INTERACTION BETWEEN THE MAIZE PATHOSYSTEM COMPONENTS AND THE CLIMATIC FACTORS, THROUGH ANOVA–TYPE ANALYSIS AND CORRELATIONS BRAVAIS – PEARSON

INTERACȚIUNEA DINTRE COMPONENTELE PATOSISTEMELOR PORUMBULUI ŞI FACTORII CLIMATICI PRIN ANALIZA DE TIP ANOVA ŞI CORELAȚII BRAVAIS – PEARSON

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Abstract: *In the period 2006/2007, in Arad region, in the experience on 8 „Pioneer" maize hybrids, we studied the interaction between climatic factors, as independent variables, and the pathogens Helminthosporium turcicum, Fusarium roseum and Ustilago maydis, as pathosystem components whose aggression (F%) was used as dependent variable. In the statistical calculation of the variables mentioned, we used one of the best and most used statistical softwares, namely SPSS (Statistical Package for the Social Sciences).*

Regarding homogeneity, the high-degree factors were represented by „temperature", „relative humidity" and „wind speed", and the low-coefficient factors were „dew", „nebulosity" and the dependent factor, namely the aggression of pathogens within the maize pathosystems - F%=33.84%; „moderation" characterizes independent variables' influence on the dependent one.

Regarding the intensity the dependent variable (F%) is influenced by the climatic factors (independent variables) with, we observed: we may speak about strong influence when the climatic factors interfere, without „dew"; moderate influence – without „dew" and „nebulosity" and low influence – when only „wind speed" and „relative humidity", of the 6 independent factors (temperature, RH, rainfall, dew, nebulosity, wind), interact. „Moderation", too, characterizes the intensity of the correlation between influence factors and the resulting one.

By excluding factors, step by step, from the „model", the F%-favoring factors become evident, namely „temperature", „rainfall", „relative humidity", „nebulosity", „dew" and „wind", less favored, although the statistical tests „t", "SIG", "Tolerance" and "VIF" (Variance Inflator Factor) produce negative values only for „rainfall", „dew" and partially for „nebulosity".

ANOVA shows that the climatic factor with a major influence upon pathogen aggression is the „wind speed", but it considers other factors that are not included in the software SPSS, too; the independent factor with negative influence on the dependent factor is the „nebulosity".

The testing of the „influence" factors excluded from data analysis has not led to significant results, because the independent variables excluded from models present a low degree homogeneity (they are characterized by „moderation" at the amplitude inferior level), a fact proved by the values of the tests "t", "Sig", „Tolerance" and „VIF".

ANOVA specifies that „wind speed", a factor disseminating and amplifying pathogens' activity, is the variable with the biggest influence on the factor F (pathogens); although this factor has had low values (homogenous), the aggression of the pathogens Helminthosporium and Fusarium has had high values (84.3%; 46.7%) – the explanation or the original conclusion, in national premiere, is that the new maize pest Diabrotica virgifera virgifera Le Conté expressed its role of „dissemination" and „amplification" of the pathogen agents mentioned. The attack produced by Ustilago was reduced and constant (13.62 – 14.0%), given this pest's trophic attitude.

The conclusions regarding the independent variables, dew, nebulosity and wind speed, are original (confirming or denying the conclusions available in the literature), and also the software SPSS initiated in the case of the other independent variables, and on the resulting factor, as well.

Rezumat: *În perioada 2006/2007, în zona Arad, într-o experiență cu 8 hibrizi de porumb „Pioneer", s-a urmărit interacțiunea dintre factorii climatici, ca variabile independente, cu patogenii Helminthosporium turcicum, Fusarium roseum şi Ustilago maydis, ca elemente componente de patosistem şi a căror agresivitate (F%), ca*

