a great range of pests and diseases which include — greening, severe tristeza, *Phytopthora citropthora*, and *P. parasitica*, citrus nematodes, severe mite and aphid infestations, as well as very strong winds, to name but a few. Some nurseries have infected water supplies that need treatment, whilst others have to deal with very high salinity levels in their water.

On top of these problems, labour efficiency generally is of a very low standard, which constrasts markedly with the high standard of management's technical capability, in general.

The adoption of tree growth in bags needs a completely new approach to principles and practices. The only similarity is the crop. Many have not understood the basics of mix aeration and because of this, root decay was evident universally. Placement and size of holes in polybags require critical attention.

There is a need to change from poor draining soils to non-soil mixes which will involve consideration of cane residue, rice hulls, hardwood sawdust, or pulverised bark. Many nurseries in South Africa had polybags on, and even buried in, poor draining sites. Methods have to be developed to raise these above ground to avoid root decay, improve aeration, and raise the standard of hygiene. The need for a reproducible, freely-aerated mix is of the highest priority.

Seed tree selection, with one notable exception, was not receiving adequate attention. Nurserymen were not considering the long term consequences of poor selection, poor culling, and poor growing of seed/seedlings with the result that problems had become inbuilt before a first class end result could be achieved.

Despite these criticisms, I found a universal willingness to highlight and discuss problems and a positive desire to take steps to correct deficiencies. There were no attempts to gloss over shortcomings, and I believe this augurs well for the Industry. I would expect to see rapid technical improvements in the next few years.

INTEGRATED PEST CONTROL OF TWO-SPOTTED MITE ON ORNAMENTAL PLANTS PROPAGATED UNDER GREENHOUSE CONDITIONS

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It is a fact that over the last 30 to 40 years there has been a world-wide trend towards the complete reliance upon chemical pesticides for the control of pests and diseases on all agricultural and horticultural crops. Nurserymen have become as reliant as any other group in this respect (12).

Public demand for undamaged plants from the nursery industry has resulted in the reliance upon strict pesticide control programmes. This approach has raised certain potential problems for all nurserymen.

Resistance can develop in pests following continued exposure to some pesticides. In addition to the more obvious signs of phytotoxicity, some pesticides may also interfere with proper plant function. There is the ever-present consideration of environmental contamination, very relevant to this public service industry. Finally, in most situations problems are experienced in incorrectly applying pesticides. The subsequent ineffective control encourages unnecessary repeated sprayings. This is time-consuming, which is expensive, and the added selection pressure increases any resistance problem.

With regard to plant propagation, some newly-rooted plants exhibit a greater sensitivity to some pesticides because of their immature root systems. Considering the five questions raised above certainly justifies at least a cursory look at alternative control measures, if not a serious consideration of their possible implementation on a commercial scale.

In New South Wales (NSW) the use of predatory mites in conjunction with pesticides to control two-spotted mite is being approached with some confidence.

PEST PROBLEM

Two-spotted mite, *Tetranychus urticae* (Koch), also known as red spider, is arguably the most important pest of ornamental plants in NSW. There are different criteria for assessing this importance, but on the basis of damage potential and control difficulties, this comment is true.

Two-spotted mite is very common and infests almost as many plants as are grown commercially for foliage or flowers.

Unlike some countries, in Australia two-spotted mite can occur as a pest problem throughout the year. In colder climates a diapause stage develops which neither feeds nor reproduces through the winter period. The onset of this stage is stimulated by temperature and photoperiod changes.

In Melbourne, Victoria, and in the Central Tablelands of NSW, observations have shown that a considerable proportion of the field population change to the orange-coloured diapause phase.

The incidence of this phase in Sydney and coastal areas, especially under protected conditions, is very low. In these situations two-spotted mite can continue its normal functions and damage plants. Generally, the activity of the two-spotted mite is favoured by warm, dry conditions. In some nurseries around Sydney, populations can be noticed with the onset of heating in glasshouses. This produces a warm, dry environment.

In other circumstances, two-spotted mite can appear on plant material transported from a warmer state at a particular time each year, e.g. palms propagated in Queesland, or the pest may occur naturally each year with the onset of warmer seasons.

