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Beyond modelling: considering user-centred and post-development aspects to ensure the success of a decision support system

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ABSTRACT

RIM, or 'Ryegrass Integrated Management', is a model-based decision support system (DSS) for weed management in broadacre cropping systems that was updated to continue aid the delivery of key recommendations to manage herbicide resistance. This article complements earlier publications by documenting the rationales that underpinned the re-development efforts. The objectives are to inform the next development cycle of RIM and its delivery, as well as its adaptation to other situations. Specifically, the article aims at providing developers and project managers with key aspects to be considered before and after (re-)developing this type of model-based agricultural DSS. Reviewers report a lack of similar efforts, with modelling aspects generally better documented than underpinning rationales, including those related to implementation. Yet, this type of initiative is necessary considering that agricultural DSS can become expensive projects, and that uptake by target audiences is typically low in spite of known pitfalls and limitations. The key elements that contributed to the thought process behind upgrade choices are thus provided, as well as practical consequences for modelling. Clearly re-asserting cost-effectiveness objectives and favouring human aspects led to: retaining the 'what-if' learning strategy rather than developing optimisation features; renouncing added modelling intricacies; enhancing the software accessibility; and anticipating future maintenance and distribution requirements. Strategies to maximise the impact of RIM are also discussed, particularly the need for qualified workshop facilitators, as well as transparency and evaluation to build user confidence.

1. Introduction

Decision support systems (DSS) are computer-based tools which can aid complex managerial decisions. Weed management DSS are generally based on mathematical models combining weed population dynamics and agricultural practices (Holst et al., 2007). Despite considerable initial investment in modelling and calibration, mathematical simulations are popular tools among the weed research community as they offer the convenience of quickly testing multiple situations and management combinations, thus offering a convenient alternative to long-term experiments seldom conducted because of implementation difficulties, practical limitations, or lack of funding. Making such models accessible to farmers and advisors through a DSS format has been a substantial effort over the past few decades by scientists to go beyond the research scope and reach out to the industry. Numerous DSS have resulted – which often justify more modelling investment. However, despite research benefits, uptake by the target audience has been acknowledged to be mediocre (Hayman, 2004; Stone and Hochman, 2004; McCown et al., 2009; Hochman and Carberry, 2011).

RIM, or 'Ryegrass Integrated Management', was one such model-based weed management DSS which proved, contrarily, to be very successful. Developed during the 1990s–2000s for the Australian southern grainbelt (Pannell et al., 2004), RIM contributed to successfully advocate sustainable practices to reduce the risk of herbicide resistance, in addition to inspiring several other weed management models (Llewellyn et al., 2005; Llewellyn and Pannell, 2009; Lacoste and Powles, 2014). However, maintenance and delivery to farmers and industry professionals ceased in 2006 due to lack of resources. A decade after its release, the original RIM is still well-known but remained mostly unchanged with its use restricted to a limited number of universities and private educators (Long and Parton, 2012; Lacoste et al., 2013). An upgrade was undertaken considering both the substantial investment in the original program and the potential for further impact in cropping contexts still threatened by the onset of herbicide resistance (Lacoste and Powles, 2014, 2015).

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This paper complements earlier descriptions by documenting key elements that contributed to the thought process behind the DSS upgrade. This initiative was motivated by reviewers reporting a lack of similar efforts, model mathematics being more often published than the logic underpinning their construction (Holst et al., 2007; McCown et al., 2009). An effort is made here to open the upgraded software and the methodology used to critique, as well as to inform the wider application of RIM, its next development cycle, and similar agricultural DSS projects. This is particularly needed as adaptations to the new RIM version have already commenced (Table 1). The rationales motivating important upgrade choices are thus discussed, in light of the lessons learnt from early RIM evaluations and from reviewers. As with any model-based program, compromises had to be made to solve overarching problems with limited resources, while following recommendations in order to reach the desired outcomes. Following this, post-development recommendations for the optimal delivery of a model-based DSS such as RIM are provided.

2. DSS and re-development overview

The usefulness of the RIM model to investigate research questions had extensively been exemplified (e.g. Doole, 2008; references within Lacoste and Powles, 2014). However, the re-development of RIM was primarily motivated by the ability of the program to support the delivery of key messages to the agricultural community through its use as a DSS. Extension activities were thus resumed with the availibility of the new version (Table 1). RIM helps providing insights into the sustainable management of ryegrass (*Lolium rigidum* Gaud.) through a convenient way of testing and comparing the long-term performance and profitability of various control options through simulations, on the long-term and at field scale. Parameters are calibrated for the dryland broadacre cropping systems of the Australian southern grainbelt where winter cereals dominate (main crops: wheat, barley, canola, lupin; main livestock systems: sheep on volunteer or improved pastures).

