Botanical Pesticides – where to now?

by Leather, S.R. and Pope, T.W.

DOI: https://doi.org/10.1564/v30_apr_07

Leather, S.R. and Pope, T.W. 2019. Botanical biopesticides – where to now? *Outlooks on Pest Management*, 30(2), pp.75 – 77.

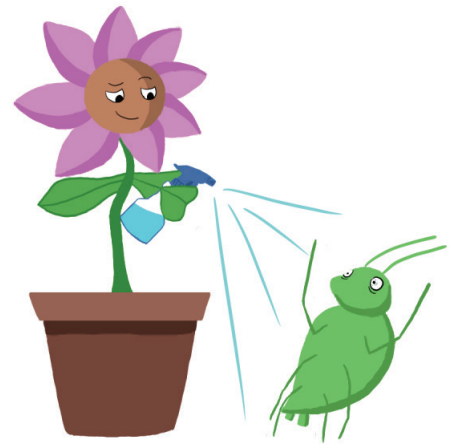
BOTANICAL BIOPESTICIDES – WHERE TO NOW?

Simon R. Leather and Tom W. Pope ask what are the problems facing the use and take-up of plant based pesticides in the UK and EU, Crop & Environment Science, Harper Adams University, Edgmond, Newport, TF10 8NB UK. E-mail: sleather@harper-adams.ac.uk; tpope@harper-adams.ac.uk detail the problems facing the use and take-up of plant based pesticides in the UK and EU

Keywords: botanical pesticides, essential oils, integrated pest management, aphids,

Simon Leather

Tom Pope



Helping plants fight back.

Introduction

Like Apollo 13 in the eponymously named 1995 film, crop protection has a problem, well actually, more than one problem. Unlike the Apollo disaster there is however, no quick fix on the horizon.

The first, and for growers often the more serious problem, is that populations of insects and other pests, are developing resistance to pesticides; indeed there are almost 600 species of arthropod for which resistance to the most commonly used crop protection products has been reported (Sparks & Nauen, 2015). The situation with weeds and plant pathogens is equally parlous (Heap, 2014; Hollomon, 2015), with cases of resistance to herbicides and fungicides growing at an alarming rate worldwide. The second problem, and one that potentially poses a danger to us all is the realization that the use of some conventional synthetic pesticides, widely perceived by the public and some scientists, as a danger to beneficial insects such as pollinators (Goulson *et al*., 2015; Regan *et al*., 2017), may also be a threat to insects in general (Sorg *et al*., 2013; Pisa *et al*., 2015; Leather, 2018; Main *et al*., 2018).

The pressure put on growers by the public condemnation of the use and the reducing commercial availability of effective conventional synthetic pesticides means that the development of viable alternatives is of increasing importance. The obvious, and the option favoured by the European Union, is to increase the wholehearted uptake of Integrated Pest Management (IPM) by growers of all kinds (Leather, 2017). Given that successful IPM programmes and those likely to gain support from growers, usually incorporate, and certainly do not preclude the use of pesticides (Bailey *et al*., 2009) it would be foolish, in most cropping situations at least, to advocate reliance on biological control options on their own. Where approaches to prevent pest problems, such as through the use of host-plant resistance and crop rotations, have been unsuccessful, this effectively leaves us with the biopesticides to combat pest outbreaks. Biopesticides are typically either derived from plants (the botanicals) (Atanasova & Leather, 2018; Smith *et al.,* 2018) or from microbial agents such as entomopathogenic fungi (Rossell *et al*., 2009).

Although a number of the microbially based biopesticides have been shown to be very effective (Tunç & Sahinkaya, 1998; Sampson *et al*., 2005), issues such as legislation, costs and specificity, and therefore niche markets, of biopesticides mean that adoption and take-up has been slow (Chandler *et al*., 2011). In the EU for example, despite the call for the increased use of IPM, there are far fewer commercially available biopesticides than those in crop-growing regions elsewhere (Balog *et al*., 2017). In the USA for example, biopesticides are approved as long as they are considered unlikely to cause harm to humans and the environment, whereas in the EU and UK there are almost 200 environmental regulatory acts and laws that restrict the take-up and adoption of biopesticides (Balog *et al*., 2017). Microbial biopesticides are often thought of as being less effective than conventional pesticides, mainly because they are generally slower acting and, for the grower, do not have the satisfying 'almost instantaneous' knock-down effect associated with many conventional synthetic pesticide. A possible alternative to both microbial biopesticides and conventional synthetic pesticides are plant

DOI: 10.1564/v30_apr_07

essential oils, which are considered to be environmentally friendly and easily produced (Tripathi *et al*., 2009).