One way or another the pest will occur seasonally in a more or less predictable way. Spider mite regularly causes considerable damage to nursery plants and, although pesticides are currently used, the range of pesticides registered in NSW for the control of spider mite in nurseries is inadequate to solve the problem to the satisfaction of nurserymen.

THE USE OF BIOLOGICAL CONTROL AGENTS IN AN INTEGRATED CONTROL PROGRAMME

Spider mites are subject to predation by a number of natural enemies including insects and other mites. Because pesticides are essential for successful horticultural production, most of the native species are easily killed. Some, through continued exposure to sprays will develop resistances. The predatory mite, *Phytoseiulus persimilis,* (Chilean predatory mite) is one of these species which has developed tolerance to a range of pesticides.

Phytoseiulus persimilis was first discovered in Chile and recognised as a potentially useful predator of spider mites in the 1950's (3). Extensive investigations in the U.K. and U.S. in the 1960's determined that its high mobility (2,11) and relatively high prey consumption rate and productive potential (1) contributed to its greater efficiency as a predator under field conditions. At 20°C a predatory population will increase 4.6 times per week compared with 2.7 times for the spider mite.

In the U.K. and in Europe, extensive areas of glasshouse production of cucumbers mainly, plus other crops, now involves the use of *Phytoseiulus*. The extent of this usage and the success rate is given in Table 1. In recent years the area of glasshouse usage of biological control increased only in England and The Netherlands. This is attributed to these two countries having private companies producing the predators and of having the service to advise growers and actively promote the system.

Table 1. List of areas using *Phytoseiulus persimilis* to commercially control two-spotted mite.

Crop	Country	Source	Total Crop area	*Phytoseiulus* introduced on (ha)	Percent success
Tomato	Denmark	Samsøe/Holmenlund	120	6	50
	England/Wales	Gould/Ledieu	550	73	95
	Finland	Markkula	180	2	100
	W. Germany	Crüger/Hassan/ Mertens	—	10	—
	Ireland	Dunne	160	10	70
	The Netherlands	Koppert/Woets	2010	14	85
	Norway	Stenseth	63	10	—
	Scotland	Foster	20	2.5	40
Cucumber	Canada B.C.	Elliott	11	8	—
	Denmark	Samøe	60	55	75
	England/Wales	Gould/Ledieu	216	161	95
	Finland	Markkula	55	45	100
	W. Germany	Hassen/Krüger/ Mertens	—	10	—
	Ireland	Dunne	11	4	75
	The Netherlands	Koppert/Woets	700	430	95
	Poland	Pruszynski	—	2	100
	Sweden	Nedstam	50	30	83
	Switzerland	Freuler/Städler	34	5	100
S. pepper	Ireland	Dunne	4	1	100
	The Netherlands	Koppert/Ramakers	100	37	95
Gerkin	The Netherlands	Koppert	240	30	90
Grape	The Netherlands	Koppert	45	3	100
Melon	The Netherlands	Koppert	45	2	100
	Sweden	Nedstam	7	5	80
Rose	Poland	Pruszyński	—	1.5	100
Strawberry	Japan	Nakazawa	6800	15	55

As can be seen from Table 1, efforts have been made to apply this method of control to a range of glasshouse crops. Different practical problems associated with the release and establishment of the predatory mites, plus its ability to tolerate field rates of specific pesticides associated with certain crops, have also been researched.

The use of a species of predatory mite, such as *Phytoseiulus persimilis*, to control two-spotted mite does not mean that pesticides are replaced entirely. It does, however, provide an additional input for the grower to consider in conjunction with a reduced number of miticide applications at a lesser strength, normally half the recommended rate. Sprays of this nature are used as an interim measure to lower an increasing spider mite population that may get too much of a head start on the predator under field conditions. Also, insecticides used to control other insect pests and fungicides, which will cause minimal damage to the predator populations, have to be included.

In the U.K., workers involved with *Phytoseiulus* to control two-spotted mite have been impressed both by the potential of this form of control and grower reaction to successful control by natural enemies. The technique does involve a higher technical input on the growers' part than chemical control alone but an increasing awareness by the user provides for easier operation each year.

In the northern hemisphere the major use for this approach has been on vegetables grown in glasshouses. In Australia, it is the nursery industry which will benefit.

