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TRENDS IN APHID OCCURRENCE IN SPRING BARLEY IN 1976–2007

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Abstract: Recently, considerable attention has been paid to climate change effects on nature and abundance of pests affecting agricultural crops. Our study was focused on the trends in aphid abundance during the growing seasons in spring barley in 1976–2007. Analysis was conducted based on the records of aphid abundance observations and detailed meteorological data.
The first step in the study was to clarify the effects of temperature on aphid occurrence and abundance in spring barley. This part of the study was restricted to Dotnuva site, which is a typical area for commercial crop production, in order to reduce the influence of such effects as management, macroclimate, soil and others.
A distinct and statistically significant increase in the mean air temperature was noted at the experimental site of the Lithuanian Institute of Agriculture in Dotnuva, Kedainiai for the period 1976–2007. A statically significant positive trend was identified for the mean air temperature during April–November. Consequently, during the last decade the occurrence of aphids has also become quite frequent.

Key words: aphids, climate change, spring barley

INTRODUCTION

Climate change and agriculture are interrelated processes. Global warming is supposed to have a significant impact on conditions affecting agriculture. Despite technological advances, such as improved varieties, soil management, and plant protection technologies, weather is still one of the key factors in agricultural productivity. The analysis of climatic fluctuations in Lithuania over the last two centuries revealed that winters

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and springs are gradually warming up, whilst the mean temperatures of summer and autumn remain more or less constant. General climate forecast predicts the growth of mean yearly temperatures in Lithuania by 1.5–1.7°C till the midst of the 21st century (Bukantis 2001; Galvonaite *et al*. 2007). Higher temperatures could increase pressure of pests for agricultural crops. Aphids, due to their short generation time and low developmental temperature threshold, are an insect group expected to respond particularly strongly to environmental changes. (Harrington *et al.* 2007). The authors in their study on the environmental change and phenology of European aphids suggest that in general, the date of first record of aphid species in suction traps is expected to advance, the rate of advance varying with location and species, but averaging 8 days over the next 50 years**.** Scottish scientists indicated that aphids, sap-sucking insects, appear to be particularly responsive to climate change, as scientists are now catching them first on averagee 16 days earlier than at the start of a 34-year period of recording (Chmielevski and Rötzer 2001). Aphids are one of the most common and harmful pests in cereals (especially spring cereals) in Lithuania. *Sitobion avenae* and *Rhopalosiphum padi* are dominating species in cereals. However, in spring barley *R. padi* is predominant (Smatas 2006). Hansen (2007) suggests that probably most aphids fly earlier and in large numbers during the critical periods when crops are especially susceptible to the damage aphids cause. Therefore**,** our study was focused on trends in aphid abundance during the growing season in spring barley during the period 1976–2007. Analysis was conducted based on the data of aphid abundance observations and meteorological data.

The first step in the study was to clarify the effects of temperature on aphid abundance in spring barley. This part of the study was restricted to Dotnuva site, which is a typical area for commercial crop production and in order to reduce the influence of such effects as management, macroclimate, soil and others.

MATERIALS AND METHODS

In order to investigate trends in climatic changes, weather data for the period 1976–2007 were collected from the Dotnuva station of the Lithuanian Hydrometeorological Service. The aphid occurrence in spring barley was observed and the data were collected by the researchers of the Lithuanian Institute of Agriculture and the specialists of the Lithuanian State Plant Protection Service. Assessment of aphid abundance and occurrence in spring barley were started at stem elongation stage (BBCH 31) and were continued until the end of heading stage (BBCH 59). An observation site 600 m^2 in size (50 m x 12 m) was marked in the field. No pest control products were applied in this site. Going diagonally through the observation site, aphids were counted on ten main stems in five places. The assessment was done once a week. For the analysis we used per cent of aphid-infested stems (occurrence) and number of aphids per stem (abundance) during the highest development of aphids in a particular year.

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 experimental period. Long-term mean air temperature was calculated since 1924. Statistically significant positive trend ($p < 0.05$) was identified (Fig. 1).

