Project Title	Phytotoxicity testing of new pesticides as dip treatments to unrooted ornamental cuttings; in order to remove or reduce the risk of *Bemisia tabaci* infestation.
Project number:	PC 254
Project leader:	Dr John Buxton, ADAS
Report:	Final, February 2007
Previous report	N/A
Key staff:	John Buxton (ADAS) Andrew Fuller (ADAS) Anna Kearton (ADAS) Harry Kitchener (HK Consultancy)
Location of project:	W J Findon & Son, Welford Nursery, Warks. R Delamore Ltd, Wisbech St. Mary, Cambs. Kinglea Plants, Nazeing, Essex.
Project coordinators:	Duncan Stevenson, Kinglea Plants Wayne Eady, R Delamore Ltd Russ Woodcock, W J Findon & Son
Date project commenced:	March 2006
Date completion due:	March 2007 , Completed June 2007
Key words:	Tobacco whitefly, dips, phytotoxicity, Fuchsia, Verbena, Poinsettia, Salvia, Certis Spraying Oil, Savona, Majestik, Mycotal, Oberon, Agri 50E.

The results and conclusions in this report are based on a series of experiments conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

Dr John Buxton
Senior Consultant
ADAS

Signature ..... Date .....

Report authorised by:

Dr W E Parker
Horticulture Sector Manager
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GROWER SUMMARY

Headline

- Crop safe, effective treatments for dipping unrooted ornamental plant cuttings as first line of defence against infestations of *Bemisia tabaci* have been identified for verbena, salvia, fuchsia and three varieties of poinsettia.

Background and expected deliverables

- The risk of tobacco whitefly infestation on UK nurseries originating from imported ornamental cuttings continues to be high. Because the UK is a Protected Zone (PZ) for tobacco whitefly within current Plant Health legislation, the presence of this pest cannot be tolerated. PHSI (Plant Health & Seeds Inspectorate) inspectors can order destruction of infested cuttings, enforce a rigorous insecticide programme, and prevent movement of infested cuttings around the nursery until a period of at least three weeks has elapsed with no tobacco whitefly being found on traps or plants.
- This approach has caused serious financial losses to several UK propagators in recent years. However, after discussion with Defra, it was agreed that providing a 'disinfestation protocol' was followed, the three week period might be set aside. Part of this protocol would be a pesticide dip for unrooted ornamental cuttings that is shown to be effective for controlling tobacco whitefly.

  However, before a dip treatment can be recommended, its safety to unrooted cuttings needs to be evaluated. Tobacco whitefly is mainly found on imported cuttings of Poinsettias, but Verbena, Fuchsia and Salvia are also susceptible to the pest.
- Once cuttings are stuck and then rooted, control of tobacco whitefly is difficult, partly due to problems of spray application to leaf undersides, but also because many strains of this insect are highly resistant to insecticides. In addition, eggs of tobacco whitefly can hatch during the rooting period, where the environment is ideal for rapid development. This means that a dip treatment of unrooted cuttings is logistically the only practical option (a dip of rooted cuttings is not feasible) and should provide the best possible contact between pesticide and plant foliage, leading to good control of the pest. The amount of insecticide required for a dip treatment would be small and this would reduce the costs.
- The expected deliverable from the project is the identification of the safety to unrooted cuttings of Integrated Pest Management (IPM)-compatible insecticides that can be used

as a single dip treatment to major ornamental species (Verbena, Fuchsia, Salvia and Poinsettia) under commercial conditions.

- Because of the potential hazard to operators when dipping, only pesticides with a physical mode of action, biological products, or products with a low hazard to operators were chosen for this project. These products are also unlikely to leave harmful residues which might affect the subsequent use of biological control organisms on the plants.
- This project was done in conjunction with a project at Central Science Laboratory, York, (Defra project PH0405) which tested similar products for biological efficacy, when applied as dips to unrooted cuttings infested with tobacco whitefly.

Summary of the project and main conclusions

- The products tested (in comparison with a water control treatment) were Majestik, Agri 50E, Certis Spraying Oil, Savona, Mycotal and Oberon. All treatments were applied at label rates, with Certis Spraying Oil applied at the lower of the two rates on the label (0.5 % product).
- Oberon and Certis Spraying Oil caused unacceptable damage (symptoms included shoot distortion, necrosis, stunting and death of cuttings) to some varieties of Fuchsia, Salvia, and Verbena, but the damage was variable and related to variety.
- The physically-acting products Majestik, Agri 50E and Savona were generally much less phytotoxic to the species tested, but occasionally minor phytotoxic effects were seen. These were generally transitory.
- Certis Spraying Oil caused severe phytotoxicity to Poinsettias when applied as a dip to unrooted cuttings, although there were large variations in the reaction of different varieties. The unpredictable nature of this damage means that Certis Spraying Oil cannot be recommended as a dip for Poinsettia cuttings.
- Majestik, Agri 50E, Savona and Oberon, did not cause significant damage to three of the five Poinsettia varieties tested, and can be suggested as dip treatments. (But given the sensitivity of some Poinsettia cultures to any from of dip treatment including water caution needs to be taken).
- Mycotal did not cause any phytotoxic effects to any of the plant species tested in this project, and can be recommended as a dip treatment, although it can leave a slight white deposit after dipping.
- The results of the efficacy work done by CSL in a related Defra-funded project (PH0405) showed that Certis Spraying Oil was the most effective product tested against eggs, scales and adults of tobacco whitefly. However, the results of the HDC-funded work

reported here have shown that its phytotoxic effects make it unsuitable for use a dip on commercial nurseries. Majestik, Agri 50E, Savona and Oberon gave good control of adult whitefly and second instar scales in PH0405 when used as a dip treatment, but were less effective against the egg stage of tobacco whitefly. However, as several of these products were relatively safe to the patio plant and poinsettia varieties tested, they have potential for growers to use as a first line of defence against tobacco whitefly. Mycotal as a dip treatment gave only moderate control of egg and second instar stages, but was more effective against adult whiteflies.

