

## Large-scale sugarcane farmers' knowledge and perceptions of *Eldana saccharina*, push-pull and integrated pest management

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### 2.1 Introduction

The South African Sugarcane Research Institute (SASRI) recommends an area-wide integrated pest management (AW-IPM) approach to controlling *Eldana saccharina* Walker (Lepidoptera: Pyralidae) (Conlong and Rutherford, 2009; Rutherford and Conlong, 2010). Laboratory, cage and field trials on push-pull, a form of habitat management, have been completed, and have shown that implementation of this strategy can lead to suppression of *E. saccharina* numbers and reduction in damage to sugarcane (Kasl, 2004; Barker, 2008). Push-pull is currently being implemented on sugarcane farms in the Midlands North area of KwaZulu-Natal (Webster *et al.*, 2005; 2009).

To facilitate successful implementation of knowledge-intensive practices such as push-pull and IPM, it is important to determine farmers' perceptions and knowledge regarding pests and pest management practices (Röling *et al.*, 2004; Meir and Williamson, 2005; Khan *et al.*, 2008a). Meir and Williamson (2005) noted that because IPM requires more complex decision making than the application of pesticides alone, farmers' perceptions of the pest and pest management need to be understood, to better understand their decision-making behaviors. IPM is a combination of various control tactics, and farmers base their decisions on how to combine these tactics on their knowledge and perceptions of pests and their ecology, yield loss, and the influence of the various tactics on the cost-benefit ratio of the various tactics (Litsinger *et al.*, 2009). By working more closely with farmers and asking them about their knowledge and perceptions of pests and pest management, collaboration between agricultural scientists and farmers can be improved (Sinzogan *et al.*, 2004). Peshin *et al.* (2009b) recommend that action research is carried out to study the implementation of IPM, after which results should be used in the development of an IPM programme which is "farmer-friendly". In action research for IPM dissemination, researchers, farmers, extension workers and other stakeholders need to collaborate to determine a good fit

between the technical aspects of IPM and the realities of farmers' situations including their needs, perceptions, resource constraints and objectives (Peshin *et al.*, 2009b).

There are many examples of studies on farmers' perceptions of pests and pest management. For example, Khan *et al.* (2008a) determined farmers' perceptions of push-pull for the management of stem borers (Lepidoptera: Pyralidae; Crambidae; Noctuidae) in small-scale maize farming systems in Kenya. They found that the high pest status of stem borers and *Striga* weed (*Striga hermonthica* (Del.) Benth. (Lamiales: Scrophulariaceae)) which are both targeted in the push-pull system, motivated farmers to adopt this system. They also found that farmer age, level of education and exposure to numerous extension activities influenced the level of adoption by farmers. In another case study, Assefa *et al.* (2008) studied farmers' knowledge and perceptions of sugarcane stem borers in Ethiopia and found that farmers had a very poor knowledge of stem borers, despite that fact that fifty-six percent of farmers interviewed described stem borers as one of the most important constraints on sugarcane production. This kind of information is important when planning extension programmes and pest management information dissemination activities, and also in the evaluation of current implementation activities (Llewellyn *et al.*, 2006; Peshin *et al.*, 2009a). Within a Research, Development and Extension (RD&E) framework, such as that employed by the South African Sugarcane Research Institute (SASRI) (SASRI, 2012), early identification of farmer perceptions can help to focus the RD&E programme (Llewellyn *et al.*, 2006).

The aim of this study was to gain an understanding of the pest knowledge of the large-scale sugarcane growers (LSGs) in the Midlands North region to facilitate successful implementation of push-pull and IPM.

To achieve this aim, the following objectives were set:

- to determine LSGs' knowledge and perception of *E. saccharina* and their current pest management activities for this pest
- to determine LSGs' knowledge and perceptions of push-pull and IPM as a means of controlling *E. saccharina*
- to get LSGs' suggestions for successful implementation of push-pull
- to determine the feasibility of introducing push-pull, using the results of the above three objectives, on LSGs' farms in the Midlands North sugarcane region of KwaZulu-Natal.

## 2.2 Materials and Methods

### 2.2.1 Study area

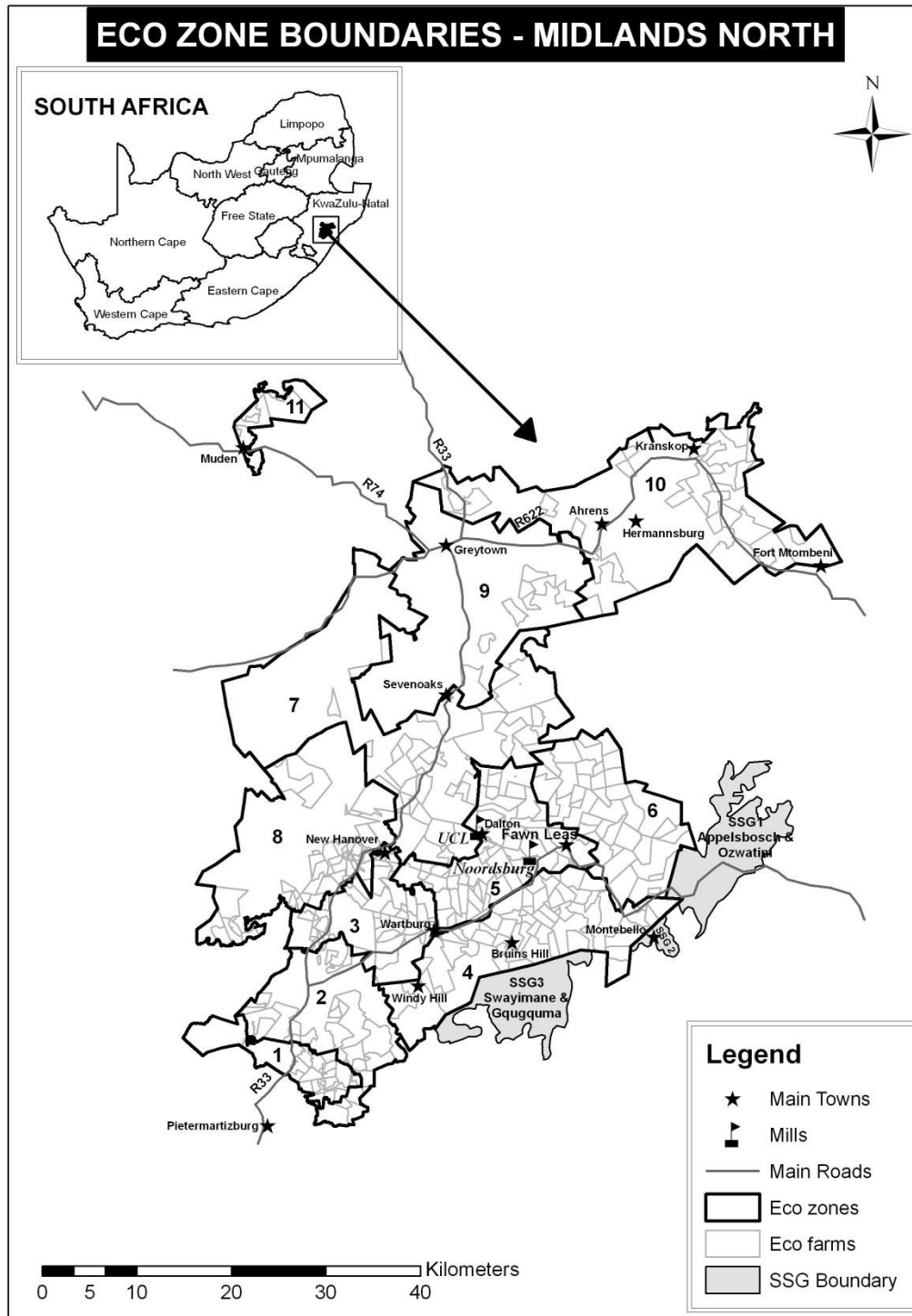
The Midlands North sugarcane region supplies sugarcane to the Illovo Sugar (South Africa) Limited mill at Noodsberg (29°21'38.83"S, 30°41'13.37"E) and to the Union Co-operative Limited mill at Dalton (29°20'18.07"S, 30°37'41.23"E) in KwaZulu-Natal, South Africa (SASA, 2011).

