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# Dynamics of distribution of the cause agent of powdery mildew Blumeria graminis tritici on wheat during 2005-2009

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**Abstract**

Powdery mildew is one of the most important diseases on wheat in regions with cool and moderate climate. Depending on the climatic conditions, yield losses may vary from 5 % to 45 %. The harmfulness of the pathogen is dependent both on the climatic factors and on the resistance of the cultivars. The dynamics of development and distribution of *Blumeria graminis tritici* in the region of Dobrudzha Agricultural Institute was followed during 2005 – 2009. Twenty lines and varieties of wheat were involved in the investigation. The dynamics of propagation of the pathogen's population in the wheat crop was highly variable over years according to the climatic conditions and the presence of virulence in the distributing population of the pathogen. Significant propagation was observed in the individual years when the maximum temperatures were over 10 °C. When temperatures exceed 25 °C, the formation of conidiospores ceased gradually. Regardless of the variable conditions over the investigated years, the observation is that there is predominance of certain virulence, which is an indication that there is effect of the genetic potential for resistance of the cultivars as well. Highest attacking rate was registered in the populations of the pathogen with virulence V-1, V-2+, V3c, V-4a, V-4b, V-6, V-7, V-8, V-2+8 and V-Mil. The virulent populations V-2+6, V-2+4+6, V-5+6 and V- Mld had low rate of propagation.

**Keywords:** powdery mildew, *Blumeria graminis tritici*, virulence, pathogen

## Introduction

Powdery mildew is one of the most important leaf diseases on wheat in regions with cool and moderate climate. Depending on the climatic conditions, the yield losses may vary from 5 % to 45 % over countries and years (Namuco et al., 1987). Besides the climatic factors, the harmfulness of the pathogen is also dependent on the resistance of the cultivars used in production.

One of the most reliable methods for reducing the losses caused by the disease is developing of cultivars with certain resistance to the pathogen. Due to the high genetic variability in the *Blumeria graminis* f.sp. *tritici* populations, the breeding approach is a difficult method (Iliev, 1990, 1996, 2002; Iliev, 1992, 1996, 1999). The regular observations on the local population are necessary for determining the process of development and distribution of the pathogen and for the choice of the best strategy of breeding for resistance.

The aim of this investigation was to follow the dynamics of development and distribution of the cause agent of powdery mildew in wheat in the region of Dobrudzha Agricultural Institute during 2005 – 2009.

## Materials and Methods

The investigation involved the same lines and varieties used in our previous studies (Iliev 2002, 2003) – Axminster n Cc 8 – with gene for resistance Pm 1, Ulka n Cc 8 – with Pm 2, Idead 59 b x Cc 8 – with Pm 2+, Asosan x Cc 8 – with Pm 3a, Chul x Cc 8 – with Pm 3b, Sonosa x Cc – with Pm 3c, Khapli x Cc 8 – with Pm 4a, Weihenstephan M 1 x Cc – with Pm 4b, Hope x Cc 8 – with Pm 5, Mich. Amber x Cc 8 – with Pm 6, varieties: Transec with Pm 7, Kavkaz – with Pm 8, Amigo – with Pm 17, Normande – with Pm 1+Pm 2 + Pm 9, Ci 12633 – Pm 2 + Pm 6, Coker 983 – Pm 5 + Pm 6, Halle Stamm 13471 with Mld, Granada – Pm 5 + Pm 8 , Dolomit – with Mli, C – 39 – with Pm 2 + Pm 4 + Pm 6. The seeds from the lines were sown in plastic pots and grown till stage second leaf in isolation to avoid possible infection with powdery mildew. After stage second leaf, the plants were transferred to the wheat crop and the insulators were removed. The plants remained in the field for 8 hrs, then were again covered with insulators and taken back to the greenhouse for further growing. During the time the plants remained in the field, there was a chance of being infected with a population of the pathogen developing in the crop.

Readings on the attacking rate of the pathogen were done on the 10th day, in % from 1 to 100 (Peterson et al. 1949), and on the type of infection according to the 0-4 scale of Mains and Dietz (1930). Based on the obtained results, the corrected relative attacking rate was calculated according to the highly susceptible monogenic line Mich. Amber x Cc 8 (Pm 6), which was used as a standard in this case. The calculated values were comparable both between themselves and by year of investigation, so that it was possible to determine the dynamics of distribution of the variable virulence in the population of the pathogen which was propagating in the investigated field.

The investigation on the dynamics was carried out at 7-day intervals. The transfer of plant to field started at the end of February or beginning of March and was terminated in the middle of June.

**Results and discussion**

The results from the investigation by year are given in Tables 1,2,3,4 and 5. The dynamics of propagation of the pathogen's population in the wheat crop varied significantly depending on the climatic conditions. On the other hand, the variation was dependent also on the available virulence in the expanding population of the pathogen. The high variability of the climatic conditions over years was typical for the period of investigation.

