Implementation of the push-pull strategy for *Eldana saccharina* control on sugarcane in KwaZulu-Natal, South Africa

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Declaration and Approval

Declaration by the candidate

I, Jessica Jane Cockburn, declare that this research project which I hereby submit for the degree of *Magister Scientea* (Zoology) at the North-West University, is entirely my original work and has not been submitted for a degree at any other University.

Signature:  Date: 8 March 2013

Approval by supervisors

The supervisors of this study give permission that the data generated during the study may be used for scientific publication by the student.

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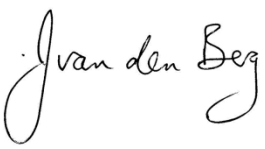
Signature:  Date: 8 March 2013

Abstract

The aim of the research presented in this dissertation was to further the implementation of push-pull for control of *Eldana saccharina* on sugarcane in the Midlands North region, KwaZulu-Natal, South Africa. *Eldana saccharina*, an indigenous stem borer, is the most damaging pest of sugarcane in South Africa, and sustainable control has still not been achieved. The push-pull strategy, a form of habitat management, has been developed for *E. saccharina* and is recommended as part of an integrated pest management (IPM) approach.

Implementation of this strategy for both large- and small-scale farmers was facilitated through mixed methods social research. It included a novel exploratory network analysis to understand the process of technology adoption by farmers. Surveys showed that large-scale farmers have a good knowledge of *E. saccharina*, IPM and push-pull but that they needed more practical knowledge for implementation of the strategy. Farmers recommended experiential learning opportunities such as field days and model farms to get to know more about this technology. Despite demonstrating a positive attitude towards push-pull, farmers perceived it to be a 'hassle' and this is potentially the biggest barrier to its adoption. However, with suitable learning opportunities for farmers and good support for planting inputs, implementation of push-pull is likely to succeed.

Sugarcane was shown to play an important role in the livelihoods and farming systems of small-scale growers. They did not perceive *E. saccharina* as a serious production constraint and had poor knowledge of the pest and its control. Extension for small-scale growers in this region should focus primarily on weed management and on reducing input costs, but still raising awareness of the increasing threat of *E. saccharina*.

On-farm push-pull field trials showed a significant reduction of *E. saccharina* damage on two farms. Mean percentage damaged internodes decreased from 4.1% to 2.7% and from 1.7% to 1.1% in the presence of the repellent grass species, *Melinis minutiflora*. Where farmers did not manage their crops well, push-pull was not effective. It is therefore crucial that push-pull within an IPM framework be implemented together with good crop management practices.

Stem borer surveys in wetlands on sugarcane farms revealed a high diversity of indigenous stem borers and parasitoids, including a stem borer species, *Pirateolea piscator,* which may pose a threat to crops in the future. These findings, together with a literature review on the

significance of on-farm biodiversity and ecosystem services, demonstrated the value which wetlands have for pest management on sugarcane farms. Wetland health assessments were used to develop a tool for farmers to assess and utilise the wetlands on their farms for improved management of *E. saccharina*.

This study highlights the importance of a farmer-participatory approach to implementation of knowledge-intensive farming practices such as push-pull. The importance of wetlands for providing pest regulatory services on sugarcane farms has shown that environmental sustainability needs to become a fundamental principle of farming and agricultural research. Participatory implementation of push-pull, as recommended in this dissertation, could act as a driving force for agroecology in the South African sugar industry and move sustainable farming practices off the pages of journals and manuals onto farmers' fields.

Keywords: agroecology, *Eldana saccharina*, farmer participation, farmer perceptions, habitat management, IPM, push-pull, sugarcane, sustainable agriculture, wetland ecosystem services.

Uittreksel

Die doel van die navorsing wat in hierdie verhandeling oor *Eldana saccharina* in suikkerriet in die 'Midlands North' streek van KwaZulu-Natal, Suid-Afrika, bespreek word, is om die implementering van push-pull as beheerstrategie vir hierdie plaag te bevorder. *Eldana saccharina* is 'n inheemse stamboorderspesie en is die skadelikste plaag van suikerriet in Suid-Afrika. Geen volhoubare beheerstrategie bestaan tans vir hierdie plaag nie. Die push-pull strategie, 'n vorm van habitatbestuur, is ontwikkel vir *E. saccharina* en word aanbeveel as deel van 'n geintegreerde plaagbestuurstrategie.

