What would make weed management decision support tools more valuable for advisers?

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Summary Despite increasing efforts in simulation modeling of weeds, the uptake of computer-based decision support tools (DSTs) by weed management advisers and farmers remains low. This study aimed to identify the potential role of DSTs for farm advisers, and what characteristics of DSTs are preferred by those giving crop-weed management advice to farmers. We used an economic valuation method involving 109 commercial, private and public-sector advisers at workshop sessions held across Australia. The study reveals what information and what attributes of a weed management DST are most valued by advisers. A tool that can inform the decision whether or not to implement weed seed set control in the current crop by predicting the next year's weed population was highly valued. Tools that require three or less hours of input/learning time will be valued much more highly than those that require more 'start-up' time. Reducing the necessary 'start-up' time from six to three hrs was more valuable than increasing the 'accuracy' of the tool from 70 to 90%. Two adviser types were revealed: (1) one that prefers a tool with more highly developed simulation capacity, who are prepared to invest time and money to achieve more accurate, customized, paddock-specific results; and (2) a type that has a preference for tools that can more rapidly deliver regionally representative output with less value placed on high accuracy. The results demonstrate what type of weed management decision support tools are valued by advisers, but also that individual preference for tool capabilities and attributes varies greatly.

Keywords Weed management, herbicide resistance, decision support, advisers.

INTRODUCTION

Weed and herbicide resistance management problems often involve complex interactions, long time frames and high levels of uncertainty. Because of this, computer-based simulation models are commonly used as weed research tools. However, the uptake and use of computer-based decision support models by advisers and farmers has generally been low, reflecting a widely recognised 'implementation problem' for agricultural decision support (Hochman and Carberry 2011, Hayman 2004, Jakku and Thorburn 2010).

Decision support tools (DSTs) can be defined as computer-based, interactive models that provide 'what-if' analyses to help evaluate the impacts of alternative management decisions (McCown, 2002). While farmers have often been the target audience for DST development, the actual users have more often been their advisers (Carberry *et al.* 2002) who then help place DST output in a farm-specific context (McCown 2002). Advisers for weed management are widely used and well-placed to make use of DSTs and achieve impact with farmers. However, as for DSTs generally (Hochman and Carberry 2011), very little attention has been paid to preferences and designing DSTs for their needs.

There is increasing use of models in weed management research and increasing interest from researchers to develop DSTs for advisers and farmers based on research models (Holst *et al.* 2006). While there are examples of successful DSTs that have found ongoing application in research and workshop settings (e.g. Pannell *et al.* 2004), or in the generation of information with extension impact (e.g. Neve 2008, Renton *et al.* 2011, Llewellyn and Pannell 2009), there appears no evidence to suggest that the use of DSTs for weed and herbicide management is higher than for other aspects of agricultural systems (Wilkerson *et al.* 2002).

The potential impact of the output of a DST is likely to be greater if it targets particular learning 'gaps', especially where there is large uncertainty and it involves a factor of importance to outcomes that cannot be readily learnt about through other sources (Llewellyn and Pannell 2009). In terms of preferences for the design of tools, this will typically involve dealing with trade-offs involving a number of non-pecuniary characteristics such as simplicity, completeness, robustness, and capacity to educate and engage users (Hochman and Carberry 2011).

This paper describes a study involving workshops and a questionnaire with advisers from across the grain growing regions of Australia who are involved with giving weed management advice to grain growers. The aim is to identify preferences from the potential end-user perspective for the form and function of DSTs for weed and herbicide resistance management.

MATERIALS AND METHODS

Workshops were conducted in Western Australia, South Australia, Victoria, New South Wales and Queensland with 134 participating advisers (Table 1). These included private fee-charging consultants, those attached to retail outlets for cropping inputs and those from the public sector. Workshops were conducted in Perth, Western Australia; Dubbo, New South Wales; Toowoomba, Queensland; Clare and Adelaide, South Australia and Horsham, Skipton and Bendigo, Victoria. The South Australian and Victorian workshops were day-long and broadly focused on 'What's new in weed management for farm advisers'. The content related to this project formed a small part of the overall program which involved expert weed management speakers aimed at attracting advisers seeking an update on weed and herbicide resistance management information.

Participants were briefly introduced to a range of existing weed management decision support tools and later asked to complete a questionnaire on the preferred format and relative value for tools capable of generating a range of different types of information (Table 3). A choice experiment (Bennett and Blamey 2001) was also used within the questionnaire, where advisers were asked to select their preferred option from a choice of tools, each with a different set of attributes. Choice experiments are widely used to estimate consumer product preferences or public values for environmental management scenarios. The choice experiment methodology and results are described in more detail in Kragt and Llewellyn (2014). The attributes include in the experiment are:

1. *Costs*: One off payment you will have to make to gain ongoing access to the tool ($0, $50, $200, $500).
2. *Accuracy of results*: The frequency that the tool generates predictions that are accurate within reasonable margins (40–60%, 61–80%, 81–100% of the time).
3. *Input time*: The time it will cost you to collect the information required and run the tool for the first time including time spent learning how to use the tool (0.5 h, 1 h, 3 h, 6 h).
4. *Specificity*: The degree to which the tool produces customised paddock results for i) an actual specific paddock or ii) for a representative paddock in that district.

