IPM Decisions

Scientific Publications

CONTENT

Summary

Several scientific publications were developed during the IPM Decisions project, intended to disseminate findings and resources associated with decision support systems (DSS) for integrated pest management (IPM). As part of the project's commitment to open data, all publications are open access, either through Gold (open access publication) or Green (self-archiving) open access models. Whether published as an open access publication or self-achieved, all work and associated data (where permissible) is deposited into a suitable repository.

Open access refers to the practice of providing online access to scientific information that is free of charge to the end-user and reusable. **'Scientific'** refers to all academic disciplines. In the context of research and innovation, **'scientific information'** can mean:

1. peer-reviewed scientific research articles (published in scholarly journals); or
2. research data (data underlying publications, curated data and/or raw data).

Green open access "*Self-archiving*"

Under self-archiving, the author or a representative archives (deposits) the published article or the final peer-reviewed manuscript in an online repository before, at the same time as, or after publication. Some publishers request that open access be granted only after an embargo period has elapsed, IPM Decisions aimed to ensure open access within 6 months of publication.

Gold open access

For open access publishing, researchers can publish in open access journals, in hybrid journals that both sell subscriptions and offer the option of making individual articles openly

accessible, or on the Open Research Europe publishing platform. Monographs can also be published either on a purely open access basis or using a hybrid business model.

Publication	Access	Link
Jørgensen, L.N., et al. (2020) Validation of risk models for control of leaf blotch diseases in wheat in the Nordic and Baltic countries. European Journal of Plant Pathology, 157, 599-613		
Midingoyi C.A., et al. (2020) Reuse of process-based models: automatic transformation into many programming languages and simulation platforms. In silico Plants, 2(1)		
Holst N. (2020) Mathematical models. In: Chantre G.R. & González-Andujar J.L. eds. Decision Support Systems for Weed Management. Berlin, Springer Verlag, 3-23		
Andersson, B., et al. (2022) Comparison of models for leaf blotch disease management in wheat based on historical yield weather data in the Nordic-Baltic region. Agronomy for Sustainable Development 42-44		
Jørgensen, L. N. et al. (2021) Using risk models for control of leaf blotch diseases in barley minimises fungicide use – experiences from the Nordic and Baltic countries. Acta Agriculturae Scandinavica, Section B — Soil & Plant Science 71:247-260		
Jalli, M, et al. (2020) Yield increases due to fungicide control of leaf blotch diseases in wheat and barley as a basis for IPM decision-making in the Nordic-Baltic region. European Journal of Plant Pathology		
Ramsden, M. and O'Driscol A. (2022) Advances in decision support systems (DSS) for integrated pest management in horticultural crops. In book: Improving integrated pest management in horticulture.		
Ramsden, M., et al. (2023) Advances in pest risk assessment techniques focusing on invertebrate pests of European outdoor crops. In book: Advances in monitoring of native and invasive insect pests of crops.		
Leybourne D., et al. (2023) Online decision support systems, remote sensing and artificial intelligence applications for wheat pest management. In book: Advances in understanding insect pests affecting wheat and other cereals		
Levionnois S., et al. (2023) Modelling the impact of proportion, sowing date, and architectural traits of a companion crop on foliar fungal pathogens of wheat in crop mixtures. Phytopathology.		
Marinko J., et al. (2023) Incentives and barriers to adoption of decision support systems in integrated pest management among farmers and farm advisors in Europe. International Journal of pest Management		
Midingoyi, C.A., et al. (2023) Crop modeling frameworks interoperability through bidirectional source code transformation. Environment Modelling & Software		

Akbarinia R. et al (2023) Life Science Workflow Services (LifeSWS): motivations and architecture, Transactions on Large-Scale Data- and Knowledge-Centered Systems, 14280, pp.1-24.		
Marinko, J., et al. (2024) Typology for Decision Support Systems in Integrated Pest Management and Its Implementation as a Web Application. Agronomy		
Helps J. et al (2024) A framework for evaluating the value of agricultural pest management decision support systems. European Journal of Plant Pathology		
Akaka J. et al (2024) Decision Support Systems adoption in pesticide management. Open Research Europe		
Marinko J. et al (2025) Overcoming Barriers to the Adoption of Decision Support Systems in Integrated Pest Management in Some European Countries.		
Ramsden M.W. et al (2025) Precision Integrated Pest Management in horticulture; pest and disease forecast, detection, and management In: Advances in understanding insect pests affecting wheat and other cereals		
Ramsden M.W. et al (In prep) Introducing the IPM Decisions Platform – a Pan-European online platform hosting decision support systems for integrated pest management		

Horizon 2020

Validation of risk models for control of leaf blotch diseases in wheat in the Nordic and Baltic countries.

