THE USE OF INTEGRATED PEST MANAGEMENT IN CITRUS ORCHARDS IN QUEENSLAND

- An Economic Perspective

by

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SUMMARY

A commercial integrated pest management (IPM) programme has been developed for Queensland citrus growers over the past 13 years. The programme services about 80% of bearing citrus grown in the Central Burnett district of Queensland and has resulted in around 90% reduction in pesticide usage. A team of professional scouts monitors and consults with growers. Two species of parasitoid are mass-reared and augmentatively released during spring and summer at rates of 10,000 per ha. *Aphytis lingnanensis* and *Leptomastix dactylopii* are produced in an insectary for the control of red scale, *Aonidiella aurantii* and citrus mealybug, *Planococcus citri* respectively. Recent developments in the biological control of a key pest - citrus snow scale, *Unaspis citri* by a predatory coccinellid beetle *Chilocorus circumdatus*, and techniques for the enhancement of a naturally occurring predatory mite *Amblyseius victoriensis* show promise.

The most significant outcomes from the use of IPM are summarised as follows:

- Large savings in pest and disease control are being achieved with the use of IPM. IPM costs range from 37% to 53% of conventional control costs, depending upon the variety of citrus.

- Using chemicals to totally control pests and diseases was once regarded as the only risk free way to maximise quality and quantity in citrus production. However evidence now suggests that widespread insect resistance has developed to two commonly used insecticides, Methidathion (Supracide [R]) and Fenbutatin oxide (Torque [R]), after 20 years of use.

- While there is a perceived element of risk, the adoption of IPM with competent scouts has shown that neither quality nor quantity need be compromised. Indeed, one of the stated aims of IPM is to produce high quality fruit through careful monitoring and timely action. Nonetheless, if a biocontrol option does not exist, a pesticide is used.

- Other benefits from using IPM include:

    - Benefits to farmers' health and to the environment from using less chemicals;

    - Greater managerial control to growers which arises from the IPM monitoring system, allowing them to concentrate more on actual growing and marketing of the crop.

For all of the above reasons the younger generation of citrus growers now taking over orchards in Queensland are likely to persist with IPM as the favoured system of pest and disease control.

INTRODUCTION

Citrus in Queensland

In Queensland only a relatively small area of citrus is grown - 3000 ha producing 85 000 tonnes of fruit worth in 1988 an estimated $60m. Of this, 80% of fruit is produced for the fresh fruit market (70% domestic, 10% export) and the remainder is processed. Two thirds of Queensland's citrus fruit and all the fruit for export is grown in the Central Burnett district at Gayndah and Mundubbera (25.5°S, 152°E) on the Burnett River, 130 km from the coast. Most Queensland citrus receives about 800 mm of rain with 250 ha in coastal areas receiving up to 2,000 mm. All commercially grown citrus in Queensland is irrigated. Mandarins make up about half of the citrus grown, oranges 40%, and lemons, grapefruit and limes together 10%.

There are about 30 pests capable of causing economic loss (Smith and Papacek, 1985) - notably scales such as red scale, *Aonidiella aurantii* (Maskell), citrus mealybug, *Planococcus citri* (Risso), Rust mites, *Tegolophus australis* (Kiefer), and *Phyllocoptruta oleivora* (Ashmead), broad mite, *Polyphagotarsonemus latus* (Banks), Queensland fruit fly, *Dacus tryoni* (Froggatt) and spined citrus bug, *Biprorulus bibax* (Breddin). The cost of controlling these solely with a schedule of chemicals can be very high (Table 1). There is evidence also of resistance or tolerance to most organophosphate scalicides in red scale and to many miticides in the rust mites.

Overseas natural enemies introduced

Over the last 20 years, up to a dozen parasitic insects ("beneficials") have been introduced to promote biological control, particularly of the 5 major scales - red, citrus snow, *Unaspis citri* (Comstock), white wax, *Gascardia destructor* (Newstead), Pink wax, *Ceroplastes rubens* (Maskell),. and circular black scale, *Chrysomphalus aonidum* (Linnaeus). There is now very effective biological control of these pests in Queensland providing the beneficials do not have to cope with serious pesticide disruption (Sands et al 1986, Smith et al 1989, Smith 1986, Smith and Papacek 1985, Smith 1978 a and b). The much improved level of biological control has been accompanied by a large decrease in organophosphate spraying so conserving a host of native natural enemies important in controlling some two dozen minor pests. (Papacek and Smith 1989, Smith and Papacek 1985).

