# STATISTIC ANALYSIS OF CLIMATIC FACTORS INFLUENCE ON BLUMERIA GRAMINIS (D.C.) SPEER FUNGUS – POWDERY MILDEW, WITH ANOVA AND MULTIFACTORIAL CORRELATION

# ANALIZA STATISTICĂ A INFLUENȚEI FACTORILOR CLIMATICI ASUPRA VIRULENȚEI CIUPERCII BLUMERIA GRAMINIS (D.C.) SPEER – FĂINAREA GRÂULUI, PRIN INTERMEDIUL ANOVA ŞI A CORELAȚIEI MULTIFACTORIALE

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***Abstract:*** *Air temperature, rainfalls, air relative humidity, dew, nebulosity and wind are climatic factors that are acting on powdery mildew-wheat tandem. Literature offers pieces of information only for the relationship with temperature and rainfalls. They have proposed a detailed research on mentioned climatic factors on fungus virulence during 2003-2005 with the help of a complete statistic interpretation with the help of SPSS programme. For statistic analysis they have introduced the data of those six climatic parameters and the fungus virulence data on 27 winter wheat varieties cultivated in the experimental plots from S.C.D.A. – Lovrin. Realised researches are allowing studies concerning the elaboration of a prognosis and warning programme for wheat powdery mildew control. They have worked with decade averages for all analysed variables. In model correlation determining they have used the exclusion of analysed factors. There have resulted five regression models that demonstrate the existence of interrelations among studied variables. For all the models the correlation coefficient is greater then 0.7 that shows the existence of interdependence among those analysed variables. Conclusions were next: the greatest influence on the increase of Blumeria graminis f. spec. tritici attack intensity, in conformity with the data obtained after the recording of empiric data is due to the next factors: relative humidity, rainfalls and temperature. The factor that cannot be excluded from the attack intensity analysis and influences conidia dispersal of the fungus is the wind.*

***Rezumat:*** *Temperatura aerului, precipitațiile, umiditatea relativă, roua, nebulozitatea şi vântul sunt factori climatici care acționează asupra tandemului grâu - făinare. Literatura de specialitate oferă informații numai la relația cu temperatura şi precipitațiile. Ne-am propus o cercetare amănunțită a influenței factorilor climatici amintiți asupra virulenței ciupercii, în perioada 2003 - 2005, abordând o interpretare statistică complexă cu ajutorul programului SPSS. Pentru prelucrarea statistică, au fost introduse datele celor şase parametri climatici şi datele virulenței ciupercii asupra a 27 soiuri de grâu de toamnă cultivate în câmpurile experimentale ale S.C.D.A.– Lovrin. Cercetările efectuate permit studii cu privire la elaborarea unui program de prognoză şi avertizare a combaterii făinării grâului. S-a lucrat cu mediile pe decade pentru toate variabilele analizate. La determinarea modelelor de corelație s-a folosit metoda excluderii factorilor analizați. Au rezultat cinci modele de regresie care demonstrează legătura dintre variabilele studiate. Pentru toate modelele coeficientul de corelație este mai mare de valoare 0,7 ceea ce arată legătura dintre variabilele analizate. Concluziile au fost următoarele: influența cea mai mare asupra creşterii intensității atacului de Blumeria graminis f. spec. tritici, conform datelor obținute în urma înregistrării datelor empirice, o au factorii: umiditatea relativă, precipitațiile şi temperatura. Factorul care nu trebuie exclus din analizele intensității atacului şi care influențează dispersia conidiilor ciupercii este vântul.*

***Key words***: *Blumeria graminis, temperature, rainfalls, wind, relative humidity, dew, nebulosity, virulence, statistics.*
***Cuvinte cheie****: Blumeria graminis, temperatură, precipitații, vânt, umiditate relativă, rouă, nebulozitate, virulență, statistică.*

## INTRODUCTION

The influence of climatic conditions on powdery mildew spores spreading in winter wheat crops is studied in Germany with the intention to develop a model of *Blumeria graminis f.sp. tritici* conidial dispersion simulation considering the entire vegetation season, spores dispersal measured parallel with disease development. The main conclusion after these researches is that the most important factors that influence the spore dispersal are wind speed, vapours from canopy and rainfalls. Also, after S. FRIEDRICH, (1995) a model for conidia dispersal course calculation from a natural infected field is realised using variable meteorological data.