variabilă dependentă. Pentru calculul statistic al variabilelor amintite s-a folosit softul SPSS (Statistical Package for the Social Sciences) ca unul dintre cele mai puternice şi utilizate programe statistice.
În privinţa omogenităţii, factorii cu grad ridicat au fost „ temperatura“, „umiditatea relativă“ şi „viteza vântului“, iar cei cu coeficientul de omogenitate scăzut sunt „roua“, „nebulozitatea“ şi factorul dependent, adică agresivitatea patogenilor din patosistemele porumbului - F%=33,84%; „moderaţia“ caracterizează influenţa variabilelor independente asupra celei dependente.
Referitor la intensitatea cu care variabila dependentă (F%), este influenţată de factorii climatici (variabile independente) a reieşit: influenţă puternică este atunci când interferează factorii climatici, fără „rouă“; influenţă moderată - fără „rouă“ şi „nebulozitate“ şi influenţă slabă - atunci când din cei 6 factori independenţi (temperatură, UR, precipitaţii, rouă, nebulozitate, vântul) interacţionează numai „viteza vântului“ şi „umiditatea relativă“. Tot „moderaţia“ caracterizează intensitatea corelaţiei dintre factorii de influenţă şi cel rezultativ.
Prin metoda de excludere a factorilor, rând pe rând, din „model“ ies la iveală factori favorizanţi ai F% -ului şi anume „temperatura“, „precipitaţiile“, „umiditatea relativă“, „nebulozitatea“, „roua“ şi „vântul“ , mai puţin favorizate, deşi testele statistice „t“,”SIG”,”Tolerance” şi “VIF”(Variance Inflator Factor) scot valori negative numai pentru „precipitaţii“, „roua“ şi parţial „ nebulozitate“.
ANOVA arată că factorul climatic cu influenţă majoră asupra agresivităţii patogenilor din patosistemele porumbului, este „viteza vântului“, dar ia în considerare şi factorii mai puţin favorizanţi şi prognozarea şi influenţa altor factori neincluşi în softul SPSS; factorul independent cu influenţă negativă asupra factorului dependent este„ nebulozitatea“.
Testarea factorilor de „influenţă“ excluşi din analiza datelor, nu au dus la rezultate semnificative, deoarece variabilele independente excluse din modele au un grad scăzut de omogenitate („moderaţia“ la nivel de prag inferior a amplitudinii le caracterizează), fapt demonstrat de valorile testelor – t., Sig. ,F.,Tolerance şi VIF.
ANOVA specifică că „viteza vântului“, factor de diseminare şi amplificare a agresivităţii patogenilor, este variabilă cu cea mai mare influenţă asupra factorului F (patogeni) ; faptul că acest factor dependent a avut valori slabe (omogene) totuşi agresivitatea patogenilor Helminthosporium şi Fusarium a avut valori ridicate (84,3%; 46,7%) – explicaţia sau concluzia originală şi în premieră naţională este că noul dăunător al porumbului Diabrotica virgifera virgifera Le Conté şi-a luat rolul de „diseminare“ şi de „amplificarea“ patogenilor agenţilor amintiţi. Atacul de Ustilago (tăciune) a fost redus şi constant (13,62 – 14,0%), dată fiind atitudinea trofică a dăunătorului.
Concluziile cu privire la variabilele independente, roua, nebulozitatea şi viteza vântului sunt originale (cu aură de confirmare sau infirmare a celor existente în literatură) ca de altfel şi softul SPSS iniţiat şi în cazul celorlalte variabile independente, dar şi asupra factorului rezultativ

Key words: Helminthosporium, Ustilago, Fusarium, Pathogen, pathosystem, aggression, temperature, rainfall, wind, relative humidity, dew, nebulosity, statistics.

INTRODUCTION

Maize pathosystems (*Zea mays - Helminthosporium turcicum* Pass; *Zea mays - Fusarium roseum f. cerealis* (Cke) Snyder and Hansen; *Zea mays - Ustilago zeae* (Beckm. Unger) have not been researched for almost 4 decades, excepting the Southern part of the country, where such activities have been performed (ANETA ELENA DRACEA, 1968; MARINA ŢÎRCOMNICU, 1971, O. COSMIN et al., 1977; N. CEAPOIU, FLOARE NEGULESCU, 1983; ELENA NAGY, 2004, etc).

