Project Title	Biobeds / biofilters for the safe treatment of pesticide waste and washings (extension to PC/HNS 255)
Project number:	PC/HNS 255a
Project leader:	Dr Paul Fogg ADAS UK Ltd Gleadthorpe Meden Vale Mansfield Nottinghamshire NG20 9PF
Report:	Final report, November 2008
Previous report	PC/HNS 255 Final report August 2008
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Location of project:	ADAS, Gleadthorpe Warwick, HRI Bordon Hill Nursery, Stratford upon Avon
Project coordinator:	Mr Kevin Hobbs, Hilliers Nursery (HNS) Mr Gary Taylor, Valley Grown Nurseries (PC)
Date project commenced:	01 June 2008
Date completion due:	30 November 2008
Key words:	Biobeds, pesticide, point source, water, pollution, waste, treatment

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The results and conclusions in this report are based on a series of experiments conducted over a 2.5 year period (including Phase I HDC Project number PC/HNS 255). 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.

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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.

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Grower Summary

Headline

- A novel biofilter was constructed for use in the ornamentals industry and succeeded in retaining comparable levels of pesticides to a traditional biobed system.

Background and expected deliverables

Routine monitoring of environmental waters has shown that contamination with pesticides does occur. To meet government targets on reducing the levels of pesticides in water, their handling and disposal needs to be improved. It should also be noted that under the Agricultural Waste Regulations (May 2006), disposing of pesticide waste and washings to soil or grass areas is now an illegal activity.

In farm businesses, pesticide handling activities are typically all performed on the same site due to location of the pesticide store and a clean water supply. Research suggests that 20-70% of the pesticide contamination measured in water can be attributed to spray fill sites. While the characteristics of the filling area, operating practices and local conditions may vary, the reasons for the origins of the contamination are generally similar. Sprayer filling, poor empty package management and machinery maintenance are the main reasons attributed to contamination.

Such 'point source' releases can be minimised by modifying handling practices. However, it is inevitable that some releases will occur. Additional treatment methodologies are therefore required to address these releases. Such treatment methodologies would supplement good handling practices that reduce inputs to aquatic systems. The methodologies need to be inexpensive to use and require low labour and time inputs. One possible approach is to use a lined biobed to intercept and treat contaminated runoff from the farmyard and/or drips and spillages arising during the filling process. However, the existing biobed system used in field produced crops is unsuitable for businesses where space is limited. Moreover, the complex mixture of fungicides, insecticides and plant growth regulators typically

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used by some sectors of the horticultural industry represent a far greater challenge to the biobed technology than those which have been evaluated previously.

The main deliverable from this project was:

- To establish whether a novel biofilter system could deliver the required level of treatment when used in commercial conditions.

Summary of the project and main conclusions

Standard biobeds have proved to be effective and popular under typical arable use conditions. However, the standard biobed, consisting of a 1 m deep hole in the ground and a surface area of typically 40 m^2 – 60 m^2, is inappropriate for many horticultural businesses such as the protected crop sector, owing to the large footprint.

A novel biofilter system was therefore developed in Project PC/HNS 255. This was initially operated under controlled conditions and was treated with a mixture of nine pesticides to simulate a realistic worst case scenario. Results from these controlled studies showed that only one pesticide (imidacloprid) was detected in water draining through the biofilter, with more than 98% of that pesticide being retained within the biofilter system. However, it was also important to be able to demonstrate that the retained pesticides were degraded.

When the prototype biofilter was destructively sampled none of the nine pesticides were detected in the biomix. Laboratory scale experiments supported this observation and demonstrated that the biofilter matrix (biomix) could effectively degrade high concentrations of relatively complex mixtures of pesticide. Moreover, with the exception of soil sterilant materials, pesticide degradation was not significantly affected by the inclusion of plant growth regulators or disinfectant chemicals.

In this project, a prototype biofilter was set up on a commercial nursery and was monitored under commercial conditions. Hydrological monitoring data for this

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system revealed that the volumes of pesticide waste being generated were far higher than originally thought, with in excess of 14,000 litres of pesticide waste and washings put through the biofilter from two glasshouse areas over a six month period.

However, the biofilter treatment train proved very effective at retaining the applied pesticides, with only the most mobile pesticide (metalaxyl-M) being detected in water draining from the outlet of the biofilter (maximum concentration 174µg per litre, inlet concentrations reduced by a factor of 31). The overall performance of the biofilter was such that more than 97.8% (one active; for the remainder 100% retained) of the applied pesticides that were monitored, were retained.

While the UK Environment Agency and Scottish Environmental Protection Agency have not seen the findings of this study, the performance of the biofilter is comparable with the standard biobed and should therefore be acceptable. However, this biofilter has not yet been granted exemption from the Agricultural Waste regulations 1996.

Financial benefits

A number of approaches are currently available for managing pesticide waste and washings. These include storage pending collection by a licensed disposal contractor, or the use of equipment to treat the waste. Storage requires the purchase of a UV resistant double skinned tank at a typical cost of £1,280 per 5,000 litre tank, with disposal charges of up to £400 per 1,000 litres if organophosphate compounds are present.

Alternatively, environmental protection equipment, for example the Sentinel, can be used to effectively treat pesticide waste. However, even though the Sentinel treatment system has been commercially available for 20 years or more, uptake has been limited. Cost has probably been the most limiting factor with regards to uptake, with an initial purchase price of £12,500 for a standard 1000 litre unit, running costs of £25 per 1,000 litres (including sludge disposal), £300 - £400 for an annual service and labour of 1 hour, per 1000 litres.

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Standard biobeds have also been developed, which in their simplest form are anticipated to cost in the region of £3,000. The biofilter system developed in this project costs less than £500 to construct. Labour costs are not included in either of the biobed / biofilter systems.

Action points for growers

- Following the introduction of the Agricultural Waste Regulations in May 2006, disposing of pesticide waste and washings to soil or grass areas is now an illegal activity. If the activity takes place no more than once in any 12 month period a ground water authorization may be granted. Alternative measures need to be considered for managing pesticide waste, washings and the associated packaging.

- Ensure that all pesticide mixing, handling and cleaning activities take place on a bunded impermeable surface, fitted with a sealed drainage system. This will prevent waste, washings and contaminated runoff from potentially contaminating surface or groundwater.

- Review pesticide management practices and try and keep the volumes of waste being generated to an absolute minimum. Wherever possible spray washings out onto the intended target, provided label restrictions are followed.

- Consider installing a biobed / biofilter as an integral part of your pesticide management facility. The use of a biobed does require you to register an exemption from the Agricultural Waste Regulations with the Environment Agency (Tel: 0845 603 3113). Biofilters still need to be approved by the Environment Agency.

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Science Section

Introduction

In its simplest form, a biobed is a hole in the ground filled with a mixture of topsoil, peat and straw providing a matrix to absorb the pesticide(s) and facilitate biodegradation, (Torstensson and Castillo 1996, 1997). The typical biobed system needs to be a least 1 m deep, with a surface area of 1 m^2 for every 1000 litres of liquid requiring treatment (Fogg *et al*., 2004b), this results in most biobeds having a footprint of at least 40 -50 m^2. Projects PC/HNS 255 and 255a aimed to establish whether the existing biobed technology could be adapted to meet the specific requirements of the horticultural sectors. In particular, the projects intended to determine whether the size of the biobed system could be reduced, whilst still achieving the required level of performance. A modified biobed or 'Biofilter' system was designed, and industry consulted. A prototype system was constructed and operated under controlled conditions for approximately 8 months. Results from these initial experiments (Fogg *et al*., 2008) demonstrated that a novel biofilter system, with a surface area requirement of ~4 m^2 retained ≥98% of the applied pesticide when operated under controlled conditions. Moreover, when the prototype biofilter was destructively sampled none of the nine pesticides under investigation were detected in the biomix. Laboratory scale experiments supported these findings and demonstrated that the biofilter matrix (biomix) could effectively degrade high concentrations of relatively complex mixtures of pesticide. Moreover, with the exception of soil sterilant materials, pesticide degradation was not significantly affected by the inclusion of plant growth regulators or disinfectant chemicals. The biofilter system was relocated to a commercial nursery, where the performance was monitored under 'real world' use conditions over a period of 6 months (April to September 2008). This report contains information relating to monitoring of the system under commercial use conditions.

Materials and Methods

Test pesticides

Several nurseries provided ADAS with chemical use records, and the Pesticide Usage Survey (PUS) data for 2004 was also studied. The pesticides chosen for monitoring

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under real world conditions of use were selected on the basis that they are all commonly used in horticultural nurseries, including the commercial nursery chosen for this phase of the project, the physico-chemical characteristics of the active substances and in particular persistence, potential mobility and water solubility, in order that 'real risk of pesticide leaching through the biofilter could be assessed. In addition the availability of suitable analytical methods had to be considered. The chemicals chosen are listed in (
Table 1).

Table 1: Properties of selected pesticides

Active	Use	DT_{50} soil (days) *	K_{oc} (mL g^{-1})*	Solubility (g L^{-1})*
azoxystrobin	Fungicide	7-56	500 slightly mobile	6
carbendazim	Fungicide	8-32	200-250 moderately mobile	29
chlorothalonil	Fungicide	5-36	1600-14000 slightly/non-mobile	0.00081
imidacloprid	Insecticide	120	132-256** moderately mobile	0.61
iprodione	Fungicide	20-160	373-1551 slightly/moderately mobile	0.013
metalaxyl-M	Fungicide	5-30	70 mobile	26
paclobutrazol	Plant growth regulator	122****	210**** moderately mobile	26

*All data from Tomlin, 2000 except **ACP Information sheets ***Agritox database
**** http://sitem.herts.ac.uk/aeru/footprint/
K_{oc} = Pesticide absorption coefficient, normalised for the amount of organic carbon present in soil

Preparation of biomix

A biobed mixture (biomix) was made up from volumetric proportions of straw (50%), peat-free compost (25%) and a loamy topsoil (25%) (Table 2). This mixture was left to compost on a concrete pad for 60 - 120 days, turned 2 – 3 times using a JCB type loader before being used in the biofilter system located on the commercial holding (Plate 1).

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Plate 1 Prepared biomix composting prior to its use on the commercial holding

Table 2 Top soil characteristics

% sand (2.00 – 0.0063 mm)	86
% silt (0.0063 – 0.002 mm)	8
% clay (< 0.002 mm)	6
Textural classification	Loamy sand
pH	5.8
Organic carbon (% wt/wt)	0.99

Residue analysis

Samples from the monitoring study conducted at Bordon Hill were sent to Warwick HRI for residue analysis.

Samples were filtered and passed, under vacuum, through a pre-conditioned C_{18} (Supelclean Envi-18) Solid Phase Extraction (SPE) cartridge. The cartridge was eluted with methanol (5 mL). The resulting solution was transferred to an autosampler vial and sealed. The vials were stored at 0°C until analysed. Samples were analysed by HPLC using either of two column types; Genesis C8 column (25 cm x 4.6 mm) and a LichroCART RP-18 (25 cm x 4.6 mm). HPLC conditions and recoveries for the 7 pesticides analysed for in the samples collected from Bordon Hill are summarised in

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Table 3.

Table 3 HPLC conditions and recoveries for the 7 pesticides used for the samples collected from Bordon Hill

Compound	Column	Mobile phase (acetonitrile:water)	Flow rate ml/min	Retention time (min)	Wavelength (nm)	% Recovery
imidacloprid	C8	55:45	1.2	3.32	280	>95
carbendazim	C8	55:45	1.2	3.47	280	>95
metalaxyl-M	RP18	55:45	1.2	4.20	230	>95
paclobutrazol	RP18	55:45	1.2	5.69	230	>95
azoxystrobin	RP18	55:45	1.2	6.83	230	>95
iprodione	RP18	55:45	1.2	9.31	230	>95
chlorothalonil	RP18	55:45	1.2	10.17	230	>95

The validated methodology for the determination of residues in water demonstrated that each of the selected determinands could accurately be determined at the limit of quantitation (LOQ) (Table 4). The limit of quantitation is defined as the lowest fortification level at which acceptable recovery data are obtained.

Table 4 Limits of quantification in water for pesticides selected for analysis

	Water LOQ (µg L^{-1})
azoxystrobin	0.6
carbendazim	0.5
chlorothalonil	0.2
imidacloprid	0.6
iprodione	1.5
metalaxyl-M	6.7
paclobutrazol	5.0

Bromide

Concentrations of bromide were quantified by ion chromatography. The limit of quantitation (LOQ) was 0.2 mg L^{-1}.

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Data

Test Site

Several nurseries were visited and assessed for suitability. Those investigated covered a range of production systems representing hardy nursery stock and ornamental protected stock. The selection criteria was based on the range of pesticides being used, the anticipated volume of waste generated by the business, as well as ease of access and the potential to use the site as a demonstration facility. Bordon Hill Nursery, Stratford-upon Avon, Warwickshire was selected as being the most appropriate for this trial. Bordon Hill Nurseries Ltd specialise in the production of young plug plants from seed and cuttings for the commercial trade, also producing finished plants, such as Poinsettia and Cyclamen. The site was considered to be conveniently located for monitoring and was also within close proximity to the analytical facility conducting the residue analysis. The nursery was considered to be of an appropriate size and infrastructure for the purpose of the project and could provide accurate records of pesticide applications and associated waste and washings. On the basis of the 2007 pesticide usage records for the nursery, the range of active substances used was considered to be typical for protected ornamental production. Furthermore, analytical techniques were already established for those pesticides likely to be used during the monitoring period.

The site at Bordon Hill is approximately 13.5 acres in total, and all waste washings currently discharge to two conventional biobeds, hence the infrastructure for collecting waste was already in place. The quantity of waste produced by the site as a whole was considered too excessive for the purpose of the project. However, two areas on the site (glasshouse blocks F & G) were isolated and the washings from these diverted to provide a more suitable level (16000 L per annum) of waste input to the prototype biofilter. The range of chemicals and quantity of waste washings were thus considered to provide a realistic scenario for the project.