RESULTS AND DISCUSSION

Respondents Most advisers were commercial (employed by an agricultural retailer or herbicide manufacturer), working in Victoria and South Australia (Table 1). They spent, on average, a third of their work time giving weed advice to farmers. They estimated that about 74% of their clients had to deal with herbicide resistant weeds. The average adviser age was 37.8 years, and 81% had university education.

Most valued tool format Advisers were asked to rank-order the usefulness of different software platforms that can be used to deliver weed advice. This showed a general preference for a weed management tool to be a stand-alone model or delivered as a mobile application (Table 2).

Integrating tools into existing paddock management software programs was the least preferred option, although all options had at least 13% of advisers ranking it the first preferred platform (Table 2). Preference for smartphone or web-reliant tools is possibly influenced by current data network reliability – which was reported as being a constraint by several respondents.

Table 1. Demographics of respondents (%).

Type of adviser	Commercial		Public		Private
	53		18		29
GRDC region	North		South		West
	12		71		18
State	Qld	NSW	Vic	SA	WA
	8	6	45	24	18

Note: 'Commercial' includes those working for retail-linked companies; 'public' includes State government agents and grower group agronomists/weed specialists; 'private' includes individual consultants and those with consultancy companies. GRDC regions: http://www.grdc.com.au/About-Us/Our-Grains-Industry.

Table 2. Preferences for delivery platforms of weed DSTs.

Platform	% times ranked first	% times ranked 4th–5th
Stand-alone Excel-based tool	42	17
App (e.g. for smartphone or tablet)	29	17
Online only	13	24
Integrated into paddock management software	17	45

Preference for this option may change as mobile and fixed data networks improve in regional areas.

Most valued tool capabilities Respondents' ratings of different herbicide and weed management capabilities are shown in Table 3. The mean values attributed to the different types of prediction capabilities were similar. Nevertheless, there are clear preferences for a tool that can predict the following year's weed population if the weed population was allowed to set seed in the current crop (e.g. if not late weed control or harvest seed kill was used). Predicting timing of weed emergence (dormancy), and predicting the spread of a herbicide resistant weed patch received the lowest mean value ratings (Table 3).

Most valued tool attributes The choice experiment analysis provided information about the attributes that are most highly valued by advisers. The value estimates are summarised in Table 4 (more detail is available in Kragt and Llewellyn 2014). Results show that, overall, tools that require three or less hours of input/learning time will be valued much more highly than those that require more 'start-up' time. On average, reducing the necessary 'set-up' time from six to three hrs was valued more than increasing the 'accuracy' of the tool from 70 to 90%. While reducing set up time to three hrs was highly valued (over $200 per h), reducing set up time from one hour to less than one hour was not valued. Increasing the frequency of accurate results from 50% to 70% was generally valued significantly higher than increasing accuracy from 70% to 90%.

The choice modelling revealed two classes of advisers: (1) one that prefers a tool with more highly developed simulation capacity, who are prepared to invest time to achieve more accurate, customized, paddock-specific results and; (2) a smaller class that has a much stronger preference for less set up time and only regionally representative output with less value placed on high accuracy.

Table 3. Advisers' value rating of tool capabilities based on a score of 1 (very low value) to 5 (very high value) showing mean score and the proportion of advisers rating the tool maximum value (5).

Capability	Mean	% max.
Predict what next year's weed population will be if the weeds are allowed to set seed in the current crop	4.3	38
Predict how using a new weed management practice will affect the weed population and profitability over the next 10 years	4.1	25
Predict what the change in the crop yield and number of weeds setting seed will be if an in-crop herbicide is applied to the current crop?	4.0	23
Predict how many applications of a soon-to-be-released new herbicide can be used before resistance is likely	4.0	22
Predict how using a new weed management practice will affect the number of herbicide applications before resistance is likely	4.0	21
Predict the herbicide resistance risk for a herbicide using a scale from 1(no risk) to 100 (extreme risk)	3.9	20
Predict how a reduced herbicide rate will affect how many more applications of the herbicide can be used before resistance is likely	3.8	23
Predict how many more applications of a herbicide can be used before resistance is likely	3.8	15
Predict how far and how quickly a patch of resistant weeds will spread under different management strategies	3.7	18
Predict whether a particular weed will have later than usual emergence in the coming growing season	3.7	13

Table 4. Choice experiment results (non-linear models) showing willingness to pay (WTP) results in $ for all advisers, and for two adviser classes.

	WTP to reduce input time			WTP to increase accuracy		
	1 h → 0.5 h	3 h → 1 h	6 h → 3 h	50% → 70%	70% → 90%	Specificity
All	NS	138	613	790	487	78
Class 1	NS	103	563***	940***	534***	155***
Class 2	NS	280**	822***	166*	292**	-240***

Notes: NS = not significant; ***, **, * = significance at 1%, 5% and 10% level.
Class 1 probability 0.81; Class 2 probability 0.19.

However, adviser type (retail agronomist; independent consultant; public district agronomist etc) or socio-demographic variables (such as age, education and resistance status of clients) did not explain whether advisers fell into category 1 or 2.

Characterising and understanding potential 'market-segments' of potential decision support tool users is not as simple as categorisations such as retail agronomist versus private consultant versus public. While a tool requiring six hrs of set up time is relatively unattractive to all, the study highlights the diversity of interests for decision support in the adviser population. Demand for decision support is based on many niches.

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