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## DSS-IWM: An improved European Decision Support System for Integrated Weed Management

*DSS-IWM: Ein verbessertes europäisches Entscheidungshilfesystem für die integrierte Unkrautbekämpfung*

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### Abstract

In the frame of the European ERA-Net project “Coordinated Integrated Pest Management in Europe (C-IPM)” scientists from Germany, Denmark and Spain design and customise an innovative online decision support system for integrated weed control (DSS-IWM) in maize and winter wheat. The project runs from 2016 to 2019 with the aim to assist farmers and farm advisors in treating weeds in crops at precisely the right times and the most efficient products in the right amounts. DSS-IWM can, therefore, contribute to reducing herbicide consumption markedly without affecting the yield. It will support reliable decisions based on local conditions and will consider thresholds for weed densities, include economic calculations of treatment costs.

The basis of herbicide recommendations is the database and the calculation/mathematics of the DSS-IWM, especially dose-response-relations of herbicides. If data gaps appear pot trials with respective weeds and herbicides are carried out. New features and information are continuously filled in. Additionally, in all countries field trials in maize and winter wheat are carried out to validate the DSS.

**Keywords:** Decision support system, DSS, herbicides, integrated weed management

### Zusammenfassung

Im Rahmen des europäischen ERA-Net Projektes „Coordinated Integrated Pest Management in Europe (C-IPM)“ entwickeln Partner aus Deutschland, Dänemark und Spanien ein innovatives, online-gestütztes Entscheidungshilfesystem für die integrierte Unkrautbekämpfung (DSS-IWM) in Mais und Winterweizen. Das von 2016 bis 2019 laufende Projekt soll sowohl Landwirte als auch Berater verlässlich dabei unterstützen, Unkräuter zum richtigen Zeitpunkt mit den geeignetsten Mitteln in richtiger Aufwandmenge zu bekämpfen. Das DSS-IWM soll somit dazu beitragen, den Herbizidaufwand zu reduzieren, ohne Ertragseinbußen zu riskieren. In die Entscheidungen werden lokale Bedingungen, Schadensschwelen und ökonomische Berechnungen der Behandlungen einbezogen.

Die Grundlage des DSS-IWM sind eine zuverlässige Datenbank und Kalkulation der Anwendungen, insbesondere der Dosis-Wirkungsbeziehungen der Herbizide. Datenlücken sollen durch Ergebnisse aus Gefäßversuchen geschlossen werden. Neue Entwicklungen und Informationen werden kontinuierlich eingearbeitet. Das DSS-IWM wird durch Feldversuche validiert.

**Stichwörter:** DSS, Entscheidungshilfesystem, Herbizide, Integrierte Unkrautbekämpfung

### Introduction

Since weeds in winter wheat and especially in maize are of major concern, herbicide input for these crops has large impacts to the environment, but also significantly effects on cost efficiency of farmers. Experiences from Denmark, Germany and other countries have shown that farmers are willing to invest in decision support systems (DSS) in order to increase cost efficiency.

Potentials of this DSS arise from the idea of adjusting control measures to specific and practical conditions on field level, without jeopardising safety in weed management. In contrast to this,

existing practices in applying herbicides in maize and cereals are very often based on general recommendations - resulting in dosages higher than necessary.

Results from field test of previous DSS prototypes show that weeds have been controlled satisfactorily even if herbicide dosages have been reduced by 20-40% compared to local recommendations (e.g. JOERGENSEN et al., 2007; MONTULL et al., 2014; SONDESKOV et al., 2014). However, recent field trials have also demonstrated that herbicide decisions resulted from DSS were often not correct, especially in maize.

During the predecessor EU project 'ENDURE' (2007-2009) 70 different regional DSS versions were analysed by a comprehensive questionnaire. Nine of these DSS included weed control, and best parts were identified in 3 of these DSS. These parts were subsequently integrated in a first draft version of DSS for herbicides designed by Aarhus University and sponsored by the EU-project 'PURE' (2010-14). During this project the few field validation tests in maize have demonstrated the potential for herbicide reduction, but have also shown different lacks in the system. Similar preliminary findings have been obtained for winter wheat during the project 'DSSHerbicide', which has run until 2014.

There are still different prototypes of DSS for herbicide use in maize and winter wheat, but at least in Europe they are not widely used. Despite the recent promising progress of designing a DSS for herbicides, the continuation on biological research and technical designing has unfortunately stopped by the end of the projects mentioned above. In order to achieve a more synergistic work on the European level the decision support system for integrated weed management (DSS-IWM) will merge existing findings and knowledge.

The DSS concept recently supported by IPM Consult Ltd. (IPMC) as a 'proof-of-concept' has been designed on the basis of analyses of existing DSS for Integrated Pest Management (IPM). Since the project will deal with maize and winter wheat growing in the partner's countries Denmark, Germany and Spain, DSS-IWM potentially covers a wide range of arable land in different climatic situations within Europe. Based on the planned structure and implementation, the DSS-IWM can easily be extrapolated to other European countries at a later stage.

