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Influence of weather conditions on entomological and phytopathogenic complexes of winter wheat in autumn and spring-summer growth season of the forest-steppe zone

A. Kyrychenko*, N. Havryliuk, L. Kuzmenko, T. Raichuk, Y.Borko

Agriculture Institute of the National Academy, Agrarian Sciences of Ukraine,
National Scientific Center, Kyiv, Ukraine
**Corresponding author E-mail: k.andrey81@ukr.net; Gavrulyuk.71@ukr.net; Klora1996@ukr.net*
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Weather condition changes (air temperature, precipitation) in the autumn and spring-summer periods have been investigated. For 12 years, the long-term seasonal dynamics in the number of the primary blasts and diseases on winter wheat crops have been analyzed, and the features of their development during climate change have been identified. Researches carried out in the forest-steppe zones shows that warming has affected the structure of the entomological and pathogenic complexes. Due to the increase in air temperature, the autumn period became longer, winter wheat, which was sown in late September-early October, has time to grow bushy and take root, and there is not enough heat for harmful objects at that time; therefore, their number is low, or they are absent. Sucking blasts were highly sensitive to climate warming. According to long-term data, the summer growing season of winter wheat is predominantly hot and dry. Such weather conditions led to a violation of the winter wheat phenology, the phases of crop growth accelerated, and the number of sucking blasts decreased.
Keywords: winter wheat, temperature, precipitation, blasts, diseases

Introduction

According to the meteorological service, the average annual air temperature in Ukraine has increased by 0.8 °C towards the climatic norm over the past two decades. The temperature increased most significantly in the summer and winter seasons, which became warmer by 1.3 and 0.9°C, respectively (Adamenko, 2013, Chajka, et al., 2016, Cherenkov, et al., 2014).

Researches of the forest-steppe of Ukraine indicate that warming affected the species composition of the insect communities of winter wheat due to changes in dominance levels, which increased the harmfulness of some plant feeders, in particular: wheat fly (Phorbia), cereal chafer (Anisoplia), sawfly (Tenthredinidae) (Demenko, et al. 2012, Kornijchuk, 2016, Kozak, 2005.

Weather condition changes affect the formation of phytopathogenic complexes in agrocoenosis. Plant diseases are spreading, their pathogens respond positively to the rise of temperature. In the forest-steppe of Ukraine, the number of leaf spots on winter wheat in the last 15 years has increased: pyrenophorosis (tan spot) and septoria, typhulosis, rust diseases, ascochytosis are increasingly common, the spread of smut diseases, root rot, and other diseases grow. In recent years, there has been an increase in rust diseases.

The appearance of aspergillosis on the grain head was seen, which did not appear before; crops are afflicted with thermophilic fusarium such as F moniliform, which produces mycotoxins and contaminates crops. There is a decrease in the number of fungi of winter wheat grain head fusarium pathogens and changes in their species composition. The isolation of the usual pathogens – *Fusarium graminearum* and *F. culmorum* is gradually decreasing, and the dominant place is taken by representatives of the Sporotrichiella – fungi that can grow during dry conditions and synthesize dangerous trichothecene mycotoxins (Parminska, 2019).

Weather condition changes influenced the sowing time of winter crops, including winter wheat, its development during the autumn growing season, and overwintering. This, in turn, affects the phytosanitary state of crops during both the autumn-winter and early spring periods and is the reason for a decrease in crop yields and the death of plants (Vlasenko, 2013).

Thus, the study of the phytopathogenic and entomological complexes formation features in winter wheat crops in the northern forest-steppe zone under climate change conditions is relevant. Our research aimed at the influence of weather conditions in the northern part of the Ukrainian forest-steppe zone on the phytosanitary state of winter wheat crops, particularly on the dynamics of harmful organisms' growth.

Materials and methods

The research was carried out in the stationary department to implement scientific developments of the "Agriculture Institute of the National Academy of Agrarian Sciences of Ukraine" National Scientific Center. Meteorological data (air temperature, precipitation, hydrothermal coefficient (HTC)) of the "Agriculture Institute of the National Academy of Agrarian Sciences of Ukraine" National Scientific Center weather station, Chabany. The results of long-term research of the department of plant protection against blasts and diseases regarding the phytosanitary state were used to accomplish the task. The results of the obtained experimental data were calculated by the method of B. Dospekhov using standard computer programs (Word, Excel). Blasts and diseases were counted according to generally accepted methods of entomological and phytopathological researches. Affection calculation of winter wheat by root rot, leaf diseases, and grain head diseases was carried out in the phases of autumn and spring tillering, heading, and yellowing according to the improved All-Russian Institute of Plant Protection scale. To determine the species composition of insects in winter wheat crops, route surveys, mowing with an entomologic net, and analysis of plants by plant organogenesis stages were carried out.

