Validating ryegrass RIM using data from IWM field trials

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Summary RIM is a bioeconomic model for simulation of annual ryegrass management strategies. The ryegrass population dynamics component of the model is tested using data from field trials located in the wheatbelt of Western Australia. Results confirm that the model has the potential to generate results similar to field outcomes once important variable parameters are adjusted to suit particular scenarios. Principles discussed and illustrated can be transferred to other locations and management systems. RIM ignores complexities of tillage, timing, soil type, and resistance evolution. However, users of RIM can make adjustments to the model to suit individual scenarios and confidently apply model results as a guide to their ryegrass management.

Keywords Annual ryegrass, *Lolium rigidum*, Integrated Weed Management, model, validation.

INTRODUCTION

The study involved the use of existing data to validate the Ryegrass RIM (Resistance and Integrated Management) model. RIM is a bioeconomic simulation model for testing the performance of Integrated Weed Management (IWM) strategies to control annual ryegrass. The model can be run over 20 years and the user can define a sequence of crops and/or pastures within this time frame. RIM does not represent year-to-year seasonal variation and therefore each year is assumed to be an average season. Any valid combination of 35 weed control treatments can be selected annually. The model can be calibrated to a variety of scenarios by changing both biological and economic parameters. Major outputs generated by the Ryegrass RIM model include simulated ryegrass plant and seed densities at various stages throughout each year, annual gross margins and 10 and 20 year profit per hectare (Pannell *et al*. 2002).

Project ACR4, to date, has generated five years of data from IWM field trials located at three different locations in the wheatbelt of Western Australia. These trials employ a range of different treatments and rotational systems aimed at controlling herbicide resistant annual ryegrass (*Lolium rigidum*) populations. Key outputs from the trial sites include assessments of ryegrass densities and crop yields through time.

The availability of the ACR4 data sets has allowed the ryegrass population dynamics component of the RIM model to be tested against actual field recordings.

MATERIALS AND METHODS

The RIM model was calibrated for each set of treatments and rotations employed within the ACR4 project involving two sites of five and nine blocks at Dowerin and one of 15 blocks at York. Different combinations of weed control treatments and rotations were applied to each trial block. Ryegrass measurements were taken at each block.

In-crop ryegrass densities in 1996 (prior to trial commencement) were recorded at each trial site. Actual treatments used in 1996 were transferred to RIM and the initial ryegrass seedbank size adjusted so that simulated in-crop densities (spring 1996) matched those in the field. This approach ensured that simulations started with the same seedbank as in the trials.

The biological structure in RIM is such that ryegrass plant (and seed) densities are predicted at six different stages throughout the year (Table 1).

In the study ryegrass counts in the field were compared with RIM's projected numbers at either 'time for post-emergent spraying' or 'early spring' densities. This rationale allowed for the effects of most control treatments to take place and for most weeds to germinate. In addition, the in-crop density is a reflection of potential seed set and influences paddock management in the subsequent year.

Efficacy of some weed control treatments are inherently variable depending on seasonal conditions, timing and other factors (e.g. stubble burning, spraytopping), even though RIM includes default values for all treatments. Treatment efficacies were

Table 1. Biological time-frame within RIM.

Plants at first chance to seed (break of season)
Plants at 10 days after break
Plants at 20 days after break
Plants at time for post-emergent spraying
Plants at early spring
Plants setting seed

adjusted in line with those achieved in the field (Table 3).

The validation included an analysis of every trial block in project ACR4 examining:

- Actual data generated in the field.
- RIM projections at original default mortality parameters.
- RIM projections with adjusted mortality parameters.

This process is reported in detail in the results for block 1a at site 1b.

RESULTS AND DISCUSSION

The first set of results presented for block 1a serve as an example of the process applied to every trial block in project ACR4. The crop and weed management system in place in block 1a at site 1b (Table 2) is very simple and effective. A wheat crop heavily infested with ryegrass was selected during the 1996 growing season ready for trial commencement in 1997. After the high ryegrass density within the 1997 chickpea crop was controlled by brown manuring, consecutive wheat crops have successfully been grown with ryegrass control predominantly from competitive crops, effective stubble burning and delayed seeding. Weed control treatments were entered into RIM and then the model's outputs were compared with the sequence of ryegrass field counts initially using default mortality parameters in RIM.