Although sugarcane is supplied by large- and small-scale growers, this study focused on large-scale growers (See Chapter 3 for the small-scale grower study). Since 1998, large-scale growers (LSGs, or commercial farmers) in this area have been involved in environmentally sustainable sugarcane management practices. The Noodsberg Cane Growers Association (NCGA) drew up an environmental management system and farms were grouped into ecozones with similar climate and potential for producing sugarcane (Figure 2.1) (Maher and Schulz, 2003). The Midlands North region was chosen as study area for implementation of push-pull, based on reports of Webster *et al.* (2005; 2009) on the implementation of an AW-IPM management system in the area. Furthermore, SASRI extension staff and the Local Pest, Disease and Variety Control Committee (LPD&VCC) together with the LSGs in this area have shown commitment to environmentally sustainable management of sugarcane.

As the range of *E. saccharina* is currently expanding inland, the Midlands North region provides a good opportunity to put preventative pest management measures in place (Webster *et al.*, 2005; 2009). Many farms in the Midlands North region are still not affected by *E. saccharina* and pre-emptive implementation of push-pull may hold future advantageous as the range of *E. saccharina* expands (Webster *et al.*, 2009).

### 2.2.2 Survey method

Using a random stratified sampling approach (Fink, 2009), 53 LSGs were selected for survey interviews from across all ecozones in the Midlands North region. The sample was stratified by ecozones and within each ecozone respondents were selected randomly. This sample represents 30% of LSGs currently registered on the LPD&VCC database (Webster pers. comm., 2012).



**Figure 2.1.** Map of the Midlands North sugarcane farming region indicating farm (grey) and ecozone boundaries (black).

LSGs were interviewed individually using a semi-structured questionnaire (Appendix A). They were asked their age, level of education (primary, secondary, tertiary), years of farming experience and

their land tenure (manager, owner or owner-manager of the farm). They were also asked whether or not they had completed the SASRI Senior Certificate Course in Sugarcane Agriculture (the SASRI sugar course). This is a six-week course hosted by SASRI, and is a well-respected training course for sugarcane farming in South Africa (SASA, 2011). The questionnaire included open-ended and closed questions (Fink, 2009) to determine their knowledge and perceptions on the following topics:

- sugarcane management and constraints
- insect pests in general as well as *E. saccharina*
- pest management including push-pull and IPM
- dissemination of information on pests and pest management.

The survey design followed guidelines from Fink (2009). Closed questions were ‘yes’ or ‘no’ questions or used categorical rank order scales or Likert-type ordinal scales. For rank order scales, respondents were given five to six items (or options) per question: the top ranked was to be assigned number 1, the bottom rank 5 or 6. For example, in ranking the worst insect pests, respondents were given the names of five pests and asked to rank them from 1 to 5 with 1 being the worst problem and 5 being the least problem. Respondents were asked to express their opinions on specific topics in a range from ‘strongly agree’ to ‘strongly disagree’, on a Likert-type ordinal scale. Guidelines for effective survey interviews, including pre-testing of the questionnaire, were followed to ensure that reliable, quality data were collected and that correct social research ethics were followed (Babbie, 2010). Respondents were asked whether they were prepared to participate in the survey, the purpose of the survey was carefully explained and privacy of personal information was assured. Interviews were recorded using a voice recorder to ensure that responses were captured correctly. Responses to questions were coded prior to analysis. A content analysis was completed on open-ended questions to identify recurrent themes which could be quantified to determine LSGs’ perceptions (Fink, 2009). For example, when they were asked “What do you see as the biggest barrier to us introducing a new method like push-pull for Eldana amongst farmers?”, the answers to this question were categorised into general themes which were then each allocated a numerical code for quantification and analysis.

### **2.2.3 Statistical analysis**

Descriptive statistics, such as frequency distributions and percentages, were used to analyse and report responses to questions (Fink, 2009). For categorical survey data, contingency tables (also called cross-tabulations) were used to display and evaluate two variables at the same time, and

determine the effect of groups. For example, the effect of respondents' level of education, their land tenure or their ecozone on their responses to questions was determined in this way (Babbie, 2010). To determine whether the proportions of the categorical survey data presented in contingency tables were significantly different or not, the Pearson's Chi-square test was used ( $\chi^2$ ) (Babbie, 2010) (See Appendix B for a summary of all data analysis methods used in Chapter 2). Respondents' answers to rank order scale questions were summarised using box and whisker plots indicating the median rank score per item as well as the minimum and maximum scores and percentiles for each ranked item.

Effect sizes, which are useful in determining the practical significance of a relationship in a contingency table (Steyn, 2002; Ellis and Steyn, 2003), were determined for variables analysed in contingency tables. The effect size for a contingency table is given by the test statistic  $w$ . When  $w = 0.1$ , the effect is small, when  $w = 0.3$  the effect is medium and when  $w = 0.5$  the effect is large (Wuensch, 2009). When  $w \geq 0.5$  the relationship is considered practically significant (Ellis and Steyn, 2003).

