THE ECONOMICS OF INTEGRATED PEST MANAGEMENT: PROCESSING TOMATOES.

P. J. Grinter
Sustainable development Unit,
Agriculture Victoria.

Paper presented at the 40th annual conference of the Australian Agricultural & Resource Economics Society, University of Melbourne, 11-16 February, 1996.

Abstract

This paper estimates the on farm economic impact of integrated pest management (IPM), as practised on Victorian processing tomato crops. It was found that for the 1993/94 season, growers using IPM were on average, $97/ha better off than growers using conventional crop protection methods. This benefit was gained through a reduction in the costs associated with pesticide use.

Introduction

IPM has been defined as "... a pest population management system that utilises all suitable techniques in a compatible manner to reduce pest populations and maintain them at levels below those causing economic injury. Integrated control achieves this ideal by harmonising techniques in an organised way, by making control practices compatible, and by blending them into a multi-faceted, flexible, evolving system." (Smith and Reynolds 1966, FAO symposium on integrated pest control).

For a particular crop in a given region, IPM will be defined according to the techniques used by IPM practitioners, which will in turn be dependent on the pests found in the given region, the technology available (and its applicability to a given situation), as well as the climate, the bionomics of the pest(s) concerned as well as other factors. eg. IPM as practised on tomato crops involves the use of crop monitoring, encouraging biological control agents through the use of selective insecticides, and an egg threshold to determine the need for insecticides to control heliothis.

Pests of Processing Tomatoes

The most important arthropod pests of tomato crops are heliothis, aphids, leafhoppers, thrips, mites and wireworms.

The two species of heliothis (*Helicoverpa armigera* and *Helicoverpa punctigera*) are the most serious tomato pests. Heliothis moths usually invade and lay their eggs in flowering crops (Hamilton and Toffolon 1987). The larva bore into green and ripening fruit causing losses due to fruit drop, rot and culling at the factory. *H. punctigera* is more prevalent early in the season, while *H. armigera* is found later in the season (ibid). *H. armigera* has displayed resistance to a range of pesticides including synthetic pyrethroids (Gunning et al. 1984).

Leaf hoppers, aphids and thrips rarely occur in numbers large enough to directly damage the crop. However, these pests are vectors of diseases such as `big bud' (leafhopper) `tomato spotted wilt virus' (onion thrips), and `yellow top' (aphids), and their control is required to prevent the spread of these diseases (Hamilton and Toffolon 1987).

Wireworms are soil dwelling larva which attack tomato seedlings early in the season. The wireworm destroys young tomato seedlings by chewing through the stem below ground level (Fullelove 1992).

Conventional Pest Management

Conventional pest control in processing tomatoes usually involves:

- applying broad spectrum insecticides (such as synthetic pyrethroids or endosulfan) after flowering, at 10-14 day intervals, to control heliothis;
- using foliar applied systemic insecticides such as dimethoate, to control mites, leafhopper, thrips and aphids;
- applying fungicides at 10-14 day intervals to control various diseases. Frequently more than one fungicide is tank mixed with insecticide and applied in the same spray event; and
- applying chlorpyrifos to the soil as a band spray for wireworm control.

Integrated Pest Management

The IPM program designed for processing tomatoes consists of the following elements:

- crop monitoring by trained consultants for (i) heliothis larvae (ii) natural predators and/or parasitoids and (iii) other pests which may have been inadvertently controlled in the conventional spray program;
- using `IPM friendly' pesticides, such as phorate, to control wireworm, aphids, mites, leafhoppers and thrips*;
- predicting periods of peak fungal activity by monitoring weather conditions; and
- making decisions on the need to control based on:
    - (i) stage of crop development, water availability and weather conditions, and
    - (ii) a scientifically determined threshold of 5 unparasitised heliothis eggs per 30 leaves (Smith et al. 1994).

Methodology and Data Sources.

The method used to evaluate the change from a conventional pest management to IPM was partial budgeting. This involves defining the change to be made, assessing any changes in inputs and outputs arising from the change and applying appropriate valuations to these changes.

Estimates relating to chemical application were formulated on the basis of spray records collected from 17 non-IPM and 9 IPM growers during the 1993/94 growing season, from 6

---

* IPM friendly insecticides kill pests but are `soft' or less harmful to beneficials due either to their mode of action or the way in which they are used. For example, phorate, a soil applied systemic insecticide, kills leafhoppers and aphids but unlike foliar applied insecticides, such as dimethoate, it does not kill the egg parasitoids of heliothis. Using soil applied systemic insecticides such as phorate allows parasitoids to establish early in the season, which is crucial if significant biological control is to occur (Smith et al. 1994).

growing regions. Table 1 provides information on the location of growers and the number of crops planted to each pest control system.

