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Original scientific paper

EVALUATION OF FIELD RESPONSE TO YELLOW RUST AND SEPTORIA LEAF BLOTCH OF MACEDONIAN BREAD WHEAT GENOTYPES[#]

Biljana Kuzmanovska[1*], Mirjana Jankulovska[1], Ljupcho Jankuloski[2], Sonja Ivanovska[1], Rade Rusevski[1], Dane Boshev[1]

[1]Faculty of Agricultural Sciences and Food, Ss. Cyril and Methodius University, Skopje, Republic of Macedonia
[2]Plant Breeding and Genetics Section, International Atomic Energy Agency, Vienna, Austria

[*]e-mail: bkuzmanovska@fznh.ukim.edu.mk

Our study had several goals: assessment of field response of 20 Macedonian bread wheat genotypes to yellow rust and Septoria leaf blotch; identification of resistant and moderately resistant genotypes; and identification of potential sources of resistance which may be used for breeding programs in the future. Field experiments were conducted during two consecutive growing seasons in two regions in the Republic of Macedonia. Examined genotypes showed different genetic response to *Zymoseptoria tritici* and *Puccinia striiformis* f. sp. *tritici*, in both regions and in the separate years of investigation. The genotype MAC10 was immune to both wheat pathogens and MAC16 was identified as immune to yellow rust and moderately resistant to Septoria leaf blotch in both regions. These genotypes will be recommended to local wheat producers, and will be used as genetic source for resistance in national wheat breeding programs.

Key words: wheat genotypes; response; yellow rust; Septoria leaf blotch

INTRODUCTION

Bread wheat (*Triticum aestivum* L.) is the main cereal crop in the Republic of Macedonia, cultivated on approximately 80,000 ha. Over the past several years, wheat production in Macedonia faced serious damages and yield losses as a result of foliar diseases, such as yellow rust and Septoria leaf blotch, mainly due to favorable conditions for their development. Yellow rust (*Puccinia striiformis* f. sp. *tritici*), is one of the most important wheat diseases worldwide, which causes yield losses from 10–70 % and reduces the quality of grain and forage [1, 2], especially in regions with cool climate [3]. However, in recent years, this disease has become a rising problem in warmer areas, which were previously considered as unfavorable for yellow rust epidemics [4–6], such as Macedonia. Besides environmental conditions, virulence of the pathogen and host resistance are also the key factors for disease severity [2, 7]. Septoria leaf blotch, caused by the *Zymoseptoria tritici* (syn. *Septoria tritici*; teleomorph *Mycosphaerella graminicola*) is one of the top two or three diseases in most wheat-growing areas around the world, including Europe, USA, South America and Australia [8]. In areas with conditions favorable for its development (high rainfall), yields can be reduced over 50 % in highly susceptible genotypes [9]. Effective control of foliar diseases in wheat can be achieved by cultural practices, use of resistant genotypes and application of fungicides [2, 6, 10–13]. In order to protect the wheat from yellow rust and Septoria leaf blotch, at least two fungicidal treatments are applied during the growing season [6, 14, 15], which significantly increases the production costs and contributes to environmental pollution [13, 16]. Moreover, fungal pathogens are able to develop resistance to commonly used fungicides, which is another disadvantage of chemical control [17, 18]. Growing re-

[#]Dedicated to academician Gjorgji Filipovski on the occasion of his 100^{th} birthday sistant genotypes is the most economically efficient and environmentally friendly approach to control foliar diseases in wheat [10, 18, 19]. Therefore, this study was carried out (1) to evaluate the field response of Macedonian bread wheat genotypes to yellow rust and Septoria leaf blotch; (2) to determine resistant and moderately resistant genotypes, which would be recommended to local wheat producers, and (3) to identify potential sources of resistance which may be used for breeding programs in the future.

