Institution: Keele University

Unit of Assessment: UoA5 Biological Sciences

Title of case study: Sustainable pest management in crops: improved traps for thrips and whiteflies

Period when the underpinning research was undertaken: 2000-2019

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Prof. William D. J. Kirk	Professor of Applied Entomology	1987- present
Prof. J. Gordon C. Hamilton	Professor	1994 – 2016
Dr Clare Sampson	PDRA, PhD	2014 - 2016

Period when the claimed impact occurred: 2000-2020

Is this case study continued from a case study submitted in 2014? N

1. Summary of the impact (indicative maximum 100 words)

Prof. Kirk's research on western flower thrips and glasshouse whiteflies has provided commercial growers of vegetable, fruit and flower crops with an effective non-insecticide solution to the control of these major worldwide pests. Prof. Kirk's group discovered that addition of pheromones and changes in trap appearance can increase trap catches of thrips and whiteflies. Bioline AgroSciences, Biobest Group and Russell IPM have used these significant findings to develop and sell innovative traps that reduce crop loss worldwide. These traps reduce the need for insecticides, thus reducing the risk of pesticide residues and the associated harms to the environment.

2. Underpinning research (indicative maximum 500 words)

Over the past 25 years, the world-leading Centre for Applied Entomology and Parasitology (CAEP) at Keele University has conducted research into the biology of agriculturally important insect pests that threaten food security and sustainability. CAEP has particularly focused on thrips and whiteflies, which are major pests of a wide range of crops worldwide, causing an estimated £20 billion of damage per year. The resistance of these pests to current insecticides and the growing consumer demand for chemical-free fruit and vegetables, mean that new control methods are needed urgently to protect the world's crops and fulfil market demand. Within CAEP, the Thrips Research Group at Keele (Prof. William Kirk, Prof. Gordon Hamilton and Dr Clare Sampson) has discovered new ways to increase trap catches, thus reducing pest numbers in a sustainable way and reducing the need for insecticide treatments.

The western flower thrips (*Frankliniella occidentalis*) is the most damaging species of thrips worldwide, causing feeding damage and transmitting plant diseases. In 2001, Prof. Kirk and Prof. Hamilton studied this species to discover the first aggregation pheromone in thrips (**3.1, 3.2**). Following this breakthrough, they identified the pheromone compounds by headspace analysis with gas chromatography and mass spectrometry. They then synthesised the pheromone and tested it in field trials in commercial greenhouses in Spain in 2004 (**3.3**). These trials showed that the pheromone doubled the trap catch of both males and females when added to blue or yellow sticky traps, which are already highly attractive and used commercially to monitor thrips (**3.3**). Further research from 2006-2014 identified the aggregation pheromone of the melon thrips (*Thrips palmi*), which is an invasive pest of many crops (**3.5**), and research from 2014-2019 identified the

aggregation pheromone of the bean flower thrips (*Megalurothrips sjostedti*), which is a major pest of legume crops in sub-Saharan Africa.

Field trials with the aggregation pheromone of the western flower thrips in UK strawberry crops by Dr Sampson and Prof. Kirk from 2011-2014 developed the traps and showed that mass trapping with pheromone traps reduced pest numbers by 73%, damage by 68% and was cost-effective for growers when used as part of an integrated pest management programme (**3.4**). This result was a breakthrough because mass trapping in this way was considered by many to be ineffective against abundant pests such as thrips. This research allowed Russell IPM Ltd to incorporate the pheromone in traps as a product for growers. In addition to attracting flying thrips and thus increasing trap catch, the research group showed that exposure to aggregation pheromone makes thrips more active, bringing them out of hiding places on plants, which can increase the efficacy of insecticides or biological agents.

From 2014-2016, Dr Sampson, Prof. Kirk and Prof. Hamilton carried out research with Russell IPM Ltd. They developed the use of geometrical patterns on traps (white on blue for thrips and black on yellow for whiteflies) to double trap catches (**3.6**) and then went on to show that subtle changes in the shade of yellow traps, according to the relative proportions of wavelengths above and below 500 nm, rather than the absolute amounts, could also double the trap catch of whiteflies (**3.6**), leading to a range of new products. Trap technology for whiteflies has been unchanged for decades, so these advances in colour and pattern are major breakthroughs.

