GENETIC MODELS CONCERNING PLANT RESISTANCE AT DISEASES WITH SPECIAL REFERRING TO POWDERY MILDEW PRODUCED BY *BLUMERIA GRAMINIS* F. SPEC. TRITICI

MODELE GENETICE PRIVIND REZISTENȚA PLANTELOR LA BOLI CU REFERIRE LA FĂINAREA GRÂULUI CAUZATĂ DE *BLUMERIA GRAMINIS* F. SPEC TRITICI

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Abstract: *Concerning plant resistance for diseases, respectively of the genes is activating as it follows: non-specific genes – non-specific resistance and specific genes – specific resistance, this classification being realised on the background of "genes functionality". In this work are presented models of non-specific genetic resistance that has as models synthesis works "SA, JA, ethylene and disease resistance in plants" by XINIANG DONG and "Infection structures of biotrophic and hemibiotrophic fungal plant pathogens" by SARAH E. PERFECT, JONATHAN R. GREEN. Non-specific or conservative resistance is expressed with the help of plant phenotype with the help of a response of systemic acquired resistance – SAR and induced systemic resistance – ISR. SAR path that helps the plants to avoid diseasing with powdery mildew are: hypersensitive resistance (RH), salicylic acid (SA), jasmonic acid (JA), ethylene, calmodulin (CA^{++}) and perhydrole (H_2O_2). ISR is a plant response for physiopathic factor, non-infectious and for the infectious factor. During 2003-2004 at S.C.D.A. Lovrin where implemented 27 wheat varieties in SAR and ISR and we have concluded next aspects: resistance is determined by non-specific genes and their activity are leading in time in wheat plant cells defensive proteins for pathogen factors (PR) preserved by PAMPs (Pathogen associated molecular patterns) and salvation as in case of physiopathic factors. These two variants (defending and curing) are implying to provide biological and organic wheat harvests, qualitative and quantitative.*

Rezumat: *Cu privire la clasificarea rezistenței plantelor la boli se prezintă astfel: gene nespecifice – rezistența nespecifică şi gene specifice – rezistența specifică, o clasificare care are la bază ,,funcționalitatea genelor". În lucrarea de față se prezintă rezistența genetică nespecifică, care are ca modele lucrările de sinteză ,,SA, JA, ethylene and disease resistance in plants" de XINIANG DONG" şi ,,Infection structures of biotrophic and hemibiotrophic fungal plant pathogens" de SARAH E. PERFECT, JONATHAN R. GREEN. Rezistența nespecifică sau conservativă se exprimă în fenotipul plantelor printr-un răspuns de ,,rezistență dobândită sistemic" – SAR- (Systemic acquired resistance) şi ,,r. indusă sistemic" – ISR-Induced systemic resistance. Căile SAR-ului prin care plantele evită îmbolnăvirea de făinare sunt: rezistența hipersenzitivă (RH), acidul salicilic (SA), acidul iasmonic (JA), etilena, calmodulinul (CA^{++}) şi perhidrolul (H_2O_2). ISR-ul este un răspuns al plantelor față de factorul fiziopatic, deci neinfecțios cât şi față de cel infecțios. În perioada 2003-2005, la SCDA Lovrin, 27 de soiuri de grâu au fost implementate în SAR şi ISR şi am ajuns la concluziile: rezistența este determinată de gene nespecifice, prin a căror activitate în timp, produc în celulele plantelor proteine de apărare care privesc factorii patogeniei (PR) conservați de PAMPs (Pathogen associated molecular patterns) şi de vindecare sau salvare în cazul factorilor fiziopatici. Cele două variante, de apărare şi videcare, se implică în asigurarea unor recolte de grâu biologice sau organice calitativ şi cantitativ.*

Key words**:** *genes, powdery mildew, specific and non-specific resistance, ethylene, calmodulin, perhydrole.*
Cuvinte cheie: *gene, făinare, rezistența specifică şi nespecifică, etilena, calmodulin, perhidrol.*

INTRODUCTION

Concerning plant resistance for diseases classifying, respectively genes classifying, the terminology adopted in this work (and expressed also by other researchers) is next: non-specific genes – non-specific resistance and specific genes – specific resistance, this classification being realised on the background of "genes functionality". In this work are presented models of non-specific genetic resistance that has as models synthesis works "*SA, JA, ethylene and disease resistance in plants*" by XINIANG DONG and "*Infection structures of biotrophic and hemibiotrophic fungal plant pathogens*" by SARAH E. PERFECT, JONATHAN R. GREEN.

Non-specific or conservative resistance is expressed with the help of plant phenotype with the help of a response of systemic acquired resistance – SAR and induced systemic resistance – ISR.

