Chapter 2. EFFECT OF CLIMATE CHANGES ON PLANT PESTS AND WEEDS

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THE IMPACT OF THE CHANGING CLIMATE CONDITIONS ON THE OCCURRENCE OF THE COLORADO POTATO BEETLE (*LEPTINOTARSA DECEMLINEATA*)

Remigijus ŠMATAS, Roma SEMAŠKIENĖ, Sigitas LAZAUSKAS

Lithuanian Institute of Agriculture
Instituto al. 1, Akademija, Kėdainiai distr., Lithuania
E-mail: remigijus@lzi.lt

Abstract

The study was focused on the trends of Colorado potato beetle (*Leptinotarsa decemlineata)* abundance during the growing season in potato. Analysis was conducted based on the data of Colorado potato beetle abundance observation in the Dotnuva site and meteorological data during the period 1980–2007. A significant increase in the abundance of this pest was recorded, especially during the last decade. The occurrence of pest during 1980–2007 plotted against time presents relatively smooth non-linear trend. A significant relationship between detrended Colorado potato beetle occurrence and mean air temperature in May ($r = –0.52$, $p<0.01$) for the period 1980–2007 was established by using a simple linear model. The level of occurrence of Colorado potato beetle in the preceding year was found also to be a very important factor. Climate change may affect the ability to control pests; therefore new strategies will be required for effective control of Colorado potato beetle.

Key words: *Leptinotarsa decemlineata*, occurrence, climate changes.

Introduction

Climate conditions exert a significant influence on the spread, population dynamics, life cycle duration, infestation pressure and the overall occurrence of the majority of agricultural pests. Climate change resulting in increased temperature could impact crop pest insect populations in several complex ways /Bale et al., 2002; Petzoldt, Seaman, 2006/. The increase in Colorado potato beetle (*Leptinotarsa decemlineata* Say.) population in many countries is related with the climate warming /Baker et al., 1998; Rafoss, Sæthre, 2003; Hansen, 2007; FAO, 2008/. This insect is a very destructive pest of potatoes and also feeds on a number of other *Solanaceous* crops /Headings, 2006/. Colorado potato beetle is a dangerous pest of potatoes over a broad area in Europe /Benkovskaya et al., 2006; Leontieva et al., 2006; Barčić, 2006/. It was first reported in Lithuania in 1936 /EPPO/ and now it is the main potato pest in Lithuania /Šurkus, 2003/.

Yield losses can be as high as 60% in the plots unprotected from Colorado potato beetle (unpublished data). Colorado beetle has a liking for warmth and is cold intolerant /Hiiesaar et al., 2001; Semaškienė, Šmatas, 2006/. The maximum feeding of the beetles occurs at a temperature of 25° C, while feeding stops at 10° C. Females lay eggs at temperatures ranging from 15 to 30° C /Tauber et al., 1988; EPPO/. The temperature for egg hatching is above 12° C, whereas optimum temperature for moulting is 30° C /EPPO/.

The number of Colorado beetle generations is largely a function of temperature, varying between about four in the hottest areas to one full and one partial generation near the colder extremes. There are some cold areas with only one partial generation /Svikle, 1976; EPPO/. Low temperatures are the main hindrance for their survival and spread, and determine the borders of the beetles distribution /Hiiesaar et al., 2006/. The European climate of the 21st century is likely to become warmer, with drier summers, wetter winters and more variable patterns of rainfall and temperatures /Temmerman et al., 2002/. An analysis of the climatic fluctuations recorded in Lithuania over the 19–20th centuries suggests that winters and springs have warmed up, precipitation in the cold period of the year has increased, whereas summer and autumn temperatures have changed just insignificantly /Bukantis, 2001/.

The aim of our investigation was to analyse the trend in Colorado beetle occurrence in relation to meteorological factors.

Materials and Methods

In order to investigate trends in climate changes, weather data for the period 1980–2007 were collected from the Dotnuva station of the Lithuanian Hydrometeorological Service. The Colorado potato beetle occurrence was observed in the experimental plots and commercial field of potato, and the data were collected by the researchers of the Lithuanian Institute of Agriculture and the specialists of the Lithuanian State Plant Protection Service. Assessments of Colorado potato beetle occurrence in potato were started at inflorescence emergence stage (BBCH 51) and were continued until the middle of fruit development stage (BBCH 75). No pest control products were applied in the assessed plot. Colorado potato beetles and their larvae were counted on ten plants in five places per plot. The assessment was done once a week. For the analysis, we used percent of Colorado potato beetle infested plants during the highest infestation in a particular year.

The trend in Colorado potato beetle occurrence in relation to meteorological factors was analysed for the period 1980–2007 following approaches and methodology used by FAO for yield forecasting as outlined by Gommes (2001).