The spring of 2005 was characterized with good moisture reserves and transfer of conidiospores occurred as early as 16th February (Table 1). At the next taking out of plants to the wheat field (2nd March), transfer of conidiospores was not detected. On 9th March conidiospores were once again registered and transfer from the pathogen's populations which were virulent to the genes for resistance Pm1, Pm 2, Pm 4b, Pm 5, Pm 7, Pm 8 and Pm Mli was detected. This part of the pathogen's population formed viable conidiospores first.

In 2006, transfer of conidiospores was detected on 22nd February during the first taking out of plants in the investigated wheat field (Table 2). During 28th February – 14th March no other transfer of conidiospores was registered. This period was characterized with low temperatures, the minimal being –8.5°C, and the mean diurnal not exceeding 3.1°C. Formation of viable conidiospores in the greater part of the population was again observed on 21st March. In contrast to 2005, in 2006 lower competitiveness was observed between the populations of different virulence, as well as lower rate of distribution of these populations. The populations overcoming the resistance of genes Pm 3c, Pm 4a, Pm 4b, Pm 6, Pm 17, Pm 2+8, Pm Mli, Pm1, Pm 2, Pm 5 and Pm 8 were with the highest rate of distribution. The populations with virulence V-3b, V-1+2+9, V-5+6 and V-Mld demonstrated low rate of distribution. Transfer of conidiospores from the populations with V-2+6 and V-2+4b+6 was noted only once, on 22nd February and 19th April, respectively. In 2007 the first taking out of plants to the field was one month later than in 2005 and 2006 and transfer of conidiospores was observed from the greater part of the pathogen's populations.

Year 2007 was characterized with lower amount of rainfalls during the investigation (66.0 l/m2), but nevertheless development of all populations of the pathogen was observed, as well as high rate of the distribution of most of them (Table 3).

The populations overcoming the resistance of genes Pm Mli, Pm 2 + 4b + 6 and Pm 5 + 6 were with low rate of distribution.

In 2008, at the first taking out of the plants to the investigated field on 21st March, transfer of conidiospores was detected in those populations of the pathogen which possessed virulent genes overcoming the resistance of Pm 1, Pm 3c,Pm 4a, Pm 6, Pm 7, Pm 17 Pm and 1 + 2 + 9 (Table 4). The conditions in 2008 were comparatively good for propagation of the pathogen and high competitiveness was observed with regard to the populations of different virulence.

The high variability was accompanied also with comparatively high rate of distribution of the individual populations. In 2007 and 2008, besides development of all populations which differed by virulence and which were identified in the reset of the years as well, a high rate of distribution of the populations with virulence V-1, V-3c, V-4a, V-4b, V-6, V-7, V-8, V-2+8,V-2+ and V-Mli was also observed. The climatic conditions of 2007 and 2008 differed, mainly by the amount of rainfalls. The precipitation during April-May of 2008 was 196.5 l/m2, and in 2007 the rainfalls during the same period were 50.8 l/m2.