Due to the non-parametric nature of the ranking data, the Wilcoxon signed ranks test was conducted to determine whether there was a significant difference between median rank scores for pairs of variables. A Bonferroni correction was applied to the  $p$ -values from the Wilcoxon signed ranks tests because multiple comparisons inflate the Type I error rate. To determine effects of LSGs' personal profiles and farm characteristics on their responses to ranking questions, Mann-Whitney U-tests and Kruskal-Wallis tests were performed. Significance for statistical tests was set at the 5% level unless otherwise stated.

## **2.3 Results**

### **2.3.1 Respondents' profiles**

All the LSGs interviewed in this survey were men and the majority was between 40 and 60 years of age (Table 2.1). Of the respondents, 77.4% had completed tertiary education, 52.8% studied agriculture at tertiary level and 56.6% had completed the SASRI sugar course. This group of LSGs also had a high level of farming experience, with 41.5% of them having 20 years or more experience farming sugarcane. Most LSGs were owners and managers of their farms (71.7%) (Table 2.1).

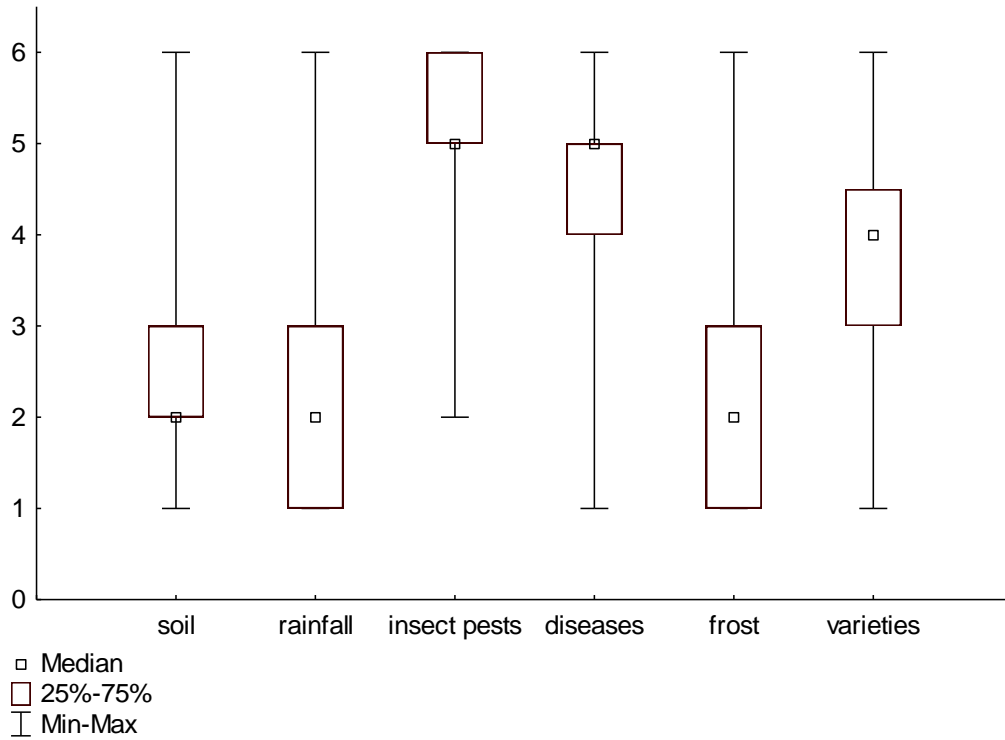
**Table 2.1** Profiles of large-scale sugarcane farmers in the Midlands North region.

Characteristics	Response frequency (N = 53)	Response percentage
Age (years)		
18-30	9	17
31-40	10	18.9
41-50	16	30.2
51-60	16	30.2
60+	2	3.8
Sugarcane farming experience (years)		
< 5	5	9.4
5-10	11	20.8
11-20	15	28.3
21-30	19	35.8
30+	3	5.7
Land tenure		
Farm manager	9	17.0
Farm owner	6	11.3
Farm owner and manager	38	71.7

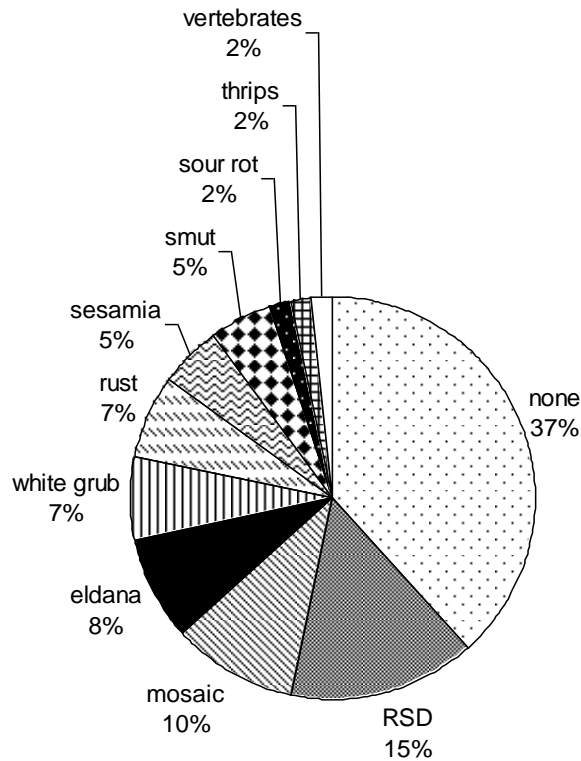
### **2.3.2 Management practices and LSGs' perceptions of insect pests**

When asked to rank five production constraints according to their importance, respondents ranked abiotic factors, i.e. rainfall, soil quality and frost as the most important (median rank score for abiotic factors = 2.0). Biotic factors were ranked as less important constraints (insects and disease median rank score = 5.0 and sugarcane varieties = 4.0) (Figure 2.2).

The median rank scores of the abiotic production constraints were all statistically different from the biotic constraints (for details of Wilcoxon signed rank tests see Appendix C). Insect pests were also ranked significantly lower than sugarcane varieties as a constraint ( $p = 0.004$ ,  $Z = 3.629$ ). Furthermore, insect pests and diseases were ranked significantly lower than any of the abiotic constraints (See Appendix C for details). When LSGs were asked which were the worst pests or diseases on their farm, 37% responded that they had not problems with pests or diseases (Figure 2.3).