Results

The analysis of weather and climatic conditions in the research area in the 2006-2016 autumn period and the 2008-2018 spring-summer period, as well as the analysis of the long-term seasonal dynamics of the primary blasts and diseases number on winter wheat crops and the features of their distribution during climate change was carried out.

1. Weather conditions in the autumn and their influence on the increase and spread of harmful organisms.

According to long-term data, the absence of rain in autumn is accompanied by warm, even hot weather. The air temperature in August over the past decade has increased by 0.5-5.1°C. The maximum temperature was noted in 2010; the air temperature reached on average almost 24°C per month. Only in 2013, 2011, and 2009 were the temperatures 0.60, 0.80, and 0.90 higher, respectively. August was dry and hot in almost all years. In the driest 2015, the monthly precipitation did not exceed 8 mm (14% of the monthly norm). Also dry were 2009 and 2014; the amount of precipitation for the month was 12 mm and 18.6 mm, with a norm of 69 mm. In other years, the moisture deficit was 0.8-46 mm. Only in August 2012, 71.8 mm of precipitation fell, which is 2.8 mm higher than the normal amount. The average September temperature in almost all years exceeded the norm by 0.6-3.9°C, and only in 2013 was it lower by 0.8°C. September was the driest in 2009, 2012, 2015-2016; there was very little precipitation – 11.3 mm, 8.4 mm, 18.2 mm, and 3.8 mm (9-28% of the monthly norm), respectively. Only September 2008 was wet; the amount of precipitation for the month was 129 mm, which is almost three times higher than the norm. September 2013 was abnormally humid for the entire period of meteorological observations. The monthly amount of precipitation was 4.5 times higher than the climatic norm; 213 mm of precipitation fell, which amounted to 475% of the monthly norm.

In almost all years of research, October was 1.8-2.3°C warmer than the norm. Only in 2014 in terms of air temperature was close to normal and it was 8.2°C. In 2010-2011, 2015-2016, the average monthly temperature in October was lower by 0.4-2.1°C. In terms of precipitation, 2008, 2013, and 2014 were drier; their amount was two to three times lower than the norm and amounted to 17.6 mm, 13.8 mm, and 3.0 mm, respectively. 2011 and 2016 were the wettest; their amount was 74 mm and 94.5 mm, respectively, which is 2-2.5 times more than the norm. The temperature in November was warmer by 1.3-0.6°C, compared to October. According to the amount of precipitation, dry or very wet. It was abnormally warm in November 2010 – the average monthly air temperature exceeded the norm by almost 6°C. The autumn months of 2006, 2008-2009, 2012-2013, and 2015 were also warmer than the norm by 1.8-4.3°C. Only in 2007, 2014, and 2016, the air temperature was below normal by 0.3-1.1°C. Waterlogging by 1.5-2 times occurred in 2007, 2010, and 2015; the amount of precipitation was 90.9 mm, 72 mm, and 70.6 mm, respectively. Moisture deficit was noted in 2011 and 2014, the amount of precipitation was 1.9 mm and 12.1 mm with a norm of 51 mm. In other years of research – 2006, 2008-2009, 2012-2013, and 2016 precipitation was less than average.

Over the past decade, there have been changes in the life of certain types of blasts and diseases, which are primarily associated with climate change. Climate changes affect the dynamics of the number of insects, the intensity of feeding, and the life cycle of insects. According to the results of long-term monitoring in the northern forest-steppe zone, common plant feeders in the autumn period were corn flies (Chloropidae), leafhoppers (Cicadelidae), and aphids (Homoptera). In some years (2006-2008 and 2011-2012), under favorable weather conditions, the number of blasts approached the EHT (Economic Harmfulness Threshold); in other years (2009-2010 and 2013-2014), blasts were few or absent (2015-2016). This was primarily due to the weather conditions of the year. Warm and dry weather in September and early October in 2006-2008 and 2011-2012 contributed to the spread of blasts on winter wheat. The air temperature in these years at the beginning of October was 2.5°C higher and amounted to 13.1-13.5°C. The number of blasts in the tillering phase reached EHT and amounted to corn flies – 30-40 ind./100 net moves, striped leafhoppers – 65-160 ind./m2, grain aphids – 100-226 ind./m2. In 2006 and 2011, the number of corn flies was also relatively high – 18-22 ind./100 net moves. This was facilitated by weather conditions in the autumn period – long and warm weather extended the growing season of winter wheat and the spread of plant feeders.