SAR path that helps the plants to avoid diseasing with powdery mildew are: hypersensitive resistance (RH), salicylic acid (SA), jasmonic acid (JA), ethylene, calmodulin (CA^{++}) and perhydrole (H_2O_2). Calcium ions and perhydrole, together with jasmonic acid (JA) and ethylene are considered curing factors for trauma mediating thionine proteins (THI) and defensive proteins (PDF) proteins synthesis, or factors of physiopathic response (X. DONG, 1998). Calmoduline and perhydrole are elements of systemic acquired resistance – SAR that must to stay in the front of non-pollutant protection of biological or organic whet for bread.

Induced systemic resistance – ISR is a response of the plants against physiopathic or non-infectious factor and against the infectious. The phenomenon noticed by C. M. J. PIETERSE *et al*. (1969) and confirmed by S. C. M. VAN WEES *et al*. (1997) is determined on plants roots colonized by bacteria antagonist against iron consuming parasitic fungi, in fact variants for nutritional competition and microbial antagonism from biotherapy (GH. POPESCU, 1998)

During 2003-2004 period at S.C.D.A. Lovrin where implemented 27 wheat varieties in SAR and ISR.

MATERIAL AND METHOD

Biologic material analysed here is represented by 27 winter wheat varieties that forms a comparative crop with I.C.D.A. Fundulea provenience.

Incidence average (F %) and severity or virulence (I %) are marked on 0-5 scale where a unit represents 20% from plant surface attacked by fungus. Great differences can appear even there is working with the same scale because the result is influenced in a great measure by analyse sample size after N. MC. ROBERTS *et al*. (2003), and in our conception by the person which is registering the data in field (OTILIA COTUNA, GH. POPESCU, 2005, 2006).

They are considering the intensity or the attack degree of the less sensitive variety from an experimental year as equal with 100%, and the values registered for the other varieties are reported as percentage to this variety.

RESULTS AND DISCUSSIONS

Wheat (*Triticum aestivum*) and *Blumeria graminis* fungus are subsystems linked between them through existent connections from a complex system named by R. S. ROBINSON (1979) as pathosystem. Because the fungus has a biotrophic nutrition the interactions are following the next motto "*Live and let live*" from the point of view of RALPH PANSTRUGA *et* PAUL SCHULZ–LEFERT (2002). In this case, every subsystem must to elaborate genetic structures and mechanisms to make

it able to evolve. Mentioned partners have acted for common evolution until now, so the interactions were realising a coevolutionary system on the background of genes activity.

Non-specific genetic resistance is determined by non-specific genes, and they are producing in plant cells defending proteins or antimicrobial (AMP) through their activity in time. These are concerning pathogen factors (PR) preserved by PAMPs and curing or saving factors in case of physiopathic factors. These two variants (defending and curing) are implying in the realisation of constant harvests from qualitative and quantitative point of view and non-pollutant.

Concerning non-specific resistance or conservative we can say next: pathogen complementary proteins (PCP) from epidermal cell membrane aren't recognizing the conservative genome of the pathogen (FCPs) but they intervene in their transmembranation, with other words its inoculation in plant cells cytoplasma where is recognized as gene/protein or complementary recognition receptor (RR).

Activity start of the genes that are weakening fungus pathogenic virulence (GP) is realised usually with the help of SAR mediators or "*VIA*" RDS as it follows: oxidative explosion of epidermal cell (ROS), RH expression (hypersensitive resistance), AS presence (salicylic acid), calmodulin presence (Ca^{++}), iasmonic acid presence (AJ), ethylene and perhydrole and also the presence of systemic induced resistance (RIS) from the roots level. In the case of *Triticum aestivum–Blumeria graminis f. sp. tritici* pathosystem, during 2003-2005 in "*VIA*" of non-specific resistance aren't implemented RH (hypersensitive resistance), iasmonic acid (AJ) and ethylene.

The proof is the lack of oxidative explosion of epidermal cells of wheat (ROS) in case of studied winter wheat varieties. Salicylic acid is considered as indispensable factor for wheat defence against powdery mildew is normal that in SAR to not be implied jasmonic acid (JA) and ethylene because those two plant hormones are blocked in the presence of the mentioned factor.

Usually the *Blumeria* antifungal genes/proteins have in *VIA*" of non-specific resistance salicylic acid (AS), calmodulin presence (Ca^{++}), and perhydrole (H_2O_2) as signallisers in defending , that until at the activity start of resistance genes are weakening the virulence of pathogeny genes (GP) from fungus.

Systemic acquired resistance or SAR is manifesting in case of varieties Ardeal, Fundulea 4, Holda, Dropia, Renan that showed 15% total resistance and with anamorphic and telomorphic potential of 21.35%, and conform with efficiency scale those varieties have satisfactory efficiency qualificative (ES) (fig. 1).