Financial benefits

- This project has made good progress towards understanding the reaction of unrooted ornamental cuttings to insecticide dips. The extent of the financial benefits will depend on the risk from tobacco whitefly on imported cuttings, and the ability of the propagator to take up the technology described in this report.

Action points for growers

- Be aware that imported cuttings of ornamental plants may introduce tobacco whitefly.
- Growers could consider a dip treatment for imported unrooted cuttings as a routine precaution against tobacco whitefly, but this would increase labour costs, and the logistics would need careful planning. For patio plants such as Fuchsia and Verbena, Certis Spraying Oil and Oberon should not be used, but Agri 50E, Majestik, Savona or Mycotal could be considered. For poinsettias, Agri 50 E, Majestik, Savona or Mycotal could be used. Oberon was safe to three varieties of poinsettia tested (the other two were sensitve even to water). It also shows potential for use as a dip, although it should be tested on any new varieties of poinsettia before use.
- Agri 50E, Savona and Majestik are all physically acting products and so their use as dips does not require a change in current label conditions of use. Mycotal and Oberon could be used as a dip providing that the statutory conditions of use are still adhered to.
- Trial dips on small batches of plants should be done by growers before using a dip treatment on any ornamental subject other than the species and varieties listed in this project, as some varieties of the same plant species are much more susceptible to phytotoxic effects than others.

SCIENCE SECTION

Introduction

The tobacco whitefly (*Bemisia tabaci*) is a highly polyphagous pest capable of vectoring a range of plant viruses, including tomato yellow leaf curl, lettuce infectious yellows and squash leaf curl, all of which are currently not present in the UK (Jones, 2003). There are more than 600 species of recorded host plants, including a very wide range of protected ornamental and vegetable crops (Smith *et al*., 1997). In temperate Europe, tobacco whitefly is only a pest of protected crops, as it cannot survive outdoors.

Tobacco whitefly is most often introduced on Poinsettia cuttings, which originate from areas where it is endemic. However, other ornamental species such as Verbena, Salvia and Fuchsia are also susceptible and the risk of introduction on these patio plant and bedding plant species is increasing (MacLeod, 2004).

The majority of European countries accept tobacco whitefly as an endemic pest, but the UK has Protected Zone (PZ) status, which means that on each occasion it is found, either on imported cuttings, or on finished plants, it must be eradicated under PHSI supervision. The risk of damage and loss to UK protected edible growers is considered unacceptably high and so the PZ is maintained. However, changes to the EU Plant Health Directive in 2003 meant that the requirement for a place of production freedom (from tobacco whitely) before plants could be marketed was increased from two to three weeks (Cannon, 2006). This means that in the event of a confirmed finding of tobacco whitefly, there is a requirement for official inspections to be carried out weekly for the three weeks prior to movement of the plants, with the last inspection being carried out immediately prior to shipment. If even one tobacco whitefly is found at this inspection, the three week period would recommence. Given this situation, potential economic losses to UK propagators and importers of unrooted cuttings from abroad are considerable.

Discussions between industry, Central Science Laboratory (CSL) and the Plant Health & Seeds Inspectorate (PHSI) led to the concept of a ‘disinfestation protocol’ which would provide an equivalent level of security to the three weeks freedom at the place of production.

This might include chemical, biological or physical control measures, and would include a dip treatment to unrooted cuttings. It was considered that a dip immediately before cuttings were stuck would give the best chance of reducing or eliminating tobacco whitefly at the earliest possible stage. For this strategy to be viable, the efficacy and safety of dip treatments to ornamental cuttings needed to be evaluated. Previous HDC funded work (PC 70) has shown that petroleum oil applied as a dip was the most effective insecticide against tobacco whitefly on rooted Poinsettia cuttings. However, the commercial-scale dipping of rooted cuttings is impractical.

This aim of this project was to test the safety of selected products used as dips to unrooted cuttings of ornamental plants, including Poinsettias. In a parallel project, Defra funded work at CSL to test the efficacy of the same products, when used as dips, against tobacco whitefly (Defra project number PH 0405, completed December 2006).

Materials and Methods

Experiment locations

Experiments were done at each of three locations:

1. W J Findon & Son Ltd, Orchard Nursery, Welford-on-Avon, Warks. Patio plant subjects tested were Verbena and Fuchsia. Period of experiment: March to May 2006.
2. R Delamore Ltd, Sutton Road, Wisbech, Cambs. Patio plant subjects tested were Verbena, Salvia and Fuchsia. Period of experiment: March to May 2006.
3. Kinglea Plants Ltd, Shottenton Farm, Nazeing, Essex. Subjects tested were Poinsettia only. Period of experiment: July to December 2006.

Experimental design

Treatments used in the experiments are given in Table 1. The experiments at all sites were a randomized complete block design with seven treatments replicated three times. Each plot for Verbena, Salvia or Fuchsia consisted of a tray of 24 or 25 cuttings, using either a net pot (Welford site) or Jiffy plug (Wisbech site). For Poinsettias (Nazeing site), each plot consisted of 12 cuttings direct stuck into 10.5 cm diameter pots.

Table 1. Products used in experiments at all locations.

