

Cook, S. M., Jönsson, M., Skellern, M. P., Murray, D. A., Anderson, P. & Powell, W. (2007). Electrophysiological and behavioural responses of *Phradis* parasitoids to volatiles of Lavender, *Lavendula angustifolia* - a possible repellent for their host, *Meligethes aeneus* *BioControl* (in press).

Abstract: Hymenopterous parasitoids of herbivorous insects can be useful biocontrol agents in integrated pest management strategies. However, the potential effects on these beneficials of new components in such strategies are often neglected. Essential oil of lavender, *Lavendula angustifolia* (Miller) (Lamiaceae), has recently been identified as a potential repellent in new control strategies being developed for the pollen beetle *Meligethes aeneus* (Coleoptera: Nitidulidae), a major pest of oilseed rape, *Brassica napus* L. (Brassicaceae). We tested the electrophysiological and behavioural responses of two common parasitoids of *M. aeneus*: *Phradis interstitialis* (Thomson) and *P. morionellus* (Holmgren) (both Ichneumonidae) using coupled gas chromatography-electroantennodetection (GC-EAD) and olfactometry techniques. Both species elicited electrophysiological responses to lavender oil volatiles, including two compounds known to be repellent to *M. aeneus*. However, the parasitoids gave no significant responses to the odours of lavender oil in behavioural bioassays and there was no evidence to suggest that lavender-treated oilseed rape plants would reduce host habitat location by parasitoids of the target pest.

Cook, S. M., Khan, Z. R. & Pickett, J. A. (2007). The use of push-pull strategies in integrated pest management. *Annual Review of Entomology*, 52: 375-400.

Abstract: 'Push-pull' strategies involve the behavioural manipulation of insect pests and their natural enemies via the integration of stimuli which act to make the protected resource unattractive or unsuitable to the pests (push) whilst luring them towards an attractive source (pull) from where the pests are subsequently removed. The 'push' and 'pull' components are generally non-toxic. Therefore, the strategies are usually integrated with methods for population reduction, preferably biological control. Push-pull strategies maximise efficacy of behaviour-manipulating stimuli by multiple deployment. By orchestrating a predictable distribution of pests, efficiency of population-reducing components can also be increased. The strategy therefore represents a useful tool for use in integrated pest management programs reducing pesticide input. We describe the principles of the strategy, list the potential components, and present case studies reviewing work on the development and use of push-pull strategies in each of the major areas of pest control.

Cook, S. M., Rasmussen, H. B., Birkett, M., Woodcock, C. M., Murray, D. A., Pye, B. J., Watts, N. P., & Williams, I. H. (2007). Behavioural and chemical ecology of the success of turnip rape (*Brassica rapa*) trap crops in protecting oilseed rape (*Brassica napus*) from the pest *Meligethes aeneus*. *Arthropod Plant Interactions* (in press).

Abstract: There is increasing interest in the use of trap crops as components of integrated pest management (IPM) strategies. Understanding the mechanisms underlying host plant preferences of herbivorous pests can lead to improved effectiveness and reliability of the trap crop. We investigated the behavioural and chemical ecology underlying the success of turnip rape, *Brassica rapa*, trap crops in protecting oilseed rape, *Brassica napus*, from the pollen beetle, *Meligethes aeneus*, which feeds in the flowers and lays its eggs in the buds causing yield loss. Using a semi-field arena bioassay, plant growth stage was found to be a major factor in the preference of this pest for *B. rapa* over *B. napus*. Plants at early-flowering growth stages were preferred over plants in the bud stage, irrespective of species. No preference was found when both species were flowering. As *B. rapa* develops faster than *B. napus* in the field, this could explain part of the mechanism of its success as a trap crop. However, *B. rapa* was preferred over *B. napus* when both species were in the bud stage, indicating some inherent preferences for *B. rapa*. Responses of *M. aeneus* in olfactometer tests to the odours of *B. napus* and *B. rapa* at the bud and flowering growth stages, reflected those of the semi-field arena bioassay. These behavioural responses can be explained by volatile compounds associated with the flowering stage. Phenylacetaldehyde, indole and

(*E,E*)-a-farnesene were found to be present in air entrainment samples of both plant species at the flowering growth stage, but only in those of *B. rapa* at the bud stage. The former two compounds were behaviourally-active in olfactometer tests. These compounds are likely to be involved in host location by *M. aeneus*, and, at least partially, responsible for the attractiveness of *B. rapa* and its success as a trap crop to protect *B. napus* from this pest.

