IMPACT OF CLIMATIC CONDITIONS ON YIELD AND PLANT DISEASES OF WINTER WHEAT IN NORTH-EASTERN ROMANIA

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Abstract

Climate elements, such as temperature and atmospheric precipitation, are driving factors in plant diseases developmenet and vary widely between years. Weather factors play a decisive role in achieving higher yields and in the development of plant pathogens. Besides temperature and atmospheric precipitation, wind and relative humidity of the air, play an important role in the development of diseases. In this study are presented the results obtained during the period 2015-2018, in the northeastern part of Romania, Iasi county. During the three agricultural years studied, the climatic conditions were different from one year to the next.

The influence of climatic factors was observed as a result of differences in production yields and the presence of the pathogens and the frequency with which they were manifested. In view of climate change and unfavorable influence on the agricultural sector, cultivation of the most suitable varieties can lead to higher yields, even in years when climatic conditions are unfavorable.

Key words: winter wheat, disease, climatic conditions

Wheat has a long history of serving as an important food crop to humankind being a staple food for the major part of the world's population. Winter wheat (*Triticum aestivum* L.) is widely grown cereal crop around the world due to its high yield potential (Mehta Y.R., 2014).

Productivity of winter wheat is a risk due to the incidence of pests and climatic conditions during the growing season (Oerke E.C., 2006).

Crop losses due to these harmful organisms, weeds, animal pests and pathogens, ca be substantial. The main changes in climate have occcurred for temperature and rainfall, with negative inffluence to wheat yields.

These study was conducted with the purpose to analyze the influence of climatic condition on wheat production and on the frequency of pathogens.

MATERIAL AND METHOD

Between October 2015 and July 2018, the behavior of 35 winter wheat cultivars were observed. The cultivars were represented by romanian varieties (from N.A.R.D.I. Fundulea: 11368G1, 11424G1, 11838G8, Boema, Glosa, Izvor, Litera, Miranda FDL, Otilia, Pajura, Pitar, Semnal, Unitar, Ursita, Vestitor, Voevod, Voinic, Zamolxe, Zina, Zamfira respectively from A.R.D.S. Turda: Andrada, Codru, Dumbrava, T.19-10, T.42-05, T.55-01, T.62-01, T.95-12, T.109-12, T.118-11, T.123-11, T.124-11, T.143-11, T.150-11), as well by the old Russian variety Bezostaia 1, used as a long-term witness in comparative crops.

The experience was placed in the experimental field of the Iasi Didactic Station, the "Ezăreni" farm being organized according to the randomized block diagram, in three replicates, each wheat cultivar representing an experimental variant.

In the experience, the specific technology of wheat cultivation was applied, no treatments against pathogens were performed. The total area of the experience was 715 m^2, comprising a total of 75 variants with a surface area of 7.7 m^2. On this surface, eight rows of wheat were sowed at a distance of 12.5 between them. The observations to identify the presence of pathogens were conducted between March-June period of each year of observation.

Meteorological data (precipitation and air temperature) were recorded at meteorological stations on site.

The control variant was the cultivar Bezostaia 1, and every cultivar was comparing with them to highlight statistical differences. The statistical and graphical processing was done in the MS Excel program.

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RESULTS AND DISCUSSIONS

The effects of climate change are a significant threat to global food security, not just by increasing the global average temperature, estimated at 1.5-2℃ during the 20th and 21st centuries, and by increasing the frequency and severity of extreme weather events (Ilangumaran G., *et al*, 2018, Pochişcanu Simona *et. al*, 2011, Săulescu N.N. *et al*, 2006).

Air temperature is the climate element that we cannot ignore any day of the year. The evolution of air temperature, whether day-to-day, from one month to the next, or from season to season influences life directly. Analyzing the evolution of air temperature, we can see the tendency to increase the average values (*table 1*).