**Table1.** Dynamics of powdery mildew development in 2005

| № | Year | Varieties and monogenic *Pm* lines | | | | | | | | | | | | | | | | | | | | Temperature | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2005** | ***Pm 1*** | ***Pm 2*** | ***Pm 2+*** | ***Pm 3a*** | ***Pm 3b*** | ***Pm 3c*** | ***Pm 4a*** | ***Pm 4b*** | ***Pm 5*** | ***Pm 6*** | ***Pm 7*** | ***Pm 8*** | ***Pm 17*** | ***Pm1+2+9*** | ***Pm 2+6*** | ***Pm 5+6*** | ***Pm Mld*** | ***Pm 2+8*** | ***Pm Mli*** | ***Pm 2+4b+6*** | **Mean diurnal** | **Max.** | **Min.** |
| 1 | 16.02 | 0.8 | 0.8 | 10 | 0.8 | 0.8 | 0.8 | 10 | 0.8 | 0.8 | 10 | 10 | 10 | 0 | 0.6 | 0.8 | 0.6 | 0 | 20 | 10 | 0 | 7.4 | 10.4 | 5.0 |
| 2 | 23.02 | 20 | 20 | 10 | 10 | 0.8 | 10 | 10 | 10 | 10 | 40 | 0 | 20 | 0.6 | 10 | 0.6 | 0.6 | 40 | 20 | 0.8 | 0.8 | 6.9 | 10.0 | 4.0 |
| 3 | 2.03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | -2.0 | -10.0 |
| 4 | 9.03 | 0.8 | 0 | 0.8 | 0 | 0 | 0 | 0 | 0.8 | 0.8 | 0 | 0.6 | 0.8 | 0 | 0 | 0 | 0 | 0 | 0 | 0.8 | 0 | -0.2 | 5.2 | -5.2 |
| 5 | 15.03 | 30 | 20 | 10 | 10 | 10 | 20 | 20 | 30 | 10 | 20 | 50 | 30 | 0.6 | 10 | 0.8 | 0.8 | 0.6 | 20 | 50 | 0.8 | 8.2 | 15.3 | 0.8 |
| 6 | 23.03 | 30 | 0.8 | 10 | 10 | 0 | 20 | 20 | 20 | 10 | 10 | 30 | 10 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 20 | 30 | 0.8 | 3.8 | 9.5 | -2.5 |
| 7 | 30.03 | 20 | 10 | 10 | 0.8 | 0.8 | 10 | 10 | 10 | 10 | 10 | 20 | 0.8 | 0.8 | 0.8 | 0 | 0 | 0.8 | 10 | 0.8 | 0 | 4.4 | 7.0 | 2.5 |
| 8 | 5.04 | 0.8 | 0 | 0 | 0.8 | 0.8 | 0.8 | 0.8 | 10 | 0 | 0.8 | 0.8 | 0.8 | 0 | 0 | 0 | 0 | 0 | 0.8 | 10 | 0 | 3.8 | 10.8 | -3.7 |
| 9 | 13.04 | 80 | 20 | 20 | 30 | 20 | 30 | 50 | 50 | 10 | 20 | 50 | 80 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 50 | 50 | 0.6 | 11.0 | 16.6 | 7.0 |
| 10 | 19.04 | 80 | 50 | 50 | 30 | 50 | 50 | 50 | 50 | 30 | 80 | 80 | 80 | 10 | 10 | 0.8 | 0 | 0.8 | 50 | 30 | 0.8 | 11.5 | 16.7 | 4.5 |
| 11 | 26.04 | 30 | 20 | 20 | 0.8 | 10 | 10 | 50 | 50 | 20 | 20 | 50 | 50 | 0.8 | 0 | 0 | 0 | 0.8 | 30 | 20 | 0 | 10.6 | 16.0 | 6.5 |
| 12 | 3.05 | 80 | 50 | 20 | 20 | 20 | 50 | 50 | 50 | 30 | 50 | 80 | 80 | 0.8 | 10 | 0.8 | 0.8 | 0.8 | 50 | 50 | 30 | 12.5 | 18.2 | 10.5 |
| 13 | 11.05 | 20 | 20 | 20 | 10 | 20 | 10 | 50 | 50 | 50 | 20 | 80 | 50 | 20 | 0.8 | 0.8 | 0 | 0 | 80 | 50 | 0.6 | 11.8 | 15.5 | 10.0 |
| 14 | 18.05 | 30 | 20 | 10 | 10 | 10 | 10 | 10 | 20 | 20 | 10 | 20 | 10 | 0.8 | 0.6 | 0.8 | 0 | 0.6 | 10 | 10 | 0 | 14.7 | 20.0 | 9.0 |
| 15 | 25.05 | 10 | 0.8 | 10 | 0 | 10 | 0 | 0.8 | 0.8 | 10 | 0 | 0.8 | 50 | 0 | 0 | 0.8 | 0 | 0 | 0.8 | 0.8 | 0 | 18.2 | 21.8 | 13.8 |
| 16 | 31.05 | 30 | 10 | 10 | 0.8 | 0.6 | 10 | 20 | 10 | 0 | 0.6 | 20 | 20 | 0.8 | 0 | 0 | 0 | 0.6 | 0.8 | 10 | 0 | 22.1 | 29.0 | 16.0 |
| 17 | 7.06 | 0.6 | 0.6 | 7.5 | 0 | 0.6 | 0.6 | 0.8 | 0.6 | 0.6 | 0.6 | 0.8 | 0.8 | 0.6 | 0 | 0 | 0 | 0 | 0.6 | 0.6 | 0 | 16.8 | 18.5 | 14.2 |
| 18 | 14.06 | 10 | 10 | 0 | 0 | 0.6 | 0.8 | 0 | 0 | 0.6 | 0.6 | 0.6 | 0.8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18.1 | 25.0 | 10.0 |
| 19 | 21.06 | 0 | 0 | 0.6 | 0 | 0 | 0 | 0.6 | 0 | 0.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.6 | 0 | 0 | 17.1 | 23.6 | 12.2 |