Barari, H., **Cook, S. M.** & Williams, I. H. (2006). Rearing the larval parasitoids of *Psylliodes chrysocephala* and *Ceutorhynchus pallidactylus* from field-collected specimens. *Bulletin IOBC/wprs: Integrated Control in oilseed crops* 29(7):213-224.

Abstract: *Psylliodes chrysocephala* (L.) (Coleoptera: Chrysomelidae) (cabbage stem flea beetle) and *Ceutorhynchus pallidactylus* (Marsh.) (Coleoptera: Curculionidae) (cabbage stem weevil) are two major stem-mining pests of oilseed rape (*Brassica napus*) in the UK. Little information is available on the occurrence, importance and efficiency of parasitoids in the biocontrol of these pests, due to sampling difficulties and inadequate knowledge on rearing and identification methods for the adults.

In this study, we developed an efficient method of rearing the larval parasitoids of *P. chrysocephala* and to a lesser extent, *C. pallidactylus* from field-collected specimens in order to identify the active larval parasitoids of these pests. Plant samples were collected in 2002 and 2003 from unsprayed winter oilseed rape crops at ~10-day intervals from mid-April until July. The samples were kept in cages in an outdoor insectary and the pest larvae were collected as they left naturally from the plant stems when ready to pupate. The larvae were identified to species and put into either 'pot emergence trap' or 'corked tube' containers containing sterilised soil, then kept under natural environmental conditions in the insectary. The adult pests were collected and counted as they emerged. The soil of the containers was then examined and parasitoid cocoons sorted from it, collected and counted. The cocoons were dissected and the pre-emergence adult parasitoids were removed and identified.

Adding 20% sharp sand to the soil increased the proportion of parasitoid cocoons found and reduced mortality in both containers. More parasitoid cocoons were found and lower mortality occurred in corked tubes than pot emergence traps in both years. These results suggest that the addition of sand to the soil and the use of corked tube containers contributed to the rearing success of the parasitoids by providing better conditions for their development. *Tersilochus microgaster* Szé. and *T. obscurator* Aub. (Hymenoptera: Ichneumonidae) were reared from *P. chrysocephala* and *C. pallidactylus* larvae, respectively. These parasitoids were identified for the first time in the UK as active parasitoids of these pests.

Cook, S.M., Murray, D.A., Watts, N.P., & Williams, I.H. (2006). Responses of pollen beetles (*Meligethes aeneus*) to conspecific odours. *Bulletin IOBC/wprs: Integrated Control in oilseed crops* 29(7):143-150

Abstract: As part of ongoing studies to investigate insect-derived semiochemicals for use in pest control strategies for oilseed rape (*Brassica napus*), the responses of male and female pollen beetles (*Meligethes aeneus*), to conspecific odours was assessed in laboratory and semi-field experiments. In laboratory bioassays using a linear track olfactometer, we found no evidence for the existence of a male-produced aggregation pheromone; male pollen beetles did not respond to the odours from groups of other males. However, female beetles were repelled by the odours from a large group of females (200 individuals). This response was not shown in tests involving male beetles. These results suggest that females show epideictic (spacing) behaviour in response to high densities of other females. This response was found to be at least partially due to the odour of the females themselves, rather than due to the volatiles from female-damaged plant material. The results from semi-field and field-scale experiments however, failed to support preliminary laboratory evidence for the existence of a female-produced epideictic pheromone in the pollen beetle.