Although *Phytoseiulus* has been in commercial use in Europe for over 15 years (8) and in the U.S. since 1971 (10), its involvement in Australia was delayed until 1978 when it was first discovered infesting commercial strawberry farms in Sydney (6).

Table 2. The effects of some pesticides on the predatory mite, *Phytoseiulus persimilis*, and on two-spotted mite (TSM).

Pest Control	Pesticide	Registered for use on Ornamentals	Percent toxicity to life stages: *P. persimilis* adult	*P. persimilis* nymph	egg	TSM adult	Safe to use with predator
TSM	Plictran		0	0	0	100	Y
TSM	Omite	Y	0	0	0	100	Y
TSM	Torque		50	0	0	75	Y
TSM	Peropal		0	10	0	100	Y
TSM	Tedion	Y	0	0	0	10	Y-poor against pest
TSM	Kelthane		100	0	5	100	N
TSM	Neoron		100	0	100	100	N
TSM	Sulfur	Y	22	0	5	0	Y-poor against pest
TSM	Pentac*		15	0	0	10	Y-poor result against pest explainable
F	*Bayleton*	Y	20	0	0	5	Y
F	Baycor		25	0	5	0	Y
TSM+F	Morestan		44	53	100	100	N
F	Benlate	Y	50	55	100	0	N
F	Captan	Y	16	0	0	0	Y
F	Saprol	Y	35	0	0	0	Y
F	Plantvax	Y	10	0	0	5	Y
F	Nimrod		0	0	0	5	Y
F	Ronilan		5	0	0	0	Y
F	Dithane		23	5	0	0	Y
F	Rovral	Y	42	0	0	5	Y
F	Cuprox		43	0	0	25	Y
I	Lorsban	Y	100	0	0	100	N
I	Dipterex		100	0	100	10	N
I	Thiodan		100	0	0	50	N
I	Pirimor	Y	39	0	0	0	Y
I	Cothion		38	0	0	21	Y

Y = Yes. N = No.

* Pentac acts by interference with oviposition; for initial results requires 3 to 5 days.

Phytoseiulus is particularly well suited to glasshouse environments and, apart from the list of vegetable uses, it is also being utilized overseas on ornamental plants (7,9). It is generlaly considered to be the best predatory mite available for use under such conditions. With glasshouse control of this pest by pesticides proving less and less reliable, it was natural for the NSW Department of Agriculture to establish a research programme to attempt to gain the acceptance of the industry for the integrated pest control concept (4,5). While *Phytoseiulus* is relatively resistant to some pesticides, it is also susceptible to others. Spray tests have been carried out with 26 pesticides to determine the susceptibility/tolerance of all stages of the predatory mite. Of pesticides tested to date, (Table 2) 73% were judged safe to use in an integrated programme with *Phytoseiulus*.

PRODUCTION OF *PHYTOSEIULUS* FOR NSW NURSERIES

Overseas, approximately 16 private companies in 9 countries rear this predator for sale to growers. In addition, other countries, e.g. USSR, have laboratories undertaking the same role.

In Australia, this concept is very new and this aspect posed a problem until 1981. A company in Queesland (Biocontrol) now provides the same service as its overseas counterparts. In addition, in NSW, the Department of Agriculture is promoting a system of the nurserymen producing their own predators (5). This overcomes a number of problems, not the least of which is the cost of regular supplies, e.g., Biocontrol charges $70/10,000 predators. Reintroduction may be necessary following the use of insecticides or fungicides toxic to the predator against a specific pest or disease. Also, *Phytoseiulus* may disappear from an area following the elimination of its food source.

For a relatively small cost in time and money any nurseryman can produce predators for his own use. Predators can be reared continuously, or according to particular seasonal requirements. The following procedure outlines for nurserymen the steps in the mass rearing of *Phytoseiulus*.

a) Germinate a dwarf bean seed grown in potting mix in each of ten 60-cell Speedling trays, or a convenient seedling tray well-stocked with bean seed. Ten trays are a nominal number only.
b) Grow-on to first true leaf stage.
c) Release spider mite infested leaves onto plants.
d) Allow 2 to 3 weeks for spider mites to spread and build-up numbers. This acts as food for the predators.
e) Release a starter culture of pedatory mite on bean plants.
f) Allow 2 to 3 weeks for predators to establish and breed-up into large numbers.

g) Transfer Speedling trays (or equivalent) to release areas and locate on benches or floor nearby. Predatory mites will eat spider mites out, then disperse onto infested ornamental plants or, cut bean foliage and distribute on plants for spider mite control. Bean foliage will dry up quickly and predators will move onto spider mite infested ornamental or flowering plants.