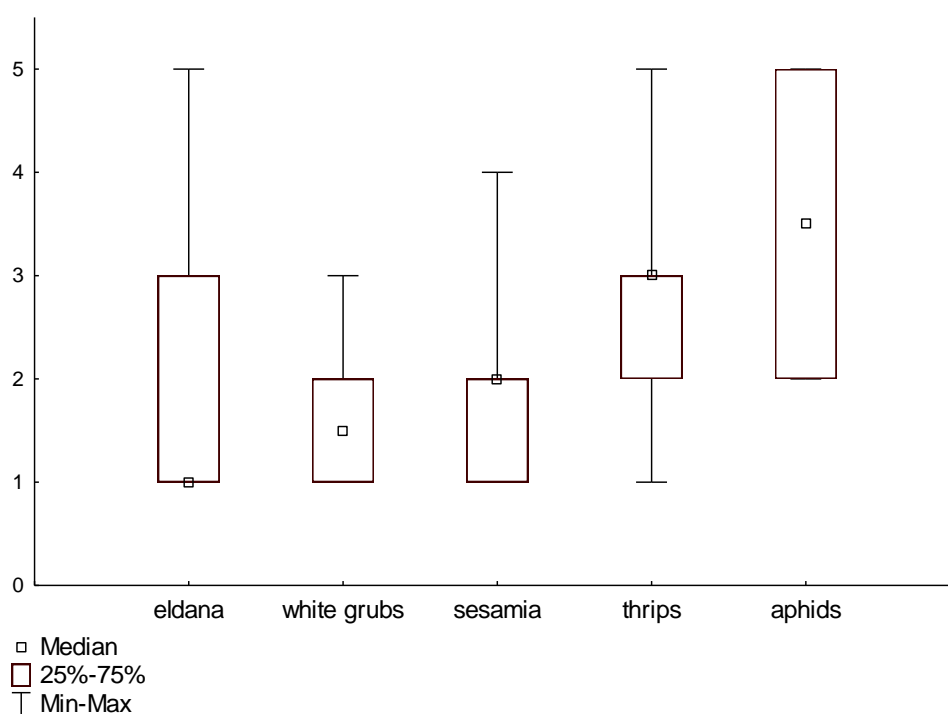
**Figure 2.2.** Box and whisker plot showing median rank scores of large-scale growers' sugarcane production constraints. (Note: low rank score: most important constraint, high rank score: least important constraint.)



**Figure 2.3.** Large-scale growers' perceptions of the worst pests or diseases on their farm (N = 53).

Ratoon stunt disease (RSD) and sugarcane mosaic virus (SCMV) were listed most often as the worst diseases, and *E. saccharina* and white grub (Coleoptera: Scarabaeidae) were listed as the worst insect pests (Figure 2.3) (Note that *E. saccharina* has been abbreviated to 'eldana' in figures and tables, and *Sesamia calamistis* Hampson (Lepidoptera: Noctuidae) as 'sesamia'). Only 8% of respondents mentioned *E. saccharina* as the worst pest or disease on their farm and diseases were mentioned more often than insect pests.

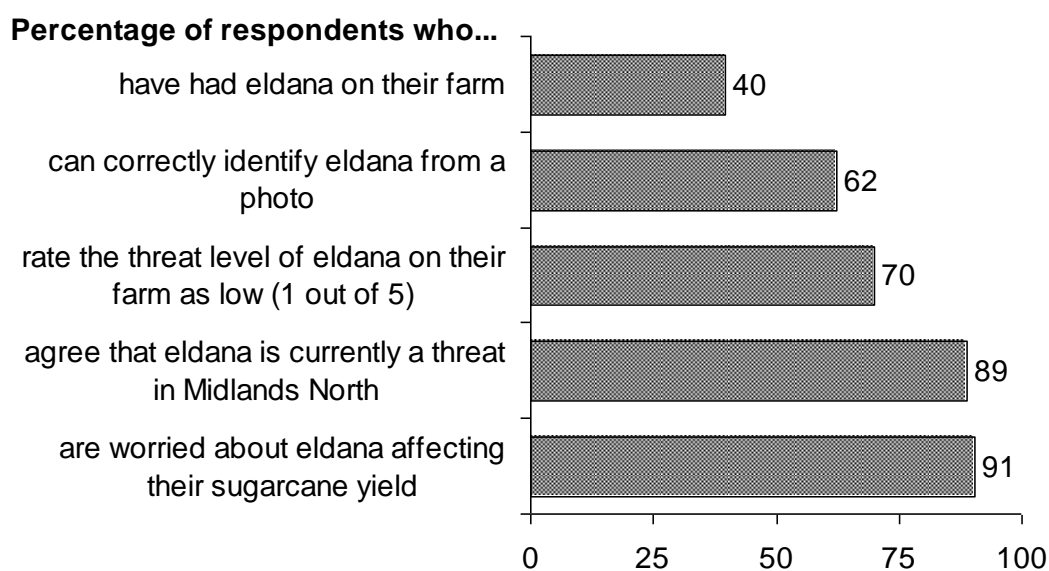
In the ranking question for insect pests (Figure 2.4), *E. saccharina* was ranked the worst. However, the Wilcoxon Signed Ranks test revealed that there was no significant difference between the average ranks of any of the insect pests (Appendix C), indicating that LSGs don't perceive any one insect pest as particularly problematic. The presence of *E. saccharina* on farms influenced the LSGs' perceptions of its importance. Of the LSGs who had a history of *E. saccharina* on their farms, 68 % ranked it as the worst pest. They also ranked it as a significantly more important pest ( $p = 0.005$ ) compared to those LSGs who had no history of *E. saccharina* on their farms. The level of tertiary education had an effect on the perception of the worst pest or disease. When asked which pests or diseases were the worst, the majority of respondents who have tertiary education answered 'none', indicating that LSGs with higher levels of education may perceive pests and diseases as less of a problem ( $X^2 = 11.269$ ,  $df = 5$ ,  $p = 0.046$ ,  $w = 0.416$ ).



**Figure 2.4.** Box and whisker plot of median rank scores of worst insect pests perceived by large-scale growers. (Note: low rank score: most important pest; high rank score: least important pest.)

### 2.3.3 Knowledge, perceptions and management practices of *Eldana saccharina*

LSGs in the Midlands North region were aware of *E. saccharina* and the threat it poses to sugarcane production, despite the fact that only 40% of respondents had a history of *E. saccharina* on their farms (Figure 2.5). The majority (70%) of LSGs rated the threat level of *E. saccharina* on their farms as low, i.e. they gave it a score of 1 out of a possible maximum of 5, where 1 is the lowest threat (Figure 2.5). Ninety-one percent of respondents were however concerned about *E. saccharina* possibly affecting their sugarcane yields in the future and 89% of them agreed that this pest is a threat to sugarcane production in the region (Figure 2.5). Almost two-thirds of respondents could identify *E. saccharina* correctly from a photograph (Figure 2.5).