The disparity between actual and RIM simulated ryegrass densities in 1997 (Figure 1) is mainly due to a higher proportion of ryegrass seed placed into windrows in the field than RIM assumed. Nevertheless, the steadying trend in the ryegrass population from 1998 is correctly predicted, albeit at slightly higher levels than in reality. A notable message that can be derived from these results is that when dealing with large densities of weeds setting seed (e.g. in 1996), the potential exists for significant variation in future years. In this case, RIM's inaccuracy is manifested in 1997, despite brown manuring in this year having reduced the discrepancy in future years.

To seek a better representation of reality than was achieved using default RIM parameters, changes were made to account for actual measurements and estimations of ryegrass mortality achieved in the field (Table 3).

Data from *in situ* resistance tests at each site in 1997 (first year of trials) enabled selective herbicides to be calibrated. Efficacies from other non-herbicidal control treatments were calibrated based on subjective estimates of mortality achieved in the field.

As shown in Figure 2, once adjustments were applied to RIM, projections approximated reality.

Table 2. Field operations and ryegrass counts, block 1a at site 1b.

1996 WHEAT in-crop ryegrass m^{-2}	608
Harvested and chaff placed into windrows*	
1997 CHICKPEAS BROWN MANURED	
SB, SS + SIM + seeded @ 110 kg ha^{-1}	
7 August ryegrass m^{-2}	184
BM, GLY fb PQT	
1998 WHEAT	
23 April ryegrass m^{-2}	95
GLY, CULT, TF + seeded @ 85 kg ha^{-1}	
4 September ryegrass m^{-2}	28
1999 WHEAT	
8 April ryegrass m^{-2}	93
GLY, SB, CULT	
24 May ryegrass m^{-2}	13
SS + TF + seeded @ 85 kg ha^{-1}, reseeded	
23 July ryegrass m^{-2}	25
Chaff carted at harvest	
2000 WHEAT	
SB	
22 May ryegrass m^{-2}	14
SS, seeded @ 140 kg ha^{-1}	
10 August ryegrass m^{-2}	60
2001 WHEAT	
SB	
1 June ryegrass m^{-2}	93
SS + seeded @ 100 kg ha^{-1}	
1 August ryegrass m^{-2}	45

*All ryegrass counts were made off windrows.
GLY = glyphosate; SS = Spray.Seed®; SB = stubble burn; SIM = simazine; PQT = paraquat; CULT = cultivation; TF = trifluralin; BM = brown manured.

Table 3. Changes made to mortality parameters (% kill) in calibrating RIM for site 1b.

Treatment	Default	Calibrated
Windrow chaff	63	85
Brown manure	98	100
Stubble burn	30	50
Simazine	75	28
Trifluralin	70	30

Further confirmation of RIM's validity was investigated by analyses of eight other trial blocks at this site. These other trial blocks included brown manured peas in 1997, followed by other combinations of crops and weed control treatments in subsequent years. In the

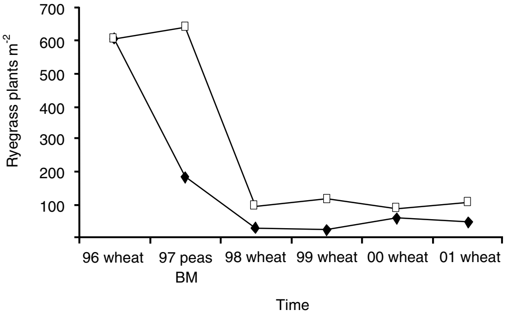

Figure 1. Actual (♦) vs. RIM (□) in-crop ryegrass densities, using default RIM mortality parameters.

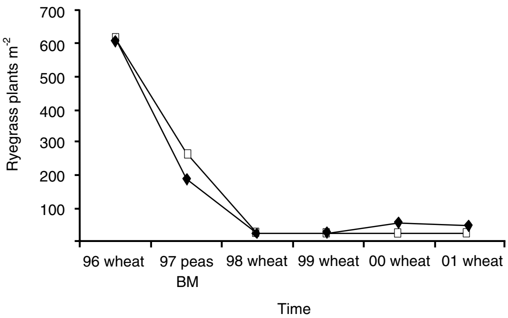

Figure 2. Actual (♦) vs. RIM (□) in-crop ryegrass densities, applying adjusted RIM mortality parameters.

field, similar trends in the ryegrass population emerged for these other blocks as was evident on block 1a. This occurrence provides a good opportunity to test whether RIM predicts similar patterns.

Average densities of the nine blocks (Figure 3) clearly show consistency across this site. Results generated by RIM for block 1a follow a similar pattern as the average.

