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INFLUENCE OF CLIMATE CHANGES ON WHEAT VIRUSES VARIABILITY IN UKRAINE

SUMMARY

Climate change is closely related to the level of losses from plant diseases because the environment significantly affects plants, pathogens and their vectors. Monitoring of viral infections in agrocenoses is one of the priority measures to preserve the harvest. However, often symptoms of the adaptive response of plants caused by environmental abiotic factors like the symptoms caused by infectious agents. In this regard, there is a problem to identify the reasons of pathological symptoms on the plants, as some of them are extremely important value for technologies of agricultural crops growing. The aim of work was to investigate the variability of composition of viruses' species infecting winter wheat, to study their prevalence in Ukraine under agro-climatic change conditions. The viral monitoring showed that the winter wheat plants cv. Russia and Smuglyanka with the yellowing symptoms on leaves and "purple-yellow" leaves were infected with BYDV. Unlike previous years, WSMV was not detected in this agrocenosis that can be related to the strong drought in autumn and considerable decline of HTC that resulted in limitation of quantity of WSMV vectors. The symptoms of leaf rolling in barley cv. Antigon, leaf yellowing of wheat cv. Ermak and leaves reddening in wheat Donetska-46 were caused by technogenic influence and other abiotic factors. The analysis of temperature indexes that characterize terms of overwintering and vegetation of winter wheat showed that in May (phase of beginning of plants earing) high plus temperatures during the day changed on low temperatures at night. It is necessary to notice that the reason for appearance of symptoms "purple-yellow" and "purple" leaves of winter wheat are changes of carbohydrate balance that arise up as a result of nonspecific reactions of plants to stress caused by virus infection (cv. Russia) or sharp temperature differential (cv. Vasylyna, Podolyanka, Albatros odessky, Myronivska-67, Smuglyanka).

Keywords: WSMV (Wheat streak mosaic virus), BYDV (Barley yellow dwarf virus), climate changes, temperature difference, HTC (hydrothermal coefficient).

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INTRODUCTION

Climate change is closely related to the level of losses from plant diseases because the environment significantly affects plants, pathogens and their vectors. Changes related to global warming affect the occurrence, prevalence, harmfulness of viral plant diseases and impact on the further co-evolution of plants and their pathogens, leading to changes in species composition of the viruses in a particular region, the emergence of differences in the properties of viruses' isolates and appearance of epiphytoties.

About absolute influence of climate changes on plants, phytopathogens and their vectors, and, especially, about direct dependence between density of insects population on the winter wheat crops and its infection with viruses goes in the many scientific works of the last years (Boland et al., 2004; Bourgeois et al., 2004; Garrett et al., 2006; Pangga et al., 2013; Murphy et al., 2013; Jones 2009; Svensson, 2010). The changes associated with global warming (i.e., increased temperatures, changes in the quantity and pattern of precipitation, increased CO2 and ozone levels, drought, etc.) thus, may affect the incidence and severity of plant disease and influence the further co-evolution of plants and their pathogens.

In connection with the expected increase in the air temperature of the Northern Hemisphere, food security will largely depend on how effectively agriculture adapts to the expected climate change, future agro-climatic conditions for growing crops. Therefore, the problem of evaluating the impact of expected climate change on agro-climatic conditions of cultivation, productivity of various crops is very relevant.

Except abiotic factors crop yields are negatively affected by many biotic factors such as fungal, bacterial, viral infections. So, the damage from viral diseases can be up to 70% of the crop and above (Boyko et al., 2004; Mishchenko, 2009). Timely detection of viruses in crops and accurate diagnosis can reduce the risk of losses in the cereal industry of the country.

