Focus Group IPM for brassica

Mini-Paper 2

Effects of landscape and region on pests and pathogens in *Brassica* vegetables and oilseed rape

Focus Group Authors: Claudia Daniel[1], Rosemary Collier[2], Jane Thomas[3], Martin Hommes[4]

[1] *Departement für Nutzpflanzenwissenschaften, Forschungsinstitut für biologischen Landbau FiBL, Ackerstrasse 113, Postfach 219, 5070 Frick, Schweiz.*
[2] *Warwick Crop Centre, School of Life Sciences, The University of Warwick, UK.*
[3] *NIAB, Huntingdon Road, Cambridge CB3 0LE UK.*
[4] *Julius Kühn-Institut, Messeweg 11/12, D-38104 Braunschweig, Germany.*

Introduction

Pests and pathogens of *Brassica* vegetables and oilseed rape are mainly managed at a field level. Management of pest insects at a farm level is only suitable for farmers owning compact areas of land, which is not the case in many central European areas. This situation favours direct, short-term control of mobile pests and pathogens over preventive, long-term strategies to lower the overall population level. Regional or area-wide control is difficult to establish because it requires considerable collaboration between neighbouring farmers. In addition, research institutions usually lack the appropriate size of farms to prove that these strategies can have a reliable efficacy which would warrant greater efforts by farmers to collaborate on a regional basis. Nevertheless, the density of *Brassica* production in an area, landscape parameters, and the management strategies of neighbouring farms are important factors influencing pest and disease pressure.

Interaction between *Brassica* vegetables and oilseed rape, and *Brassica* species grown as green manure

In the past, the crop protection activities of arable farmers probably had very little impact on the pests and pathogens of *Brassica* vegetables and indeed, arable crops such as wheat and barley form a valuable part of the rotation since they are hosts to an entirely different spectrum of pests and pathogens. Generalist pests such as slugs may be an exception to this 'rule'. For example, in the UK, until about 25 years ago, cultivars of *Brassica oleracea* (e.g. cabbage, cauliflower, Brussels sprout) and *B. napus var. napobrassicae* (swede) were the commonest crucifers grown on a field scale. However, following the expansion in the area of land drilled with oilseed rape during the mid 1970s, the oil-bearing cultivars of *B. napus* and *B. campestris* have become the commonest *Brassica* crops. Not only are such plants grown at a much higher density (80-120 plants m^{-1}) than the *B. oleracea* cultivars (2-20 m^{-1}), but they are also grown on an area of about 750,000 ha in the UK, approximately 25 times the area used for growing *Brassica* vegetable crops (Source: Defra Statistics).

Oilseed rape can act as a 'green bridge' in both space and time for the pests and pathogens of *Brassica* vegetable crops. In central European countries with cold winters, there is usually a break in *Brassica* vegetable production between January and March and this provides a similar break in the presence of relatively large areas of the host plants suitable for *Brassica* pests and pathogens, although this is not the case in maritime climates such as the UK where *Brassica* vegetables, albeit of different types and cultivars, are grown year-round. However, winter oilseed rape sown in August can sustain *Brassica* pests and pathogens through the winter and because of the relatively large areas grown this crop is likely to have a major impact in all regions.

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Different crop types are impacted differently by different pests and pathogens and have different tolerance levels and this is particularly true for oilseed rape compared with *Brassica* vegetables. In particular, economic thresholds for pests on oilseed rape are usually higher than on vegetables. Therefore, less control is used in oilseed rape and this, in itself, might lead to the build-up of large pest and pathogen populations, threatening nearby vegetable fields. A crop of winter-sown oil seed rape might tolerate an infestation of *Delia radicum* larvae that requires no control at the time of the first generation in the spring. However, when the crop senesces in summer this may lead to a very large population of second generation flies, since although each plant may produce a relatively small number of pupae, the high plant density can lead to a large emergent population per hectare, ready to oviposit on nearby *Brassica* vegetable crops. In recent years in field trials on *Brassica* vegetables at Warwick Crop Centre, UK, the second generation of *D. radicum* has become dominant numerically which can be attributed to the large area of oilseed rape now grown in the area. This situation occurs also now in Germany and Scotland (Personal communications; M. Hommes (Germany) and N. Birch (Scotland). Similarly, Vogler et al (2014) provided evidence that in Switzerland oil seed rape may not only be an important source for cabbage root flies causing economically significant yield losses in vegetable Brassiceas but also for the pathogen *Peronospora parasitica*.

