Title:
Mathematical Models and Optimal Control for Alternative Pest Management to Alfalfa Agroecosystems

Alfalfa is the most cultivated forage legume in the world supporting dairy and cattle productions, and with growing export market for U.S. farmers. The Potato Leafhopper (PLH) is a pest that costs serious and costly damages to the host-plant alfalfa in traditional monoculture fields. Moreover, chemical pesticides are increasingly costly and unsafe. It is critical to explore natural and sustainable alternative pest management strategies to reduce PLH abundance and damage to alfalfa while making them viable by considering production and revenues levels for farmers. Based on actual field experiments, this project developed mathematical models, computer simulations and optimal control theory for sustainable, revenue effective and environmentally-safe strategies that minimize alfalfa-plant damage from PHL pests. The models incorporated enemies hypothesis (natural predators), polyculture farming (growing other plants with alfalfa), and movement-risk hypothesis (moving pests are vulnerable to predators), that have been shown to be effective in field experiments (Straub et al.). Mathematical models including twelve size- and time-dependent parameters were created using systems of differential equations. They were shown to accurately fit results from open-field experiments and were used to predict outcomes for polyculture scenarios not covered by these experiments. A sensitivity analysis established the relative importance of each parameter. Optimal control theory results showed sustainable and viable designs of plant-diversity levels that minimize the alfalfa damage, preserve the nutritional efficacy of the harvests, minimize production costs, and maximize farmers' profit over several years of the alfalfa life cycles.