Product	Rate/100 litres water	Active ingredient	Mode of action	Comments
Untreated (water)	-	-	-	-
Majestik	2,500 ml	Natural plant extracts & polymers	Physical	Coats pests and suffocates them
Agri 50E	300 ml	Alginate + polysaccarides	Physical	Removes cuticular waxes leading to dessication
Certis Spraying Oil	500 ml	Petroleum oil	Physical	Coats pests and suffocates them
Savona	1,000 ml	Potassium salts of fatty acids	Physical	Removes cuticular waxes leading to dessication
Mycotal	100 g	*Verticillium lecanii*	Insect pathogenic fungus	Infects and kills whitefly adults and scales
Oberon	50 ml	spiromesifen	Lipid synthesis inhibitor	-

Plant species and varieties tested at each site were as follows:

1. *Welford site*: Verbena - Aztec Magic Pink, Aztec White; Fuchsia: Loves Reward, La Campanella.
2. *Wisbech site*: Verbena - Tapien Violet, Temari Scarlet; Fuchsia - Eva Boerg, Southgate; Salvia – Purpurea, Tricolour.
3. *Nazeing site*: Poinsettia – Mars, Millenium, Already Red, Euroglory, Infinity,

Dipping method

All treatments were made up in 10 L of water in separate, labelled, plastic boxes. Bunches of cuttings were separated out and placed into a wire mesh cage, immersed in the dip solution and gently agitated for 30 seconds to ensure good contact. Excess solution was then shaken off.

Cuttings were then stuck immediately into plugs, labelled, and placed on benches in normal production areas in the nursery. Rooting took place on benches or on the floor, under mist (Welford and Wisbech sites) or perforated polythene (Nazeing site).

Assessments

Fuchsia, Salvia and Verbena

1. Phytoxicity assessments were done seven, 15 and 28 days after treatment (DAT) at Welford, and seven and 28 DAT at Wisbech. Assessments were done by firstly scoring the degree of any damage on a scale of 1 to 5 where 1 = no damage (with reference to the water dip control plants) and 5 = plant death. The type of damage was then categorized according to EPPO Guideline PP1/135(2) 'Guideline for the efficacy evaluation of plant protection products, phytotoxicity assessment'. The categories were:
   A. Loss of whole plants
   B. Modification in leaf or flower colour
   C. Necrosis
   D. Deformation
   E. Effect on fresh weight
2. Fresh weights were calculated by growing-on plants until they were judged to be marketable, then cutting 10 plants per treatment off at compost level and weighing them to an accuracy of 0.1 g.
3. Once the initial assessments were done, three plants per treatment were potted on and grown on for further assessment. Scores for the amount of flower (on a scale of 1 to 5, where 1= abundant, even flowering and 5= no flowers present) were done approximately five and six weeks after potting at Welford and Wisbech respectively.
4. Photographs were taken at intervals to illustrate the range of phytotoxic symptoms recorded.

Poinsettias

1. Plants were scored for phytotoxicity three to five weeks after sticking using a scale devised by Mr. H Kitchener.

1 All plants standing upright. Little flagging of leaves. No losses.
2 Plants standing upright. Little flagging. Some leaf discoloration. No losses.
3 Plants mainly standing up. Little flagging. Tendency to yellowing or leaf necrosis. No losses.
4 Plants either damaged or not turgid. Foliage flagging, damaged and/or yellowing.

1. Fresh weights of rooted poinsettia cuttings were calculated at 5 weeks after sticking by cutting off six plants per replicate (18 per treatment) at compost level and weighing them to an accuracy of 0.1 g.
2. Root vigour scores were assessed at approximately 3 and 5 weeks after sticking using the following scale:

    0 No apparent roots

    1 Slight roots at edge of pot

    2 Some roots at edge of pot

    3 Roots at edge of pot and starting to travel down pot

    4 Roots at edge of pot and travelling down pot

    5 Roots at edge of pot, travelling down pot and crossing base of pot

2. When the Poinsettias were in bract and ready for market in late November/early December, all plants were scored against the specification that the nursery used to judge marketability of the crop. An illustration of this specification is shown in Appendix I. The scoring system used was as follows:

    1 Fully meets specification

    2 Slight decrease in plant vigour; slightly fewer breaks than the specification.

    3 Obvious decrease in plant vigour; bract size reduced; fewer breaks than the specification.

    4 Plants unmarketable, bract size severely reduced; plants stunted.

3. Mean height (cm) and the mean number of primary breaks was also measured in late November/early December.

Results and Discussion

Welford site (patio plants)

The results of the phytotoxicity assessments made at seven, 15 and 28 DAT are given in Tables 2, 3 and 4 respectively.

At 7 DAT, the Certis Spraying Oil treatment was found to be highly phytotoxic to Verbena Magic Pink cuttings, causing plant death with almost 100% plants affected by 15 DAT. The effect of Certis Spraying Oil on Verbena Aztec White was similar but less severe, with plant losses reaching *c*. 50% by 15 DAT. Majestik, Agri 50E, Mycotal and Savona also resulted in mild phytotoxicity seven and 15 DAT, but by 28 DAT (Table 4) damage was no longer evident (with exception of Savona). The Oberon treatment resulted in little or no damage at assessments made seven and 15 DAT, but by 28 DAT severe foliage distortion had developed on Verbena Magic Pink. The effect was present but much less marked (leaf edge necrosis) on Verbena Aztec White. The Verbena Magic Pink was a cut leaf variety, with numerous leaf hairs, whereas Verbena Aztec White had a solid leaf with fewer leaf hairs. It is possible that differences in leaf morphology contributed to the difference in response between these varieties to both Certis Spraying Oil and Oberon.