Cabbage whitefly, *Aleyrodes proletella,* overwinters as an adult insect on *Brassica* crops. Winter oilseed rape fields can act as an overwintering habitat. As whiteflies do not cause economic damage in oilseed rape, they are rarely controlled. At the beginning of June, during senescence of oilseed rape leaves, numbers of whiteflies in oilseed rape crops decline – most probably due to emigration into brassicaceous vegetables in the surroundings. It is an increasing problem in Germany (M. Hommes, personal communication).

Swede midge, *Contarinia nasturtii* overwinters as pupae in the soil. First flight starts in May/June, a second flight occurs in July and a third in August and sometimes a fourth flight can be observed. During these flight periods, winter oilseed rape is not an attractive host for *C. nasturtii*, because of advancing senescence. Summer oilseed rape, sown in March, is known to be a host for *C. nasturtii* and heavy damage has been reported from America, but rarely from Europe (Abraham *et al.* 2012). It is therefore very likely that the first two generations of *C. nasturtii* can develop on summer oilseed rape. Volunteer oilseed rape plants can also play an important role in the life cycle of swede midge since if they are not removed after harvest, volunteer oilseed rape plants are hosts for the third generation of *C. nasturtii* (T. Haye, personal communication).

Pollen beetle, *Meligethes spp.*, is a major pest of oilseed rape. Control focuses on immigrating adult beetles in spring. Larvae of *Meligethes spp*. develop on oilseed rape but only cause damage at very high population densities. Therefore, usually no control is applied against larval stages, which leads to the development of an abundant new generation of adult beetles in June. The new beetles need to feed on pollen before they migrate to their overwintering sites in August. Although adult beetles can survive on pollen from different plant species, they often feed on brassicaceous plants and they are particularly damaging when they feed on the heads of cauliflower or broccoli. In the UK, there were instances of high levels of damage to cauliflower at the end of the last century, which led to the development of a temperature-based forecast to predict the emergence of beetles from oil seed rape crops (Finch *et al.*, 1990; Phelps *et al.*, 1993). During recent years, reports of pollen beetles migrating into broccoli and cauliflower fields have become more frequent in northern Germany (C. Daniel, personal communication). The control of pollen beetles in these crops is nearly impossible because pollen beetles prefer crops that are close to harvest. Although damage to cauliflower and broccoli plants is caused only at high beetle densities, even low numbers of pollen beetles are a problem for

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marketing: beetles hide inside the heads of broccoli and cauliflower and thus are caught in the plastic packaging leading to rejection by consumers. In Germany, some growers have stopped growing broccoli or cauliflower in areas where beetle densities are high or have to protect their crops with insect-proof nets (M. Hommes, personal communication).
Finally it is worth pointing out that with the current EU ban on the use of neonicotinoid seed treatments on flowering *Brassica* crops, the incidence of autumn and winter pests of oilseed rape is likely to increase. Insecticides that may be used in their stead include pyrethroids, but there is an increasing incidence of insecticide resistance in *Brassica* pest species which includes *Myzus persicae*, *Aleyrodes proletella, Meligethes* spp., *Scaptomyza flava, Thrips tabaci* and *Psylliodes chrysocephala.*

Overwintering oilseed rape provides a substantial 'green bridge' for light leaf spot *Pyrenopeziza brassicae* and as a consequence it is the major foliar disease of that crop. In turn, rape provides a reservoir of infection that transfers onto vegetable *Brassica* crops and can cause appreciable losses of quality. Similar effects have been noted with blackleg (*Leptosphaeria maculans*) and dark leaf and pod spot (*Alternaria* spp.) where the production of large areas of oilseed rape adjacent to vegetable crops poses considerable threats due to their release of vast quantities of inoculum (Dixon, 2007).

In addition to the green bridge provided by oil seed rape, several Brassicaceous species are grown as green manure on farmland, both for nitrogen retention and prevention of soil erosion (*Brassica chinensis x Brassica rapa; Raphanus sativus, Sinapis alba*), as well as for biofumigation (*Brassica juncea*). These species are typically grown during winter and also in summer after cereals and potatoes have been harvested and before autumn crops are sown. No plant protection products are applied to green manure, which makes these crops a perfect reservoir for many pests and pathogens.

Pest and disease dispersal and persistence
The importance of regional effects and the value of regional management will depend on the dispersal potential of the pest or pathogen and also, in cases of diseases such as club root, the persistence of the organism in the soil.