In 2009, 2014-2016, due to the lack of moisture in the soil or waterlogging in 2013, sowing was carried out in late September - early October. As a result of late sowing, the abundance of the before mentioned plant feeders was significantly lower than EHT, or they were absent.

According to the monitoring results, the phytopathogenic complex included the pathogens of powdery mildew (*Erysiphe graminis*), Septoria leaf blotch (*Septoria tritici*) and root rot (*Fusarium* sp., *Bipolaris sorokiniana* Shoem., *Cercosporella herpotrichoides*). In 2012, warm and lingering autumn contributed to the overgrowth of plants and their diseases. The number of diseases exceeded EHT and amounted to powdery mildew – 20.5%, Septoria leaf blotch – 9.5%, root rot – 8.3%.

Abnormally warm weather in November 2010 contributed to the fast development of the diseases mentioned above – up to 10.2%, 7.1%, and 9.1%. Weak or moderate spread of diseases was also observed in 2006-2008, 2011, and 2013-2014: powdery mildew – 0.4-5.6%, Septoria leaf blotch – 0.4-1.0%, root rot – 0.7-1.7%. In 2014-2015, due to the late sowing of winter wheat (late September) and dry conditions, diseases were practically absent. Thus, because of climate change, the autumn vegetation is extended due to an increase in temperature, which leads to the colonization of crops by blasts and damage to plants by pathogens. In autumn, diseases of winter wheat led to the weakening of plants during overwintering, infection with Fusarium mold, and loss in the early spring growing season. Due to a lack of moisture and waterlogging, the sowing time for winter wheat in the northern part of the forest-steppe zone has shifted by 7-10 days towards later dates. Thanks to the late sowing (late September - early October), the phytosanitary state of winter wheat crops is better; there is not enough heat for harmful objects, so their number is low, or they are absent.

2. Weather conditions in the spring-summer period and their impact on the spread of blasts in the northern forest-steppe zone

Following the long-term average indicators, April was 2.1°C warmer than the norm. In some years (2011 and 2015), temperature indicators almost corresponded to long-term ones. In 2016 and 2017, the air temperature turned out to be 3.9 and 4.6°C higher than the long-term indicators. Significant precipitation took place only in 2008; their amount exceeded the norm by 2.6 times (HTC 4.7). Precipitation above the norm was observed in 2012 and 2016; their amount exceeded 1.2 and 1.1 times (HTC 5.2 and 1.9), respectively. April 2009 was very dry, almost without precipitation; the amount of precipitation was 0.8 mm (HTC 0.1), in 2015 and 2018 – 5.6 mm (11% of the norm, HTC 0.6 and 0.1, respectively). An increased air temperature of 1.4°C marked the weather conditions in May. The average monthly air temperature in 2008 was 0.5°C lower than the norm and, in absolute determination, was 14.6°C. In 2009, 2016-2017, the air temperature indicators almost corresponded to the long-term average. 2013 and 2018 turned out to be hot with a meager amount of precipitation (2-3 times lower than the norm), the air temperature exceeded the norm by 4-4.5°C (HTC 0.5, 0.3), the sum of active temperatures above 100°C was 595-599 respectively. In May 2014, there were heavy rains, 167 mm (321.2% of the norm), which contributed to the inclination of plants to the ground and the progression of diseases; the air temperature exceeded the average monthly by 2°C (HTC 3.3).