Design and construction

Three new 1.0 m^3 HDPE (high density polyethylene) open-topped IBC tanks were acquired for the nursery biofilter system. To increase rigidity, the tanks were encased in galvanised frames and to reduce the overall working height of the system, the tanks were fitted with horizontal valve outlets and were of a palletised design. To

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prevent the biobed matrix entering the valve, the base of the tank outlet of each tank was lined with a square of wire mesh which was covered with Plantex ® (permeable landscape membrane). A layer (approximately 10 cm) of washed quartzite pea gravel was placed on top of the membrane to ensure that the membrane did not become blocked and that good drainage was maintained (Plate 2a). The biomix used to fill the tanks was prepared on 29 January 2008 and stored in the open to 'compost' until used. The test system tanks were filled with the composted material on 11-12 February 2008 (Plate 2b) , transported to Bordon Hill Nursery on 14 February 2008 (Plate 2c), and positioned one on top of the other as a biofilter, adjacent to the glasshouse and existing biobed complex, on 20 February 2008. To increase rigidity of the biofilter, a framework of scaffolding was attached to the stacked tanks. To prevent natural rainfall inputs to the system, the top tank was covered (Plate 2d).

To distribute the discharge draining from the upper (tank 1) and middle (tank 2) tanks onto the surface of the biomix of the tank immediately below, a rigid grid work of perforated pipe work was attached to the horizontal valve outlets (Plate 2e). To monitor pesticide concentrations in leachate draining from the top and middle tanks, the pipe work was fitted with a 'Y' connector to which a 1 L capacity SCHOTT Duran® borosilicate glass bottle was attached (Plate 2f). The outlet of the bottom tank (tank 3) was instrumented to measure the total volume of discharge exiting the system and enable samples of leachate to be collected automatically.

The system was operated at ambient temperature. Monitoring was completed on 30 September 2008. In the event that it was to be required as a demonstration facility, the system was left fully constructed at the nursery following completion of the monitoring phase.

Instrumentation

The nursery biofilter system was instrumented on 03 March 2008. A standard 1000 L IBC container was positioned next to the biofilter in order to collect the pesticide waste and washings generated from the spraying operations in glasshouses F and G. The tank was instrumented with a float switch in order to enable an automatic water

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sampler to be triggered and submersible pump fitted with its own float switch to pump the pesticide waste and washings onto the biofilter. The float switch on the pump was positioned such that when activated, the pump discharged *ca*. 155 L of waste onto the biomix surface of the top tank via a grid of perforated pipe work. On 22 May 2008, the position of the float switch was changed such that the volume of washings applied to the top tank when the pump was activated increased to 197 L. This was done to increase the discharge exiting the biofilter system and provide a greater number of samples for residue analysis. A standard flow meter was used to measure the total amount of waste washings applied to the system.

The stainless steel tipping bucket flow meter (0.135 L per tip) was used to measure discharge exiting the biofilter. The flow meter was placed within a new glass tank (length 450 mm; width 450 mm; height 300 mm) to facilitate the collection of samples for pesticide residue analysis. The glass tank was placed within a larger plastic tank, which in turn was positioned within one of the nursery standard biobeds.

Discharge from the tower was piped a distance of approximately 2 m from the biofilter to the tipping bucket. To ensure that the discharge was replenished regularly, thus ensuring that any sample collected was representative of the discharge generated at the time, the glass tank was fitted with a 19 mm outlet positioned approximately 20 mm from the bottom. This allowed approximately 5.5 L to be retained at any given time for collection, excess discharge being allowed to drain and retained for subsequent disposal. Excess discharge (i.e. that not collected for pesticide residue analysis) drained from the glass tank into the larger plastic tank and then onto the nursery's own standard biobed.

Two automatic water samplers (ISCO; Model 3700) configured with twenty-four (polypropylene) wedge shaped bottles were installed adjacent to the biofilter. The first sampler was set-up to collect a single *ca*. 1 L sample pre-biobed sample when triggered by a float switch installed into the waste collection tank. The second autosampler was configured to sample discharge exiting the treatment system on a flow-proportional basis. The sampler was attached to a data logger (CR200), which was programmed to measure the total output from the tipping bucket flow meter for every 15 minutes and also record the cumulative volume of discharge. The

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autosampler was calibrated in accordance with manufacturer's instructions to nominally collect a 'shot' volume of 100 mL (+/- 10 mL). The sampler was programmed to collect a 'shot' for every 16 tips of the tipping bucket flow meter as recorded by the data logger, with each sample comprising of 9 shots. This equated to a composite 1 L sample being collected for every 20 L of 'treated' discharge exiting the bottom tank.

Approximately 4 months after monitoring commenced, the frequency of sample collection was reduced. On 19 June 2008 the logger program was changed such that a 1 L sample was collected for every 50 L of discharge.

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(a)

(b)

(c

(d)

(e)

(f)

Plate 2 Biofilter under construction at commercial nursery site

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Pesticide Treatment

Monitoring of the nursery biofilter commenced immediately following completion of the instrumentation, on 03 March 2008. All of the pesticide waste and washings associated with any spraying activity conducted within the glasshouse blocks F and G was captured and diverted away from the nursery's own standard biobed treatment system and applied to the biofilter. Pesticide waste and washings were generated by the nursery following treatment using either a drum or knapsack sprayer, or a watering can. The nursery estimated that the volume of waste washings generated by each of these three application methods was 40, 5 and 2 L, respectively. Twenty-five different active substances were used by the nursery in glasshouse blocks F and G during the monitoring period. These are considered to be representative of the broad range of chemical classes typically used in commercial protected ornamental cropping. Seven of these active substances were selected for analysis as described earlier,
Table 1. The first pesticide waste washings to be redirected through the biofilter following its construction and instrumentation, were those generated by the nursery on 10 March 2008. Details of the products used by the nursery during the period 10 March to 30 September 2008, including the amount of product and volume mixed, are provided in Appendix I.

Control and reference substances

Potassium bromide (KBr) was used as an inert tracer to track water movement and hence determine the breakthrough timing of infiltrating water within the nursery biofilter system. As with the prototype system, the tracer was applied at a rate equivalent to 100 kg KBr ha^{-1} (11.66 g KBr applied to tank 1; surface area 1.1664 m^2) in an application volume of 1 L using tap water. The tracer was applied on 07 March 2008 using a hand-held plant sprayer.

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Sampling

Leachate

Pre-biobed treatment

Representative samples of the waste washings applied to the biofilter treatment system were collected for pesticide residue analysis in order to determine pesticide loadings to the system. A 1 L sample was collected every time the submersible pump was activated to discharge waste onto the biofilter. This equated to a 1 L sample being collected for every 155 L (197 L from mid-May to the end of the monitoring period) discharge applied to the biofilter.

Post-biobed treatment

Samples of leachate draining from each of the three tanks (1, 2 & 3) were collected for pesticide residue analysis. Leachate draining from the top and middle tanks was collected manually twice a week. On each occasion a 1 L sample was collected into a one litre High Density Polyethylene (HDPE) bottle. Leachate draining from the bottom of the biofilter system was sampled automatically on a flow proportional basis using the ISCO automatic water sampler. As previously, samples were collected into 1 L capacity polypropylene bottles and transferred to 1 L HDPE bottles prior to storage. A 60 mL sub-sample was decanted from each sample into a polypropylene bottle for bromide analysis. Samples collected for pesticide residue analysis were individually bagged and stored frozen (-18°C or colder) and samples for bromide analysis were stored refrigerated at 0-10°C.

Bromide

A 60 mL sub-sample was taken from each leachate sample collected for residue analysis. The flow data were analysed and expert judgment was used to determine which samples were forwarded to the analytical facility for bromide analysis. Bromide analysis was carried out by Natural Resources Management Ltd (NRM Ltd).

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All samples were identified with the project number, a unique sample number and the sampling date. An inventory of all study samples collected was maintained. Analysis of pesticide residues in water and biomix was performed by Warwick HRI.

Results

Hydraulic monitoring

The biofilter system was instrumented to enable the total amount of dilute pesticide waste applied as well as the total amount of discharge to be measured. The amount of dilute pesticide waste produced from the glasshouse areas F + G and applied to the surface of the top tank of the biofilter between 10 March 2008 and 30 September 2008 was 14177 L. Total discharge from the biofilter over the same time period was 10248 L. The disparity in the amount of liquid applied to the top of the biofilter and that exiting the system (3930 L) is considered to be mainly due to evaporation from the biomix surface of each tank. However, a total of approximately 120 L was removed from the top and middle tanks for pesticide residue and bromide analysis during the monitoring period. In addition, an airlock in the pipe work caused the discharge from the bottom tank to by-pass the tipping bucket during the first three weeks of monitoring.

Chemical loading

The pesticide waste generated by from the glasshouse areas F and G was applied to the surface of the top tank of the biofilter system over a course of time (11 March 2008 to 29 September). In total, the dilute waste was applied on seventy-seven separate occasions as 155 L (or later as 197 L) at a time. On each occasion that pesticide waste was applied to the biosystem, a sample was collected and analysed for pesticide residues. It was therefore possible to estimate the chemical loading associated with each occasion that dilute waste was applied to the system. (assuming that the concentration (mg/L) on a sampling date was representative of the total amount of waste applied to the system on that date (L)).

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Bromide in leachate

Figure 1 shows the concentration of bromide detected in leachate collected from the tank outlets of each of the three tanks for the period March to July 2008. The tracer was applied on 07 March 2008, three days prior to any pesticide waste being applied to the biotower. However, as the tracer was applied in a small volume of water (1 L), movement through the biomix profile in the tanks is considered to be negligible prior to any pesticide waste inputs being applied to the system. For the purpose of describing the movement and breakthrough of tracer and hence pesticides within the biotower following commercial use of the system, the day of application (Day 0) is taken as being 10 March 2008 (date pesticides first introduced to the system).

Breakthrough of bromide in leachate from the top and middle tanks was almost simultaneous and the subsequent breakthrough profiles were very similar. Bromide was first observed in leachate collected four days after treatment (DAT), at concentrations of 0.2 to 4.0 mg L^{-1}, respectively. Three days later (7 DAT) , concentrations increased to a maximum of 6.3 mg L^{-1}, demonstrating significant movement of water had occurred through the top and middle tanks by this time. Thereafter, concentrations of the tracer in leachate collected from these two tanks decreased rapidly to 0.9 and 1.4 mg L^{-1}, respectively, by 03 April 2008 (24 DAT). Bromide was also detected for the first time in leachate collected from the bottom tank at this time, at a maximum concentration of 2.5 mg L^{-1}. Owing to the tipping bucket malfunctioning during the first three weeks of monitoring, no discharge samples were collected by the autosampler from the bottom tank during this period. Given the rapid breakthrough of the tracer in the upper two tanks, it is likely that the peak concentration of bromide in leachate from the bottom tank would have occurred prior to 03 April 2008 (second or third week following introduction of pesticide waste washings). The breakthrough curves for all three tanks strongly suggest that this was the case.

Over the next six weeks, concentrations of bromide in leachate collected from all three tanks decreased gradually. By 23 May 2008 (74 DAT) bromide detected in leachate from all tanks was just above the LOQ, at a

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concentration of 0.3 mg L^{-1}. Concentrations in leachate collected during June and July 2008 (88 to 137 DAT) were generally below the LOQ in leachate collected from the upper two tanks (top and middle) and at low concentrations (up to 0.5 mg L-1) in leachate collected from the bottom tank.

A simple estimate of the amount of bromide leaching from each of the three 1 m deep tanks was made. The calculations were based on the following assumptions:

1. Discharge recorded from the bottom tank (3) was taken as an indicator of the volume of water leaching from the top and middle tanks (1 & 2).
2. The flux or total amount of bromide leaching from each of the three tanks was calculated as the product of the concentration of bromide in leachate from each respective tank on a sampling date, and the total amount of discharge (from tank 3) since the previous sampling date.
3. The flux of bromide for the top and middle tanks is calculated for 10 March 2008 to 25 July 2008 following application of the tracer and doesn't take account of any losses after these periods.

On the basis of the assumptions described above, 15, 22 and 29 % of the total amount of bromide applied to the system, is estimated to have leached from the top, middle and bottom tanks, respectively.

It should be noted that the amount of bromide recovered at each 1 m depth from the system will be an under-estimate, in particular the top and middle tanks, as the calculations are based on the discharge measured from the bottom tank, in which the equipment malfunctioned during the first two weeks of monitoring for which no discharge data was generated.

Overall, the bromide data demonstrate that significant movement of water, and hence potential for pesticide movement, had occurred through each of the three tanks during the course of the monitoring period.

