

SHORT NON-REFEREED PAPER

UNDERSTANDING ADOPTION OF PUSH-PULL FOR CONTROL OF *ELDANA SACCHARINA* WALKER (LEPIDOPTERA: PYRALIDAE) USING EXPLORATORY NETWORK ANALYSIS

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Abstract

‘Push-pull’, a pest management strategy recommended for control of *Eldana saccharina* in sugarcane, is currently being implemented as part of an integrated pest management programme in the Midlands North region of KwaZulu-Natal, South Africa. However, adoption of new agricultural practices takes place within a complex system in which social, technical, economic and environmental factors all play a role. Understanding such complex systems is important, but difficult. A novel network analysis method for exploring adoption of new pest management technologies was employed to identify drivers of and barriers to adoption. Analysis of the resulting network indicated that the biggest barriers to adoption were perceived ‘hassle’ and cost of implementation at farm level, and insufficient knowledge of how to implement the technology. The adoption ‘leverage points’ identified in the exploratory network analysis provide opportunities for more relevant and focused extension activities.

Keywords: exploratory network analysis, farmers’ perceptions and behaviour, integrated pest management, IPM, technology adoption

Introduction

The ‘push-pull’ strategy, where attractant and repellent plants are used to reduce pest damage to crops (Cook *et al.*, 2007), has recently been developed for control of *Eldana saccharina* Walker (Lepidoptera: Pyralidae) in South Africa (Kasl, 2004; Barker, 2008) and is promoted as part of an area-wide integrated pest management (AW-IPM) strategy against this pest (Conlong and Rutherford, 2009; Rutherford and Conlong, 2010; Webster *et al.*, 2005; 2009). To implement push-pull, plants attractive or repellent to *E. saccharina* are added to the sugarcane agro-ecosystem, to reduce pest incidence and damage to sugarcane. The push (repellent) plant used is *Melinis minutiflora* P. Beauv (Cyperales: Poaceae) and the pull (attractant) plants are Bt maize,

or *Cyperus papyrus* L. and *Cyperus dives* Delile (Cyperales: Cyperaceae) (Rutherford and Conlong, 2010).

Adoption of new agricultural practices is highly complex, and social, technical, economic and environmental factors all play a role (Jakku and Thorburn, 2010; Fisher *et al.*, 2000; Vanclay, 2004; Llewellyn, 2011). Understanding complex systems is difficult (Spector *et al.*, 2001). Farmers' decisions to adopt a new agricultural technology requires behaviour change which, in itself, is also complex (Knowler and Bradshaw, 2007; Reimer *et al.*, 2012). However, techniques such as network analysis are powerful when rapid learning about complex systems is needed (Bezuidenhout *et al.*, 2012; Bezuidenhout *et al.*, 2013).

To facilitate learning and to better understand the complexities of push-pull adoption, an exploratory network analysis methodology was implemented. This was achieved by:

- identifying grower issues within the complex system of push-pull adoption
- using exploratory network analysis to identify potential adoption drivers and barriers to adoption
- using leverage points identified in the analysis to provide recommendations for improving push-pull and IPM adoption in the study and other regions of the South African sugar industry.

Methodology

This study was conducted with large-scale sugarcane farmers (LSGs) in the Midlands North sugarcane region, supplying sugarcane to mills at Noodsberg and Dalton in KwaZulu-Natal, South Africa (SASA, 2011).

An exploratory network was generated and analysed as follows:

Holistic, qualitative data collection methods were employed to gather input data for the network analysis (Hollstein, 2011). The research question asked was: "What issues might be causing large-scale sugarcane farmers not to adopt push-pull?" A list of these issues was drawn up from data obtained from a survey completed on LSG perceptions of *E. saccharina* and push-pull (Cockburn *et al.*, 2012); discussions with extension staff and farmers at meetings and field days on *E. saccharina* and push-pull; and observations of practical field level problems in implementing push-pull on selected model farms.

The list of issues was entered into *Pajek* software (<http://pajek.imfm.si/doku.php>) (de Nooy *et al.*, 2005). Each issue was represented by a single vertex in the network, and vertices were connected by lines or edges (vertices will be referred to as 'issues' in this short paper). The issues were inter-connected from first principles to represent first order cause and effect relationships (Bezuidenhout *et al.*, 2012). For example, if 'knowledge of push-pull', 'planting maize' and 'hassles' were issues, then from first principles, 'knowledge of push-pull' influences 'planting maize', and 'planting maize' influences how much 'hassle' a farmer experiences, but 'knowledge of push-pull' is only indirectly linked to hassles and the two are not directly connected.