Information on other aspects of IPM, including application and scouting costs, was obtained from entomologists involved in the research, a local farm management economist, industry representatives and a pest management consultant. Chemical resellers from Quambatook, Rochester, Cowra, and Griffith were also interviewed to obtain retail prices for the materials used by growers (1994/95 prices were used).

This data was used to prepare representative pest control programs. Budgets were developed and analysed using the EXCEL spread sheet.

Assumptions and Limitations.

1) Non-IPM growers failed to include wireworm control in their spray records. It was assumed that these growers applied chlorpyrifos as a band spray to the soil at a rate of 1 litre/ha and at a cost of approximately $25/ha (including the cost of application). This assumption was derived from label rates and discussions with entomologists, chemical resellers and pest management consultants. It represents a typical non-IPM control method.

2) A significant proportion of non-IPM growers failed to enter chemical application rates into their spray records. It was assumed that growers who had not entered rates used rates similar to those used by growers who had entered rates.

3) It was assumed that the rate of crop damage did not vary between systems. This assumption was based on a pest damage survey, which found that both IPM and non-IPM crops had less than 1% damage during 1993/94.

4) It was not possible to draw direct comparisons between all IPM and non-IPM growers due to variations in pest and disease pressures from region to region. Instead pest control programs were derived for IPM growers in the Boort area, and for non-IPM growers in the Rochester and Goulburn Valley area. It was possible to compare the two programs using this approach as pest and disease pressures are similar for these regions (M. Hind 1995, pers. comm.).

5) Only one years data was available, for the 1993/94 season. Ideally, pest management programs should be compared over a number of seasons, however for processing tomatoes, accurate records were only available for the 1993/94 season.

Table 1 **Profile of Growing Regions**

Growing Region	IPM Growers	IPM Plantings	Non-IPM Growers	Non-IPM Plantings	Total Growers	Total Plantings
Boort	3	19	0	0	3	19
Rochester	1	1	10	47	10†	48
Goulburn Valley	0	0	2	6	2	6
Southern NSW	5	14	2	5	7	19
Northern NSW	0	0	2	9	2	9
Cowra	0	0	2	19	2	19
Totals	9	34	18	86	26	120

COSTINGS:

(i) IPM Method of Crop Protection

Chemical costs under the IPM method of crop protection are summarised in Table 2.

Other costs which were considered were chemical application, monitoring and consultation costs. The pre-plant application of phorate costs \$3/ha. Other pesticides are applied using either ground or aerial spray equipment, at a cost of between \$20 and \$40/ha‡. The cost of monitoring and consultation was \$45/ha.

† One grower had both IPM and non-IPM plantings.

‡ The cost of application depends on whether aerial or ground application is used. Ground application was costed at \$5/ha and aerial application at \$8/ha.

Table 2: Chemical costs under IPM.

Number of applications	Chemical	Rate per ha	Cost per application($ ($/ha)	Cost ($/ha)
1-2	endosulfan	2.1 litres	17.45	17.45 - 34.90
1	esfenvalerate	300 ml	13.45	13.45
2	betacyfluthrin	450 ml	11.03	22.06
1	phorate	10 kg	59.80	59.80
3	copper hydroxide	2 kg	14.78	44.34
2	mancozeb	2 kg	13.92	27.84
1	sulphur	2 kg	4.58	4.58
			Total	190 - 207

(ii) Conventional Method of Crop Protection

Chemical costs under the conventional method of crop protection are summarised in Table 3.

The cost of chemical application is the only other cost incurred by conventional growers. The application of chlorpyrifos for wireworm control is applied using ground spray equipment at a cost of $5/ha. The other pesticides are applied in nine applications, at a cost of between $45 and $72/ha[5].

[5] see previous footnote.

Table 3: Chemical costs under conventional control.

Number of applications	Chemical	Rate per ha	Cost per application ($/ha)	Cost ($/ha)
1	chlorpyrifos	1 litres	18.81	18.81
2	dimethoate	825 ml	7.12	14.24
1	alphamethrin	300 ml	14.97	14.97
3	betacyfluthrin	450 ml	11.03	33.09
1	esfenvalerate	300 ml	13.45	13.45
2	endosulfan	2.1 litres	17.45	34.90
6	copper hydroxide	2 kg	14.78	88.68
1	zineb	1.7 kg	19.06	19.06
2	mancozeb	2 kg	13.92	27.84
2	metiram	2 kg	15.20	30.40
3	sulphur	2 kg	4.58	13 74
			Total	309

Comparison Between IPM and Conventional Program:

Pesticide costs under the IPM system were lower than those under the conventional system. IPM growers use 2 or 3 less insecticide applications for heliothis control, and 8 less fungicide applications than conventional growers, leading to savings of $110/ha.

Pesticide application costs were also reduced under IPM. IPM growers made only 5 or 6 applications (including phorate application), conventional growers made 10, leading to savings of $32/ha.
The cost of crop scouting and consultation was $45/ha for IPM growers, this cost is not incurred by conventional growers.