Table 1

AIR TEMPERATURE – Average values recorded during the main phenophases of wheat crop

– Celsius degrees (℃) –

	Average monthly temperature		Agricultural year				Temp. med. of phenophases				
Month	**1901-2000**	**2005-2014**	**2015/2016**	**2016/2017**	**2017/2018**	**Phenophases**	**1901-2000**	**2005-2014**	**2015/2016**	**2016/2017**	**2017/2018**
August	20.50	21.93	23.04	21.38	21.95	*Uncultivated land*	20.50	21.93	23.04	21.38	21.95
September	15.90	16.57	19.23	18.27	17.18	*Sowing – Emergency*	10.00	10.90	11.66	10.15	11.33
October	10.00	10.36	9.37	8.15	10.96						
November	4.10	5.76	6.37	4.03	5.85						
December	-0.80	-0.02	2.04	0.35	3.00	*Winter reserve*	-0.75	0.25	2.82	0.66	0.40
January	-3.50	-2.15	-2.54	-4.89	-0.84						
February	-1.80	-1.47	5.26	-0.81	-1.75						
March	3.10	4.63	6.52	8.00	1.18						
April	10.20	11.34	13.33	10.05	15.43	*Increased growth–flowering*	13.10	14.25	14.32	13.06	17.05
May	16.00	17.15	15.31	16.07	18.67						
June	19.50	20.80	20.86	21.11	20.78	*Ripening*	19.50	20.80	20.86	21.11	20.78
July	21.20	22.91	22.64	21.64	21.30	*Uncultivated land*	21.20	22.91	22.64	21.64	21.30
Average	**9.53**	**10.65**	**11.79**	**10.28**	**11.14**						

For a good understanding of the air temperature evolution, the average air temperature values recorded during the study period were compared with the average values of the last decade (2005-2014), which precede the beginning of the present study, as well as the average values of the last century (1901- 2000).

A simple analysis of the data presented in the table below shows that the annual average temperature has an upward trend. If the annual average of the period 1901-2000 is 9.5℃, it is noticed that the average of the period 2005-2014 is 10.7℃, indicating an increase in temperature by 1.2℃. Comparing the annual air temperature values for the studied years, it can be noticed that the annual average exceeds the average of the period 2005-2014, which is why these years may be considered warmer than the reference periods.

Analyzing the average air temperatures recorded during the period of the main wheat phenophases, it is observed that the values recorded during the studied period show positive deviations from the average values taken as a reference. The largest deviation is observed during the vegetative rest of the agricultural year 2015-2016, when the average is 2.82℃, superior to all the ranges taken as a reference. This deviation, above 2℃, is due to February 2016 when the average temperature of this month was 5.26℃, and for the other agricultural years in which observations were made, as well as for reference periods the average air temperature for February was negative.

For the completion of the thermal panel characteristic of the period studied in *table 2* are presented the average values of the soil temperature. Soil temperature directly influences biotic processes in the soil, its values diminishing or accelerating the pace at which they occur.

Soil temperature is strongly influenced by the shape of the relief, the type of vegetation present on the soil surface, the degree of humidity, etc.

In the first part of the growing season of wheat crops, as with other crops, the temperature of the soil must be taken into account with the air temperature. Seeming in autumn, normal air and soil temperatures do not create problems for wheat crops such as the problems created by the low values of these two climatic elements in crops sown in the spring, especially those that are sensitive to low temperatures.