European Journal of Plant Pathology

Authors:	Jørgensen, L.N., Matzen, N., Ficke, A., Nielsen G.C., Jalli M., Ronis A., Andersson B, and Djurle A.
Year:	2020
DOI:	https://doi.org/10.1007/s10658-020-02025-6
Access:	Gold

Abstract

Risk models for decisions on fungicide use based on weather data, disease monitoring, and control thresholds are used as important elements in a sustainable cropping system. The need for control of leaf blotch diseases in wheat (caused by Zymoseptoria tritici, Parastagonospora nodorum and Pyrenophora tritici-repentis) vary significantly across years and locations. Disease development is mainly driven by humidity events during stem elongation and heading. Two risk models were tested in field trials in order to identify situations favourable for the development of leaf blotch diseases in Lithuania, Norway, Sweden, Finland and Denmark. The Crop Protection Online (CPO) model uses days with precipitation (>1 mm), while the humidity model (HM) uses 20 continuous hours with relative humidity (RH) ≥ 85% as criteria for the need of a fungicide application. Forty-seven field trials were carried out during two seasons to validate these two risk-models against reference fungicide treatments. The season 2018 was dry and 2019 had an average precipitation profile. The two risk models with few exceptions provided acceptable disease control. In 2018, very few treatments were recommended by the models, saving 85–98% of treatments compared to the reference treatments, while in the wetter season 2019, 31% fewer applications were recommended. Based on specific criteria including fungicide input and net yield responses the models gave correct recommendations in 95% of the trials in 2018 and in 54–58% of the trials in 2019 compared with reference treatments dominated by 2–3 sprays. In comparison with single spray references, the models gave correct recommendations in 54–69% of the situations.

Reuse of process-based models: automatic transformation into many programming languages and simulation platforms

In Silico Plants

Authors:	Midingoyi C.A., Pradal C., Athanasiadis I.A., Donatelli M., Enders A., Fumagalli D., Garcia F., Holzworth D., Hoogenboom G, Porter G., Raynal H., Thorburn P., and Martre P.

Year:	2020
DOI:	https://doi.org/10.1093/insilicoplants/diaa007
Access:	Gold

Abstract

The diversity of plant and crop process-based modelling platforms in terms of implementation language, software design and architectural constraints limits the reusability of the model components outside the platform in which they were originally developed, making model reuse a persistent issue. To facilitate the intercomparison and improvement of process-based models and the exchange of model components, several groups in the field joined to create the Agricultural Model Exchange Initiative (AMEI). Agricultural Model Exchange Initiative proposes a centralized framework for exchanging and reusing model components. It provides a modular and declarative approach to describe the specification of unit models and their composition. A model algorithm is associated with each model specification, which implements its mathematical behaviour. This paper focuses on the expression of the model algorithm independently of the platform specificities, and how the model algorithm can be seamlessly integrated into different platforms. We define CyML, a Cython-derived language with minimum specifications to implement model component algorithms. We also propose CyMLT, an extensible source-to-source transformation system that transforms CyML source code into different target languages such as Fortran, C#, C++, Java and Python, and into different programming paradigms. CyMLT is also able to generate model components to target modelling platforms such as DSSAT, BioMA, Record, SIMPLACE and OpenAlea. We demonstrate our reuse approach with a simple unit model and the capacity to extend CyMLT with other languages and platforms. The approach we present here will help to improve the reproducibility, exchange and reuse of process-based models.

Chapter: Mathematical Models

In: Decision Support Systems for Weed Management

Authors:	Holst N.
Editors:	Chantre G.R. & González-Andujar J.L.
Year:	2020
DOI:	https://doi.org/10.1007/978-3-030-44402-0_1
Access:	Green

Abstract

Decision support systems (DSSs) rely on computational machinery in which mathematical models often constitute an important part. In this chapter it is discussed which kinds of models are best suited for different kinds of DSSs. The practical steps involved in model construction is outlined, keeping in mind that model construction is a process that must be integrated into the larger software development project launched to construct the whole DSS. You are invited into the modeller's workshop, as you follow the considerations involved in formulating a simple model of weed emergence. Two case studies close the chapter, demonstrating models of the population dynamics of annual weeds in a crop rotation and of an invasive weed. R scripts for all models can be found in the book's online appendix. It is concluded that weed modellers must be prepared to work in multidisciplinary teams, and that they should be better at considering the needs of the DSS users. For purposes of quality control, the mathematical models should be published open-source while the DSS itself might be proprietary.