3. References to the research (indicative maximum of six references)

3.1. **Hamilton, J.G.C. & Kirk, W.D.J.** (2003) *Method of monitoring/controlling thrips. Priority date: 21 December 2001. International patent application published under the Patent Cooperation Treaty WO 03/055309*. World Intellectual Property Organization, Geneva. https://patents.google.com/patent/WO2003055309A1/

3.2. **Kirk, W.D.J. & Hamilton, J.G.C.** (2004) Evidence for a male-produced sex pheromone in the western flower thrips *Frankliniella occidentalis*. *Journal of Chemical Ecology* 30, 167-174. DOI: 10.1023/B:JOEC.0000013189.89576.8f

3.3. **Hamilton, J.G.C.**, Hall, D.R. & **Kirk, W.D.J.** (2005) Identification of a male-produced aggregation pheromone in the western flower thrips *Frankliniella occidentalis*. *Journal of Chemical Ecology* 31, 1369-1379. DOI: 10.1007/s10886-005-1351-z

3.4. **Sampson, C. & Kirk, W.D.J.** (2013) Can mass trapping reduce thrips damage and is it economically viable? Management of the western flower thrips in strawberry. *PLOS ONE* 8(11), e80787. DOI: 10.1371/journal.pone.0080787

3.5. Akella, S.V.S., **Kirk, W.D.J.**, Lu, Y.-B., Murai, T., Walters, K.F.A. & **Hamilton, J.G.C.** (2014) Identification of the aggregation pheromone of the melon thrips, *Thrips palmi*. *PLOS ONE* 9(8), e103315. DOI: 10.1371/journal.pone.0103315

3.6. **Sampson, C.**, Covaci, A.D., **Hamilton, J.G.C.**, Hassan, N., Al-Zaidi, S. & **Kirk, W.D.J.** (2018) Reduced translucency and the addition of black patterns increase the catch of the greenhouse whitefly, *Trialeurodes voracious*, on yellow sticky traps. *PLOS ONE* 13(2), e0193064. DOI: 10.1371/journal.pone.0193064

Grants

- 2010-2012. **W.D.J. Kirk**. Marie Curie International Incoming Fellowship for "Pheromone identification for environmentally responsible control of thrips (PERFECT)". European Union FP7-PEOPLE-2009-IIF (proposal 252258) grant of €181,103 (=£129,359).
- 2010-2015. **W.D.J. Kirk & J.G.C. Hamilton** and EMR, ADAS Boxworth, NRI and Warwick HRI. Biological, semiochemical and selective chemical management methods for insecticide resistant western flower thrips on protected strawberry (HL01107, SF120). Defra Horticulture LINK grant of £874,717 [£94,602 for Keele]
- 2014-2016. **W.D.J. Kirk & J.G.C. Hamilton**. Knowledge Transfer Partnership (KTP) No KTP009757 between Keele University and Russell IPM Limited. Improved traps for the control of thrips and whiteflies in greenhouse crops. Innovate UK, Welsh Government and Russell IPM Ltd grant of £161,177.
- 2017-2019. **W.D.J. Kirk**, F. P. Drijfhout and M. O'Brien with Harper Adams University. Improving food safety by reducing pesticide residues: developing a pheromone alternative to insecticides for control of thrips on legumes in Kenya (BB/P022391/1). Global Challenges Research Fund (GCRF) Foundation Award for Global Agriculture and Food Systems Research from the BBSRC to the value of £455,334.

4. Details of the impact (indicative maximum 750 words)

The work on thrips pheromones, trap patterns and trap colours by CAEP's Thrips Research Group has been applied to a range of products used to control thrips and whiteflies in crops around the world. The impact of this research has reached across a range of geographical scales, from local to global, by enabling a UK-based manufacturer to grow its business, as well as being part of the solution to securing food crops in developing countries and reducing pesticide use.

Product Innovation and Business Growth

The western flower thrips pheromone that Keele discovered in 2001 (**3.1**, **3.2**) is currently used in at least 10 different commercial products sold by Bioline AgroSciences (formerly Syngenta Bioline), Biobest Group and Russell IPM (**5.1**). In particular, the application of this research has enabled Russell IPM, an SME based in the UK, to expand their products and increase their turnover by more than £6 million from 2013 to 2018, doubling profit in that period (**5.2**, **5.3**). A significant proportion of the increase in turnover was due to the success of insect traps developed from CAEP research, with over 200,000 of the traps sold in 2017, most of which were exported to Europe, America, Asia, Africa and Australasia (**5.3**). For example, as a result of Keele's research for a Knowledge Transfer Partnership (KTP), sales of board traps alone increased from £0.5 million to £1 million between 2014 and 2016. The company has been able to increase market share and expand by employing 16 new staff in 2018 (**5.2**).