Table 2

SOIL TEMPERATURE – Average values recorded during the main phenophases of wheat crop

– Celsius degrees (℃) –

	Average monthly temperature	*Agricultural year*				*Temp. med. of phenophases*			
Month	***1961-1996***	***2015/2016***	***2016/2017***	***2017/2018***	***Phenophases***	***1961-1996***	***2015/2016***	***2016/2017***	***2017/2018***
August	24.30	22.94	20.81	20.95	*Uncultivated land*	24.30	22.94	20.81	20.95
September	17.90	18.92	18.06	16.71	*Sowing – Emergency*	10.60	11.49	10.54	10.97
October	10.40	9.91	9.12	10.13					
November	3.50	5.64	4.44	6.08					
December	-1.30	1.90	0.46	2.30	*Winter reserve*	-1.10	1.90	0.99	1.39
January	-4.10	-1.68	-1.50	0.86					
February	-2.10	2.32	-0.59	0.36					
March	3.10	5.06	5.60	2.05					
April	11.90	11.08	8.38	12.27	*Increased growth–flowering*	15.80	13.00	11.56	15.03
May	19.70	14.91	14.74	17.79					
June	24.00	20.53	20.80	21.27	*Ripening*	24.00	20.53	20.80	21.27
July	25.60	21.99	21.69	21.13	*Uncultivated land*	25.60	21.99	21.69	21.13
Average	**11.08**	**11.13**	**10.17**	**10.99**					

The atmospheric precipitation, without neglecting the importance of other climatic elements, whose influence is observed through the evolution and distribution of weather precipitations in time and space, is the most important climatic element. The importance of this climatic element is observed daily in various economic sectors, but the most powerful is felt in the agricultural sector.

The influence of atmospheric precipitation is very well observed when significant amounts of rainfall occur in a short period of time, or when over a long period of time, the amount of precipitation is negligible. The effect of lack of precipitation is well known, leading to the occurrence of drought and dryness phenomena, and their persistence produces serious damage to the agricultural sector. No excess rainfall is undesirable if recorded in short intervals. Excess rainfall causes floods, overflows of running water, excess humidity and stagnation of water in low-lying areas, damaging agriculture.

Table 3

ATMOSPHERIC PRECIPITATIONS – Values recorded during the main phenophases of wheat crop

– mm –

	Monthly amount		*Agricultural year*				*Amount of phenophase*				
Month	***1901-2000***	***2005-2014***	***2015/2016***	***2016/2017***	***2017/2018***	***Phenophases***	***1901-2000***	***2005-2014***	***2015/2016***	***2016/2017***	***2017/2018***
August	56.0	45.4	40.8	53.4	61.8	*Uncultivated land*	56.0	45.4	40.8	53.4	61.8
September	45.3	36.8	19.8	10.2	23.2	*Sowing – Emergency*	114.8	104.4	190.4	292.0	113.6
October	32.5	40.1	66.4	212.0	69.8						
November	37.0	27.5	104.2	69.8	20.6						
December	29.7	39.1	10.2	20.6	48.2	*Winter reserve*	114.7	134.4	152.8	465.0	148.6
January	29.7	32.6	80.0	323.6	18.8						
February	26.9	28.9	28.8	13.8	24.8						
March	28.4	29.7	33.8	107.0	56.8						
April	43.9	54.0	76.2	140.4	18.0	*Increased growth–flowering*	99.8	123.8	146.6	**213.2**	**34.8**
May	55.9	69.8	70.4	72.8	16.8						
June	82.6	77.8	142.4	71.6	216.0	*Ripening*	82.9	77.8	142.4	71.6	216.0
July	69.3	66.1	24.0	84.4	136.6	*Uncultivated land*	69.3	66.1	24.0	84.4	136.6
Amount	**537.2**	**547.7**	**697.0**	**1179.6**	**717.6**						

Analyzing the distribution of precipitations on the main wheat phenophases (*table 3*) is observed that values recorded are not very different from the average values of the references period. Exceptions are the *increased growth-flowering* period of 2017, when total rainfall was 213.2 mm. These amount of precipitation has created good conditions for the development of pathogens. The second exception was recorded in 2018, the same period of wheat growing when total rainfall was 34.8 mm. These period extremely droughtless with negative influences on wheat production.

