Project title:	The Bedding and Pot Plant Centre – new product opportunities for bedding and pot plant growers. ***Work package 2. Spray application***
Project number:	PO 019d
Project leader:	Dr Jill England, ADAS Boxworth
Report:	Annual report, 31 March 2021
Previous report:	None
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Date project commenced:	1 April 2020
Date project completed **(or expected completion date):**	31 March 2023

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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

- Reducing water volumes when spraying can result in savings in spray application.

Background

The Bedding and Pot Plant Centre (BPPC) has been established to address the needs of the industry via a programme of work to trial and demonstrate new product opportunities and practical solutions to problems encountered on nurseries.

This is the Bedding and Pot Plant Centre report for:

Objective 2. Spray application.

This programme of work focuses on improving the application of plant protection products (PPPs) for bedding and pot plants through identifying alternative approaches to existing hand-held high-volume systems, which can improve the quantity, uniformity, and distribution of PPPs over plants. These include: 1) air-assisted sprayer (such as Birchmeier AS 1200), 2) an alternative spray gun that solves the issue of repeatability (i.e. has fixed settings to enable consistent results to be achieved, 3) a boomless nozzle from a UK supplier.

Summary

This project is at an early stage and results are not yet available on the suitability of alternative spray application equipment that may help growers to consistently achieve lower water volumes when spraying. A standard cropping programme of three crops of six pack pansies followed by three crops of six pack summer bedding represents a typical year's production on a bedding nursery.

Pansies are an important crop for most bedding nurseries, particularly during the autumn / winter. They are produced in large volumes under permanent protection with full enclosure by many bedding plant producers and so were selected as a representative crop to base spray application costs on,

Downy mildew and leaf spots are the predominant pathogens affecting this crop, and aphids are key pest that can cause problems in both Pansy and summer bedding crops. Plant growth regulators are also routinely applied to both Pansy and summer bedding crops. Details of the main plant protection products recommended for the control of aphids and downy mildew (two application scenarios) have been collated in **Appendix 1**

Table 1. Products and crops used to base spray application costs on

Crop	Insecticide	Fungicide	PGR / no. of applications
Pansies (3 crops / year)	Majestik	Amistar, Fubol Gold, Percos, Switch	Bonzi x 2
Mixed summer bedding (3 crops / year)	Mainman, Majestik	Serenade ASO	Bonzi x 2

Financial benefits

Based on the assumption that the pesticides and bioprotectants listed in **Table 1** are applied in six-pack pansy production, with production commencing around week 28, with three pansy crops produced per hectare (ha) and are followed by three crops of summer bedding from week 10 onwards in a typical year. In, this study reducing the water volume that sprays are applied in from 1000 L/ha to 400 L/ha results in a saving of £2,311.14 per hectare.

Savings are achieved through a combination of energy, labour and water savings combined with product savings where products such as Bonzi are applied at a rate per litre. The typical margin on six pack bedding is in the region of £0.20 per pack therefore this saving equates to the margin on an extra 11,555 extra packs per hectare per year.

Action points

- The spreadsheet in Appendix 2 can be used to calculate savings achieved through applying pesticides in lower water volumes.
- Growers should engage with the project and the results generated during the next, experimental, phase of the work.

Science Section

Introduction

The Bedding and Pot Plant Centre (BPPC) has been established to address the needs of the industry via a programme of work to trial and demonstrate new product opportunities and practical solutions to problems encountered on nurseries.

This is the Bedding and Pot Plant Centre report for:

Objective 2. Spray application.

Background

Application practice in the UK protected ornamentals industry remains generally poor, despite previous work highlighting the issues (**Talbot, 2014**). This has been re-enforced in the AMBER project (**Chandler, 2020; Butler Ellis *et al*, 2020**). Foqué (**2012**) also investigated distribution of sprays for protected ornamentals and found that booms performed better than handheld application equipment. There are several barriers to growers making improvements to the equipment they use, including a lack of practical alternatives and a failure to demonstrate the economic benefit of investment (or the economic losses due to a lack of investment).