Results and Discussion

A distinct and statistically significant increase in the long-term mean air temperature was noted at the experimental site of the Lithuanian Institute of Agriculture in Dotnuva, Kedainiai for the whole study period. Long-term mean air temperature has been calculated since 1924. Statistically significant positive trend ($p<0.05$) was identified. The positive trend was identified also for the study period (Figure 1).

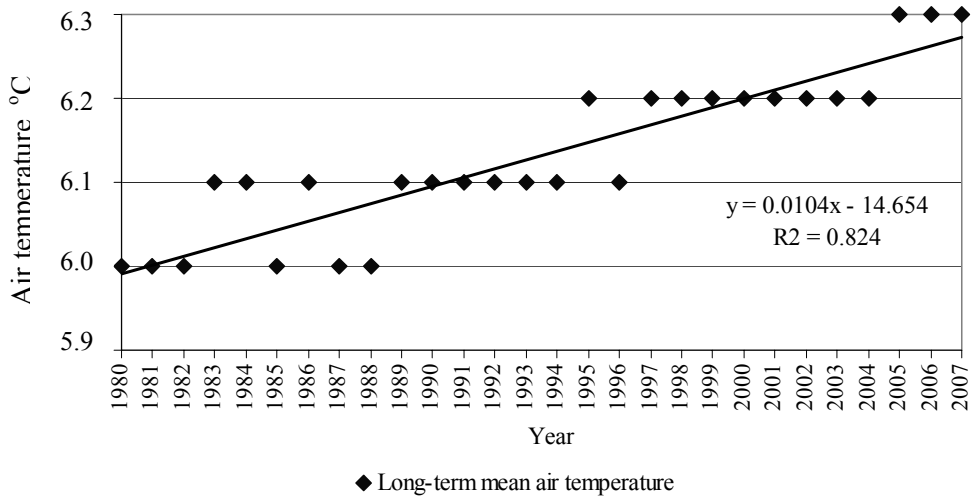

Figure 1. Trend of annual mean air temperatures over the study period Dotnuva 1980–2007

The study was designed to evaluate possible trends in Colorado potato beetle occurrence on a regional scale as part of the climate change project, therefore fundamental aspects of Colorado potato beetle biology and relationships with specific agrometeorological variables were not covered. The data of Colorado potato beetle occurrence during the period 1980–2007 plotted against time presents relatively smooth non- linear trend, with only 2 points outside the main trend (Figure 2). Very high level of Colorado potato beetle occurrence in these two cases can be explained by the high mean air temperature in May (14.5^{o} C in 1983 and 14.1^{o} C in 1984). In scientific literature it is indicated that thermal threshold is approximately 12^{o} C for reproductive development of Colorado potato beetle after dormancy /Tauber et al., 1988/. In previous and other studies it was established that the important factors in inducing hibernation are photoperiod and temperature, whereas it is primarily temperature which determines the length of diapause and emergence from the soil; in spring the first adults emerge at 68 days-degrees above 10.5^{o} C /Mailloux et al., 1988; Tauber et al., 1988; Lefevere, de Kort, 1989/, therefore it is likely that warmer springs promoted higher infestation of Colorado potato beetle.

For further statistical analyses, the data of Colorado potato beetle occurrence was de-trended using regression equation $y = 1161573.4 – 1168.7\ x + 0.29395\ x^2$; ($R^2 = 0.73$; $p < 0.01$); where x – year, y – Colorado potato beetle occurrence. After removing the trend of Colorado potato beetle occurrence, the data were plotted against each individual meteorological variable (monthly mean air temperatures, rainfall and HTC for May, June and July) and afterwards these variables were ranked according to the magnitude of correlation coefficient. The highest correlation coefficient ($r = 0.523$; $p<0.01$) was found for the mean air temperature in May. Significant but weaker correlation ($r = –0.404$; $p<0.05$) was found also for the mean air temperature in June.

Consequently, more detailed analyses were performed in relation to the mean air temperature in May.