Table 4

Yields achieved by the winter wheat cultivars during 2016-2018

– kg/ha –

No.	Wheat variety	Agricultural year					
		2015 / 2016		2016 / 2017		2017 / 2018	
		Yield	Means	Yield	Means	Yield	Means
1	**BEZOSTAIA 1**	**3857.29±120.46**	**Mt.**	**5866.77±194.38**	**Mt.**	**5490.92±179.99**	**Mt.**
2	**11368G1**	5589.19±35.72	***	-	-	-	-
3	**11424G1**	4819.56±54.25	***	6469.94±238.94	*	5222.24±152.74	ns
4	**11838G8**	4579.24±66.07	***	-	-	-	-
5	**ANDRADA**	5296.39±28.20	***	7004.02±259.31	***	5756.16±208.42	ns
6	**BOEMA**	4534.99±105.59	***	-	-	-	-
7	**CODRU**	5095.36±102.04	***	7147.66±516.64	***	5976.00±87.66	*
8	**DUMBRAVA**	4416.71±83.81	***	6963.15±139.25	***	5802.06±54.09	ns
9	**GLOSA**	5165.46±45.47	***	6026.14±563.31	ns	6554.06±129.37	***
10	**IZVOR**	4269.77±86.62	**	6955.46±308.08	***	5726.99±166.29	ns
11	**LITERA**	4304.08±125.28	**	6304.44±982.74	ns	-	-
12	**MIRANDA FDL**	5201.57±88.82	***	8005.70±545.17	***	6882.84±199.32	***
13	**OTILIA**	5422.43±207.14	***	7884.54±477.29	***	6651.20±262.05	***
14	**PAJURA**	3551.14±66.22	0	7438.19±343.61	***	6503.56±144.68	***
15	**PITAR**	4558.00±221.52	***	6702.62±380.16	***	6339.18±413.09	***
16	**SEMNAL**	6155.54±121.21	***	7463.46±237.04	***	5904.54±683.02	ns
17	**T.19-10**	4789.01±202.33	***	6609.05±281.76	**	5280.79±168.50	ns
18	**T.95-12**	-	-	6960.76±84.45	***	6733.64±829.37	***
19	**T.109-12**	-	-	7215.77±254.79	***	6374.40±298.94	***
20	**T.118-11**	-	-	7091.88±236.84	***	4780.50±425.78	**
21	**T.123-11**	4359.87±194.48	***	6853.89±823.38	***	5845.88±596.07	ns
22	**T.124-11**	4304.56±148.32	**	7470.01±336.07	***	6195.03±394.33	**
23	**T.143-11**	-	-	7765.58±397.94	***	6599.47±257.37	*
24	**T.150-11**	6383.79±42.50	***	-	-	-	-
25	**T.42-05**	4781.61±208.05	***	-	-	-	-
26	**T.55-01**	6138.55±229.91	***	-	-	-	-
27	**T.62-01**	4200.27±269.96	*	-	-	-	-
28	**UNITAR**	6633.22±171.72	***	8518.11±450.52	***	6406.32±109.17	***
29	**URSITA**	5991.77±123.05	***	8659.54±248.25	***	7064.18±416.52	***
30	**VESTITOR**	-	-	7380.98±225.00	***	-	-
31	**VOEVOD**	-	-	6701.42±433.06	***	-	-
32	**VOINIC**	-	-	7562.01±130.81	***	6499.43±230.30	***
33	**ZAMFIRA**	-	-	-	-	6781.08±127.90	***
34	**ZAMOLXE**	-	-	-	-	6500.97±72.47	***
35	**ZINA**	-	-	-	-	6106.40±514.38	*
		DL 5% = 277.72 kg DL 1% = 367.04 kg DL 0.1% = 474.50 kg		DL 5% = 485.44 kg DL 1% = 641.56 kg DL 0.1% = 829.40 kg		DL 5% = 387.17 kg DL 1% = 511.69 kg DL 0.1% = 661.50 kg	

The control variant (Mt.) of the experience was the wheat variety Bezostaia 1. These cultivars recorded between 3857.29±120.46 kg/ha and 5866.77±194.38 kg/ha (*table 4*).