The air temperature in June in all years exceeded the norm and, on average, for the years of research, amounted to 20.2°C, which is 2.2°C above the norm. Only in 2014 and 2017, these indicators were close to the norm. June 2015 and 2017 were dry; the monthly norm in these years did not exceed 9.8 mm (13.4% of the norm). The hydrothermal coefficient in these years was only 0.2, and the sum of active temperatures above 10°C reached 619-589°C, respectively. Precipitation in 2011-2012 and 2018 exceeded the norm by 1.5-1.6 times (HTC 2.2, 2.1, 1.8). In July, an increase in air temperature was observed annually from 2008 to 2018. The average monthly temperature for the years of research was 2.7°C above the norm, and in absolute determination was 220°C. In some years (2010 and 2012), this indicator was 5.2, and 4.2°C from the norm and in absolute determination was 24.2, and 23.5°C, the sum of active temperatures above 100°C reached 751 and 728 C, respectively. Heavy rains fell in 2011; their amount was 124.2 mm, which is 1.4 times higher than the norm. This led to waterlogging of the soil and created conditions for the inclination of plants to the ground, and the progression of diseases and grain germination began. The amount of precipitation in 2008, 2010, and 2018 was almost the same as for many years. 2013 turned out to be dry; precipitation was insignificant, the amount was 10 mm (11.4% of the norm).

Thus, the climatic features of the growing season of the last decade were characterized by an increase in temperatures and a deficit of precipitation compared with the long-term average indicators. The spring-summer growth season (April-July) was distinguished by higher temperatures in April (by 2.1 °C), May (by 1.4 °C), June (by 2.2 °C), and July (by 2.7 °C). In terms of precipitation, the growing season was dry, and in some years, it was contrasting. According to the results of HTC, June was excessively wet only in 2011, 2012, and 2018 (2.2, 2.1, and 1.8) and July 2018 (HTC 2.0). June was wet only in 2008 (HTC 1.1) and July in 2008 and 2018 (HTC 1.5 and 1.3). In other years, these months were dry (HTC 0.2-0.9).

Such weather conditions influenced the phytosanitary state of winter wheat crops. According to the monitoring results during the 2008-2018 spring-summer growth season, among the primary blasts of the northern forest-steppe zone, a complex of sucking insects is represented by wheat thrips (Haplothrips tritici Kurd.), grain aphids – large grain aphid (*Sitobion avenat* F.,) and wheat aphid (*Rhopalosiphum padi* L.) and capsid grain bugs – corn-bug (*Eurygaster integriceps* Put.) and *Aellia rostrata* (*Aellia rostrata* Boh.). Also, cereal chafers were encountered annually, such as Anisoplia austriaca beetle (*Anisoplia austriaca* Hrbst.), Anisoplia segetum beetle (*Anisoplia segetum* Hrbst.), and grain sawflies – *Cephus pygmaeus* L. and *Trachelus tabidus* F. In some years, the number of blasts was low, under favorable weather conditions it approached or exceeded the EHT.

Wheat thrips are the most widespread and numerous on winter wheat in the northern forest-steppe zone. During the researches, the mass appearance of thrips grub is noted in the phase of milky grain ripeness. The number of plant feeders varied over the years of research from 5.5 to 32 ind./head. The rate of breeding and the harmfulness of plant feeders primarily depended on the year's weather conditions. The highest number of wheat thrips was in 2011-201 – 26.5-32 ind./head; this was facilitated by dry and warm weather (HTC of the 2nd decade of June – 0.2-1.0). Excessive moisture in the form of heavy rains in 2008 and 2018 (HTC 1.6 and 1.2) did not contribute to the development of wheat thrips, so the number was 2-4 times lower than 5.5-6 ind./head. Our research has confirmed that the breeding of wheat thrips grubs was facilitated by warm and dry weather (HTC of the 2nd decade of June – 0.2-1.0). Excessive moisture in the form of heavy rains restrains the number of blasts. In 2010, 2014-2018, hot and dry weather accelerated the ripening of wheat, which shortened the feeding period of the plant feeders; therefore, its number in these years is low. The long-term dynamics of the number of grain aphids ranged from 2 to 25 ind./head. Good conditions for developing aphids were formed in 2011-2012 when their number reached 18-25 ind./head. This was facilitated in June by moderately warm weather with precipitation (HTC 2.1-2.2). In other years, the number of plant feeders was significantly lower than EHT – 2-12.6 ind./head. The high temperature of 25-300C and low air humidity restrained the colonization of crops by aphids due to premature ripening of plants and drying out of the green matter. The time of the mass laying of the sawfly eggs fell on the winter wheat heading phase. The weather conditions of 2010-2011 and 2016 contributed to developing the sawfly (3.5-4.5% of the populated footstalks), HTC – 1.2, 2. Heavy rains in May-early June 2014 did not contribute to the colonization of crops with plant feeders 0.2%, HTC – 3.3. In 2008-2009, 2012-2013, 2015, 2017-2018, due to high temperatures and lack of moisture (HTC – 0.3-0.4), the percentage of populated footstalks was significantly lower than the EHT 0.5-1.5%.