Fuchsia Love's Reward was severely affected by the Certis Spraying Oil treatment, but Fuschia La Campanella was unaffected, until 28 DAT. Majestik, Agri 50E, and Savona caused only minor effects (slight necrosis or browning of leaf edges) on both Fuchsia varieties, and there were no significant plant losses. Mycotal dip did not cause any damage. Oberon did not cause any symptoms on either Fuchsia variety.

Fresh weight assessments 28 DAT indicated no significant effect of treatment on Verbena Magic Pink (apart from the complete loss of plants caused by the Certis Spraying Oil treatment (Figure 1a). This latter treatment also significantly reduced the fresh weight of Verbena Aztec White cuttings compared to all other treatments except water. On the Fuchsias (Figure 1b), Certis Spraying Oil significantly reduced the weight of Fuchsia Love's Reward cuttings, but had no effect on Fuchsia La Campanella cuttings. Savona treatment significantly reduced the weight of cuttings of this variety when compared to the Mycotal treatment. Other treatments had no effect on fresh weight.

Table 2. Welford site: mean phytotoxicity scores and damage category for Verbena and Fuchsia 7 DAT.

	Verbena Magic Pink		Verbena Aztec White		Fuschia Love's Reward		Fuschia La Campanella	
Treatment	**Score**	**Category**	**Score**	**Category**	**Score**	**Category**	**Score**	**Category**
Water	1.0	No damage	1.0	No damage	1.0	No damage	1.0	No damage
Majestik	1.7	B	1.3	C	1.0	No damage	1.0	(Slight white deposit)
Agri 50E	1.3	B	2.3	C	1.0	No damage	1.0	No damage
Certis Spraying Oil	4.0	C	3.0	B	2.0	B/C	1.0	No damage
Savona	1.0	No damage	1.3	B	1.3	No damage	1.3	C
Mycotal	1.3	(White deposit on leaves)	1.0	(White deposit on leaves)	1.0	No damage	1.0	No damage
Oberon	1.7	C	1.0	No damage	1.0	No damage	1.0	No damage

Score 1 – 5 where 1 = no damage

KEY: B = Modification in leaf colour, C = Necrosis

Table 3. Welford site: mean phytotoxicity scores and damage category for Verbena and Fuchsia 15 DAT.

	Verbena Magic Pink		Verbena Aztec White		Fuschia Love's Reward		Fuschia La Campanella	
Treatment	**Score**	**Category**	**Score**	**Category**	**Score**	**Category**	**Score**	**Category**
Water	1.2	C	1.0	No damage	1.0	No damage	1.0	No damage
Majestik	2.0	C	2.0	C	1.0	No damage	1.0	No damage
Agri 50	2.0	C	2.3	C	1.0	No damage	1.7	C
Certis Spraying Oil	5.0	A	4.0	C	3.0	A/E	1.0	No damage
Savona	1.2	C	1.6	C	1.0	No damage	1.3	C
Mycotal	1.0	No damage	1.0	No damage	1.0	No damage	1.0	No damage
Oberon	1.3	No damage	1.0	No damage	1.0	No damage	1.0	No damage

Score 1 – 5 where 1 = no damage

KEY: A = Loss of whole plants, B = Modification in leaf colour, C = Necrosis, E = Effect on plant weight

Table 4. Welford site: mean phytotoxicity scores and damage category for Verbena and Fuchsia 28 DAT

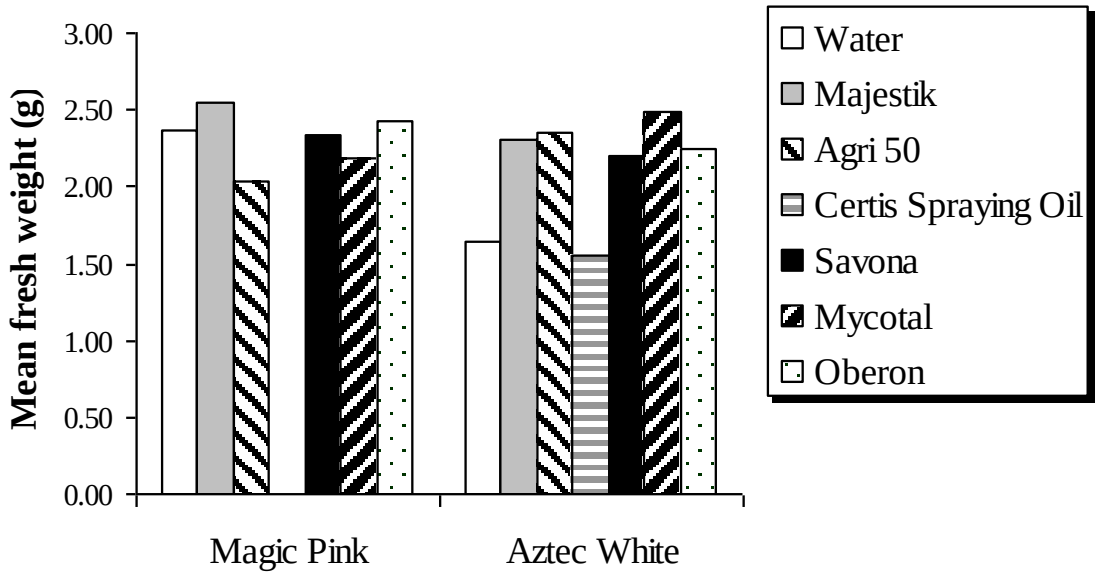
	Verbena Magic Pink		Verbena Aztec White		Fuschia Love's Reward		Fuschia La Campanella	
Treatment	**Score**	**Category**	**Score**	**Category**	**Score**	**Category**	**Score**	**Category**
Water	1.0	No damage	1.0	No damage	1.0	No damage	1.0	No damage
Majestik	1.0	No damage	1.0	No damage	1.0	No damage	1.0	No damage
Agri 50	1.0	No damage	1.0	No damage	1.0	No damage	1.0	No damage
Certis Spraying Oil	5.0	A	4.0	A	3.0	A	2.0	E
Savona	1.0	No damage	2.0	E	1.0	No damage	1.0	No damage
Mycotal	1.0	No damage	1.0	No damage	1.0	No damage	1.0	No damage
Oberon	3.0	B/C	3.0	C	1.0	No damage	1.0	No damage