MATERIAL AND METHODS

Field experiments were conducted during two consecutive growing seasons (2014/2015 and 2015/2016) in two regions in the Republic of Macedonia (Skopje and Gradsko). A total of 20 bread wheat genotypes (MAC1 to MAC20, consecutively) were evaluated for their response to yellow rust and Septoria leaf blotch in the field. The experiment was set as randomized block design with two replications. Each plot consisted of 5 rows, with 1 m length and between-row distance of 20 cm. Trials were conducted based on natural infections by yellow rust and Septoria leaf blotch pathogens. During each growing season, standard agrotechnical practices for wheat were applied. In each plot, 50 plants were randomly selected for evaluation of the severity of Septoria leaf blotch (at GS 55 – heading) and yellow rust (at GS 73 – early milk development, according to Zadoks' scale) [20]. The severity of Septoria leaf blotch was evaluated using the modified Saari and Prescott's double-digit scale (00–99). The first digit refers to vertical disease progress of the plant (1–9) and the second digit indicates severity measured as diseased leaf area (1–9; where 1 = 10 %; and so forth, consecutively up to 9 = 90 %) [8]. After evaluation, genotypes were classified in 7 categories: immune (00), highly resistant (11–14), resistant (15–34), moderately resistant (35–44), moderately susceptible (45–64), susceptible (65–84) and highly susceptible (85–99) [8]. Severity of yellow rust was evaluated by using the modified Cobb scale (1–100 %), along with the variety response [21]. Response refers to the infection type and is classified according to the following scale: 0 – no visible infection; R – resistant; necrotic areas with or without small pustules; MR – moderately resistant; small pustules surrounded by necrotic areas; M – intermediate; pustules of variable size; some necrosis and/or chlorosis; MS – moderately susceptible; medium-sized pustules; no necrosis, but some chlorosis possible and S – susceptible; large pustules, no necrosis or chlorosis. These scores were then converted to coefficient of infection (CI) by multiplying severity by an assigned constant value for the variety response, where R = 0.2, MR = 0.4, M = 0.6, MS = 0.8, and S = 1 [22]. The genotypes were then classified into: immune (0); highly resistant (1–5); resistant (6–10); moderately resistant (11–20); moderately susceptible (21–30) and susceptible (31–100).

RESULTS AND DISCUSSION

Examined genotypes showed different genetic response to *Zymoseptoria tritici* and *Puccinia striiformis* f. sp. *tritici*, in two consecutive growing seasons. In 2015, disease pressure by Septoria leaf blotch was higher in comparison with yellow rust, while in 2016, climate conditions were particularly favorable for development of P. *striiformis f. sp. tritici*, which resulted in severe yellow rust infections.

In 2015, in both regions, 4 wheat genotypes (MAC2, MAC10, MAC12 and MAC 15) were evaluated as immune and three genotypes (MAC3, MAC11 and MAC18) were found to be highly resistant to Septoria leaf blotch infections. Resistance was observed in genotypes MAC4, MAC8 and MAC17, while MAC16 and MAC19 expressed moderate resistance. Genotypes MAC9 and MAC13 were moderately resistant to moderately sensitive, MAC1 and MAC14 were moderately sensitive, MAC6 was marked as sensitive and MAC20 as moderately sensitive to sensitive. The response of other 2 genotypes (MAC5 and MAC7) significantly differed between two regions (sensitive to highly resistant and moderately sensitive to resistant, respectively). In 2016, in most of the genotypes leaf area was almost fully covered with yellow rust pustules, which obstructed infections by *Zymoseptoria tritici*. Namely, out of 20 genotypes, 15 were determined as immune to Septoria leaf blotch infections, one genotype was highly resistant (MAC3), one was resistant (MAC11) and one was moderately resistant (MAC16). Genotype MAC13 was moderately sensitive to moderately resistant, while the genotype MAC9 was determined as sensitive to *Z. tritici* infection. However, it is important to point out that genotypes MAC2, MAC10, MAC12, MAC15, MAC3 and MAC16 displayed uniform host response regarding the region and growth seasons. Field response of other 14 investigated genotypes significantly differed depending on the region and the growing season.

