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THE EFFICACY OF NOVEL PHYSICAL BARRIERS FOR THE MANAGEMENT OF PESTS OF FIELD VEGETABLE CROPS

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Summary: The revocation of many horticultural insecticides, particularly for cabbage root fly (*Delia radicum*) control, has increased the need to evaluate practical alternatives for the control of insect pests on vegetable field crops. One innovative approach being pursued is the use of novel physical barriers that can be applied to crops, which protect them from insect attack. An overview of the initial stages of this work in swedes and carrots, the methodology being followed and some results are presented.

INTRODUCTION

Horticultural production within the UK is a £3 billion industry and a significant employer within rural areas (Spedding *et al*. 2002). The horticultural industry is under increasing pressure to combine sustainable food production with minimal agrochemical use. The increased pressure on UK growers of field vegetables from overseas imports and the revocation of many agrochemicals (particularly organophosphate insecticides), has also led to a need for developing novel approaches to the management of invertebrate pests.

The reliance on specific off-label approvals for many insecticides such as chlorfenvinphos on swedes and turnips for cabbage root fly (*Delia radicum*) control is only a short-term answer and is unsustainable in the long-term. Similarly, dependence on pyrethroid and carbamate insecticides for aphid control increases the risk of insecticide resistance arising, particularly in the peach-potato aphid (*Myzus persicae*), where problems with resistance to organophosphates, pyrethroids and carbamates have been noted in England in the mid-1990's and more recently in Scotland (Woodford *et al*. 2002). In the absence of any effective control measures for cabbage root fly, it will not be possible to grow the high quality root brassica crops demanded by the consumer, which could lead to a cessation of UK grown produce and a significant increase in imported produce.

Physical methods for protecting brassica crops from pest attack have tended to concentrate on minimising damage by cabbage root fly, which lays its eggs at the base of plants. Consequently the use of mesh crop covers (Finch & Collier 2000) and collars around the base of the plant (Mathews-Gehringer & Hough-Goldstein 1988) have been effective. However, these approaches are often labour-intensive, expensive and prone to damage (covers in particular). Use of crop covers limit the options available for control of pests such as slugs, which can thrive under covers, and of weeds and fungal disease. Where covers are damaged, insect pests can gain access to crops and find themselves trapped and protected underneath. Also mesh covers do not act as a barrier to some pests such as aphids and egg-laying by diamondback moth (*Plutella xylostella*), as seen in 2003. Covers can not be used on fields that were previously sown with a similar crop, as emergence of pests such as cabbage root fly after overwintering will lead to them being trapped under the covers.

In response to the concerns outlined above, SAC has obtained funding from DEFRA to assess the efficacy of several innovative approaches to the management of specific pests of brassica and carrot crops through the use of novel physical barriers. Approaches being adopted are summarised below. Whilst these methods are also applicable to organic crop production, we will be assessing their efficacy within conventional field vegetable production, where agrochemicals can be applied if necessary, and will allow the development of IPM programmes that can be utilised within conventional and organic production.

Hemp-derived hydromulch (HHM)
One of the approaches adopted will be the use of a flowable mulch (hydromulch) derived from the biomechanical pulping of hemp, developed by Biofibres Ltd. This process involves the harvesting of annually grown hemp fibres after they have reached their maximum dry weight and are capable of being harvested with standard forage harvesters. The harvested material, after being chopped, is treated with enzymes and allowed to 'biopulp' in a silo. After 6 weeks, the pulp can be mechanically treated, cleaned, and washed for a wide range of applications in the textile and paper industry. Initial trials with several formulations (including coloured mulches) of the hemp flowable hydromulch have produced promising results in terms of pest and weed control in calabrese (Davies, 2001).

Kaolin particle films (KV-6)
Another approach is the use of biodegradable particle films derived from kaolin that can be sprayed onto foliage and the base of plants (Puterka *et al*. 2000). This approach has been comprehensively assessed in top fruit with no deleterious effects on fruit yield and quality (Glenn *et al*. 2001), and initial studies on beans show no negative effects (Tworkoski *et al*. 2002). Use of particle films on fruit crops, based on the inert biodegradable material kaolin, have demonstrated a wide range of effects on invertebrate pests (Puterka *et al*. 2000). The kaolin film also acts as a barrier at the soil-plant interface, and incorporating insect repellents and/or oviposition deterrents into the formulation may enhance its efficacy against some pests (Puterka, pers. comm.).