Score 1 – 5 where 1 = no damage

KEY: A = Loss of whole plants, B = Modification in leaf colour, C = Necrosis, E = Effect on plant weight

Figure 1. Mean fresh weight (g) of patio plant cuttings 28 DAT

a) Verbena; LSD (Least Significant Difference) for Verbena Magic Pink = 0.39; LSD for Aztec White = 0.29) (P=0.05).



b) Fuschia; LSD (Least Significant Difference) for Love's Reward = 0.37; LSD for La Campanella = 0.25) (P=0.05).

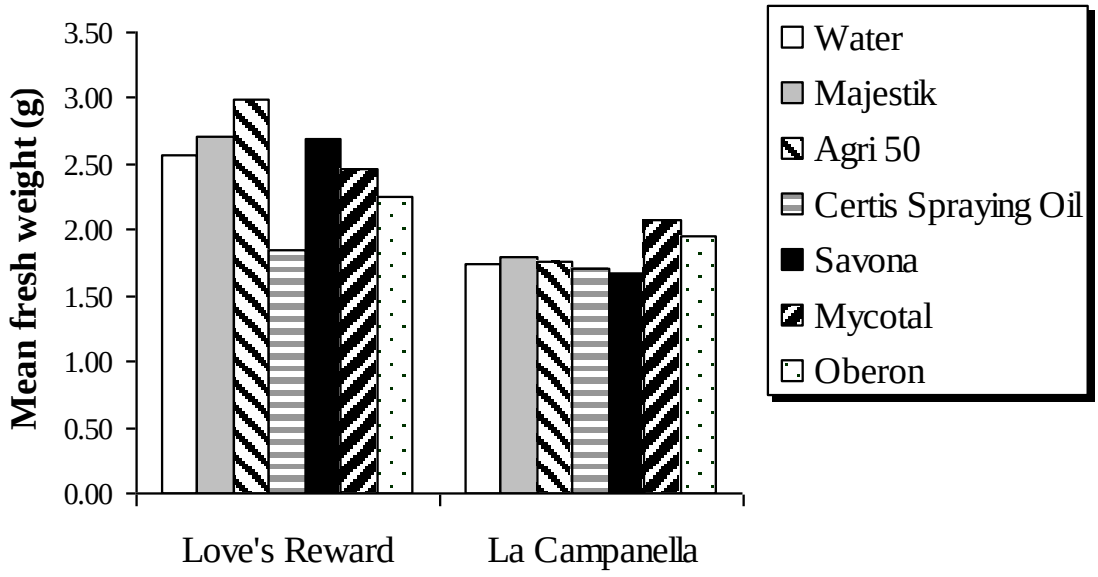


Table 5. Welford site: mean score when plants were in flower, and associated comments 3-5 weeks after potting.

	Verbena Magic Pink		Verbena Aztec White		Fuschia Love's Reward*		Fuschia La Campanella	
Treatment	**Score**	**Comment**	**Score**	**Comment**	**Score**	**Comment**	**Score**	**Comment**
Water	2.0	OK	1.7	OK	No data	No data	1.3	OK
Majestik	1.7	OK	1.3	OK	No data	No data	1.3	OK
Agri 50	1.7	OK	1.7	OK	No data	No data	1.7	OK
Certis Spraying Oil	n/a	All dead	2	Some flower delay	No data	No data	1.7	OK
Savona	2.3	Slight flower delay	2.3	Some flower delay	No data	No data	1.3	OK
Mycotal	1.3	OK	1.7	OK	No data	No data	1.7	OK
Oberon	2.3	Foliage distortion & flower delay	2.3	Obvious flower delay	No data	No data	1.7	OK

* Fuchsia Love's Reward was not in flower 5 weeks after potting.

KEY: Vigour score 1 – 5

In the assessments made on potted-on plants (Table 5), the phytotoxic effect of Certis Spraying Oil on Verbena Aztec White caused a delay in flowering on surviving plants. Savona treatment caused a slight reduction in flowering in both Verbena varieties. Similarly, Oberon treatment also delayed flowering. All other treatments (Majestik, Agri 50, and Mycotal) had no effect on the Verbenas.

Flowering of Fuchsia La Campanella was unaffected by any treatment; Fuchsia Love's Reward was not in flower when the assessments were made.

Wisbech site (patio plants)

The results of the phytotoxicity assessments made at seven and 28 DAT are given in Tables 6 and 7 respectively.

At 7 DAT, the Certis Spraying Oil treatment was found to be phytotoxic to all the plant subjects (Table 6), with both Fuchsia varieties showing deformation and white deposits on the leaves, and the Verbena and Salvia cuttings mainly showing necrotic symptoms; the Salvias also had white deposits on the leaves. Oberon caused stunting and necrosis of shoot tips of both varieties of Verbena, but had caused no symptoms on Salvia or Fuchsia. All other treatments caused no visible effects.