Cook, S.M., Skellern, M.P., Smith, M.J. & Williams, I.H. (2006). Responses of pollen beetles (*Meligethes aeneus*) to petal colour. *Bulletin IOBC/wprs: Integrated Control in oilseed crops* 29(7):151-160

Abstract: It is well known that the pollen beetle (*Meligethes aeneus*), a major pest of oilseed rape (*Brassica napus*) inflorescences, is attracted to the yellow colour of the flowers. Little is known however, about how variation in flower colour might affect host plant location and subsequent infestation by this pest. We investigated the responses of new-generation pollen beetles to a range of differently-coloured traps and to flowers of a white-petalled oilseed rape cultivar that had been dyed different colours. In the field, beetles were significantly more attracted to sticky traps coloured yellow than other colours. Black and blue coloured traps caught fewest beetles. In wind tunnel and field experiments using racemes and potted plants with dyed flowers, flowers dyed blue were less attractive than yellow, untreated white, and red flowers. The potential for manipulation of petal colour in control strategies for this pest is discussed.

Cook, S.M., Smart, L.E., Martin, J.L., Murray, D.A., Watts, N.P. & Williams, I.H. (2006). Exploitation of host plant preferences in pest management strategies for oilseed rape (*Brassica napus*). *Entomologia Experimentalis et Applicata* 119:221-229.

Abstract: New control strategies for insect pests of arable agriculture are needed to reduce current dependence on synthetic insecticides, the use of which is unsustainable. We investigated the potential of a simple control strategy to protect spring-sown oilseed rape, *Brassica napus* L. (Brassicaceae), from two major inflorescence pests: the pollen beetle, *Meligethes aeneus* (Fabricius) (Coleoptera: Nitidulidae), and the seed weevil *Ceutorhynchus assimilis* (Paykull) (Coleoptera: Curculionidae), through exploitation of their host plant preferences. The strategy comprised, for the main crop, Starlight [an oilseed rape cultivar with relatively low proportions of alkenyl glucosinolates in the leaves (thereby releasing lower levels of attractive isothiocyanates than conventional cultivars)] and turnip rape, *Brassica rapa* (L.) (Brassicaceae), as a trap crop. We tested the system in laboratory, polytunnel semi-field arena, and field experiments. The odours of Starlight were less attractive in olfactometer tests to both pests than those from a conventional cultivar, Canyon, and the plants were less heavily colonized in both polytunnel and field experiments. Turnip rape showed good potential as a trap crop for oilseed rape pests, particularly the pollen beetle as its odour was more attractive to both pests than that of oilseed rape. Polytunnel and field experiments showed the importance of relative growth stage in the system. As turnip rape flowers earlier than oilseed rape, beetles would be maintained on turnip rape past the damage-susceptible growth stage of oilseed rape. The development of a pest control regime based on this strategy is discussed.

Cook, S.M., Watts, N.P., Castle, L.M., & Williams, I.H. (2006). Determining the sex of insect pests of oilseed rape for behavioural bioassays. *Bulletin IOBC/wprs: Integrated Control in oilseed crops* 29(7):205-212.

Abstract: Male and female insects of the same species often have different requirements for host plants, food resources and space. Therefore, insect responses to such stimuli in behavioural bioassays may vary according to the sex of the individuals tested. In order to compare differences in behavioural responses between female and male subjects, it is often necessary to determine the sex of an individual before its use in bioassays. Reliable techniques of determining the sex of live subjects which do not harm them are available for some species. We describe methods used to determine the sex of live, field-collected individuals of three major pest species of oilseed rape: pollen beetles (*Meligethes aeneus*), cabbage seed weevils (*Ceutorhynchus assimilis*) and cabbage stem flea beetles (*Psylliodes chrysocephala*).

Barari, H., **Cook, S. M.** & Williams, I. H. (2005). The effect of a turnip rape (*Brassica rapa*) trap crop on stem-mining pests and their parasitoids in oilseed rape (*Brassica napus*). *BioControl* 50 (1):69-86.