Comparison of models for leaf blotch disease management in wheat based on historical yield and weather data in the Nordic-Baltic region

Agronomy for Sustainable Development

Authors:	Andersson, B., Djurle, A., Ørum, J.E., Jalli, M., Ronis, A., Ficke, A. and Jørgensen, L.N.

Year:	2022
DOI:	https://doi.org/10.1007/s13593-022-00767-7
Access:	Gold

Abstract

Validation of models for plant disease management is a crucial part in the development of decision support systems in plant protection. Bespoke field trials are usually conducted to determine the performance of a model under practical conditions. However, field trials are very resource-demanding, and the use of already existing field trial data could significantly reduce costs for model validation. In this study, we took this novel approach to verify the performance of models for determining the need of fungicide applications against leaf blotch diseases in wheat by utilising historical weather data and yield data available from fungicide efficacy field trials. Two models based on humidity factors were used in the study. To estimate how specific humidity settings in the two models affect the number of recommended fungicide treatments per season, historical weather data from a 5-year period from weather stations in Denmark, Sweden, Norway, Finland, and Lithuania was used. The model output shows major differences between seasons and regions, typically recommending between one and three treatments per season. To determine the prediction potential of the models, data on yield gains from either one or two fungicide applications in fungicide efficacy trials conducted in wheat over a 5-year period in the five countries was utilised. The yield responses from fungicide treatments in the efficacy trials varied considerably between years and countries, as did the proportion of predictions of profitable treatments. In general, there was a tendency for the models to overestimate the need to apply fungicides (low specificity), but they rarely failed to recommend an application that was needed (high sensitivity). Despite the importance of having specific trials across regions in order to adjust models to local cropping and weather conditions, our study shows that historical weather data and existing field trial data have the potential to be used in model validation.

Using risk models for control of leaf blotch diseases in barley minimises fungicide use – experiences from the Nordic and Baltic countries.

Section B — Soil & Plant Science

Authors:	Jørgensen, L.N., Matzen,N., Ficke, A., Andersson, B., Jalli, M., Ronis, A., Nielsen, G.C., Erlund, P., and Djurle, A.

Year:	2021
DOI:	https://doi.org/10.1080/09064710.2021.1884742
Access:	Gold

Abstract

The disease pressure from *Pyrenophora teres*, *Rhynchosporium graminicola*, and *Ramularia collo–cygni* varies widely between years and locations, which highlights the need for using risk models to avoid unnecessary use of fungicides. Three disease risk models were tested in thirty–three field trials during two seasons in five countries in order to validate and identify situations favourable for barley leaf blotch diseases in the Nordic–Baltic region. The tested models were: The Crop Protection Online (CPO), which uses number of days with precipitation (>1 mm), cultivar resistance and disease data as basis for risk assessments; the humidity model (HM) which signals a risk warning after 20 continuous hours with high humidity, and the Finnish net blotch model (WisuEnnuste), which calculates a risk based on previous crop, tillage method, cultivar resistance and weather parameters. The risk models mostly gave acceptable control of diseases and yield responses compared with untreated and reference treatments. In the dry season of 2018, the models recommended 88–96% fewer applications than the reference treatments, while in 2019, the number of applications was reduced by 0–76% compared to reference treatments. Based on yield increases, the recommendations were correct in 50–69% of the trials compared to one–treatment references and 69–80% of the trials when references used mainly two treatments.

Yield increases due to fungicide control of leaf blotch diseases in wheat and barley as a basis for IPM decision-making in the Nordic-Baltic region

European Journal of Plant Pathology

Authors:	Jalli, M., Kaseva, J., Andersson, B., Ficke,A., Jørgensen, L.N., Ronis,A., Kaukoranta, T., Ørum, J.E., and Djurle, A.
Year:	2020
DOI:	https://doi.org/10.1007/s10658-020-02075-w
Access:	Gold