There are a little number of recent studies on the influences of factors like CO2, elevated temperature and rainfall-related parameters upon a small number of important viruses, eg, PLRV and Potato yellow vein virus (PYVV) (Jones, 2014), BYDV (Nancarrow et al., 2014; Rua et al., 2013), BYMV (Guerret et al., 2016), CMV,PVY, PVX (Del Torro et al., 2015) TYLCV, and TuMV (Chung et al., 2015), and several important their vectors (Gillespie et al., 2012; Ryalls et al., 2015)

It was noted that during extreme weather conditions the emergence of new viruses that cause epiphytotic episodes is occasionally monitored, diagnosed and identified. However, often the manifestation of the adaptive reaction of the plant to the action of environmental factors is similar to the manifestation of pathologies caused by infectious defeat of the plant organism. In 1999, 2001 and 2006 in Poltava, Ivano-Frankivsk, Kyiv regions, and in Khmelnytsky region (2006), we found winter wheat plants with purple flag leaves, which are similar to the symptoms caused with BYDV. It was found that these symptoms are

caused by both viral infections and extreme weather conditions (a sharp drop in the air temperature in the phase of the output of the tube) (Reshetnyk, 2010). An important diagnostic feature of BYDV is that this pathogen causes different symptoms on different cereal crops: on wheat and barley - yellowing of the leaves, and on oats - reddening of leaves in the upper part. It is known that the process of infecting a plant with a virus is largely due to the genetic properties of both organisms. But a significant effect on the course of such process can be caused by external conditions, in particular, abiotic factors. Both the reproduction and the transport of the virus can be limited by the various protective mechanisms that arise in the plant. Recent studies have shown that the number of primary and secondary metabolites (including sugars that fulfill the cryoprotective role) increases and enzymatic activity of winter wheat plants decreases under cold stress (Gaudet et al., 1999; Olenichenko et al., 2008). In this regard, we put forward two hypotheses regarding the reasons of reddening of winter wheat leaves: ecological and infectious. According to the ecological hypothesis, the appearance of red color is caused by cold stress, which plants have undergone in some phase of vegetation. It is known that an enhanced synthesis of anthocyanins in wheat plants appear under the cold effect which manifests in the color of leaves from green to red. In this connection, there is a problem to identify the reasons of the appearance of such pathological symptoms, since some of them are extremely important for the technology of growing crops.

The aim of work was to investigate the variability of composition of viruses' species infecting winter wheat, to study their prevalence in Ukraine under agro-climatic change conditions.

MATERIAL AND METHODS

Monitoring of viruses was carried out on wheat crops of winter cv. Russia, Vasylyna, Smuglyanka, Ukrainka poltavska, Kolomak, Donska napivkarlykova, Albatros odessky, Perlyna Lisostepy etc. (Poltava region), Ermak (Sumy region), cv. Poliska-90 and barley cv. Antigon (Khmelnitsky region), Podolyanka, Kyivska 8, Myronivska 65, Myronivska 68 (Kyiv region), Donetska-46 (Donetsk region, 2008), Podolyanka (Ivano-Frankivsk region).

Identification of the viruses in sap of wheat and barley leaves was performed by DAS-ELISA. Specific antibody against *Wheat streak mosaic virus, Barley yellow dwarf virus*, *Brome mosaic virus* (BMV), *Wheat dwarf virus* (WDV), *Wheat spindle streak mosaic virus* (WSSMV), *Soil-borne cereal mosaic virus* (SbCMV) (Loewe, Germany) were used. Antigen samples were prepared by grinding of leaf tissue in PBS-buffer pH 7.4 in ratio 1:2 (w/V). Leaf samples from healthy plants were also included as negative controls. Positive controls were commercial (Loewe, Germany). The results were recorded on Termo Labsystems Opsis MR reader (USA) with Dynex Revelation Quicklink software at wavelengths of 405 nm. Samples were considered positive when their absorbance values at 405 nm were at least three times higher those of negative controls (Crowther, 1995).

Purification of BYDV was performed using Hammond et al. method in our modification (Hammond *et al*., 1983), WSMV purification – by Mishchenko method (Mishchenko, 2009).