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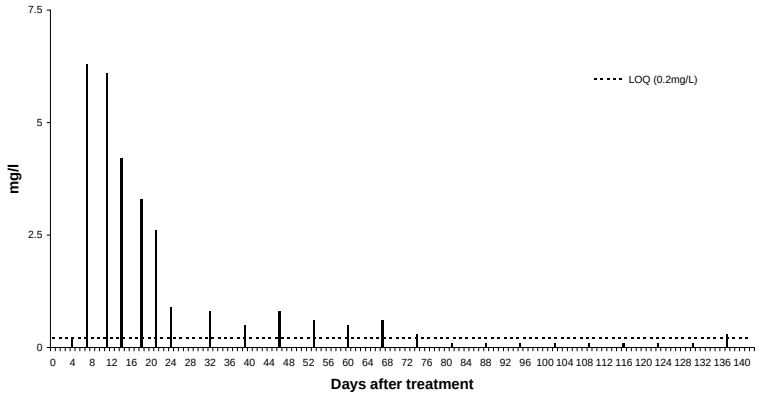
Figure 1 Bromide concentrations in leachate from a) top tank; b) middle tank and c) bottom tank



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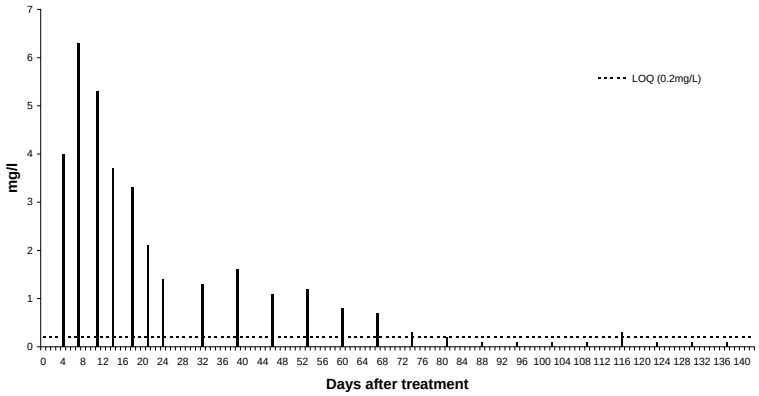

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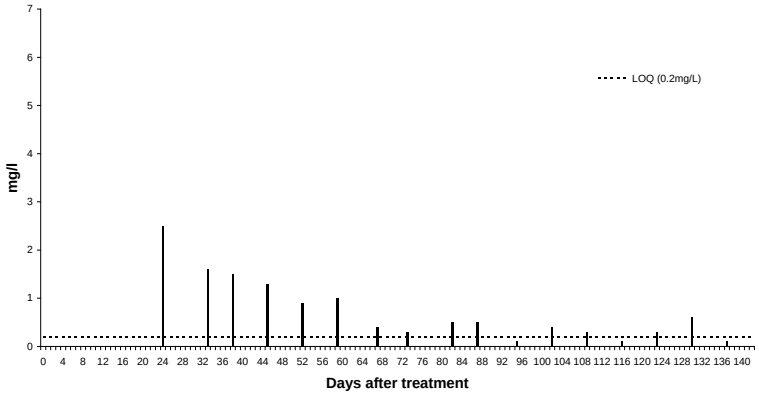

(c)

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Pesticide residues in water

Of the twenty-five different actives used by the nursery in glasshouse blocks F and G, only seven were selected for monitoring; azoxystrobin, carbendazim, chlorothalonil, imidacloprid, iprodione, metalaxyl-M and paclobutrazol.

A sample of the waste washings generated by the nursery and discharged to the biofilter system was first collected from the inlet tank on 11 March 2008 (1 DAT; 24 hours after the system was commissioned). The first set of grab water samples from the upper and middle tanks were collected on 14 March 2007. The first composite sample of leachate draining from the bottom tank of the biofilter was not collected until 03 April 2008 (24 DAT) as a result of the discharge passing the tipping bucket as described earlier. From March to September 2008, a total of 75 samples were collected by the autosampler from the inlet tank. During the same monitoring period, 59 and 61 grab samples were collected from each of the top and middle tanks, respectively and 258 composite samples of discharge were collected from the bottom tank. The flow data were used to determine which samples were forwarded for residue analysis.

Of the grab samples collected from the top and middle tanks, a total of 60 (30 from each) were forwarded for residue analysis. Of the composite samples collected by the two autosamplers from the inlet tank and the outlet of the bottom tank (3), a total of 28 and 68 samples, respectively, were selected for residue analysis. Figure 2 to Figure 8 show the concentrations of pesticides detected in the inlet samples (untreated washings) and in the leachate samples draining from each of the three tanks.

All seven pesticides (azoxystrobin, carbendazim, chlorothalonil, imidacloprid, iprodione, metalaxyl-M and paclobutrazol) were detected in the samples of waste washings collected from the inlet tank that were forwarded to the analytical facility for residue analysis. Carbendazim and azoxystrobin were the most frequently detected compounds, being present in 93 and 86% of samples analysed, respectively. Imidacloprid and chlorothalonil were detected in the least number of samples analysed (14%). Iprodione and

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metalaxyl-M were detected at the greatest concentrations, these being 5.7 and 5.4 mg L^{-1}, respectively.

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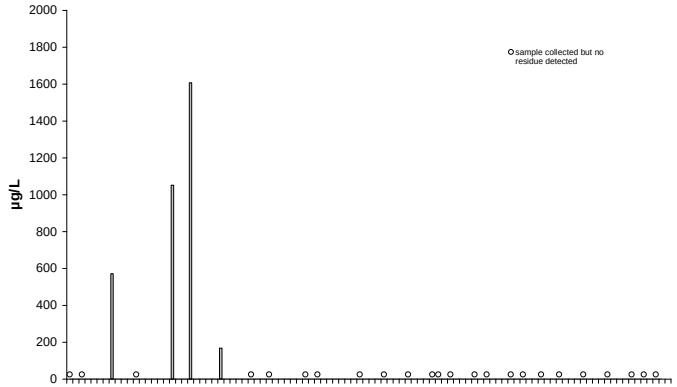
Figure 2 Concentrations of imidacloprid in leachate from a) inlet tank; b) top tank; c) middle tank and d) bottom tank



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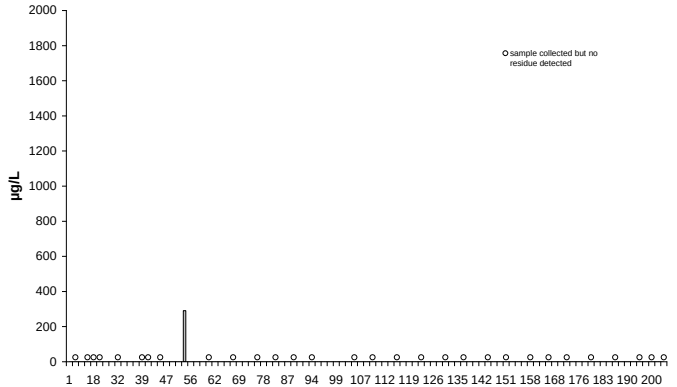

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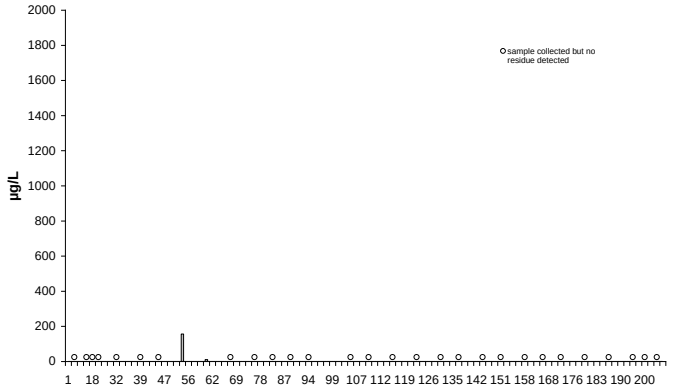

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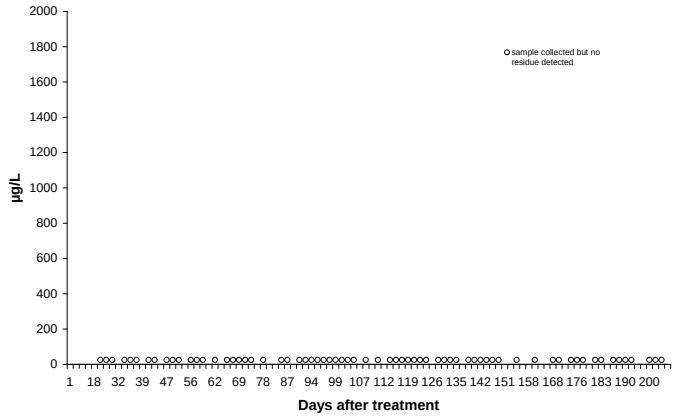

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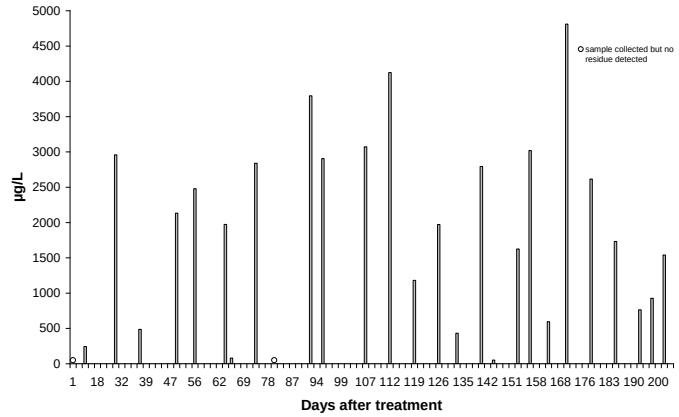
Figure 3 Concentrations of carbendazim in leachate from a) inlet tank; b) top tank; c) middle tank and d) bottom tank



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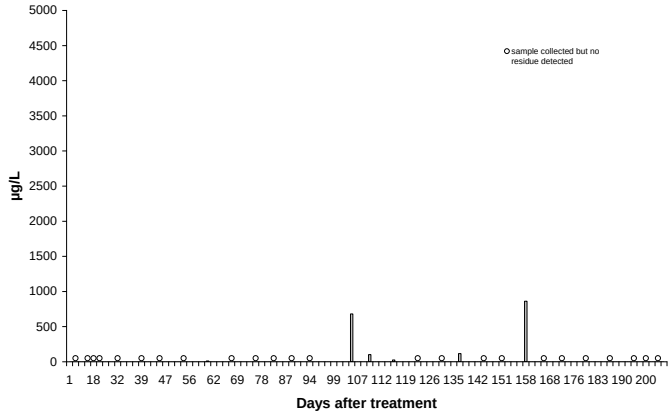

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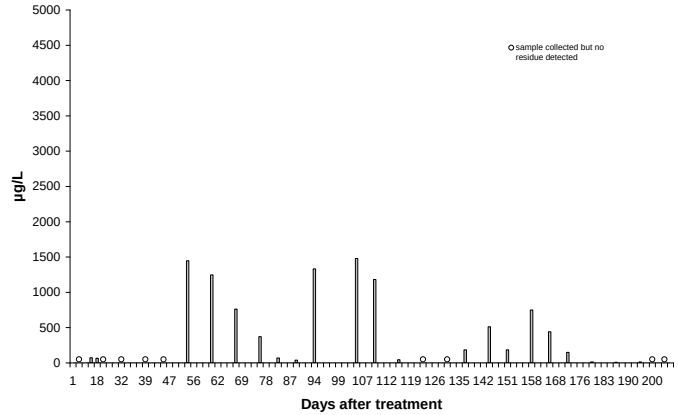

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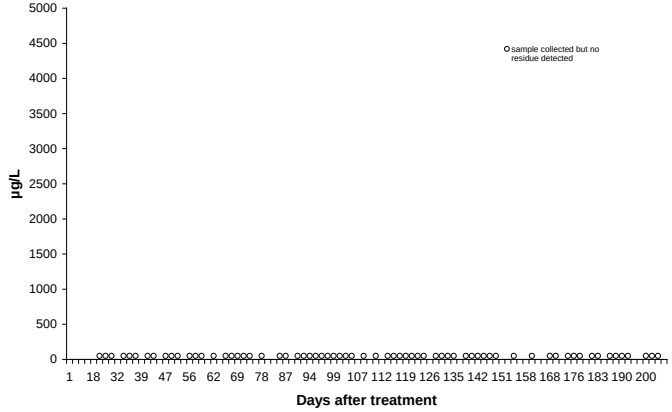

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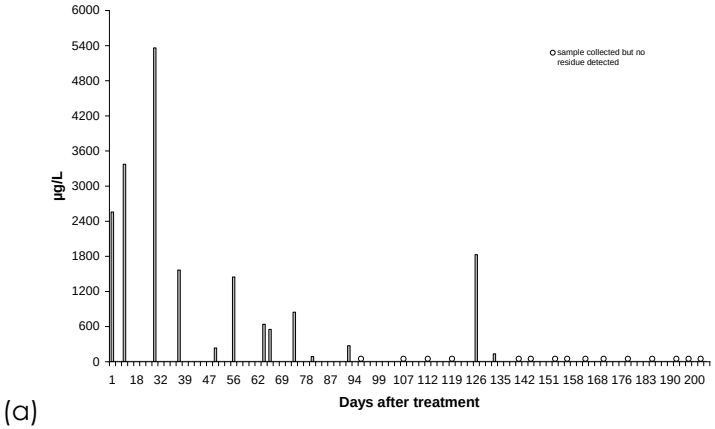
Figure 4 Concentrations of metalaxyl- M in leachate from a) inlet tank; b) top tank; c) middle tank; d) bottom tank



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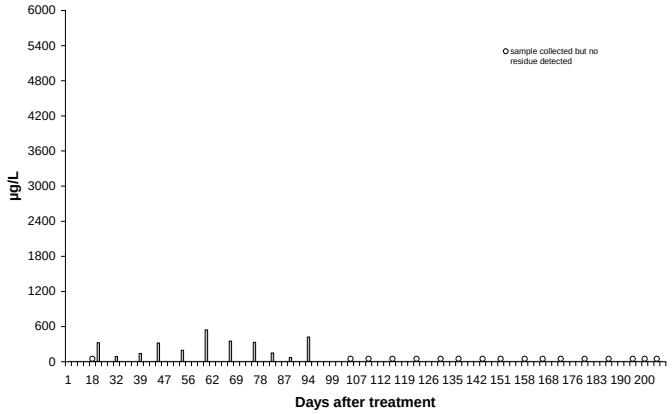

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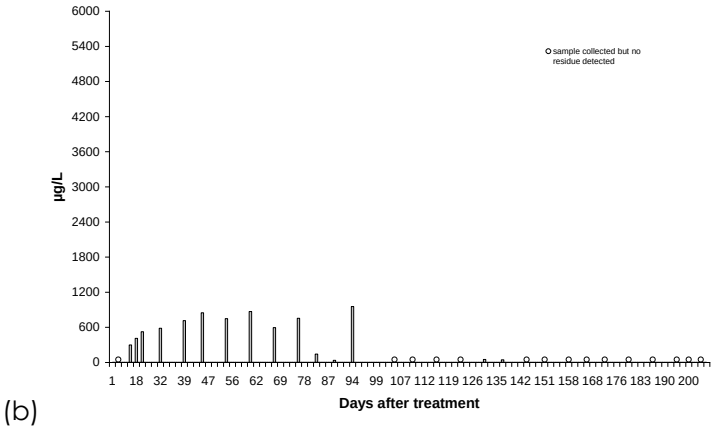