Abstract

Fungal plant diseases driven by weather factors are common in European wheat and barley crops. Among these, septoria tritici blotch (*Zymoseptoria tritici*), tan spot (*Pyrenophora tritici-repentis*), and stagonospora nodorum blotch (*Parastagonospora nodorum*) are common in the Nordic-Baltic region at variable incidence and severity both in spring and winter wheat fields. In spring barley, net blotch (*Pyrenophora teres*), scald (*Rhynchosporium graminicola*, syn. *Rhynchosporium commune*) and ramularia leaf spot (*Ramularia collo-cygni*) are common yield limiting foliar diseases. We analysed data from 449 field trials from 2007 to 2017 in wheat and barley crops in the Nordic-Baltic region and explored the differences in severity of leaf blotch diseases between countries and years, and the impact of the diseases on yield. In the experiments, septoria tritici blotch dominated in winter wheat in Denmark and southern Sweden; while in Lithuania, both septoria tritici blotch and tan spot were common. In spring wheat, stagonospora nodorum blotch dominated in Norway and tan spot in Finland. Net blotch and ramularia leaf blotch were the most severe barley diseases over large areas, while scald occurred more locally and had less yield impact in all countries. Leaf blotch diseases, with severity >50% at DC 73–77, caused an average yield loss of 1072 kg/ha in winter wheat and 1114 kg/ha in spring barley across all countries over 5 years. These data verify a large regional and yearly variation in disease severity, distribution and impact on yield, emphasizing the need to adapt fungicide applications to the actual need based on locally adapted risk assessment systems.

Chapter: Advances in decision support systems (DSSs) for integrated pest management in horticultural crops

In: Improving integrated pest management in horticulture

Authors:	Ramsden, M.W., and O'Driscoll, A.
Editors:	Collier, R.
Year:	2020
DOI:	https://doi.org/10.19103/AS.2021.0095.07
Access:	Green

Abstract

Decision support systems (DSS) are an vital tool in advancing the integrated management of horticultural pests. Whether the DSS support strategic, tactical or operational decisions, they can enable growers and their advisors to make difficult choices based on the best information on potential risks to a crop. This chapter looks at the availability of DSS in horticulture, they typical inputs required and outputs provided to the user, and discuss their role in crop management. It provides case studies on the use of specific systems, and how online platforms are helping to standardise outputs to improve user experience.

Chapter: Advances in pest risk assessment techniques focusing on invertebrate pests of European outdoor crops

In: Advances in monitoring of native and invasive insect pests of crops

Authors:	Ramsden, M.W., Telling, S., Leybourne, D.J., Alonso, N., White, S., and Georgantzis, N.
Editors:	Fountain, M., and Pope, T.
Year:	2020
DOI:	http://dx.doi.org/10.19103/AS.2022.0113.10
Access:	Green

Abstract

Pest Risk Assessments (PRAs) provide a simple evidence-based evaluation of risk posed by one or more pests to crops and can support farmers and farm advisors in developing integrated pest management strategies. By providing a structured approach to estimating the likelihood of pests infesting crops, and the hazard they present to crop production, these assessments enable targeted preventative and mitigating actions with a clear link to impact. In this chapter we break down the processes and tools available to undertake a pest risk assessment, the potential influence of the perception of risk on decision making and provide a worked example for a priority pest in wheat.

Chapter: Online decision support systems, remote sensing and artificial intelligence applications for wheat pest management

In: Advances in understanding insect pests affecting wheat and other cereals

Authors:	Leybourne, D.J., Ramsden, M.W., White, S., Wang, R., Huang, H., Xie, C., and Yang, P.
Editors:	Eigenbrode, S., and Rashed, A.
Year:	2023
DOI:	https://doi.org/10.19103%2FAS.2022.0114.21
Access:	Green

Abstract

Infestation with herbivorous insects and other invertebrates ("pests") can be extremely damaging to wheat production, potentially resulting in up to 80% yield loss. Reducing the damage caused by these pests is a central component of crop protection practices. Decision Support Systems (DSS) are interactive systems (usually software based) that help users identify and solve problems and make decisions as part of an IPM strategy. DSS play an important role in pest management, especially in relation to treatment application. DSS can be used as an umbrella term for any software-based support system that helps farmers make management and production decisions. The chapter will focus on providing an overview of DSS targeting the primary wheat pests covered in this book, we will cover both forecasting and prediction DSS available for wheat pest management as well as remote sensing and AI tools available for pest detection.