According to the results of many years of research, the percentage of the Anisoplia segetum beetle among cereal chafers increased compared to the Anisoplia austriaca beetle in winter wheat crops. However, in June, when the crops were colonized, the Anisoplia austriaca beetle remained the predominant species. A large number of the blast was noted in 2010-2012 and 2014-2016, where HTC>1. Mass development of cereal chafers occurred after sufficient precipitation during the development of eggs and grub. Summer drought limited blast breeding. Fluctuations in the number distinguished the long-term dynamics of the number of the corn-bug in the northern forest-steppe zone from 0.5 to 3 ind./m2. In 2009, 2013, 2017, and 2018, the number of plant feeders was higher – from 2 to 3 specimens, HTC<1. In subsequent years, in the phase of grain filling – milk ripeness, the number significantly decreased – 0.5-1.5 ind./m2. The corn bug is adapted to dry, hot weather. Simultaneously, such weather conditions influenced the accelerated development of winter wheat and earlier harvesting periods, so the bug population did not have time to feed, which reduced the overall survival of the blast during wintering.

In the northern part of the forest-steppe zone, the most common diseases of winter wheat during the spring-summer growth season were: powdery mildew (*Erysiphe graminis* pathogen), Septoria leaf blotch (*Septoria tritici*), Fusarium head blight (*Fusarium* sp), Septoria blight (*Septoria nodorum*), and root rot (*Fusarium* sp., *Bipolaris sorokiniana* Shoem., and *Cercosporella herpotrichoides*).

2009 and 2011 were dry, almost without precipitation. This did not contribute to the development of plant diseases. The development of diseases did not exceed EHT and amounted to: powdery mildew – 14.0% (in 2009) and 15.0% (in 2011), Septoria leaf blotch – 5.0% (in 2009) and 4.0% (in 2011), Fusarium head blight – 2.3% (in 2009) and 2.8% (in 2011), root rot – 17.5% (in 2009) and 13.0% (in 2011). Heavy rains and high air humidity (100%) in June 2012 contributed to the infection of the winter wheat head by leaf mold, which reached a maximum of 68% (HTC 2.1). The rains in 2018 (air humidity 30%) also contributed to developing the disease (HTC 1.8). Warm and rainy weather in May 2014 (HTC 3.3) was highly favorable to the development of powdery mildew (30%) and Septoria leaf blotch (25%); the prevalence of diseases reached 100%. Such weather conditions during the flowering of winter wheat contributed to the infection of the grain head with Fusarium head blight, the development of the disease – 27%, the prevalence – 60%. There was a severe infection of the grain head with Septoria leaf blotch – 40%, with the prevalence of 10-90%, and root rot – 23%.

The infection of plants by diseases was also observed in 2008, 2012-2018, with a strong development, which was at the level or exceeded the EHT 2 times: powdery mildew – 30-45%, Septoria leaf blotch – 18-42%, Septoria blight –10-35%, root rot – 3.2-15%. Thus, dry years, with almost no rains, do not contribute to plant diseases' development. Heavy rains create conditions for the inclination of plants to the ground and the development of diseases. An increase in air temperature in April-May with a sufficient amount of precipitation leads to plants diseases' development – powdery mildew and Septoria leaf blotch. In some years, moisture and warm weather in June-early July contribute to Septoria, Fusarium, and leaf mold. Root rot, which infects wheat annually, deserves special attention in the northern forest-steppe zone. The root rot spreads due to primary sources of infection in seeds, soil, and plant fragments. The intensity of the disease development and its harmfulness is promoted by soil moisture and temperature, seed condensation and treatment, selection of predecessors, and other agrotechnical measures.