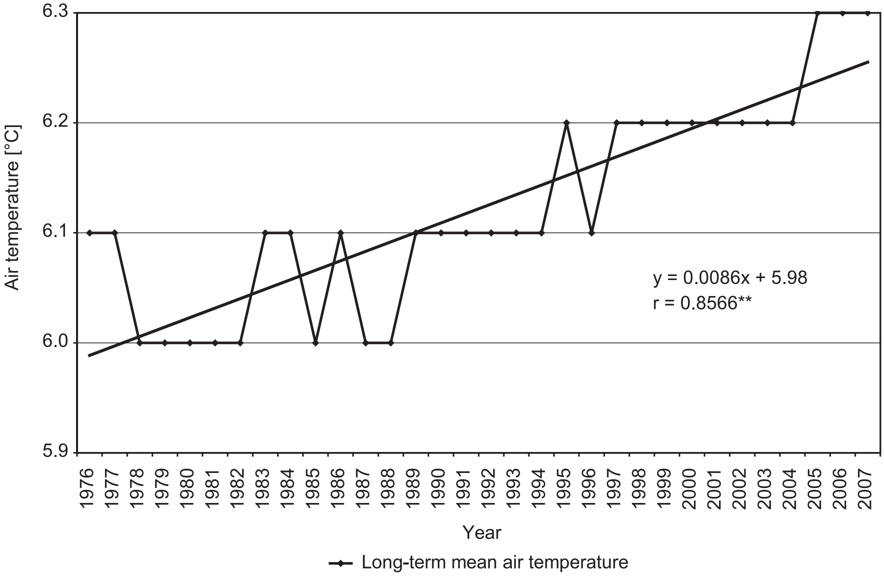

Fig. 1. Trend of long-term air temperatures, Dotnuva 1976–2007

It was noted that the mean air temperature showed a positive significant trend for the period 1976–2007 in the Dotnuva location as well (Fig. 2).

Similarly, a positive increase in mean temperatures was noted during the aphid flying period from April to November during the period 1976–2007 (Fig. 3).