**Table2.** Dynamics of powdery mildew development in 2006

| № | Year | Varieties and monogenic *Pm* lines | | | | | | | | | | | | | | | | | | | | Temperature | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2006 | *Pm 1* | *Pm 2* | *Pm 2+* | *Pm 3a* | *Pm 3b* | *Pm 3c* | *Pm 4a* | *Pm 4b* | *Pm 5* | *Pm 6* | *Pm 7* | *Pm 8* | *Pm 17* | *Pm1+2+9* | *Pm 2+6* | *Pm 5+6* | *Pm Mld* | *Pm 2+8* | *Pm Mli* | *Pm 2+4b+6* | Mean diurnal | Max. | Min. |
| 1 | 22.02 | 15 | 0 | 0 | 0 | 0 | 0.6 | 0 | 0.6 | 0 | 15 | 0.6 | 0.8 | 0.6 | 0 | 0.6 | 0.6 | 0.6 | 0.6 | 15 | 0 | 9.7 | 17.0 | 4.0 |
| 2 | 28.02 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.1 | 5.0 | -1.5 |
| 3 | 9.03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -3.0 | 0.8 | -8.5 |
| 4 | 14.03 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -0.6 | 2.0 | -2.0 |
| 5 | 21.03 | 0.6 | 0 | 0.6 | 0 | 0 | 0.6 | 0 | 0.6 | 15 | 15 | 0.6 | 0.6 | 0.6 | 0.6 | 0 | 0 | 0 | 0.8 | 0.6 | 0 | 9.1 | 17.0 | 1.0 |
| 6 | 28.03 | 0 | 0 | 0 | 0 | 0 | 0.6 | 0.6 | 0 | 0 | 0.6 | 0 | 0 | 0.6 | 0 | 0 | 0 | 0 | 0.8 | 0.6 | 0 | 12.2 | 20.5 | 4.0 |
| 7 | 4.04 | 0 | 15 | 20 | 0 | 0.6 | 0.6 | 0.8 | 0.6 | 0 | 0.6 | 20 | 20 | 0 | 0 | 0 | 0 | 0 | 0.6 | 15 | 0 | 9.1 | 15.5 | 3.0 |
| 8 | 11.04 | 20 | 0.8 | 0.6 | 0.6 | 0 | 0 | 0.6 | 0.6 | 0 | 0.6 | 0 | 0.8 | 0.6 | 0 | 0 | 0 | 0 | 0 | 15 | 0 | 10.3 | 15.0 | 3.5 |
| 9 | 19.04 | 20 | 0.8 | 0.8 | 0.6 | 20 | 20 | 20 | 0.6 | 0.8 | 20 | 20 | 0.8 | 0.8 | 0 | 0 | 0 | 0 | 40 | 0 | 15 | 10.0 | 14.0 | 8.0 |
| 10 | 25.04 | 20 | 0.8 | 0.8 | 20 | 20 | 0.6 | 40 | 0.6 | 0 | 40 | 20 | 15 | 0.8 | 0 | 0 | 0 | 0 | 0.6 | 20 | 0 | 10.3 | 17.7 | 1.5 |
| 11 | 2.05 | 40 | 20 | 0.8 | 20 | 0 | 0.6 | 0 | 0 | 20 | 20 | 20 | 20 | 0 | 0 | 0 | 0 | 0 | 60 | 60 | 0 | 9.1 | 15.5 | 3.5 |
| 12 | 10.05 | 20 | 0.8 | 0 | 0 | 0 | 0 | 0.8 | 0 | 0 | 0.8 | 0.6 | 20 | 0 | 0 | 0 | 0 | 0 | 0.8 | 20 | 0 | 13.1 | 19.5 | 7.5 |
| 13 | 16.05 | 20 | 20 | 0.8 | 40 | 0 | 40 | 20 | 20 | 20 | 0.8 | 40 | 80 | 40 | 0 | 0 | 0 | 0 | 40 | 20 | 0 | 15.6 | 21.0 | 7.6 |
| 14 | 23.05 | 20 | 20 | 0.8 | 0.8 | 0 | 0.8 | 40 | 20 | 20 | 20 | 20 | 0 | 0.8 | 0 | 0 | 0 | 0.8 | 20 | 80 | 0 | 19.6 | 24.5 | 14.0 |
| 15 | 30.05 | 10 | 20 | 0 | 0 | 0 | 0.8 | 40 | 0.8 | 20 | 20 | 20 | 0.8 | 20 | 0.8 | 0 | 0.8 | 0 | 20 | 20 | 0 | 18.8 | 24.5 | 13.5 |
| 16 | 6.06 | 40 | 40 | 40 | 20 | 0.8 | 80 | 80 | 80 | 40 | 80 | 20 | 40 | 80 | 0.8 | 0 | 0 | 0 | 80 | 80 | 0 | 15.8 | 20.7 | 8.2 |
| 17 | 13.06 | 40 | 20 | 20 | 20 | 0.8 | 0.8 | 80 | 40 | 40 | 60 | 0.8 | 20 | 80 | 0.8 | 0 | 0 | 0 | 40 | 40 | 0 | 15.3 | 20.0 | 12.7 |
| 18 | 20.06 | 0 | 0 | 0 | 0.8 | 0.8 | 0 | 0.6 | 0 | 0.6 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 40 | 0.6 | 0 | 20.8 | 27.8 | 15.0 |