IPM ADOPTION

IPM was first adopted by one large grower at Mundubbera in the 1978-79 season. By 1985, about 40% of the citrus area was using IPM and by 1991-92, the percentage has risen to at least 75% (80% in the Central Burnett). Table 1 shows the recent history of two exporting orchards at Mundubbera, both efficiently managed, but the second more intensively than the first. In Orchard 1, control costs using IPM averaged $295 per ha in comparison with costs of $924 using a full chemical schedule - a reduction of 68%. In Orchard 2, the corresponding costs were $340 and $1784 - a reduction of 81%. The average savings to growers over some 2000 ha of mature trees in Queensland has been about $2m annually. Pesticide usage from 1980 to 1990 has dropped by 90%.

Not all the pests are successfully controlled under biological control and there is selective use of some pesticide eg. yeast autolysate plus chlorpyrifos bait spray are used to control Queensland fruit fly. Narrow range oil can be used to control soft scale infestations, low rates of endosulfan to control flatids and bugs and fenbutatin oxide to control troublesome mite infestations. Encouraging trial results have been given by selective insect growth regulators such as buprofezin against scales and jassids (Smith and Papacek, 1989).

Because of the complexity of pests, the role of scouts is considered vital and there are currently six, each handling about 350 ha. The orchards are monitored, usually fortnightly, from flowering to near harvest by a comprehensive examination of most parts of the tree (Broadley et al 1987, Smith 1990).

PROBLEM STATEMENT

Up to this point, the benefits of IPM compared with conventional pest and disease control have been imprecisely estimated. There is a need to adopt a standardised approach to more accurately estimate these benefits. However, IPM and conventional pest and disease control systems are not mutually exclusive. As previously explained, there is usually some combination of both systems on most farms. The analysis in this report takes this interdependence into account.

OBJECTIVES

The main aim of this analysis is to more accurately quantify the benefits of IPM in citrus and express them in financial terms. Other benefits of a health, environmental, or managerial nature are acknowledged but not treated in this report. The methodology used and the results generated may also be of assistance in the adoption of IPM for other crops.

Table 1. Fruit ratings, yields and pest management costs at two Mundubbera orchards

Year	Fruit ratings**			Total production* 18 kg boxes	Costs (Aust $ - expressed in 1992 dollars)					
	1st Grade	2nd Grade	Juice		Pesticides only	Pesticide application (labour* and fuel)	IPM costs: Monitoring	IPM costs: Parasitoids	Total	Per Ha
Orchard 1 (44 ha)										
1978-79 (chemical)	81.2	12.6	6.2	50 240	31 800	8 100	-		39 900	907
1979-80 (chemical)	79.5	16.3	4.2	38 075	33 300	8 100	-		41 400	941
1980-81 (partial IPM)	91.0	6.8	2.2	68 230	18 250	5 400	2 200		25 850	588
1981-82 (IPM)	80.9	9.8	9.3	62 960	4 950	990	6 600		12 540	285
1982-83 (IPM)	[illegible]	6.6	13.0	72 750	3 200	640	6 600		10 440	237
1983-84 (IPM)	81.5	7.4	10.8	79 080	4 500	900	6 600		12 000	273
1989-90 (IPM)	78.0	7.0	15.0	85 000	100	20	8 800	1 500	10 420	237
1990-91 (IPM)	88.0	1.0	11.0	97 000	1 375	275	8 800	8 100	18 550	421
Orchard 2 (44 ha)										
1980-81 (chemical)	82.5	12.4	5.1	138 391	69 000	9 500	-		78 500	1 784
									13 550	308
1981-82 (IPM)	86.5	9.5	4.0	134 800	6 250	700	6 600		13 550	308
1982-83 (IPM)	88.6	7.4	4.0	141 818	6 250	700	6 600		15 700	357
1983-84 (IPM)	81.8	11.7	6.5	127 015	8 100	1 000	6 600			
1989-90 (partial IPM)	77.0	8.0	15.0	147 240	17 500*	2 000	8 800	1 500	29 800	677
1990-91 (IPM)	83.0	9.0	8.0	130 438	280	50	8 800	8 100	17 200	390

** Improved factory outlets after 1981 took most of the fruit discarded before that date. No record was kept of discarded fruit before 1979-80, but it was less than 1% after that.