Implemented in Microsoft Excel®, RIM follows a 3-step progression with the user navigating between panels (Fig. 1). The steps involve customising a profile with field characteristics and economic information, building a 10-year rotation, and defining a ryegrass control strategy through a combination of field operations to choose from over 40 chemical, mechanical and cultural options. The main outputs include the impacts through time on ryegrass seed and plant numbers and on gross margins. Lacoste and Powles (2014) provide extensive examples of how results can be used to support extension messages and educate the farming community about herbicide resistance. An important feature of RIM is that notwithstanding customisation, the software provides general trends without environmental or year-to-year variations, which thus are not accurate predictions for a specific location. Therefore, RIM's simulations are to be used and understood as a comparative analysis tool, not as a forecast instrument.

RIM is essentially constructed with interlinked tables and formulas connecting input parameters, user's choices, equations and model outputs (Lacoste and Powles, 2015). The core components of RIM are a weed population dynamic model linked to a rule-based model. A software-like behaviour is provided with a Visual Basic for Applications (VBA) framework.

Prior to starting the re-development, issues limiting the overall lack of agricultural DSS adoption were investigated and found to be strikingly consistent (Wilkerson et al., 2002; Stone and Hochman, 2004; Holst et al., 2007; McCown et al., 2009; Hochman and Carberry, 2011). Typical pitfalls and limitations identified by the above reviewers include a general lack of definition of the DSS objectives and target audience, which result in various development issues. These issues include misdirected efforts, a lack of

Table 1
Projects extending from RIM 2013.

RIM 2013 and current adaptations			
Name and weed species	Cropping systems, location	Publications, contacts	Release date, funding agencies
RIM: Ryegrass (*Lolium rigidum*)	Dryland crop-livestock (wheat, barley, legumes, sheep), Southern Australia	Lacoste and Powles (2014, 2015), AHRI, University of Western Australia	2013, GRDC
BYGUM: Barnyard grass (*Echinochloa colona*)	Sub-tropical and temperate systems (cotton), Eastern Australia	Thornby and Werth (2015), Inokas Intellectual Services and DAF	2015, CRDC and DAF
PAM: Palmer amaranth (*Amaranthus palmeri*)	Row crops (cotton, corn, soy), Southern US	Bagavathiannan et al. (2014, 2015), Texas A&M University	2016, USDA and industry sponsors
Brome RIM: Brome grass (*Bromus* spp.) **Barley RIM:** Barley grass (*Hordeum* spp.) **Mallee Ryegrass RIM:** Ryegrass (*Lolium rigidum*)	Dryland crop-livestock (wheat, barley, legumes, sheep), South-Eastern Australia	Monjardino et al. (pers. comm.), CSIRO Adelaide	Late 2016, GRDC
Perennial ryegrass (*Lolium perenne*) Wild oat (*Avena fatua*) Fleabane (*Conyza bonariensis*)	Semi-arid cropping (barley, soybean, wheat, sunflower), Eastern Argentina	Chantre (pers. comm.), Universidad Nacional del Sur/ INTA	Unannounced
RIM 2013 extension activities (Australia)			
Type	Location, dates, attendance	Contact, delivery	Funding agencies
RIM hands-on workshops and factsheets: Financial and non-financial costs of new integrated weed management tools based on regionally specific RIM outputs, update on weed management issues with farmers	Events around Australia: 4 in 2013, 7 in 2014, 1 in 2015, ongoing. 415+ attendees, farmers and consultants	Micallef and Newman (pers. comm.), AHRI extension and research staff with farmers	GRDC, WeedSmart Initiative
RIM presentations: RIM outputs presented and discussed as part of a larger weed management event	Events around Australia: 16 in 2014, 12 in 2015, ongoing. 1100+ attendees, farmers and consultants	Micallef and Newman (pers. comm.), AHRI staff	GRDC, industry companies
Online communication: RIM outputs of realistic scenarios based on farmer consultation using social media, videos and website, marketed mainly through newsletter (2 500 subscribers)	Online, 2015–2016, ongoing. For website, 670+ unique page views as of mid-2015	Micallef and Newman (pers. comm.), AHRI staff	GRDC