AGRICULTURAL SCIENCE AND TECHNOLOGY, VOL. 12, No 2, pp 114-117, 2020
Published by Faculty of Agriculture, Trakia University, Bulgaria
ISSN 1313-8820 (print)
ISSN 1314-412X (online)
http://www.agriscitech.eu
DOI: 10.15547/ast.2020.02.019

Contribution of *Parastagonospora nodorum* to the leaf and glume blotch of durum wheat in Bulgaria

S. Nedyalkova[1], Z. Stoyanova[2], R. Rodeva[2]*

[1]Field Crop Institute, Agricultural Academy, 6200 Chirpan, Bulgaria
[2]Institute of Plant Physiology and Genetics, Bulgarian Academy of Sciences, 21 Acad. G. Bonchev Str., 1113 Sofia, Bulgaria

(Manuscript received 12 February 2020; accepted for publication 4 May 2020)

Abstract. *Parastagonospora nodorum is an important necrotrophic fungal pathogen causing leaf and glume blotch of wheat worldwide. The disease can result in significant losses in grain yield and quality. The purpose of the current investigation was to estimate the occurrence of P. nodorum as a foliar and ear pathogen of durum wheat and disease severity on a set of cultivars under natural infection. Field experiments were performed at two locations (Sofia and Chirpan) in the period 2010-2017. Twelve winter cultivars of durum wheat were involved in the study. P. nodorum was not found at both locations in 2010 and 2011. Thereafter the pathogen was recorded on the leaves of durum wheat in Sofia every year except 2013. Symptoms included chlorosis and necrosis of the leaf tissue. The strongest manifestation of the disease was observed in 2016 and especially in 2017. In Chirpan leaf blotch was noticed only in 2 out of 8 growing seasons. The ear infection led to development of dark brown patches on the glumes, which later became purple-brown. These symptoms were noted in Sofia in 2014, 2016 and 2017. In Chirpan, glume blotch of studied cultivars was recorded in 2017 but in the previous year the symptoms were widely observed on some genotypes among the initial breeding material of durum wheat. In the present investigation P. nodorum caused leaf and glume blotch only. Symptoms on stems, nodes and leaf sheaths were not noted at both locations. The 12 cultivars under study differed in their susceptibility to leaf and glume blotch. The leaf symptoms caused by P. nodorum were recorded on all cultivars, but were more pronounced on Zvezditsa, Deyana and GK Bétadur. The glume blotch was more noticeable on Vazhod. The results of this multiyear research showed that although P. nodorum did not appear every year, the pathogen could contribute to the leaf and glume blotch of durum wheat under conditions favourable for disease development. The evaluation of cultivars demonstrated encouraging preliminary results. Several cultivars showed lower disease severity on flag leaf and no or little infection on the ear. They deserve further studies on resistance to P. nodorum.*

Keywords: Triticum durum, wheat foliar and ear disease, fungal pathogen, disease incidence and severity, cultivar reaction

Introduction

Parastagonospora (synonyms: *Septoria*, *Stagonospora, Leptosphaeria, Phaeosphaeria*) *nodorum* (Berk.) Quaedvlieg, Verkley & Crous is an important necrotrophic fungal pathogen which occurs in wheat-growing areas worldwide including Europe, North America and Australia (Solomon et al., 2006; Francki, 2013). It provokes leaf and glume blotch of wheat (*Triticum aestivum* and *T. durum*). The disease has significant economic impact on the wheat production. It causes losses in grain yield and quality, which can reach up to 31% (Bhathal et al., 2003). The pathogen *P. nodorum* along with other two species (*Zymoseporia tritici* and *Parastagonospora avenae* f. sp. *triticea*) gives rise to a complex of symptoms known as septoria diseases. These fungi co-exist together in the wheat management systems in Bulgaria and incite similar leaf symptoms (Rodeva, 1989). Lately, an attempt has been made to distinguish that three fungal species using classical and molecular methods (Nedyalkova et al., 2019a). The typical symptoms caused by the respective pathogens were described and illustrated. Details of the morphological and cultural characteristics of each fungus were provided (Nedyalkova et al., 2019a). On bread wheat in Bulgaria *Z. tritici* was the most prevalent pathogen (70%), followed by *P. avenae* f. sp. *triticea* (18%). *P. nodorum* appeared with the least frequency (12%) mainly as a leaf pathogen but in some years other organs as ear, leaf sheath and stem node were also affected (Rodeva, 1989). On durum wheat *P. avenae* f. sp. *triticea* was established as a major pathogen occurring in both asexual and sexual morphs (Nedyalkova et al., 2013; Rodeva et al., 2014a). Estimating the vertical distribution of foliar pathogens on bread and durum wheat *P. avenae* f. sp. *triticea* was found on *T. aestivum* and *T. durum* cultivars with slight prevalence on durum wheat. *P. nodorum* was recorded very seldom (on bread wheat) or missing at all (on durum wheat) (Rodeva et al., 2014b). The information in Bulgaria about *P. nodorum* as a causal agent of leaf and glume blotch of durum wheat and the cultivar reaction to this pathogen is scarce. The purpose

