Scientific Papers. Series A. Agronomy, Vol. LXIII, No. 1, 2020
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

EFFECT OF HUMIDITY AND TEMPERATURE ON THE INCIDENCE OF ATTACK OF *Zymoseptoria tritici* IN WHEAT

Andrei-Mihai GAFENCU, Andreea-Mihaela FLOREA, Florin-Daniel LIPȘA, Eugen ULEA

"Ion Ionescu de la Brad" University of Agricultural Sciences and Veterinary Medicine of Iasi,
3 Mihail Sadoveanu Alley, 700490, Iasi, Romania

Corresponding author email: agafencu@uaiasi.ro

Abstract

Septoria tritici blotch, caused by Zymoseptoria tritici, is a major disease of wheat in many areas of the world. Optimal conditions for development of Zymoseptoria tritici take place during April and May. High risk of Septoria tritici blotch disease periods are defined as days with at least 10 mm rain, or else up to three consecutive days with 10 mm or more rain. The research was conducted during 2015-2019 (four agricultural years). The climatic conditions specific for these interval of time made it to be present in wheat fields Zymoseptoria tritici which causes Septoria tritici blotch disease of wheat. The aim of this paper is to describe the behaviour of eleven Romanian winter wheat varieties (Glosa, Izvor, Miranda FDL, Otilia, Pajura, Pitar, Semnal, Ursita, Andrada, Codru and Bezostaia 1) under natural infection conditions with Zymoseptoria tritici.

Key words: *winter wheat, Zymoseptoria tritici, diseases, weather conditions.*

INTRODUCTION

The filamentous fungus *Zymoseptoria tritici* infects wheat plants and causes the disease known as *Septoria tritici* blotch. Because of its negative impact on crop management and yield *Septoria tritici* blotch is considered, nowadays, the major diseases of wheat (Greiner et al., 2019; Arraiano et al., 2001). Until 1960s, economically significant losses caused by this disease were occasionally reported (Eyal et al., 1987) but from the 1980s *Zymoseptoria tritici* becomes an extremely important disease, being reported all over the world (Eyal, 1999; Halama, 1996), causing yield losses ranched between 10% and 50%, depending on the region and the pressure with which the disease manifests during the vegetation period (Heick et al., 2017). This situation was favoured by the replacement of the local wheat varieties with semi-dwarf cultivars, with early maturation which proved to be susceptible to this disease (Muckle, 2013; Eyal, 1987). Besides this, the intensification of the agriculture of that period, the application of high doses of synthetic fertilizers and, very important, the climatic conditions favourable to the development of the disease, represented by high precipitation and low temperatures (Eyal, 1999; Lovell et al., 1997) made *Septoria tritici* blotch the most popular foliar disease of wheat with the greatest negative economic impact. Yield losses caused by this disease have large limits, from 10-20% when the infection pressure is moderate, reaching severe losses, up to 60% in the years when the pathogen produces epidemics (Fones et al., 2015; Torriani et al., 2015; Goodwin et al., 2004).

Even if beneficial measures are taken to control the disease, such as cultivation of resistant varieties and application of fungicides, yield losses of about 5-10% are frequently recorded (Fones et al., 2015). The production losses are mainly due to the reduction of the size and weight of wheat kernels and their number on spike (Shipton et al., 1971).

Zymoseptoria tritici is considered the most economically important fungal disease in Europe and the second, after black rust, in the United States of America (Ponomarenko et al., 2011; Palomar, 2014), the production losses are estimated to be around \$400 million in Europe and \$275 million in the USA.

Being a such important disease, in Europe, of \$2.4 billion, as it represents the market for fungicides used for cereals, \$1.7 billion represents fungicides applied to wheat cultivation, and of this value about 70% (\$1.2

billion) represents the value of the fungicides aimed at the management of the pathogen *Zymoseptoria tritici* (Torriani et al., 2015).