BISSONNETTE SUZANNE (2002) shows the importance of climatic condition monitoring with the appearance of flag leaf (( growing stage).

The purpose of this work is to realise a detailed research of the influence of some climatic factors on fungus virulence during 2003-2005 with the help of a complex statistic interpretation realised with SPSS programme. In this way we have monitored six climatic factors (air temperature, rainfalls, relative humidity, dew, nebulosity and wind) during mentioned period on wheat-powdery mildew pathologic system.

From 2003 to 2005 there where studied 27 winter wheat varieties with different resistance on *Blumeria grminis f. spec. tritici* fungus attack. Among studied wheat varieties are some new genotypes (Falnic, Gloria, Gruia, Izvor şi Holda). Experimental plots are placed in the area of Agricultural Development and Research Station Lovrin.

## MATERIAL AND METHOD

Temperature, air relative humidity, rainfalls, wind, nebulosity and dew daily data were obtained from the meteorological station of Lovrin research station placed nearby experimental plot. Climatic data registration started at 1$^{st}$ April and stopped at 30$^{th}$ June in every experimental year.

Disease severity or attack intensity is marked for every variety on a scale 0-5, the obtained data being transformed in percentage. Disease observation is realised at 10 days there being registered powdery mildew attack intensity during these time intervals. Powdery mildew appearance is marked in every experimental year as it follows: 30$^{th}$ April 2003 (G. S. 8 – Feekes Wheat Growth Stages); 20$^{th}$ April 2004 (G. S. 7); 14$^{th}$ May 2005 (G .S. 9-10). They consider that infection is realised with 10 days before disease appearance in experimental field.

In SPSS programme they have introduced climatic data (six climatic parameters) and powdery mildew intensity on wheat. They have worked with decade averages for all studied variables (Table 1).

## RESULTS AND DISCUSSIONS

Climatic conditions during those three experimental years where very different registered data having a great variability.

Attack severity in all studied wheat varieties is between 9.33-81.33% in 2003, 37-80% in 2004 and 0-50% in 2005. The lowest intensity is registered in case of Dor variety with a great resistance for powdery mildew, and the greatest intensity is registered for Bezostaia, an old variety not cultivated today but used by crop inbreeders in experimental fields as control.

For statistic analysis with SPSS programme they have worked with the averages on studied decades in case of attack intensity of powdery mildew and for climatic factors monitored during April-May (2003-2005).

All the data are transformed in indexes for a correct analysis (Table 1).

For quantitative and qualitative interpretation we have analysed measured data having in view the determination of the main influence factors that have leaded to powdery mildew attack intensity, being considered as dependent factor.

We are considering as independent factors humidity, temperature, dew, nebulosity, rainfalls and wind. Because the rainfalls empiric data contains 0 results we have used theoretical values calculated on the background of average values registered during studied periods.

*Table 1*

Meteorological variables used in statistic calculus (decadal averages) during April-June, 2003-2005

| Observation data | Factorii climatici analizați (medii)<br>Climatic factors (averages) | | | | | | **I %**<br>**($\bar{X}$)** |
|---|---|---|---|---|---|---|---|
| | Relative humidity (%) | Temp. ($^oC$) | Dew (hours) | Wind speed h=2m (m/s) | Total nebulosity (0-10) | Rainfalls (mm) | |
| **2003** | | | | | | | |
| **30 April** | 69.4 | 13.3 | 13h11’ | 0.94 | 4.64 | 6.5 | 4.29 |
| **9 May** | 61.4 | 18.6 | 19h15’ | 0.96 | 3.56 | 0 | 8.8 |
| **19 May** | 67.8 | 22.4 | 16h | 1.13 | 5.11 | 9 | 12.46 |
| **29 May** | 73.9 | 22.2 | 25h25’ | 0.9 | 5.95 | 16.6 | 23.56 |
| **9 June** | 63.8 | 25.5 | 32h28’ | 0.84 | 3.25 | 4.3 | 21.63 |
| **2004** | | | | | | | |
| **20 April** | 84.3 | 10.03 | 43h2’ | 0.93 | 7.83 | 36 | 3.86 |
| **30 April** | 80.5 | 12.74 | 106h51’ | 2.88 | 5.64 | 14.2 | 6.95 |
| **10 May** | 85.1 | 10.64 | 48h52’ | 1.31 | 6.09 | 49.8 | 17.97 |
| **20 May** | 80.9 | 13.52 | 83h11’ | 1.02 | 5.27 | 0 | 22.98 |
| **30 May** | 73.8 | 13.76 | 75h5’ | 1.17 | 4.84 | 0 | 31.33 |
| **9 June** | 87 | 15.52 | 47h15’ | 0.72 | 6.71 | 59.6 | 38.77 |
| **19 June** | 86 | 17.74 | 82h26’ | 0.82 | 4.46 | 28.3 | 42.26 |
| **2005** | | | | | | | |
| **11-20 May** | 63 | 11.8 | 29 h20’ | 2.5 | 7.1 | 35.2 | 3 |
| **21-31 May** | 77 | 14.5 | 118h53’ | 1.5 | 3.7 | 0.0 | 6 |
| **1-10 June** | 77 | 15.8 | 53h10’ | 2.6 | 6.5 | 21.8 | 19 |
| **11-20 June** | 76 | 16 | 74h20’ | 1.6 | 4.1 | 9.6 | 25 |