Abstract Concerns about the negative effects of chemical control of oilseed rape (*Brassica napus* L.) pests on non-target species, human safety, and development of insecticide resistance, require alternative control strategies such as the use of trap crops and biocontrol to be developed. *Psylliodes chrysocephala*(L.) (Coleoptera: Chrysomelidae) (cabbage stem flea beetle) and *Ceutorhynchus pallidactylus* (Marsh.) (Coleoptera: Curculionidae) (cabbage stem weevil) are two major stem-mining pests of oilseed rape. This study investigated the phenology of these pests and their main parasitoids in the UK, the potential use of turnip rape (*Brassica rapa* L.) as a trap crop to reduce oilseed rape infestation, and the effects of insecticide treatment on pest incidence and larval parasitism. Water trap samples, plant dissections and pest larval dissections were done to determine: the incidence of adult pests and their parasitoids, the level of plant infestation by the pests and percentage larval parasitism, respectively. The turnip rape trap crop borders reduced *P. chrysocephala* but not *C. pallidactylus* infestation of oilseed rape plots. Treatment of the trap crop with insecticide had little effect on either pest or parasitoid incidence in the oilseed rape. *Tersilochus microgaster* Szé. and *T. obscurator* Aub. (Hymenoptera: Ichneumonidae) were the main larval parasitoids of *P. chrysocephala* and *C. pallidactylus*, respectively. *Tersilochus microgasteris* reported for the first time in the UK. The implications for integrated pest management are discussed.

Cook, S. M., Sandoz, J.C., Martin, A. P., Murray, D. A., Poppy, G. M., & Williams, I. H. (2005). Could learning of pollen odours by honey bees (*Apis mellifera*) play a role in their foraging behaviour? *Physiological Entomology* 30 (2) 164-174.

Abstract: The role of pollen odour cues in the foraging behaviour of honey bees (*Apis mellifera* L.) is poorly understood. Using classical conditioning of the proboscis extension response, in which bees learn to associate an odour with a sucrose reward, the present study tests whether odours of bee-collected pollen from the hive environment or odours of fresh pollen on the anthers of flowers could be used in pollen foraging. Honey bees efficiently learn odours from field-bean (*Vicia faba*) bee-collected pollen and oilseed-rape (*Brassica napus*) bee-collected pollen, hand-collected pollen, anthers and whole flowers, demonstrating that honey bees can learn pollen odours associatively in biologically realistic concentrations. Honey bees learn pollen odours of oilseed rape better than field bean and, although they generalize these two odours, they easily distinguish between them in discrimination tests, suggesting that pollen odours may be used in species recognition/discrimination. There is little evidence that honey bees can recognize whole flowers based on previous experience of bee-collected pollen odour. However, they generalize the odours of oilseed-rape anthers and whole flowers, suggesting that anther pollen *in situ* may play a more prominent role than bee-collected pollen in foraging behaviour.

Cook, S. M., Watts, N. P., Hunter, F. J., Smart, L. E., & Williams, I. H. (2004). Effects of a turnip rape trap crop on the spatial distribution of *Meligethes aeneus* and *Ceutorhynchus assimilis* in oilseed rape. *Bulletin IOBC/wprs: Integrated Control in oilseed crops* 27 (10): 199-206.

Abstract: Alternative control strategies for insect pests of oilseed rape (*Brassica napus*) are needed to help reduce the current reliance on insecticide treatments. We investigated the effect of a turnip rape (*Brassica rapa*) trap crop border on the abundance and spatial distribution of two major oilseed rape pests, the pollen beetle (*Meligethes aeneus*) and the cabbage seed weevil (*Ceutorhynchus assimilis*) in oilseed rape plots. Pest abundance was recorded throughout the growing season at spatially referenced sampling points evenly arranged within the plots. Growth stage of the plants in the plot centres and borders were also assessed. The turnip rape developed more quickly than the oilseed rape. Pollen beetle abundance was greater overall in the plot with a turnip rape border than in the control plot. However, beetles were retained in the turnip rape border and consequently the population in

the oilseed rape plot centre was lower than in the plot without a turnip rape trap crop. This effect lasted throughout the pollen beetle damage-susceptible stage of oilseed rape (green-yellow bud) and until the oilseed rape was in late flower and the turnip rape trap crop was in pod. Seed weevil infestation was low and the turnip rape trap crop had little effect on weevil distribution. The usefulness of this trap-cropping strategy for control of the pollen beetle and seed weevil is discussed.

Cook, S. M., Murray, D. A., & Williams, I. H. (2004). Do pollen beetles need pollen? The effect of pollen on oviposition, survival, and development of a flower-feeding herbivore *Ecological Entomology* 29:164-173

Abstract. 1. Pollen is considered to be an important dietary component for many species of flower-feeding herbivores. Its influence on oviposition site selection by the pollen beetle *Meligethes aeneus*, and on the development of its larvae was investigated.

