SHORT NON-REFEREED PAPER

# OPTIMISING SUGARCANE FIELD LAYOUTS FOR PEST CONTROL

POTGIETER L[1], VAN VUUREN JH[2], CONLONG DE[3,4] AND VAN VUUREN BJ[2]

[1]*Department of Logistics, Stellenbosch University, Private Bag X1, Matieland, 7602, South Africa*
[2]*Department of Industrial Engineering, Stellenbosch University, Private Bag X1, Matieland, 7602, South Africa*
[3]*South African Sugarcane Research Institute, P/Bag X02, Mount Edgecombe, 4300, South Africa*
[4]*Department of Conservation Ecology and Entomology, Stellenbosch University, Private Bag X1, Matieland, 7602, South Africa*
*lpotgieter@sun.ac.za vuuren@sun.ac.za Des.Conlong@sugar.org.za*

## Abstract

The contribution of a heterogeneous agricultural landscape (in terms of field layouts of diversified crop ages) towards pest suppression is considered in this study. In order to investigate the population dynamics of the pest species *Eldana saccharina* Walker (Lepidoptera: Pyralidae) in differently configured sugarcane habitats, mathematical simulation models of Eldana population growth and dispersal in temporally variable and spatially heterogeneous environments are formulated. Infestation levels in a number of different mosaic configurations of differently aged agricultural crops across a spatial domain, where the harvesting of these fields occurs at different times, are compared to establish which field layout structures perform best in terms of average infestation over time. It has been found that more diversified field configurations (in terms of crop age) yield lower average infestation levels.

*Keywords: Eldana saccharina*, population dynamics, pest control, sugarcane field configurations

## Introduction

*Eldana saccharina* Walker (Lepidoptera: Pyralidae) has been a serious pest in South Africa since 1971 (Carnegie, 1974). A number of intensive research programmes at the South African Sugarcane Research Institute (SASRI) have been conducted against this pest. Various methods have been proposed and researched for the control of Eldana. Although contributing to suppression, none of these have proven very successful in preventing Eldana infestations, and harvesting at a younger age is still considered the most effective method of controlling Eldana in sugarcane (Atkinson and Carnegie, 1989).

The manipulation of planting and harvesting schedules has been recognised to have a negative impact on pest populations. This may be as a result of a more diverse habitat in terms of crop age. It has been shown that population densities of herbivore pest insects are often reduced in vegetationally more diverse habitats (Mazzi and Dorn, 2012). Due to harvesting being considered as such a large controlling factor of pest species in crop plants, the question has been raised whether there exists suitably diversified agricultural landscapes (with respect to crop age), in which the harvesting of the different fields at different times impact negatively on pest populations. If this question can be answered in the affirmative, then a combination of such field layouts with other pest control methods such as the sterile insect technique may significantly reduce the cost of achieving suppression.

The primary objective of this study is therefore to establish, using mathematical simulation models, whether or not there exist certain heterogeneous spatial configurations of sugarcane (with respect to fields with differently aged crops), in which harvesting of these fields at different points in time yield lower average infestation levels than in other spatial configurations.

## Methods

Two models are developed to describe the population growth and dispersal of a wild Eldana population in sugarcane.

The first model consists of a deterministic system of discretised reaction-diffusion equations subject to strictly positive initial data and zero-flux Neumann boundary conditions. The spatial domain considered in the model is assumed to be an isolated set of adjacent sugarcane fields with heterogeneous cane age and cane variety, surrounded by land uses not suitable as possible habitats for Eldana. Not much is known about the dispersal patterns of Eldana moths, besides that they are weak fliers. For this study, adult moths are assumed to have no spatial working memory with individual movement represented by a pure random walk. If individual moths follow a pure random walk, population movement may be approximated by a pure diffusion process (Ovaskainen, 2008). Also, a diffusion process is a good approximation in the case of weak fliers. Larval dispersal is not considered applicable since the distances they cover are very small compared to the spatial scale of the model. Promotions from different life stages occur at certain temperature-dependent maturation and mortality rates. During each day, a certain proportion of adult moths were assumed to leave the area in which they emerged so as to colonise neighbouring areas within their flight range.