*e-mail: r.rodeva@abv.bg

of the current investigation was to assess the incidence of *P. nodorum* as a foliar and ear pathogen of durum wheat and disease severity on a set of cultivars under natural infection.

Material and methods

Twelve winter cultivars of durum wheat were involved in the investigation: six Bulgarian cultivars (Progress, Vazhod, Victoria, Predel, Zvezditsa and Deyana) created at the Field Crops Institute (FCI) - Chirpan and commonly grown in Bulgaria and six foreign cultivars originating from different European countries: Saragolla and Meridiano (Italy), Auradur (Austria), Pescadou (France), Yukon (Germany) and GK Bétadur (Hungary). Field experiments were carried out at the experimental fields of the Institute of Plant Physiology and Genetics (IPPG) - Sofia and FCI - Chirpan in the period from 2010 to 2017 with an exception of 2015 in Chirpan. The trials were arranged in a randomized block design with two replicates which consisted of 3 rows 2 m long of each cultivar. The cropping system was managed as 2-year rotations, durum wheat being rotated with apiaceous vegetables (dill, coriander or caraway) in Sofia and forage pea in Chirpan. Fungicides were not applied either for seed treatment or during the growing season.

Sofia (alt. 539 m) and Chirpan (alt. 168 m) are situated in two different climatic zones of Bulgaria: Moderate continental and Transitory continental, respectively. The main climatic characteristics of both locations and meteorological data with special emphasis to the major climatic factors, temperature and rainfall, were previously presented in details (Nedyalkova et al., 2019b).

Leaf samples were collected in June when the crop was approaching maturity. Ten leaves (usually flag leaves) of each cultivar were taken randomly from each of both replicates. Only the leaves with spots bigger than 1 cm^2 were used for further phytopathological analysis. The procedures of isolation and morphological and cultural characterization of *P. nodorum* were previously described (Nedyalkova et al., 2019a).

Disease incidence was determined on the basis of number of leaf samples bearing symptoms of the disease. A visual estimation of the disease severity for all cultivars was performed at IPPG - Sofia in 2016 and 2017. The disease degree was assessed separately for flag leaf and ear. The affected area was shown as a percentage of the total surface of the plant part examined according to the diagrammatic scale developed by Brönnimann for *P. nodorum* (Brönnimann, 1968).

The data were statistically processed using the software SPSS 16 (SPSS Inc., USA). Duncan's multiple range test was performed at $p \leq 0.05$.

Results

Parastagonospora nodorum was not found at both locations in 2010 and 2011. Thereafter the pathogen was recorded on the leaves of durum wheat in Sofia every year except 2013. The strongest manifestation of the disease was observed in 2016 and especially in 2017. In Chirpan leaf blotch was established in 2014 and 2017 only (Figure 1).

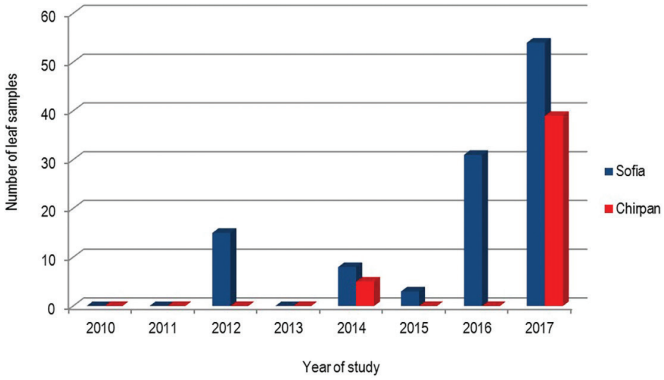

Figure 1. Occurrence of *Parastagonospora nodorum* on durum wheat leaves in Sofia and Chirpan regions depending on the year of study

The appearance of *P. nodorum* was registered for all cultivars, but it was more significant for Zvezditsa and Deyana (Figure 2). The smallest number of leaf samples bearing leaf blotch caused by *P. nodorum* was recorded for GK Bétadur, Victoria, Yukon and Progress.