Viral particles morphology was studied by transmission electron microscopy (TEM). Negative staining of virions was performed with the 2% solution of phosphotungstic acid for 2 minutes and studied by electron microscope JEM 1400 (JEOL, Japan).

Statistical analysis of experimental data was carried out according to the parametric criteria of the normal distribution option, the standard deviation of the mean values - according to the generally accepted method.

RESULTS AND DISCUSSION

A survey of winter wheat plants in a field in Poltava, Kyiv, Sumy, Ivano-Frankivsk and Khmelnytsky regions of Ukraine showed yellowing symptoms, streaking or mosaic patterns, “purple-yellow” and "purple" leaves and spiral twisting of the barley leaves (fig. 1-2).

Plant samples with mentioned symptoms were taken for the study. Plants were tested for the presence of viruses which are most harmful and widespread in these regions by ELISA and TEM methods: *Wheat streak mosaic virus, Barley yellow dwarf virus, Brome mosaic virus* (BMV), *Wheat dwarf virus* (WDV), *Wheat spindle streak mosaic virus* (WSSMV), *Soil-borne cereal mosaic virus* (SbCMV).

None of the viruses taken into the study were detect in barley plants cv. Antigon and wheat cv. Vasylyna and Ermak. As in previous years, the reason of these symptoms could be a significant temperature difference.

The results showed that wheat plants cv. Russia and Smuglyanka were infected with BYDV in 2012 (table 1). Unlike previous years, WSMV was not detected under the conditions of the same agrocenosis of the Poltava region.

Figure 1. Viral symptoms on the leaves of winter wheat plants, Poltava region, 2012: a – yellowing on the leaves of wheat cv. Smuglyanka caused by BYDV, 2012; b – streaking and mosaic patterns on the leaves of wheat cv. Smuglyanka caused by WSMV, 2013; c - “purple-yellow” leaves of winter wheat cv. Russia caused by BYDV, 2012.

Figure 2. Symptoms caused by abiotic factors: a - yellowing symptoms on the leaves of winter wheat plants cv. Ermak, Sumy region; b -"purple leaves" of winter wheat cv. Vasylyna, Poltava region; c - spiral twisting of the barley leaves cv. Antigon, Khmelnytsky region

Table1. Detection of viruses in winter wheat plants

Virus	Positive control	Negative control	Wheat				Barley
			Russia	Smuglyanka	Vasylyna	Ermak	Antigon
BYDV	1,603 ±0,110	0,103 ±0,008	1,443 ±0,01	0,938±0,01	0,179±0,005	0,087± 0,002	0,109 ±0,004
WSMV	2,108 ±0,145	0,100 ±0,007	0,090 ±0,001	0,079±0,003	0,082±0,005	0,102 ±0,004	0,102 ±0,007
SbCMV	1,950 ±0,137	0,088 ±0,003	0,105 ±0,007	0,086±0,005	0,093±0,007	0,045± 0,002	0,075 ±0,002
WDV	1,905 ±0,132	0,102 ±0,003	0,092 ±0,005	0,087±0,003	0,094±0,003	0,076 ±0,002	0,108 ±0,006
BMV	1,987 ±0,142	0,069 ±0,002	0,079 ±0,002	0,087±0,005	0,096±0,003	0,079 ±0,003	0,083 ±0,004
WSSMV	1,756 ±0,100	0,105 ±0,005	0,142 ±0,005	0,109±0,007	0,108±0,003	0,091± 0,001	0,118 ±0,003

Indeed, during the analysis of temperature indicators characterizing the conditions of overwintering and the restoration of the winter wheat vegetation, it was found that in May 2012, in the phase of the beginning of earing plants, high positive temperatures in the day changed at low rates at night. Thus, the temperature difference in the Kyiv region in the first decade of the month was 19.2 °C, in the second - 20 ° C and in the third - 23.9 °C. Similar results we obtained earlier for Khmelnitsky and Poltava regions (Reshetnyk, 2010). It should be noted that significant decrease in temperature were registered on the days of the samples selection in the fields:14 th May – on 5 °C, 25th – on 7.2 °C compared to last day. In addition to temperature changes, a lack of humidity and precipitation in this area during the spring also recorded.