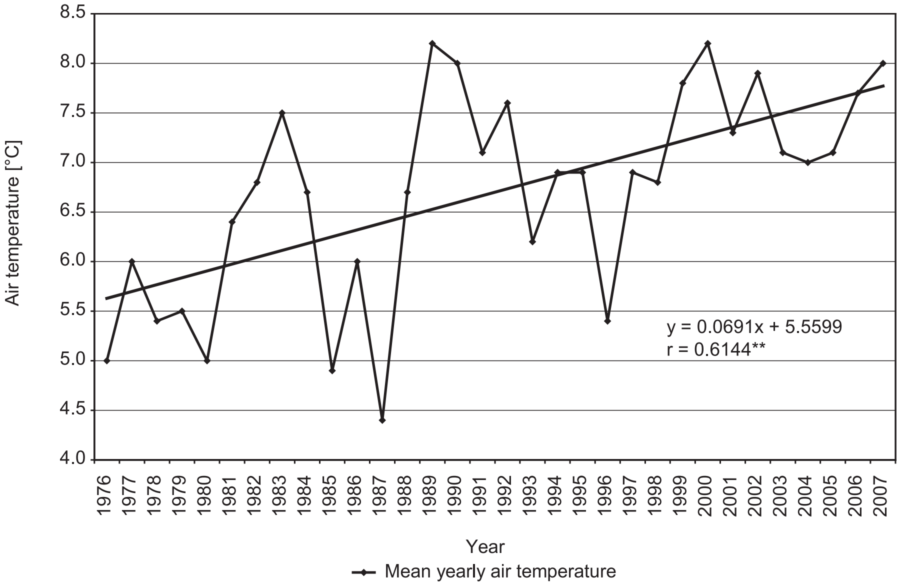

Fig. 2. Trend of mean yearly air temperatures, Dotnuva 1976–2007

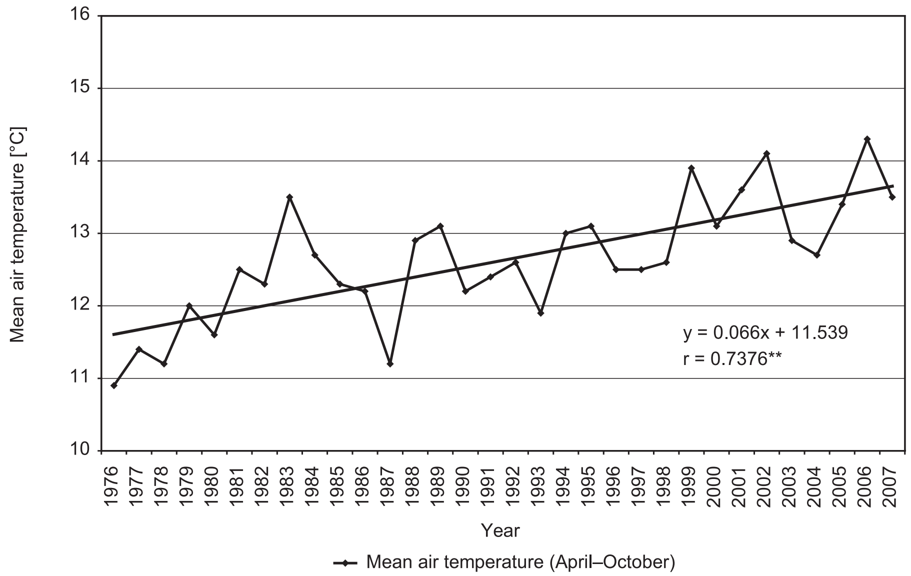

Fig. 3. Trend of mean air temperatures, Dotnuva 1976–2007 (April–October)

The aphid development is highly dependent on air temperature or more specifically on the sum of active temperatures. Cereal aphids reproduce more rapidly when the sum of active temperatures rises, and temperature increases would accelerate the rate of multiplication even further, allowing more generations per season (Honek 1985). During the 1976–2007 sums of accumulated active temperatures were increasing, especially in the last decade (Fig. 4).

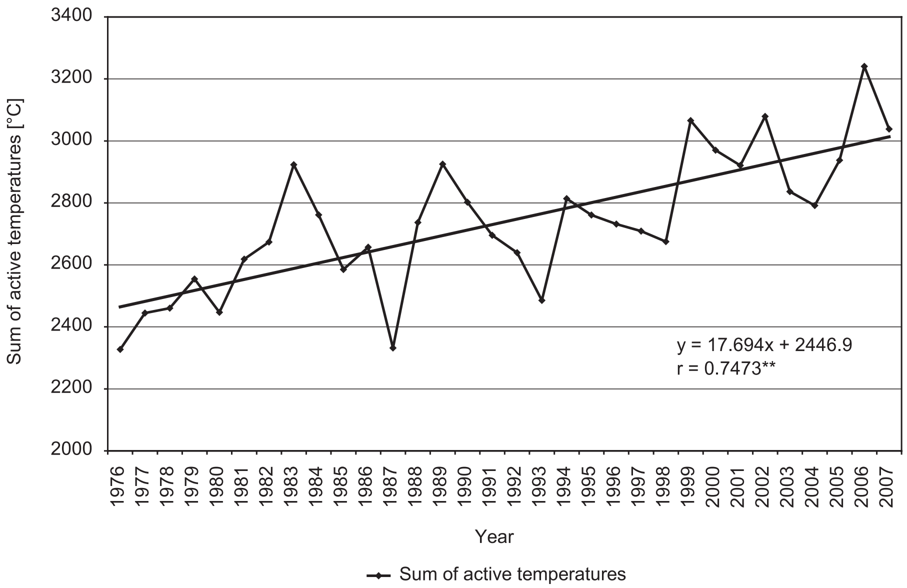

Fig. 4. Trend of sum of active temperatures, Dotnuva 1976–2007

Consequently, during the last decade (1998–2007), the occurrence of aphids has become quite frequent. In Lithuania, recommendation to spray insecticides against aphids in spring barley is suggested when 50 per cent of plants are infested with aphids. Over the period 1976–1996 aphids in spring barley infested over 50 per cent of plants 9 times, while during the last decade – 6 times, of which four times the infestation was as high as 100 per cent (Fig. 5). It is likely that high temperature stimulates the development of winged forms of aphids (Zhou *et al.* 1995). As a result, the per cent of infested stems is higher during a warmer season. It is noteworthy, that over the last decade the increase in aphid populations was more rapid than during the previous decades, because of the warmer and more favourable weather conditions.

The study was designed to evaluate possible trends in aphid development on the regional scale as part of climate change project, therefore fundamental aspects of aphid biology and relationships with specific agrometeorological variables are not covered.

