IPM Decisions

D4.5 Models tested for validity: aphids and vegetable pests

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Contents

1 Public Summary

The use of modelled pest phenology as decision support systems in Europe work best if used in conjunction with local pest monitoring (e.g., by trapping) and, ideally, web-based regional pest monitoring networks.

2 Executive Summary

Models of cereal and vegetable aphids, cabbage root fly, carrot fly and cutworm in Europe should be used in combination with a monitoring network operated to issue early warnings and pest forecasts.

3 Introduction

In the previous report *D4.4 Data set for DSS validation collected: aphids and vegetable pests*, we presented the data set that was put together based on data provided by several project partners. The data set contains time series of trap catches from Denmark, France, Sweden, and UK on the following pests:

- cereal aphids (*Sitobion avenae, Rhopalosiphum padi* and *Metopolophium dirhodum*)
- vegetable aphids (*Aphis fabae, Acyrthosiphon pisum, Aulacorthum solani, Brevicoryne brassicae, Macrosiphum euphorbiae, Myzus ascalonicus* and *Myzus persicae*)
- cabbage root fly (*Delia radicum*)
- carrot fly (*Psila rosae*)
- cutworm (*Agrotis segetum*)

The motivation to develop models that predict the phenology (seasonal occurrence), and density of these pests is that, with sufficient accuracy, they can be valuable tools to guide IPM control measures. In this report we present phenological models for these pests, which have been tested for their validity to predict the occurrence.

The data collected under D4.4 will be made freely available under D4.8, for researchers and advisors to test more advanced models for insect pest management.

4 Cereal and vegetable aphid phenology models

The phenology of aphids caught in a European network of suction traps was analysed by Harrington et al. (2007). Their analysis included weather attributes, landscape characteristics and geolocation as variables to predict the first date of occurrence for all species encountered (including aphid pests). The study was followed up by Bell et al. (2015), who found that aphids now occur earlier than previously due to climate change.

Several models have been developed to predict the migration of aphids into fields. These models are always temperature-driven (often parameterised on a day-degree scale) and often combined with crop growth stage, which delimits a window agreeable to the aphid pest. Klueken et al. (2009) provide one example of such a model. It should be noted that even though all these models predicted aphid phenology with statistical significance, this does not mean that they are necessarily accurate enough for practical IPM.

Where aphids act as vectors for disease, such as *R. padi* as a vector of Barley Yellow Dwarf Virus (BYDV) in winter cereals, models can predict when alate adults appear in the crop. These winged aphids are largely responsible for the in-field spread of disease, and phenological models predicting in-field migration support improved targeting of management to minimise spread (e.g. the AHDB T-SUM BYDV model in the UK). This model (which is a simple day-degree model) guides the farmer when to scout for aphids. We were not able to test the accuracy this model with the available data set. Where aphids cause direct damage to crops, usually in the spring and summer months, population growth is exponential. This rapid growth is related to crop condition and local weather and might be curtailed by the senescence of the crop before harvest (Karley et al. 2004) or by a complex of natural enemies (Ramsden et al. 2017). Even if an accurate model of a certain crop-aphid-natural enemy existed, these would require in-field data on a number of variables in order to predict aphid population dynamics.

4.1 Conclusion

Predictive models relating to migration of pests into and within crops, in combination with details on the vulnerability of the crop to damage (i.e. growth stage, varietal tolerance, etc), provide guidance on when to commence the monitoring in the field as exemplified by Hansen (2006). The most cost-efficient method for IPM of aphids is monitoring of the aphid density in the fields with reference to pre-defined treatment thresholds. Ideally such thresholds should incorporate key factors, such as crop tolerance to pests, contribution of natural enemies, and other critical factors (Ramsden et al 2017). Examples of pre-defined treatment thresholds for insect control can be found in the Danish Crop Protection Online and in the UK review of economic threshold, Ramsden et al (2017).

5 Cabbage root fly (*Delia radicum*) phenology models

SWAT is a generic model that incorporates temperature-dependent development and reproduction with options for winter and summer diapause (Otto and Hommes 2000). It is available online at www.isip.de according to Collier et al. (2021). Both a SWAT model and more simple day-degree models have been developed for cabbage root fly, as reviewed by Collier et al. (2021). They investigated the variability in diapause among cabbage flies sampled throughout Europe and found marked differences in diapause biology among the populations.