2. The effects of pollen presence and absence on adult, egg, and larval incidence in the field, and on larval development in the laboratory were compared through the use of Synergy, a composite hybrid oilseed rape *Brassica napus* variety comprising male-fertile (with pollen) and male-sterile (without pollen) plants.

3. In the field, adult females were more abundant on male-fertile plants during flowering, and a greater proportion of male-fertile than male-sterile buds were accepted for oviposition. These data indicate a possible role of pollen in oviposition site selection by female pollen beetles.

4. The numbers of first instar larvae on the two plant lines did not differ; however, more second instars were found on male-fertile than on male-sterile flowers. This suggests a greater larval survival on male-fertile plants, possibly due to the more readily available food resources and better nutrition afforded by the presence of pollen.

5. Laboratory experiments confirmed that a diet which included pollen improved survival to adulthood and resulted in heavier pupae and adults; however, pollen was not obligatory for larval survival and development.

6. The pollen beetle, previously thought to be an obligate pollen feeder, is therefore more generalist in its requirements for development. These findings may relate to the nutritional and behavioural ecology of other flower-feeding herbivores.

Cook, S. M., Awmack, C. S., Murray, D. A., & Williams, I. H. (2003). Are honeybees' foraging preferences affected by pollen amino acid composition? *Ecological Entomology* 28: 622-627.

Abstract. 1. Although pollen is a vital nutritional resource for honey bees, *Apis mellifera*, the influence of pollen quality on their foraging behaviour is little understood.

2. In choice-test experiments, bees showed no innate pollen-foraging preferences, but preferred oilseed rape *Brassica napus* pollen over field bean *Vicia faba* pollen after previous foraging experience of oilseed rape.

3. The free amino acid content of oilseed rape and field bean pollen was compared using high-performance liquid chromatography. Oilseed rape pollen contained a greater proportion of the *most essential* amino acids required by honey bees (valine, leucine, and isoleucine) than field bean, suggesting that oilseed rape pollen is of greater nutritional quality for honey bees than is field bean pollen.

4. Honey bee foraging preferences appeared to reflect pollen quality. The hypothesis that pollen amino acid composition affects the foraging behaviour of honey bees is discussed.

Cook, S. M., Smart, L. E., Rasmussen, H. B., Bartlet, E., Martin, J. L., Murray, D. A., Watts, N. P., Williams, I. H. (2003). Push-Pull strategies to reduce insecticide input to oilseed rape (*Brassica napus*): Potential of low alkenyl glucosinolate oilseed rape varieties (push!), and turnip rape (*Brassica rapa*) trap crops (pull!). *Proceedings of the 11th International Rapeseed Congress: Toward enhanced value of cruciferous oilseed crops by optimal production and use of high quality seed components*. The Royal Veterinary and Agricultural University, Copenhagen, Denmark. July 6-10 2003. Volume 3 pp1018-1021.

Abstract The potential use of low alkenyl glucosinolate oilseed rape cultivars (Low GS) and a turnip rape trap crop in a push-pull strategy to control insect pests on oilseed rape was investigated. In olfactometer studies, a low GS cultivar was less preferred by pollen beetles (*Meligethes aeneus*) and cabbage seed weevils (*Ceutorhynchus assimilis*) than a conventional cultivar. This preference was not observed in the field, although turnip rape was preferred over oilseed rape and showed good potential as a trap crop for pollen beetles, though not for seed weevils.

Barari, H., **Cook, S. M.**, Watts, N. P., Williams, I. H. (2003). Effects of a turnip rape (*Brassica rapa*) trap crop and insecticide treatment on infestation of winter oilseed rape (*Brassica napus*) by coleopteran stem-mining pests and their parasitoids. *Proceedings of the 11th International Rapeseed Congress: Toward enhanced value of cruciferous oilseed crops by optimal production and use of high quality seed components*. The Royal Veterinary and Agricultural University, Copenhagen, Denmark. July 6-10 2003. Volume 3 pp1015-1017.