Experimental data regarding the interaction between pathosystems’ pathogens and the climatic factors are presented, for the first pathosystem, by M.C SHURTLEFF (1980); H. CEBALLOS et al. (1991); S. BENTOLILA et al. (1991); P. VINCELLI et D.E. HERSHMAN (1997); P.E. LIPPS and D. MILLS (2002); P. VINCELLI (2004); ELENA NAGY (2004); D. ALDERMAN (2006); FLOAREA ADAM, GH. POPESCU (2007a), etc. In the case of the second pathosystem, this interaction is presented by AL. ALEXANDRI et al. (1969); J.C.

SUTTON (1982); J.D. MILLER (1994); L.M. REID and R.L. HALMILTON (2002); F. TRAIL et al. (2002); GH. POPESCU (2005); FLOAREA ADAM, GH. POPESCU (2007b), etc. Regarding the third pathosystem, this relationship is reminded by TR. SĂVULESCU (1957); AL. ALEXANDRI et al. (1969); EUGENIA ELIADE (1985); M. HATMAN et al. (1989); VIORICA IACOB, E.ULEA, I.PUIU (1998); ELENA NAGY (2004), etc.

The objective of our research was to observe the maize parasitism level, generated by pathosystems' pathogens, what are the climatic factors favoring pathogens, what is the trophic base that multiplies the „inoculum source", how does the genetic factor influence the host and the pathogens, respectively if there is a „risk" of remarkable losses at the moment.

MATERIAL AND METHOD

We researches maize pathosystems (*Zea mays - Helminthosporium turcicum*; *Zea mays - Ustilago zeae; Zea mays - Fusarium roseum)* in relationship with climatic factors, in the region Arad, during 2006-2007. Each pathogen of the system plant – host – parasite (pathosystem) was included into a biotrophic diversity represented by 8 Pioneer maize hybrids (PR 39 D81 – extra early; PR 38R92 - early; PR 38A24, PR 37D25, PR 37M34, PR 37W05 – mid early; PR 35P12, PR 36K67 – mid late). The expressions of the interaction between trophic base and pathogens were assessed through percentages of aggression and virulence in the pathosystem *Zea mays - Helminthosporium turcicum*, only through attack frequency in the other two systems; assessment of aggression. In the case of the first pathosystem, it was performed in concordance with an original method (FLOREA ADAM, GH. POPESCU, 2007). The interaction between pathosystems' components and climatic factors was included into a modern statistical analysis.

The study of the statistical relationships between the **dependent variable** – the pathogen (F%) within the pathosystem structure and the independent variables (temperature, relative humidity - %, rainfall – mm, wind speed – m/s, nebulosity – 0-10, dew – hours) was performed with the help of:

- method of dynamic indices - dynamics of variables as resulting factors (F% - the effect) and as factors of influence (climatic – the cause).

- ANOVA dispersional analysis (Analysis of variance); for hypothesis testing we applied the test F (Fischer).

- analysis of regression, correlation and colinearity; as regression model, we applied the one compatible with the multiple correlative analysis. The verification of model probability was performed according to the **test F**, to the **correlation coefficients – Pearson** (-1 and +1), the **determination coefficients** (0 and +1), to the concept Durbin-Watson (another possibility to confirm if there are or nor significant relationships between the resulting factors and the influencing ones) and to the colinearity coefficients, namely of **tolerance** and of variance inflation or VIF (Variance Inflation Factor). For the statistical calculation, we used the software SPSS, one of the best statistical softwares (IRINA ORIOL, 2002, 2004).

RESULTS AND DISCUSSIONS

The experimental data regarding pathogens' aggression (F% - resulting factor or of effect), within the structure of the 3 maize pathosystems, and also those related to the factors of influence (cause), namely climatic factors like temperature, relative humidity, rainfall, wind speed, nebulosity and dew are presented in table 1.