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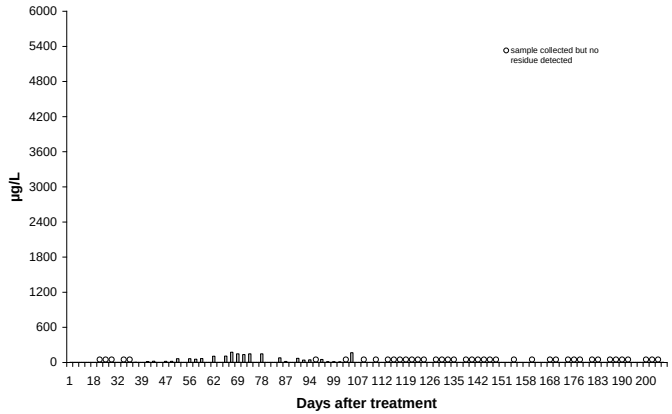

(d)

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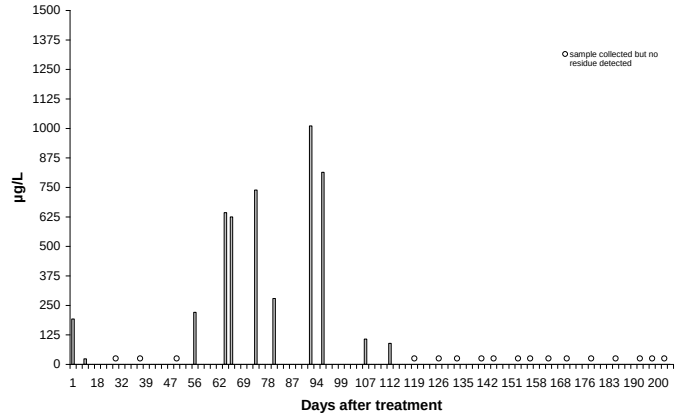
Figure 5 Concentrations of paclobutrazol in leachate from a) inlet tank; b) top tank; c) middle tank and d) bottom tank



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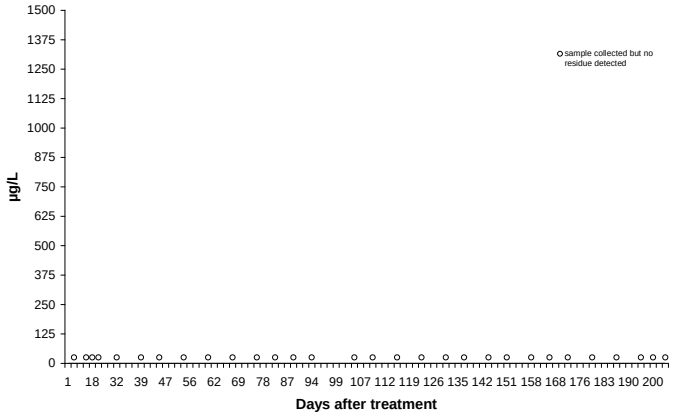

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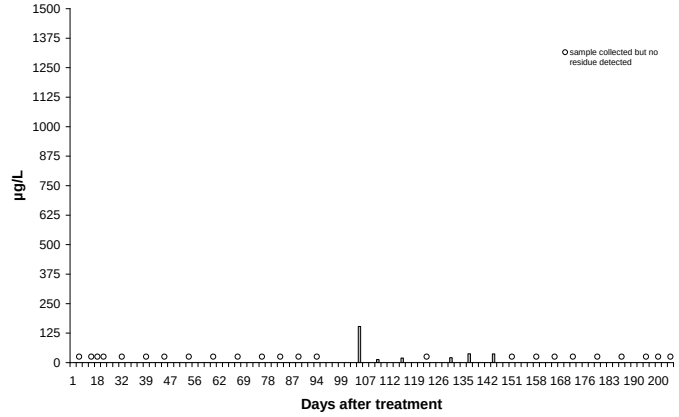

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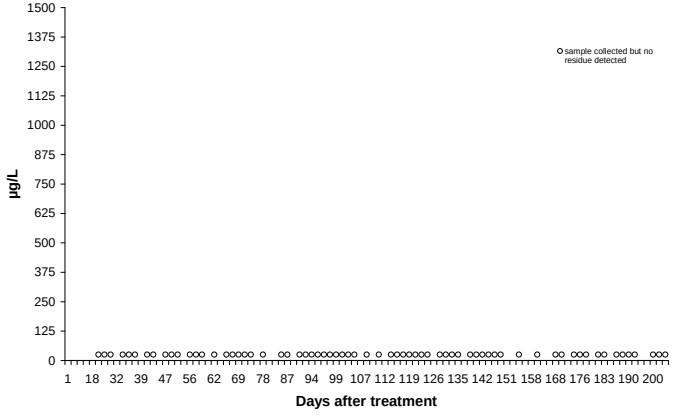

(d)

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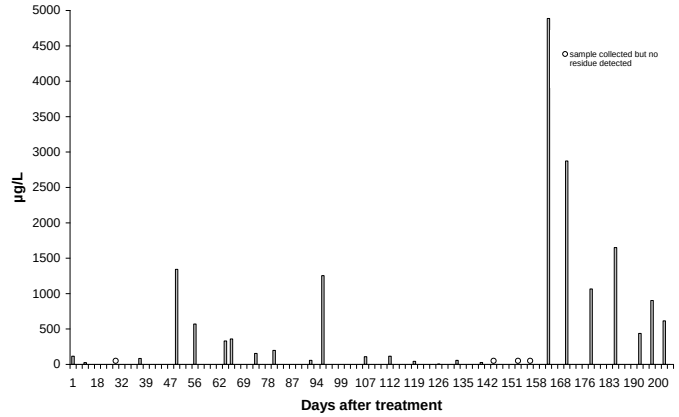
Figure 6 Concentrations of azoxystrobin in leachate from a) inlet tank; b) top tank; c) middle tank and d) bottom tank



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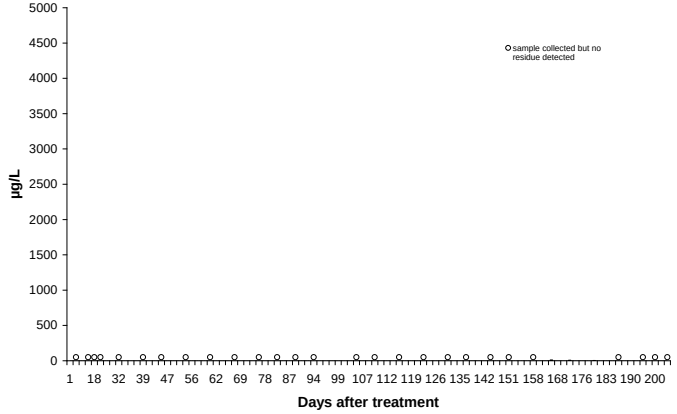

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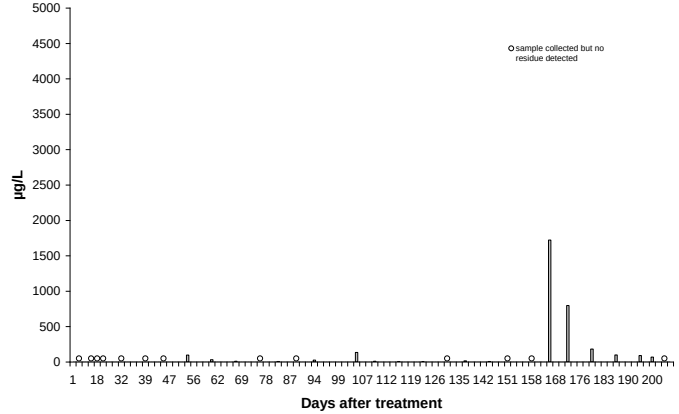

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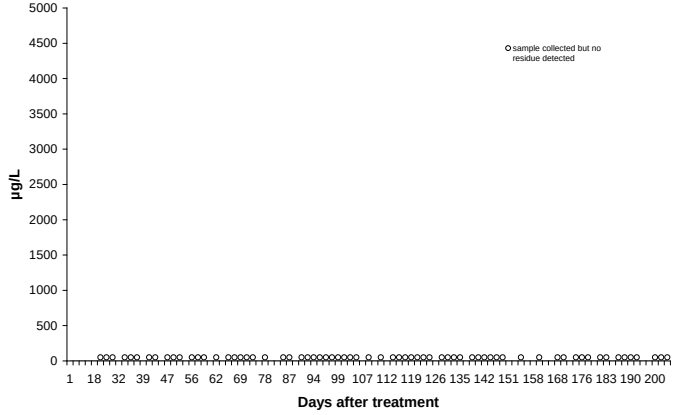

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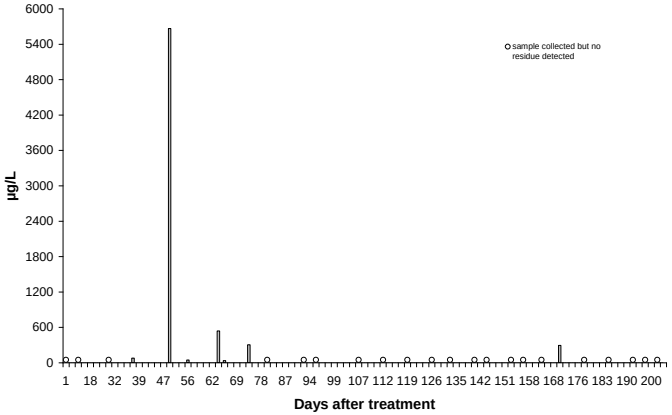
Figure 7 Concentrations of iprodione in leachate from a) inlet tank; b) top tank; c) middle tank and d) bottom tank



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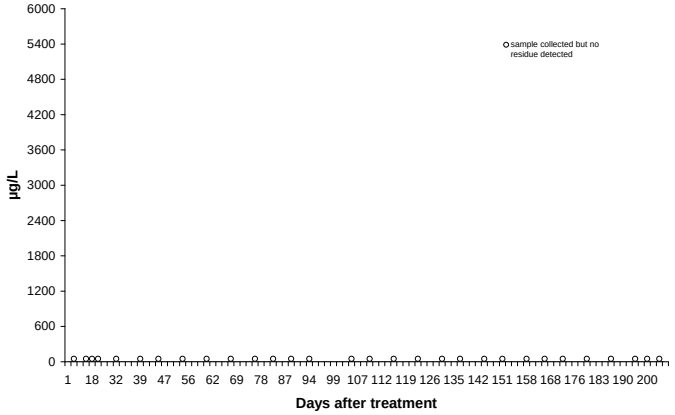

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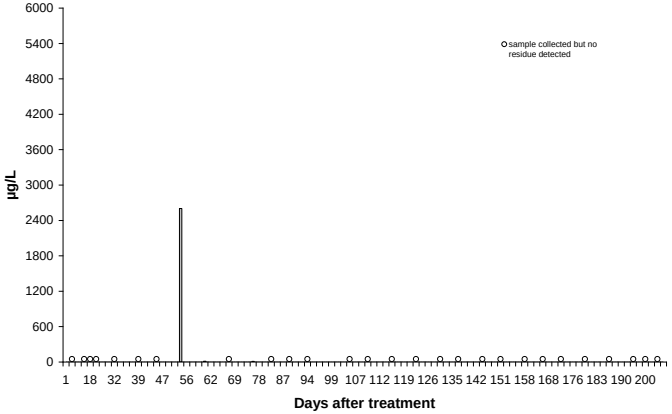

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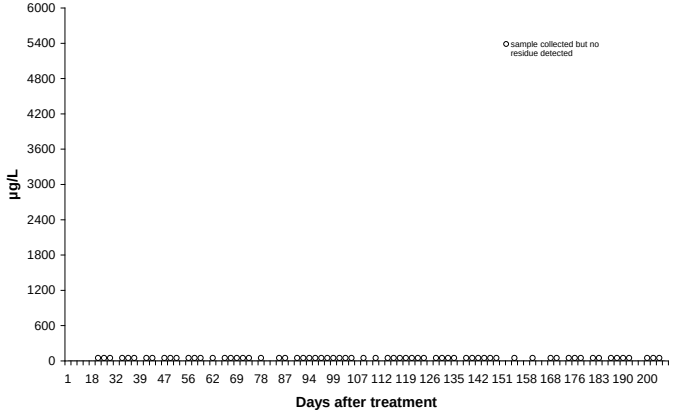

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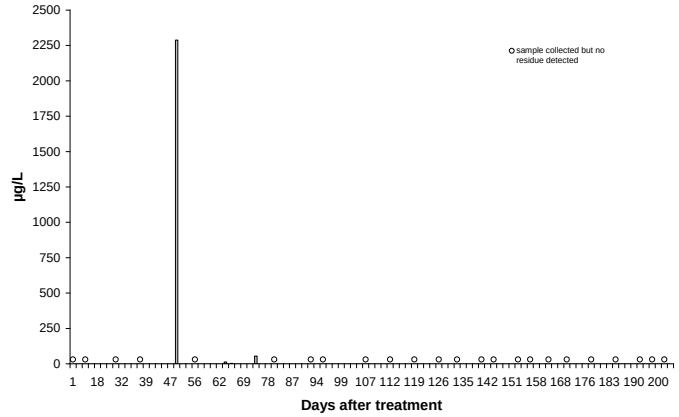
Figure 8 Concentrations of chlorothalonil in leachate from a) inlet tank; b) top tank; c) middle tank and d) bottom tank



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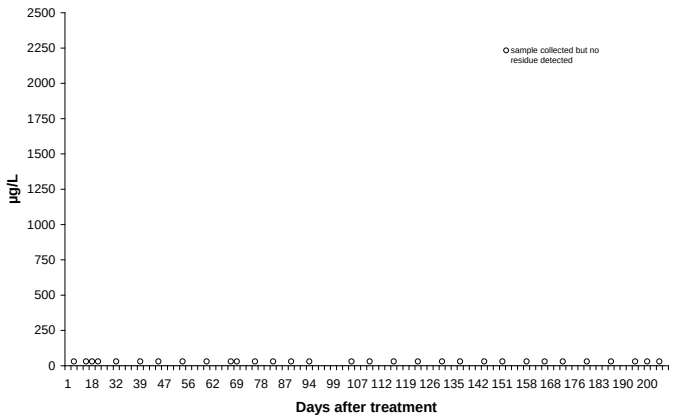