The application component of the Amber project has focused on exploring the relationship between applied water volumes and aspects of application performance, including the quantity of plant protection product (PPP) retained on plants and its distribution over the plant. It has not been possible, however, to optimise water volumes for bioprotectants (previously called biopesticides) because of the high cost and challenges associated with efficacy trials. Experiments on water volume have been conducted on the pot-grown ornamentals *Chrysanthemum* and Poinsettia, and on pot-grown basil, which has a similar architecture. These experiments suggest water volumes in the range 600 – 800 L/ha deposit the maximum amount of product on the plant when a fixed concentration is specified on the product label. However, volumes as low as possible will put the maximum PPP on plants when a fixed dose is specified, providing concentration can be increased (**Butler Ellis *et al*, 2020**). Distribution over the plant was unaffected by volume, despite increasing volume to improve distribution being a common recommendation on product labels.

It is accepted that higher volumes are associated with less active substance retained on plants for a very wide range of crops e.g. Brusselman *et al* (**2012**), Butler Ellis *et al* (**2003**), Miller *et al* (**2010**), Butler Ellis *et al* (**2012**). These studies strongly support the assertion that a boom operated with lower volumes than the current UK practice in ornamental crops could deliver improved control compared with typical hand-held systems.

Booms are not necessarily a practical option for many growers because of the varying width of beds within many production units, vertical supports within protected crop structures and the difficulty in moving down the rows without automation and particularly in manoeuvring between benches. The much-maligned Ripa nozzle can deliver a long throw ensuring that spray can reach the furthest plants, something which no other system other than a full boom can achieve. However, the well-documented problems with the Ripa nozzle (that droplet size and flow rate are hugely variable, make calibration difficult and application unrepeatable) (**Talbot, 2014**), and that uniformity is poor, mean that this approach to application needs to change. There are, potentially, alternative systems available that can deliver a greater throw than a conventional hand lance, but these have not been evaluated for use within protected crops and selecting an appropriate one for these purposes needs care. There are some data available from manufacturers and from an independent laboratory **(Deveau, 2020**) which will be used as a baseline for selecting options for testing.

Published data showing a strong relationship between application technique and efficacy for any crop is limited, however, so some of the main benefits of improving application that we will be able to demonstrate in this project are likely to be in improving the logistics (**Talbot, 2014**). This will enable the labour cost of application to be reduced, minimise losses of PPPs from crops, reduce operator exposure, and optimise timeliness of application and improve working conditions for the application operation.

Independent science-based advice to growers is limited. Two comprehensive factsheets were produced by the HDC (**Buxton and Hewson, 2007**; **Talbot and Basford, 2015**) but it seems that their recommendations have yet to be widely adopted by the industry. Updating these, providing a greater focus on the most important issues to address using modern communication techniques, could lead to greater uptake.

Project objectives

- To examine current information available to growers and recommendations for application.
- To conduct a cost-benefit analysis for investment in new equipment, based on indicative costs and savings.
- To develop an experimental protocol for measuring the performance of an application, which is likely to include volume used, speed of travel, time taken and spatial distribution of spray
- To use the protocol for an evaluation of the baseline performance of a typical application at a commercial site (Postponed to year 2 due to Covid-19).

Methods and materials

Examination of current information available to growers and recommendations for application.

Pansies are an important crop for most bedding nurseries, particularly during the autumn / winter. They are produced in large volumes under permanent protection with full enclosure by many bedding plant producers and so were selected as a representative crop to base spray application costs on,

Downy mildew and leaf spots are the predominant pathogens affecting this crop, and aphids are key pests that can cause problems. Plant growth regulators are also routinely applied to this crop. Details of the main plant protection products recommended for the control of aphids and downy mildew (two application scenarios) have been collated in **Appendix 1**. Several products are approved under an extension of authorisation for use on minor crops (EAMU), where less information relating to application is usually available, and application is at the growers' own risk. Application recommendations have been extracted from the labels and EAMUs to ensure that legal requirements are considered during the project. Label information for crops of a similar size / structure can be useful in assessing how the manufacturer might expect the product to be sprayed.