Die implementering van hierdie strategie deur beide groot- en kleinskaalse boere is bemiddel deur gebruik te maak van "gemengde-metode" sosiale navorsing. Hierdie navorsing het onder meer gebruik gemaak van 'n nuwe ondersoekende netwerkanalise in 'n poging om die proses van tegnologie-aanvaarding deur boere te verstaan. Opnames het getoon dat grootskaalse boere oor goeie kennis rakende *E. saccharina*, geintegreerde plaagbestuur en push-pull beskik maar dat hulle meer praktiese kennis benodig aangaande die implementering van hierdie strategie. Boere het aangedui dat hulle ondervinding-leergeleenthede soos boeredae en model-plase verkies om meer te wete te kom rakende hierdie tegnologie. Ten spyte daarvan dat boere 'n positiewe houding teenoor push-pull getoon het, het hulle die indruk gehad dat dit 'n groot moeite-faktor het wat moontlik die grootste struikelblok in die aanneem van hierdie tegnologie mag wees. Met toepaslike leergeleenthede vir boere asook die verskaffing van goeie insette rakende plantmateriaal, is die kans op suksesvolle implementering van hierdie tegnologie egter groot.

Hierdie studie het bevind dat suikerriet 'n belangrike rol speel in die lewensonderhoud en boerderystelsels van kleinskaalse boere. Laasgenoemde het nie *E. saccharina* as 'n ernstige produksieknelpunt beskou nie en beskik oor min kennis rakende die plaag en die beheer daarvan. Voorligting vir kleinskaalse boere in hierdie streek behoort primêr te fokus op onkruidbestuur en vermindering van insetkoste terwyl dit ook bewustheid kweek van die bedreiging wat *E. saccharina* inhou.

Push-pull veldproewe wat op twee plase gedoen is het getoon dat hierdie strategie tot betekenisvolle vermindering in *E. saccharina* skade gelei het. Die gemiddelde persentasie beskadigde internodes het afgeneem van 4.1% tot 2.7% en van 1.7% tot 1.1% in die aanwesigheid van die afwerende grasspesie, *Melinis minutiflora*. In areas waar suikerriet nie

goed bestuur is nie, was die push-pull strategie nie effektief nie. Dit is daarom belangrik dat push-pull in die konteks van geintegreerde plaagbestuur geimplementeer moet word, saam met ander goeie gewasbestuurspraktyke.

Stamboorderopnames in vleilande op suikerrietplase het aangedui dat ‘n hoë diversiteit van inheemse stamboorders en parasitoïde voorkom, insluitend ‘n stamboorderspesie, *Pirateolea piscator,* wat ‘n toekomstige bedreiging vir gewasse inhou. Hierdie bevindinge asook ‘n literatuuroorsig oor op-plaasbiodiversiteit en ekosisteemdienste, het die waarde van vleilande in plaagbestuur op suikerrietplase beklemtoon. Vleilandgesondheid-assesserings is gebruik as instrument vir boere om vleilande op plase te assesseer en te benut met die oog op verbeterde bestuur van *E. saccharina*.

Hierdie studie beklemtoon die belangrikheid van ‘n deelnemende proses met boere om kennis-intensiewe plaasbestuurspraktyke soos push-pull te implementeer. Die belangrikheid van vleilande in die bied van plaagregulerende dienste het aangedui dat omgewingsvolhoubaarheid ‘n fundamentele beginsel in boerdery asook navorsing moet word. Deelnemende implementering van push-pull, soos voorgestel in hierdie verhandeling, kan dien as motivering vir aanneem van agro-ekologie in die Suid-Afrikaanse suikerrietindustrie, en daartoe lei dat volhoubare landboupraktyke hulle weg vind vanaf die bladsye van joernale en handleidings na boere se landerye.

Sleutelwoorde: agro-ekologie, *Eldana saccharina*, habitatbestuur, geintegreerde plaagbestuur, stimulo-afwerende wegwysing, suikerriet, volhoubare landbou, vleilandekosisteemdienste.