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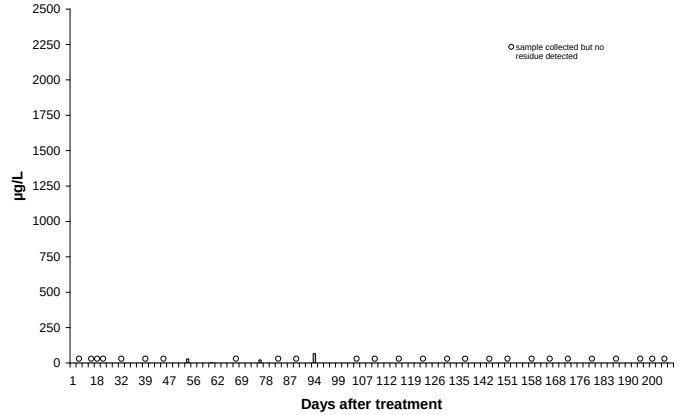

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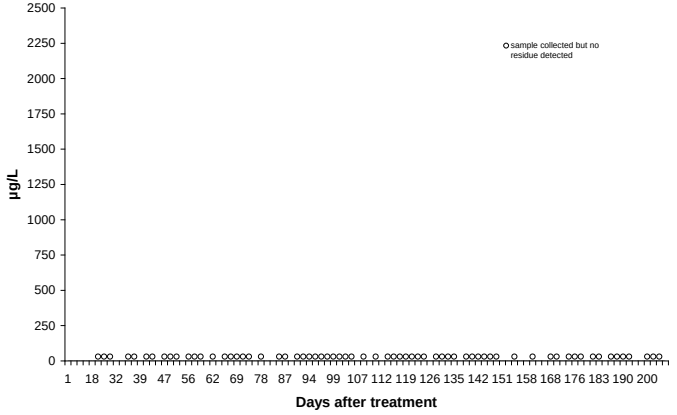

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Of the grab and composite samples analysed from the top, middle and bottom tanks, all of the pesticides were detected.

Carbendazim and metalaxyl-M were the first pesticides to be detected above the LOQ in leachate samples collected from the top tank. Concentrations of 73 and 298 µg L^{-1}, respectively were detected on 21 March 2008 (11 DAT). A further four compounds (imidacloprid, azoxystrobin, iprodione and chlorothalonil), were all first detected in leachate samples collected on 02 May 2008 (53 DAT). The remaining compound, paclobutrazol, was first detected in leachate collected from the top tank on 20 June 2008 (102 DAT). Maximum concentrations from the top tank were detected either on 02 May 2008 (53 DAT; imidacloprid and iprodione), 12 June 2008 (94 DAT; metalaxyl-M and chlorothalonil), 20 June 2008 (102 DAT; carbendazim and paclobutrazol), or 22 August 2008 (165 DAT; azoxystrobin). Of the compounds detected, iprodione, carbendazim, metalaxyl-M and azoxystrobin were detected at the highest concentrations (955 to 2602 µg L^{-1}). Carbendazim, azoxystrobin and metalaxyl-M were the most frequently detected compounds, 70, 57 and 50% of samples analysed containing residues, respectively.

Only four compounds were detected in leachate samples collected from the middle tank. Imidacloprid was detected transiently in two samples collected around the same time (53 and 60 DAT), at concentrations of 10 to 156 µg L^{-1}. Of the thirty samples analysed, azoxystrobin and carbendazim were also both detected in a relatively small number of samples (3 and 6, respectively). Azoxystrobin was detected at concentrations ranging from 4 to 10 µg L^{-1} in samples collected during late August/early September 2008 (165 to 179 DAT). Carbendazim was detected at much higher concentrations (10 to 861 µg L^{-1}) from 60 DAT to 158 DAT (early May to mid-August 2008). The other compound, metalaxyl-M was detected much more frequently. The compound was consistently detected in samples collected during the first three months of monitoring at concentrations ranging from 43 (4 DAT) to 544 µg L^{-1} (60 DAT). By 12 June 2008 (last date analysed), metalaxyl-M concentrations were 422 µg L^{-1}.

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Of the 68 leachate samples collected by the autosampler from the bottom tank and analysed, the only pesticide to be detected above the LOQ in any sample was metalaxyl-M. Twenty-six (38%) samples contained quantifiable residues
(>6.7 µg L^{-1}). The compound was first detected in a sample collected on 17 April 2008 (38 DAT) at a concentration of 1.54 µg L^{-1}. Thereafter, concentrations increased steadily, peaking at 174 µg L^{-1} by mid-May 2008 (67 DAT). In general, residues of the compound were much lower in samples collected during June 2008 (range 11 to 70 µg L^{-1}) and whilst a concentration of 166 µg L^{-1} was detected in a single sample collected on 20 June 2008 (102 DAT), concentrations in samples thereafter (35) were all below the LOQ.

Mass balance

As with bromide, a simple estimate of the amount of active substance leaching from each of the three 1 m deep tanks was made for each of the seven pesticides. As previously, the calculations were based on the assumption that discharge recorded from the bottom tank was taken as an indicator of the volume of water leaching from the top and middle tanks and the total amount of pesticide leaching from each tank was calculated to be the product of the concentration of residues in leachate from each respective tank on a sampling date, and the total amount of discharge (from tank 3) since the previous sampling date. Table 5 shows the chemical loading (total) and the corresponding mass calculated to have leached from each tank.

Table 5 Chemical loading and amount calculated to have leached

Active substance	Amount applied (mg)	Amount leached					
		Top tank		Middle tank		Bottom tank	
		(mg)	(%)	(mg)	(%)	(mg)	(%)
azoxystrobin	10377	474	4.6	-	-	-	-
carbendazim	28277	3838	13.6	896	3.2	-	-

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chlorothalonil	1817	28	1.5	-	-	-	-
imidacloprid	1523	56	3.7	56		-	-
iprodione	5182	505	9.8	-	-	-	-
metalaxyl-m	8348	1850	22.2	752	9	185	2.2
paclobutrazol	1644	186	11.3	-	-	-	-

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Discussion and Conclusions

For biobed technology to provide a useful tool for the treatment of the pesticide waste and washings it is essential that the applied pesticides are retained in the biomix (the matrix material used in the biobed / biofilter) and then subsequently degraded. Experiments reported previously (Fogg et al., 2008) demonstrated that a novel biofilter system, with a surface area requirement of ~4 m^2 retained ≥98% of the applied pesticide when operated under controlled conditions. Moreover, when the prototype biofilter was destructively sampled none of the nine pesticides under investigation were detected in the biomix. Laboratory scale experiments supported these findings and demonstrated that the biofilter matrix (biomix) could effectively degrade high concentrations of relatively complex mixtures of pesticide. Moreover, with the exception of soil sterilant materials, pesticide degradation was not significantly effected by the inclusion of plant growth regulators or disinfectant chemicals.

The prototype biofilter was recommissioned on commercial protected crop facility and its performance monitored over a 6 month period. Operational monitoring of the biofilter under 'real world' use conditions showed that all of the pesticides in the agreed analytical suite (
Table 1) were detected in leachate from the top tank (1). However, despite the challenging hydrological conditions being observed under commercial use, the treatment train was considered to be effective. Only four (carbendazim, azoxystrobin, imidacloprid and metalaxyl-M) of the seven pesticides analysed for were detected in leachate from the middle tank (2) and apart from metalaxyl-M, the detections were transient. Carbendazim azoxystrobin and imidacloprid have K_{oc} values of 132 – 500, which classifies them as moderately or slightly mobile. However, metalaxyl-M has a K_{oc} of 70 and is classified as mobile and this would explain why the frequency and magnitude of the concentrations were greater from the middle tank than for the other pesticides. Metalaxyl-M was the only pesticide detected in the final discharge from the biofilter and was found in 38% of the samples sent for analysis. However mass balance calculations show that ≤ 2.2% of the applied

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metalaxyl-M leached. For the other six pesticides 100% was retained within the biofilter.

The overall performance of the biofilter would suggest that its use in commercial horticulture could significantly reduce point source losses of pesticides originating from the pesticide mixing/ wash down area. The cost of the core biofilter is calculated to be <£500 with new 1000 litre IBC containers available for approximately £80 + VAT but second hand containers are available at fraction of this cost. However, the biofilter should be considered as part of the overall pesticide handing facility and therefore some additional structure works may be required to integrate the biofilter into existing facilities. As a minimum requirement, an impermeable mixing / filling / wash down area with a sealed drainage system would be required. All waste, washing and runoff from this handling area would then need to be discharged onto the biofilter. It should however be reiterated the biofilter is not a substitute for best practices being followed and wherever possible the volume of pesticide waste and washing should be kept to an absolute minimum.

The biofilter is a novel development of the existing biobed technology and while consideration has been given to the existing exemption throughout both this project and PC/HNS 255 the biofilter is not currently covered by the existing exemption from Agricultural Waste Regulations. However, the data generated in this study would suggest that the performance of the biofilter is comparable if not better than the standard biobed. This performance was achieved with what is considered to be realistic but high hydraulic inputs. The current exemption for a biobed permits a maximum of 15,000 litres of pesticide waste and washings to be applied to single biobed in any period of 12 months. Under the use conditions described in this report in excess of 14,000 litres of pesticide waste and washings were recorded over a period of < 7 months. Under the current exemption conditions it is likely that several biofilters would be required. The concept of a number of strategically placed biofilters idea was proposed to the commercial collaborator on this project and the idea was consider to offer a practical solution to reducing pesticide emissions from the business. It is proposed that the data generated under

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PC/HNS 255 and 255a are presented to the Environment Agency at the earliest opportunity in order initiate revision of the existing exemption.

Technology Transfer

There have been no specific technology transfer activities to date. However, the project was presented at the HDC / BPOA / BOPP seminar in June 2008. In addition, biobeds are to be included in 3 integrated crop management workshops in September 2008. Plans are also in place to produce an article for HDC News and also a technical factsheet. In addition, opportunity will be sought to publish the findings of this work in suitable peer-reviewed journals.

Acknowledgments

Bordon Hill Nursery, Stratford-upon Avon, Warwickshire.

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Appendix I

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Product Two (g or ml)	Volume of Solution Mixed (litres)
10/03/2008	Bonzi (PGR)	paclobutrazol			60		60
11/03/2008	Pan PCH	propamocarb hydrochloride			240		160
11/03/2008	Subdue	metalaxyl-M			12.5		100
11/03/2008	Subdue	metalaxyl-M	Delsene 50 Flo	carbendazim	2.63	21	21
12/03/2008	Delsene 50 Flo	carbendazim			7		7
12/03/2008	Pan PCH	propamocarb hydrochloride			10.5		7
12/03/2008	Pan PCH	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	270	180	180
12/03/2008	Pan PCH	propamocarb hydrochloride	Rovral		21	14	14
12/03/2008	Subdue	metalaxyl-M	Delsene 50 Flo	carbendazim	22.5	180	180
13/03/2008	Pan PCH	propamocarb hydrochloride			150		100
13/03/2008	Pan PCH	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	21	14	14
13/03/2008	Subdue	metalaxyl-M			3.5		28
14/03/2008	Delsene 50 Flo	carbendazim	Subdue	metalaxyl-M	14	1.75	14
14/03/2008	Pan PCH	propamocarb hydrochloride			10.5		7
14/03/2008	Subdue	metalaxyl-M			7.5		60
15/03/2008	B-Nine (PGR)	daminozide			40		10

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Quantity Used Product Two (g or ml)	Volume of Solution Mixed (litres)
17/03/2008	B-Nine (PGR)	daminozide			240		60
18/03/2008	Pan PCH	propamocarb hydrochloride			31.5		21
18/03/2008	Rovral	iprodione			14		14
18/03/2008	Subdue	metalaxyl-M			7.5		60
18/03/2008	Subdue	metalaxyl-M	Delsene 50 Flo	carbendazim	10	80	80
19/03/2008	Pan PCH	propamocarb hydrochloride			45		30
19/03/2008	Pan PCH	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	10.5	7	7
19/03/2008	Subdue	metalaxyl-M			3.5		28
19/03/2008	Subdue	metalaxyl-M	Delsene 50 Flo	carbendazim	1.75	14	14
20/03/2008	Pan PCH	propamocarb hydrochloride			42		28
20/03/2008	Pan PCH	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	15	10	10
20/03/2008	Subdue	metalaxyl-M			0.88		7
21/03/2008	B-Nine (PGR)	daminozide			8		2
21/03/2008	Subdue	metalaxyl-M			0.88		7
24/03/2008	B-Nine (PGR)	daminozide			80		20
25/03/2008	Bonzi (PGR)	paclobutrazol			21		21

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Quantity Used Product Two (g or ml)	Volume of Solution Mixed (litres)
25/03/2008	Cycocel New 5C (PGR)	chlormequat			10		40
26/03/2008	Pan PCH	propamocarb hydrochloride			31.5		21
26/03/2008	Standon	iprodione			7		7
26/03/2008	Subdue	metalaxyl-M			12.5		100
27/03/2008	Pan PCH	propamocarb hydrochloride			42		28
27/03/2008	Pan PCH	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	42	28	28
28/03/2008	Cycocel New 5C (PGR)	chlormequat			20		80
28/03/2008	Pan PCH	propamocarb hydrochloride			90		60
28/03/2008	Subdue	metalaxyl-M			7.5		60
28/03/2008	Subdue	metalaxyl-M	Delsene 50 Flo	carbendazim	1.75	14	14
31/03/2008	B-Nine (PGR)	daminozide			240		60
01/04/2008	Cycocel New 5C (PGR)	chlormequat			30		120
01/04/2008	Pan PCH	propamocarb hydrochloride			10.5		7