We may observe that there is a moderate correlation between the factors mentioned (t°, RH, wind speed) and that big variations occurred in dew, rainfall, nebulosity and pathogens' aggression – F% (all of them with 2 acrogens). The 2 variations with a character of independence with lower influence on the dependent factor (F %) are the dew, rainfall and nebulosity. In table 2, we may observe the homogeneity degree of the independent factors or variables, and also of the F% – the dependent variable, according to the values of the homogeneity coefficient chronologically presented. For example, the „moderate" factors, namely temperature, relative humidity and wind speed present the homogeneity coefficients with the lowest values (7.56%, 14.33%, 16.85%) – with a high degree homogeneity; those with big variations (excepting „nebulosity"), so with a quite low homogeneity degree, have big values: F% - 75.18%, dew – 73.75%, rainfall – 53.93%, nebulosity – 22.0%.

Table 1

Meteorological variables used in statistic calculus during the studied period (Aug – Sept.) 2006-2007

Pathogen agent	Observation data	Climatic factors (averages)						F%
		Temp. (°C)	Relative humidity (%)	Rainfall (mm)	Wind speed h=2m (m/s)	Total nebulosity (0-10)	Dew (hour	
2006								
Helminthosporium turcicum	1 August	23.1	64	65.3	1.5	3.2	130^{50}	37.7
	10 Sept.	19.6	74	81.8	1.5	5.6	108^{10}	56.3
Fusarium roseum	August	19.6	74	81.8	1.5	5.6	108^{10}	25.7
Ustilago zeae	August	19.6	74	81.8	1.5	5.6	108^{10}	7.58
2007								
Helminthosporium turcicum	1 August	24.0	52	41.2	1.7	3.3	31^{00}	47.7
	22 August	21.9	65.4	71.0	2.4	4.2	52^{05}	84.3
Fusarium roseum	22 Jul.	22.1	54	48	1.8	3.7	38^{05}	4.8
	5 August	20.2	57	6.8	2.0	4.1	7^{05}	46.7
Ustilago zeae	22 Jul.	22.1	54	48	1.8	3.7	38^{05}	13.62
	5 August	20.2	57	6.8	2.0	4.1	7^{05}	14.0
Average aggression attack % - 33.84								

Table 2

Mean and standard deviation for analyzed factors

Analyzed variables	Mean	Std. Deviation	Homogeneity coefficients
F%	33,8400	25,43987	75,18
Temp. (°C)	21,2400	1,606376	73,75
Rel. humid (%)	62,5400	8,96068	53,93
Rainfall (mm)	53,2500	28,71528	22,00
Wind speed (m/s)	1,7700	0,29833	16,85
Total nebul. (0-10)	4,3100	0,94804	14,33
Dew (hours)	62,8050	46,31728	7,56

Because we didn't observe any high degree homogeneity in the case of the independent variables, we must study their influence on F%. Regarding correlation models (4), we applied the exclusion method, step by step, from the model (table 3). So, model 1 excludes „dew"; model 2 excludes „dew" and „nebulosity"; model 3 excludes „dew", „nebulosity" and

„rainfall”, and model 4 excepts „dew”, „nebulosity”, „rainfall” and „temperature”. For this multiple regression analysis, the dependent factor was represented by the factor F, whose average aggression to the 8 „Pioneer” maize hybrids was 33.84% (tables 1 and 2). The intensity of the correlation or relationship between the dependent variable and the independent ones is given by the value of the coefficients of „correlation Pearson” (R), of „determination” (R SQUARE) and by the concept „Durbin – Watson”, presented in table 3. So, the strongest correlation characterizes the first „model” (0.833; 0.693; 1.950); on the opponent position, we may observe „wind speed” and „relative humidity”, components of the model 4 (0.58; 0.337; 1.862); in the case of the models 2 and 3, we may notice a moderate correlation between F% and the „influence” factors (table 3). Only model 2 (wind, rainfall, relative humidity, temperature) have the factor F Sig. of almost 5% (0.414).

In the case of this multifactorial model, with application of ANOVA in all models 91 – 4), we achieved, between the calculated value F (Fc) of the test and the table value (Ft), the relationship Fc<Ft, namely 1.809<9.01 (model 1), with a probability P of results ensuring of 2.93%; 2.127<6.39 (model 2) - P=2.15%; 2.579<5.41 (model 3) - P=1.49%; 1.777<5.14 - P=2.38% (table 4). The conclusion is that the biggest influence upon the factor F is wind speed, with the regression coefficient of 0.438, where the calculation significance is 0.103, and the factor „nebulosity” has a negative influence (-0.036 – 0.461) – table 5.