Conduct a cost-benefit analysis for investment in new equipment, based on indicative costs and savings.

A 6-pack of pansies typically costs in the region of £1.00 per pack to produce, with a margin of around £0.20 per pack for the grower before wastage is considered. Figures are based upon three consecutive crop cycles from week 28 through the winter to week 10. Three crops of mixed summer bedding were also used to calculate typical spray application costs per hectare per annum to reflect the crop cycle and spray application costs on a typical bedding nursey.

Costs associated with applying the products listed (**Table 2**) were calculated for the respective crops as three applications for each crop cycle. The calculations are provided in **Appendix 2**.

Table 2. Products and crops used to base spray application costs on

Crop	Insecticide	Fungicide	PGR / no. of applications
Pansies (3 crops / year)	Majestik	Amistar, Fubol Gold, Percos, Switch	Bonzi x 2

Mixed summer bedding (3 crops / year)	Mainman, Majestik	Serenade ASO	Bonzi x 2

These figures can be used to justify investment in better application equipment as it becomes available. For example, if new equipment is identified in this study that results in improved pest and disease control, less pesticide use per hectare or other efficiency savings the figures will be used to calculate the breakeven point of equipment purchases. An alternative approach that may be explored is the margin on x square meters of 6-pack Pansy production (assuming a typical figure for wastage) that would pay for the new equipment.

To develop an experimental protocol for measuring the performance of an application, which is likely to include volume used, speed of travel, time taken and spatial distribution of spray

An experimental protocol has been developed which takes account of the length and width of the area treated, pressure, flow rate, application volumes per hectare and work rates.

Use the protocol for an evaluation of the baseline performance of a typical application at a commercial site.

Work has begun on identifying the specification for alternative equipment for testing. The basis for this will be data collected relating to current application practice as part of AHDB project PO 008. These include the width over which the spray needs to be delivered (for handheld systems), the flow rate and the spray quality.

The required spray width needs to be based on current bed sizes – there was no information on this in PO 008 and so data has been collected from a small number of nurseries. Bed sizes range from 2.0 m to 6.4 m width. This presents a problem, because it is likely that different equipment will be needed for beds of 2 – 3 m width compared with >5 m. There is currently insufficient resource to include bed width as a variable as well as the different equipment types so some prioritisation will be required in the protocol.

Information about flow rate was not published in the PO 008 report but data was collected. This has been passed to SSAU and analysis is underway.

Baseline performance will be evaluated on a commercial bedding plant nursery.

The equipment that has been proposed for testing includes boomless nozzles, alternative spray guns and the Birchmeier AS1200 air-assisted sprayer. Once the required flow rate range has been identified, the ability of each of these alternatives to meet this and provide the required spray quality will be assessed. Additional considerations will include the cost, and current availability in the UK due to Brexit and the pandemic.

Results

In this study, the cost benefit analysis has identified that reducing the water volume that sprays are applied in from 1000 L/ha to 400 L/ha over three pansy crops and three mixed summer bedding crops results in a saving of £2,311.14 per ha per year.

The typical margin on six-pack bedding is in the region of £0.20 per pack, therefore the potential savings predicted by this study equates to the margin on an extra 11,555 extra packs per ha per year.

Discussion

The savings detailed above are achieved through a combination of energy, labour and water savings combined with product savings where products such as Bonzi are applied at a rate per litre of water. Where products such as Amistar (EAMU 3388/18) are used, which have a rate per hectare (rather than a rate per litre), it is considered best practice to maintain the rate of active substance per hectare, even if the water volume is reduced as this minimises the risk of insecticide / fungicide resistance developing. It is worth noting that products such as Amistar (ref. EAMU 3388/18) that are used under EAMUs in the production of ornamentals have on-label uses at lower water volumes for field grown crops. Pesticides are also likely to be more effective when applied at higher concentrations in lower water volumes where it is legal to do so. Applying some pesticides at lower water volumes / a higher concentration may increase the risk of crop damage so it is considered a wise precaution to carry out in-house trials to confirm crop safety at reduced water volumes prior to widespread adoption.