* The dominant factors in production increases were due to seasonal variations and increased yield as trees matured.

* Includes a labour cost estimate for scouting by the grower in pre-IPM years of $1500 per year; does not include machinery depreciation and maintenance.

* Most of this was for chlorpyrifos applied for citrus snow scale.

METHODS

While Table 1 provides useful information for two Mundubbera orchards, it does not take into account the age and varietal breakdown of the trees. Since orchards are highly unique with respect to their age/varietal mix, there is a need to standardise their composition when comparing treatments. Further, Table 1 provides an estimate of pest control costs only and not disease control costs. Determining the economic benefits of IPM more precisely requires a holistic approach to the complete pest and disease control program for an orchard. This is because:

a) the lower costs of IPM need to be compared against conventional or "control" costs for citrus in a given time period;

b) disease control costs (fungicides) under IPM are also typically less than those under the conventional regime so the totals of both pest and disease control costs need to be measured;

c) pest and disease control measures vary according to variety; and

d) discounted cash flow (DCF) analysis is required to measure costs which occur over a tree life of 20 to 35 years, depending upon the variety.

Traditionally, when comparisons are made of IPM and conventional pest and disease control, the costs for a "mature hectare" only are considered. This approach fails to take into account the long term life of citrus, and the unique build up in the early years of pest and disease control costs for each variety. DCF analysis is used in this report to allow for this. Further, average annual costs are determined by taking the annuity of the Net Present Value of these costs. It should also be noted that for the first three years life of all varieties, conventional pest and disease control is standard procedure, whether or not IPM is used later.

The methodology is illustrated in Appendix Table 1 for the conventional method and Appendix Tables 2 to 7 for IPM. Appendix Table 8 illustrates how DCF analysis is used (discount rate 6%) to estimate average pest and disease costs per ha in present dollars, and compares IPM costs against conventional costs.

RESULTS

The benefits of using IPM rather than a conventional pest and disease program are summarised in Table 2 over the life of the orchard. They are based on using DCF analysis with a discount rate of 6%.

Table 2 The Benefits of IPM in Citrus

Item	Variety					
	Oranges ($/ha/yr)	Ellendales ($/ha/yr)	Imperials ($/ha/yr)	Murcotts ($/ha/yr)	Lemons ($/ha/yr)	Grapefruit ($/ha/yr)
Conventional pest & disease control	2081	2081	2081	2081	2081	2081
Estimated IPM costs	768	762	771	1103	913	791
IPM savings	1313	1318	1310	977	964	1086
IPM / conventional	37%	37%	37%	53%	49%	42%

Large savings are apparent through the use of IPM. For example, a fully mature orchard of say 50 ha would save approximately $50 000/year, based on IPM savings of about $1000/ha/year. In practice, the actual saving in any one year could be considerably less than this because all orchards have trees of varying ages. This applies particularly to orchards with a considerable proportion of immature trees (less than 9 years of age).

APPENDIX 1: COMPARISON OF CONVENTIONAL PEST AND DISEASE CONTROL VERSUS INTEGRATED PEST MANAGEMENT FOR CITRUS IN THE CENTRAL BURNETT REGION, QUEENSLAND.

GENERAL NOTES ON THE USE OF THIS FILE

BEFORE PROCEEDING WITH ALTERATIONS TO TABLES ON THIS FILE, PLEASE MAKE WHATEVER CHANGES ARE NECESSARY TO THE FOLLOWING INPUTS.