By 28 DAT (Table 7), the severe damage caused by the Certis Spraying Oil dip to all the varieties of Fuchsia, Verbena and Salvia was still clear. Although the treated cuttings did not die, they were severely affected and were not marketable. Damage caused by Oberon was now apparent (and severe) on both varieties of Verbena and Fuchsia, but Salvias were unaffected. Effects from treatment with Majestik, Agri 50E, Savona and Mycotal were observed but were only mild.

Fresh weight assessments done 28 DAT (Table 8) indicated that the dip treatment with Certis Spraying Oil significantly reduced cutting fresh weight in four out of the six plant specie cultures. Cuttings treated with Oberon were more variable in fresh weight, and only in two species (Salvia Purpurea and Verbena Tapien Violet) was cutting weight significantly less than the water only treatment.

The fresh weight data for the remaining treatments (Majestik, Agri 50E, Savona and Mycotal) were variable and there was no consistent effect of dip treatment.

The vigour scores for potted-on plants (Table 9) showed no definite trends, although Oberon-treated plants of Fuchsia Eva Boerg and both varieties of Salvia were noticeably smaller when compared with plants treated with water only. Flower scores were not possible for the latter, as all plants were still in the vegetative phase.

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Table 6. Wisbech site: damage categories for Fuchsia, Verbena and Salvia 7 DAT (no scores of phytoxicity were made).

	Fuchsia				Verbena				Salvia			
	Eva Boerg		Southgate		Tapien Violet		Temari Scarlet		Tricolour		Purpurea	
Treatment	**Score**	**Category**	**Score**	**Category**	**Score**	**Category**	**Score**	**Category**	**Score**	**Category**	**Score**	**Category**
Water only	n/a	No damage	n/a	No damage	n/a	No damage	n/a	No damage	n/a	No damage	n/a	No damage
Majestik	n/a	No damage	n/a	No damage	n/a	No damage	n/a	No damage	n/a	slight necrosis	n/a	No damage
Agri 50	n/a	No damage	n/a	No damage	n/a	No damage	n/a	C	n/a	Slight necrosis	n/a	No damage
Certis Spraying Oil	n/a	D (& white deposit on leaves)	n/a	D (& white deposit on leaves)	n/a	B	n/a	C	n/a	C (& white deposit on leaves)	n/a	C (& white deposit on leaves)
Savona	n/a	No damage	n/a	No damage	n/a	No damage	n/a	E	n/a	C	n/a	No damage
Mycotal	n/a	No damage	n/a	No damage	n/a	No damage	n/a	No damage	n/a	No damage	n/a	B
Oberon	n/a	No damage	n/a	No damage	n/a	C/E	n/a	C/E	n/a	No damage	n/a	No damage

KEY: B = Modification in leaf colour, C = Necrosis, E = Effect on plant weight

Table 7. Wisbech site: mean phytoxicity scores and damage category for Fuchsia, Verbena and Salvia 28 DAT.

	Fuchsia				Verbena				Salvia			
	Eva Boerg		Southgate		Tapien Violet		Temari Scarlet		Tricolour		Purpurea	
Treatment	**Score**	**Category**	**Score**	**Category**	**Score**	**Category**	**Score**	**Category**	**Score**	**Category**	**Score**	**Category**
Water	1.0	No damage	1.7	E	1.0	No damage	1.0	No damage	1.0	No damage	1.0	No damage
Majestik	1.0	No damage	1.3	E	1.0	No damage	2.0	E	1.7	E	1.7	C
Agri 50	2.0	E	1.7	E	1.7	C	2.3	E	1.7	E	1.7	C
Certis Spraying Oil	3.0	E	2.1	C	3.7	C/E	3.0	E	3.7	E	4.0	E
Savona	1.7	E	1.7	E	1.3	No damage	1.3	No damage	1.7	C	2.1	C
Mycotal	1.0	No damage	1.7	E	1.0	No damage	1.3	No damage	1.0	No damage	1.0	No damage
Oberon	3.3	C/E	2.1	C/E	4.0	C/E	4.0	C/E	1.0	No damage	1.0	No damage

Score 1 – 5 where 1 = no damage

KEY: C = Necrosis, E = Effect on plant weight

Table 8. Wisbech site: mean fresh weight (g) of patio plant cuttings 28 DAT. LSD = Least Significant Difference.

	Fuchsia		Verbena		Salvia	
Treatment	**Eva Boerg**	**Southgate**	**Tapien Violet**	**Temari Scarlet**	**Tricolour**	**Purpurea**
Water only	1.5	0.8	1.4	1.2	1.3	1.8
Majestik	1.3	0.9	1.5	1.4	1.5	1.9
Agri 50	1.1	1.0	1.1	1.2	1.3	2.4
Certis Spraying Oil	1.1	0.9	0.9	1.4	0.8	1.0
Savona	1.4	0.8	1.3	1.4	1.3	1.7
Mycotal	1.2	1.0	1.4	1.1	1.3	1.6
Oberon	1.2	0.6	1.0	0.9	1.2	1.2
F value (54 d.f.)	**1.82**	**3.41**	**4.17**	**2.05**	**5.75**	**9.40**
P	0.112	0.006	0.002	0.112	<0.001	<0.001
LSD (*P* = 0.05)	0.35	0.20	0.31	0.35	0.26	0.41

Table 9. Wisbech site: plant vigour scores for potted on plants 42 DAT.