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Product Two (g or ml)	Volume of Solution Mixed (litres)
01/04/2008	Pan PCH	propamocarb hydrochloride	Rovral	iprodione	15	10	10
01/04/2008	Rovral	iprodione			20		20
01/04/2008	Subdue	metalaxyl-M			10		80
01/04/2008	Subdue	metalaxyl-M	Delsene 50 Flo	carbendazim	3.5	28	28
02/04/2008	Pan PCH	propamocarb hydrochloride			31.5		21
02/04/2008	Subdue	metalaxyl-M			3.5		28
03/04/2008	Pan PCH	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	10.5	7	7
03/04/2008	Subdue	metalaxyl-M	Delsene 50 Flo	carbendazim	2.63	21	21
04/04/2008	Bonzi (PGR)	paclobutrazol			25		25
04/04/2008	Cycocel New 5C (PGR)	chlormequat			5		20
04/04/2008	Pan PCH	propamocarb hydrochloride			120		80
04/04/2008	Pan PCH	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	15	10	10
07/04/2008	Subdue	metalaxyl-M			10		80

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Quantity Used Product Two (g or ml)	Volume of Solution Mixed (litres)
08/04/2008	Delsene 50 Flo	carbendazim			5		5
08/04/2008	Pan PCH	propamocarb hydrochloride			21		14
08/04/2008	Pan PCH	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	90	60	60
08/04/2008	Rovral	iprodione			21		21
08/04/2008	Subdue	metalaxyl-M			2.63		21
09/04/2008	Pan PCH	propamocarb hydrochloride			90		60
09/04/2008	Pan PCH	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	10.5	7	7
09/04/2008	Pan PCH	propamocarb hydrochloride	Rovral	iprodione	90	60	60
09/04/2008	Subdue	metalaxyl-M			1.75		14
09/04/2008	Subdue	metalaxyl-M	Delsene 50 Flo	carbendazim	2.63	21	21
10/04/2008	Pan PCH	propamocarb hydrochloride			10.5		7
10/04/2008	Subdue	metalaxyl-M	Delsene 50 Flo	carbendazim	0.88	7	7
11/04/2008	Pan PCH	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	7.5	5	5

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Product Two (g or ml)	Volume of Solution Mixed (litres)
12/04/2008	Subdue	metalaxyl-M	Pan PCH	propamocarb hydrochloride	1.25	10.5	
15/04/2008	Pan PCH	propamocarb hydrochloride			120		80
15/04/2008	Pan PCH	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	150	100	100
15/04/2008	Rovral	iprodione			10		10
15/04/2008	Subdue	metalaxyl-M			17.5		14
17/04/2008	Bonzi (PGR)	paclobutrazol			120		120
17/04/2008	Delsene 50 Flo	carbendazim			7		7
17/04/2008	Pan PCH	propamocarb hydrochloride			120		80
17/04/2008	Pan PCH	propamocarb hydrochloride			90		60
17/04/2008	Pan PCH	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	42	28	28
17/04/2008	Subdue	metalaxyl-M			4.38		35
17/04/2008	Subdue	metalaxyl-M	Delsene 50 Flo	carbendazim	0.88	7	7
21/04/2008	Bonzi (PGR)	paclobutrazol			200		200
21/04/2008	Cycocel New 5C (PGR)	chlormequat			26.5		80

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Product Two (g or ml)	Volume of Solution Mixed (litres)
22/04/2008	Pan PCH	propamocarb hydrochloride			150		100
22/04/2008	Pan PCH	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	150	100	100
22/04/2008	Subdue	metalaxyl-M			6.25		50
23/04/2008	Delsene 50 Flo	carbendazim			5		5
23/04/2008	Pan PCH	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	10.5	7	7
23/04/2008	Standon	iprodione	Pan PCH	propamocarb hydrochloride	5	7.5	5
23/04/2008	Subdue	metalaxyl-M			1.25		10
24/04/2008	Bonzi (PGR)	paclobutrazol			300		300
24/04/2008	Pan PCH	propamocarb hydrochloride			10.5		7
25/04/2008	Subdue	metalaxyl-M			3.38		27
28/04/2008	B-Nine (PGR)	daminozide			160		40
28/04/2008	Bonzi (PGR)	paclobutrazol			270		180
28/04/2008	Cycocel New 5C (PGR)	chlormequat			26.4		80
29/04/2008	Pan PCH	propamocarb hydrochloride			120		80
29/04/2008	Pan PCH	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	120	80	80

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Quantity Used Product Two (g or ml)	Volume of Solution Mixed (litres)
29/04/2008	Subdue	metalaxyl-M	Delsene 50 Flo	carbendazim	7.5	60	60
30/04/2008	Pan PCH	propamocarb hydrochloride			90		60
30/04/2008	Pan PCH	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	31.5	21	21
30/04/2008	Subdue	metalaxyl-M			1.75		14
01/05/2008	Bonzi (PGR)	paclobutrazol			480		240
01/05/2008	Pan PCH	propamocarb hydrochloride			6		4
01/05/2008	Subdue	metalaxyl-M			0.5		4
02/05/2008	Bonzi (PGR)	paclobutrazol			220		220
03/05/2008	Bravo	chlorothalonil			160		80
05/05/2008	Bonzi (PGR)	paclobutrazol			400		200
05/05/2008	Bonzi (PGR)	paclobutrazol			140		140
07/05/2008	Alliette	fosetyl-aluminium	Rovral	iprodione	5	5	5
07/05/2008	Amistar	azoxystrobin			40		40
07/05/2008	Pan PCH	propamocarb hydrochloride			21		14
07/05/2008	Pan PCH	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	31.5	21	21
07/05/2008	Rovral	iprodione			30		30
08/05/2008	B-Nine (PGR)	daminozide			160		40
08/05/2008	Bonzi (PGR)	paclobutrazol			480		240

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08/05/2008	Bonzi (PGR)	paclobutrazol	300	300

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Quantity Used Product Two (g or ml)	Volume of Solution Mixed (litres)
08/05/2008	Pan PCH	propamocarb hydrochloride			60		40
08/05/2008	Subdue	metalaxyl-M			7.5		60
09/05/2008	Bonzi (PGR)	paclobutrazol			140		140
10/05/2008	Bonzi (PGR)	paclobutrazol			80		80
10/05/2008	Bravo	chlorothalonil			120		60
12/05/2008	Bonzi (PGR)	paclobutrazol			160		80
12/05/2008	Bonzi (PGR)	paclobutrazol			330		330
14/05/2008	Pan PCH	propamocarb hydrochloride			180		120
14/05/2008	Pan PCH	propamocarb hydrochloride	Delsene 50 Flo	carbendazim iprodione	60	40	40
14/05/2008	Standon				3		3
15/05/2008	Bonzi (PGR)	paclobutrazol			260		260
15/05/2008	Cycocel New 5C (PGR)	chlormequat			26.4		80
19/05/2008	Bonzi (PGR)	paclobutrazol			2,300.00		1150
20/05/2008	Pan PCH	propamocarb hydrochloride	Delsene 50 Flo	carbendazim iprodione	90	60	60
21/05/2008	Alliette	fosetyl-aluminium	Rovral		5	5	5
21/05/2008	Bravo	chlorothalonil			10		5
22/05/2008	B-Nine (PGR)	daminozide			80		20
22/05/2008	Bonzi (PGR)	paclobutrazol			280		140

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Quantity Used Product Two (g or ml)	Volume of Solution Mixed (litres)
22/05/2008	Coolglass (Shading)	n/a			22,500.00		360
22/05/2008	Cycocel New 5C (PGR)	chlormequat			26		80
22/05/2008	Pan PCH	propamocarb hydrochloride			42		28
24/05/2008	Bonzi (PGR)	paclobutrazol			5		5
27/05/2008	Bonzi (PGR)	paclobutrazol			50		50
28/05/2008	Bravo	chlorothalonil			80		40
28/05/2008	Delsene 50 Flo	carbendazim			7		7
28/05/2008	Delsene 50 Flo	carbendazim	Pan PCH	propamocarb hydrochloride	7	10.5	7
28/05/2008	Pan PCH	propamocarb hydrochloride			30		20
28/05/2008	Rovral	iprodione			20		20
28/05/2008	Rovral	iprodione			20		20
28/05/2008	Subdue	metalaxyl-M			10		80
28/05/2008	Systhane 20EW	myclobutanil			0.3		1
29/05/2008	B-Nine (PGR)	daminozide			4		1
29/05/2008	Bonzi (PGR)	paclobutrazol			240		120
29/05/2008	Bonzi (PGR)	paclobutrazol			440		220

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Quantity Used Product Two (g or ml)	Volume of Solution Mixed (litres)
29/05/2008	Cycocel New 5C (PGR)	chlormequat			23		70
29/05/2008	Delsene 50 Flo	carbendazim			10		10
29/05/2008	Pan PCH	propamocarb hydrochloride			75		50
29/05/2008	Pan PCH	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	45	30	30
29/05/2008	Subdue	metalaxyl-M			5		40
30/05/2008	Bonzi (PGR)	paclobutrazol			80		80
30/05/2008	Cycocel New 5C (PGR)	chlormequat			0.33		1
30/05/2008	Pan PCH	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	21	14	14
30/05/2008	Pan PCH	propamocarb hydrochloride	Standon	iprodione	10.5	7	7
02/06/2008	Cycocel New 5C (PGR)	chlormequat			26.4		80
02/06/2008	B-Nine (PGR)	daminozide			12		3
03/06/2008	Bonzi (PGR)	paclobutrazol			28		14
03/06/2008	Bonzi (PGR)	paclobutrazol			5		5
04/06/2008	Pan PCH	propamocarb hydrochloride			10.5		7
04/06/2008	Bonzi (PGR)	paclobutrazol			200		100

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Quantity Used Product Two (g or ml)	Volume of Solution Mixed (litres)
04/06/2008	Cycocel New 5C (PGR)	chlormequat			26.4		80
04/06/2008	Intercept	imidacloprid			2		10
04/06/2008	Pan PCH	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	495	330	330
04/06/2008	Subdue	metalaxyl-M			0.6		5
04/06/2008	Bravo	chlorothalonil			20		10
05/06/2008	Pan PCH	propamocarb hydrochloride			10.5		7
05/06/2008	Pan PCH	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	21	14	14
06/06/2008	Bonzi (PGR)	paclobutrazol			25		25
06/06/2008	Bonzi (PGR)	paclobutrazol			100		50
09/06/2008	Bonzi (PGR)	paclobutrazol			320		160
10/06/2008	Bonzi (PGR)	paclobutrazol			80		40
10/06/2008	Cycocel New 5C (PGR)	chlormequat			20		60
11/06/2008	Delsene 50 Flo	carbendazim			5		5
11/06/2008	Pan PCH	propamocarb hydrochloride			15		10
11/06/2008	Intercept	imidacloprid			8		40

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Product Two (g or ml)	Volume of Solution Mixed (litres)
11/06/2008	Subdue	metalaxyl-M	Delsene 50 Flo	carbendazim	1.75	14	14
11/06/2008	Alliette	fosetyl-aluminium	Rovral	iprodione	7	7	7
11/06/2008	Basilex	tolclofos-methyl			6.3		7
11/06/2008	Pan PCH	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	480	320	320
11/06/2008	Systhane 20EW	myclobutanil	Bravo	chlorothalonil	0.6	4	2
11/06/2008	Delsene 50 Flo	carbendazim	Filex	propamocarb hydrochloride	180	270	180
13/06/2008	Delsene 50 Flo	carbendazim			60		60
13/06/2008	Filex	propamocarb hydrochloride			120		80
13/06/2008	Filex	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	10.5	7	7
16/06/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	12	1.5	3
16/06/2008	Bonzi (PGR)	paclobutrazol			260		130
17/06/2008	Filex	propamocarb hydrochloride			10.5		7
17/06/2008	Filex	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	660	440	440
18/06/2008	Bravo	chlorothalonil			10		5

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Product Two (g or ml)	Volume of Solution Mixed (litres)
18/06/2008	Filex	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	420	280	280
18/06/2008	Subdue	metalaxyl-M	Delsene 50 Flo	carbendazim	2.5	20	20
18/06/2008	Subdue	metalaxyl-M			0.88		7
18/06/2008	Dynamec (Pesticide)	abamectin	Delsene 50 Flo	carbendazim	20	40	40
19/06/2008	Filex	propamocarb hydrochloride			10.5		7
19/06/2008	Subdue	metalaxyl-M			2.63		21
19/06/2008	B-Nine (PGR)	daminozide			8		2
19/06/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	16	2	4
19/06/2008	Bonzi (PGR)	paclobutrazol			360		180
20/06/2008	Delsene 50 Flo	carbendazim			320		320
21/06/2008	Proplant	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	810	540	540
23/06/2008	Filex	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	150	100	100
23/06/2008	Filex	propamocarb hydrochloride			180		120
23/06/2008	B-Nine (PGR)	daminozide	Cycocel New 5C	chlormequat	360	45	90

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(PGR)

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Quantity Used Product Two (g or ml)	Volume of Solution Mixed (litres)
23/06/2008	B-Nine (PGR)	daminozide			240		60
24/06/2008	Filex	propamocarb hydrochloride			10.5		7
24/06/2008	Bonzi (PGR)	paclobutrazol			35		35
24/06/2008	Filex	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	660	440	440
24/06/2008	Bonzi (PGR)	paclobutrazol			50		25
25/06/2008	Delsene 50 Flo	carbendazim			40		40
25/06/2008	Proplant	propamocarb hydrochloride			150		100
25/06/2008	Proplant	propamocarb hydrochloride	Delsene 50 Flo	carbendazim	120	80	80
25/06/2008	Delsene 50 Flo	carbendazim			1,100.00		1100
25/06/2008	Rovral	iprodione			40		40
25/06/2008	Alliette	fosetyl-aluminium	Rovral	iprodione	32	32	32
25/06/2008	Bravo	chlorothalonil	Systhane 20EW	myclobutanil	60	9	30
25/06/2008	Delsene 50 Flo	carbendazim	Dynamec	abamectin	20	10	20
25/06/2008	Delsene 50 Flo	carbendazim			150		150