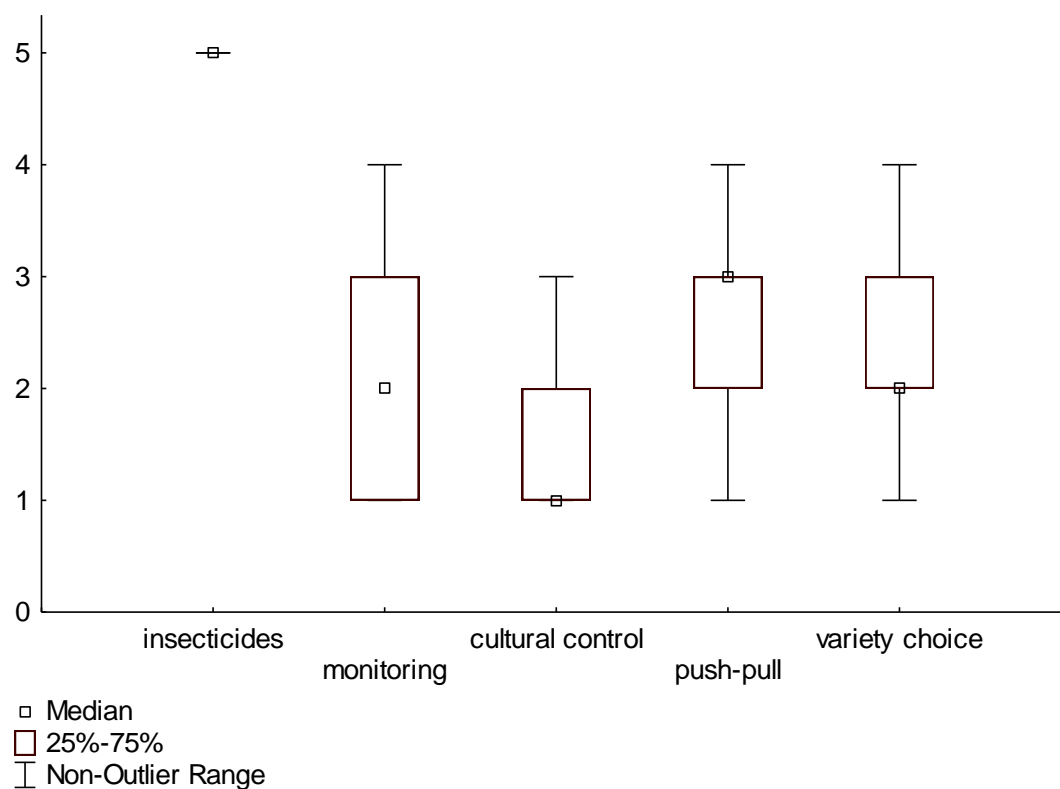


**Figure 2.5.** Summary of key descriptive statistics illustrating large-scale growers' knowledge and perceptions of *E. saccharina*, reported as percentages of total respondents (N = 53).

Results of the ranking questions on *E. saccharina* pest management activities (Figure 2.6) indicate that LSGs rely mostly on cultural control, i.e. correct cutting cycle and good field hygiene, for pest management (median rank score = 1.0). The least used pest management activity is insecticide application (median rank score = 5.0) (Figure 2.6) which was ranked significantly lower than both monitoring ( $p = 0.077$ ,  $Z = 2.666$ ) and cultural control ( $p = 0.077$ ,  $Z = 2.666$ ) at a 10% level of significance. This was not surprising as none of the respondents used insecticides against *E. saccharina* and those who had used insecticides (30%), targeted nematodes (68%) and white grubs (32%). Note that respondents who did not have *E. saccharina* on their farm were asked to consider a hypothetical situation in which they did have the pest when answering this question.

Respondents who had completed the SASRI sugar course were more likely to be able to identify *E. saccharina* correctly from a photograph than those who hadn't. The Chi-square test showed borderline statistical significance of this effect at a 5% level ( $X^2 = 3.605$ ,  $df = 1$ ,  $p = 0.058$ ,  $w = 0.261$ ).

The ecozone in which farms were located had an effect on the respondents' perception of the threat of *E. saccharina* in the Midlands North region. Most LSGs who 'strongly agreed' that '*E. saccharina* is currently a threat to sugarcane production' were from an ecozone with high *E. saccharina* infestation (more than 30% of farms affected). Conversely, the majority of respondents from ecozones with low infestations (<30% of farms affected) chose to 'agree' rather than 'strongly agree' with the statement ( $X^2 = 8.88$ ,  $df = 3$ ,  $p = 0.031$ ,  $w = 0.409$ ).



**Figure 2.6.** Median rank scores of *E. saccharina* pest management activities used by large-scale growers. (Note: low rank score: most used activity; high rank score: least used activity).

### 2.3.4 Knowledge and perceptions of push-pull and IPM

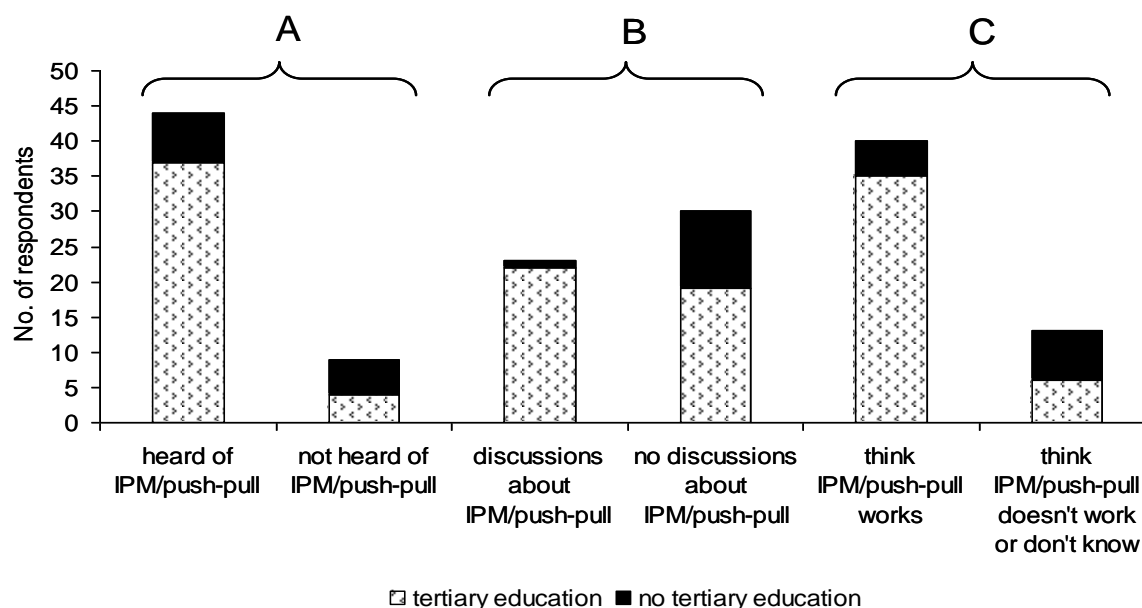
Awareness of push-pull and IPM among LSGs in the Midlands North was high and they demonstrated a largely positive attitude towards these strategies (Table 2.2). 83% of respondents