Modeling the Impact of Proportion, Sowing Date, and Architectural Traits of a Companion Crop on Foliar Fungal Pathogens of Wheat in Crop Mixtures

Phytopathology

Authors:	Levionnois, S., Pradal, C., Fournier, C., Sanner, J., and Robert, C.
Year:	2023
DOI:	https://doi.org/10.1094/PHYTO-06-22-0197-R
Access:	Gold

Abstract

Diversification of cropping systems is a lever for the management of epidemics. However, most research to date has focused on cultivar mixtures, especially for cereals, even though crop mixtures can also improve disease management. To investigate the benefits of crop mixtures, we studied the effect of different crop mixture characteristics (i.e., companion proportion, sowing date, and traits) on the protective effect of the mixture. We developed a SEIR (Susceptible, Exposed, Infectious, Removed) model of two damaging wheat diseases (*Zymoseptoria tritici* and *Puccinia triticina*), which were applied to different canopy components, ascribable to wheat and a theoretical companion crop. We used the model to study the sensitivity of disease intensity to the following parameters: wheat-versus-companion proportion, companion sowing date and growth, and architectural traits. For both pathogens, the companion proportion had the strongest effect, with 25% of companion reducing disease severity by 50%. However, changing companion growth and architectural traits also significantly improved the protective effect. The effect of companion characteristics was consistent across different weather conditions. After decomposing the dilution and barrier effects, the model suggested that the barrier effect is maximized for an intermediate proportion of companion crop. Our study thus supports crop mixtures as a promising strategy to improve disease management. Future studies should identify real species and determine the combination of host and companion traits to maximize the protective effect of the mixture.

Incentives and barriers to adoption of decision support systems in integrated pest management among farmers and farm advisors in Europe.

International Journal of Pest Management

Authors:	Marinko, J., Ivanovska, A., Marzidovsek, M., Ramsden, M., & Debeljak, M.
Year:	2023
DOI:	https://doi.org/10.1080/09670874.2023.2244912
Access:	Gold

Abstract

The effectiveness of integrated pest management (IPM) could be improved by using decision support systems (DSS). To identify barriers and incentives to the adoption of DSS in IPM in Europe, we conducted a survey among farmers and farm advisors in 12 European countries. The data were analysed using state-of-the-art machine learning methods complemented by statistical analysis. The results reveal region-specific barriers to DSS adoption among both farmers and advisors. Among farmers, lack of trust in DSS and the perceived need for additional information technology training are the predominant barriers, while among advisors, limited access to information about DSS is predominant.

Crop modeling frameworks interoperability through bidirectional source code transformation

Environmental Modelling & Software

Authors:	Midingoyi, C.A., Pradal, C., Enders, A., Fumagalli, D., Lecharpentier, P., Raynal, H., Donatelli, D., Fanchini, D., Athanasiadis, I.N., Porter, C., Hoogenboom, G., Oliveira, F.A.A., Holzworth, D., and Martre, P.
Year:	2023
DOI:	https://doi.org/10.1016/j.envsoft.2023.105790
Access:	Gold

Abstract

Recently, we proposed Crop2ML, an open-source modeling framework for exchanging and reusing crop model components between modeling platforms. Here, we present an approach based on reverse engineering to automatically extract and transform meta-information and algorithms of existing crop biophysical models into a platform-independent model component. A search algorithm using Crop2ML concepts, and a many-to-one transformation system were used for producing high-level models. The system consists of parsing the codebase of model components written in different languages using the ANother Tool for Language Recognition (ANTLR) parser generator and processing the generated syntax trees to produce various model implementations. The system was evaluated for three crop model components provided by the BioMA, SIMPLACE, and DSSAT platforms. We demonstrated the extensibility of our approach with the STICS, OpenAlea, and SiriusQuality modeling platforms. CyMLTx is a significant contribution towards the interoperability of crop modeling platforms and the reuse of model components beyond programming languages.

Life Science Workflow Services (LifeSWS): motivations and architecture

Transactions on Large-Scale Data- and Knowledge-Centered Systems

Authors:	Akbarinia, R., Botella, C., Joly, A., Masseglia, F., Mattoso, M., Ogasawara, E., de Oliveira, D., Pacitti, E., Porto, F., Pradal, C., Shasha, D., and Valduriez, P.

Year:	2023
DOI:	https://dx.doi.org/10.1007/978-3-662-68100-8_1
Access:	Gold

Abstract

Data driven science requires manipulating large datasets coming from various data sources through complex workflows based on a variety of models and languages. With the increasing number of big data sources and models developed by different groups, it is hard to relate models and data and use them in unanticipated ways for specific data analysis. Current solutions are typically ad-hoc, specialized for particular data, models and workflow systems. In this paper, we focus on data driven life science and propose an open service-based architecture, Life Science Workflow Services (LifeSWS), which provides data analysis workflow services for life sciences. We illustrate our motivations and rationale for the architecture with real use cases from life science.