MATERIALS AND METHODS

To know the effect that the climatic conditions, represented by the air temperature and humidity, have on the development of the *Zymoseptoria tritici* and on the infection pressure of this pathogen on the wheat plants, in the period 2015-2019, within the Didactic Station Iasi - Ezareni Farm, a research was carried out that that aimed at the analysis of eleven Romanian wheat varieties. The experience was placed in the experimental field of the Iasi Didactic Station, the Ezareni Farm, being organized according to the randomized block diagram, in three replicates, each wheat cultivar representing an experimental variant.

The crop technology applied in the experimental field was classical technology. Soil tillage consisted of the ploughing and the preparation of seedbed, the fertilization was realized by applying moderate doses of fertilizers to the preparation of the seedbed and in the spring. Regarding the protection of wheat crop, it should be noted that no phytosanitary treatments were applied, which is why the studied cultivars were analysed in terms of their behaviour of winter wheat cultivars under natural conditions of infection with the pathogens.

The observations made to identify the presence of pathogens were conducted between March-June each year. In order to determine Frequency (F%), Intensity (I%) and to calculate the Degree of Attack (DA%), were made observations with metric frame (50 x 50 cm) in each variant. The genotype reaction was estimated by F.A.O. scale rate, with 9 attack classes in which, 1 = very resistant; 9 = very sensitive (Roelfs et al., 1992; FAO, 2016).

For a real and objective estimation of the intensity of the attack (I%) of the identified pathogens, guides and scientific papers were studied, of which the most useful ones were published by Muhammad et al., 2017; Manandhar et al., 2016; FAO, 2016.

Data regarding air temperature, atmospheric precipitation, relative humidity for the studied period (2015-2019) were obtained from the Meteorological Station 000019B located on the territory of the Ezareni Farm - where the observations of the present study were made - through the site www.fieldclimate.com.

Data on the multiannual values of air temperature, precipitation and relative humidity, as well as other climate information, were obtained considering studies published by the National Meteorological Administration (www.meteoromania.ro) and the National Institute of Statistics (www.insse.ro).

The data obtained during the four years of observations were statistically interpreted using the SPSS program (IBM SPSS Statiscs 20), and the graphical representation was performed using the Excel program within the Microsoft Office 2016 package.

RESULTS AND DISCUSSIONS

Based on the economic importance of *Septoria tritici* blotch disease, a series of studies have been carried out to understand the effects of the weather on the incidence of the pathogen's attack. Some of the risk factors have been identified and described (e.g. air temperature, precipitation, air relative humidity), with varying degrees of validation (O'Driscoll et al., 2014; Fones et al, 2015; Simon et al., 2002; Gladders et al., 2001; Thomas et al., 1989).

Analysis of *Septoria tritici* blotch disease development under weather conditions records show that optimal conditions for development of *Zymoseptoria tritici* take place during April and May. High risk of *Septoria tritici* blotch disease periods are defined as days with at least 10 mm rain, or else up to three consecutive days with 10 mm or more rain (Gladders et al., 2001; Thomas et al., 1989).

Considering that the research was performed under field conditions, the results were influenced by weather. Table 1 presents the air temperatures, rainfall and relative humidity registered between 2015-2019 at Ezareni Farm - Iasi Didactic Station during the vegetation period of wheat. The weather data recorded were carefully analysed (Table 1).

During the research period the average monthly air temperature showed some differences compared to the multiannual value of temperature, the most obvious differences were noted at the level of 2018, when the deviations from the multiannual monthly average were significant. The biggest difference was observed in April 2018, when the monthly air temperature was with 5.2°C higher compared to the multiannual average of air temperature. Also, the next two months (May and June), when the wheat crop is in the phenophase of intense growth, the monthly air temperatures were higher than the multiannual average. For the other years, March was the month in which the temperatures shown the most obvious differences from the multiannual average.