'Independent' dispersal potential ranges from organisms such as clubroot (*Plasmodiophora brassicae*) or slugs, whose dispersal range is limited, to *Plutella xylostella* which is able to disperse many hundreds of miles and arrives in northern Europe as a migrant each year, although not always in damaging numbers (Chapman *et al.*, 2002). Some fungal pathogens are dispersed very effectively by air currents. In many cases, levels of infestation in new crops would at least be reduced by decreasing the prevalence of 'green bridges'. However, whilst regional management of some species may be possible, it is hard to envisage a strategy that would reduce the impact of the initial immigration of *P. xylostella*, although subsequent generations may undertake more trivial dispersal, where regional strategies may be more effective.

Obviously pests and pathogens are also dispersed through agronomic practices through propagating infected or infested material or by moving infected soil and there is considerable scope for management at a field or larger scale.

Regional races or biotypes
There are some areas of the UK where a proportion of the *D. radicum* population emerge later in the spring than would be expected. These are called 'late emerging' flies and they are genetically different from 'early-emerging' flies (Finch *et al.*, 1986; 1988). In the UK, relatively large numbers of late-emerging flies occur in some parts of Devon and south-west Lancashire. The late-emerging biotype

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has also been found elsewhere in Europe (Finch *et al.*, 1988). We do not completely understand the reasons for these differences but the prevailing biotype(s) certainly has implications for control strategies. A study in Switzerland found as much sensory/behavioural variation between different populations of *D. radicum* as between four species of *Delia* (Gouinguene & Stadler, 2005).

In the case of pathogens on oilseed rape, there is evidence of newly emerging populations of *Pyrenopeziza brassicae* (light leaf spot) which are virulent on the limited sources of high level resistance currently available, causing them to be much less effective. Though this is so far causing only localized problems in northern parts of the UK, weather patterns have led to increasing light leaf spot levels in the south of the country, and potentially this could increase the chances of variants arising over a wider area. *Leptosphaeria maculans*, the cause of stem canker, is a more variable pathogen, with virulences against Rlm resistances emerging world-wide over the years. More recently virulence to the RLm7 resistance has emerged in Europe, though to date only resistance to the leaf spot phase has been eroded, with oilseed rape cultivars retaining resistance to the damaging canker phase, possibly due to very effective quantitative resistance factors. Regional diversification of RLm factors in reaction to local pathogen populations has been devised in Australia, and France, but to date has not been put into widespread practice in Europe. The availability of fungicides, and the over-riding issue of yield potential, which governs cultivar choice for many European growers, probably makes such structured and coordinated diversification difficult to achieve.

Variants of clubroot able to infect previously resistant cultivars have become dominant in some growing areas, including in Germany (M. Hommes, personal communication). However, there is no pan-European pathotype survey which might inform where some resistances are still effective, and where there is a high risk of failure.

New pests and pathogens

The prevalence of a certain crop in an area, leading to increased abundance of certain pest species, may lead to them becoming a 'new' pest on other related crops. Although hard to prove, it is possible that the increased incidence of oil seed rape (together with other factors) has led to the occurrence of the leaf miner *Scaptomyza flava* as a new pest of specialty *Brassica* crops grown for bagged salads (e.g. mizuna, rocket, Chinese cabbage and pak choi). Although the presence of mines in cabbage, cauliflower and Brussels sprout crops does not appear to be an economic problem, in field trials at Warwick Crop Centre, UK there has been a noticeable increase in the incidence of damage over the last 5 years.

Similarly *Ceutorhynchus pallidactylus*, which is among the main pests of oilseed rape can cause damage to *Brassica* vegetables – mainly kohlrabi. Increased areas of oilseed rape production might lead to higher population levels of *C. pallidactylus* and therefore more damage to other *Brassica* vegetables.

The increase of oilseed rape production close to vegetable *Brassica* growing regions in many countries has resulted in several diseases becoming more problematic on vegetable crops. In northern Europe, *Pyrenopeziza brassicae* (light leaf spot) is one of the major examples. Spread from oilseed rape causes loss of quality in several vegetable crops, notably Brussels sprout buttons, but also cabbage leaves. Oilseed rape cyst nematode (*Heterodera schachtii*) is increasing as a problem where oilseed rape is grown in rotation with sugar beet, another host (beet cyst nematode). It remains to be seen whether this nematode will start to increase in vegetable *Brassica* crops, though in the UK there have been recent, isolated instances of infestations on Brussels sprout. Similarly, *Verticillium longisporum* has

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increased in importance on oilseed rape in the UK, Sweden, and Germany, though at present, with the exception of cauliflower in some areas, vegetable *Brassica* crops appear to be little affected. *Alternaria brassicae* and *brassicicola* seldom cause significant damage to oilseed rape crops, though inoculum on crop residues may cause significant loss in quality in any neighbouring vegetable *Brassica* crops through the appearance of dark brown spots and flecks.