Therefore, the project DSS-IWM, which runs from 1st April 2016 to 30th March 2019, will develop a tool for Integrated Weed Management in winter wheat and maize. The main target groups are farmers and plant protection advisors, who can use the system via web portals which already exist for integrated pest management (e.g. ISIP in Germany). Farmers will benefit from economical savings in input of herbicides by maintaining a high efficacy and market profit. These economic effects are accompanied by positive environmental effects due to reduced herbicide dosages.

### **Objectives and Measures**

Based on recent research work on many different regional prototypes of decision support systems for herbicides, data gaps and additional research needs were identified. For example, combinations of efficacy targets and dose-response functions have to be validated under field conditions. Furthermore, specific tools like resistance management have to be added to DSS-IWM. Finally, the project aims to select and improve the best test version (in terms of agronomical robustness and potential for reducing use of herbicides) for practical applications.

For feasible purposes and dissemination, the DSS-IWM will be demonstrated to farmers and advisors on field days and exhibitions. In addition, first experiences and results will be published in relevant national journals for farmers and for similar interesting groups. The project partners also expect feed-back by farmers and advisors organised by meetings or web-based queries. There is an additional opportunity to publish the findings of the project in a more scientific manner in international journals, as well as presentations on national and international conferences.

The final system DSS-IWM may gradually improve farmer's understanding of integrated pest management as well as the knowledge on weeds and control options. In this way farmers may get stronger focus on successful control options. In detail, DSS-IWM will enable farmers and advisors

to follow the 8 general principles for integrated pest management as defined in Directive 2009/128/EC and simultaneously reduce costs for herbicides. DSS-IWM also provides appropriate assistance to select options which might reduce or avoid herbicide resistance. If herbicides are classified according to their environmental behaviour and restrictions for use, farmers can use this additional information for a better herbicide choice. Some of these features are already principally included in some DSS prototypes but have never been filled with data (e.g. costs for maize herbicides). So far, other new parts of information (e.g. mechanical control in maize) are not yet considered at all.

The main results of the new scheduled project will be the following: DSS-IWM

- is ready to online use for weed control in maize and winter wheat
- provides reliable decisions and considers national conditions
- enables to consider thresholds for weed densities
- includes economic calculation on treatment costs
- offers mechanical options wherever possible
- facilitates herbicide resistance management
- is the basic platform for uses in other crops and countries

All in all, the project DSS-IWM will create nationally adapted tool-boxes for more efficient integrated weed control in maize and winter wheat. Therefore, it covers two major crops in Europe. There is also a high potential for using DSS-IWM outside of the three participating countries. However, before a commercial use can start, the system has to be significantly improved and finalised during the project period. The consortium of Julius Kühn-Institut (JKI), Informationssystem Integrierte Pflanzenproduktion e.V. (ISIP), IPM Consult Ltd. (IPMC) and University of Lleida (UdL) is aiming to improve the functionality and application of the DSS-IWM.

In terms of the technical structure, DSS-IWM will address potential users by linking a basic DSS database to other IPM portals already used by these target groups. For example, as far as DSS-IWM is adapted for Germany, it will be part of the well-known ISIP web portal. This approach will be the basis for a successful use of DSS-IWM also in other countries.

Because of the known large interest in using different decision supports systems and because of the scheduled professional release of DSS-IWM, a long-term viable product can be expected in Europe. The new scheduled decision support system will not only help farmers. It will also relieve advisors in giving safe and efficient recommendations which may fully covers IPM principles.

For the future there is a high potential for using DSS-IWM also in other crops and countries. We see promising options especially by combining the system with new site-specific technique like GPS, automatic weed detection and programmes for field and pesticide application management (e.g. via smart phone).

### **Results of the first project period**

In the 1st half of the DSS-IWM project, operational, online DSS prototypes have been constructed for wheat and maize in Germany, Spain and Denmark. These prototypes include 2 levels of 'target efficacy' and full assortments of herbicide products and as many weed species as possible, according to available datasets on efficacy of mainly herbicides. From a study on data gaps it was concluded that sufficient datasets have been supported for professional use in the 3 countries. The DSS prototypes also integrate default adjustments of dose-response calculations of single herbicides for classes of weed size, temperatures and water stress. On top of this, options for 2-4 way tank-mixtures have been included, as such are needed in complex weed infestations.

Field validation trials have been initiated to validate recommendation from the DSS prototypes in both crops in the 3 countries, and provisional results are currently in processing. After 2 years of validation, it is(?) expected that prototype version can be identified, which demonstrate suitable levels of weed control and hopefully also potentials for reducing the input of herbicides.

Missing or not exact efficacy data for herbicides and weeds will be obtained by pot and field experiments, if required.

Simultaneously, additional functionality will soon be designed and integrated in terms of:

- measures for mechanical control
- measures for resistance management.

The latter including:

- measures control of weed biotypes, which have already gained resistance to different 'mode-of-action'
- measures to prevent/delay development of additional herbicide resistance.

Separate dissemination and business plans will be set up in the 3 countries.

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