The idea of using plant-based products as pesticides has been around a long time; after all, pyrethroids are based on natural pyrethrins, which were originally extracted from *Chrysanthemum cinerariifolium* and *Chrysanthemum coccineum* while rotenone is derived from plants in the Genus *Derris*. As the flow of new conventional synthetic pesticide products coming to market slows down and more cases of resistance to existing products come to light, the interest in using naturally available products with insecticidal, fungicidal and herbicidal properties is growing (Atanaova & Leather, 2018; Smith *et al.,* 2018). Essential oils, such as citronella, extracted from lemongrass *Cymbopogon* spp. has been used as an insect repellent for decades and has been registered as such in the USA since 1948. It is, despite being used in perfumes and other toiletry items, banned for use as a topically applied insect repellent in the EU primarily based on concerns about methyl eugenol. As a plant protection product trials have shown that is a highly effective biopesticide performing better than many conventional synthetic alternatives (Atanasova & Leather, 2018). A growing body of evidence suggests that insecticides based on essential oils are as good as, and in some cases, better than commercially available synthetic pyrethroids, pyridine and keto-enol based products, especially those based on orange oil and *Chenopodium* based products (Atanaosova *et al.,* 2018; Smith *et al*., 2018). For example, biopesticide products based on the active ingredients azadirachtin A, a *Chenopodium ambrosioides* extract or orange oil was as effective as spirotetramat, a keto-enol based synthetic insecticide, against the peach-potato aphid (*Myzus persicae*) (Smith *et al*., 2018). The biopesticide based on orange oil also reduced aphid numbers significantly faster than the synthetic insecticide in this study.

As a consequence of their perceived advantages over conventional pesticides, ease of extraction, and compatibility with natural enemies, formulations based on essential oils, once mainly confined to organic horticulture, are becoming more mainstream, although their use varies greatly between countries (Sampson *et al*., 2005). Despite the generally positive outcomes from trials to date, there are still some issues that need addressing. Many of the studies that have been published to date, appeared in low impact, regional journals. Studies on phytotoxicity and impacts on natural enemies and non-target organisms, although they do exist, are rare or are not publically available. Importantly, for biopesticides to be used more widely, it will be important to improve formulations to deliver improved consistency in efficacy and persistence of these products. With greater uptake of biopesticides, however, comes the need for more studies on the modes of action of essential oils and other plant-based products so that the likelihood of pest resistance developing can be assessed and countered. Remember, that although these are components of the plant's natural defence systems, there are pests and diseases that have naturally overcome them and are able to make a living, albeit as specialists, on these same plants, termed in the ecological literature as a co-evolutionary arms race.

We desperately need further work in this area, without increased funding and just as importantly, changes in the regulatory framework and the attitudes of growers, improvements in developing sustainable and environmentally friendly crop production will be a long time coming.

Acknowledgements

We are extremely grateful to Samantha Blackburn-Turner for providing the cartoon.

References

Atanasova, D. & Leather, S.R. (2018) Plant essential oils: the way forward for aphid control? *Annals of Applied Biology*, **173**, 175–179.

Atanasova, D., Ganchev, D. & Nevov, N. (2018) Efficacy of some plant essential oils against cotton aphid, *Aphis gossypii* Glover (Hemiptera: Aphididae) under laboratory conditions. *MAYFEB Journal of Agricultural Science*, **1**, 10–16

Bailey, A.S., Bertaglia, M., Fraser, I.M., Sharma, A., & Douarin, E. (2009) Integrated pest management portfolios in UK arable farming: results of a farmer survey. *Pest Management Science*, **65**, 1030–1039.

Balog, A., Hartel, T., Loxdale, H.D. & Wilson, K. (2017) Differences in the progress of the biopesticides revolution between the EU and other major crop-growing regions. *Pest Management Science*, **73**, 2203–2208.

Chandler, D., Bailey, A.S., Tatchell, G.M., Davidson, G., Greaves, J. & Grant, W.P. (2011) The development, regulation and use of biopesticides for integrated pest management. *Philosophical Transactions of the Royal Society B*, **366,** 1987–1998.

Goulson, D., Nicholls,E., Botías, C. & Rotheray, E.L. (2015) Bee declines driven by combined stress from parasites, pesticides, and lack of flowers. *Science*, **347**, 1435–1444.