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DATE

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GENERAL		DATA
TREE NUMBER	=	[illegible] TREES
ORCHARD AREA(HA)	=	[illegible] AREA
NUMBER OF BLOCKS	=	5 BLOCKS
TRACTOR($/HR)	=	7.50 TRACTOR
TRACTOR($/HR)	=	11.00 TRACTORSLASH
DISCOUNT RATE (%)	=	6.00 DISCOUNT

INSECT AND DISEASE CONTROL (Source: Mr.[illegible], Aptek,Gayndah. Tele: 071-[illegible])

METHIDATHION ($/L)	=	22.50 M	($450/20L)	Common name Supracide
WHITE OIL($/L)	=	1.65 W	($330/200L)	
TORQUE($/L)	=	76.00 T	($380/5L)	Also called fenbutatin oxide.
CopperOXYCL($/kg)	=	2.10 C	($70/25kg)	Said to be superseded by [illegible] at $[illegible].
DITHANE($/kg)	=	5.60 D	($140/25kg)	
CHLORPYRIFOS($/L)	=	19.00 LOR	($380/20L)	Lorsban
YEAST AUTOLYSATE($/L)	=	7.00 YAU	($1400/200L)	
D-C-TRON OIL ($/L)	=	1.88 Do	([illegible])	
KELTHANE($/L)	=	12.40 K	($248/20L)	
ENDOSULPHAN($/L)	=	7.50 E	($150/20L)	
NOVRAL($/kg)	=	60.00 N		

BENEFICIAL INSECTS

APHYTIS ($/ha/ap)	=	135.00 A
LEPTOMASTIX($/ha/a)	=	135.00 L
[illegible]($/ha/yr)	=	[illegible]

DETAILS OF CHEMICALS

Symbol	Product	Chemical/ 100L spray L or kg	Cost/L /kg chemical ($)	Chemical cost ($/100L)
M	Methidathion(400g/L)	0.115	22.50	2.59
W	White oil (for scale)	1.000	1.65	1.65
T	Torque (for mites)	0.030	76.00	2.28
C	Copperoxychloride(for fungus)	0.400	2.80	1.12
D	Dithane(Mancozeb)	0.200	5.60	1.12
LOR	Chlorpyrifos 500ep (Lorsban)	0.800	19.00	15.20
Y	Yeast autolysate(500g/L)	2.000	7.00	14.00
Do	D-C-Tron oil	1.000	1.88	1.88
K	Kelthane (miticide 20%)	0.200	12.40	2.48
E	Endosulphan (Thiodan)	0.030	7.50	0.23
N	Novral(Murcotts only)	0.075	60.00	4.50

Notes :
1. An air blast sprayer is used for trees up to four years of age,and a high volume boomspray is used for older trees.
2. Bait sprays are usually applied at the rate of about 50ml per tree or 12.5L/ha using a small tractor travelling about 8km/h. Tractor costs for bait sprays are not included in the above table because of their insignificance.Some growers use up to 12 bait sprays per year.
3. Pest and disease control sprays have a dual role in that they also provide trace elements.

Appendix Table 1: Insect and disease control CONVENTIONAL

Test	Rate	INSECTICIDES			FUNGICIDES			[illegible]			TRACTOR			TOTAL	TOTAL
		Applic.	Chemical (refer below)	Cost	Applic.	Chemical (refer below)	Cost	Applic.	Chemical (refer below)	Cost	Number	Work rate	Cost	COST/HA	COST OF TREE
	(t/ha)	(No.)		($/ha)	(No.)		($/ha)	(No.)		$/ha		(h/ha)	($/ha)	($/HA/YR)	($/YEAR)
1	250	3	Er	72.53	0	0	0	0	*		3	1	22.50	55	331
2	1000	3	Er	130.13	1	Cr	27.38	0			4	1	30.00	188	3281
3	1500	3	Er	135.13	1	Cr	41.55	0			4	1.5	45.00	223	5072
4	2000	3	Er	228.25	2	Cr	55.40	0			4	1.5	45.00	303	6102
5	5250	2	Er	353.65	1	Cu	313.13	1	1	105.37	5	3	135.00	1508	23131
		3	T		2	B		6	1						
6	7500	2	Er	1153.63	1	Cr	375.35	1	1	327.46	5	3	135.00	3151	30101
		3	T		2	F		6	6						
7	1750	2	Er	1357.56	1	Cs	431.31	1	1	257.86	5	3	135.00	2211	39304
		3	T		2	B		6	1						
8,9,...	11000	2	Er	1111.51	1	Cr	551.38	1	1	357.53	5	3	135.00	3152	51331
		3	T		2	B		6	6						
		1	E(50%)												