Information on minimum water volumes for application – where supplied by pesticide manufacturers / marketing agents has been collated (Appendix 1). Water volumes are not excessively high (between 100 and 400 L/ha) whereas maximum volumes (up to 1500 L/ha) are often likely to be inappropriate for the small plants we are considering in our case studies.

Because other work, particularly under the AMBER project, has demonstrated that lower volumes (<600 L/ha) are likely to be optimum for small plants, we will focus on equipment and application techniques that deliver in the range of 200 – 400 L/ha. This will allow all the identified products to be sprayed legally, and volumes to be closer to what we expect to be the optimum. However, it is possible that where handheld equipment is required (which is the focus of the planned experimental work) such relatively low volumes may not be achievable.

Only three products defined a maximum concentration, which might also limit how low the volume can be to deliver an effective dose.

Several of the products specified fine or medium spray quality. Fine sprays are typically recommended for insecticides, and fine / medium for fungicides, but evidence across a wider range of crops is weak and the basis for such recommendations is usually historical. Label requirements are often based on safety – either environmental or human. The use of a coarser spray is unlikely to compromise safety and could in fact improve it. It is possible that a coarser spray could compromise efficacy, however, and this is another reason why manufacturers are reluctant to change, as their own trials tend to be small-scale with fine or fine / medium sprays. Automated spraying booms are known to deliver the most uniform spray application and are likely to offer further reductions in labour costs. Automated spray application systems enable low water volumes to be utilised so also offer savings in water and pesticides (for products such as Bonzi that are applied at a rate per litre). Retro fitting booms to older glasshouses can be cost prohibitive and not all older glasshouses can accommodate boom-based application systems

As the number of conventional pesticides declines and the number of bioprotectants (such as Botanigard WP) increases, automated application systems enable these products to be applied when temperature and relative humidity are optimum to maximise product efficacy. Such conditions often occur outside of normal nursery working hours and can limit the use and / or effectiveness of these products on some bedding and pot plant nurseries. Therefore, automated application systems are likely to become increasingly important in the future and should be considered carefully when planning new structures.

Conclusions

This cost benefit analysis has demonstrated how reducing water volumes when spraying ornamental crops can result in substantial savings per year per hectare, which if adopted by the industry has the potential to contribute to increased profitability within the bedding and pot plant and the wider ornamentals sector

Acknowledgements

Our thanks to:

- Stefan Atanasov, Coletta and Tyson, (Grower champion to this work package).
- Gary Woodruff, Bordon Hill Nurseries
- Matt Cole, Bryants Nurseries
- Stuart Halman, Les Halman Nurseries
- Mike Smith, W.D. Smith & Sons

References

Brusselman E, Beck B, Pollet S, Temmerman F, Spanoghe P, Moens M, Nuyttens D. 2012. Effect of the spray application technique on the deposition of entomopathogenic nematodes in vegetables. Pest Management Science 68:444–453.

Butler Ellis, M C, Scotford, I Webb, D A, (2003) The deposit characteristics of pesticide sprays applied at low volumes. Proceedings of the BCPC International Congress – Crop Science and Technology, Glasgow, 2003, 279-284.

Butler Ellis, M C, Lane, A G, O'Sullivan, C M (2012) Distribution of spray applied to a cereal crop and the effect of application parameters on penetration. Aspects of Applied Biology 114, International Advances in Pesticide Application, pp. 347-354.

Butler Ellis, M C, Lane, A G, O'Sullivan, C M, Chandler, D, Prince, G (2020) Application of Biopesticides in the UK – Lessons from the Amber project and optimisation of applied volume. Aspects of Applied Biology 144, International Advances in Pesticide Application, 11-18.

Buxton, J and Hewson, A (2007) Guidelines and best practice for pesticide spray application in protected ornamental crops HDC Factsheet 14/06 (revised).