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Quantity Used Product Two (g or ml)	Volume of Solution Mixed (litres)
26/06/2008	Delsene 50 Flo	carbendazim propamocarb			14		14
26/06/2008	Proplant	hydrochloride			42		28
26/06/2008	B-Nine (PGR)	daminozide			32		8
27/06/2008	Delsene 50 Flo	carbendazim propamocarb			30		30
27/06/2008	Proplant	hydrochloride spiromesifin			45		30
28/06/2008	Oberon				60		120
28/06/2008	Delsene 50 Flo	carbendazim propamocarb			1,100.00		1100
01/07/2008	Proplant	hydrochloride			60		40
02/07/2008	Subdue	metalaxyl-M propamocarb			19		150
02/07/2008	Proplant	hydrochloride imidacloprid			330		220
02/07/2008	Intercept				30		150
02/07/2008	Bravo	chlorothalonil myclobutanil			6		3
02/07/2008	Systhane 20EW				0.6		2
04/07/2008	Proplant	propamocarb hydrochloride			165		110

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Product Two (g or ml)	Volume of Solution Mixed (litres)
05/07/2008	Alliette	fosetyl-aluminium	Standon Cycocel New 5C	iprodione	100	100	100
07/07/2008	B-Nine (PGR)	daminozide	(PGR)	chlormequat	880	90	220
07/07/2008	Proplant	propamocarb hydrochloride			300		200
07/07/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	880	110	220
07/07/2008	Cercobin WG	thiaphanate-methyl	Proplant	propamocarb hydrochloride	868	930	620
08/07/2008	Bonzi (PGR)	paclobutrazol			80		40
08/07/2008	Cercobin WG	thiaphanate-methyl	Proplant	propamocarb hydrochloride	924	990	660
09/07/2008	Subdue	metalaxyl-M			72.5		580
09/07/2008	Dynamec	abamectin			7		14
09/07/2008	Bravo	chlorothalonil			80		40
09/07/2008	Rovral	iprodione	Alliette	fosetyl-aluminium	100	40	100
09/07/2008	Starion Flo	bifenthrin	Standon	iprodione	7	14	14
09/07/2008	Proplant	propamocarb hydrochloride			300		200

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09/07/2008	Proplant	propamocarb hydrochloride	Standon	iprodione	3	2	2

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Quantity Used Product Two (g or ml)	Volume of Solution Mixed (litres)
09/07/2008	Standon	iprodione			50		50
09/07/2008	Subdue	metalaxyl-M			5		40
09/07/2008	Proplant	propamocarb hydrochloride	Cercobin WG	thiaphanate-methyl	30	28	20
10/07/2008	Intercept	imidacloprid			1		5
10/07/2008	Proplant	propamocarb hydrochloride			120		80
10/07/2008	Standon	iprodione			20		20
10/07/2008	Subdue	metalaxyl-M			3.38		27
10/07/2008	Oberon	spiromesifin			110		220
10/07/2008	B-Nine (PGR)	daminozide			160		30
10/07/2008	Dynamec	abamectin			15		20
11/07/2008	Bonzi (PGR)	paclobutrazol			60		60
11/07/2008	Bonzi (PGR)	paclobutrazol			125		250
11/07/2008	Bonzi (PGR)	paclobutrazol			240		120
11/07/2008	Proplant	propamocarb hydrochloride			180		120
11/07/2008	Bonzi (PGR)	paclobutrazol			40		40

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Quantity Used Product Two (g or ml)	Volume of Solution Mixed (litres)
14/07/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	880	80	220
14/07/2008	B-Nine (PGR)	daminozide			12		3
14/07/2008	Proplant	propamocarb hydrochloride			1,980.00		1320
14/07/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	868	108.5	217
15/07/2008	Bonzi (PGR)	paclobutrazol			100		50
15/07/2008	Bonzi (PGR)	paclobutrazol			60		60
15/07/2008	Subdue	metalaxyl-M			0.88		7
15/07/2008	Subdue	metalaxyl-M			0.88		7
15/07/2008	Filex	propamocarb hydrochloride			1,560.00		1040
16/07/2008	Subdue	metalaxyl-M			0.88		7
16/07/2008	Proplant	propamocarb hydrochloride	Standon	iprodione	10.5	7	7
16/07/2008	Dynamec	abamectin	Amistar	azoxystrobin	45	90	90
16/07/2008	Alliette	fosetyl-aluminium	Standon	iprodione	10	10	10
16/07/2008	Bravo	chlorothalonil	Systhane 20EW	myclobutanil	12	1.8	6

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Product Two (g or ml)	Volume of Solution Mixed (litres)
16/07/2008	Proplant	propamocarb hydrochloride			750		500
17/07/2008	Proplant	propamocarb hydrochloride	Standon	iprodione	21	14	14
17/07/2008	Proplant	propamocarb hydrochloride			300		200
17/07/2008	B-Nine (PGR)	daminozide			8		2
18/07/2008	Bonzi (PGR)	paclobutrazol			240		120
18/07/2008	Bonzi (PGR)	paclobutrazol			140		140
18/07/2008	Bonzi (PGR)	paclobutrazol			4.5		9
19/07/2008	Alliette	fosetyl-aluminium	Standon	iprodione	220	220	220
19/07/2008	Subdue	metalaxyl-M			15		120
21/07/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	1,960.00	220	440
21/07/2008	Subdue	metalaxyl-M			0.88		7
21/07/2008	B-Nine (PGR)	daminozide			80		20
21/07/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	800	100	200
21/07/2008	Proplant	propamocarb hydrochloride			1,170.00		780
22/07/2008	B-Nine (PGR)	daminozide	Cycocel New 5C	chlormequat	24	2	6

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			(PGR)		
22/07/2008	Bonzi (PGR)	paclobutrazol		80	80

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Product Two (g or ml)	Volume of Solution Mixed (litres)
22/07/2008	Standon	iprodione			7		7
22/07/2008	Proplant	propamocarb hydrochloride			1,440.00		960
22/07/2008	Bonzi (PGR)	paclobutrazol			50		50
22/07/2008	Bonzi (PGR)	paclobutrazol			240		120
23/07/2008	Starion Flo	bifenthrin			7		14
23/07/2008	Starion Flo	bifenthrin	Alliette	fosetyl-aluminium	7	14	14
23/07/2008	Alliette	fosetyl-aluminium	Standon	iprodione	120	120	120
23/07/2008	Bravo	chlorothalonil	Systhane 20EW	myclobutanil	200	12	100
23/07/2008	B-Nine (PGR)	daminozide			80		40
23/07/2008	Intercept	imidacloprid	Bravo	chlorothalonil	2.8	28	14
23/07/2008	Bravo	chlorothalonil	Systhane 20EW	myclobutanil	14	2.1	7
23/07/2008	Proplant	propamocarb hydrochloride			720		480
24/07/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	200	10	50
24/07/2008	Proplant	propamocarb hydrochloride			10.5		7

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Product Two (g or ml)	Volume of Solution Mixed (litres)
24/07/2008	Proplant	propamocarb hydrochloride	Standon	iprodione	10.5	7	7
25/07/2008	Subdue	metalaxyl-M			110		880
25/07/2008	Bonzi (PGR)	paclobutrazol			220		440
25/07/2008	Proplant	propamocarb hydrochloride			150		100
25/07/2008	Standon	iprodione	Proplant	propamocarb hydrochloride	7	10.5	7
25/07/2008	Oberon	spiromesifin			490		980
25/07/2008	Cercobin WG	thiaphanate-methyl	Proplant	propamocarb hydrochloride	364	390	260
25/07/2008	Cercobin WG	thiaphanate-methyl	Proplant	propamocarb hydrochloride	364	390	260
26/07/2008	Subdue	metalaxyl-M			27.5		220
27/07/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	720	60	180
28/07/2008	B-Nine (PGR)	daminozide			1,200.00		300
28/07/2008	Proplant	propamocarb hydrochloride			90		60
28/07/2008	Subdue	metalaxyl-M			0.88		7
28/07/2008	B-Nine (PGR)	daminozide			4		1

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Quantity Used Product Two (g or ml)	Volume of Solution Mixed (litres)
28/07/2008	Cercobin WG	thiaphanate-methyl	Proplant	propamocarb hydrochloride	1,092.00	1,170.00	780
28/07/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	60	5	15
28/07/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	816	102	204
29/07/2008	Subdue	metalaxyl-M			192.5		1540
29/07/2008	Subdue	metalaxyl-M			25		200
29/07/2008	Bonzi (PGR)	paclobutrazol			140		70
29/07/2008	Proplant	propamocarb hydrochloride			21		14
29/07/2008	Standon	iprodione			7		7
29/07/2008	Subdue	metalaxyl-M			1.75		14
29/07/2008	Bonzi (PGR)	paclobutrazol			110		110
29/07/2008	Pan PCH	propamocarb hydrochloride	Cercobin WG	thiaphanate-methyl	1,170.00	1,092.00	780
29/07/2008	Subdue	metalaxyl-M			7.5		60
30/07/2008	Bravo	chlorothalonil	Systhane 20EW	myclobutanil	60	10	30

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30/07/2008	Standon	iprodione	Alliette	fosetyl-aluminium	300	300	300

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Quantity Used Product Two (g or ml)	Volume of Solution Mixed (litres)
30/07/2008	Proplant	propamocarb hydrochloride			10.5		7
30/07/2008	Systhane 20EW	myclobutanil			3		10
30/07/2008	Intercept (Pesticide)	imidacloprid			44		220
30/07/2008	Bravo	chlorothalonil			20		10
30/07/2008	Proplant	propamocarb hydrochloride	Cercobin WG	thiaphanate-methyl	750	700	500
31/07/2008	B-Nine (PGR)	daminozide			240		60
01/08/2008	B-Nine (PGR)	daminozide			440		220
01/08/2008	Bonzi (PGR)	paclobutrazol			200		200
01/08/2008	Dynamec	abamectin	Amistar	azoxystrobin	90	180	180
01/08/2008	Proplant	propamocarb hydrochloride			120		80
01/08/2008	Proplant	propamocarb hydrochloride	Cercobin WG	thiaphanate-methyl	210	196	140
01/08/2008	Standon	iprodione			7		7
01/08/2008	Subdue	metalaxyl-M			0.88		7
02/08/2008	Oberon	spiromesifin			440		880
02/08/2008	Subdue	metalaxyl-M			8		1
03/08/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	300	25	75
04/08/2008	B-Nine (PGR)	daminozide	Cycocel New 5C	chlormequat	16	1.2	4

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(PGR)

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Product Two (g or ml)	Volume of Solution Mixed (litres)
04/08/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	2,400.00	300	550
04/08/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	720	90	180
04/08/2008	Proplant	propamocarb hydrochloride			630		420
04/08/2008	Proplant	propamocarb hydrochloride	Cercobin WG	thiaphanate-methyl	810	756	540
05/08/2008	Bonzi (PGR)	paclobutrazol			160		80
05/08/2008	Bonzi (PGR)	paclobutrazol			220		220
05/08/2008	Proplant	propamocarb hydrochloride			240		160
05/08/2008	Proplant	propamocarb hydrochloride	Cercobin WG	thiaphanate-methyl	870	812	580
05/08/2008	Subdue	metalaxyl-M			324		2640
06/08/2008	Alliette	fosetyl-aluminium	Standon	iprodione	40	40	40
06/08/2008	Bravo	chlorothalonil			100		50
06/08/2008	Bravo	chlorothalonil	Systhane 20EW	myclobutanil	100	15	50
06/08/2008	Dynamec	abamectin			3.5		7
06/08/2008	Intercept	imidacloprid			10		50
06/08/2008	Signum (Fungicide)	boscalid & pyraclostrobin			7		7

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06/08/2008	Standon	iprodione			80		80
06/08/2008	Starion Flo	bifenthrin	Alliette	fosetyl-aluminium	3.5	7	7

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Quantity Used Product Two (g or ml)	Volume of Solution Mixed (litres)
06/08/2008	Systhane 20EW	myclobutanil			3		10
07/08/2008	B-Nine (PGR)	daminozide			320		80
07/08/2008	Proplant	propamocarb hydrochloride			21		14
07/08/2008	Proplant	propamocarb hydrochloride			390		260
07/08/2008	Proplant	propamocarb hydrochloride	Cercobin WG	thiaphanate-methyl	390	364	260
08/08/2008	Bonzi (PGR)	paclobutrazol			200		200
08/08/2008	Dynamec	abamectin	Amistar	azoxystrobin	25	50	50
08/08/2008	Dynamec	abamectin	Amistar	azoxystrobin	30	60	60
08/08/2008	Subdue	metalaxyl-M			22		440
09/08/2008	Gazelle	acetamiprid			500		1000
10/08/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	600	50	150
11/08/2008	B-Nine (PGR)	daminozide			600		150
11/08/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	360	30	90
11/08/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	880	110	180
11/08/2008	Cycocel New 5C (PGR)	chlormequat			60		120
11/08/2008	Proplant	propamocarb			120		801

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11/08/2008	Proplant	propamocarb hydrochloride	Cercobin WG	thiaphanate-methyl	660	616	440

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Quantity Used Product Two (g or ml)	Volume of Solution Mixed (litres)
12/08/2008	Bonzi (PGR)	paclobutrazol			100		100
12/08/2008	Dynamec	abamectin	Amistar	azoxystrobin	20	40	40
12/08/2008	Proplant	propamocarb hydrochloride	Cercobin WG	thiaphanate-methyl	990	924	660
12/08/2008	Subdue	metalaxyl-M			175		1430
12/08/2008	Subdue	metalaxyl-M			32.5		250
13/08/2008	Alliette	fosetyl-aluminium	Standon	iprodione	7	7	7
13/08/2008	Amistar	azoxystrobin			3		3
13/08/2008	Bravo	chlorothalonil	Systhane 20EW	myclobutanil	120	20	60
13/08/2008	Dynamec	abamectin			2		4
13/08/2008	Proplant	propamocarb hydrochloride			42		28
13/08/2008	Proplant	propamocarb hydrochloride	Cercobin WG	thiaphanate-methyl	420	392	280
13/08/2008	Starion Flo	bifenthrin			20		40
13/08/2008	Subdue	metalaxyl-M			1.75		14
13/08/2008	Subdue	metalaxyl-M			9.5		75
13/08/2008	Systhane 20EW	myclobutanil			2		6
14/08/2008	B-Nine (PGR)	daminozide			420		110
14/08/2008	Proplant	propamocarb hydrochloride			270		180
15/08/2008	Bonzi (PGR)	paclobutrazol			150		150
15/08/2008	Proplant	propamocarb hydrochloride			31.5		21