had heard of push-pull and the main source of information on push-pull and IPM was the LPD&VCC. Results of contingency table analyses and Chi-square tests showed that LSGs' level of experience and education had significant effects on where they sourced information on push-pull and IPM. More experienced LSGs obtained their information from the LPD&VCC, whereas the less experienced, and probably younger LSGs, obtained information from other sources such as SASRI extension staff and the SASRI sugar course ( $X^2 = 23.4$ ,  $df = 12$ ,  $p = 0.024$ ,  $w = 0.665$ ). The majority (75.5%) of LSGs were confident that push-pull and IPM were good methods for controlling *E. saccharina* and 59% indicated that they had sufficient knowledge to implement push-pull on their farms.

**Table 2.2** Large-scale growers' knowledge and perceptions of push-pull and IPM as shown by responses to interview questions.

LSGs' responses	Response frequency (N = 53)	Response percentage
Source of information on push-pull and IPM		
LPD&VCC	28	52.8
SASRI Extension	6	11.3
SASRI sugar course	6	11.3
Other	7	13.3
None	6	11.3
Have discussed push-pull and IPM with others		
Yes	23	43.4
No	30	56.6
Discussions about push-pull and IPM were (N = 23)		
Positive	18	78.3
Positive and negative	5	21.7
Opinion on the efficacy of push-pull for eldana control		
Effective	40	75.5
Maybe effective	9	17.0
Don't know enough about it	4	7.5
Respondents who say they know how to implement push-pull		
Yes	31	58.5
No	22	41.5
Respondents who would like to learn more about push-pull		
Yes	48	90.6
No	5	9.4
Respondents who would be willing to be involved in push-pull research		
Yes	45	84.9
No	8	15.1

Whether LSGs had completed tertiary education or not also had a significant effect on their knowledge of and attitude towards push-pull and IPM for three of the questions asked (Figure 2.7).



**Figure 2.7.** Effect of tertiary education on large-scale growers' knowledge and perceptions of push-pull and IPM (data from contingency tables).

Significantly more LSGs with tertiary education had heard of push-pull and IPM (Figure 2.7 A,  $X^2 = 6.7$ ,  $df = 1$ ,  $p = 0.01$ ,  $w = 0.356$ ). Tertiary education had an effect on respondents' discussions of push-pull with other LSGs and almost all of those who had no tertiary education also had no discussions about push-pull (Figure 2.7 B,  $X^2 = 7.8$ ,  $df = 2$ ,  $p = 0.02$ ,  $w = 0.384$ ). Most farmers with tertiary education considered push-pull a good method for controlling *E. saccharina*, compared to those without tertiary education (Figure 2.7 C,  $X^2 = 9.6$ ,  $df = 2$ ,  $p = 0.008$ ,  $w = 0.426$ ).

Similarly, completing the SASRI sugar course had a significant effect on respondents' knowledge of push-pull and IPM (Figure 2.8). Significantly more LSGs who had attended the sugar course had heard of push-pull and IPM (Figure 2.8 B,  $X^2 = 5.22$ ,  $df = 1$ ,  $p = 0.022$ ,  $w = 0.310$ ) and were confident in their ability to implement push-pull on their farms (Figure 2.8 A,  $X^2 = 3.77$ ,  $df = 1$ ,  $p = 0.052$ ,  $w = 0.267$ ).

Despite showing a good awareness and basic knowledge of push-pull and IPM, most respondents did not have a thorough understanding of the details of push and pull plants and where to access these plants. When asked about Bt maize, most respondents didn't know or understand how Bt maize works (76%) and only 9% had a basic understanding of the Bt mechanism and its effect on

stem borers. This is important since Bt maize is one of the possible components of a habitat management strategy against *E. saccharina*. LSGs' responses indicated that only 49% knew where to purchase Bt maize seed. Between 50% and 72% say they know the specific push-pull plants i.e. Bt maize, molasses grass, *Cyperus papyrus* and *Cyperus dives*. Only 42% of respondents knew where to get molasses grass while 40% knew where to get sedges, even though these are growing on some local farms and are readily available.



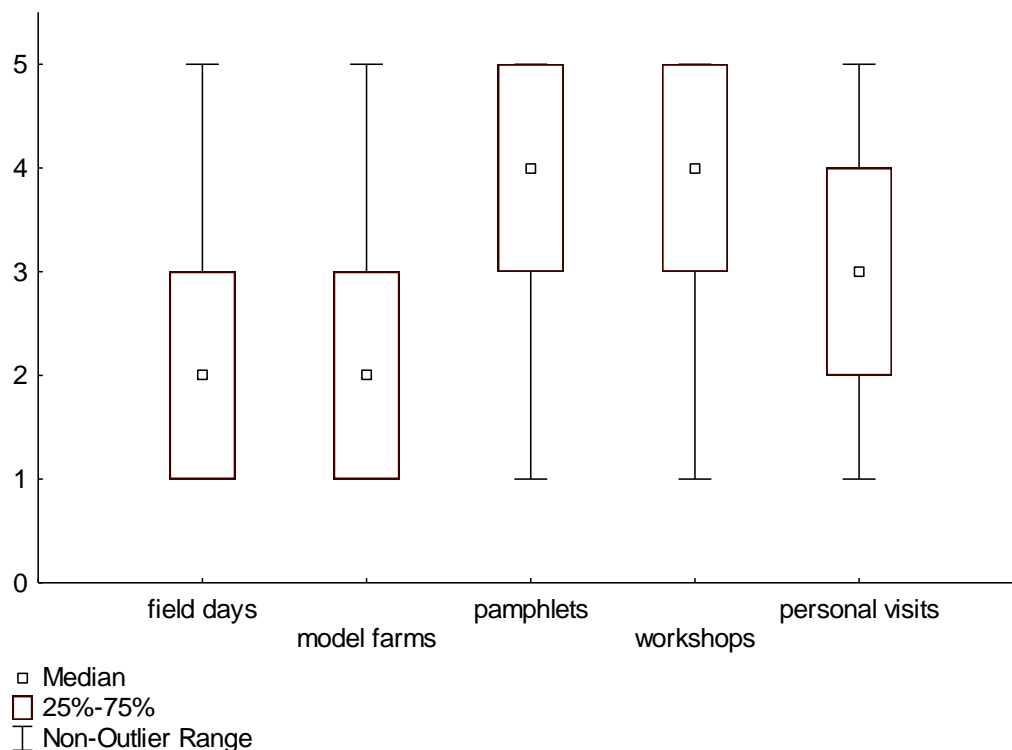
**Figure 2.8.** Effect of large-scale growers' having completed the SASRI sugar course on their knowledge of push-pull and IPM (data from contingency tables).