Kafuphi

Inhloso yalolu cwaningo olwethulwa lapha ukuchaza ngokusetshenziswa kwendlela kadudula-donsa ekulweni nenhlava i-*Eldana saccharina* ezimobeni enyakatho-maphakathi nelakwaZulu-Natali eNingizimu-Afrika, okuyinhlava yomdabu enomonakalo ngokwedlulele nengakatholakalelwa su lokuyinqoba. Isu likadudula-donsa liyindlela yokuhlakula nokunakelela amasimu nezivande eyaphenjelwa ukulwa nale nhlava, i-*E. saccharina*. Laziselwa ukuthi liyingxenye yenyanda yezaba zekhethelo (NZK) ekulweni nale nhlava.

Ukusetshenziswa leli su kukhuthazwe wucwaningo olundlela-ningi olwenziwa nabalimi abakhulu nabancane kanye nendlela entsha yokuhlaziya izimo emphakathini ukuze kuqondakale ngokwemukeleka kwamakhono amasha. Kuphenywe kwabonakala ukuthi abalimi bamasimu amakhulu bayazi nge-*E. saccharina,* nangenqolobane yezaba (NZK) kanye nangesu likadudula-donsa, kodwa basadinga ulwazi olunezibonelo abangase bazilandele. Bacebisana ngamathuba okufundisana ngokufuniselisa nanokucathulisana - ngokuqopha usuku lwamasimu noma ngokusika amasimu okuyoboniselwa kuwo. Nòma babekhombisé ukuyithakasela idudula-donsa, bathi iyabacasula, lokho-ke okuyisithikaziso esikhulu ekwemukelekeni kwayo. Nokho-ke kungachuma ukwemukeleka kwedudula-donsa ngamathuba afanele angase avele okufundisana kwabalimi nokuxhaswa kwezaba kwezolimo.

Umoba uya ngokubaluleka empilweni nasekuziqhwisheleni kwabalimi bamasimu amancane. I-*E. saccharina* babengayixwayile kanganko njengesiphazamiso esivunweni, bengazi nangalo monakalo nokubhekana nawo. Ukusebenzisana nabalimi bamasimu amancane kufanele kuthi kugxilé ekuhlakulweni kokhula nasekuncishisweni kwezindleko, kube kuthuthukisa ulwazi ngokwanda kwengozi yenhlava i-*E. Saccharina*.

Izaba ezivandeni ezikhethiwe zakuveza ngokubonakalayo ukuncipha kwale nhlava emasimini amabili. Izinga lomonakalo ngasigaba sinye ohlangeni lehla lisuka ku-4.1% liya ku2.7% naku-1.7% liya ku1.1% lapho kwakukhona khona i-*M. Minutiflora.* Aliphumelelanga isu likadudula-donsa lapho abalimi babengazinakekelanga kahle izitshalo zabo. Ngakho-ke kusemqoka kakhulu ukuthi ududula-donsa ahambisane nokunakekelwa kwensimu.

Ekuhlolweni emaxhapozini ezimobeni kwatholakala izinhlobo ngezinhlobo zezinhlava zemvelo kanye nemidlavuna eminye yayo engagcina iyingozi enkulu ezitshalweni – njenge-*Pirateolea*

piscator. Lolu lwazi oselutholakele kanye nokubukezwa kwezincwadi ngokubaluleka kwengxubevange ekulimeni nakwezemvelo ezivandeni ezikhethiwe luqakamise ukuba semqoka kwamaxhaphozi ekulweni nenhlava ezimobeni. Ulwazana olukhona ngesimo sempilo emaxhapozini lusetshenziswe ukwelekelela abalimi emizamweni yabo yokusebenza emaxhaphozini asemasimini abo, kulweke kangcono ne-*E. saccharina.*

Lolu cwaningo luqakamisa ukubaluleka kwenqubo ebambisana nabalimi ekusebenziseni izindlela zokulima ezidinga ulwazi njengayo le kadudula-donsa. Amaxhaphozi nokubaluleka kwawo ekuncishisweni kwenhlava ezimobeni kukhombisile ukuthi isimo semvelo esiphilile kufanele sibe yisisekelo salo lonke ucwaningo ngezolimo namasimu. Ubanjiswano ekusetshenzisweni kukadudula-donsa okugqugquzelwa ngalo kulo mbhalo, lungaluthuthukisa kakhulu ulimo-mvelo kwezezimoba eNingizimu-Afrika, kuluqhube ulwazi ngamakhono okulima aneso nenhlakanipho, luphume ezincwadini, lungene emasimini!