Typology for Decision Support Systems in Integrated Pest Management and Its Implementation as a Web Application

Agronomy

Authors:	Marinko, J., Blazica, B., Jorgensen, L.N., Matzen, N., Ramsden, M.W., and Debeljak, M.
Year:	2024
DOI:	https://doi.org/10.3390/agronomy14030485
Access:	Gold

Abstract

Decision support systems (DSSs) enable the optimisation of pesticide application timing to increase pesticide efficacy and thus reduce pesticide use without compromising yield quality and quantity. Limited access to information about available DSSs for use in integrated pest management (IPM) is a major barrier to the uptake of DSSs for IPM across Europe. To overcome this barrier, a typology for DSSs for IPM in Europe was developed, introducing a systematic approach to describe the ever-growing number of DSSs for IPM. The developed IPM-DSS typology was implemented in the free web tool "IPM Adviser", where currently 79 IPM DSSs are described with over 50 attributes describing their structural and performance characteristics. The information about IPM DSSs, which was previously scattered on different websites and difficult to compare, is now standardised and presented in a uniform way, so that it is possible to compare different IPM DSSs on the basis of all the attributes described. The presented IPM-DSS typology implemented in the web tool IPM Adviser facilitates the dissemination and uptake of DSSs for IPM and thus contributes to the achievement of the EU targets for the sustainable use of pesticides.

A framework for evaluating the value of agricultural pest management decision support systems

European Journal of Plant Pathology

Authors:	Joe Helps, Frank van den Bosch, Neil Paveley, Lise Jorgensen, Niels Holst, Alice Milne
Year:	2024
DOI:	https://doi.org/10.1007/s10658-024-02878-1
Access:	Gold

Abstract

Disease management decision support systems (DSS) are typically prediction algorithms that help farmers assess the risk of an epidemic, to guide whether, and to what extent, fungicide treatment is needed. However, there is frequently little information presented to quantify the value of using the DSS, i.e. the likely increased profit or reduced impact to the environment, and the risks of failing to control the pest. Validation of DSS is often limited to a small number of sites and seasons, as extensive field testing is prohibitively expensive. It would therefore be beneficial to have a method to estimate the value of a DSS using existing data sets gathered for other purposes.

We present a theoretical framework for evaluating the value of DSS, and then describe how this can be applied in practice using four case studies of contrasting DSS under different data constraints. The four case studies include DSS that guide (i) the total dose of pesticide applied; (ii) the number of sprays required; (iii) the timing of the first fungicide application in a spray programme; and (iv) infection risk alerts. We demonstrate how our theoretical framework can be used to evaluate DSS, using existing field and literature data to infer the benefits and risks associated with their use. The limitations of using existing data are explored.

Overcoming Barriers to the Adoption of Decision Support Systems in Integrated Pest Management in Some European Countries

Agronomy

Authors:	Marinko J., Kuzmanovski V., Ramsde, M.W., and Debeljak, M.
Year:	2025
DOI:	https://doi.org/10.3390/agronomy15020426
Access:	Gold

Abstract

Decision support systems (DSSs) can improve decision making in integrated pest management (IPM), but are still underutilised despite proven environmental and economic benefits. To overcome the barriers to DSS adoption, this study analyses survey data from 31 farmers and 94 farm advisors, researchers and developers across 11 European countries. Using machine learning techniques, respondents were first categorised into clusters based on their responses to the questionnaire. The clusters were then explained using classification trees. For each cluster, customised approaches were proposed to overcome the barriers to DSS adoption. For farmers, these include building trust through co-development, offering free trials, organising practical workshops and providing clear instructions for use. For farm advisors and researchers, involvement in the development of DSS and giving them access to information about the characteristics of the DSS is crucial. IPM DSS developers should focus on 14 key recommendations to improve trust and the ease of use, increase the transparency of DSS descriptions and validation, and extend development to underserved sectors such as viticulture and vegetable farming. These recommendations aim to increase the uptake of DSSs to ultimately improve the implementation of IPM practises and help reduce the risk and use of pesticides across Europe despite the ever-growing challenges in agriculture.

