PUSH-PULL - a novel strategy for pest management

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Figure 1. Trap catch of hoverflies, *Episyrphus balteatus*, on yellow sticky traps baited with MagiPal.

A PUSH-PULL pest management strategy has been tested in fruit, vegetable and tree crops. PUSH-PULL uses semiochemical techniques to PUSH pests away from crops, PULL pests onto traps and to PULL natural enemies into crops. Very small quantities of naturally occurring semiochemicals are required to elicit a response from insects. They do not need to be applied directly onto crops, making them safe to use for growers and consumers alike. Initial studies showed that PUSH-PULL strategies can make a useful contribution to Integrated Pest Management (IPM) programmes by increasing natural enemy establishment and reducing pest numbers by 39-95% in replicated field trials.

In high value crops, most European growers rely on natural enemies as the first line of defence for pest management, only using pesticides when the predator prey ratio gets out of balance. Biocontrol can break down when natural enemy establishment is disrupted by pesticide use, or by poor environmental conditions, so there is a need for more robust IPM programmes. Russell IPM is developing a push-pull crop management strategy to complement biological pest control, combining specialist traps and pheromone lures together with the natural enemy attractant/ pest repellent, MagiPal™. The addition of PUSH-PULL solutions can make IPM programmes more robust, thereby reducing reliance on chemical insecticides.

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Components of the strategy

Plants respond to adverse conditions and insect attack by synthesising phenolic compounds (PCs), which offer them some protection (Filgueiras *et al.,* 2019). These aromatic compounds are used as a cue by other organisms. Pests avoid areas with PCs when they are looking for a food source free from other pests. Predators and parasitoids use PCs as a cue to find prey or hosts. They spend more time searching for prey within the vicinity of PCs, resulting in increased predation and fewer pests (Kelly *et al.,* 2014). A wide range of natural enemies from different insect orders are attracted to PCs, including hoverflies (Diptera), ladybirds (Coleoptera), lacewings (Neuroptera) and predatory mites (Phytoseiidae) (Salamanca *et al.,* 2019). This makes them a useful addition to IPM programmes where natural enemies are released routinely to control a range of pests. MagiPal™ dispensers are specially formulated to give an even release of PCs for a period of 2- 3 months dependent on temperature. To test the attraction to natural enemies, a trial was set up in semi-protected strawberry using yellow sticky traps baited with MagiPal. The addition of MagiPal to traps tripled the trap catch of hoverflies, *Episyrphus balteatus* (Figure 1).

PULL - Traps and pheromones

Colours and scents are used by flower-inhabiting pests to locate flowers, and both are utilised to increase trap catch for pest monitoring or control (Kirk, 1984). Western flower thrips (WFT) *Frankliniella occidentalis* is most attracted to a specific shade of blue, with a peak reflectance at 450 nm, in greenhouse-grown crops (Brødsgaard, 1989). This attraction can be enhanced by the addition of the WFT aggregation pheromone, neryl (*S*)-2-methylbutanoate, which activates both males and females (Sampson *et al.,* 2012). The blueberry midge, *Dasineura oxycoccana*, is attracted to white, which is the colour of its host plant flowers. This attraction can be enhanced by adding their sex pheromone (Fitzpatrick *et al.,* 2013) which attracts males. Russell IPM has developed a specialist range of traps (Optiroll PLUS™) of optimum colour that incorporate species-specific pheromones into the glue of sticky roller traps to maximise trap catch. Optiroll PLUS™ has proved a powerful PULL to pests, sufficient to reduce pest numbers and crop damage (Sampson and Kirk, 2013).

Field trial results in UK

Strawberry

The western flower thrips is a cosmopolitan, polyphagous insect pest that causes bronzing to fruit of strawberry. Control relies on releases of predatory mites as

Figure 2 a) Optiroll Super Plus Blue in strawberry.

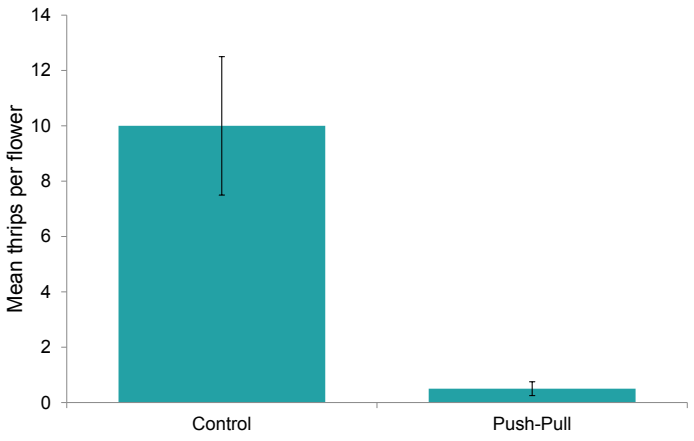

Figure 2 b) The effect of push-pull strategy on thrips numbers.