However ANOVA shows that there are factors whose influence is present, but their action is not so significant (tables 4 and 5), given their low homogeneity, and it does not exclude the existence of other factors, too, that are not included in the software SPSS, and which might exert a stronger influence.

If there is correlation between the factors and the independent variables (table 5), where we may observe direct, inverse, low or significant relationships, and the coefficients' values show that the results are ensured with values between 1.49-2.93%, so that a probability (P) of below 5% (table 5)? Then the testing of the „influence” factors excluded from data analysis, respectively from models 2, 3 and 4, specified below table 6, would make evident the following:

- nebulosity (model 2), if it was excluded, would have increased the aggression of pathogens within the maize pathosystems with 1.076 units (a unit includes nebulosity in model 3, rainfall and temperature in model 4); the dependent factor F% and rainfall (-0.639) in model 3 and nebulosity (-0.715) in model 4 would have decreased. Unfortunately, the values of the other statistical tests, namely „t”, „SIG”, „Tolerance” and „VIF” show that data have a low homogeneity degree.

Table 3

Multiple regression models resulted from statistic calculus

Model	R	R Square	Adj. R Square	Std. Err. of the estimate	Change statistics			Durbin - Watson
					R Square Change	F Change	Sig. F. Change	
1	0,833[a]	0,693	0,310	21,132	0,693	1,809	0,293	1,950
2	0,794[b]	0,630	0,334	20,766	-0,064	0,829	0,414	2,505
3	0,750[c]	0,563	0,345	20,591	-0,067	0,899	0,387	2,731
4	0,580[d]	0,337	0,147	23,492	-0,227	3,112	0,128	1,862

a. Predictors: (Constant), Neb., Wind Sp., Rainf., Rel. humid.,Temp.

b. Predictors: (Constant), Wind Sp., Rainf., Rel. humid.,Temp.

c. Predictors: (Constant), Wind Sp., Rel. humid.,Temp.

d. Predictors: (Constant), Wind Sp., Rel. humid.

Table 4

Analysis of variance results

Model		Sum of Squares	df	Mean Square	F	F tab. 5%	Sign.
A		1	2	3	4	5	6
1	Regression	4038,366	5	807,673	1,809	9,01	0,293 [a]
	Residual	1786,319	4	446,580			
	Total	5824,685	9				
2	Regression	3668,372	4	917,093	2,127	6,39	0,215 [b]
	Residual	2156,312	5	431,262			
	Total	5824,685	9				
3	Regression	3280,645	3	1093,548	2,579	5,41	0,149 [c]
	Residual	2544,040	6	424,007			
	Total	5824,685	9				
4	Regression	1961,337	2	980,669	1,777	5,14	0,238 [d]
	Residual	3863,347	7	551,907			
	Total	5824,685	9				

a. Predictors: (Constant), Neb., Wind Sp., Rainf., Rel. humid.,Temp.
b. Predictors: (Constant), Wind Sp., Rainf., Rel. humid.,Temp.
c. Predictors: (Constant), Wind Sp., Rel. humid.,Temp.
d. Predictors: (Constant), Wind Sp., Rel. humid.

Table 5

Matrix of correlation coefficient

		F	Temp. (°C)	Rel. humid. (%)	Rainfall (mm)	Wind speed (m/s)	Total nebul. (0-10)
Pearson Correlation	F	1,000	0,172	0,159	0,155	0,438	-0,036
	Temp. (°C)	0,172	1,000	- 0,649	-0,125	0,144	0,867
	Rel. humid. (%)	0,159	-0,649	1,000	0,769	-0,424	0,861
	Rainfall (mm)	0,155	-0,125	0,769	1,000	-0,467	0,544
	Wind speed (m/s)	0,438	0,144	-0,424	-0,467	1,000	-0,345
	Total nebul. (0-10)	-0,036	-0,867	0,861	0,544	-0,345	1,000
Sig. (1 – tailed)	F		0,317	0,330	0,335	0,103	0,461
	Temp. (°C)	0,317		0,021	0,365	0,346	0,001
	Rel. humid. (%)	0,330	0,021		0,005	0,111	0,001
	Rainfall (mm)	0,335	0,365	0,005		0,087	0,052
	Wind speed (m/s)	0,103	0,346	0,111	0,087		0,165
	Total nebul. (0-10)	0,461	0,001	0,001	0,052	0,165	

