COSMOS, A SPATIALLY EXPLICIT MODEL TO SIMULATE THE EPIDEMIOLOGY OF *COSMOPOLITES SORDIDUS* IN BANANA FIELDS

Fabrice Vinatier[1*], Philippe Tixier[1], Christophe Le Page[2], Pierre-François Duyck[1] & Françoise Lescourret[3]

[*]Corresponding author: fabrice.vinatier@cirad.fr

[1] CIRAD, Systèmes de culture bananes, plantains et ananas, B.P. 214, F-97285, Le Lamentin, Martinique, France

[2]CIRAD, Gestion des ressources renouvelables et environnement, Montpellier, F-34000 France and CU-CIRAD ComMod Project, Chulalongkorn University, Bangkok, Thailand

[3] INRA, Unité Plantes et Systèmes de Culture Horticoles, Domaine St. Paul, Site Agroparc, Avignon Cedex 9, 84914, France

ABSTRACT

Although few studies use Individual-Based Models to explain epidemiology of pests, IBMs offer interesting perspectives when the behaviour of the pest is of importance, especially in interaction with agricultural practises and environment. A stochastic individual-based model called COSMOS was developed to simulate the epidemiology of *Cosmopolites sordidus* in banana fields, based on simple rules of local movement of adults, egg-laying of females, development and mortality, and infestation of larvae inside the banana plants. The model was validated and an exhaustive sensitivity analysis using the Morris method was performed. The model helps us to understand how different spatial arrangement of banana plants affects epidemiology of *C. sordidus*. COSMOS shows that planting in patches should limit the time necessary for the pest to colonize a new field, in comparison to a regular planting, but attacks might be more severe in patches after two or three cropping cycles. By adding a submodel of pheromone trapping in COSMOS, we show that the best trapping efficiency is reached when spatial organization of traps is clustered in relation to the patchy distribution of *C. sordidus*. In case of invasion of a new plantation from a nearby infested plantation, it is necessary to regularly dispose the traps in line all along the neighbouring border. The best distance between each trap is correlated to the wind direction, with the largest distances for a wind direction parallel to the trap line.

INTRODUCTION

Understanding the epidemiology of pests is of special importance for better management (Madden, 2006). The spatial component of epidemiology is a crucial element in the spread of damages from a localised inoculum or when pest dispersal is limited (Winkler and Heinken, 2007). In some cases, individual behaviour of pest leads to the emergence of population-level properties, and the individual-based modelling (IBM) is an interesting approach for understanding emerging properties of a system.

In this study, we use an individual based model (IBM) for studying the epidemiology of *Cosmopolites sordidus* (Coleoptera: curculionidae) (Germar, 1825) (Vinatier et al., 2009). *C. sordidus* is a major pest of banana cropping system. This IBM called COSMOS was designed using bibliographical data on the pest and was validated at field scale. COSMOS is used to answer the question: How agricultural practises affect epidemiology of a pest? We focus on spatial arrangement of plantation and spatial organisation of trapping.

DESCRIPTION OF THE MODEL

COSMOS is based on simple rules of local movement of adults, egg-laying of females, development and mortality, and infestation of larvae inside the banana plants. Model is validated

on a dataset of infested plots during two consecutive cropping cycles. Sensitivity of the model to each biological trait is analysed using the Morris method. A module allows the simulation of pheromone trapping of *C. sordidus*. Each trap is spatially located and has a finite attractivity that decreases with the distance to the trap. The trapping module was calibrated using data from Tinzaara et al. (2005).

In a first step, we simulate three spatial arrangements of plantation based on farmer practises: regular (Pattern 1), in double rows (Pattern 2) and in patches (Pattern 3). We hypothesise that spatial arrangement of a plot affects colonisation process of the pest and we calculate the time necessary to colonise the whole plot and the level of damage during three cropping cycles. In a second step, we simulate an increasing density of regular trapping in a field to evaluate the maximal trapping density beyond which there is no more effect on intensity of damages in the field.

RESULTS AND DISCUSSION

Our simulations on the effect of different spatial arrangements of banana plants on the epidemiology of *C. sordidus* show that planting in patches with a large distance between patches should limit the time necessary for the pest to colonise a new field. In contrast, the simulations indicate that the severity of attacks may increase when banana plants are planted in patches. Our simulations on the effect of trapping density on attacks show that control of damages is not improved beyond 16 traps/ha. However, intensity of attacks increases in all cases and interest of mass trapping in those conditions is discussed.

COSMOS helps to understand links between population structure of pests and management practises of farmers, such as planting and use of pheromone trapping. Further improvements of COSMOS would consist in integrating effects of management practises at farm scale on dispersal abilities of *C. sordidus*, as presence of residues or old banana plant. Management practises at landscape scale should consist in studying effects of fallow as source of contamination for neighbouring plots.

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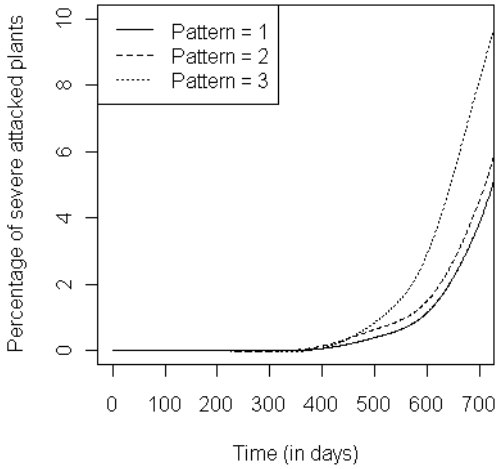

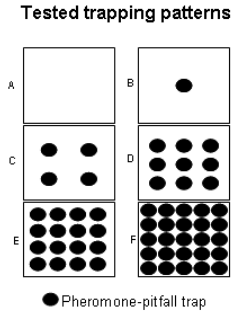

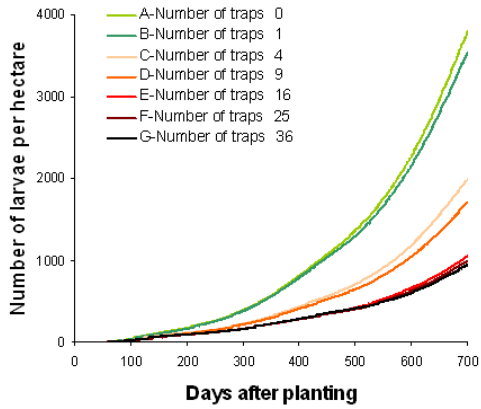

Figure 1 Simulation with COSMOS model of three spatial arrangements of plantation

Figure 2 Simulation with COSMOS model of an increasing density of traps.