Amaphuzu: ulimo-mvelo; i-*Eldana saccharina* (inhlava); ubanjiswano nabalimi; imibono nolwazi lwabalimi; ukunakekelwa kwezivande namasimu; inyanda yezaba zekhethelo (NZK) ekulweni nenhlava; dudula-donsa, umoba, ikhono lokulima elineso nenhlakanipho; ezemvelo emaxhaphozini.

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Chapter 7: Conclusions and Recommendations

Glossary

Agroecology

the science of applying ecological concepts to the design and management of sustainable agricultural food production systems (Gliessman, 2007)

amadumbe

(Zulu) species of plant with edible tuber (= taro) (Doke *et al.*, 2005)

area-wide integrated pest management

a coordinated, sustainable and preventive approach that targets pest control over complete ecological zones/areas in which pest populations occur; aims at integrating environment-friendly control measures such as the Sterile Insect Technique, to reduce losses and insecticide use, and to facilitate the expansion of international agricultural trade, while minimizing the further global spread of some major invasive pests (Vreysen *et al.*, 2007)

Bt maize

transgenic maize containing cry genes expressing insecticidal protein from *Bacillus thuringiensis* (Bt) (= Bt corn) (Keeping *et al.*, 2007)

classical biological control

the intentional introduction of an exotic, usually co-evolved, biological control agent for permanent establishment and long-term pest control of an exotic pest (Eilenberg *et al.*, 2001)

coding

the process whereby raw data are transformed into standardised form suitable for machine processing and analysis (Babbie, 2010)

communication for rural innovation

a series of embedded communicative interventions that are meant, among others, to develop and/or induce innovations which help to resolve problematic situations (suggested as a term to replace 'extension') (Leeuwis, 2004)

complex systems

a complex system has many parts; there are many relationships/interactions between those parts; the parts produce combined effects that are not easily foreseen and may often be novel or surprising (Corning, 1998)

conservation biological control

modification of the environment or existing practices to protect and enhance specific indigenous natural enemies or other organisms performance to reduce the effect of pests (Eilenberg *et al.*, 2001)

content analysis

examining a class of social artefacts, typically written documents (Babbie, 2010)

contour bank

structures which are built at intervals down the slope of cultivated land in order to intercept runoff before it causes erosion, and to lead it off the land to a safe discharge point (McAlister and Russell, 1999)

diffusion of innovation

the process in which an innovation is communicated thorough certain channels over time among the members of a social system (Rogers, 1983)

ecozone

areas of similar climate and potential for sugarcane production, derived from the bioresource units as defined by the KwaZulu-Natal Department of Agriculture and Environmental Affairs (DAEA) (Webster *et al.*, 2005)

exploratory network analysis

consists of four parts: the definition of a network, network manipulation, determination of structural features, and visual inspection (de Nooy *et al.*, 2005)

farmer field schools (FFS)

exemplifies the new type of extension that is consistent with facilitating more sustainable forms of agriculture, using local farmer input and interaction (for a detailed description see Röling & van de Filert (1994))

farmer first

an approach in which it is argued that much of the problem with conventional agricultural research and extension lies with the processes of generating and transferring technologies, and that much of the solution lies with farmers' own capacities and participation in the research process (Scoones and Thompson, 2009)

focus group discussions (FGDs)

social research in which 12-15 people are brought together to engage in a guided discussion of some topic (Babbie, 2010)

free-listing

an interview in which informants create an inventory of all the items they know within a given category (Quinlan, 2005)

habitat management

a form of conservation biological control: an ecologically based approach aimed at favoring natural enemies by manipulating their habitat to make them more effective, and thus enhancing biological control in agricultural systems (Landis *et al.*, 2000)

induna

(Zulu) headman or councilor (Doke *et al.*, 2005)

inhlava, inhlakava, isihlava

(Zulu) stem borer (lepidopteran larva which bores into plant stems)

inkosi

(Zulu) chief (Doke *et al.*, 2005)

integrated pest management (IPM)

IPM is a decision support system for the selection and use of pest control tactics, harmoniously co-ordinated into a management strategy, based on efficient pest control, and cost/benefit analyses that take into account the interests of and impacts on producers, society, and the environment (Kogan, 1998)

invasive alien plants (IAPs)

plants which are not indigenous to South Africa but were introduced either intentionally (for domestic or commercial use) or accidentally, and have become invasive, competing with indigenous plant species for resources (Wyatt, 1997)

isiZulu

the Zulu language: most widely spoken indigenous language in South Africa, and the main language in KwaZulu-Natal