The diapause of cabbage root fly seems to depend on two factors that vary with location and climate: fly genetics and weather. Since the phenology of cabbage root fly is determined partly by the extent of diapause at a given location in a given year, this makes it difficult to produce a reliable generic model of cabbage root fly phenology.

5.1 Conclusion

Until the diapause of cabbage root fly can be reliably incorporated into phenology models, monitoring in the field seems the only method that will produce information accurate enough for practical use in IPM strategies. Where models have been developed and validated locally, and where diapause is consistent over time, these models will continue to support IPM decisions locally.

6 Carrot fly (*Psila rosae*) phenology models

Carrot fly produces one to three generations per year in Europe depending on latitude: from one generation in Norway (Johansen 1999) to two-three further south (Villeneuve and Latour 2017). Its hibernation mode is plastic, as it may overwinter as larva or pupa or, sometimes, as a mixture of the two (Collier et al. 1994). The adaptability of this species to the local environment makes it difficult to develop a generic model that is valid for any location in any year.

Villeneuve and Latour (2017) tested the predictions of the German SWAT model (Otto and Hommes 2000) against flight trap catches from south-western France. However, the validation failed: Of the two generations occurring in south-western France, neither was predicted accurately. They conclude that an accurate model of carrot fly phenology will be difficult to construct, because of the high variance in winter and summer diapause induced by weather. Collier et al. (2021) likewise concluded that current carrot fly models are too simplistic, as they lack proper modelling of the mechanisms of diapause.

6.1 Conclusion

Until the diapause and multi-generation aspects of the carrot fly can be reliably incorporated into generic phenology models, monitoring in the field seems the only method that will produce information accurate enough for practical use in IPM strategies. Where models have been developed and validated locally, and where diapause is consistent over time, these models will continue to support IPM decisions locally.

7 Cutworm (*Agrotis segetum*) phenology models

Cutworms are moth larvae that attack plant roots, including many crops. The larvae are sensitive to excess moisture, while temperature influences the development of all life stages. Esbjerg and Sigsgaard (2014) developed a multiple regression model to predict the timing of adult flight. They suggested that this model could be useful in conjunction with pheromone traps to provide early warnings of cutworm attacks. The model could elicit a cutworm warning which would signal that monitoring of adult flight by pheromone traps should be initiated.

The phenology of adult flight is important because it defines the time window for egg laying. It is necessary to know when eggs have been laid to predict the subsequent larval development. The larvae must be controlled before they reach the 3rd instar, when they move underground and so cannot be treated using insecticide sprays. The weather-based model of Bowden et al. (1983) predicts the timing of larval development to inform the farmer when control is possible. They suggested the use of light traps to detect the first flying adults, at which time the first eggs were assumed to be laid.

Correct timing is only one aspect of pest control, another is the assessment whether pest density warrants control. Unfortunately, Jakubowska et al. (2020) found only little correlation between the number of moths trapped and the severity of the subsequent attack of the larvae.In areas where cutworm may be caused by migratory moths (Bowden et al. 1983), early warnings cannot rely on weather-based models but only on a monitoring network of traps.

7.1 Conclusion

For IPM of cutworms, monitoring of first arrival of adult moths in the field seems the only method that will produce information accurate enough for practical use. Models of the subsequent development of growth stages in the crop can still support improved decision making (see D4.14).

8 Conclusion and recommendations

Genetic variability within species, which causes marked differences in life history traits (such as diapause), combined with sensitivity to local abiotic (weather, microclimate) and biotic (natural enemies) conditions, all combine to make predictions on the phenology and pest pressure inaccurate at the field level without additional field specific data being incorporated.

For practical IPM, farmers need to know if and when control of these pests is necessary. For this purpose, advice cannot be given based on models alone. Rather, a monitoring network must be set up with easy access to pest status and forecasts; an overview of existing pest monitoring networks, on which to base a complete EU-wide monitoring network, is lacking. Short-term pest forecasts, like weather forecasts, could be given based on monitoring input fed into pest models developed for the purpose. Current models could provide guidance when the monitoring season should begin for different pests in different regions.

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