The network generated in *Pajek* was energised to optimise layout using the Kamada-Kawai energy transformation (Kamada and Kawai, 1989). This positions issues in the network based on their connectivity to others, and positions related issues in close proximity to each other (Bezuidenhout *et al.*, 2012).

Two network validation workshops were conducted with experts on push-pull adoption, including farmers who had started implementing push-pull, extension staff, local pest and disease staff and researchers. Based on the validation workshops, adjustments were made to the network. It was then analysed by visual inspection, theme identification and calculation of values of betweenness centrality of the issues (de Nooy *et al.*, 2005; Hanneman and Riddle, 2011). Betweenness centrality is a sum of the proportion of times that an issue lies between other issues within the network (Hanneman and Riddle, 2011). Centrality of an issue within a network is used as an indicator of that issue's power or influence on other issues within a network (Hanneman and Riddle, 2011).

Results and Discussion

The network (Figure 1) comprises 25 issues (listed in the figure legend), connected by 88 lines. The densest part of the network, with the highest concentration of edges and vertices, is around the 'costs' and management 'hassles' issues near the centre. The central position of the 'hassles' and 'costs' issues means that these are both highly connected and thus have much influence over other issues in the network.

Four themes, farm management (blue), knowledge (green), people and society (yellow) and effect of *E. saccharina* (pink), are highlighted in the network (Figure 1). As 'farm management' is the biggest theme and includes the most central and most highly connected issues, the analysis suggests that addressing farm level aspects of push-pull adoption is crucial to facilitate adoption.

The issues with the highest values of betweenness centrality are 'hassles' (14.89), 'costs' (8.40) and 'knowledge of how to implement push-pull' (5.47) (Figure 1). The high values for the perceived 'hassle' and 'costs' of implementing push-pull indicate that these two issues may be the strongest barriers to adoption, as they are connected to so many other practical implementation problems. They may also be the most difficult to address, due to their high degree of connectedness. The 'knowledge of how to implement push-pull' issue acts as an agent (Hanneman and Riddle, 2011), between the farm management and knowledge themes in the network. This is confirmed by its high betweenness centrality value (5.47), and means that it is a strong leverage point within the network. Provision of knowledge to farmers is the responsibility of extension specialists (SASA, 2011), and the centrality of this issue within the network clearly indicates the crucial role of extension in facilitating adoption of push-pull. 'Wetland management' also has one of the highest betweenness centrality values in the network (5.23). Managing wetlands correctly is essential for effective push-pull implementation as they provide habitats for *C. dives* and *C. papyrus*, the indigenous host plants of *E. saccharina* (Cockburn, 2013). However, correct wetland management requires a good knowledge of push-pull and is perceived by farmers as a hassle and a costly activity.