Standard deviations of the analysed factors (table 2) show that registered data have a great variation. The lowest standard deviation is registered for wind (-0.68 m/s), and relative air humidity (8.07 %); the greatest variation is found in case of dew factor (32.6 hours).

For correlation models there is used analysed factors exclusion method. There are resulting five regression models that demonstrate the existence of the interrelation among studied variables.

In table 3 are represented five multiple regression models that are resulting after calculus. For all the models correlation coefficient is greater then 0.7 that shows the interrelation among analysed variables there being a direct and moderated relationship. Direct relationship shows that the increase of the factors values included in model is determining the increase of the dependent factor – fungus attack intensity. Moderated intensity shows that there are in the same time other factors that are influencing the dependent factor, but they aren't included in this analysis. The same aspect is demonstrated by determination coefficient (R Square).

*Table 2*

Mean and standard deviation for analyzed factors

| Analysed variables | Mean | Standard deviation | N |
|---|---|---|---|
| intensity | 17.9913 | 12.41198 | 16 |
| air relative humidity | 75.7188 | 8.07327 | 16 |
| temperature | 15.8950 | 4.43988 | 16 |
| dew | 54.1650 | 32.60287 | 16 |
| wind | 1.3650 | 0.68885 | 16 |
| nebulosity | 5.3012 | 1.34358 | 16 |
| rainfalls | 21.3588 | 12.92842 | 16 |

*Table 3*

Multiple regression models resulted from statistic calculus

| Model | **R** | R Square | Adjusted R Square | Std. Error of the Estimate | Change Statistics | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | R Square Change | F Change | df 1 | df2 | Sig. F Change |
| 1 | **0.748(a)** | **0.560** | 0.266 | 10.63129 | 0.560 | 1.908 | 6 | 9 | 0.184 |
| 2 | **0.747(b)** | **0.558** | 0.337 | 10.10330 | -0.002 | 0.031 | 1 | 9 | 0.863 |
| 3 | **0.725(c)** | **0.526** | 0.354 | 9.97592 | -0.032 | 0.724 | 1 | 10 | 0.415 |
| 4 | **0.715(d)** | **0.511** | 0.389 | 9.70217 | -0.015 | 0.350 | 1 | 11 | 0.566 |
| 5 | **0.705(e)** | **0.497** | 0.419 | 9.45898 | -0.015 | 0.356 | 1 | 12 | 0.562 |

a Predictors: (Constant), rainfalls, wind, nebulosity, relative humidity, temperature, dew
b Predictors: (Constant), rainfalls, nebulosity, relative humidity, temperature, dew
c Predictors: (Constant), rainfalls, nebulosity, relative humidity, temperature
d Predictors: (Constant), rainfalls, relative humidity, temperature
e Predictors: (Constant), relative humidity, temperature

ANOVA (Analysis of Variance) is a procedure for variance analysis of the variable under the analysis of one/more then one variable (Table 4) – uni/bifactorial or multifactorial analysis model. In the case of multifactorial models with ANOVA we can present the way of the independent variables interaction between them each other and the effects of these interactions on dependent variables.