The highest aphid abundance was recorded in 2002 and 2006 when the weather was very warm and dry (Fig. 6). The amount of rainfall during May–July over the period 1976–2007 is shown in Fig. 7.

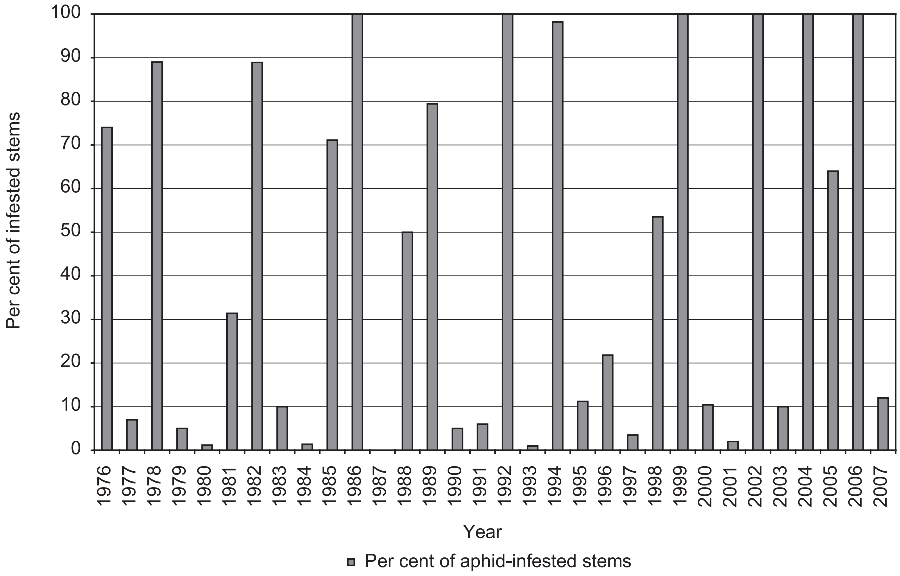

Fig. 5. Per cent of aphid-infested stems in spring barley over the period 1976–2007, Dotnuva

The correlation analyses, using a simple linear model, showed a significant relationship between aphid occurrence and June rainfall ($r = -0.42$, $p < 0.05$) as well as hydrothermal coefficient HTC ($r = -0.43$, $p < 0.05$) for the period 1976–2007. There was no significant correlation with May values of these variables, or with mean May and June temperature. Having used multiple regression between aphid occurrence and May and June rainfall ($R = -0.57$, $p < 0.05$), coefficient of determination increased up to 32%. Air temperature seems to be an important factor for aphid occurrence during the season, however, summing up variables of May and June temperatures increased coefficient of determination up to 33%.

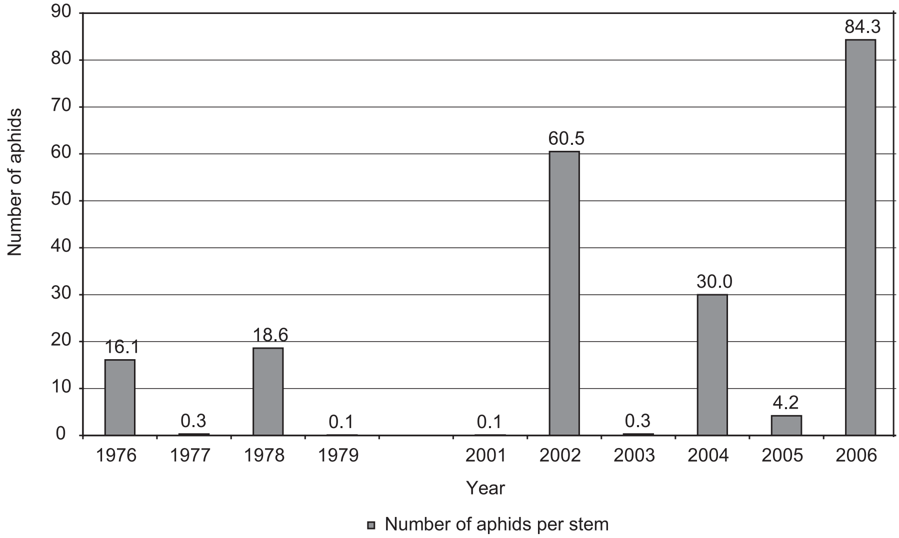

Fig. 6. Abundance of aphids in spring barley during 1976–1979 and 2001–2006, Dotnuva