	Fuchsia		Verbena		Salvia	
Treatment	**Eva Boerg**	**Southgate**	**Tapien Violet**	**Temari Scarlet**	**Tricolour**	**Purpurea**
Water only	2.0	1.3	1.0	2.0	1.7	2.0
Majestik	1.7	1.3	1.3	2.0	1.5	1.7
Agri 50	1.7	1.3	1.3	2.3	2.0	2.0
Certis Spraying Oil	1.0	1.0	2.0	1.7	2.0	1.7
Savona	1.7	2.0	1.0	1.0	1.3	2.0
Mycotal	2.0	2.0	1.7	1.0	2.0	2.0
Oberon	3.3	1.0	1.7	3.3	2.3	2.3

Nazeing site (Poinsettia)

The results of the phytotoxicity assessments made 21 and 35 DAT are given in Tables 10 and 11 respectively.

Table 10. Nazeing site: mean plant vigour scores for Poinsettia varieties 21 DAT.

Treatment	Euroglory	Infinity	Millennium	Mars	Already Red
Water only	1.0	2.0	1.0	3.0	1.0
Majestik	2.0	3.0	3.0	3.0	2.0
Agri 50E	2.0	3.0	2.0	3.0	2.0
Certis Spraying Oil	2.0	3.0	4.0	4.0	1.0
Savona	2.0	2.0	2.0	3.0	1.0
Mycotal	2.0	2.0	2.0	3.0	1.0
Oberon	2.0	2.0	1.0	3.0	2.0

Three weeks after sticking (Table 10) the Poinsettia varieties Mars and Millenium were most sensitive to the Certis Spraying Oil dip treatment, with plants showing symptoms such as leaf paling and necrosis. Mars was also adversely affected by all dip treatments, including water only. None of the treatments significantly affected Euroglory and Already Red.

The second assessment (35 DAT, Table 11) showed similar trends to the first; Certis Spraying Oil was very damaging to Mars, Millenium and, to a lesser extent, Infinity. Mars showed an adverse reaction to all dip treatments as before. The varieties Euroglory and Already Red were unaffected or only slightly affected by all treatments.

Table 11. Nazeing site: mean plant vigour scores for Poinsettia varieties 35 DAT.

Treatment	Euroglory	Infinity	Millennium	Mars	Already Red
Water only	1.0	2.0	1.0	3.0	1.0
Majestik	1.0	3.0	2.0	3.0	2.0
Agri 50E	1.5	3.0	2.0	3.0	2.0
Certis Spraying Oil	1.0	3.0	4.0	4.0	1.0
Savona	1.0	2.0	2.0	3.0	1.0
Mycotal	1.0	2.0	2.0	3.0	1.0
Oberon	1.0	2.0	1.0	3.0	2.0

Table 12. Nazeing site: mean fresh weights (g) of Poinsettia cuttings 35 DAT. LSD = Least Significant Difference.

Treatment	Euroglory	Infinity	Millenium	Mars	Already Red
Water only	2.77	3.40	4.40	3.80	3.50
Majestik	2.98	2.95	3.67	4.90	3.72
Agri 50E	4.12	3.42	3.60	3.40	3.07
Certis Spraying Oil	2.80	2.68	1.57	1.77	3.05
Savona	2.92	2.93	3.87	3.83	3.13
Mycotal	2.47	3.18	3.88	2.83	3.75
Oberon	2.60	3.37	4.53	3.25	3.43
F value (30 d.f.)	**4.90**	**1.22**	**6.89**	**6.09**	**0.81**
P	<0.001	0.326	<0.001	<0.001	0.57
LSD (*P* = 0.05)	0.71	0.74	1.17	1.13	0.96

Table 13. Nazeing site: mean root vigour scores for Poinsettias 21 and 35 DAT.

	Euroglory		Millenium		Infinity		Mars		Already Red	
Treatment	**21 DAT**	**35 DAT**	**21 DAT**	**35 DAT**	**21 DAT**	**35 DAT**	**21 DAT**	**35 DAT**	**21 DAT**	**35 DAT**
Water only	5.0	5.0	5.0	5.0	5.0	5.0	3.0	5.0	5.0	4.0
Majestik	5.0	5.0	2.0	3.0	4.0	5.0	3.0	4.0	5.0	5.0
Agri 50E	5.0	5.0	2.0	4.0	4.0	5.0	4.0	5.0	4.0	4.0
Certis Spraying Oil	5.0	4.0	1.0	2.0	3.0	3.0	0.0	1.0	5.0	4.0
Savona	4.0	4.0	3.0	4.0	3.0	4.0	4.0	5.0	5.0	5.0
Mycotal	4.0	5.0	4.0	4.0	4.0	4.0	1.0	2.0	5.0	5.0
Oberon	4.0	4.0	5.0	5.0	2.0	3.0	2.0	3.0	5.0	5.0

KEY: (Scale 1 – 5)

Table 14. Nazeing site: mean quality scores for Poinsettias at marketing.

Treatment	Euroglory	Millennium	Infinity	Mars	Already Red
Water only	1.3	1.2	1.0	1.2	1.3
Majestik	1.0	1.3	1.2	1.0	1.0
Agri 50	1.3	1.0	1.3	1.3	1.0
Oil	1.0	2.3	1.5	1.5	1.0
Savona	1.0	1.3	1.0	1.2	1.0
Mycotal	1.2	1.2	1.0	1.8	1.3
Oberon	1.0	1.2	1.0	1.0	1.0

KEY: Scale 1 – 5 where 1 = best

Fresh weights of the rooted cuttings were determined 35 DAT (Table 12). The Certis Spraying Oil treatment significantly reduced the fresh weights of the varieties Millenium and Mars, compared to the water only treatment. The differences in fresh weight of varieties Already Red and Infinity did not reach significance. Treatment of the variety Euroglory with Agri 50E caused a significant increase in fresh weight. The reasons for this are unknown. Infinity and Already Red were unaffected.