### 2.3.5 Dissemination of pest management information

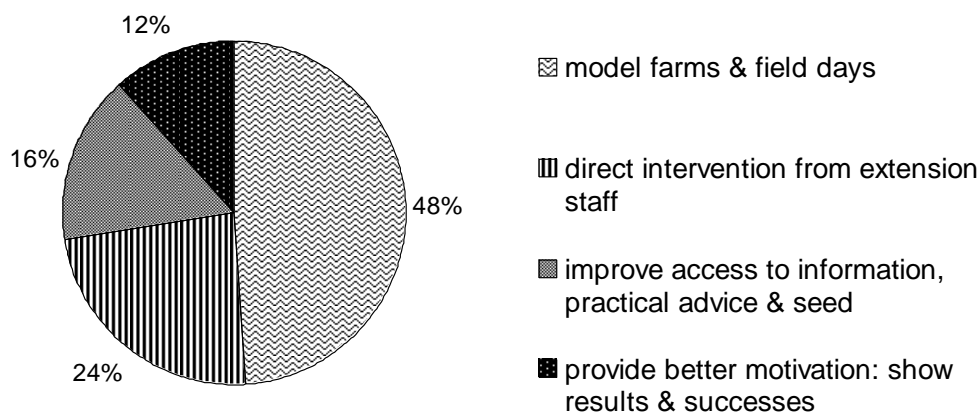
All LSGs said that the information on pest management which they received from the LPD&VCC was useful to them. A large number of LSGs (60%) were satisfied with the current level of information and knowledge available to them, and the remaining 40% said they would like to receive more information on pest management.

When respondents were asked to rank five different extension methods for disseminating information on pest management, model farms and field days were ranked highest (model farm median rank = 1.0, field day median rank = 1.0), and pamphlets and workshops lowest (pamphlets median rank = 4.0, workshops median rank = 4.0) (Figure 2.9). The Wilcoxon signed rank test indicated a significant difference between the ranks for both model farms and field days compared

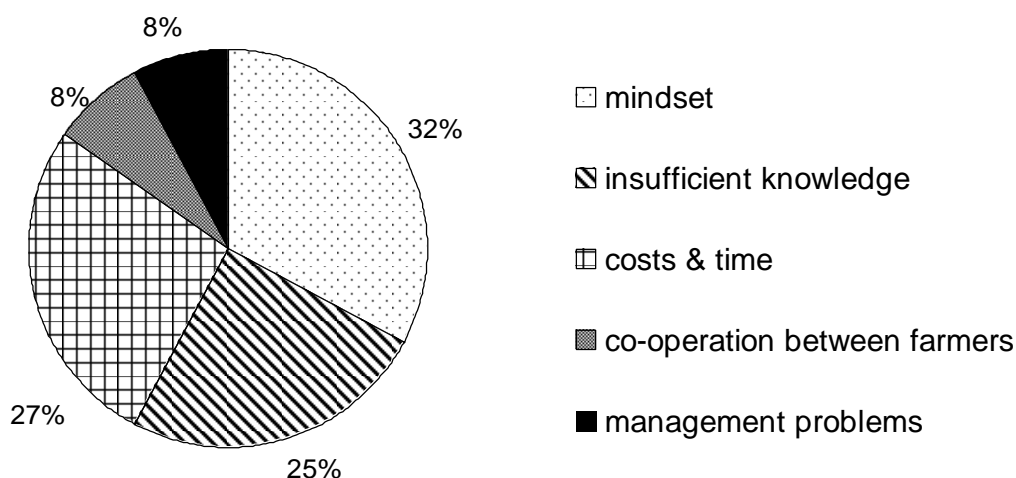
to both pamphlets and workshops. Model farms were ranked significantly higher than pamphlets ( $Z = 3.75$ ,  $p = 0.002$ ) and workshops ( $Z = 4.412$ ,  $p < 0.001$ ) and field days were also ranked significantly higher than pamphlets ( $Z = 4.03$ ,  $p < 0.001$ ) and workshops ( $Z = 4.10$ ,  $p < 0.001$ ). This demonstrates the LSGs' preferences for hands-on, farm-based learning opportunities.



**Figure 2.9.** Box and whisker plots showing median rank scores of extension methods favoured by large-scale growers. (Note: low rank score: most favoured method; high rank score: least favoured method).



**Figure 2.10.** Large-scale growers' suggestions for successful implementation of push-pull in the Midlands North region (N = 53).



**Figure 2.11.** Large-scale growers' perceptions of possible barriers to successful implementation of push-pull (N = 53).

The LSGs were asked in an open-ended question to make suggestions for how best to implement push-pull in the Midlands North area. The largest response category (49%) suggested model farms and field days (Figure 2.10). The respondents also indicated that more direct intervention from the LPD&VCC, and possibly also stricter intervention with non-compliant LSGs, could be helpful. Furthermore, LSGs want to have more detailed information on implementing push-pull, improved access to material (planting) inputs and need evidence of the method working successfully.

When asked what they thought might be barriers to adoption of push-pull, respondents recognised that their mind sets or attitudes towards the pest and push-pull could possibly be a barrier (33%) (Figure 2.11). They also mentioned cost and time constraints, and insufficient knowledge as potential barriers to successful implementation of push-pull.

## 2.4 Discussion

The LSGs' awareness and general knowledge of *E. saccharina*, push-pull and IPM is good, especially when one considers that only 25% of farms have so far been affected by *E. saccharina* (Webster pers. comm., 2012). However, respondents do not perceive insect pests in general, nor *E. saccharina* specifically, as a priority production constraint. Most LSGs rated the threat level of *E. saccharina* on their farm as low (Figure 2.5) because it has not yet been found on their farms, and according to the LPD&VCC database for the Midlands North, 69% of farms have, as yet, no record of *E. saccharina*.