Insecticide resistance

Insecticide resistance is an increasing problem for those who grow *Brassica* crops. At present, with the exception of *M. persicae,* this mainly concerns resistance to pyrethroid insecticides in the species listed above and is a reflection of the wide and prolonged use of broad-spectrum pyrethroid insecticides. One of the factors influencing the occurrence of insecticide resistance is the degree of exposure of a pest population through time and space and thus management strategies on one crop can affect the resistance status of a pest, which then has implications for its control on other crops. It is worth asking the question whether it would be possible to have a regional resistance management strategy for certain pest insects?

Conservation biocontrol

All of the pest species discussed above have natural enemies - predators, parasitoids and pathogens, which have an impact on the overall population size and in some cases, may provide economically effective control (e.g. the mid-season aphid crash if this occurs at the right time for commercial crops). It is therefore reasonable to ask, what is the potential for conservation biocontrol on a landscape scale and what impact might it have?

Parasitism of pollen beetle larvae is higher in structurally complex landscapes due to positive effects of old field margins and old fallow habitats (Thies & Tscharntke 1999). Although Swiss agricultural landscapes are structurally complex in most areas, parasitism rates observed in experiments have been very low (C. Daniel, personal communication). This might be due mainly to intensive insecticide spraying programmes: parasitoids immigrating into oilseed rape fields are very likely suffer due to exposure to insecticide residues, or a lack of host larvae. In addition, ploughing after harvesting oilseed rape destroys a large proportion of parasitoid pupae overwintering in the soil (Nitzsche & Ulber 1998). These negative impacts of agricultural practices cannot be mitigated by field margins. In order to profit from the effects of functional agrobiodiversity, agricultural practice needs to be adapted at crucial points. However, farmers are reluctant to change their customary practices, especially as the short-term benefits for their own fields are rather low. Positive effects of conservation programmes for parasitoids would need a contribution by all farmers in a region.

Pollen beetles can fly up to three kilometres a day (Stechmann & Schütte 1976). During migration to their overwintering sites in Switzerland (forest slopes) in August, as well as during migration to oilseed rape fields in early spring, they cover large distances. Therefore, control focuses on adult beetles shortly after immigration into the fields and before they cause damage. This strategy is reasonable for the individual farmer, because it is the only way to prevent damage to their own crop. However, control of larvae – by parasitoids, or the use of biocontrol agents to increase winter mortality – might provide more sustainable, long-term effects on the population level.

Forecasting and monitoring

There are a number of approaches available to monitor and forecast colonisation by the pests and pathogens of *Brassica* crops. Monitoring approaches include trapping systems (suction traps for aphids (e.g. Rothamsted Insect Survey http://www.rothamsted.ac.uk/insect-survey), water and sticky traps

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for a range of pests, pheromone traps for Lepidoptera in particular and possibly radar for *P. xylostella* (Chapman *et al.*, 2002))*,* spore traps for fungal pathogens (Wakeham *et al.*, 2000)). Forecasting systems are available for both pests and pathogens (e.g. cabbage root fly, pollen beetle, fungal pathogens) and some of these approaches are appropriate for use on both a local and regional basis. A system where information was available across a country or region would be very useful, particularly where there is a progression of pest or disease colonisation over time e.g. from north to south. In the UK, the Rothamsted Insect Survey suction trap network also provides information on the incidence of the different resistance mechanisms in different regions and this is extremely useful information for honing control strategies in real time. A simulation model for the cabbage root fly (SWAT) can be downloaded from the internet (http://www.jki.bund.de/no_cache/de/startseite/institute/pflanzenschutz-gartenbau-und-forst/swat.html**)** and is used by the German plant protection service and ZEPP (Central Institution for Decision Support Systems in Crop Protection /www.zepp.info) to inform growers about the population dynamics of three major root fly species (Hommes & Gebelein, 1996). In the UK, information on pest activity (weather-based forecasts (Phelps *et al.*, 1993) and monitoring data) are available as part of the HDC Pest Bulletin http://www3.syngenta.com/country/uk/en/AgronomyTools/HDCPestBulletin/Pages/HDCPestBulletin.aspx.

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