Table 1. Climatic conditions at Ezareni Farm - Iasi Didactic Station, during 2016-2019

Month		March	April	May	June	July
Air Temperature (^{0}C)						
Multiannual average (^{0}C) (last century)		3.1	10.2	16.0	19.5	21.2
2016	Month average (^{0}C)	6.5	13.3	15.3	20.9	22.6
	Deviation (^{0}C)	+3.4	+3.1	-0.7	+1.4	+1.4
2017	Month average (^{0}C)	8.0	10.0	16.1	21.1	21.6
	Deviation (^{0}C)	+4.9	-0.2	+0.1	+1.6	+0.04
2018	Month average (^{0}C)	1.2	15.4	18.7	20.8	21.3
	Deviation (^{0}C)	-1.9	+5.2	+2.7	+1.3	+0.1
2019	Month average (^{0}C)	7.3	10.6	16.1	21.9	21.2
	Deviation (^{0}C)	+4.2	+0.4	+0.1	+2.4	0.0
Rainfall (mm)						
Multiannual sum (mm) (last century)		28.4	43.9	55.9	82.6	69.3
2016	Month sum (mm)	33.8	76.2	70.4	97.0[a]+45.4[b]	24.0
	Deviation (mm)	+5.4	+32.3	+14.5	+59.8	-45.3
2017	Month sum (mm)	107.0	140.4	72.8	17.6[a]+54.0[b]	84.4
	Deviation (mm)	+78.6	+96.5	+16.9	-11.0	+15.1
2018	Month sum (mm)	56.8	18.0	16.8	57.0[a]+159.0[b]	136.6
	Deviation (mm)	+28.4	-25.9	-39.1	+133.4	+67.3
2019	Month sum (mm)	40.4	62.6	125.2	67.6[a]+46.2[b]	24.2
	Deviation (mm)	+12.0	+18.7	+69.3	+31.2	-45.1
HC Relative Humidity (%)						
Multiannual average (%) (last century)		80.0	72.0	70.0	72.0	72.0
2016	Month average (%)	72.9	69.0	70.7	76.0	60.0
	Deviation (%)	-7.1	-3.0	+0.7	+4.0	-12.0
2017	Month average (%)	80.1	65.7	65.9	65.6	69.0
	Deviation (%)	+0.1	-6.3	-4.1	-6.4	-3.0
2018	Month average (%)	85.3	60.0	59.5	73.1	80.1
	Deviation (%)	+5.3	-12.0	-10.5	+1.1	-8.1
2019	Month average (%)	61.5	65.4	80.9	78.2	70.8
	Deviation (%)	-18.5	-6.6	+10.9	+6.2	-1.2

[a]Rainfall recorded between 01-15 of June
[b]Rainfall recorded between 16-30 of June

Regarding the air relative humidity, the values of this climatic element data recorded during the studied period showed deviations from the multiannual monthly values, the most obvious differences being recorded during the wheat vegetation period of the last two years of research.

Of the three climatic elements analysed, the atmospheric precipitation represents the element that presented the most volatile values, being also the most important climatic element that influenced the frequency and intensity of attack with which *Zymoseptoria tritici* manifested.

In the years when during the wheat vegetation period a significant amount of precipitation was recorded (2017 and 2019), the characteristic symptoms produced by this disease (Figure 1) were easy to notice.

Carefully analysing the distribution of atmospheric precipitation during these four years of research, it was observed that when the days with rainfall exceeding 10 mm, or two or three consecutive days in which precipitations fell was more than 10 mm were more numerous, the intensity of the attack of the pathogen was higher. Considering this situation during the research 12 cases were registered in 2016, 13 cases in 2017, 4 cases in 2018 and 14 in 2019.