Heap, I. (2014) Global perspective of herbicide-resistant weeds. *Pest Management Science*, **70**, 1306–1315.

Hollomon, D.W. (2015) Fungicide resistance: facing the challenge. *Plant Protection Science*, **41**, 170–176.

Leather, S.R. (2017) Mind the gap: time to make sure that scientists and practitioners are on the same page. *Annals of Applied Biology*, **170**, 1–3.

Leather, S.R. (2018) "Ecological Armageddon" – more evidence for the drastic decline in insect numbers. *Annals of Applied Biology*, **172**, 1–3.

Main, A.R., Webb, E.B., Goyne, K.W. & Mengel, D. (2018) Neonicotinoid insecticides negatively affect performance measures of non-target terrestrial arthropods: a meta-analysis. *Ecological Applications*, **28**, 1232–1244.

Pisa, L.W., Amaral-Rogers, V., Belzunces, L.P., Bonmatin, J.M., Downs, C.A., Goulson, D., Kreutzweiser, D.P., Krupke, C., Liess, M., McField, M., Morrissey, C.A., Noome, D.A., Settele, J., Simon-Delso, N., Stark, J.D., Van der Sluijs, J.P., Van Dyck, H. & Wiemers, M. (2015) Effects of neonicotinoids and fipronil on non-target invertebrates. *Environmental Science & Pollution Research*, **22**, 68–102.

Regan, K.,Ordosch, D., Glover, K.D. Tilmon, K.J. & Szczepanie, A. (2017) Effects of a pyrethroid and two neonicotinoid insecticides on population dynamics of key pests of soybean and abundance of their natural enemies. *Crop Protection*, **98**, 24–32.

Rosell, G., Querco, C., Coll, J., & Guerrero, A. (2008) Biorational insecticides in pest management. *Journal of Pesticide Science*, **33**, 103–121.

Sampson, B. J., Tabanca, N., Kirimer, N., Demirci, B., Baser, K. H. C., Khan, I. A., Spiersi, J. M., & Wedge, D. E. (2005). Insecticidal activity of 23 essential oils and their major compounds against

adult *Lipaphis pseudobrassicae* (Davis) (Aphididae: Homoptera). *Pest Management Science*, **61**, 1122–1128.
Smith, G., Roberts, J. & Pope, T.W. (2018) Terpene based biopesticides as potential alternatives to synthetic insecticides for control of aphid pests on protected ornamentals. *Crop Protection*. **110**, 125–130.
Sorg M., Schwan H., Stenmans W., Müller A. (2013) Ermittlung der Biomassen flugaktiver Insekten im Naturschutzgebiet Orbroicher Bruch mit Malaise Fallenin den Jahren 1989 und 2013. *Mitteilungen aus dem Entomologischen Verein Krefeld*, **1**, 1–5.
Tripathi, A.K., Upadhyay, S., Bhuyian, M. & Bhattacharya, P.R. (2009) A review on prospects of essential oils as biopesticide in insect-pest management. *Journal of Pharmacognysy & Phytopathology*, **1**, 52–63.
Tunç, I., & Sahinkaya, S. 1998. Sensitivity of two greenhouse pests to vapours of essential oils. *Entomologia Experimentalis et Applicata*, **86**, 183–187.

Simon Leather is Professor of Entomology at Harper Adams University. His research focuses on integrated pest management programmes in arable, forestry and horticultural crops and he works with Tom Pope on a number of biological control projects. He worked for ten years with Forestry Commission Research (Roslin) moving to Imperial College London in 1992. He took up his current position in 2012 to head up the Centre for Integrated Pest Management and to run the MSc course in Entomology.

Tom Pope is a Reader in Entomology at Harper Adams University. His research focuses on development of integrated pest management programmes in arable and horticultural crops. Current work is investigating the potential of microbial and botanical biopesticides used in combination with macro biological controls for the control of key pest species. He was formerly an Entomologist at ADAS UK Ltd.

Similar articles that appeared in *Outlooks on Pest Management* include – 2010 **21(4)** 156; 2010 **21(6)** 265; 2011 **22(2)** 83; 2011 **22(3)** 122; 2011 **22(6)** 280; 2012 **23(1)** 30; 2014 **25(3)** 200; 2015 **26(6)** 281; 2016 **27(1)** 10; 2016 **27(2)** 136; 2016 **27(5)** 226