Chandler, D, Prince, G, Talbot, D, Wedgwood, E, Gwynn, R, Jacobson, R, Butler Ellis, M C, Bennison, J (2020) Helping growers get the best out of biopesticides – the AMBER project. Aspects of Applied Biology 144, International Advances in Pesticide. Application, 1 – 10.

Deveau, J (2020) sprayers101.com/boomless-nozzle-performance

Foqué D, Pieters J G, Nuyttens D. 2012. Comparing Spray Gun and Spray Boom Applications in Two Ivy Crops with Different Crop Densities. Hortscience 47(1):51–57.

Miller, P C H, Butler Ellis, M C, Bateman, R, Lane, A G, O'Sullivan, C M, Tuck, C R, Robinson, T H (2010) Deposit distributions on targets with different geometries and treated with a range of spray characteristics. Aspects of Applied Biology, 99, International Advances in Pesticide Application, 241-248.

Talbot, D. (2014). Improving the efficiency of spray application for ornamental crops: a study of current spraying methods and novel spraying technologies. (phase 2, laboratory and nursery studies) PO 008 HDC Final Report.

Talbot, D, Basford, B (2015) Improving the efficacy of plant protection applications to ornamental crops via hand-held sprayers. HDC Factsheet 06/15.

Appendix 1. Product information

The aim will be to consider equipment that can deliver in a water volume range of 200 - 400 L/ha*. This will allow these products to be applied legally, and at the lower end of the permitted range which we believe will be optimum. Handheld equipment may not be able to deliver within this range - higher volumes may be necessary. NS = not specified

Aphids								
Product	**Label recommendation**	**EAMU**	**Systemic/contact**	**Volume range (L/ha)***		**Max. concentration**	**Spray quality**	**Comments**
				min	**max**			**Other info**
Spruzit	yes	no	Contact	not specified	600	ns	fine	Increase volume for taller crops. Achieve under-leaf coverage
Sequoia	yes	no	Systemic	400	1200	ns	ns	
Mainman	no	yes	Systemic	200	1500	ns	ns	High volume probably relevant only to trees/very tall crops
Gazelle SG	yes	no	Systemic	not specified	1500	ns	fine/medium	For outdoor crops; thorough coverage
					1000	ns	fine/medium	For protected crops; thorough coverage
Aphox	no	yes	Contact	300	ns	50 g a.s./hl	medium	Label states 200-400 L/ha for other crops
Batavia	no	yes	Systemic	ns	ns	ns	ns	Label states 1000-1500 for protected strawberries. EAMU suggests 'sufficient volume'!

Downy Mildew								
Product	**Label recommendation**	**EAMU**	**Systemic / contact**	**Water volume range (L/ha)***		**Max. concentration**	**Spray quality**	**Comments**
				min	**max**			**Other info**
Amistar	no	yes	Systemic	200	not specified	ns	ns	
Pecos	no	yes	Systemic	100	1000	ns	medium	
Fubol Gold	no	yes	Systemic	250	not specified	ns	medium	Label has min. water volume of 200 L/ha

Fungal leaf spots								
Serenade ASO	no	yes	Contact	400	1000	ns	not specified	Bioprotectant that colonises treated plant leaf surfaces
Switch	yes	no	Contact	not specified	not specified	80g/100l	medium	Apply at a minimum pressure of 2 bar

Plant Growth Regulators (PGRs)								
Product	**Label recommendation**	**EAMU**	**Systemic/contact**	**Volume range (L/ha)**		**Max concentration**	**Spray quality**	**Comments**
				min	**max**			**Other info**
Bonzi	yes	no	Absorbed by stems and roots	not specified	2000	25ml/L	ns	Max. concentration too strong for bedding and pot plants. Avoid run off into growing media of bedding plants as root uptake can result in excessive growth regulation