Decision Support Systems adoption in pesticide management

Open Research Europe

Authors:	Akaka, J., Garcia-Gallego, A., Georgantzis, N., Tisserand, J-C., Vasileiou, E., and Ramsden, M.W.
Year:	2024
DOI:	https://doi.org/10.12688/openreseurope.17577.2
Access:	Gold

Abstract

This paper presents the findings from a survey on factors influencing the adoption of agricultural Decision Support Systems (DSS). Our study focuses on examining the influence of behavioural, socioeconomic and farm specific characteristics on DSS adoption. Using two structural equation models, we investigate how these factors influence the willingness to pay (WTP) and willingness to adopt. Our analysis reveals nuanced insights into the user and farm-specific factors that influence the decision-making process of DSS adoption and WTP. Notably, farm size significantly influences both adoption and WTP, with larger farms more likely to adopt and exhibit higher WTP. To promote adoption, it is important to adapt promotion strategies, with a focus on productivity benefits for large-scale farms and addressing price barriers for smaller ones. Additionally, the main crop type grown impacts WTP and adoption, with arable crop farmers exhibit a lower WTP but more likely to adopt, especially in large-scale operations. Conversely, small-scale arable farmers exhibit higher WTP but lower adoption rates due to scale constraints. Farmer characteristics such as experience and attitudes also play a crucial role, with experienced users and those perceiving productivity improvements due to DSS showing higher WTP. In addition, adoption is also influenced by ease of use and pricing, underpinning the importance of user-friendly designs and clear cost justifications. DSSs with user-centric designs and clear cost justifications can enhance adoption rates.

Chapter: Precision Integrated Pest Management in horticulture; pest and disease forecast, detection, and management

In: Advances in understanding insect pests affecting wheat and other cereals

Authors:	Ramsden M.W., Furiosi M., and Caffi, T.
Year:	2025
DOI:	https://doi.org/10.1007/978-3-031-96534-0_4
Access:	Green

Abstract

Demand for large quantities of high-quality horticultural produce, at a low price, is driving growers towards more intensive production systems. This in turn drives application of digital technologies, improves targeted management of crop, and the associated risks posed by a range invertebrate and pathogens. Predictions about the timing and severity of these pests, along with advances in landscape and crop monitoring support improved decision making and help avoid unnecessary applications of pesticides. In this chapter, we summarise the current options available, and future opportunities for managing horticultural pests using precision technology, within the context of a transition towards wider uptake of more holistic approaches to crop protection.

Introducing the IPM Decisions Platform – a Pan-European online platform hosting decision support systems for integrated pest management.

In preparation for Open Research Europe

Authors:	Ramsden M.W., Nordskog B., Skog TS, Skirvin D., Marguglio A., Caruso A., Pradal C., Jorgensen L., Sonderskov M., Georgantzis N., Debeljak M., Marinko J., Brinks H., Andersson B., Travlos I., Dearlove E., Paveley. N.
Year:	2025
DOI:	https://doi.org/10.12688/openreseurope.21411.1
Access:	Gold

Abstract

Crop protection and pest management are major economic and environmental concerns throughout Europe. The consultation of decision support systems (DSS) to guide decisions relating to Integrated Pest Management (IPM) is one of the key principles of IPM, reducing the ambiguity around potential risks to crop health. 'Pests' in this context include invertebrate pests, weeds and pathogens. The impact of DSS can be limited by a lack of awareness of DSS availability, inconsistencies in the user functions of different DSS, regional fragmentation of access, and a lack of transparency of the origin, validity, and benefits of DSS. Failure to address these limitations undermines trust in IPM DSS and leads to a reluctance of farmers and advisors to invest time in consulting multiple DSS sources as part of their agronomic decision toolbox. The EU-funded IPM Decisions project (Grant agreement ID: 817617) addressed these limitations by creating a Europe-wide free-access online platform. The IPM Decisions platform was designed in consultation with farmers, advisors and wider stakeholders to increase access to and uptake of IPM DSS integrated within it. It offers an end-point for IPM researchers and DSS developers to make adapted and novel DSS available to users, and provides a 'one-stop shop' for farmers and advisors looking to consult free access or paid IPM DSS. Dedicated dashboards within the platform facilitate farm set up, consultation of DSS, comparison of DSS outputs, and adjustment of model parameters for adaption to different pests/regions. The IPM Decisions digital infrastructure enables easy integration of models and data with external platforms, providing a framework for accessing and sharing models and data between researchers and developers. The platform therefore provides both a ready to go user interface for new DSS, as well as the infrastructure to support and connect existing and future user interfaces.

1 Work in preparation for publication post project period

Publication	Planned Access
Hkelkrem A.R., et al (Submitted 2025) Leaf wetness – calculations for use in agricultural decision support systems targeting multiple crops and climatic zones.	
Huitu, H., et al (in prep) Developing a generic DSS model metadata catalogue and APIs for crop protection.	
Ramsden et a. (In prep) Socioeconomic evaluation of decision support systems in UK agriculture.	