Appendix Table 2: Insect and disease control [illegible]

Year	Rate	INSECTICIDES			FUNGICIDES			[illegible]			TRACTOR			I.P.M.			TOTAL COST/HA	TOTAL COST OF [illegible]
		Applic.	Chemical (refer below)	Cost	Applic.	Chemical (refer below)	Cost	Applic.	Chemical (refer below)	Cost	Number	Fuel rate	Cost	Insects	Monitor	Cost		
	(t/ha)	(No.)		($/ha)	(No.)		($/ha)	(No.)		($/ha)		(l/ha)	($/ha)	($/ha)	($/ha)	($/ha)	($/HA/YR)	($/[illegible])
1	250	3	Bx	32.55	0	0	0	0			3	1	22.50				55	351
2	1000	3	Bx	132.33	1	Cu	37.70	0			4	1	30.00				311	[illegible]
3	1500	3	Bx	155.19	1	Cu	43.55	0			4	1.5	45.00				[illegible]	[illegible]
4	[illegible]	1	La	33.50	2	C	41.10	0			3	1.5	33.75	218	208	418	552	[illegible]
5	[illegible]	1	La	105.48	2	C	110.30	6	1	21.50	3	3	45.92	218	[illegible]	418	[illegible]	[illegible]
6	[illegible]	1	T(20%)*	36.20	2	C	111.00	6	1	21.50	3	3	45.00	218	208	418	[illegible]	[illegible]
7	[illegible]	1	T(20%)*	45.11	2	C	251.00	6	1	21.50	5	3	75.00	218	208	418	[illegible]	[illegible]
		1	T(50%)*		1	D												
8,9,...	[illegible]	1	T(20%)*	51.55	2	C	265.50	6	3	21.50	5	3	75.00	218	208	418	[illegible]	[illegible]
		1	T(50%)*		1	D			*									

* Signifies sprays are for [illegible] of 20% and 50% of area respectively.

Appendix Table 3: Insect and disease control I.P.M. – [illegible]

Year	Rate	INSECTICIDES			FUNGICIDES			[illegible]			TRACTOR			I.P.M.			TOTAL COST/HA	TOTAL COST OF [illegible]
		Applic.	Chemical (refer below)	Cost	Applic.	Chemical (refer below)	Cost	Applic.	Chemical (refer below)	Cost	Number	Fuel rate	Cost	Insects	Monitor	Cost		
	(t/ha)	(No.)		($/ha)	(No.)		($/ha)	(No.)		($/ha)		(l/ha)	($/ha)	($/ha)	($/ha)	($/ha)	($/HA/YR)	($/[illegible])
1	250	3	Bx	32.55	0	0	0	0			3	1	22.50				55	[illegible]
2	[illegible]	3	Bx	135.33	1	Cu	37.70	0			4	1	30.00				111	[illegible]
3	1500	3	Bx	195.19	1	Cu	41.55	0			4	1.5	45.00				[illegible]	[illegible]
4	[illegible]	0	La	[illegible]	1	C	[illegible]	0			3	1.5	33.75	218	208	418	[illegible]	[illegible]
5	[illegible]	0	La	[illegible]	2	C	[illegible]	6	1	21.50	2	2	[illegible]	218	208	418	[illegible]	[illegible]
6	[illegible]	1	T(20%)	[illegible]	2	C	[illegible]	6	1	21.50	3	2	[illegible]	218	208	418	[illegible]	[illegible]
7	[illegible]	1	T(20%)	51.31	2	C	251.00	6	1	21.50	5	2	75.00	218	208	418	[illegible]	[illegible]
		1	Z(50%)		1	D												
8,9,...	[illegible]	1	T(20%)	[illegible]	2	C	265.50	6	2	21.50	5	2	75.00	218	208	418	572	[illegible]
		1	Z(50%)		1	D												