The second model is an agent-based simulation model, where the movement patterns of each individual moth is modelled using, for example, a pure random walk or a biased random walk. In contrast to the reaction-diffusion model, more behavioural characteristics, such as lek-mating, may be incorporated into such a model.

## Results and Discussion

A rectangular spatial domain is assumed, which is partitioned into smaller rectangular or square fields that are heterogeneous in terms of crop age. They are assumed to be arranged according to the spatial patterns shown in Figure 1. The average Eldana infestation levels over a set period of time are compared for these different patterns in order to establish whether the average infestation level over time is reduced as a result of certain field layout structures.

Preliminary simulation results of the reaction-diffusion model indicate that average infestation levels are significantly lower over heterogeneous domains in which fields are larger, compared to smaller fields. This difference is more pronounced when assuming that the initial infestation is mainly as a result of diffusion from neighbouring fields (spreading from the edges inwards). Results also indicate that the average infestation value is slightly lower over a heterogeneous domain with more crop ages than the corresponding value for a domain with only two crop ages present. Furthermore, average infestation is lower over a heterogeneous domain with fields of different crop ages arranged in lanes (according to the patterns b) or c) in Figure 1) compared to the case of fields arranged in a checkerboard pattern (according to the patterns d), e) or f) in Figure 1).

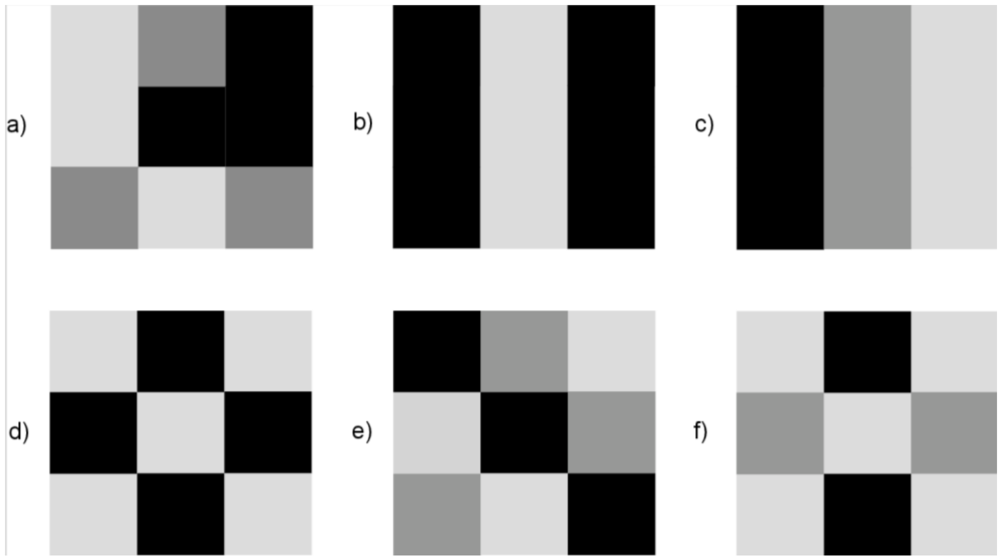


**Figure 1. Spatial patterns formed by differently aged fields (each crop age is represented by a unique colour) in the spatial domain. a) A random segmented pattern, b) two age categories distributed in lanes, c) three age categories distributed in lanes, d) two age categories distributed in a checkerboard pattern, e) three age categories distributed along diagonals in a checkerboard pattern, f) three age categories distributed in an alternative checkerboard pattern. These patterns, as well as the dimensions of the fields are varied in simulations.**

Taking all of the above observations into account, simulations indicate that when assuming that individual moths follow a pure random walk with no spatial working memory, and infestation occurring mainly as a result of movement from neighbouring fields, a domain in which same-aged crops are grouped together (i.e. *n* fields for *n* crop ages) and with more than two crop ages present, results in a lower average infestation than domains in which the opposite is true. Also, an optimal partition of the spatial domain into *n* fields containing *n* different crop ages is one for which the total length of boundaries shared between fields containing different crop ages is minimised.

The above results may, however, not be valid in the case of individual moths having spatial working memory and following a biased random walk (having preference for certain crop ages and varieties in their flying behaviour).

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