Appendix 2. Cost savings achievable through reducing water volumes

	Example spray program for pansies				*Tank mixing is at growers own risk									
		Inputs			Unit costs				Cost, £/ha					
		water vol, L/ha	dose, L/ha or KG/ha	Workrate, ha/h	water cost £/L	Pesticide, £/L or £/KG	labour cost, £/h	Energy, £/h	Water	Pesticide	Labour	energy	Total cost, £/h
	Baseline												
spray 1 Pansy*		1000		0.2	0.02		10	0.11	20.00		50.00	0.55	**70.55**
	Amistar		1			46				46.00			**46.00**
	Majestik		25			10.6				265.00			**265.00**
spray 2 Pansy*		1000		0.2	0.02		10	0.11	20.00		50.00	0.55	**70.55**
	Fubol Gold		1.9			£22.11				42.01			**42.01**
	Bonzi		1			£100.00				100.00			**100.00**
spray 3 Pansy*		1000		0.2	0.02		10	0.11	20.00		50.00	0.55	**70.55**
	Percos		0.8			£32				25.60			**25.60**
	Switch		0.8			130				104.00			**104.00**
	Bonzi		1			£100.00				100.00			**100.00**
								Total	60.00	682.61	150.00	1.65	894.26
	Improved equipment												
	Baseline												
spray 1 Pansy		400		0.3	0.02		10	0.09	8.00		33.33	0.30	**41.63**
	Amistar		1			46				46.00			**46.00**
	Majestik		10			10.6				106.00			**106.00**
spray 2 Pansy		400		0.3	0.02		10	0.09	8.00		33.33	0.30	**41.63**
	Fubol Gold		1.9			£22.11				42.01			**42.01**
	Bonzi		0.4			£100.00				40.00			**40.00**
spray 3 Pansy		400		0.3	0.02		10	0.09	8.00		33.33	0.30	**41.63**
	Percos		0.56			£32				17.92			**17.92**
	Switch		0.56			130				72.80			**72.80**
	Bonzi		0.4			£100.00				40.00			**40.00**
								Total	24.00	364.73	100.00	0.90	489.63
								Savings per ha per crop					404.63
								Savings over three crop cycles Pansy per ha					1213.89

	Example spray program for summer bedding, various species							*Tank mixing is at growers own risk							
		Inputs				Unit costs					Cost, £/ha				
		water vol, L/ha	dose, L/ha or KG/ha	Workrate, ha/h		water cost £/L	Pesticide, £/L or £/KG	labour cost, £/h	Energy, £/h		Water	Pesticide	Labour	energy	Total cost, £/
	Baseline														
spray 1 Summer bedding*		1000		0.2		0.02		10	0.11		20.00		50.00	0.55	**70.55**
	Serenade ASO		10				14.8					148			**148.00**
	Majestik		25				10.6					265.00			**265.00**
spray 2 Summer bedding		1000		0.2		0.02		10	0.11		20.00		50.00	0.55	**70.55**
	Bonzi		1				£100.00					100.00			**100.00**
spray 3 Summer bedding*		1000		0.2		0.02		10	0.11		20.00		50.00	0.55	**70.55**
	Mainman		0.14				£220					30.80			**30.80**
	Bonzi		1				£100.00					100.00			**100.00**
										Total	60.00	643.80	150.00	1.65	855.45
	Improved equipment														
	Baseline														
spray 1 Summer bedding		400		0.3		0.02		10	0.09		8.00		33.33	0.30	**41.63**
	Serenade ASO		10				14.8					148			**148.00**
	Majestik		10				10.6					106.00			**106.00**
spray 2 Summer bedding		400		0.3		0.02		10	0.09		8.00		33.33	0.30	**41.63**
	Bonzi		0.4				£100.00					40.00			**40.00**
spray 3 Summer bedding		400		0.3		0.02		10	0.09		8.00		33.33	0.30	**41.63**
	Mainman		0.14				£220					30.80			**30.80**
	Bonzi		0.4				£100.00					40.00			**40.00**
										Total	24.00	364.80	100.00	0.90	489.70
									Savings per ha per crop						365.75
									Savings over three crop cycles summer bedding per ha						1097.25
								Total savings per Ha per year (three crop cyles of both Pansy and summer bedding)							**2311.14**