Appendix Table 4: Insect and disease control I.P.M. - [illegible]

Year	Rate	INSECTICIDES			FUNGICIDES			[illegible]			TRACTOR			I.P.M.			TOTAL COST/HA	TOTAL COST OF [illegible]
		Applic.	Chemical (refer below)	Cost	Applic.	Chemical (refer below)	Cost	Applic.	Chemical (refer below)	Cost	Number	Work rate	Cost	Insects	Monitor	Cost		
	(L/ha)	(No.)		($/ha)	(No.)		($/ha)	(No.)		($/ha)		(h/ha)	($/ha)	($/ha)	($/ha)	($/ha)	($/HA/YR)	($/[illegible])
1	250	3	Br	32.53	0	0	0	0			3	1	22.58				55	551
2	1000	3	Br	130.33	1	Cr	27.38	0			4	1	30.84				188	3311
3	1500	3	Br	195.13	1	Cr	41.55	0			4	1.5	45.48				282	5871
4	2000	1	La	33.60	1	C	22.49	0			2	1.5	22.58	210	200	410	513	9333
5	4250	1	La	135.80	2	C	118.84	6	3	21.58	3	2	45.88	210	200	410	752	13536
6	7500	1	T(2%)	31.28	2	C	151.88	6	3	21.58	3	2	45.88	210	200	410	789	17351
7	8750	1	T(3%)	51.71	2	C	351.88	6	3	21.58	5	2	75.65	210	200	410	813	15817
		1	B(5%)		1	B												
8,9,...	11000	1	T(2%)	55.51	2	C	369.58	6	3".	21.58	5	2	75.08	210	200	410	852	17487
		1	B(5%)		1	B												

Appendix Table 5: Insect and disease control I.P.M. - [illegible]

Year	Rate	INSECTICIDES			FUNGICIDES			[illegible]			TRACTOR			I.P.M.			TOTAL COST/HA	TOTAL COST OF [illegible]
		Applic.	Chemical (refer below)	Cost	Applic.	Chemical (refer below)	Cost	Applic.	Chemical (refer below)	Cost	Number	Work rate	Cost	Insects	Monitor	Cost		
	(L/ha)	(No.)		($/ha)	(No.)		($/ha)	(No.)		($/ha)		(h/ha)	($/ha)	($/ha)	($/ha)	($/ha)	($/HA/YR)	($/[illegible])
1	250	3	Br	32.53	0	0	0	0			3	1	22.58				55	551
2	1000	3	Br	130.33	1	Cr	27.75	0			4	1	30.33				188	3381
3	1500	3	Br	195.13	1	Cr	41.55	0			4	1.5	65.82				283	5871
4	2000	1	La	33.63	1	C	22.49	0			2	1.5	22.58	210	200	410	515	9333
5	4250	1	La	185.80	2	C	118.00	6	3	21.58	3	2	45.88	210	200	410	752	13531
6	7500	1	T(2%)	31.38	2	C	151.33	6	3	21.58	3	2	45.88	210	200	410	729	17251
7	8750	1	T(3%)	415.46	2	C	352.38	6	3	21.58	5	2	58.03	210	200	410	1231	22215
		1	B(5%)		1	B												
		1	T															
8,9,...	11000	1	T(2%)	558.31	2	C	359.58	6	3	21.58	6	2	58.02	210	200	410	1082	25557
		1	B(5%)		1	B												
		1	T															

Appendix Table 6: Insect and disease control I.P.M. - [illegible]