Abstract The effects of turnip rape (*Brassica rapa*) trap crop borders with and without insecticide treatment on infestation of winter oilseed rape (*Brassica napus*) by the coleopteran stem-mining pests: *Psylliodes chrysocephala* and *Ceutorhynchus pallidactylus* and their parasitoids were investigated. The presence of turnip rape borders reduced *P. chrysocephala* but not *C. pallidactylus* infestations in the oilseed rape crop. Insecticide treatment of the turnip rape borders had no further effect on infestation of the oilseed rape by either pest. No parasitised larvae of *P. chrysocephala* were found in the oilseed rape crop centres, but parasitism was highest on unsprayed turnip rape borders. Parasitism of *C. pallidactylus* was high and was unaffected by treatment or plant species. Thus, an untreated trap crop of turnip rape has potential for reducing infestation of oilseed rape by *P. chrysocephala* but not by *C. pallidactylus* within an integrated pest management system.

Cook, S. M., Smart, L. E., Potting, R. J. P., Bartlet, E., Martin, J. L., Murray, D. A., Watts, N. P., & Williams, I. H. (2002). Turnip rape (*Brassica rapa*) as a trap crop to protect oilseed rape (*Brassica napus*) from infestation by insect pests: potential and mechanisms of action. *Proceedings of the British Crop Protection Council International Conference*. 18-21 November 2002. Volume 2 pp 569-574.

Abstract The potential of turnip rape (*Brassica rapa*) for use as a trap crop to protect spring oilseed rape (*Brassica napus*) from infestations by pollen beetles (*Meligethes aeneus*) and seed weevils (*Ceutorhynchus assimilis*) was demonstrated in the field, and experiments investigating the mechanisms of its successful action initiated. Turnip rape plots developed more quickly, and became infested with pests earlier than those of oilseed rape. Pollen beetles remained on turnip rape until the oilseed rape was well past the damage-susceptible stage of yellow bud. Seed weevil numbers remained low on oilseed rape throughout the observation periods, being consistently higher on turnip rape. Results indicate that turnip rape has good potential as a trap crop to protect oilseed rape from these pests. Novel experiments conducted on a semi-field scale, and olfactometry studies suggest that the success of turnip rape as a trap crop is due to its earlier flowering with respect to oilseed rape and its more attractive odour. Computer simulations indicate that the trap cropping system

could be effective on a whole-field scale. A model based on data from these experiments predicted less damage from pests in crops protected by a turnip rape trap crop than in oilseed rape monocultures.

Cook, S. M., Bartlet, E., Murray, D. A., & Williams, I. H. (2002). The role of pollen in the attraction of pollen beetles to oilseed rape flowers *Entomologia Experimentalis et Applicata* 104 (1): 43-50.

Abstract The role of pollen odour in resource location by the pollen beetle, *Meligethes aeneus* (Fabricius) (Coleoptera: Nitidulidae), a pollen-feeding insect regarded as a pest of oilseed rape, *Brassica napus* L., (Brassicaceae) crops, was investigated in a linear track olfactometer. Both male and female beetles were attracted to the odour of whole oilseed rape flowers, indicating that these insects can locate their host plants using floral odours as cues. The attractive odour of flowers was found to emanate from all floral parts tested: the petals/sepals, the anthers, and from pollen itself. Therefore, at least part of the attractive odour of oilseed rape flowers emanates from pollen. Beetles were more attracted to floral samples containing anthers than those without anthers when these odours were directly compared in a choice-test, and this indicates that there were detectable differences between them. Anthers and pollen may therefore release distinctive odours that are quantitatively and/or qualitatively different from the odour of the rest of the flower. These experiments support the hypothesis that pollen-seeking insects use pollen odour cues to locate this food source.

Cook, S. (2000). The use of pollen cues in resource location by a pollinator and a pest. *PhD Thesis, Nottingham University.* 266pp.

This thesis presents evidence that pollen colour and odour may be used as cues in resource-location by pollen feeding insects; namely, the pollen beetle, *Meligethes aeneus*, a pest of cruciferous crops such as oilseed rape, *Brassica napus* (OSR), and the honey bee, *Apis mellifera*, an economically important generalist pollinator.