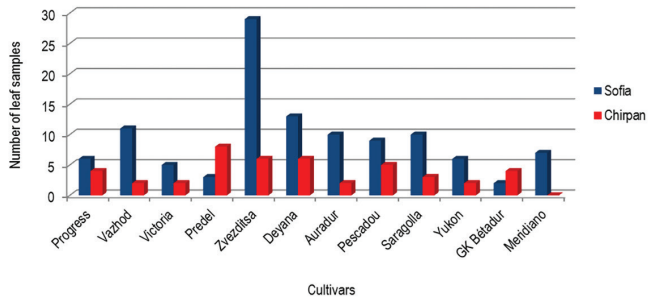

Figure 2. Occurrence of *Parastagonospora nodorum* on durum wheat leaves in Sofia and Chirpan regions depending on the cultivar

In 2017 symptoms of leaf blotch incited by *P. nodorum* were observed in the spring (early May) in both localities. The spots were relatively small, oval to lenticular, initially chlorotic, later light brown with no or a few pycnidia (Figure 3a). The symptoms on adult plants included necrosis and chlorosis of the leaf tissue. They were oval to elongated, with pointed ends, reddish-brown with a fading center, where a lot of scattered pycnidia occurred. The lesions expanded with the disease progress and often coalesced (Figure 3b).

Figure 3. Symptoms caused by *Parastagonospora nodorum* on leaves of durum wheat: a) on young plants in the spring; b) on adult plants

The head infection led to development of dark brown patches mainly on the upper half and the edge of glumes, which later became purple-brown. Small brown spots were also observed on the awns (Figure 4). These symptoms were noted in Sofia in 2014, 2016 and 2017. In Chirpan, glume blotch of

the studied cultivars was recorded in 2017 but in the previous year the symptoms were widely observed on some genotypes among the initial breeding material of durum wheat.

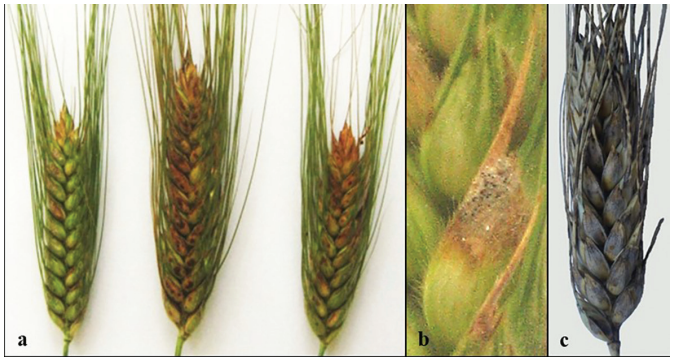

Figure 4. Symptoms caused by *Parastagonospora nodorum* on heads of durum wheat: a) dark brown patches on the glumes; b) pycnidia immersed in the glume tissue; c) purple-brown glume blotch

The strong incidence of *P. nodorum* in Sofia in two consecutive growing seasons allowed to evaluate the field reaction of the cultivars included in the experiment. They differed in susceptibility to leaf and glume blotch (Table 1). The disease was recorded on the leaves of all cultivars even though with a different severity ranging from 17 to 55%. The highest disease severity on flag leaf was established for Zvezditsa (55%) and Deyana (39%). The lowest severity was recorded for Victoria, Meridiano and Yukon. The disease was more severe on the ear compared to the flag leaf and varied in a broader range (from 0 to 75%). The strongest attack on ear reached 75% for Vazhod. No symptoms on the ear of Progress, GK Bétadur and Meridiano were observed in both years.