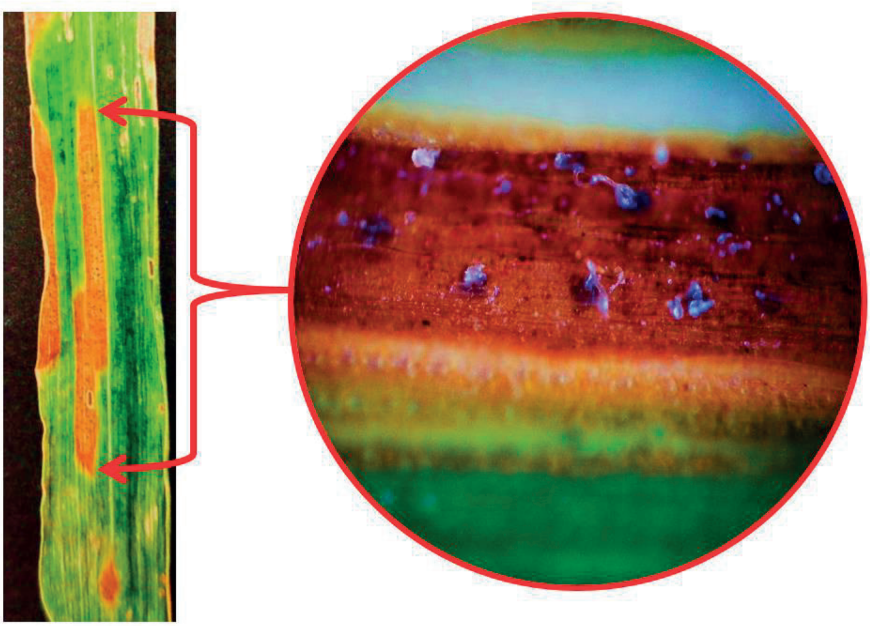

Figure 1. *Zymoseptoria tritici* disease symptoms on wheat plants (Photo: A.M. Gafencu)

The presence of these typical periods with precipitations witch favour the evolution of the disease can be observed very well by analysing the values of the degree of attack with which the pathogen was manifested during this period (Table 2). In the years when were recorded a higher number of disease periods (2017, 2019) the evolution of the disease was favoured, the symptoms produced by it gradually covering the leaves of the wheat and extending its covered surface.

Table 2. *Septoria tritici* blotch caused by *Zymoseptoria tritici* - degree of attack (DA %), during 2015-2019

No.	Variety	*Zymoseptoria tritici* Degree of Attack (%)							
		2016		2017		2018		2019	
1.	BEZOSTAIA 1	0.84±0.12	Cv	3.46±0.59	Cv	0.66±0.22	Cv	3.22±0.38	Cv
2.	GLOSA	0.39±0.03	NS	2.68±0.62	NS	0.76±0.32	NS	3.19±0.19	NS
3.	IZVOR	0.45±0.18	NS	1.79±0.24	*	0.27±0.05	NS	2.29±0.36	NS
4.	MIRANDA FDL	0.45±0.12	NS	2.31±0.55	NS	0.84±0.29	NS	3.80±0.60	NS
5.	OTILIA	0.57±0.10	NS	2.17±0.46	NS	0.29±0.06	NS	1.47±0.36	**
6.	PAJURA	0.14±0.03	*	1.95±0.75	NS	0.46±0.19	NS	1.85±0.70	*
7.	PITAR	0.80±0.21	NS	3.35±0.37	NS	1.66±0.20	**	1.97±0.56	*
8.	SEMNAL	0.95±0.39	NS	2.91±0.24	NS	0.42±0.11	NS	1.36±0.23	**
9.	URSITA	0.98±0.36	NS	2.10±0.81	NS	0.39±0.06	NS	1.50±0.04	**
10.	ANDRADA	0.32±0.06	NS	2.26±0.52	NS	0.67±0.51	NS	3.38±0.38	NS
11.	CODRU	0.81+0.20	NS	1.97+0.14	NS	0.43+0.12	NS	2.05±0.33	NS

Ns - Not Significant (P>0.05) Cv – control variant
* - Significant (P>0.01)
** - Distinguish significant (P>0.001)
*** - Very significant (P<0.001)

Analyzing Figure 2, it is observed that the values of the degree of attack with which *Zymoseptoria tritici* manifested during this period were influenced by the climatic conditions of the studied period.