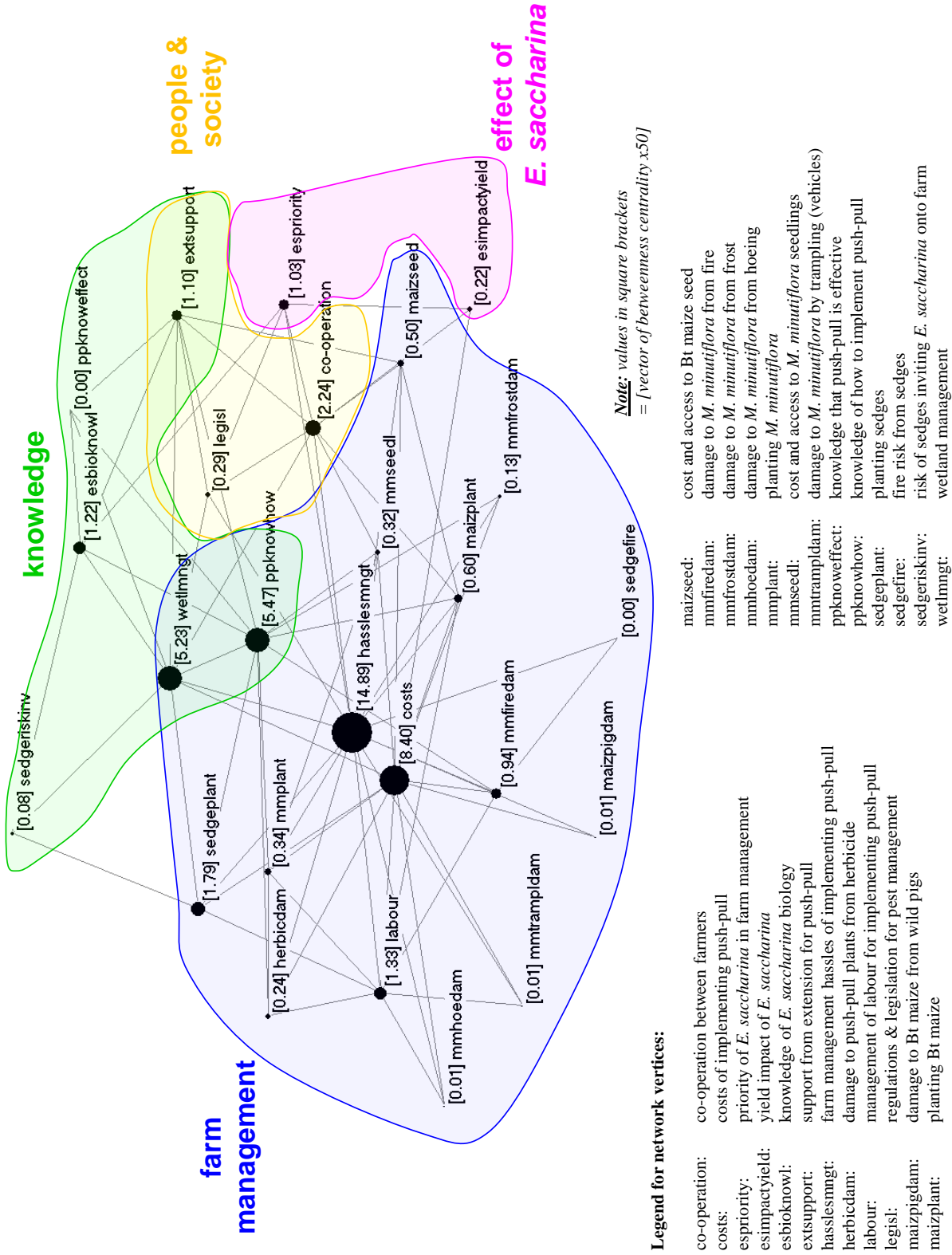


Figure 1. Exploratory network of push-pull adoption issues in the Midlands North region.

Most issues in the push-pull network are related to farm-level management ‘hassles’. Farmers’ perceptions of ‘hassles’ as reasons for not adopting push-pull mostly centred around planting of *M. minutiflora* which confirmed this aspect as the biggest barrier to push-pull adoption. The compatibility of a new management practice with farmers’ current practices is an important adoption driver, as has been shown for apple farmers’ adoption of IPM in Australia (Kaine and Bewsell, 2008), and maize farmers’ adoption of push-pull in Kenya (Khan *et al.*, 2011). Röling *et al.* (2004) regard the ‘farmer’s veto’ an important factor in non-adoption of new agricultural practices. While researchers and extension workers may provide knowledge, learning and input support necessary, farmers may ‘veto’ the new technology if not suitable to their on-farm context, since they make the final management decisions. Urquhart (1999) emphasised the management-intensive nature of IPM, and highlighted that such agricultural practices may not be suitable for adoption by all farmers. It must be accepted that ‘farmers are not all the same’ (Vanclay, 2004).

Conclusions

By employing exploratory network analysis, a structured interpretation of issues involved in adoption of push-pull has been completed. It has highlighted key leverage points within this complex system which should be addressed by extension specialists to improve adoption of push-pull. ‘Knowledge of how to implement push-pull’ was identified as an important adoption driver and leverage point. Opportunities for experiential learning can improve farmers’ knowledge of how to implement push-pull and may reduce the perceived ‘hassle’ thereof. However, it is important to recognise that knowledge and management-intensive agricultural practices such as push-pull and IPM may not be suitable for all farmers.

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