Additional trial sites at Dowerin (site 1a) and York (site 2) were analysed to see if similar results emerged from other locations. Averages of five blocks at each site are presented in Figures 4 and 5, respectively.

The RIM model generated consistent results across all sites. RIM projections at default treatment efficacies did not match real data. However, the trends evident in these projections were in line with expectations, based on the parameters used. Predictive accuracy at all sites was improved by changing key parameters in line with field measurements and estimations. The effects of these changes can be large, as seen in site 1a (Figure 4) or relatively small, as seen in site 2 (Figure 5). Therefore it is important for users of

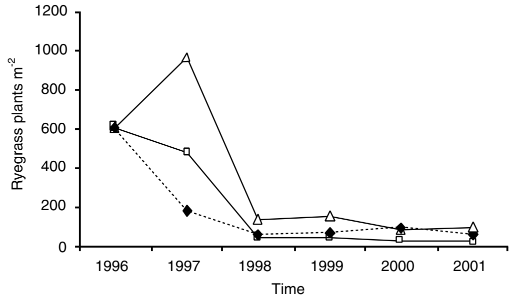

Figure 3. Actual in-crop ryegrass densities (--♦--) vs. RIM in-crop ryegrass densities at default mortality parameter values (Δ) and adjusted mortality parameter values (□), average of nine blocks at site 1b.

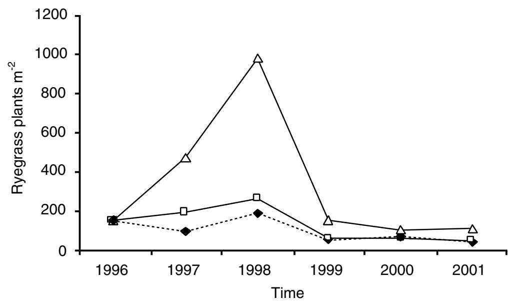

Figure 4. Actual in-crop ryegrass densities (--♦--) vs. RIM ryegrass densities at default mortality parameter values (Δ) and adjusted mortality parameter values (□), average of five blocks at site 1a.

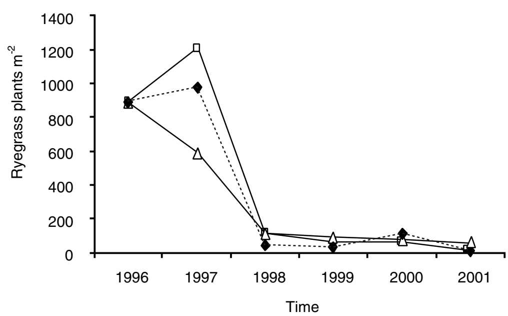

Figure 5. Actual ryegrass densities (--♦--) vs. RIM ryegrass densities at default mortality parameter values (□) and adjusted mortality parameter values (Δ), average of five blocks at site 2.

RIM to understand the crop/weed management system that they are simulating and to take note of particular treatments or other factors that can have a large impact on ryegrass densities.

RIM is a basic rotational model incorporating annual ryegrass as a constraint to crop production. The model results are largely reliant on assumptions involving average biological events and control efficacies occurring. In reality, variability exists from year-to-year and from site to site, so for any given strategy a range of outcomes is possible. Hence RIM is used as a guide rather than a prescriptive tool for ryegrass management. RIM is a long-term (up to 20 years) ryegrass management tool that is best suited to dealing with strategic issues rather than short-term tactical or seasonal issues. Effects of seasonal and treatment variations are of lesser significance in the long run. Given the relatively simplified structure of the model, RIM displays a remarkable ability to reflect reality, partly due to the relatively short seedbank life of ryegrass. These similarities were possible once alterations were made to RIM's mortality parameters.

The study raises a number of time-related issues that affect both results presented and also implications for future management when using RIM. Past data were used to calibrate treatment efficacies. These efficacies will not necessarily be the same in the future. In addition, future replication of strategies used in project ACR4 may result in different ryegrass densities due to seasonal and other variations. As treatment efficacies and other effects are not known in the future, RIM projections simply offer a guide as to what might happen if a certain set of assumptions occur. Therefore users of RIM will find that field results in future years are often different to corresponding RIM projections. In this context, sensitivity analysis can be conducted within RIM to investigate a range of possible outcomes.

RIM has achieved an acceptable fit of the data in the examples provided in this paper. RIM's major use is as a tool for investigating the principles of IWM and conducting some virtual experiments within a simple analytical framework. Results from this project confirm that RIM has sufficient accuracy for these purposes.

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