Because of the fact that these varieties were instable concerning antifungal reaction during 2003-2005, manifesting a changeable complementary pattern against physiological races of *Blumeria graminis f. sp. tritici* have determined their framing in non-specific resistance group with other 17 wheat varieties where Pm genes became inefficient from efficient loosing their resistance action. In this case, non-specific resistance has 82% from the total of functional resistance of wheat against powdery mildew (27 winter wheat varieties), and from the point of view of plant surface covered with powdery mildew mycelia this is 59.5% (21.35 % MR + 38.2% S) having a unsatisfactory efficiency (EN) (fig.1).

Wheat varieties with non-specific resistance but productive can be helped in their *Blumeria graminis f. sp. tritici* antifungal activity with specific signalisers (SAR) as is salicylic acid, calmodulin and perhydrole, or with chemical treatments where to be used fungicides verified during time (copper and sulphur compounds) or triazolic substances that are totally metabolized by plants, without ppm and LMA.

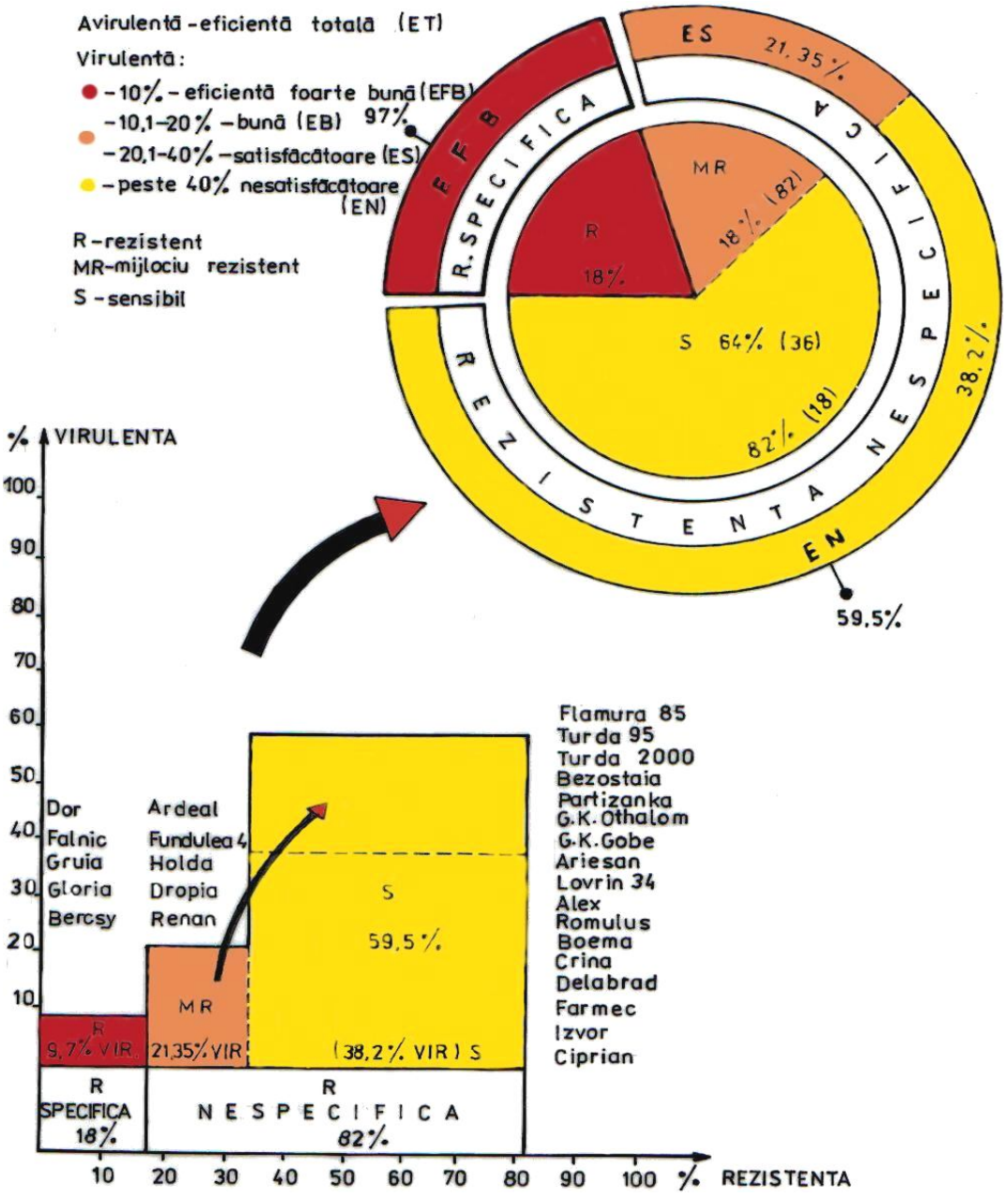

Fig.1. Control efficiency of specific and **non-specific** genetic efficiency of winter wheat against powdery mildew

Wheat varieties with powdery mildew resistance genes are losing this feature after a period of time after their introduction in culture, so they are loosing this kind of efficiency in disease control (N. CEAPOIU, FLOARE NEGULESCU, 1983; OTILIA COTUNA, GH. POPESCU, 2006) becoming sensitive. In this way specific resistance Pm have past in non-specific resistance as is the case of Flamura 85, Turda 95, Turda 2000, Bezostaia, Partizanka, G. K. Othalom, G. K. Göbe, Arieşan, Lovrin 34, Alex, Romulus, Boema, Crina, Delabrad, Farmec, Izvor and Ciprian varieties.