**Table3.** Dynamics of powdery mildew development in 2007

| № | Year | Varieties and monogenic *Pm* lines | | | | | | | | | | | | | | | | | | | | Temperature | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2007 | *Pm 1* | *Pm 2* | *Pm 2+* | *Pm 3a* | *Pm 3b* | *Pm 3c* | *Pm 4a* | *Pm 4b* | *Pm 5* | *Pm 6* | *Pm 7* | *Pm 8* | *Pm 17* | *Pm1+2+9* | *Pm 2+6* | *Pm 5+6* | *Pm Mld* | *Pm 2+8* | *Pm Mli* | *Pm 2+4b+6* | Mean diurnal | Max. | Min. |
| 1 | 19.03 | 7.5 | 0.6 | 20 | 7.5 | 10 | 20 | 10 | 20 | 20 | 10 | 20 | 10 | 10 | 0 | 0 | 0 | 0 | 30 | 30 | 0 | 12.5 | 20.0 | 4.0 |
| 2 | 23.03 | 0.8 | 0 | 0.8 | 0 | 0.6 | 0.6 | 0.8 | 0.8 | 0.8 | 0.6 | 0.6 | 10 | 0 | 0.6 | 0 | 0 | 0.8 | 0.8 | 0.6 | 0 | 8.0 | 10.5 | 6.8 |
| 3 | 30.03 | 40 | 10 | 10 | 20 | 0.8 | 20 | 20 | 10 | 0.8 | 10 | 20 | 20 | 0.8 | 10 | 0.8 | 0.8 | 0.8 | 20 | 10 | 0 | 5.4 | 9.5 | -1.0 |
| 4 | 6.04 | 40 | 10 | 10 | 10 | 10 | 10 | 20 | 10 | 10 | 10 | 30 | 40 | 10 | 10 | 10 | 0.8 | 0.8 | 40 | 40 | 0.8 | 10.6 | 17.0 | 3.5 |
| 5 | 13.04 | 120 | 40 | 80 | 40 | 40 | 80 | 120 | 40 | 40 | 40 | 100 | 80 | 40 | 80 | 20 | 7.5 | 10 | 80 | 80 | 10 | 12.2 | 16.5 | 10.5 |
| 6 | 21.04 | 80 | 20 | 20 | 20 | 20 | 40 | 40 | 40 | 10 | 20 | 20 | 20 | 10 | 20 | 0.8 | 0.8 | 0.8 | 80 | 40 | 0.8 | 12.2 | 21.0 | 4.0 |
| 7 | 27.04 | 80 | 20 | 40 | 20 | 10 | 40 | 80 | 40 | 20 | 40 | 80 | 40 | 10 | 20 | 20 | 0.8 | 0.8 | 80 | 80 | 0.8 | 10.8 | 14.5 | 1.0 |
| 8 | 4.05 | 80 | 40 | 40 | 20 | 20 | 80 | 80 | 40 | 40 | 80 | 100 | 100 | 40 | 40 | 20 | 15 | 0.6 | 80 | 80 | 10 | 11.2 | 15.0 | 8.0 |
| 9 | 11.05 | 40 | 10 | 10 | 0.8 | 20 | 10 | 40 | 20 | 20 | 20 | 40 | 40 | 20 | 10 | 0.8 | 0 | 0 | 40 | 40 | 0 | 16.2 | 23.8 | 9.5 |
| 10 | 18.05 | 40 | 10 | 10 | 10 | 0.8 | 10 | 20 | 20 | 10 | 10 | 20 | 20 | 20 | 10 | 10 | 0.8 | 0.8 | 20 | 20 | 0 | 16.4 | 22.0 | 10.0 |
| 11 | 28.05 | 40 | 10 | 20 | 0.8 | 10 | 0 | 20 | 20 | 10 | 20 | 40 | 40 | 10 | 10 | 10 | 0 | 0 | 20 | 40 | 0 | 21.5 | 28.0 | 13.0 |
| 12 | 1.06 | 20 | 20 | 20 | 10 | 0.8 | 10 | 0 | 20 | 10 | 10 | 20 | 0.8 | 10 | 0 | 0.8 | 0 | 0 | 20 | 0.8 | 0.6 | 18.5 | 24.5 | 10.7 |
| 13 | 8.06 | 20 | 10 | 10 | 0.8 | 0.8 | 40 | 20 | 0.8 | 10 | 10 | 40 | 10 | 10 | 10 | 0.8 | 0 | 0 | 40 | 40 | 0.8 | 19.5 | 26.5 | 11.0 |
| 14 | 15.06 | 10 | 0.6 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 20 | 0.8 | 0.8 | 0.8 | 0.8 | 0 | 0.8 | 10 | 0.8 | 0 | 21.5 | 29.5 | 15.0 |