Table 1. Severity of Septoria leaf blotch infection and wheat genotype response during 2015 and 2016 growing seasons in Skopje and Gradsko

	2015				2016			
	Skopje		Gradsko		Skopje		Gradsko	
Genotype	Double digit score	Response	Double digit score	Response	Double digit score	Response	Double digit score	Response
MAC1	45	Moderately sensitive	46	Moderately sensitive	00	Immune	00	Immune
MAC2	00	Immune	00	Immune	00	Immune	00	Immune
MAC3	12	Highly resistant	11	Highly Resistant	11	Highly resistant	13	Highly resistant
MAC4	34	Resistant	33	Resistant	00	Immune	00	Immune
MAC5	75	Sensitive	13	Highly resistant	00	Immune	00	Immune
MAC6	75	Sensitive	73	Sensitive	00	Immune	00	Immune
MAC7	45	Moderately sensitive	34	Resistant	00	Immune	00	Immune
MAC8	26	Resistant	23	Resistant	00	Immune	00	Immune
MAC9	43	Moderately resistant	33	Resistant	67	Sensitive	82	Sensitive
MAC10	00	Immune	00	Immune	00	Immune	00	Immune
MAC11	13	Highly resistant	11	Highly Resistant	33	Resistant	24	Resistant
MAC12	00	Immune	00	Immune	00	Immune	00	Immune
MAC13	45	Moderately sensitive	41	Moderately resistant	46	Moderately sensitive	37	Moderately resistant
MAC14	64	Moderately sensitive	52	Moderately sensitive	00	Immune	00	Immune
MAC15	00	Immune	00	Immune	00	Immune	00	Immune
MAC16	35	Moderately resistant	35	Moderately resistant	42	Moderately resistant	43	Moderately resistant
MAC17	21	Resistant	23	Resistant	00	Immune	00	Immune
MAC18	11	Highly resistant	12	Highly Resistant	00	Immune	00	Immune
MAC19	44	Moderately resistant	36	Moderately resistant	00	Immune	00	Immune
MAC20	76	Sensitive	46	Moderately sensitive	00	Immune	00	Immune

As previously mentioned, climate conditions during 2016 were favorable for yellow rust development, which lead to severe infections. As a result, disease severity ranged from 15 to 100 % in both investigated regions (Table 3). The highest disease severity was observed in genotypes MAC1, MAC5 and MAC15 in both regions. On the contrary, in 2015, disease severity was significantly lower and ranged between 10 in the region of Gradsko and 45 % in the region of Skopje (Table 2). Out of 20 examined genotypes, 3 genotypes (MAC9, MAC10 and MAC16) were found to be immune, while 2 genotypes (MAC11 and MAC12) were identified as resistant in both regions, during the two consecutive years. Other 15 genotypes (MAC1, MAC2, MAC3, MAC4, MAC5, MAC6, MAC7, MAC8, MAC13, MAC14, MAC15, MAC17, MAC18, MAC19 and MAC20) exhibited inconsistent response to yellow rust in terms of region and growing season. Differences in the genotypes' response to yellow rust (*Puccinia striiformis f.sp. tritici*) and Septoria leaf blotch (*Zymoseptoria tritici*) are in agreement with many previous studies [18, 23–26]. However, in those studies only resistant and moderately resistant genotypes were identified, while immune genotypes to yellow rust and Septoria leaf blotch were not observed.

Table 2. Severity and coefficient of infection (CI) of yellow rust and wheat genotype response during 2015 growing season in Skopje and Gradsko

Genotype	Skopje			Gradsko		
	Severity and response	CI	Reaction type	Severity and response	CI	Reaction type
MAC1	25 MR	10	R	10 R	2	HR
MAC2	0	0	I	0	0	I
MAC3	0	0	I	0	0	I
MAC4	10 R	2	HR	0	0	I
MAC5	40 MS	32	S	0	0	I
MAC6	45 S	45	S	0	0	I
MAC7	40 MS	32	S	0	0	I
MAC8	20 MR	8	R	0	0	I
MAC9	0	0	I	0	0	I
MAC10	0	0	I	0	0	I
MAC11	20 MR	8	R	20 R	8	R
MAC12	20 MR	8	R	15 MR	6	R
MAC13	0	0	I	0	0	I
MAC14	0	0	I	0	0	I
MAC15	0	0	I	0	0	I
MAC16	0	0	I	0	0	I
MAC17	0	0	I	0	0	I
MAC18	0	0	I	0	0	I
MAC19	0	0	I	0	0	I
MAC20	0	0	I	20 MR	8	R