The highest yields were recorded in 2017 and lowest in 2016. In the first year of observations, the Pajura variety recorded the lowest yields. The difference without control variant was statistically. In the case of the rest of varieties the difference from the Bezostaia 1 was positive, being statistically assured.

In the second year of observation, except the Litera and Glosa varieties whose difference from control variant was insignificant, all other cultivars recorded positive differences, statistically assured. In the last year of obseration, statistically assured difference was recorded in the case of 19 varities, and in the case of 5 the difference was insignificant.

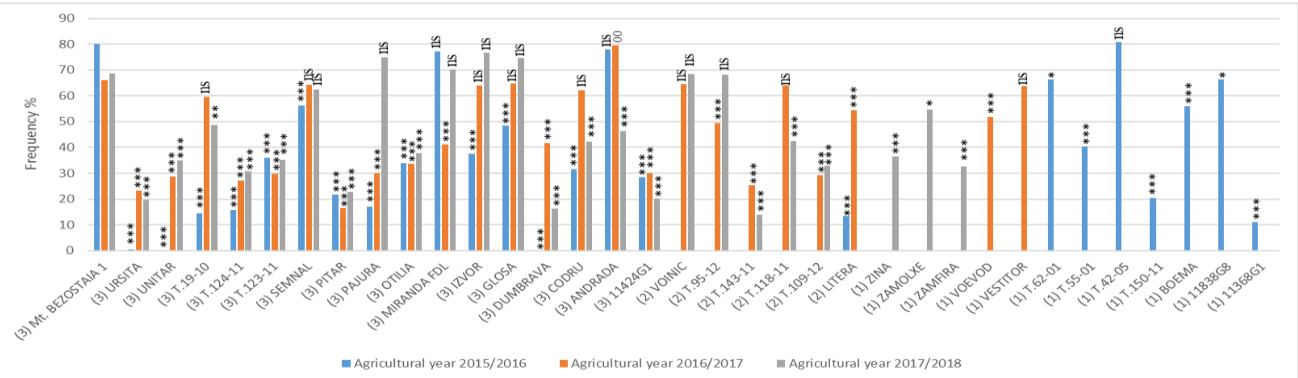

Figure 1 ***Blumeria graminis* f.sp. *tritici* E.J. Marchal- frequency of attack, during 2016-2018**

Powdery mildew disease of winter wheat was observed every year with a frequency up to 80,89% (*figure 1*), record in first year of observation in case of cultivar T.42-05. In this years, in case of Unitar and Dumbrava varieties the pathogen was not observed. In the second and third year of observation powdery mildew affect all the winter wheat cultivars taken under observation.

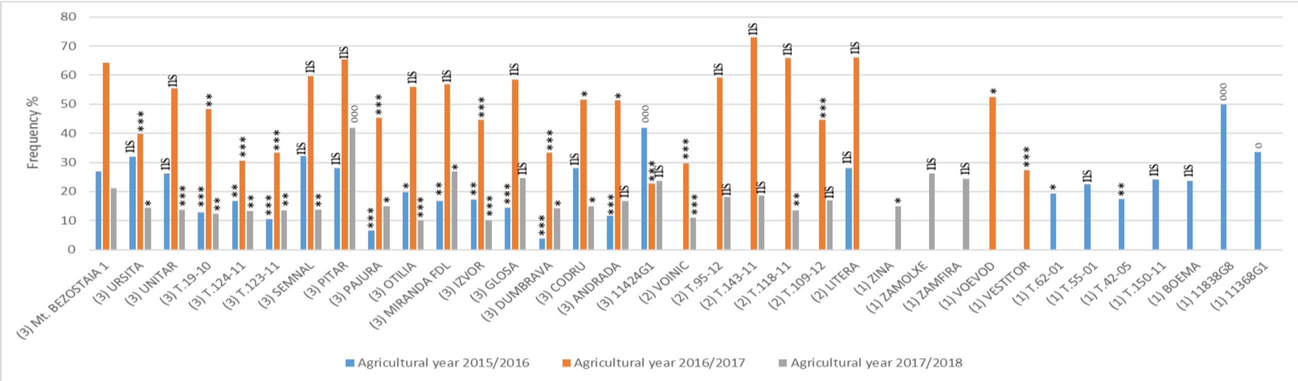

Figure 2 ***Septoria tritici* Rob. et. Desm. - frequency of attack, during 2016-2018**