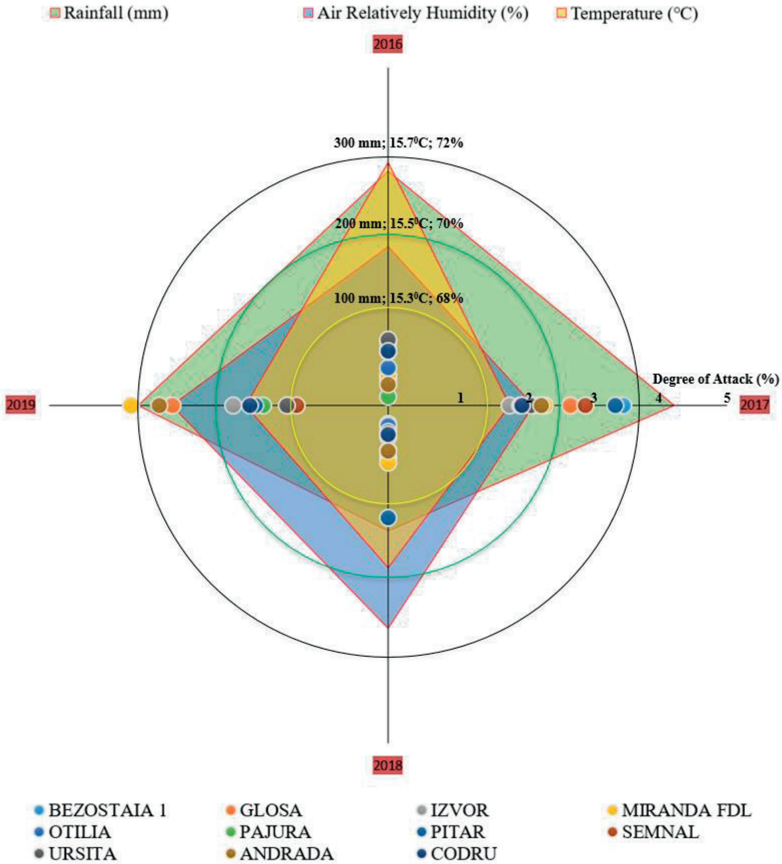

Figure 2. Evolution of the degree of attack of the *Zymoseptoria* tritici under the influence of precipitation, air temperature and air relative humidity, during 2015-2019

In 2017, when the amount of rainfall was higher and the air temperature was lower, the values of the degree of attack with which *Zymoseptoria tritici* manifested were the highest. A similar situation was encountered also at the level of 2019, when the precipitations were higher, but the average value of the temperatures was slightly higher, which is why the values of the attack degree of the pathogen were lower.

In the other two years studied, when the precipitations recorded were reduced, and the air temperature was higher it is observed that the pathogen manifested with low values of the degree of attack.

CONCLUSIONS

As a result of the research carried out, it can be observed that atmospheric precipitation, together with other climatic elements influence the occurrence and development of the disease produced by *Zymoseptoria tritici*.
The rains over 10 mm fallen within 24 hours, or the sum of the precipitations fallen during 3 consecutive days which exceed 10 mm of rain favours the evolution of disease.
Knowing the behaviour of wheat varieties in front of pathogens attack is important, because under the current situation of agriculture and plant protection, the most important measure

for limiting the pressure of pathogens in the field is the cultivation of genotypes that show resistance to them.

REFERENCES

Arraiano, L.S., Brading, P.A., Brown, J.K.M. (2001). A detached seedling leaf techniqueto study resistance to *Mycosphaerella graminicola* (anamorph *Septoria tritici*) inwheat. *Plant. Pathol*., *50*, 339–346.

Eyal, Z. (1999). The Septoria tritici and Stagonospora nodorum blotch diseases of wheat. *Eur. J. Plant Pathol.*, *105*, 629–641.

Eyal, Z., Scharen, A.L., Prescott, J.M., van Ginkel, M. (1987). *The Septoria Diseases of Wheat: Concepts and Methods of Disease Management*. CIMMYT, Mexico.

FAO (2016). *Guidelines for monitoring diseases, pests and weeds in cereal crops*.

Fones, H., Gurr, S. (2015). The impact of *Septoria tritici* Blotch disease on wheat: An EU perspective. *Fungal Genetics and Biology*, *79*, 3–7.

Gladders, P., Paveley, N.D., Barrie, I.A., Hardwick, N., Hims, M.J., Langton, S., Taylor M.C. (2011). Agronomic and meteorological factors affecting the severity of leaf blotch caused by *Mycosphaerella graminicola* in commercial wheat crops in England. *Ann. Appl. Biol.*, *138*, 301–311.

Goodwin, S.B., Waalwijk, C., Kema, G.H.J. (2004). Genetics and Genomics of *Mycosphaerella graminicola*: A Model for the Dothideales. *Applied Mycology & Biotechnology*, *4*, 315–330.