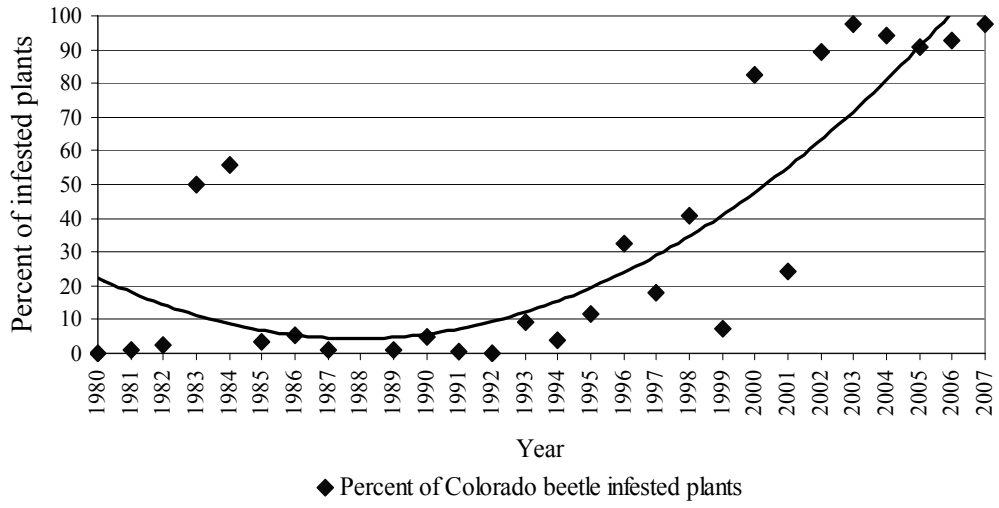

Figure 2. Percent of Colorado potato beetle infested plants Dotnuva, 1980–2007

The trend in the mean air temperature in May during the period 1980–2007 was very low (only 0.018ºC per year) and insignificant, so it was possible to use de-trended data in statistical analyses. The correlation analyses, using a simple linear model, showed a significant relationship between de-trended Colorado potato beetle occurrence and mean air temperature in May ($r = -0.52$, $p<0.01$) for the period 1980–2007 (Figure 3).

Some authors emphasize wintering influence on Colorado potato beetle abundance /Hiiesaar et al., 2006; Valosaari et al., 2008/. Through climatic change and changes in the beetle's winter tolerance, it is possible that the winter survival of the beetle population improves /Knight, Wimshurst, 2005/. Heikkila and Peltola (2006) assume that, in slow change, winter survival increases in 50 years from 30% to about 45%. In rapid change, the change is from 30% to about 60%.

The trend in Colorado potato beetle occurrence in general is in a good agreement with recent changes in Lithuanian climate and especially prevalence of mild winters. During the period 1991–2003 the mean air temperature in winter all over Lithuania was markedly higher than the climate norm calculated from the data of the period 1961–1990 /Galvonaitė et al., 2007/.

The level of the occurrence of Colorado potato beetle in the preceding year was found also to be a very important factor: the correlation between the occurrence of Colorado potato beetle in preceding (x) and current year (y) was highly significant ($r = 0.671$; $p<0.01$), and positive. From this relationship we can assume, that high occurrence of Colorado potato beetle in the preceding year is one of the important preconditions for high occurrence of this beetle.

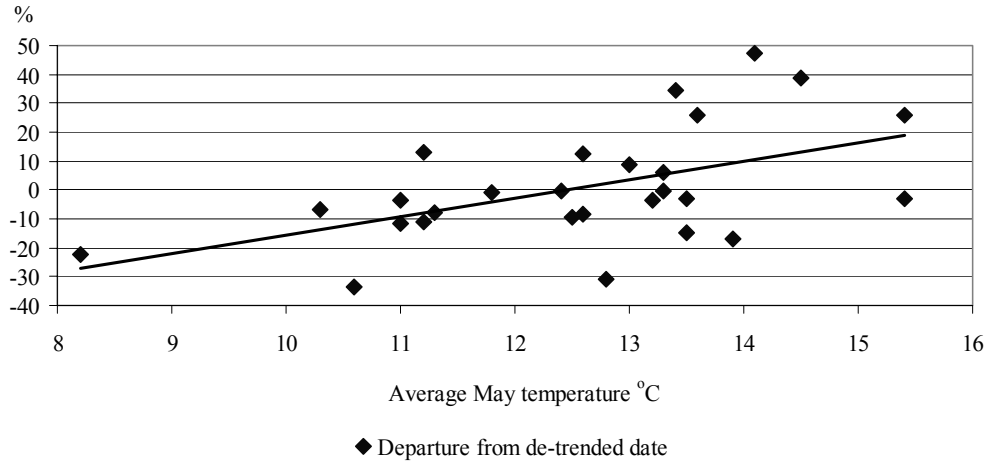

Figure 3. The relationship between de-trended Colorado potato beetle occurrence and average May temperature

Dotnuva 1980–2007

Mild winters, as forecasted by the climate change scenarios, high level of Colorado potato beetle occurrence during the last decade suggest that this pest is likely to be important and harmful in potato crop. The climate change may affect the ability to control pests; therefore new strategies will be required for effective control of Colorado potato beetle which ceases to follow established patterns of behaviour.

Conclusions

A significant increase in the abundance of Colorado potato beetle was recorded during the period 1980–2007, especially over the last decade. The occurrence of pest during 1980–2007 plotted against time presented a relatively smooth non- linear trend.

A significant relationship between de-trended Colorado potato beetle occurrence and the mean air temperature in May ($r = -0.52$, $p<0.01$) for the period 1980–2007 was established using a simple linear model.

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