The most successful new product, *Optiroll Super Plus*, a sticky trap for thrips, incorporated Keele's thrips pheromone and was developed further through Keele's KTP. The Russell IPM team with Keele scientists carried out multiple field trials to identify the most attractive pattern (**5.1**, **5.4**). Following this, testing in various crops across the globe, in South America, Africa and the UK, proved the effectiveness of the trap against thrips (**5.4**).

The *Optiroll Super Plus* trap has been found to offer effective protection against thrips in UK strawberry crops, resulting in 73% less fruit damage and a reduction of thrips on the crop by 53-87%, when used as part of an integrated pest management programme (**5.5**) and was also effective in strawberry crops in Mexico, reducing infestation levels by 50% (**5.6**). When using *Optiroll*, strawberry growers' returns in the UK increased by an estimated £2,000 per hectare, as a result of reduced fruit damage (**5.5**). These pheromone traps are being used increasingly by commercial flower growers in Kenya. At an integrated thrips management workshop near Nairobi in 2019, 31% of participants had used thrips pheromones and 65% were considering using them (66 participants in total) (**5.7**). In 2016, the *Optiroll Super Plus* trap won an Innovation Award at an agricultural expo (expoDirekt and expoSE) in Karlsruhe, Germany, which is an international annual event with up to 500 exhibitors and over 6000 visitors (**5.8**). In 2018, Russell IPM was awarded the Queen's Award for Enterprise: Innovation for the *Optiroll Super Plus* trap for western flower thrips, developed with Keele University (**5.9**).

Sustainable farming: reducing pesticide use

Growers faced with damaging western flower thrips have had little choice but to turn to chemical pesticides to save the crop, however, populations of western flower thrips throughout the world have become resistant to commonly used pesticides, such as spinosad. The *Optiroll Super Plus* trap and other traps with patterns and improved colours developed by Keele offer an effective alternative to pesticides when used as part of a sustainable integrated pest management programme. For example, in Ecuador a field trial of the *Optiroll Super Plus* trap showed that the capture rate of the trap was high enough to significantly suppress thrips populations when compared to conventional chemical applications (**5.4**). The commercial availability of these traps has allowed farmers from across the globe to use less pesticide. In the UK, strawberry farmers using the traps have changed from routine applications of pesticide to just one or two applications in a six-month season (**5.5**); and in Nairobi, Kenya, Evergreen Crops Limited, which grows herbs for export to Europe, now use two initial sprays instead of five, reducing their insecticide use by 15-20% (**5.10**). Strawberry growers in Mexico reported that the traps gave adequate control of western flower thrips without the need for insecticides (**5.6**). Collectively, this reduces pesticide residues in fruit and the environment, to the benefit of wildlife and consumers.

5. Sources to corroborate the impact (indicative maximum of 10 references)

5.1 Product brochure, 2019, 'Changing the pattern of IPM' from Russell IPM Ltd

5.2 Russell IPM Ltd. Key financials and employee numbers (2012-2018)

5.3 Testimonial letter, 9 October 2020, from Dr Shakir Al-Zaidi, CEO of Russell IPM Ltd

5.4 Online article, 14 Sep 2015, 'Patterned sticky roll captures 450% more thrips' in HortiDaily.com

5.5 'Thrips come to a sticky end' in Advances Wales: The Journal for Science, Engineering and Technology, Issue 85, Summer 2018, p.11

5.6 'Russell IPM is launching Optiroll Super Plus in USA' from Russell IPM Ltd, Newswire, 9th October 2017

5.7 Mentimeter survey of growers, 24 May 2019, from a Sustainable Thrips Management Workshop in Kenya

5.8 'Russell IPM wins an innovation award at the Strawberry and Asparagus Fair', AgroNews, 18 Nov 2016

5.9 The Queen's Awards for Enterprise 2018 Winners, pg 107.

5.10 Testimonial Mr Arun Singh, General Manager of Evergreen Crops Ltd (Nairobi, Kenya), 26th March 2019