Systemic induced resistance is dependent to jasmonic acid (JA) and ethylene. Mentioned hormones are determining ISR to cure the root injuries and are implying in infectious agent therapy with the help of thionine proteins (THY 2.1) mediation (X. DONG, 1998).

CONCLUSIONS

Non-specific or conservative resistance named also SAR (*Systemic Acquired Resistance*) is the response of the genes from wheat varieties to the fungus conservative genome action or PAMPs (*Pathogen Associated Molecular Patterns*). Proportion of the manifestation is 82%, and the efficiency in control is represented by Ardeal, Fundulea 4, Holda, Dropia and Renan varieties, with a fungus anamorphic and telomorphic coverage potential of 21.35%, which is instable during 2003-2005. These weren't efficiently supported by specific signalisers (salicylic acid, calmodulin, and perhydrole), and by sensitive varieties (17) is unsatisfactory.

Specific resistance genes are singular but powerful, usually allelic, and systemic acquired resistance non-specific genes or mixed genes are exteriorizing in the winter wheat varieties phenotype a defending synergism or antifungal activity superior in comparison with a the separated induced type, providing a genetic control of wheat powdery mildew with partial protection.

Isn't excluded that genetic control to determinate protection and total efficiency trough natural selection, through receptor proteins elimination from wheat epidermal cell membrane. This elimination is blocking blocked evolutionary pathogenic factors (AVR) or conservative PAMPs factors of *Blumeria graminis f. sp. tritici.*

Knowledge of specific and non-specific resistance of wheat for powdery mildew is very important for agricultural practice because these two genetic activity forms can be implied to provide biological and organic wheat harvests, qualitative and quantitative.

REFERENCES

1. CEAPOIU N., NEGULESCU FLOARE, 1983 - *Genetica şi ameliorarea rezistenței la boli a plantelor*. Ed. Acad RSR, Bucureşti, 298 p.
2. COTUNA OTILIA, GH. POPESCU, 2005a - *Contributions to Blumeria graminis f. spec. tritici (DC) Speer fungus (powdery mildew) inoculus potential knowledge depending on infected wheat genotypes.* Scientifical papers Faculty of agric., XXXVII, 610- 615, Ed . Agroprint, Timişoara .
3. COTUNA OTILIA, POPESCU GH., 2006a - *Răspândirea raselor fiziologice (patotipuri) de făinare la grâul de toamnă (Blumeria graminis f. spec. tritici (DC) Speer, în partea de vest a României.* Simpozionul internațional pentru studenți, masteranzi şi doctoranzi-10 martie 2006 .
4. DONG X., 1998 – *SA, JA, Etylene, and disease resistance in plants*. Current Opinion, in Plant Biology, 1, 316–323.
5. PIETERSE C. M. J., VAN WEES S. C. M., HOFFLAND E., VAN PELT J. A., VAN LOON L. C., 1996 - *Systemic resistance in Arabidopsis induced by biocontrol bacteria is independent of salicylic acid accumulation and pathogenesis-related gene expression.* Plant Cell, 8, 1225-1237.

6. PERFECT S. E., GREEN J. R., 2001 – *Infection structures of biotrophic fungal plant pathogens.* Molecular Plant Pathology 2 (2), 101-108.
7. POPESCU GH., 1998 **–** *Fitopatologie generală*, vol. I. Ed. Mirton Timişoara, 289p
8. PANSTRUGA R., SCHULZE-LEFERT P., 2002 - *Live and let live: insights into powdery mildew disease and resistance.* Molecular plant pathology. 2002 Nov. 3(6) p. 495-502.
9. ROBINSON R. S., 1979 - *Permanent and impermanent to crop parasites; A re-examination of the pathosystem concept with special reference to rice blast*, Z. Pflanzenzüchtung., 83, 1, 1-39.
10. VAN WEES S. C. M., PIETERSE C. M. J., TRIJSSENAAR A., VANT WESTENDE YAM, HARTOG F., VAN LOON L. C., 1997 - *Differential induction of systemic resistance in Arabidopsis by biocontrol bacteria.* Mol. Plant. Microbe-Interact., 10, 716-724.