Table 6

Excluded factor analysis from model (tests stat. – t. Sig., Tolerance and VIF – Variance Inflation Factor)

Model	Beta In	t	Sig.	Partial Correlation	Colinearity Statistic	
					Tolerance	VIF
2. Total nebul. (0-10)	1,076 [a]	0,910	0,414	0,414	0,055	18,243
3. Total nebul. (0-10)	0,104 [b]	0,107	0,919	0,048	0,092	10,924
Rainfalls (mm)	-0,639 [b]	-0,948	0,387	-0,390	0,163	6,128
4. Total nebul. (0-10)	-0,715 [c]	-1,223	0,267	-0,447	0,259	3,866
Rainfalls (mm)	0,311 [c]	0,597	0,573	0,237	0,384	2,604
Temp. (°C)	0,637 [c]	1,764	0,128	0,584	0,558	1,791

a. Predictors in the model: (Constant), Wind Sp., Rainf., Rel. humid.,Temp.
b. Predictors in the model: (Constant), Wind Sp., Rel. humid.,Temp.
c. Predictors in the model: (Constant), Wind Sp., Rel. humid.
d. Dependent Variable: F%

CONCLUSIONS

1. Regarding homogeneity, the factors with a high degree homogeneity were „temperature", „relative humidity" and „wind speed", and the factors with a low coefficient of homogeneity were „dew", „nebulosity" and the dependent factor, namely the aggression of pathogens within maize pathosystems - F%=33.84%; „moderation" characterized the influence exerted by the independent variables on the dependent one.

2. Regarding the intensity the dependent variable (F%) is influenced with by the climatic factors (independent variables), we observed that: we may speak about **strong influence** when the climatic factors interfere, without „dew"; **moderate influence –** without „dew" and „nebulosity" and **low influence** - when only „wind speed" and „relative humidity", of the 6 independent factors (temperature, RH, rainfall, dew, nebulosity, wind), interact. „Moderation", too, characterizes the intensity of the correlation between influence factors and the resulting one.

3. By excluding factors, step by step, from the „model", the F%-favoring factors become evident, namely „temperature", „rainfall", „relative humidity", „nebulosity", „dew" and „wind", less favored, although the statistical tests „t", "SIG", "Tolerance" and "VIF" (Variance Inflator Factor) produce negative values only for „rainfall", „dew" and partially for „nebulosity".

4. ANOVA shows that the climatic factor with a major influence upon pathogen aggression is the „wind speed", but it considers other factors that are not included in the software SPSS, too; the independent factor with negative influence on the dependent factor is the „nebulosity".

5. The testing of the „influence" factors excluded from data analysis has not led to significant results, because the independent variables excluded from models present a low degree homogeneity (they are characterized by „moderation" at the amplitude inferior level), a fact proved by the values of the tests "t", "Sig", „Tolerance" and „VIF". The conclusions regarding the independent variables, dew, nebulosity and wind speed, are original (confirming or denying the conclusions available in the literature), and also the software SPSS initiated in the case of the other independent variables, and on the resulting factor, as well.

6. ANOVA specifies that „wind speed", a factor disseminating and amplifying pathogens' activity, is the variable with the biggest influence on the factor F (pathogens); although this factor has had low values (homogenous), the aggression of the pathogens Helminthosporium and Fusarium has had high values (84.3%; 46.7%) – the explanation or the original conclusion, in national premiere, is that the new maize pest Diabrotica virgifera virgifera Le Conté expressed its role of „dissemination" and „amplification" of the pathogen agents mentioned. The attack produced by Ustilago was reduced and constant (13.62 – 14.0%), given this pest's trophic attitude.

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