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Potential Infection Pressure of Codling Moth (*Laspeyresia = Cydia pomonella*) as Influenced by Changing Climate in the Conditions of Slovak Republic

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Abstract

Model of Codling Moth seasonal occurrence was proposed on the base of effective air temperature sums *for climatic conditions not influenced by climate change* (*1xCO₂*). Hypothesis was consequently tested in conditions of Slovak republic. The model was applied for prediction of possible infection pressure in condition of climate change (2x CO_2) for different growing areas of Apple trees in Slovakia. Not more then 2 generations of moth were found in lowland areas of Slovakia during years 1961 – 90 and the moth was not found in areas with altitude above 500 m. From 2 to 3 generations of codling moth will probably occur on lowland in condition of climate change and the moth will occur in 1 generation in higher altitudes too.

Key words: codling moth, cydia pomonella, apple tree, climate change, SAU Nitra

Introduction

Theory and practise of plant productive processes in last decades confirm very important influence of weather, which becomes one of the limiting factors of agricultural general and special plant production. This influence will increase in the future. Climatic system of the Earth is consequently affected by increasing of greenhouse effect gases concentration in atmosphere as well as land using changes. Energy and water balance will also changed in dependence on emission scenarios (IPCC, 2001). The aim of fruit growing is high and quality production, following with economy rentability even in climate change conditions. Therefore increasing of work efficiency in fruit orchards, improving of growing shapes, plant breeding of new more pests and disease resistant trees, is only part of problems solved in intensive orchards. There are also nowadays problems, which belong to influence of climate change and its impact on agriculture. Global warming, water safety changes of plants, introduction of new biological species that is only insignificant consequence of expected climate changes, which will influence not only fruit growing. There are some actual climate bases for evaluation of plants productive conditions in relation to climate change partially made within the framework of some another tasks (Šiška, Špánik, Igaz, D., 2005, Šiška, Špánik, Tomlain, 2000), even thought there is still missing spatial elaboration by the help of modern methods. The situation with phenological data is similar. They are also made particularly in some tasks (Šiška, Špánik, 1999, Špánik, Hričovský, Šiška, 2003, Špánik, Šiška, Gálik, 2004), but spatial studies and impact studies of climate change influence on pests and disease occurrence are completely absent. Determination of possible pests and diseases expansion and extension of apple tree in dependence on climate change characteristics becomes very important in consequence of these facts. In contribution we oriented to the most important apple tree pest, which is Codling Moth *(*Laspeyresia = Cydia pomonella*)*. Concerning to insect biology, larva hibernate in cocoons in tree cracks, under dropped bark, in protected areas at the base of tree, eventually shallow in soil, or above ground in plant residues or fruit bins. First pupas could be discovered in the end of April. Adult moths' raid starts in the end of May, with the highlight of raid in June. Highlight of eggs laid can be usually observed in second part of June. Imagas laid eggs on fruit, eventually on leaves of host plants. One female

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moth can lay 40 – 50 eggs. Embryonic growth lasts 7 – 14 days. Hatched larva is boring in to the fruit. After completing development, first larvae exit from fruit in the end of June. Raid of second generation imagas can be expected in the end of July. Fully-grown larvae hibernate. There are usually two pest generations during the year in Slovak Republic (BAYER, 2007). Codling Moth biology cycle was analyzed on the base of average air temperature sum and it was also created hypothesis of pest generations occurrence during the year in conditions 1 x CO_2 and 2 x CO_2 atmosphere in chosen areas of Slovak Republic. The project was supported by grant agency of Slovak republic – VEGA 1/4427/07: Design of new agroclimatic regionalisation of plant production in condition of changing climate in Slovakia and aAV/1109/2004: Climate change and drought in SR. VEGA 1/1313/04.

Material and methods

It was chosen 13 phenological stations for detailed covering of Slovak Republic territory in horizontal and vertical way. The cumulated average air temperature sum of 10 °C was counted for every chosen station for climate normal average 1961 – 1990 (conditions 1 x CO_2 atmosphere) and model average from the years 2061 – 2090 (conditions 1 x CO_2 atmosphere). CO_2 concentration is defined in table 1.

Table 1 CO_2 concentration related to time horizons

CO_2 concentration		Time horizons
$1xCO_2$	330 ppm	1961 – 1990
$2xCO_2$	660 ppm	2061 – 2090

Climate data for task solving in case of conditions 1 x CO_2 atmosphere were obtained from Slovak Hydrometeorological Institute database from Bratislava. Beginning and ending of T≥10, 0 °C was determinate by numerical methodology according to Nosek, (1972).

Climate data from chosen climate stations for conditions $2xCO_2$ atmosphere according to climate change scenarios were made by results of global circulation of atmosphere model CCCM20 (SRES B2) (Melo, 2004) and from adapted outputs obtained within the frame of solving 2004 SP 20/06K 0A 03/ 000 00 10: Climate change and its influence on society progress. According to GIS analysis by the help of interpolating technique (regularising spline with tension and kriging) spatial changes of average values of climate characteristics were counted. The cumulated average air temperature sum needed for individual periods of Codling Moth biological cycle was counted by the help of data from table 2.