Table 1. Evaluation of leaf and glume blotch of 12 durum cultivars in the experiment carried out in Sofia in 2016 and 2017

Cultivar	Severity on flag leaf, %*	Severity on ear, %*
Progress	20^{c**}	0^{d}
Vazhod	23^{c}	75^{a}
Victoria	17^{cd}	39^{bc}
Predel	21^{c}	32^{bc}
Zvezditsa	55^{a}	45^{b}
Deyana	39^{b}	41^{b}
Auradur	22^{c}	25^{c}
Pescadou	24^{c}	35^{bc}
Saragolla	23^{c}	38^{bc}
Yukon	18^{cd}	22^{c}
GK Bétadur	29^{bc}	0^{d}
Meridiano	17^{cd}	0^{d}

*Data averaged over the two growing seasons;
**Data with different letters are significantly different according to Duncan's multiple range test at $p \leq 0.05$.

Discussion

Parastagonospora nodorum could provoke symptoms on all aboveground plant parts of bread wheat (Rodeva, 1989). In the present investigation the pathogen caused leaf and glume blotch only. Symptoms on stems, nodes and leaf sheaths were not noted.

The incidence of *P. nodorum* differed between years in both locations. In Sofia, the pathogen occurred in 5 out of 8 growing seasons. Chirpan is situated in climatic region of Eastern Central Bulgaria, which is the most appropriate for durum wheat cultivation. Importantly, *P. nodorum* appeared in this location only in two of the studied years. The strongest occurrence of leaf and glume blotch was noted in Sofia in 2016 and 2017 and in Chirpan in 2017 probably due to the more favourable weather conditions for disease development. In those years the temperature in March was up to 4°C higher than the 30-yr period. It could be suggested that leaf infections have initiated earlier in the growing season, allowing more time for pathogen reproduction and dissemination. The appearance of *P. nodorum* varied also depending on the cultivar susceptibility to the pathogen being more significant for Zvezditsa and Deyana and less for GK Bétadur, Victoria, Yukon and Progress.

The visual rating of disease severity showed a considerable variation in cultivar reaction. The leaf blotch was recorded on all cultivars, but the symptoms were more pronounced on Zvezditsa and Deyana. The glume blotch was more noticeable on Vazhod. Some of the cultivars expressed a low percentage of diseased tissue on both leaves and ears (Yukon and Auradur). Another one exhibited a relatively lower severity on leaves compared to the ears (Vazhod, Victoria). There were cultivars showing leaf blotch but no ear infection (GK Bétadur, Progress, Meridiano). It is possible to find leaf blotch without glume blotch and vice versa because it has been reported that foliar and glume resistance is under different genetic control. Several independent genes that regulate flag leaf and ear resistance have been identified (Fried and Meister, 1987; Wicki et al., 1999). The cultivars which showed lower disease severity deserve further studies on resistance to *P. nodorum*.

In common, the disease level was higher in Sofia compared to Chirpan. It is difficult to explain the differences in disease incidence and severity only by changes of monthly air temperature and rainfall patterns. In Sofia, due to the higher altitude, it is possible for the morning dew to retain longer. There are also variations and interactions among air temperature, precipitation, and many other factors as soil temperature, relative humidity, altered atmospheric composition, the topography and direction of prevailing winds or air streams. Except the climatic and cultivar characteristics the presence of inoculum, debris management, soil type, and predecessor could play a role in disease incidence and severity.

Pycnidio- and ascospores from infected wheat debris, pycnidiospores from alternative graminaceous hosts and infected seed have been reported as sources of inoculum of *P. nodorum* (Harrower, 1974; 1977; Cunfer, 1978; Shah et al., 1995; Bathgate and Loughman, 2001). Although the ascocarp of *P. nodorum* was recorded on bread wheat in Bulgaria, the importance of ascospores as source of inoculum was not significant (Rodeva, 1989). In the present investigation pycnidiospores were found as the main source of primary and

secondary inoculum for durum wheat. A 2-year crop rotation was applied at both locations, durum wheat being rotated with non-host predecessors.

Conclusion

The results of this multiyear research showed that although *P. nodorum* did not appear every year the pathogen could contribute to the leaf and glume blotch of durum wheat under conditions favourable for disease development. The evaluation of cultivars demonstrated encouraging preliminary results. Some cultivars showed less symptoms suggesting that they could serve as resistance sources. So, these results must be confirmed in a larger study applying artificial inoculation by *P. nodorum*.

Acknowledgement

Financial support by the Bulgarian National Science Fund (project DNTS Slovakia 01/5) is gratefully acknowledged.

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