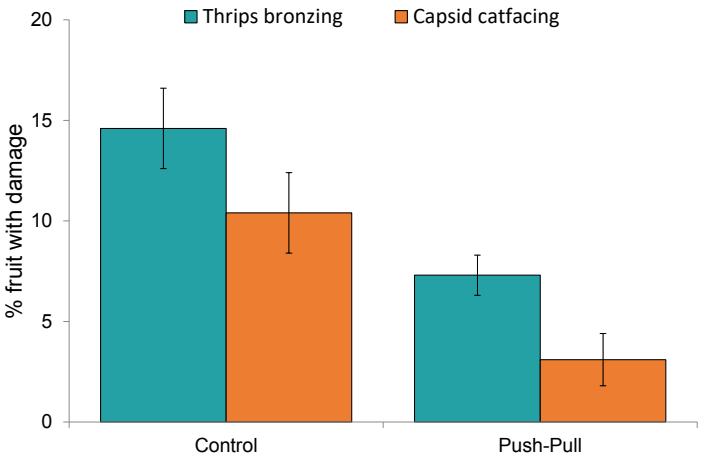

Figure 2 c) The effect of push-pull strategy on thrips and capsid damage.

WFT is resistant to most pesticides approved for its control. The aim of this study was to test whether the addition of the push-pull strategy could reduce thrips numbers and crop damage. Fruit was also assessed for capsid damage. In semi-protected strawberry crops, the push-pull strategy using blue sticky roller traps infused with WFT pheromone down the leg rows of the polytunnel (Figure 2a), plus MagiPal™ at 10 m intervals, reduced adult thrips numbers per flower by 95% and fruit bronzing by 50% (Figure 2b, 2c). The strategy also reduced capsid damage (cat-facing) by 70%.

Blueberry

The blueberry gall midge, *Dasineura oxycoccana,* is a damaging invasive pest of highbush blueberry, in Europe. It is also a serious pest in North America. The midge lays its eggs in shoot tips, causing leaf distortion and blackening buds. Serious attacks can affect the following season's growth. With the withdrawal of thiacloprid from the market, growers have limited IPM compatible control methods available against this pest. The aim of this study was to test whether the push-pull strategy could reduce blueberry midge numbers →

Figure 3 a) Optiroll Super Midge White (top) and b) MagiPal in blueberry

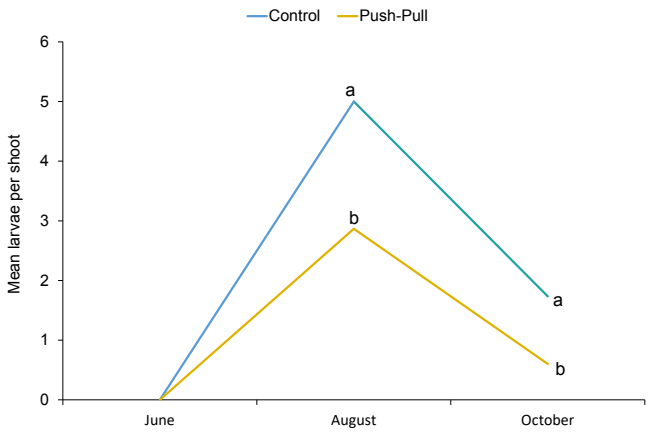

Figure 3 c) The effect of push-pull strategy on blueberry midge larvae per shoot.

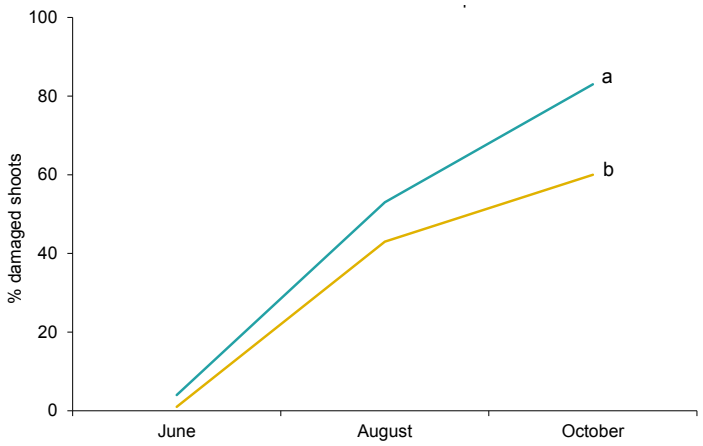

Figure 3 d) The effect of push-pull strategy on shoot damage.

and crops damage. The push-pull strategy consisted of MagiPal blister packs attached to the top of 1 m posts, at 10 m intervals and white roller traps infused with midge pheromone (Optiroll super Midge white) along the polytunnel 'legs' at 20 cm above ground (Figure 3a, 3b). Treatments were applied in June before blueberry midge emergence. In semi-protected blueberry, the push-pull strategy reduced the number of midge larvae per shoot by 65% and reduced the shoot damage by 28% (Figure 3c, 3d).

This strategy is being tested in a wide range of crops against pest species from different insect orders with very promising results (Table 1). ■

▶ MagiPal™ was developed in a three year Agri-Tech project (Innovate UK, 132167) with Russell IPM, University of Greenwich, NIAB-EMR (East Malling Research), Russell IPM Bangladesh Ltd and Bangladesh Agricultural Research Institute (BARI).

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Table 1. Summary of initial trial results testing the push-pull strategy in different crops.