This procedure must be undertaken under protected conditions, either polyhouse or glasshouse facilities. Controlled temperature conditions are ideal for supplementing heat in winter to maintain the rate of production, but in a coastal climate it is not essential to have access to an air conditioned house. Temporary temperature control facilities may be required. It is essential that regular production of spider mite and predatory mite is maintained.

In releasing the predatory mite a knowledge should be obtained of the extent of spider mite infestation in the nursery. This should be done with the aid of a hand lens and a very thorough inspection, remembering that nearly all populations of spider mites are to be found on the undersides of leaves. Then release the predators systematically. Supplementary applications of reduced strength miticides may be necessary. The predatory mite is very active in moving through a poly or glasshouse; it has a large appetite and it has the reproductive capacity to build-up into large numbers. However, there are circumstances where it may require the additional help of miticides to control the pest; e.g., large infestations of spider mites will content the predator and it will not spread quickly, leaving some areas unpopulated by the predator. Also, low winter temperatures will reduce the activity and reproduction of the predator.

The benefits of the predatory mite are in the reduced usage of miticides, by applying at lower strength and less frequently. In some instances, in protected environments, no miticides will be necessary.

In applying *Phytoseiulus* in a commercial nursery, the main criteria is what kind of control is needed. Some examples are given below:

1) Fruit trees — young plants; some slight damage unimportant and predator control effective.
2) Stock plants for propagation — same.
3) Young plants with juvenile foliage — same, but heavy damage may cause plant losses.
4) Ornamental plants in pre-sale stage — infestations of spider mites must be kept *below* levels likely to cause visable damage. This level varies with the type of plant.

5) Flowering plants which will refoliate if spider mite gets out-of-hand, e.g., roses. This should not be aimed for, but it is a consideration.

The predatory mite, following the control of the pest, will seek other sources of food. This may result in the loss of the predator after one season. To counter this the recommendation to nurserymen is for the continuous production of the predator and release into the nursery area, even when it may seem as though the spider mite is absent. There is no necessity to wait until a spider mite infestation occurs. It is preferable to maintain the predator's presence and to aim to keep the spider mite at low levels or absent.

CONCLUSIONS

To be committed to using *Phytoseiulus* in an integrated pest control programme, nurserymen must appreciate the following points:

1. It does require some learning to recognise early signs of two-spotted mite infestations and damage.
2. It does require discipline in only applying pesticides compatible with the predator that will, at their worst, permit the continuation of the predator population.
3. It does require an acceptance that there are direct benefits to be gained.
4. It does require informed management decisions from the grower, faith in the value if this microscopic predator, and a willingness to persevere even if complete success isn't always achieved.

It should be noted that pesticides applied soon after the introduction of predators will be more harmful than when applied after predators are well established. That "once-off" spray will be less harmful than routine programmes. The harmful effect of a pesticide toxic to the predator can be minimised by using "spot-treatments" against other pests and diseases, e.g. mealybugs and scale insects.

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MECHANICAL HANDLING OF PROPAGATION BENCHES

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The purpose of this paper is to introduce the initial physical developments of a system in which I have been interested for several years. The developments discussed arise from the aim, which may be broken into three parts;

1. To re-think the basic approach to the volume production nursery and to develop an integrated nursery system with stock control which economically enables increased production volume and efficiency.

2. *To design* a system around the plant's growth requirements of moisture, light, temperature, humidity, and nutrition.

3. *To develop* mechanical systems and aids on a universal or multi-purpose basis, especially in the early stages of propagation — by seed, cuttings, or tissue culture — from small parent stock to 100 mm and 125 mm pot production.

A basic design criterion was adopted with regard to the species most likely to be grown, (indoor and outdoor container foliage plants), available energy sources, local engineering fa-