Greiner, S.D., Racca, P.,Jung, J., von Tiedemann, A. (2019). Determining and modelling the effective period of fungicides against Septoria leaf blotch in winter wheat. *Crop Protection, 117*, 45–51.

Halama, P. (1996). The occurrence of *Mycosphaerella graminicola*, teleomorph of *Septoria tritici* in France. *Plant Pathol*., *45*(1), 135–138.

Heick, T.M., Justensen, A.F., Jorgensen, L.N. (2017). Anti-resistance strategies for fungicides against wheat pathogen *Zymoseptoria tritici* with focus on DMI fungicides. *Crop Protection, 99*, 108–117.

Lovell, D.J., Parker, S.R., Hunter, T., Royle, D.J., Coker, R.R. (1997). Influence of crop growth and structure on the risk of epidemics by *Mycosphaerella graminicola* (*Septoria tritici*) in winter wheat. *Plant Pathol*., *46*, 126–138.

Manandhar, H.K., Timila, R.D., Sharma, S., Joshi, S., Manandhar, S., Gurung, S.B., Sthapit, S., Palikhey E., Pandey, A., Joshi, B.K., Manandhar, G., Gauchan, D., Jarvis, D.I., Sthapit, B.R. (2016). *A field guide for identification and scoring methods of diseases in the mountain crops of Nepal*. NARC, DoA, LI-BIRD and Bioversity International, Nepal.

Morais, D., Laval V., Sache I., Suffert F. (2015). Comparative pathogenicity of sexual and asexual spores of *Zymoseptoria tritici* (*Septoria tritici* blotch) on wheat leaves. *Plant Pathology, 64*(6), 1429–1439.

Muckle, A.E. (2013). *Management of Fusarium Head Blight and Septoria tritici Blotch in Winter Wheat through the use of Host Resistance and Chemical Controls and the Investiagation of Fusarium graminearum Chemotype Diversity, Aggressiveness and Toxicity*. MSc. Thesis, University of Guelph, Ontario, Canada.

Muhammad, R., Yong, W. (2017). Estimation of Yield Losses due to Leaf Rust and Late Seeding on Wheat (*Triticum aestivum* L) Variety Seher-06 in District Faisalabad, Punjab, Pakistan. *Advances in Biotechnology and Microbiology*.

O'Driscoll, A., Kildea, S., Doohan, F., Spink, J., & Mullins, E. (2014). The wheat - Septoria conflict: a new front opening up? *Trends in plant science*, *19*(9), 602–610.

Palomar, M.A.Q. (2014).*Impact of fungicide mode of action and application timing on the control of Mycosphaerella graminicola and the physiology and yield of wheat*. PhD Thesis. Institue of Phytopathology and Applied Zoology, JLU Giessen.

Ponomarenko, A., Gooding, S.B., Kema, G.J. (2011). *Septoria Tritici Blotch (Stb)*. Plant Health Instructor (www.apsnet.org).

Roelfs, A.P., Singh, R.P., Saari, E.E. (1992). *Rust Diseases of Wheat: Concepts and methods of disease management*. CIMMYT, Mexico.

Shipton, W.A., Boyd, S.R.J., Rosielle, A.A., Shearer, B.I. (1971). Common Septoria Diseases of Wheat. *Botanical Review, 37*(2), 231–262.

Simon, M.R., Perello, A.E., Cordo, C.A., Struik, P.C., (2002). Influence of Septoria tritici onyield, yield components, and test weight of wheat under two nitrogen fertilizationconditions. *Crop Sci*., *42*, 1974–1981.

Thomas, M.R., Cook, R.J., King, J.E., (1989). Factors affecting development of Septoria tritici in winter wheat and its effect on yield. *Plant Pathology, 39*, 246–257.

Torriani, S. F., Melichar, J. P., Mills, C., Pain, N., Sierotzki, H., & Courbot, M. (2015). Zymoseptoria tritici: a major threat to wheat production, integrated approaches to control. *Fungal Genetics and Biology*, *79*, 8–12.