Table 3. Severity and coefficient of infection (CI) of yellow rust and wheat genotype reaction during 2016 growing season in Skopje and Gradsko

Genotype	Skopje			Gradsko		
	Severity and response	CI	Reaction type	Severity and response	CI	Reaction type
MAC1	95 S	95	S	100 S	100	S
MAC2	70 S	70	S	40 S	40	S
MAC3	50 S	50	S	45 S	45	S
MAC4	60 S	60	S	40 S	40	S
MAC5	100 S	100	S	75 S	75	S
MAC6	75 S	75	S	60 S	60	S
MAC7	75 S	75	S	50 S	50	S
MAC8	80 S	80	S	85 S	85	S
MAC9	0	0	I	0	0	I
MAC10	0	0	I	0	0	I
MAC11	25 MR	10	R	15 MR	6	R
MAC12	20 MR	8	R	15 MR	6	R
MAC13	20 MR	8	R	30 MS	24	MS
MAC14	80 S	80	S	100 S	100	S
MAC15	90 S	90	S	95 S	95	S
MAC16	0	0	I	0	0	I
MAC17	70 S	70	S	60 S	60	S
MAC18	80 S	80	S	95 S	95	S
MAC19	25 MS	20	R	40 S	40	S
MAC20	50 S	50	S	65 S	65	S

If we compare the results for genotypes response to *Puccinia striiformis f.sp. tritici* and *Zymoseptoria tritici*, during the two years in two examined regions, it is noticeable that the genotype MAC10 was immune to both wheat pathogens. Moreover, the genotype MAC16 was identified as immune to yellow rust and moderately resistant to Septoria leaf blotch in two consecutive years, in both regions. These two genotypes can be recommended to local wheat producers, and in the future they should be used as genetic source for resistance in national wheat breeding programs.

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ЕВАЛУАЦИЈА НА РЕАКЦИЈАТА НА МАКЕДОНСКИ ГЕНОТИПОВИ ПЧЕНИЦА КОН ЖОЛТАТА ’РЃА И СЕПТОРИОЗАТА ВО ПОЛСКИ УСЛОВИ

Билјана Кузмановска[1*], Мирјана Јанкуловска[1], Љупчо Јанкулоски[2], Соња Ивановска[1], Раде Русевски[1], Дане Бошев[1]

[1]Факултет за земјоделски науки и храна, Универзитет „Св. Кирил и Методиј“, Скопје, Република Македонија

[2]Оддел за генетика и селекција на растенија, Меѓународна агенција за атомска енергија, Виена, Австрија

Испитувањата беа спроведени со неколку цели: да се евалуира реакцијата кон жолтата ’рѓа и септориозата на 20 македонски генотипови пченица во полски услови, да се идентификуваат отпорни и умерено отпорни генотипови и да се идентификуваат потенцијалните извори на отпорност што би се вклучиле во идните селекциски програми. Полските опити беа спроведени во текот на две последователни вегетациски сезони, во два региона во Република Македонија. Испитуваните генотипови во двете вегетациски сезони покажаа различна генетска реакција кон двата патогена, *Zymoseptoria tritici* и *Puccinia striiformis* f. sp. *tritici*, во двата региона. Генотипот MAC10 покажа имуна реакција кон двата патогена, додека генотипот MAC16 покажа имуна реакција кон жолтата ’рѓа и умерена отпорност кон септориозата, во двата испитувани региона. Овие генотипови ќе се препорачаат на локалните производители на пченица за одгледување, а воедно ќе се користат и во националните селекциски програми како извор на гени за отпорност кон овие два патогена.

Клучни зборови: генотипови пченица; реакција; жолта ’рѓа; септориоза на листот