After the analysis of the data the most relevant can be considered the next:

- model number four, where the independent factors are considered rainfalls, relative air humidity, temperature. Between calculated value of *F* and table value is registered the $F \succ F_t$ relationship, respectively the result probability guaranty (*P*) is $4{,}183 \succ 3{,}49$.

*Table 4*

ANOVA results

| **Model** | | **Sum of Squares** | **Df** | **Mean Square** | **F** | **Sig.** |
|---|---|---|---|---|---|---|
| 1 | Regression | 1293,638 | 6 (l1) | 215,606 | 1,908 | 0,184(a) |
| | Residual | 1017,220 | 9 (l2) | 113,024 | | |
| | Total | 2310,858 | 15 | | | |
| 2 | Regression | 1290,091 | 5 | 258,018 | 2,528 | 0,099(b) |
| | Residual | 1020,767 | 10 | 102,077 | | |
| | Total | 2310,858 | 15 | | | |
| 3 | Regression | 1216,150 | 4 | 304,037 | 3,055 | 0,064(c) |
| | Residual | 1094,708 | 11 | 99,519 | | |
| | Total | 2310,858 | 15 | | | |
| **4** | **Regression** | **1181,272** | **3** | **393,757** | **4,183** | **0,030(d)** |
| | **Residual** | **1129,585** | **12** | **94,132** | | |
| | **Total** | **2310,858** | **15** | | | |
| **5** | **Regression** | **1147,717** | **2** | **573,858** | **6,414** | **0,012(e)** |
| | **Residual** | **1163,141** | **13** | **89,472** | | |
| | **Total** | **2310,858** | **15** | | | |

*Table 5*

Excluded factor analysis from model

| Model | | Beta In | t | Sig. | Partial Correlation | Collinearity Statistics | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | **Tolerance** | **VIF** | Minimum Tolerance |
| 2 | wind | -0,065(a) | -0,177 | 0,863 | -0,059 | **0,361** | **2,771** | 0,138 |
| 3 | wind | -0,180(b) | -0,734 | 0,480 | -0,226 | **0,745** | **1,343** | 0,275 |
| | dew | -0,335(b) | -0,851 | 0,415 | -0,260 | **0,285** | **3,514** | 0,188 |
| 4 | wind | -0,197(c) | -0,842 | 0,418 | -0,246 | **0,761** | **1,314** | 0,282 |
| | dew | -0,040(c) | -0,148 | 0,885 | -0,045 | **0,618** | **1,618** | 0,266 |
| | nebulosity | -0,150(c) | -0,592 | 0,566 | -0,176 | **0,670** | **1,492** | 0,287 |
| 5 | wind | -0,154(d) | -0,688 | 0,504 | -0,195 | **0,807** | **1,239** | 0,686 |
| | dew | 0,013(d) | 0,053 | 0,958 | 0,015 | **0,696** | **1,438** | 0,664 |
| | nebulosity | -0,115(d) | -0,475 | 0,644 | -0,136 | **0,698** | **1,432** | 0,675 |
| | rainfalls | 0,220(d) | 0,597 | 0,562 | 0,170 | **0,299** | **3,344** | 0,299 |

**-** model number five, where after the factor exclusion remain only relative air humidity and temperature. For this model the relationship between registered value and table value (*F* test) is $6{,}414 \succ 3{,}80$ with 1.2% result guarantee probability.

In conclusion, on the background of ANOVA analysis of analysed data we can confirm the fact that the variations from empirical data series as are air relative humidity, rainfalls and air temperature are relatively low, that meaning the null hypothesis ($H_0$) can be rejected for both models (four and five).

SPSS programme allow the analysis of the excluded factors from the model, which can provide pieces of information concerning their influence on obtained results (table 5).

Tolerance coefficient has a calculated value greater in case of wind variable that indicate a high colinearity degree with the other values from four and five model, this fact determining the registration of a variant inflation low degree (table 5).

## CONCLUSIONS

Finally we have found next aspects: the greatest influence on *Blumeria graminis f. spec. tritici* attack intensity increase is registered after the analysis of empiric data, the influencing factors being air relative humidity, rainfalls, and temperature.

The factor wind has a great importance and influence on the dispersal of conidia in case of *Blumeria graminis*, this being the reason that this factor mustn't be excluded from the model.

## LITERATURE


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