Leaf wetness – calculations for use in agricultural decision support systems for integrated pest management across multiple climate zones

Authors: Hjelkrem, A.R., Linnestad, B, and Nordskog, B.

Planned access: Gold

Abstract

Leaf wetness is an important input variable in web-based decisions support systems developed for optimized crop protection, as presence of leaf wetness is crucial for infection and reproduction of both bacterial and fungal pathogens. Leaf wetness is difficult to measure as no international standardization in how to measure leaf wetness exists. The variable is often missing in standardized weather data services, hence mathematical models to estimate leaf wetness from other commonly available weather variables are developed and used. Numerous mathematical models have been developed to estimate leaf wetness duration, but still, no standard model has been chosen for exclusive use internationally. The objective of this study was to identify a robust "default" model to calculate leaf wetness accurately across geographical regions and different climate zones within Europe.

Five machine learning based models were developed in this study and compared with five existing empirical models from the peer-reviewed literature. All the newly developed models performed better or on the same level as the existing empirical models in the predictions of leaf wetness. The Long Short-Term Memory (LSTM) model was the most advanced algorithm included in this study and stood out as the overall best model to predict leaf wetness. The model performed with the overall highest accuracy, the second highest specificity and the second lowest sensitivity. In addition, it was found to perform well across locations, having the second lowest variability in accuracy. The LSTM model should thus work well to provide inputs for decision support systems across multiple climate zones. Still, through a site-specific training and testing of the LSTM model, using data from Norwegian weather stations within the cold climate zone only, an improved sensitivity was achieved along with an unchanged accuracy and specificity. Hence, if possible, a site-specific training of the LSTM model should replace the general model.

Developing a generic DSS model metadata catalogue and APIs for crop protection

Authors:	Huitu, H., Skog, T, Pradal, C., Calatayud, A., Skaslien, T, Linnestad, B., Ronkainen, A., Fournier, C., Labadie, M., Skirvin, D., Pastell, M., Melchior, D., Langvatn, J.T., and Nordskog, B.
Planned access:	Gold

Abstract

Decision Support Systems (DSS) in crop protection can give helpful pest risk prognosis or recommendations for pest control, allowing farmers or advisors to make better-informed decisions. DSS´s for crop protection have become increasingly relevant, as control measures are to be carried out with best available information to lessen the environmental pressure and harmful organisms in cultivation are spreading to new areas.

As a part European Union policy strategy to steer at sustainable use of plant protection products, the EU H2020 project "IPM Decisions" assessed and analyzed a set of very heterogeneous research verified DSS´s for integrated pest management. Information on these models have been collected into a freely available model catalogue, which is employed as models are provided for use in the IPM Decisions platform.

Application Programming Interfaces (APIs) have been built to access to the model catalogue and models in it, one managing DSS Model data (DSS API) and another to access and manage weather input data (Weather API). The new APIs work as part of the IPM Decisions Platform, but they are publicly available and as such they also enable other agricultural software such as farm management information systems (FMIS) or crop protection applications to use them.

In the spirit of FAIR (Findable, Accessible, Interoperable, Reproducible), the DSS API provides access to DSS models with their metadata, including description of their input- and output parameters. Weather API allow access to European on-line weather data sources and adapt their offering to the needs of the DSS models. In this article we discuss the development of DSS and Weather APIs. We review the requirements for the model metadata, input- and output schemas that are stemming from the characteristics of available DSS models. In addition, we review the requirements of the weather data as model input and present the respective schema. Finally, we present the services that DSS API and Weather API provide, and demonstrate the use of the APIs in three application cases.

Socioeconomic evaluation of decision support systems in UK agriculture

Authors:	Ramsden, M.W., Webb, E., Wynn, S., Ffoulks, C., Furiosi, M., Caffi, T., and Paveley, N.
Planned Access:	Gold

Abstract

Agriculture in the UK is facing increasing pressure to improve productivity while also improving its sustainability. While there are no legally binding targets in place to reduce fungicide usage in the UK, it is recognised that the use of plant protection products needs to decrease. Decision support systems can be used as part of integrated disease management strategies to reduce the use of fungicides by informing farmers about the risk of disease to their crops, allowing them to avoid unnecessary treatments. However, the current uptake of decision support systems by all farmers is estimated to be relatively low throughout the UK. This study evaluates the socioeconomic impacts associated with widespread implementation of decision support systems in wheat and potato production. The results indicate that using decision support systems can provide economic benefits for farmers by reducing the treatment frequency index, thus lowering total fungicide usage and overall cost of production. This would therefore help to maintain crop productivity while also minimising the risk of resistance development.