**Table 4.** Dynamics of powdery mildew development in 2005

| № | Year | Varieties and monogenic *Pm* lines | | | | | | | | | | | | | | | | | | | | Temperature | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2008** | ***Pm 1*** | ***Pm 2*** | ***Pm 2+*** | ***Pm 3a*** | ***Pm 3b*** | ***Pm 3c*** | ***Pm 4a*** | ***Pm 4b*** | ***Pm 5*** | ***Pm 6*** | ***Pm 7*** | ***Pm 8*** | ***Pm 17*** | ***Pm1+2+9*** | ***Pm 2+6*** | ***Pm 5+6*** | ***Pm Mld*** | ***Pm 2+8*** | ***Pm Mli*** | ***Pm 2+4b+6*** | **Mean diurnal** | **Max.** | **Min.** |
| 1 | 21.03 | 10 | 0 | 0 | 0 | 0 | 0.8 | 0.8 | 0 | 0 | 10 | 0.8 | 0 | 0.8 | 0.8 | 0 | 0 | 0 | 0 | 0 | 0 | 3.3 | 8.0 | 1.8 |
| 2 | 28.03 | 20 | 10 | 0.8 | 0.8 | 10 | 20 | 10 | 20 | 10 | 20 | 30 | 20 | 10 | 10 | 10 | 0.8 | 0 | 30 | 20 | 0 | 5.2 | 9.0 | 0.8 |
| 3 | 4.04 | 10 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 10 | 0.8 | 0.8 | 0.8 | 10 | 10 | 0.6 | 0 | 0 | 0.8 | 0.8 | 10 | 10 | 0.8 | 8.5 | 10.6 | 4.5 |
| 4 | 11.04 | 20 | 10 | 10 | 10 | 0.8 | 20 | 30 | 10 | 40 | 20 | 80 | 30 | 30 | 20 | 10 | 0 | 0.6 | 20 | 40 | 0.8 | 16.1 | 22.0 | 9.5 |
| 5 | 18.04 | 80 | 10 | 80 | 10 | 10 | 20 | 40 | 80 | 40 | 40 | 80 | 40 | 30 | 10 | 10 | 0.8 | 7.5 | 40 | 40 | 0.8 | 13.4 | 18.2 | 7.5 |
| 6 | 25.04 | 80 | 20 | 20 | 40 | 30 | 40 | 80 | 40 | 30 | 40 | 100 | 80 | 30 | 20 | 20 | 0.8 | 10 | 80 | 80 | 0.8 | 9.0 | 15.2 | 6.0 |
| 7 | 8.05 | 40 | 0.8 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 20 | 40 | 40 | 0.8 | 0.8 | 0.6 | 0.8 | 0.6 | 20 | 40 | 0 | 10.6 | 15.5 | 4.0 |
| 8 | 15.05 | 40 | 20 | 80 | 40 | 20 | 40 | 80 | 40 | 40 | 80 | 80 | 40 | 20 | 20 | 20 | 0 | 0.6 | 80 | 80 | 0.8 | 15.8 | 22.0 | 7.1 |
| 9 | 22.05 | 10 | 0 | 7.5 | 0.8 | 0.6 | 10 | 0.8 | 0.8 | 10 | 0.8 | 20 | 10 | 10 | 0.8 | 0.8 | 0.8 | 0 | 10 | 20 | 0 | 18.6 | 23.8 | 15.0 |
| 10 | 29.05 | 40 | 10 | 40 | 10 | 10 | 20 | 20 | 20 | 10 | 20 | 20 | 40 | 10 | 10 | 10 | 0.6 | 0.8 | 40 | 40 | 0.6 | 13.7 | 20.0 | 8.7 |
| 11 | 5.06 | 40 | 10 | 10 | 10 | 20 | 10 | 20 | 20 | 20 | 20 | 10 | 10 | 0.6 | 10 | 0.8 | 0 | 0.6 | 20 | 10 | 0.8 | 16.2 | 21.6 | 9.5 |
| 12 | 12.06 | 20 | 10 | 10 | 10 | 0.8 | 0.8 | 10 | 10 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0 | 0.8 | 0.6 | 0 | 10 | 20 | 0 | 22.6 | 29.6 | 14.5 |
| 13 | 20.06 | 10 | 0.6 | 0.8 | 0 | 0.8 | 0 | 0 | 10 | 0.6 | 0 | 10 | 0.8 | 0.8 | 0 | 0 | 0.6 | 0.8 | 0.8 | 0.8 | 0.6 | 20.9 | 25.0 | 17.0 |