Year	Rate (L/ha)	INSECTICIDES Applic. (No.)	Chemical (refer below)	Cost ($/ha)	FUNGICIDES Applic. (No.)	Chemical (refer below)	Cost ($/ha)	CHEMICAL AND BAIT Applic. (No.)	Chemical (refer below)	Cost ($/ha)	TRACTOR Number	Work rate (h/ha)	Cost ($/ha)	I.P.M. Insects ($/ha)	Monitor ($/ha)	Cost ($/ha)	TOTAL COST/HA ($/HA/YR)	TOTAL COST OF [illegible] ($/YEAR)
1	250	3	Ex	32.53	0	0	0	0			3	1	22.50				55	351
2	1000	3	Ex	130.33	1	Cr	21.78	0			4	1	30.00				111	3311
3	1500	3	Ex	195.19	1	Cr	41.55	6	1	21.50	4	1.5	45.00				354	5155
4	2000	4	La	8.00	1	C	22.40	6	1	21.50	3	1.5	31.25	240	208	448	456	1320
5	4250	4	La	8.20	2	C	110.36	6	1	21.50	2	2	31.00	240	208	448	632	11374
6	7500	1	T[SR]	201.15	1	C	251.63	6	1	21.50	5	2	75.50	240	282	448	1031	11561
		1	Ex[SR]		2	B												
7	1150	1	T[SR]	293.36	1	C	291.40	6	1	21.50	6	2	50.40	245	220	448	1165	28655
		1	Ex[SR]		2	B												
		1	X[SR]															
8,9,...	11000	1	T[SR]	335.31	1	C	353.52	6	1*	21.50	.	2	51.32	240	258	448	1291	23361
		1	Ex[SR]		2	B												
		1	X[SR]															

Appendix Table 7: Insect and disease control I.P.M. - [illegible]

Year	Rate (L/ha)	INSECTICIDES Applic. (No.)	Chemical (refer below)	Cost ($/ha)	FUNGICIDES Applic. (No.)	Chemical (refer below)	Cost ($/ha)	CHEMICAL AND BAIT Applic. (No.)	Chemical (refer below)	Cost ($/ha)	TRACTOR Number	Work rate (h/ha)	Cost ($/ha)	I.P.M. Insects ($/ha)	Monitor ($/ha)	Cost ($/ha)	TOTAL COST/HA ($/HA/YR)	TOTAL COST OF [illegible] ($/YEAR)
1	250	3	Ex	32.53	0	0	0	0			3	1	22.50				55	151
2	1000	3	Ex	133.13	1	Cr	21.78	0			4	1	32.00				111	3312
3	1500	3	Ex	155.15	1	Cr	41.55	0			4	1.5	45.00				312	5011
4	2500	4	La	8.03	1	C	55.40	0			3	1.5	11.35	242	238	448	527	3128
5	4250	4	La	8.20	2	C	110.84	5	1	21.50	2	2	32.00	240	238	448	632	11324
6	1500	1	T[75]	121.25	2	C	161.83	6	1	21.50	3	2	45.00	241	238	448	803	11657
7	4750	1	T[75]	153.47	1	C	251.03	6	1	21.50	5	2	75.00	240	238	448	925	17077
		1	X[SR]		2	B												
8,9,...	11220	1	T[75]	218.41	1	C	303.48	6	1	21.50	5	2	75.00	249	238	448	1107	19926
		1	X[SR]		2	B												

Appendix Table 4: SUMMARY OF RESULTS (DCF analysis)

ORANGES

Year	Non-IPM pest and disease control ($/ha/yr)	Estim. IPM costs ($/ha/yr)
1	55	55
2	111	111
3	222	222
4	351	552
5	1501	753
6	1191	703
7	2111	877
8	2152	954
9	2152	954
10	2152	954
11	2152	954
12	2152	954
13	2152	954
14	2152	954
15	2152	954
16	2152	954
17	2152	954
18	2152	954
19	2152	954
20	2152	954
21	2152	954
22	2152	954
23	2152	954
24	2152	954
25	2152	954
26	2152	954
27	2152	954
28	2152	954
29	2152	954
30	2152	954
31	2152	954
32	2152	954
33	2152	954
34	2152	954
35	2152	954
NPV(Total)	30155	11133
Av($/ha/yr	2082	763
IPM savings($/ha/y)=		1313
IPM/Conventional(%)=		37