Sprayable non-woven fibres (EVA)
The third approach to be assessed will be the application of sprayable non-woven fibre barriers applied to the base of plants (Hoffmann *et al*. 2001). Glasshouse and field trials in the use of sprayable non-woven fibre barriers based on extruded polymers (ethyl vinyl acetate – EVA) have demonstrated effective control of root pests such as cabbage root fly and onion fly (Hoffmann *et al*. 2001). Further developments in the use of biodegradable polymers and incorporation of repellent colours and/or contact chemicals can make the use of sprayable fibre barriers more practical, environmentally acceptable and affordable for the management of several root feeding pests of vegetable crops (Hoffmann *et al*. 2001).

Two field trials were carried out in 2003 to evaluate the field efficacy of hemp hydromulch (HHM), kaolin particle films (KV-6) and non-woven fibres (EVA) in protecting a swede crop and a carrot crop from pest damage. Only details of the swede trial are presented here. As the research is still in its infancy, an outline of the approach taken during the first season's field trial is summarised below, with some initial results on cabbage root fly damage and aphid numbers in swedes.

MATERIALS AND METHODS

Swede trial

Initially, nine treatments were applied to a swede crop (cv. Magres, sown on 24/25 May 2003) near Smailholm in the Scottish Borders. The majority of the crop was covered with enviromesh, but the endriggs (which had uncovered plants) were used for the following treatments:

1. Untreated (control)
2. Hemp hydromulch (HHM) at a rate of 2.5% wt/v along the drill in a band 30 cm wide
3. Hemp hydromulch (HHM) at a rate of 2.5% wt/v around the base of individual plants
4. Non-woven fibre (EVA) applied at a pressure of 2 bar
5. Non-woven fibre (EVA) applied at a pressure of 4 bar
6. Kaolin (KV-6) at 1.4g/m2, increasing to 2.8g/m^2 weekly
7. Kaolin (KV-6) at 1.4g/m2, increasing to 2.8g/m^2 bi-weekly
8. Chlorfenvinphos (Birlane 24) at 3 litres/ha
9. Enviromesh

In the trial there were four replicates per treatment, the plots consisting of 4 rows 5 m long arranged in a randomised block design. The HHM treatments were applied prior to cabbage root fly activity (determined from four water traps) at GS20 of the swede crop (23 May 2003). Other treatments were applied when first generation cabbage root fly activity was detected (29 May 2003). The kaolin (KV-6) rate was increased as the plants grew in size, the spray being applied to runoff. The non-woven fibre (EVA) treatments were applied at the same time as the HHM treatments, however technical problems and failure of the EVA fibres to bind to the dry soil surface meant that this treatment was discarded from the trial. Chlorfenvinphos was applied twice for first generation cabbage root fly control (29 May and 5 June 2003), and once for second generation control (16 July 2003). Damage scores (on a scale of 0-5, where 0 = no damage and 5 = no root system left) were assessed for 1st and 2nd generation cabbage root fly (n=80 per treatment). Data was analysed using analysis of variance.

RESULTS

The root damage scores for 1st generation cabbage root fly are shown in Fig. 1. Swedes under the mesh had little root damage, whilst the chlorfenvinphos treatment suffered the highest level of damage, despite two applications, although this was not significantly different from the other treatments. The only significant differences in damage were obtained for 2nd generation damage (results not shown) between the two HHM treatments, where damage to the plants when HHM was applied along the drill was greater than HHM applied to the base of the plant ($P < 0.05$) – mean damage scores of 3.55 and 3.28 respectively. The mesh treatment was significantly less damaged by 1st and 2nd generation cabbage root fly ($P < 0.01$).