Septoria leaf blotch of wheat, caused by *Septoria tritici* Rob. et. Desm. was present every year and in the case of all cultivars (*figure 2*). The influence of climatic conditions, and especially of rainfall is very noticeable in the case of this disease. In the second year of observation, when the total amount of rainfall was higher in winter and spring, with major influence on development of Septoria tritici, the frequency of attack of the pathogen was realy high if we compare with the other years of observation. The highest value was 73.11% and was recorded by T.143-11 cultivar. In the first year the highest value was 49.89% (Wheat line 11838G8) and in the last year the highest value was 41.83% (Wheat cultivar Pitar).

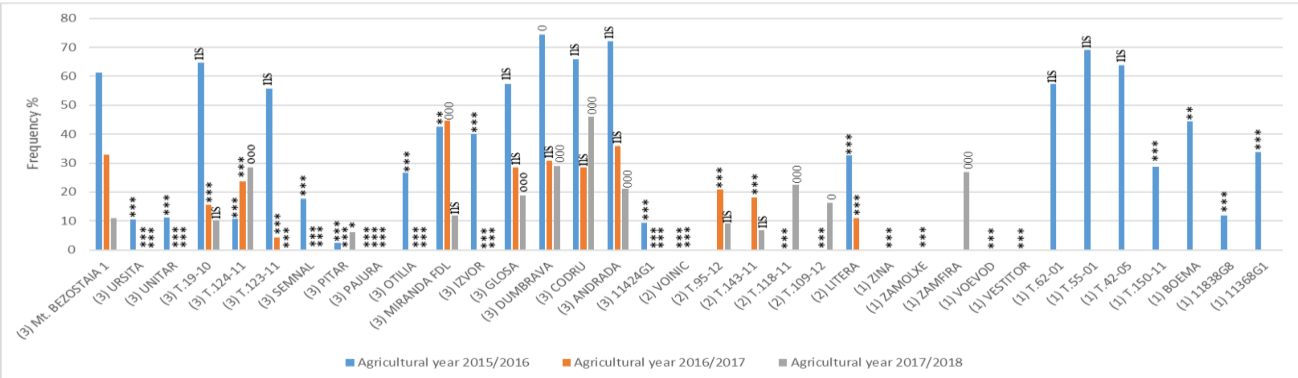

Figure 3 ***Puccinia recondita* f.sp. *tritici* C.O. Johnson - frequency of attack, during 2016-2018**

Puccinia recondita f.sp. *tritici* C.O. Johnson is the most common rust of wheat in the north-eastern part of Romania. These pathogen was present in each of the three years of observation but with very different values of frequency of attack from year to year. The highest values of frequency were recorded in first year of observation. In the second year the *Puccinia recondita* f.sp. *tritici* C.O. Johnson was present in case of 12 cultivars (*figure 3*).