Conclusion

With an increase in the temperature conditions in the forest-steppe zone, the growth season of winter wheat in the autumn period was lengthened, which lead to a more extended period of crop colonization by blasts and damage to plants of early crops by pathogens. When the number of plant feeders reached EHT, in case of further unfavorable weather conditions for the development of blasts, chemical treatment should be postponed until the onset of a period with conditions close to favorable. To protect winter wheat during the autumn growth season against diseases, the spraying should be carried out in the presence of the first signs of plant disease infestation under favorable weather conditions (sufficient heat and moisture).

According to long-term data, the summer growing season of winter wheat is primarily hot and dry; in some years, it is contrasting concerning precipitation.

An increase in the average air temperature and a shortage of precipitation in the summer months led to a violation of the winter wheat development phenology (accelerated development of the crop during the flowering period, milky and milky-wax ripeness, and earlier harvesting periods). Such weather conditions affected the phytosanitary state of winter wheat crops. Sucking blasts have shown greater sensitivity to climate warming over the past decade. Wheat thrips, grain aphids, and capsid grain bugs appear on crops every year, but their numbers have decreased significantly in the phase of mass reproduction. The dry weather conditions of the growing season of winter wheat lead to a reduction in the development period of sucking blasts and activity.

The phytosanitary situation in the northern forest-steppe zone with winter wheat crops under warming conditions contributed to a decrease in the number of main plant feeders in the autumn and spring-summer periods. However, as long-term observations have shown, this indicator is not stable. Under favorable conditions, each of the harmful objects can pose a threat to crops; therefore, the relevance of entomological and phytopathological monitoring for making decisions on plant protection and determining the feasibility of using protective equipment increases.

References

Adamenko, T.I (2015). Pogodni umovy vegetacijnogo periodu ta yix vplyv na urozhaj zerna. Agronom, 3, 14-17. [in Ukrainian].

Adamenko, T.I. (2014). Agroklimatychne zonuvannya terytoriyi Ukrayiny z vraxuvannyam zminy klimatu. Kyiv [in Ukrainian].

Chajka, V.M., Neverovska, T.M., Gavej, I.V. (2016). Dynamika shkidlyvosti komax-fitofagiv pshenyci ozymoyi u Lisostepu Ukrayiny v umovax zminy klimatu. Naukovyj visnyk Nacionalnogo universytetu bioresursiv i pryrodokorystuvannya Ukrayiny. Agronomiya, 235, 267-275. [in Ukrainian].

Cherenkov, A.V., Solodushko, M.M., Solodushko, V.P. (2014). Vplyv klimatychnyx zmin na stroky sivby pshenyci ozymoyi v umovax pivnichnogo Stepu. Agronom, 3, 80-84. [in Ukrainian].

Demenko, V.S., Vlasenko, O.M., Yemecz, V.M., Sarbash. (2012) Obgruntvannya chyselnosti osnovnyx shkidnykiv zernovyx kultur v umovax pivnichno-sxidnogo Lisostepu Ukrayiny. Visnyk Sumskogo nacionalnogo agrarnogo universytetu: seriya Agronomiya i biologiya, 9 (24), 14-18. [in Ukrainian].

Kornijchuk, M.S. (2016). Napryamy pokrashhennya fitosanitarnogo stanu gruntiv i posiviv silskogospodarskyx kultur. Shlyaxy pidvyshhennya efektyvnosti vykorystannya zemli v suchasnyx umovax. Kyiv. VP Edelvejs.

Kozak, G.P. (2005). Shkidlyvyj entomokompleks ozymoyi pshenyci v Lisostepu Ukrayiny v umovax zminy klimatu. Zemlerobstvo, 77, 65-72. [in Ukrainian].

Parminska, L.M., Gavrylyuk, N.M. (2019). Vplyv pogodnyx umov v osinnij period na rozvytok osnovnyx shkidnykiv ta xvorob agrocenozu pshenyci ozymoyi u zoni Lisostepu. Karantyn i zaxyst roslyn, 1-2, 10-14. [in Ukrainian].

Trybel, S.O., Syadrysta, O.B. (2002) Pogoda i fitosanitarnyj stan agrocenoziv. Karantyn i zaxyst roslyn. Kiyv. Kolobig, 7, 1.

Vlasenko, V.A. (2013). Zminy klimatu ta chyselnist osnovnyx shkidnykiv zernovyx kultur v umovax pivnichno-sxidnogo Lisostepu Ukrayiny. Posibnyk ukrayinskogo xliboroba. Part 4. Agroekologiya, 180-182. [in Ukrainian].

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