Pollen beetle adults were attracted to both the colour and odour of OSR flowers in a wind tunnel, and linear track olfactometer studies showed that part of the attractive floral odour emanated from pollen. Beetles were attracted to OSR floral odour throughout their life cycle, indicating that 'innate' search images may be important in location of hosts upon which they can reproduce. Responses to floral odours from plants upon which the beetles do not reproduce varied according to the beetle's sex, life cycle phase and feeding history. There was some evidence for the use of pollen cues in oviposition, when oviposition incidence in male-fertile buds containing pollen and male-sterile buds without pollen were compared in the field. In feeding studies conducted in the laboratory, larvae displayed obligatory requirements for the resources from OSR flowers; they were unable to develop in field bean, *Vicia faba* (FB) flowers. Although pollen consumption was not obligatory for larval survival and development, it reduced developmental time, and improved survival and 'fitness'.

Restrained honey bees were able to learn the odours of OSR and FB pollens associatively, and could discriminate between them in the conditioned proboscis extension bioassay. This ability was confirmed in more natural conditions; free-flying bees discriminated between OSR and FB pollens on the basis of their odour, but showed a colour preference for the yellow OSR pollen over the grey pollen of FB.

The relative importance of pollen as an attractive signal in OSR and FB is discussed.

Cook, S., Murray, D. A., & Williams, I. H. (1999). Pollen beetle, *Meligethes aeneus* Fabricius, incidence in the composite hybrid winter oilseed rape, Synergy. *Proceedings of the 10th International Rapeseed Congress: 'New horizons for an old crop'* September 26-29 1999, Canberra, Australia. Ed. GCIRC. Abstract book pg. 248; Full text on CD-ROM and at <http://www.regional.org.au/au/gcirt/3/454.htm>

Abstract The pollen beetle, *Meligethes aeneus* F. (Coleoptera: Nitidulidae), is an important pest of oilseed rape crops throughout Europe. It poses a particular threat to crops

of Synergy, a composite hybrid oilseed rape consisting of 20% pollinator plants and 80% male sterile hybrid plants, as adults and larvae consume the pollen necessary to pollinate the male sterile plants. The effects of pollen presence/absence on adult infestation, oviposition, and larval development were investigated. Adult infestation was greater on fertile plants than sterile ones. Although more sterile than fertile buds were devoid of eggs and larvae despite oviposition damage, there was no difference in the mean number of eggs laid per bud, indicating that females do not adjust clutch size in response to any host quality assessments. More second instar larvae were present on fertile than sterile plants, indicating a greater rate of survival, although fitness (weight) of larvae found on each plant type did not differ. Since more adults and second instar larvae were found on fertile plants than sterile, the need for pollen beetle control to ensure adequate pollination of the crop is highlighted.

Cook, S. (1998). Pollen cues for pollinators and pests. *Antenna* 22 (3): 146-147.

Abstract Insect pollination is crucial for the seed set of over 140 crops in the EU. Pollen is an essential food resource for these pollinators as well as for many other beneficial insects and some agricultural pests. Floral colour and fragrance are well known to be important in the attraction of such insects to flowers. However, it has recently been shown that all composite parts of a flower may be involved in scent production, and that each part produces a distinctive volatile blend. Pollen volatiles emanate from the pollenkitt (the oily coating of the pollen grain) and provide pollen with an odour which is both chemically distinct from other components of the whole-flower fragrance and species specific. It seems likely that pollen-seeking insects respond to pollen odour cues for location of this resource, yet this possibility has received little attention to date.

The objective of this project are to:-

- Identify and compare volatiles from pollens of selected crop plants including oilseed rape (*Brassica napus*) and field bean (*Vicia faba*)
- Investigate the role of pollen volatiles in the attraction of pollinators- honey bees (*Apis mellifera*), and bumble bees (*Bombus terrestris*)- as well as pests- pollen beetles (*Meligethes aeneus*)- to the flowers of oilseed rape and field bean plants
- Investigate the role of these volatiles in stimulating different elements of pollinator/pest behaviour such as pollen collection and packing, feeding and oviposition

Methods used include:-

- Volatiles from flowers and their pollens are obtained using dynamic headspace air entrainment methods followed by solvent desorption from the adsorbent compound. Volatiles are separated using gas chromatography (GC) and identified using coupled GC-Mass spectrometry
- Bee bioassays utilise an artificial flower and are conducted in the bee flight room; a controlled environment facility
- Pollen beetle orientation studies are conducted using a linear track olfactometer

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