Due to the fact that in 2012 we revealed BYDV and did not detect WSMV, in contrast to the previous year, an analysis of meteorological data was carried out. The results for the period 2011-2012 showed that the average monthly temperature in April-May 2012 was higher than in 2011, which could contribute to the propagation of aphids (vectors of BYDV) (table 2).

As seen from Table 2, the air temperature in February 2012 is much lower. Also average monthly temperature at soil surface and minimum soil temperature on tillering node depth of winter crops in 2012 were significantly lower. Minimum soil temperature on tillering node depth of winter crops and perennial grasses was higher than in 2011. Such agro-climatic factors, to our opinion, could assist elimination of WSMV vector - *Aceria tritici*.

Table 2. Meteorological data for 2011-2012 years, Poltava region

Data	Month	2011	2012
Average air monthly temperature , ºC	December	-1.0	- 3.9
	January	-4.9	- 3.5
	February	-4.5	- 12.4
	March	1.5	0.7
	April	10.5	14.1
	May	18.3	20.7
	June	24.1	22.9
	July	21.8	25.4
Maximum soil freezing depth, cm	December	17.0	20.0
	January	14.5	19.0
	February	26.0	43.0
Average monthly temperature at soil surface, ºC	December	- 1.0	-1.0
	January	-3.5	- 2.5
	February	0.5	- 8.4
Minimum soil temperature on tillering node depth of winter crops and perennial grasses (5 cm), ºC	December	- 1.0	-3.5
	January	-3.5	-3.4
	February	-7.5	-10.0

An interesting phenomenon was noted in 2017 on winter wheat and oats. Our previous studies have shown that the reddening of oat leaves is usually a reaction to BYDV infection because oat is the indicator-plant of BYDV (Mishchenko, 2007, 2009; Mishchenko *et al.*, 2010; Reshetnyk, 2010). In 2017 we found winter wheat cv. Smuglyaka and oat plants with leaves yellowing and reddening respectively under optimal agro-technic growing conditions (Poltava region) and droughty spring and summer beginning. But we did not detect any viruses (first of all BYDV as in 2012) in these plants. Only WSMV was detected in single plants which demonstrated classic WSMV symptoms. So, leaves reddening of oats and yellowing of winter wheat are consequence of a significant temperature difference in May. It was registered that air temperature at the night

was -3 °C (May, 11th) and +20...+22 °C - during the day i.e. temperature difference was over 25 °C. We continue to observe the effect of temperature difference (cold stress) on cereals and vectors of plant viruses.

CONCLUSIONS

Thus, the viral monitoring showed that the winter wheat plants cv. Russia and Smuglyanka with the yellowing symptoms on leaves and "purple-yellow" leaves were infected with BYDV. Unlike previous years, in 2012 WSMV was not detected in this agrocenosis that can be related to the strong drought in autumn and considerable decline of HTC that resulted in limitation of quantity of WSMV vectors. The symptoms of leaf rolling in barley cv. Antigon, leaf yellowing of wheat cv. Ermak and leaves reddening in wheat Donetska-46 were caused by technogenic influence and other abiotic factors. The analysis of temperature indexes that characterize terms of overwintering and vegetation of winter wheat showed that in May (phase of beginning of plants earing) high plus temperatures during the day changed on low temperatures at night. It is necessary to notice that the reason for appearance of symptoms "purple-yellow" and "purple" leaves of winter wheat are changes of carbohydrate balance that arise up as a result of nonspecific reactions of plants to stress caused by virus infection (cv. Russia) or sharp temperature differential (cv. Vasylyna, Podolyanka, Albatros odessky, Myronivska-67, Smuglyanka).

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