damaged (Mean Value)			
	1976[b/]	1977[b/]	1978[b/]	Three Year Ave.
Every Middle	2.8	1.5	2.7	2.3
Alternate Middle	2.9	2.5	3.4	2.9

a/ Only summary data are shown.

b/ Based on 6 acres for each treatment.

c/ Based on 15 acres for each treatment.

Grading results from the test blocks based on 1976 and 1977 experiments yielded 8.18 and 11.18 bushels of culls per acre for the every middle

and alternate middle treatments respectively. No difference in total yield was evident. The difference in terms of undamaged fruit was 3 bushels. The net difference in market value of damaged versus undamaged fruit was about $4. Therefore, the loss in product value was $12. In 1978 data was not collected on the quantity of culls from grading because of the greatly expanded acreage involved. However, no difference in total yield was apparent.

An alternative approach to estimation of losses would be to assume a representative total fruit yield of 750 bushels per acre and multiply this by the difference in the percentage of injured fruit. The three year average of damaged fruit from every middle spraying was 2.3 percent and for alternate middle spraying was 2.9 percent. The difference is 0.6 percent. Therefore, the added quantity of damaged fruit from alternate middle spraying would be .006 x 750 = 4.5 bushels. In 1978 the difference in price between damaged and undamaged fruit was estimated to be $3.25 per bushel. Therefore, the loss in value of fruit would be 4.5 x $3.25 = $14.63.

These experimental findings show that the alternate middle spray program appears to be nearly as effective for insect control as the every middle system. The results should still be regarded as somewhat tentative, however, since they are based on only three years results on a relatively limited acreage. The possible long term consequences and interactive effects remain to be explored. However, should these preliminary results remain valid, the opportunities for cost savings and increasing net returns can be significant for commercial orchardists. The potential increased returns for Massachusetts apple growers would be nearly $500,000 and for New England would be $1.7 million should all growers adopt this practice.

Impacts on Energy Use

A secondary benefit of the alternate middle spray program results from the reduction in direct and invested energy required. In this section, an attempt is made to assess the magnitude of this reduction and the potential impact if such a spray technique were adopted by New England apple growers.

According to the records kept in connection with the study, approximately 45 pounds of various pesticides are used on an acre of commercial apple orchard per year using an every middle spraying program. Since the alternate middle program uses half the spray materials, the savings in pesticides would be 22.5 pounds. Since each pound of pesticide is estimated to represent the consumption of about 56,500 Btu's, the savings per acre would be about 1.25 million Btu's. In addition, if it is assumed that the adoption of alternate middle spraying saves 5 gallons per acre in annual fuel use, this energy saving may be as high as 620,000 Btu's per acre. The total savings would, therefore, be on the order of 1.85 million Btu's per acre.

Recent inventories of the acrage of apple trees in the six New England states are at about 25,000 acres. Therefore, if this technique were adopted by all growers on all acreage, the potential aggregate annual energy savings would be 46.25 billion Btu's. Converted back to energy source equivalents, this is equivalent to 8,260 barrels of crude oil. Based on oil prices of $13, the value involved would be $108,000.

Discussion

Potential hazards to public health and the environment have caused a reassessment of pest and disease control programs in agriculture. While national and world food needs may make it impractical to totally eliminate the use of pesticides, it may be possible to reduce pesticide use and still maintain current production levels though seeking alternative pest management strategies. The work described here outlines one rather simple technique for reducing pesticide use in apple production by half and at the same time showing relatively little difference in product quantity or quality. At the same time the cost-benefit analysis indicates that the technique is profitable since net income is indicated to increase. In sum, costs, pesticide use, and energy use is reduced while net incomes are increased. As yet there is no indication of increased incidence of risk although the data should still be regarded as tentative. For example, the long run consequences in terms of pest and disease incidence remain to be determined.

Another aspect worth mentioning is the integration of economic and biological research in approaching problems. The objectives of the research were conceived broadly enough initially that data were collected not only on the entomological parameters but also on the economic factors. The economic methodology is sufficiently uncomplicated that it is easily communicated to noneconomists involved in field work and the significance of the results of the economic analysis is obvious to farmer cooperators. As a tool for extension education in economics, it permits illustration of marginal concepts and profit maximization as opposed to revenue maximization.

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