Root vigour scores done 21 and 35 DAT (Table 13) confirmed the adverse effects of the Certis Spraying Oil dip; as well as severe phytotoxicity, rooting was delayed in Millennium, Mars and Infinity, but not apparent in the varieties Euroglory and Already Red. There was a delay in rooting of the variety Mars following Mycotal and Oberon treatments, and in the variety Infinity from Oberon treatment. However, this did not result in a detrimental effect on fresh weight (Table 12).

Quality evaluation of Poinsettias at marketing (Table 14) showed that the marketable quality of Already Red and Euroglory was not affected by any of the dip treatments when compared to plants dipped in water only. The Certis Spraying Oil dip caused a reduction in quality and marketability of the varieties Millenium, Infinity and Mars. Overall quality of the plants of the variety Mars was variable, and the Mycotal treatment of this variety had the lowest quality score.

The results of the assessment of plant height and the number of primary breaks (Table 15) detected few treatment effects, but since the interval since the dip treatments being applied and the assessment date was 137 days, it is not surprising that any minor phytotoxic effects had been outgrown. However, the Certis Spraying Oil dip treatment had the lowest number of breaks in the variety Infinity.

Table 15. Nazeing site: mean height (cm) and number of breaks on Poinsettias ready for market.
This data was not statistically analysed as few trends were evident.

	Euroglory		Millenium		Infinity		Mars		Already Red	
Treatment	**Height**	**Breaks**	**Height**	**Breaks**	**Height**	**Breaks**	**Height**	**Breaks**	**Height**	**Breaks**
Water	14.0	4.5	13.4	5.6	13.8	5.3	14.5	4.3	16.2	3.7
Majestik	14.3	5.0	12.8	4.2	13.5	4.5	17.0	5.5	16.0	4.7
Agri 50E	14.3	5.8	12.5	4.5	14.0	5.3	14.8	3.8	15.2	3.5
Certis Spraying Oil	14.5	4.7	15.3	5.3	15.3	2.7	14.3	6.3	14.8	4.8
Savona	15.7	5.0	14.5	4.0	15.8	4.8	17.2	4.0	19.7	4.3
Mycotal	13.7	5.0	17.0	3.5	13.7	5.3	14.8	5.3	15.0	3.5
Oberon	14.5	5.0	15.2	4.8	14.2	4.8	14.6	5.0	16.2	4.8

Discussion

Richter (2005) tested various products against tobacco whitefly as dips to unrooted cuttings of the Poinsettia variety Cortez Red. She found that insecticidal soap (trade name not specified) at 4% concentration was phytotoxic. Mineral oil (trade name not specified) at 2% was the most effective of eight products tested as a dip treatment against tobacco whitefly, but did not cause phytotoxicity. Buxton & Clarke (1994) tested a range of insecticides as a dip treatment to rooted cuttings of Poinsettia, and found that oil at 1% concentration gave excellent control of all stages of tobacco whitefly. No phytotoxicity was recorded using rooted cuttings of Poinsettia. Cuthbertson (2006) found that spraying oil at 1% was the most effective product tested against eggs, scales and adult tobacco whitefly in leaf dip tests. Other products, including Majestik, Agri 50E, and Savona were effective against scales and adults, but not the egg stage. In later tests using potted Poinsettia plants, sprays of the products mentioned were less effective than dips, and Agri 50E caused phytotoxicity at label rate, although the variety of Poinsettia used was not specified.

In this work, Certis Spraying oil at 0.5 % (the lowest label concentration) caused unacceptable damage to unrooted cuttings of both patio plants and Poinsettia, but Majestik, Agri 50E, Savona and Mycotal were all safe to both patio plants and Poinsettias, and could be used by growers (subjective relative label approvals). Dipping of rooted cuttings is logistically not feasible, so for practical reasons, only unrooted cuttings could be dipped on a commercial scale. However, the finding by Cuthbertson (2006) that tobacco whitefly eggs were only susceptible to spraying oil means that products such as Majestik have less value as a dip treatment, because it is the egg stage of tobacco whitefly that is most commonly present on imported ornamental cuttings.

Conclusions

- Dip treatments with Majestik, Agri 50E and Mycotal had little or no effect on unrooted cuttings of the varieties Verbena, Fuchsia and Salvia tested in this project. Savona dip treatment was mildly phototoxic. Poinsettia varieties tested varied in their response, some such as Mars and Infinity displayed an adverse reaction to all dip treatments including water.

- Oberon is safe as a dip to three varieties of Poinsettia tested, but can have adverse effects on some patio plants. (Note: Current label does nor permit growers to apply this product as a dip treatment.)
- Certis Spraying Oil is unsafe to use as a dip treatment to unrooted cuttings of any of the plant species tested.

Technology transfer

- Fact sheet or Grower summary of results of Poinsettia dip trials, and efficacy trials conducted by CSL to be sent to all registered poinsettia growers by end June 2007.
- ADAS/CSL to make joint presentation to patio plant producers in winter 2007/08, illustrating the results of both projects.

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APPENDICES

Appendix 1: Plant specification used by Kinglea Plants Ltd for Poinsettias in 10.5 cm. pots ready for marketing.

Product: 10 cm Poinsettia, Variety: Reds. Minimum height 15 cm, maximum height 19 cm. Minimum width 15 cm, maximum width 25 cm.

Minimum Spec

Optimum Spec

Maximum Spec

Minimum Height: 15cm

Optimum Height: 17cm

Maximum Height: 1