Introduction

Disease and pest attack intensities are mainly determined at the plot level through interactions between the host, noxious organism, environment and agricultural management (Zadoks and Schein, 1979). However, the immigration of noxious and beneficial organisms from outside may also affect pest and disease incidences at the plot scale. Successful immigration is facilitated in landscapes with greater connectivity between resources (Zadoks, 1999). Functional connectivity of landscapes depends on the distribution and density of specific land uses, on how these are perceived (hostile or not) by specific organisms, and on organisms’ dispersal ability to move across non-habitat areas. In a given landscape context, higher connectivity is therefore expected for generalist noxious organisms with high dispersal abilities. Here, we study the relationship between coffee pest and disease incidence in coffee farms and landscape context. We hypothesize that greater coffee cover within the local context (<1500 m) will increase pest and disease incidence whereas greater forest cover will decrease it. We use three focal organisms to test these hypotheses: (1) coffee rust (Hemileia vastatrix), (2) coffee berry borer (Hypothenemus hampei), and (3) the root-knot nematodes (Meloidogyne spp.). These noxious organisms differ by their host specificity and dispersal ability. Coffee rust is coffee specific. Its uredospores are spread by wind over great distances and can even cross oceans (Bowden, 1971). The coffee berry borer is very specific to coffee, however it has been found to reproduce in several plant species (Davidson, 2000). The females are able to fly, and probably can be transported by convection winds, over a few hundred meters (Baker, 1984). Root-knot nematodes are able to infect different plant species and, when not dispersed through human activities, can be considered nearly immobile.

Materials and Methods

We conducted a one-year survey starting in November 2008 through November 2009 on 50 coffee plots in the Turrialba region of Costa Rica (Figures 1 and 2a). The plots were distributed within a wide range of landscape contexts, from highly fragmented (Figure 2b) to intact coffee plots (Figure 2c). Coffee plots were comprised of eight rows of 15 coffee plants (120 coffee trees per plot). We quantified noxious organism incidence on five systematically distributed coffee trees in each plot, in 2.5 evaluation periods depending on the organism: February-March, May, June-July, September, October-November. We measured coffee rust incidence in all five periods by counting the number of diseased and healthy coffee leaves on three branches per coffee plant (a total of 15 branches per plot). We estimated coffee berry borer abundance four times only (excluding February-March) by counting the number of bored coffee fruits on four branches per coffee tree (20 branches per plot) and the total number of fruiting branches. We assessed root-knot nematodes population densities twice only (May and September) by sampling coffee roots from the four neighboring coffee plants of each of the five selected trees (20 subsamples per plot).

In our analyses we used the maximum annual percentage of diseased coffee leaves as our descriptor of coffee rust infection. In the case of the coffee berry borer we used the maximum annual number of bored coffee fruits estimated per coffee plant. Finally, for the root-knot nematodes, we used the average population density per 100 g of coffee roots.

Results

We found diverse responses to landscape context for each of the study organisms. There were no correlations between landscape context and population densities of root-knot nematodes as expected. We found multiple significant positive correlations between coffee berry borer infestation and proportion of the landscape in coffee (Figure 3a). The significance of this relationship peaked at the 150 m radius (r=0.28, P<0.05; Figures 3a and 4a). Similarly, we found multiple significant positive correlations between coffee rust incidence and proportion of the landscape in coffee (Figure 3b). In contrast to the coffee berry borer, the significance of this relationship was especially high at the 300 m radius (P<0.05; Figures 3b and 4b). In addition, multiple negative correlations were obtained for coffee berry borer and the proportion of pasture in the landscape (Figure 3b) and for the coffee rust with the proportion of coffee in the landscape (Figure 3a).

Discussion and Conclusion

Our results can be interpreted according to the dispersal ability of the studied organisms. Coffee berry borer has a dispersal ability much higher than other land uses as hostile. As a consequence, fragmenting coffee farms at small scales (i.e. interspersing alternate land uses or linear barriers such as riranuan corridors) may help to significantly reduce coffee berry borer movement between plots. In contrast, fragmentation of coffee landscape, particularly by pasture, may increase coffee rust dispersal. This is probably because coffee rust is an airborne pathogen whose dispersal is favored by open spaces. Finally, nematodes, which are nearly immobile, were not influenced by landscape context.

References