ELLENDALE MANDARINS

Year	Non-IPM pest and disease control ($/ha/yr)	Estim. IPM costs ($/ha/yr)
1	55	55
2	111	111
3	222	222
4	351	474
5	1501	632
6	1191	703
7	2111	833
8	2152	972
9	2152	972
10	2152	972
11	2152	972
12	2152	972
13	2152	972
14	2152	972
15	2152	972
16	2152	972
17	2152	972
18	2152	972
19	2152	972
20	2152	972
21	2152	972
22	2152	972
23	2152	972
24	2152	972
25	2152	972
26	2152	972
27	2152	972
28	2152	972
29	2152	972
30	2152	972
31	2152	972
32	2152	972
33	2152	972
34	2152	972
35	2152	972
NPV(Total)	30165	11052
Av($/ha/yr	2081	762
IPM savings($/ha/y)=		1311
IPM/Conventional(%)=		37

IMPERIAL MANDARINS

Year	Non-IPM pest and disease control ($/ha/yr)	Estim. IPM costs ($/ha/yr)
1	55	55
2	111	111
3	222	222
4	351	515
5	1501	752
6	1191	703
7	2111	833
8	2152	972
9	2152	972
10	2152	972
11	2152	972
12	2152	972
13	2152	972
14	2152	972
15	2152	972
16	2152	972
17	2152	972
18	2152	972
19	2152	972
20	2152	972
21	2152	972
22	2152	972
23	2152	972
24	2152	972
25	2152	972
26	2152	972
27	2152	972
28	2152	972
29	2152	972
30	2152	972
31	2152	972
32	2152	972
33	2152	972
34	2152	972
35	2152	972
NPV(Total)	30155	11177
Av($/ha/yr	2081	771
IPM savings($/ha/y)=		1310
IPM/Conventional(%)=		37

MURCOTT MANDARINS

Year	Non-IPM pest and disease control ($/ha/yr)	Estim. IPM costs ($/ha/yr)
1	55	55
2	111	111
3	222	222
4	351	519
5	1501	752
6	1191	703
7	2111	1191
8	2152	1402
9	2152	1402
10	2152	1402
11	2152	1402
12	2152	1402
13	2152	1402
14	2152	1402
15	2152	1402
16	2152	1402
17	2152	1402
18	2152	1402
19	2152	1402
20	2152	1402
21	2152	1402
22	2152	1402
23	2152	1402
24	2152	1402
25	2152	1402
26	2152	1402
27	2152	1402
28	2152	1402
29	2152	1402
30	2152	1402
31	2152	1402
32	2152	1402
33	2152	1402
34	2152	1402
35	2152	1402
NPV(Total)	30155	15995
Av($/ha/yr	2081	1103
IPM savings($/ha/y)=		977
IPM/Conventional(%)=		53

LEMONS

Year	Non-IPM pest and disease control ($/ha/yr)	Estim. IPM costs ($/ha/yr)
1	55	55
2	111	111
3	222	304
4	351	456
5	1501	632
6	1191	1037
7	2111	1145
8	2152	1238
9	2152	1238
10	2152	1238
11	2152	1238
12	2152	1238
13	2152	1238
14	2152	1238
15	2152	1238
16	2152	1238
17	2152	1238
18	2152	1238
19	2152	1238
20	2152	1238
NPV(Total)	21528	10433
Av($/ha/yr	1377	913
IPM savings($/ha/y)=		554
IPM/Conventional(%)=		43

GRAPEFRUIT

Year	Non-IPM pest and disease control ($/ha/yr)	Estim. IPM costs ($/ha/yr)
1	55	55
2	111	111
3	222	222
4	351	507
5	1501	632
6	1191	803
7	2111	930
8	2152	1107
9	2152	1107
10	2152	1107
11	2152	1107
12	2152	1107
13	2152	1107
14	2152	1107
15	2152	1107
16	2152	1107
17	2152	1107
18	2152	1107
19	2152	1107
20	2152	1107
NPV(Total)	21528	5371
Av($/ha/yr	1377	751
IPM savings($/ha/y)=		1315
IPM/Conventional(%)=		42

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