KwaZulu-Natal Department of Agriculture and Environmental Affairs (DAEA)

Provincial government authority responsible for agricultural and environmental matters

lacustrine wetland

lake-side wetland, includes permanently flooded lakes and dams (Dini *et al.*, 1998)

large-scale growers (LSGs)

commercial sugarcane farmers, farming on freehold land larger than 30 hectares (Eweg, 2005b)

local pest, disease and variety control committee (LPD&VCC)

a committee formed by sugarcane farmers in the South African sugar industry, within a defined geographic area, which conducts pest and disease surveys on farms, provides support and advice for management of pests and diseases, reports unusual incidence of pests and diseases to SASRI and regulates the use of sugarcane varieties and certified seed cane (Mathew *et al.*, 1990)

likert-type scale

widely used scale in survey research in which people express attitudes or other responses in terms of ordinal-level categories (e.g. agree, disagree) that are ranked along a continuum (de Vos *et al.*, 2011)

Midlands North region

A geographical region defined within the South African sugar industry as the area of land from which sugarcane farmers deliver sugarcane to two sugar mills: 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) (See Figure 2.1 in Chapter 2) (SASA, 2011)

mixed methods research

a social research methodology in which both qualitative and quantitative approaches, methods and procedures are combined or 'mixed' to come up with a more complete picture of the research problem (Onwuegbuzie *et al.*, 2009)

new association biological control

introductions of exotic natural enemies against pests with which they did not co-evolve (Eilenberg *et al.*, 2001)

Pajek

(Slovenian: spider) computer program used to analyse and draw social networks (de Nooy *et al.*, 2005)

palustrine wetland

vegetated wetlands traditionally called marshes, swamps, bogs, fens and vleis (Dini *et al.*, 1998)

participatory matrix scoring

a participatory methodology in which a matrix of columns and rows is set up and populated by local farmers or other participants using local materials (e.g. stones, beans, seeds) in which the objective is to determine or identify one, or a few items, as being the most important (Abeyasekera, 2001; Chambers, 2008)

participatory rural appraisal (PRA)

an approach which 'seeks and embodies participatory ways to empower local and subordinate people, enabling them to express and enhance their knowledge and take action (Chambers, 2008)

participatory sketch map

a participatory methodology in which local farmers or other participants express their spatial realities by drawing maps (also called participatory ground and paper mapping) (Chambers, 2008)

push-pull

the behavioral manipulation of insect pests and their natural enemies via the integration of stimuli that act to make the protected resource unattractive or unsuitable to the pests (push) while luring them toward an attractive source (pull) from where the pests are subsequently removed (Cook *et al.*, 2007)

qualitative research

research that elicits participant accounts of meaning, experience or perceptions (Creswell, 2009)

quantitative research

research that describes trends or explains relationships between variables (de Vos *et al.*, 2011)

riverine wetland

includes all wetlands contained within a channel (Dini *et al.*, 1998)

South African Sugarcane Research Institute (SASRI)

the agricultural research arm of the South African Sugar Association (SASA), which is an organisation not for gain, without private ownership; created under statute: Section 2 of the Sugar Act, 9 of 1978 (South Africa, 1978)

small-scale growers (SSGs)

sugarcane farmers who farm on plots of less than 30 hectares, mostly on traditional communal trust land (Eweg, 2005b). In practice, most SSGs farm on less than 4ha (Bates and Sokhela, 2003).

social network analysis

a method used to detect and interpret patterns of social ties amongst actors or components in a network (de Nooy *et al.*, 2005)

SUSFARMS

Sustainable Sugarcane Farm Management System: a system designed to encourage sustainable sugarcane production through the implementation of better management practices (BMPs) which reduce the negative impacts of agriculture on the environment (Maher, 2007)

transfer of technology (ToT)

an extension paradigm which assumes a one-way and uninterrupted flow of technologies from fundamental scientists, to ultimate users via various intermediaries and delivery mechanisms, also called the linear model of innovation (Leeuwis, 2004; Röling, 2004)

vlei

(Afrikaans) marsh-like wetland area

wetland

land which is transitional between terrestrial and aquatic systems, where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil (according to the South African National Water Act) (DWAF, 2005)