**Table5.** Dynamics of powdery mildew development in 2009

| № | Year | Varieties and monogenic *Pm* lines | | | | | | | | | | | | | | | | | | | | Temperature | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2009** | ***Pm 1*** | ***Pm 2*** | ***Pm 2+*** | ***Pm 3a*** | ***Pm 3b*** | ***Pm 3c*** | ***Pm 4a*** | ***Pm 4b*** | ***Pm 5*** | ***Pm 6*** | ***Pm 7*** | ***Pm 8*** | ***Pm 17*** | ***Pm1+2+9*** | ***Pm 2+6*** | ***Pm 5+6*** | ***Pm Mld*** | ***Pm 2+8*** | ***Pm Mli*** | ***Pm 2+4b+c*** | **Mean diurnal** | **Max.** | **Min.** |
| 1 | 4.03 | 0.8 | 0.8 | 0.8 | 0.6 | 0.8 | 20 | 0.8 | 0.6 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0 | 0 | 0 | 0.8 | 0.8 | 0 | 4.0 | 5.8 | 1.0 |
| 2 | 10.03 | 80 | 40 | 80 | 20 | 20 | 80 | 20 | 40 | 40 | 20 | 80 | 80 | 0.8 | 0.8 | 0.8 | 20 | 0.8 | 80 | 40 | 0.6 | 5.0 | 10.0 | 2.5 |
| 3 | 18.03 | 0.6 | 0.6 | 20 | 0 | 0 | 0.8 | 0.8 | 0.6 | 0 | 0.6 | 0.6 | 0.8 | 0.6 | 0 | 0 | 0 | 0 | 0.8 | 0.6 | 0 | 2.7 | 5.2 | -1.5 |
| 4 | 24.03 | 40 | 40 | 40 | 20 | 20 | 40 | 80 | 40 | 40 | 20 | 40 | 80 | 0 | 20 | 20 | 20 | 0.8 | 80 | 40 | 0 | 10.0 | 15.5 | 1.0 |
| 5 | 31.03 | 20 | 40 | 0.8 | 20 | 20 | 0 | 0 | 40 | 40 | 0 | 40 | 40 | 20 | 40 | 20 | 20 | 40 | 20 | 40 | 40 | 12.9 | 20.0 | 10.5 |
| 6 | 7.04 | 40 | 40 | 80 | 20 | 20 | 40 | 40 | 40 | 40 | 20 | 40 | 80 | 0.8 | 80 | 20 | 0 | 0.6 | 80 | 40 | 0.6 | 10.4 | 16.5 | 3.5 |
| 7 | 14.04 | 0.8 | 0.8 | 20 | 0 | 0 | 0 | 0.6 | 0 | 0 | 0.8 | 0.8 | 0.8 | 0 | 0 | 0 | 0 | 0 | 0.8 | 7.5 | 0 | 7.8 | 10.5 | 5.5 |
| 8 | 22.04 | 40 | 20 | 20 | 0.8 | 20 | 40 | 40 | 40 | 40 | 20 | 80 | 40 | 20 | 40 | 20 | 0.8 | 0 | 80 | 40 | 0.8 | 6.5 | 11.5 | 3.5 |
| 9 | 28.04 | 20 | 20 | 20 | 20 | 20 | 40 | 40 | 40 | 20 | 40 | 80 | 40 | 0.8 | 40 | 0.8 | 0.8 | 20 | 80 | 80 | 20 | 12.5 | 18.6 | 2.5 |
| 10 | 4.05 | 80 | 20 | 40 | 0 | 20 | 20 | 40 | 40 | 40 | 40 | 80 | 80 | 0.8 | 20 | 20 | 0 | 20 | 40 | 40 | 0.8 | 10.4 | 16.0 | 5.8 |
| 11 | 13.05 | 40 | 0.8 | 0.8 | 0.6 | 20 | 20 | 20 | 20 | 40 | 40 | 40 | 40 | 20 | 0.8 | 0.8 | 0 | 0 | 20 | 20 | 0.8 | 12.5 | 18.0 | 10.0 |
| 12 | 19.05 | 50 | 20 | 40 | 20 | 20 | 50 | 50 | 20 | 40 | 50 | 20 | 40 | 40 | 20 | 0.8 | 0.8 | 20 | 80 | 40 | 0.8 | 15.2 | 21.5 | 9.0 |
| 13 | 26.05 | 80 | 0.8 | 0 | 0.8 | 0.8 | 20 | 20 | 0.8 | 40 | 40 | 40 | 40 | 40 | 20 | 0 | 0 | 0 | 80 | 20 | 0 | 15.5 | 21.5 | 12.0 |
| 14 | 2.06 | 20 | 0.8 | 40 | 0.8 | 20 | 20 | 40 | 20 | 40 | 80 | 80 | 20 | 20 | 0.8 | 0 | 0.6 | 0 | 40 | 40 | 0.8 | 20.0 | 27.5 | 12.5 |
| 15 | 11.06 | 0 | 0 | 0 | 0 | 0 | 0 | 0.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 0.8 | 23.8 | 30.5 | 13.0 |
| 16 | 16.06 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.8 | 0.8 | 0 | 0.8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 21.7 | 29.5 | 12.5 |
| 17 | 23.06 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 21.4 | 27.6 | 14.5 |

The results from the investigation showed that in 2009 there was formation of conidiospores in the greater part of the population of the pathogen at the beginning of March (Table 5). On 4th March, at the first taking out of the plants to the field, transfer of conidiospores was not observed only from the populations with V-2 + 6, V-5 + 6,V-Mld and V-2 + 4b + 6. The conditions for propagation of the pathogen in 2009 were comparatively good and the competitiveness between the populations with different virulence was high. In that year there was development of all populations differing by virulence which were observed in the rest of the investigated years as well, and a high distribution rate of the populations with virulence V-1, V-2+, V-3c, V-4a, V-6, V-7, V-8, V-1+2+9,V-2+8 and V- Mli was noted. Low rate of distribution and no transfer of some populations were observed on 18th March and 14th April.

The variability in the population of the pathogen and its respective development were closely related to the temperature variations and to the amount of rainfalls. In some cases these climatic conditions stimulated the pathogen's development, while in other cases strongly reduced the rates of the disease's multiplication and spreading. The favorable conditions with regard to the indices precipitation and temperature in 2005 and 2006 allowed the very early occurrence of conidiospores, as early as the second half of February.