Table 4 summarises the average cost of inputs for each system.

Table 4: **Summary of input costs for IPM & non-IPM growers.**

Item	Conventional program ($/ha)	IPM program ($/ha)	Cost difference between conventional & IPM program ($/ha)
pesticides	309	199	110
application cost	64	32	32
scouting & consultation	-	45	(45)
Total	373	276	97

OTHER BENEFITS AND COSTS OF IPM

IPM systems have other benefits that a e not readily measurable. These benefits may include decreased soil compaction fro:n spray equipment, decreased risk of adverse effects of pesticides on human health, the environment and other off site effects, improved scheduling of other crop management operations eg. irrigation, better crop management through increased crop monitoring, a reduction in the likelihood of resistance to chemicals through less reliance of pesticides to control outbreaks and by targeting the most susceptible life stage of the pest.

Reduced likelihood of pest resistance to chemicals.

The tomato grub, *Helicoverpa armigera*, has displayed its ability to develop resistance to a variety of pesticides including the synthetic pyrethroids. In order to reduce the possibility of resistance IPM growers use a number of management techniques that reduce the likelihood of resistance occurring:

1) Use of phorate or mineral oil for the control of sap sucking insects Using these materials allows for an increase in biological control, most notably through a species of parasitic wasp. This biological control decreases the amount of selection pressure placed on the pest through the use of insecticides, and therefore lessens the chance of resistance to the insecticides used.

2) Selection of different chemicals
Non-Ipm growers tend to rely more on synthetic pyrethroid sprays to control heliothis compared to IPM growers. Overuse of a particular chemical or class of chemical may lead to resistance to that chemical and related products.

3) Timing the most susceptible pest life stage.
Daly etal (1988) found that selection for pyrethroid resistance occurred when adult moths and older caterpillars were exposed to synthetic pyrethroids but did not occur in the neonate larva. Through monitoring IPM growers are better able to time sprays to control neonates, or select a chemical more suitable for large caterpillars.

Findings.

For the 1993/94 growing season the net cost of an IPM program was on average $276/ha compared with $373/ha for a conventional program. This constitutes a saving of $97/ha, (about 2% of the costs associated with tomato production or an 11% increase in net returns to the grower**).

CONCLUSION.

The IPM program for processing tomatoes utilises a combination of pest monitoring, heightened awareness of the role of parasitoids, and the use of thresholds to guide spray decisions. In contrast, conventional approaches usually involve spraying at regular intervals, often without knowledge of pest densities in the crop.

A shift from the conventional to the IPM approach of crop protection involves costs and benefits. Costs include professional scout hire. Potential benefits include the decreased use of some inputs, eg. pesticides.

Studies which have measured the on-farm benefits of IPM reveal that when an IPM system is used, costs for controlling pests are usually lower, net returns greater, and risk is the same as or lower than that found with conventional control programs.

Other likely benefits of a switch to IPM in processing tomatoes include decreased likelihood of heliothis resistance to insecticides, more judicious pesticide use, and decreased risk of crop damage through undetected insect infestations.

REFERENCES

Daly, J.C., Fisk, J.H. and Forrester, N.W. (1988). Selective mortality in field trials between strains of *Heliothis armigera* (Lepidoptera: Noctuidae) resistant and susceptible to pyrethroids: functional dominance of resistance and age class. *Journal of Econ. Entom.* 81:1000-1007.

Fullelove, G. (1992). Tomato pest and disorders. Queensland Department of Primary Industries. Agdex 262/620.

Grinter, P. & Malcolm, L.R. (1994) An economic evaluation of alternative pest management strategies in northern Victorian peach orchards. Paper presented at the 38th Annual Conference of the Australian Agricultural Economics Society. Wellington New Zealand, February 1994.

Gunning,R.V., Easton, C.S., Greenup, L.R., Edge, V.E. (1984). Pyrethroid resistance in *Heliothis armigera* (Hubner)(Lepidoptera: Noctuidae) in Australia. *Journal of Economic Entomology*, 77: 1283-87.

** Assumes production costs of $4900/ha and returns of $820/ha (Ray Holland, pers. comm.).

Hamilton, J.T., & Toffolon, R.B. (1987) Pests of tomatoes. Agfacts. Department of Agriculture NSW. Agdex 262/620.

Parigi, P. (1995). Measuring the on-farm economic impact of Integrated Pest management: An introductory guide. Agriculture Victoria. ISBN: 0 7306 6450 3.

Smith M., Ridland P., Bentley J., Walker B., Hind M. (1994). Integrated Pest Management - It Works! *Australian Processing Tomato Grower* 15:24-27.

Smith, R.F., and Reynolds, H.T. (1966). Principles, definitions and scope of integrated pest control. In: . FAO symposium on integrated pest control, Rome, Italy 1:11-17.