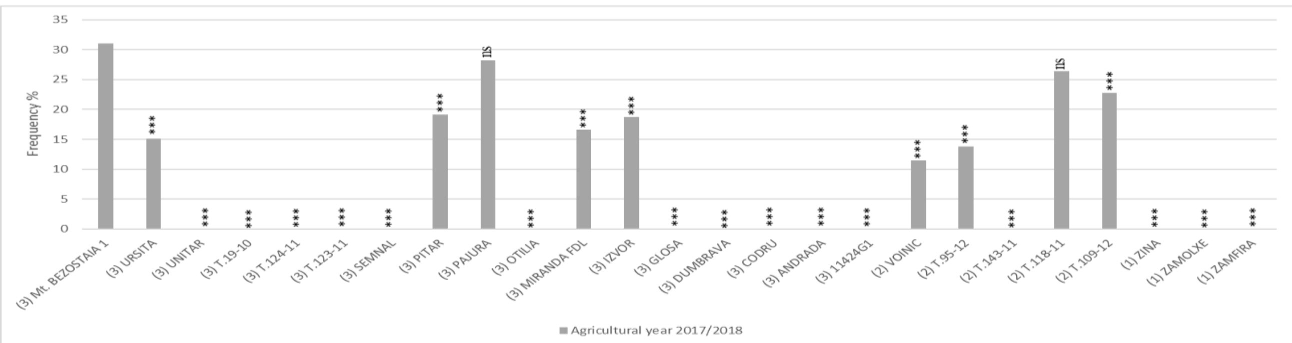

Figure 4 ***Puccinia striiformis* f.sp. *tritici* Eriks. - frequency of attack in 2018**

In the last year of observation, the pathogen was observed with low values of frequency because in these year the wheat crop was very stressed by high temperatures and lack o precipitation, reason why at the moment when the first symptoms of the disease occured the wheat crop were in an advanced stage of development, some of the leaves being already dried.

In the third year of obseration the climatic conditions in the spring, high temerature and low amount of precipitation have created conditions for development of yellow rust of wheat caused by *Puccinia striiformis* f.sp. *tritici* Eriks. (*figure 4*).

The pathogen was observed in case of teen cultivars, with highest value recorded by Bezostaia 1. Close values were recorded by Pajura and T.118-11 wheat varieties (insignificant statistically).

CONCLUSIONS

The climatic conditions play a key role in obtaining high yields in winter wheat crop and in the presence and frequency of attack of winter wheat pathogens.

Studying the behavior of wheat varieties in terms of climatic conditions and the presence of pathogens that produce diseases with negative influences on the quantity and quality of production is necessary for a good characterization and correct recommendation as to how each cultivar reacts to abiotic and biotic conditions of stress.

As a result of the different climatic conditions characteristic of the studied years there was a variability of the wheat production from one year to the next.

Wheat crop studied, under the influence of climate conditions that favored the presence of pathogens, reacted differently from the pathogens encountered.

REFERENCES

Ilangumaran G., Lamont R.J., Smith L.D., 2018 – *The role of the phytomicrobiome in maintaining biofuel crop in a changing climate.* In Microbes for Climate Resilient Agriculture, edited by Kashyap Prem Lal, Srivastava Alok Kumar, Tiwari Shree Prakash and Kumnar Sudheer, John Wiley & Sons, DOI10.1002/9781119276050.ch1

Oerke E.C., 2006. *Crop losses to pests*. The Journal of Agricultural Science. 144: 31-43. DOI: https://doi.org/10.1017/S0021859605005708.

Mehta Y.R., 2014. Wheat Diseases and their management. Springer. DOI: https://doi.org/10.1007/978-3-319-06465-9.

Pochișcanu Simona-Florina, Negru Silvia, Gherasim Alexandra, 2011 - *Comportarea unor soiuri de grâu de toamnă, în condițiile climatice din Podișul Central Moldovenesc*. Analele I.N.C.D.A. Fundulea, Genetica și ameliorarea plantelor, Vol. LXXIX (2), pp. 193-200, ISSN 2067-7758.

Săulescu N.N., Ittu Gh., Mustățea P., Păunescu Gabriela, Stere Ioana, Nistor G., Rînchiță L., Voinea I., 2006 – *Comportarea unor soiuri de grâu de toamnă românești în condiții constrastate de aprovizionare cu apă*. Probleme de genetică teoretică și aplicată, XXXVIII, 1-2:21-29.