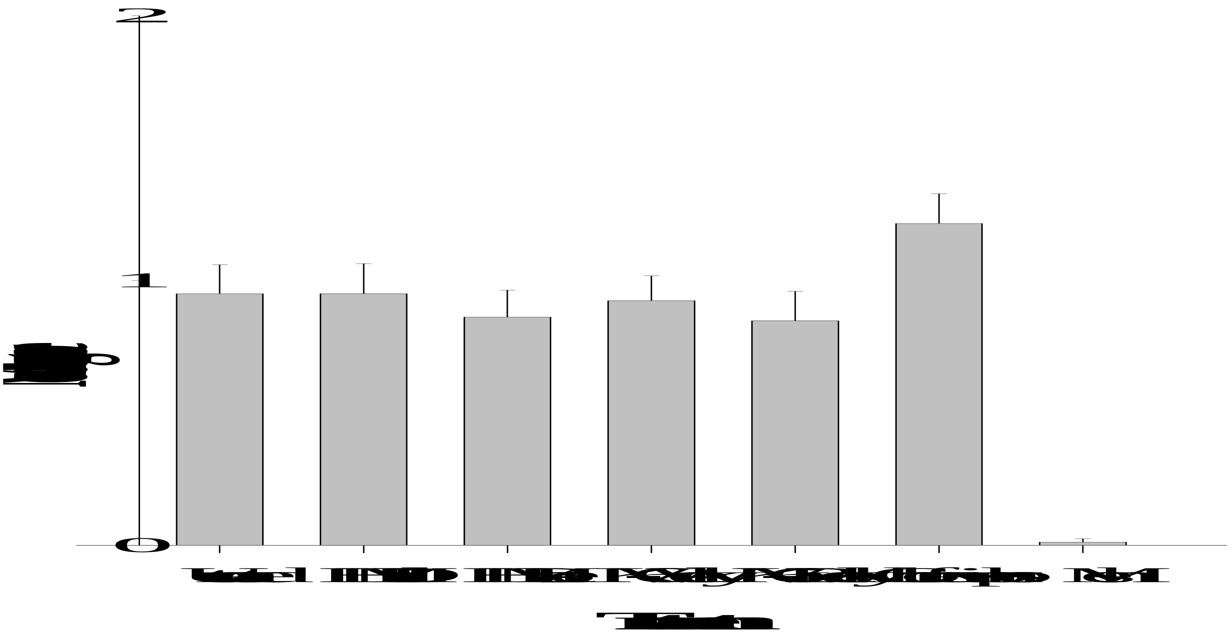

Fig. 1. Mean root damage (± SE) by 1st generation cabbage root fly on a score of 0-5 (n=80).

The HHM Drill and KV-6 treatments tended to delay the infestation of plants with aphids (Figs. 2 & 3). Peach-potato aphid (*Myzus persicae*) numbers (counted biweekly on 10 plants per plot) do not rise until 2 weeks after the peak numbers on the untreated, chlorfenvinphos and HHM Base-treated plants (Fig. 2). Cabbage aphids (*Brevicoryne brassicae*) are absent on the KV-6 Weekly plots until September (Fig. 3).

DISCUSSION

The experience of carrying out the first season of trials on swedes and carrots have highlighted certain areas that need to be addressed before further trials are carried out in Scotland and England in 2004 and 2005.

Applying the hemp hydromulch (HHM) was difficult, and issues regarding application of an even distribution and thickness of the mulch need to be addressed. Glasshouse results suggest that mulch thickness is important in preventing cabbage root fly eggs/larvae reaching the roots.

The application of the kaolin (KV-6) treatments were relatively straightforward, being a wettable powder formulation suspended in water. The results from the trials suggest that the weekly application in particular is effective at keeping aphids off plants for at least 2 weeks compared to other treatments. The sprayable non-woven fibre treatments were disappointing, mainly due to a failure of the fibres to adhere to the soil surface, which meant that windy conditions blew the fibres off the plants. Glasshouse tests indicate that soil surfaces need to be wet to achieve adhesion of the fibres, so this will need to be taken into account for future trials.

There was a very high pressure of 2nd generation cabbage root fly on the swede trial in 2003 (up to 40 eggs per plant in the untreated plots) which is likely to be due to a combination of the season, and also flies being diverted away from the mesh onto the uncovered trial plots. Even the use of the chlorfenvinphos insecticide treatment did not have an effect on cabbage root fly damage (Fig. 1).