Considerable propagation during the respective years was observed when the maximum temperatures exceeded 10 °C. In this respect, there were optimal conditions for development and propagation of powdery mildew about 15th March and from 13th April to 18th May. The optimal conditions in 2007, 2008 and 2009 did not differ significantly. In all three years the conditions for development and propagation of the pathogen were very good. In 2007 they began on 19th March and were present till 8th June. In 2008, they continued from 28th March to 12th June, and in 2009 – from 10th March to 2nd June. The conditions in 2006 were very different from the rest of the years. After the initially observed transfer of conidiospores on 22nd February, a period with low temperatures occurred without any transfer. With the increase of temperatures about 20th March the transfer of conidiospores was resumed. Optimal conditions for propagation of the pathogen were present from 4th April to 13th June but highest rate of propagation of most of the pathogen's populations was observed during 6-13th June. In 2006 there were significant rainfalls, their amount by the end of May reaching 228.1 l/m2. These rainfalls contributed to washing out of the formed conidiospores while strongly reducing their transfer as shown by the lower rate of the development of the pathogen on the indicator plants in 2006 (Table 2).

With the increase of temperatures above 25 °C, another factor limiting the development of powdery mildew occurred and the formation of conidiospores was terminated. This termination was earliest in 2009 – after 11th June. In 2007 the termination occurred after 15th June, and in 2005, 2006 and 2008 – after 20th June.

The investigation showed that different virulence developed in the pathogen's populations which varied over years by quantity and distribution rate. Regardless of the variable year conditions, the predominance of certain virulence was observed which implied influence of the genetic potential for resistance of the cultivars. Highest attacking rate was realized by the pathogen's populations with virulence V-1, V-2+, V3c, V-4a, V-4b, V-6, V-7, V-8, V-2+8 and V-Mil. The virulence populations V-2+6, V-2+4+6, V-5+6 and V- Mld had lowest rate of propagation. Besides these marginal groups, there were populations with virulence causing moderate attacking rate. These were the populations with virulence V -2, V-3a, V-3b, V-5, V-17 and V-1+2+9.

***Conclusions***

During the investigated period virulence V-1, V-2+, V-3c, V-4a, V-4b, V-6, V-7, V-8, V-2+8 and V-Mli was predominant in the population of the pathogen.

The populations with virulence V-2, V-3a, V-3b, V-5, V-1+2+9 and V-17 demonstrated moderate rate of propagation during the period of study.

The populations with virulence V-2+6, V5+6, V-Mld and V-2+4b+6 had low rate of development and propagation.

**References**

Iliev I., 1990. Race and genetic characteristics of Blumeria graminis (DC) Speer f.sp. tritici in Bulgaria during 1984-1986. Plant breeding sciences, XXVII, 8, 78-83 (in Bg).

Iliev I., 1996. Investigation on the race variability in the populations of the cause agent of powdery mildew in wheat during 1990-1992. Plant breeding sciences, XXXIII, No 2, 81-85 (in Bg).

Iliev I., 2002. Dynamics of distribution of the cause agent of powdery mildew Blumeria graminis tritici in wheat. 50 years of Dobrudzha Agricultural Institute – 4. Jubilee session on "Breeding and Agro technology of Field Crops", DAI – General Toshevo, vol. II, 742-748 (in Bg).

Iliev I., 2003. Dynamics of distribution of powdery mildew on wheat in the region of DAI – General Toshevo. Proceedings of international conference on the 50th Anniversary of the University of Forestry, Sofia, , 249-253 (in Bg).

Iliev I., 1992. Physiological races of Blumeria (Erysispe) graminis f.sp. tritici in Bulgaria during 1987-1989. Proceedings of the Eigth European and Mediterranean Cereal Rust and Mildewe Conference, September 8-11, 1992, Cereal Rusts and Mildewe 24, 175-177.

Iliev I., 1996. Diversity of the population of Blumeria (Erysispe) graminis f.sp. tritici in Bulgaria during 1993-1994. Wageningen, Cereal Rust and Powdery Mildews Conference, 150.

Iliev I., 1999. Pathogen Variability in the Bulgarian Populations of the Wheat Powdery Mildew (Blumeria graminis f.sp. tritici) for the Period 1995-1997. The First International Powdery Mildew Conference, Avignon, France, 25.

Namuco L. O., Coffman W.R., Bergstro G.C., Sorrells M.E., 1987. Virulence spectrum of the Erysispe graminis f.sp. tritici in New York. Plant Disease, 71: 539-541.

Mains E. B., Dietz M. S., 1930. Physiologic form of barley mildew Erysiphe graminis hordei Marshal. Phytopathology, 3: 229-239.

Peterson R. F., Campbella A. B., Hanon A. E., 1948. A diagrammatic scale for estimating intensity on leaves on stems of cereals. Can. J. res. Bot. Sci., 26: 496-500