Farmers are the final decision makers on their farms and their priorities may not always match those of the agricultural researchers or extension staff. Röling *et al.* (2004) pointed out that agricultural researchers can sometimes be unaware of the phenomenon of 'farmer's veto'. By this they mean that farmers, as the owners and/or managers of the farm, have the final say in whether a certain agricultural innovation is accepted or not, and that they have the ability to 'veto' innovations which they may not perceive a need for. Considering the Midlands North LSGs' current production constraints, they may indeed not perceive adoption of push-pull for control of *E. saccharina* as a top priority at the moment.

The perceived benefit of a new innovation or best management practice has been found to have a large impact on adoption, and this needs to be further investigated with LSGs in the Midlands North region (Kabii and Horwitz, 2006). The LSGs in this survey suggested that 'farmers' mindsets' may be a key barrier to adoption of push-pull (Figure 2.11), and that they may need to change their mindsets or perceptions of *E. saccharina* and push-pull. This could also point to an opportunity for learning, since Llewellyn (2011) indicated that when potential adopters have different perceptions of a practice compared to those who already use the practice, there is potential for learning.

For learning more about push-pull and IPM, respondents indicated a preference for farm-based, experiential, hands-on methods such as model farms and farm days (Figures 2.9 and 2.10). This is consistent with literature on effective IPM dissemination practices (Peshin and Dhawan, 2009) and highlights the importance of social and experiential learning for dissemination of IPM (Röling and de Jong, 1998; Meir and Williamson, 2005). Leeuwis (2004) describes how Kolb's model of experiential learning (Kolb, 1984) can be used as a basis for social learning in agriculture. According to this model, conclusions which people draw based on their own experiences tend to have a bigger impact than knowledge which has been formulated by others based on experiences that the learners cannot identify with (Leeuwis, 2004).

The respondents' level of farming experience, tertiary education and completion of the SASRI sugar course all had an effect on various aspects of their knowledge and perceptions of *E. saccharina*, push-pull and IPM (Figures 2.7 and 2.8). LSGs in the Midlands North have a high level of education and a lot of farming experience. Higher levels of education have been linked to higher adoption rates in other studies (Waller *et al.*, 1998). The significant effect of higher education and completion of the SASRI sugar course on LSGs' knowledge and perceptions is a positive indicator since it has been shown that information, knowledge and learning are important adoption drivers,

especially for agricultural innovations which are integrated and complex in nature, as push-pull and IPM are (Llewellyn, 2011). LSGs with high land tenure security who own, rather than lease or manage farms, have been shown in some cases to more readily adopt environmentally sustainable practices with long-term benefits (Soule *et al.*, 2000). The fact that the majority of LSGs in the Midlands North are either owners or owner-managers of their farms also indicates a higher likelihood of adoption.

The agroclimatic location of the respondents, i.e. the ecozone which they farmed in, affected their perception of the pest. This emphasizes the importance of a local approach to disseminating this technology. Knowler and Bradshaw (2007) and Kaine and Bewsell (2008) argued that local context, i.e. agro-climatic and soil factors, such as those which determine the ecozone delineations in the Midlands North (Webster *et al.*, 2005), play a more important role in adoption decisions than do demographic and general enterprise factors such as farmer age, experience and land tenure. This also supports the suggestion that experiential learning activities with small, local groups of farmers are suitable for introducing new pest management strategies. According to Llewellyn (2007), Australian farmers valued information generated from local, farmer-lead agricultural research highly, and farmer groups are very effective vehicles of learning.

This study investigating LSGs' knowledge and perceptions of *E. saccharina*, push-pull and IPM has shown that introducing push-pull as part of an IPM strategy for control of this pest of sugarcane is indeed feasible. The respondents' high levels of farming experience, education and training in sugarcane agriculture indicate that they are competent to adopt a complex, knowledge-intensive pest management strategy like push-pull. Furthermore, their strong linkages to the LPD&VCC and SASRI extension staff mean that they are involved in a learning network which is conducive to the implementation of new agricultural innovations (Llewellyn, 2007). These LSGs also have a high level of financial capacity, as they run large-scale sugarcane farms which provide good financial returns. According to Baumgart-Getz *et al.* (2012), a meta-analysis of adoption literature in the United States of America revealed three variables which have the largest impact on adoption of best management practices, i.e., 1. access to quality information, 2. belonging to a group or being connected to an agency or network, and 3. financial capacity. Our study showed that the LSGs in the Midlands North do indeed have the capacity to adopt push-pull as part of an IPM programme based on these three important variables.

Despite these positive indicators for the successful implementation of push-pull in the Midlands North region, we must not expect high rates of adoption very soon. Not only does adoption of new

agricultural innovations have a time lag (D'Emden *et al.*, 2006; Murage *et al.*, 2011b), but the current threat level of *E. saccharina* in the Midlands North region may not yet warrant adoption of this technology by some farmers in lower risk areas, as it may not be perceived as economically necessary. Khan *et al.* (2008a) found that high pest pressure was a strong motivation for adoption, and Barker *et al.* (2006) showed that push-pull for controlling *E. saccharina* was only economically feasible at higher pest pressures. This also points to the fact that further extension and learning activities for push-pull and IPM should be focused at a local level, and resources should be prioritized for areas where this pest is currently the most threatening and damaging.

## 2.5 Conclusion and recommendations

Notwithstanding good basic knowledge of *E. saccharina*, push-pull and IPM which these LSGs have demonstrated, there is still a need for more detailed and practical knowledge on the implementation of push-pull at farm level. This should also include information on access to plants and seed. This knowledge should be made available to LSGs in a hands-on manner with an emphasis on locally-oriented field days and model farms within ecozones, with the continued involvement of the LPD&VCC and SASRI extension staff. Model farms should be used to illustrate practically how to implement push-pull and demonstrate cost- and time- efficient implementation approaches to demonstrate to LSGs that it is not a very time and/or cost intensive procedure. The LSGs should be encouraged to form local groups in which they experiment with implementing push-pull and adapt the technology to suit the conditions on their farms.

Although *E. saccharina* may not be a priority for all LSGs in the Midlands North region at this time, and they may employ their 'farmers' veto' and not adopt push-pull, the LPD&VCC and SASRI extension staff should continue raising awareness about the long-term value of this method as a sustainable way of managing this indigenous pest. LSGs must not be allowed to become complacent about this pest, particularly in the Midlands North where the 24-month cutting cycle for sugarcane means that high levels of *E. saccharina* could severely affect profit margins for this crop. Consumer pressure for sustainably produced agricultural commodities is on the rise world-wide, and it is only a matter of time until sugar producers need to practice more sustainable agricultural methods. Push-pull within an IPM framework currently provides the only suitable solution for managing *E. saccharina* in this context.