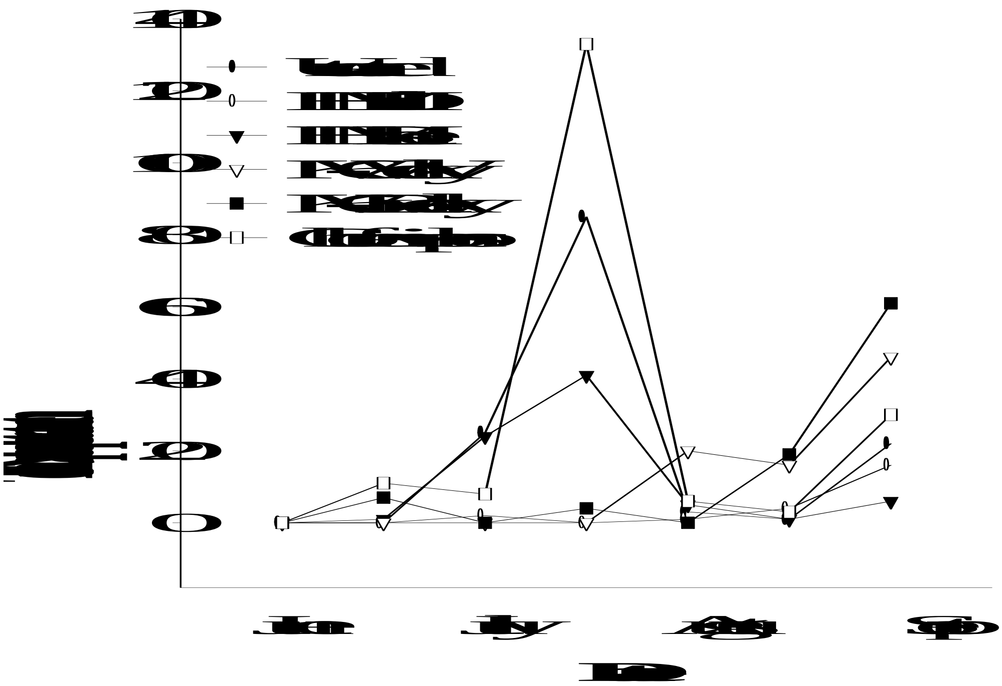

Fig. 2. Total No. of peach-potato aphids (*Myzus persicae*)/treatment sampled bi-weekly.

A broader range of treatments are envisaged for future trials, which will include the addition of colour to the different treatments for visual repellency and the inclusion of specific insect pest repellents and oviposition deterrents. Glasshouse and laboratory studies are on-going to identify which additional treatments will be utilised in trials on swedes, carrots and calabrese crops in 2004.

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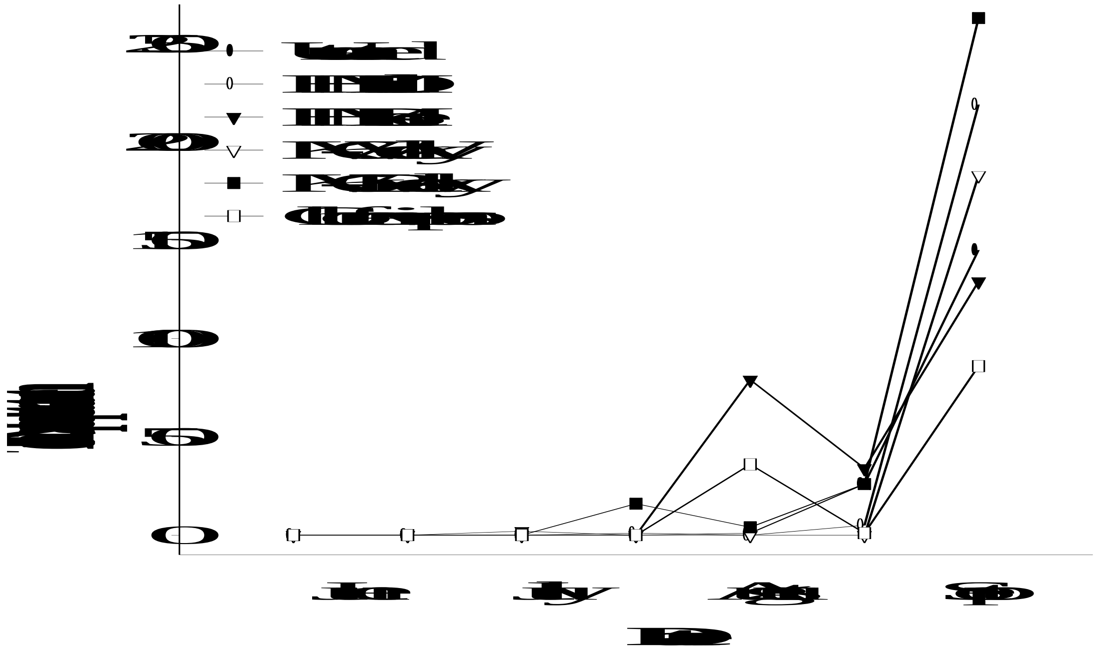

Fig. 3. Total No. of cabbage aphids (*Brevicoryne brassicae*)/treatment sampled bi-weekly.

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