Results

The cumulated average air temperature sum needed for first and second generation of observed pest was counted according to table 2. On the basis of active average air temperature it was counted effective TS 10°C for selected phenological stations. By the help with effective average air temperature there were created hypotheses for number of Codling Moth generations in conditions of 1 and 2 x CO_2 atmosphere in the territory of Slovak Republic. The results of hypotheses are summarized in table 3 for climate normal 1961 – 1990, and table 4 for model situation.

There were occurred from 1 to 2 generations of Codling Moth in average during the years 1961 – 90 on selected Slovak localities in lowland areas. The sum of effective average air temperatures needed for 1 generation was not reached in altitudes higher than 500 meters above sea level according to results on experimental stations Hermanovce (519 ALT) and Zázrivá (729 ALT) (table 3). Following the results in next table, infection pressure of Codling Moth could be more intensive in the future, because of average temperatures increasing. Number of potential generations of observed pest is from 2 to 3 in lowlands and in higher altitudes it increase to 1 full generation per year (table 4).

Table 2 Major events in a codling moth management program, based on accumulated degree days (Utah State University, 2006)*

Codling moth (Cydia pomonella) Degree days °C **	% Adults Emerged	% Egg Hatch	Management Event
First generation			
0	0	0	• Reset degree days to 0
10 - 25	5 - 9	0	• Check traps every 1-2 days until biofix is determined • First eggs are laid
40 - 95	15 – 40	0	• Early egg-laying period • Apply insecticides that target early egg-laying period
105 - 120	45 - 50	1 - 3	• Beginning of egg hatch • Apply insecticides that target newly hatched larvae
170 - 340	67 – 98	12 - 80	• Critical period for control, high rate of egg hatch • Important to keep fruit protected during this period
490	100	99	• End of egg hatch for 1st generation
Second generation			
540 - 565	5 - 8	0	• First eggs of 2nd generation are laid • Apply insecticides to target early egg-laying
590	13	1	• Beginning of egg hatch • Apply insecticides that target newly hatched larvae
705 - 940	46 - 93	11 - 71	• Critical period for control, high rate of egg hatch
1150	100	99	• End of egg hatch for 2nd generation

* Table has been transformed in to °C from °F, as it was used in Utah

** Begin accumulating degree days after daily temperatures begin to exceed 10°C

Table 3 Number of Codling Moth generations in dependence on air temperature on selected phenological stations in conditions of *1 x CO_2 atmosphere*

Phenological stations	Altitude	TS 10 °C active	TS 10 °C effective	Number of generations
Dvory nad Zitavou	122	3112,4	1232,4	2
Čachtice	173	2661,2	931,2	1
Bottovo	202	2837,3	1067,3	1
Kuchyňa	206	3017,2	1167,2	2
Moldava nad Bodvou	210	2748,3	938,3	1
Volkovce	231	3048,1	1178,1	2
Klatova Nova Ves	232	2661,2	931,2	1
Adamovské Kochanovce	283	2661,2	931,2	1
Varín	352	2661,2	931,2	1
Gemerská Poloma	357	2748,3	938,3	1
Spisska Nova Ves	458	2389,6	709,6	1
Hermanovce	519	1997,8	447,8	0
Zázrivá	729	1496,6	316,6	0

Table 4 Number of Codling Moth generations in dependence on air temperature on selected phenological stations in conditions of 2 x *CO_2 atmosphere*

Phenological stations	Altitude	TS 10 °C Active	TS 10 °C Effective	Number of generations
Dvory nad Zitavou	*122*	4203,2	1913,2	3
Čachtice	*173*	3675,3	1525,3	2
Bottovo	*202*	3785,7	1615,7	2
Kuchyňa	*206*	4056,0	1796,0	3
Moldava nad Bodvou	*210*	3725,8	1595,8	2
Volkovce	*231*	4095,0	1825,0	3
Klatova Nova Ves	*232*	3675,3	1525,3	2
Adamovské Kochanovce	*283*	3675,3	1525,3	2
Varín	*352*	3675,3	1525,3	2
Gemerská Poloma	*357*	3725,8	1595,8	2
Spisska Nova Ves	*458*	3399,3	1379,3	2
Hermanovce	*519*	2987,2	1087,2	1
Zázrivá	*729*	2278,0	738,0	1

Conclusions

Expected increasing of average annual air temperature, as well as average monthly air temperature during the winter months will cause higher infection pressure of some pests and diseases (low freezing temperatures will not eliminate the pests enough) and also ideal term for bionomic cycle of pests will be extend. In submitted contribution we oriented on apple tree most important pest – Codling Moth *(*Laspeyresia = Cydia pomonella*) and the analysis of its generation life cycle in dependence on air temperature. On the basis of detailed research of climate characteristics influence on pest bionomic cycle development, in consequence of right agricultural engineering and pest protection, it would be Codling Moth infection pressure minimized or keep within accepted limits in the economy point of view.*

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