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Quantity Used Product Two (g or ml)	Volume of Solution Mixed (litres)
16/08/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	560	46	140
16/08/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	560	46	140
16/08/2008	Subdue	metalaxyl-M			0.8		7
18/08/2008	B-Nine (PGR)	daminozide			12		3
18/08/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	880	110	220
18/08/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	880	90	220
18/08/2008	Bonzi (PGR)	paclobutrazol			10		5
18/08/2008	Cycocel New 5C (PGR)	chlormequat			130		260
18/08/2008	Proplant	propamocarb hydrochloride			540		360
18/08/2008	Proplant	propamocarb hydrochloride	Cercobin WG	thiaphanate-methyl	330	308	220
18/08/2008	Subdue	metalaxyl-M			0.88		7
19/08/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	24	3	6
19/08/2008	Bonzi (PGR)	paclobutrazol			130		130

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19/08/2008	Bonzi (PGR)	paclobutrazol			200		100
19/08/2008	Proplant	propamocarb hydrochloride	Cercobin WG	thiaphanate-methyl	1,140.00	1,064.00	760
19/08/2008	Subdue	metalaxyl-M			310.5		2530

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Product Two (g or ml)	Volume of Solution Mixed (litres)
20/08/2008	Alliette	fosetyl-aluminium	Standon	iprodione	30	30	30
20/08/2008	Bravo	chlorothalonil			80		40
20/08/2008	Bravo	chlorothalonil	Systhane 20EW	myclobutanil	80	12	40
20/08/2008	Dipel (Bio R)	bacillus thuringiensis var kurstaki			20		20
20/08/2008	Dynamec	abamectin			2		4
20/08/2008	Proplant	propamocarb hydrochloride			300		200
20/08/2008	Rovral	iprodione			30		30
20/08/2008	Starion Flo	bifenthrin			15		30
20/08/2008	Starion Flo	bifenthrin			1		2
20/08/2008	Subdue	metalaxyl-M			10		80
20/08/2008	Systhane 20EW	myclobutanil			1		3
21/08/2008	B-Nine (PGR)	daminozide			1,920.00		480
21/08/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	720	10	180
21/08/2008	Cycocel New 5C (PGR)	chlormequat			80		160
22/08/2008	Bonzi (PGR)	paclobutrazol			100		100
22/08/2008	Proplant	propamocarb hydrochloride			570		380
23/08/2008	B-Nine (PGR)	daminozide	Cycocel	chlormequat	880	75	200

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New 5C
(PGR)

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Product Two (g or ml)	Volume of Solution Mixed (litres)
			Cycocel New 5C	chlormequat			
23/08/2008	B-Nine (PGR)	daminozide	(PGR)		880	75	210
25/08/2008	Amistar	azoxystrobin	Dynamec	abamectin	200	100	200
			Cycocel New 5C	chlormequat			
25/08/2008	B-Nine (PGR)	daminozide	(PGR)		760	63	190
			Cycocel New 5C	chlormequat			
25/08/2008	B-Nine (PGR)	daminozide	(PGR)		720	60	180
25/08/2008	Cycocel New 5C (PGR)	chlormequat			50		100
25/08/2008	Cycocel New 5C (PGR)	chlormequat			80		160
26/08/2008	Bonzi (PGR)	paclobutrazol			80		40
26/08/2008	Bonzi (PGR)	paclobutrazol			90		90
26/08/2008	Dynamec	abamectin	Amistar	azoxystrobin	70	140	140
26/08/2008	Proplant	propamocarb hydrochloride			330		220
26/08/2008	Proplant	propamocarb hydrochloride			690		460
27/08/2008	Amistar	azoxystrobin			2		2
27/08/2008	B-Nine (PGR)	daminozide			200		50
27/08/2008	Bravo	chlorothalonil			8		4
			Systhane	myclobutanil			
27/08/2008	Bravo	chlorothalonil	20EW		6	0.9	3

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27/08/2008	Dipel (Bio R)	bacillus thuringiensis var kurstaki	40	40

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Product Two (g or ml)	Volume of Solution Mixed (litres)
27/08/2008	Proplant	propamocarb hydrochloride			10.5		7
27/08/2008	Standon	iprodione			10		10
27/08/2008	Standon	iprodione	Starion Flo	bifenthrin	40	20	40
27/08/2008	Subdue	metalaxyl-M			189		1540
27/08/2008	Systhane 20EW	myclobutanil			2.1		7
28/08/2008	B-Nine (PGR)	daminozide			2,200.00		550
28/08/2008	B-Nine (PGR)	daminozide			480		120
28/08/2008	Calypso	thiacloprid					
28/08/2008	Cycocel New 5C (PGR)	chlormequat			220		220
28/08/2008	Cycocel New 5C (PGR)	chlormequat			140		140
			Cycocel New 5C	chlormequat			
29/08/2008	B-Nine (PGR)	daminozide	(PGR)		160	13	40
29/08/2008	Bonzi (PGR)	paclobutrazol			50		50
29/08/2008	Proplant	propamocarb hydrochloride			150		100
			Cycocel New 5C	chlormequat			
30/08/2008	B-Nine (PGR)	daminozide	(PGR)		800	66	200
31/08/2008	Dynamec	abamectin	Amistar	azoxystrobin	190	380	380
01/09/2008			Cycocel New 5C				
	B-Nine (PGR)	daminozide	(PGR)	chlormequat	800	66	200

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01/09/2008	Cycocel New 5C (PGR)	chlormequat	280	280

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Quantity Used Product Two (g or ml)	Volume of Solution Mixed (litres)
01/09/2008	Cycocel New 5C (PGR)	chlormequat			280		280
01/09/2008	Proplant	propamocarb hydrochloride			300		200
02/09/2008	Cercobin WG	thiaphanate-methyl	Proplant	propamocarb hydrochloride	11	10.5	
02/09/2008	Proplant	propamocarb hydrochloride			210		140
02/09/2008	Subdue	metalaxyl-M			50		400
02/09/2008	Subdue	metalaxyl-M			50		400
03/09/2008	Alliette	fosetyl-aluminium	Standon	iprodione	60	60	60
03/09/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	240		60
03/09/2008	Bravo	chlorothalonil	Systhane 20EW	myclobutanil	28	4.2	14
03/09/2008	Dipel (Bio R)	bacillus thuringiensis var kurstaki			80		80
03/09/2008	Dipel (Bio R)	bacillus thuringiensis var kurstaki			70		70
03/09/2008	Proplant	propamocarb hydrochloride			10.5		7
03/09/2008	Subdue	metalaxyl-M			6.25		50
04/09/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	80	6.6	20

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Quantity Used Product Two (g or ml)	Volume of Solution Mixed (litres)
04/09/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	280		70
04/09/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	800		200
04/09/2008	Cycocel New 5C (PGR)	chlormequat			440		440
04/09/2008	Cycocel New 5C (PGR)	chlormequat			600		400
04/09/2008	Proplant	propamocarb hydrochloride			31.5		21
05/09/2008	Bonzi (PGR)	paclobutrazol			9.9		30
05/09/2008	Bonzi (PGR)	paclobutrazol			80		80
05/09/2008	Systhane 20EW	myclobutanil			144		480
05/09/2008	Systhane 20EW	myclobutanil			70		210
05/09/2008	Systhane 20EW	myclobutanil			66		200
06/09/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	720	60	180
06/09/2008	Dynamec	abamectin	Amistar	azoxystrobin	90	180	180
07/09/2008	Alliette	fosetyl-aluminium	Dynamec	abamectin	80	40	80
08/09/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	240	20	60
08/09/2008	Cycocel New 5C (PGR)	chlormequat			680		680

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Quantity Used Product Two (g or ml)	Volume of Solution Mixed (litres)
08/09/2008	Cycocel New 5C (PGR)	chlormequat			200		200
08/09/2008	Cycocel New 5C (PGR)	chlormequat			200		200
08/09/2008	Nu-Glass (Acid Washing)				10,000.00		400
08/09/2008	Proplant	propamocarb hydrochloride			360		240
09/09/2008			Cycocel New 5C (PGR)	chlormequat	8	0.66	2
09/09/2008	Bonzi (PGR)	paclobutrazol			26.4		80
09/09/2008	Bonzi (PGR)	paclobutrazol			60		60
09/09/2008	Bonzi (PGR)	paclobutrazol			20		40
09/09/2008	Bonzi (PGR)	paclobutrazol			14		7
09/09/2008	Jet 5 (GH Treatment)				3,520.00		440
09/09/2008	Proplant	propamocarb hydrochloride			31.5		21
09/09/2008	Subdue	metalaxyl-M			25		200
10/09/2008	Gazelle(Insecticide)	acetamiprid			710		1420
10/09/2008	Jet 5 (GH Treatment)				5,500.00		440
10/09/2008	Starion Flo	bifenthrin			4		8
10/09/2008	Subdue	metalaxyl-M			27.5		220
10/09/2008	Subdue	metalaxyl-M			39		320
10/09/2008	Systhane 20EW	myclobutanil			2.4		8

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10/09/2008	Systhane 20EW	myclobutanil	1.5	5

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Quantity Used Product Two (g or ml)	Volume of Solution Mixed (litres)
11/09/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	48	4	12
11/09/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	160		40
11/09/2008	Cycocel New 5C (PGR)	chlormequat			140		140
11/09/2008	Cycocel New 5C (PGR)	chlormequat			380		380
11/09/2008	Cycocel New 5C (PGR)	chlormequat			180		180
11/09/2008	Nemasys (Bio R)				250		200
12/09/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	40	3.3	10
12/09/2008	Bonzi (PGR)	paclobutrazol			13.2		40
12/09/2008	Gazelle(Insecticide)	acetamiprid			930		1860
12/09/2008	Gazelle(Insecticide)	acetamiprid			145		290
12/09/2008	Intercept (Pesticide)	imidacloprid			8		40
12/09/2008	Proplant	propamocarb hydrochloride			240		160
15/09/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	40	3.3	10
15/09/2008	Bonzi (PGR)	paclobutrazol			50		200
15/09/2008	Cycocel New 5C (PGR)	chlormequat			320		320

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Product Two (g or ml)	Volume of Solution Mixed (litres)
15/09/2008	Cycocel New 5C (PGR)	chlormequat			720		720
15/09/2008	Cycocel New 5C (PGR)	chlormequat			60		60
15/09/2008	Proplant	propamocarb hydrochloride			31.5		21
16/09/2008	Bonzi (PGR)	paclobutrazol			20		60
16/09/2008	Proplant	propamocarb hydrochloride			420		280
17/09/2008	Alliette	fosetyl-aluminium	Rovral		60	45	60
17/09/2008	Bravo	chlorothalonil	Systhane 20EW	myclobutanil	14	2.1	7
17/09/2008	Bravo	chlorothalonil			14		7
17/09/2008	Rovral	iprodione			7.5		10
17/09/2008	Subdue	metalaxyl-M			46		370
17/09/2008	Systhane 20EW	myclobutanil			528		1760
18/09/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	200		50
18/09/2008	Cycocel New 5C (PGR)	chlormequat			120		120
18/09/2008	Cycocel New 5C (PGR)	chlormequat			320		320
18/09/2008	Proplant	propamocarb hydrochloride			7.5		5
19/09/2008	Proplant	propamocarb hydrochloride			31.5		21
19/09/2008	Systhane 20EW	myclobutanil			67.5		225

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used Product One (g or ml)	Product Two (g or ml)	Volume of Solution Mixed (litres)
19/09/2008	Systhane 20EW	myclobutanil			66		220
22/09/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR)	chlormequat	160		40
22/09/2008	Bonzi (PGR)	paclobutrazol			30		90
22/09/2008	Bonzi (PGR)	paclobutrazol			100		300
22/09/2008	Cycocel New 5C (PGR)	chlormequat			50		50
22/09/2008	Proplant	propamocarb hydrochloride			270		180
23/09/2008	Bonzi (PGR)	paclobutrazol			3		3
23/09/2008	Proplant	propamocarb hydrochloride			10.5		7
23/09/2008	Scala	pyrimethanil			165		220
23/09/2008	Subdue	metalaxyl-M			3.5		28
23/09/2008	Systhane 20EW	myclobutanil			48		160
23/09/2008	Systhane 20EW	myclobutanil			20		60
24/09/2008	Alliette	fosetyl-aluminium	Rovral		20	15	20
24/09/2008	Bravo	chlorothalonil	Systhane 20EW	myclobutanil	80	12	40
24/09/2008	Dipel (Bio R)	bacillus thuringiensis var kurstaki			30		30
24/09/2008	Dynamec	abamectin			3.5		7
24/09/2008	Systhane 20EW	myclobutanil			1.5		5
26/09/2008	Cercobin WG	thiaphanate-methyl	Proplant	propamocarb hydrochloride	4.35	3	16

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Date	Product One	Active ingredient	Product Two	Active ingredient	Quantity Used	Volume of Solution Mixed (litres)
				Product One (g or ml)	Product Two (g or ml)	
26/09/2008	Proplant	propamocarb hydrochloride		390		260
29/09/2008	B-Nine (PGR)	daminozide	Cycocel New 5C (PGR) chlormequat	160	13.2	40
29/09/2008	B-Nine (PGR)	daminozide		120		30
29/09/2008	Cycocel New 5C (PGR)	chlormequat		100		100
29/09/2008	Proplant	propamocarb hydrochloride		471		314
30/09/2008	Bonzi (PGR)	paclobutrazol		80		80
30/09/2008	Gazelle(Insecticide)	acetamiprid		605		1210
30/09/2008	Gazelle(Insecticide)	acetamiprid		50		100
30/09/2008	Proplant	propamocarb hydrochloride		90		60

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