Bioclimate Approach to Integrated Crop Management within Agro-Ecosystems of Western Canada

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Introduction

The Prairie Ecozone in western Canada contains a large agro-ecosystem of about 29 million ha of cropped land

Throughout its history, prairie agro-ecology has been challenged by intense infestations of insect pests: indigenous, invasive alien and migratory species

Climate is the dominant factor determining the distribution and population abundance of most insects. To date, the focus of climate change impacts on insect populations have focused on individual species

However, producers must consider crop management decisions based on the potential impact of multiple pest species. There has been little or no analyses on how multiple insect pest species interact in response to future climates

Impact of Climatic Warming on Insects

- Increased growth & development
- Shorter generation times
- Increased feeding rates
- Reduced overwintering mortality
- Colonization of new habitats
- Reduced biodiversity

Figure 1. Predicted Temperature Change (°C) from 1961-1990 to 2040-2060 based on Coupled General Circulation Model 2
(http://atlas.gc.ca/site/english/maps/climatechange/scenarios)

Objectives

Bioclimatic simulation models have been developed to predict the potential range and relative abundance of three cereal crop pests, grasshoppers (*Melanoplus sanguinipes*), wheat midge (*Sitodiplosis mosellana*) and cereal leaf beetle (*Oulema melanopus*). The objectives of this study were to:

- Identify geographic areas that are at risk for establishment of economic levels of pest population density
- Quantify the changes in regional crop risk due to overlap of the three pest species in future climates (2030 and 2070), relative to current conditions

Methods

Bioclimate simulation software, CLIMEX (Sutherst et al. 2007), was used to derive an Ecoclimatic Index (EI), which described the suitability of geographic locations for species survival and reproduction as well as an estimate of relative population abundance.

Model parameters included temperature, diapause, light, moisture, heat stress, cold stress, wet stress, and dry stress

General Circulation Models (Kriticos *et al.* 2012) were then applied to the bioclimate models to assess ecosystem vulnerability due to climate and the potential impact on important ecological processes. Contour maps were generated using EI values.

Results

Results identified which pest species posed a significant risk to agro-ecosystems in western Canada

- Compared to current climate, projected changes in insect distributions due to future climates expanded polewards and contracted from its southern temperature range limits (Figure 2)
- Multi-species analysis showed that the geographic overlap of economic populations (crop risk) was slightly greater between 1975 (current) and 2030 than 2030 to 2070 (Table 1)
- Total geographic area of where economic populations of all three species, grasshoppers, wheat midge and cereal leaf beetle, overlapped increased from 2.4% currently to 4.7% and 6.4% for 2030 and 2070, respectively

Discussion

Notable changes were predicted to occur across the Canadian prairies, particularly across the northern half of the Ecozone (56° - 58° N latitude)

Identifying the risks provides producers, governments and industry an opportunity to optimize pest management using best practices most suitable for the specific situation

Figure 2. Potential pest risk to cereal crop production in North America for (A) 1975, (B) 2030 and (C) 2070. Values represent mean Ecoclimatic Index (EI) values for grid cells in which all three species (*M. sanguinipes, O. melanopus* and *S. mosellana*) were predicted to have EI values indicative of risk to wheat. EI categories: Grey 18-24, Green 24-26, Yellow 26-27, Orange 27-28, Red 28-32

	1975 % of Total	2030 % of Total	2070 % of Total
MS	13.4	15.6	17.6
WM	12.1	15.6	17.2
CLB	19.5	25.6	30.8
MS - WM Overlap	3.1	4.9	6.4
MS - CLB Overlap	6.1	8.6	11.4
WM - CLB Overlap	9.7	13.8	17.1

Table 1. Effect of climate (CSIRO Mark 3.0 (A1B) 1975, 2030 and 2070) on distribution of insect species associated with cereal crops (*M. sanguinipes* (MS), *S. mosellana* (WM) and *O. melanopus* (CLB)). The overlap values represent grid cells in which both species were predicted to have Ecoclimatic Index values representative of pest risk to host crops. Values represent percent of total area in North America.

Conclusions

Early warning of major changes in insect pest abundance and geographic distribution is required to assess the threat to field crops

Under current climate conditions, rarely are there pest outbreaks of multiple species. Under climate change scenarios, the risks of multiple species outbreaks doubles by 2070

Information provided by bioclimate models gives scientists a window of opportunity to develop and transfer mitigation tactics that can reduce the establishment or spread of these pests

References

Kriticos, D.J., Webber, B.L., Leriche, A., Ota, N., Macadam, I., Bathols, J. and Scott, J.K. 2012. CliMond: global high-resolution historical and future scenario climate surfaces for bioclimatic modelling. Methods in Ecology and Evolution **3**: 53-64.

Sutherst, R.W., Maywald, G.F. and Kriticos, D.J. 2007. CLIMEX Version 3 User's Guide. Hearne Scientific Software Pty Ltd, Melbourne.

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