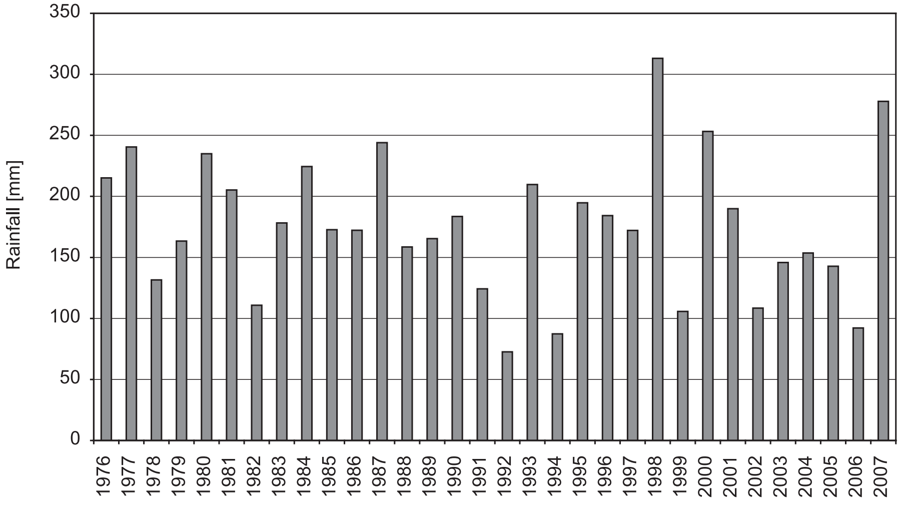

Fig. 7. Precipitation mm (May–July) over the period 1976–2007, Dotnuva

Changes in aphid occurrence in the field as well as agrometeorological variables were much more expressed during the last two decades. During the period 1996–2007 the correlation between aphid occurrence and rainfall was relatively high not only for June ($r = -0.51$, $p < 0.06$), but also for May ($r = -0.54$, $p < 0.05$). Having applied multiple regression between aphid occurrence and May and June rainfall ($R = -0.74$, $p < 0.05$) coefficient of determination increased up to 56% and addition of variables of May and June temperatures – ($R = –0.82$, $p < 0.05$) increased coefficient of determination up to 67%.

The correlation analyses between aphid abundance and agrometeorological variables of May and June performed using the data on aphid number per stem covering the period 1976–2007 (17 years) showed significant correlation only for the June rainfall ($r = –0.53$, $p < 0.05$). Multiple regression between aphid abundance and May and June rainfall ($R = –0.58$, $p < 0.06$) resulted in inappreciable higher coefficient of determination, but addition of May and June temperature variables was inefficient.

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POLISH SUMMARY

TENDENCJE W WYSTĘPOWANIU MSZYC W JĘCZMIENIU JARYM W LATACH 1976−2007

Ostatnio zwraca się znaczną uwagę na wpływ zmian klimatu na rodzaj i liczebność organizmów szkodliwych dla roślin rolniczych. Przeprowadzone badania koncentrowały się na tendencjach w zakresie liczebności mszyc na jęczmieniu jarym w sezonach wegetacyjnych lat 1976–2007. Wykonana analiza uzyskanych wyników uwzględniała ilościowe obserwacje występowania mszyc, jak również szczegółowe dane meteorologiczne.

Pierwszym etapem pracy było wyjaśnienie wpływu temperatury na liczebność występowania mszyc na jęczmieniu jarym. Ta część pracy była ograniczona do lokalizacji w miejscowości Dotnuva, która jest typowa dla produkcji rolniczej i to pozwoliło na ograniczenie wpływu takich czynników jak: zabiegi uprawowe, makroklimat, gleba i inne.

W latach badań (1976–2007) na terenie doświadczalnym Litewskiego Instytutu Rolnictwa w Dotnuva, Kedainiai, stwierdzono wyraźną i istotną statystycznie tendencję wzrostu średniej temperatury powietrza w miesiącach kwiecień–listopad. W konsekwencji, w ostatniej dekadzie, wzrosła także częstotliwość występowania mszyc.