Article

Competitive ability of breeds of leaf rust from of crystalline wheats

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Abstract

In the process of genetic improvement of wheat, the evaluation of genotypes for resistance to rusts is essential; often breeders must mix different races; however, it is essential to know the competitive hability of the rust, and the wheat genotype used for increase. The aim of the study was to measure the competitive ability of four-leaf rust races caused by *Puccinia triticina* E. attacking durum wheat (*Triticum durum* L.). The study was conducted in a greenhouse during the year 2015. Leaf rust races BBG/BN, BCG/BN, BBG/BP and CBG/BP, were proportionally mixed and multiplied for three successive generations in the susceptible genotypes (Atil C2001 and Morocco); resistant genotypes: (Samayoa C2004 and Thatcher-Lr16 (RL6005]) in addition to them Júpare C2001 resistant to BBG/BN and BCG/BN, but susceptible to BBG/BP and CBG/BP. After urediniospore multiplication, 100 single pustule isolates obtained were increased in the cultivar Morocco before proceeded to the race identification. The most frequently identified race was CBG/BP with 46%, followed by BBG/BP with 34% and BBG/BN with 18%. BCG/BN was the less frequent with 2%. Only among urediniospores composite mass (CM) obtained from RL6005 and Morocco allowed the identification of the four races; in Atil C2001, Júpare C2001 Samayoa C2004 allowed the identification of three. The race identified more frequently in Atil C2001, RL6005 and Samayoa C2004 was BBG/BP, while in Morocco and Júpare C2001, CBG/BP. It is concluded that CBG/BP is more competitive than BBG/BP, BBG/BN and BCG/BN and it is recommended to be used in the mixture.

Keywords: competition between races, leaf rust races, monopostular isolates.

Reception date: January 2020
Acceptance date: February 2020

Introduction

In 2001, the National Institute of Agricultural and Livestock Forestry Research (INIFAP) released the Atil C2001 wheat variety, with high yield potential (Camacho *et al*., 2001) developed in cooperation with the improvement program of the International Center for Improvement of Corn and Wheat (CIMMYT). Unfortunately, a new breed of leaf rust (BBG/BN) of exotic origin overcame the resistance not only of Atil C2001 and Altar C84, but also of more than 80% of the germplasm of crystalline wheats available in Mexico (Singh *et al*., 2004).

Since Altar C84 was released in 1984, the most common leaf rust breed identified in samples of crystalline wheats, it was BBB/BN being only partially virulent in the Mexicali C75 variety and other flour wheats whose resistance is based on genes Lr10, Lr23 or in the combination of both (Singh, 1991) but a virulent one in Altar C84.

Júpare C2001, was released in 2001 for its resistance to BBG/BN after evaluating thousands of lines (Singh *et al*., 2004) and a special urgent seed multiplication program (Camacho *et al*., 2002).

The resistance in Júpare C2001 to the BBG/BN breed is based on the complementary rust resistance genes of the Lr27+31 leaf (Herrera-Foessel *et al*., 2005; Huerta-Espino *et al*., 2009, 2010). During the same 2001, another breed called BCG/BN was identified in low frequency (Singh *et al*., 2004) that differs from BBG/BN because of its virulence to Lr26 present in translocation 1B.1R from rye. Virulence for this gene in leaf rust isolates from crystalline wheats is considered unnecessary (Huerta-Espino *et al*., 2006).

Well, this particular gene is not found naturally in the genome of crystalline wheats. Subsequently, in 2004 the varieties Samayoa C2004 and Banamichi C2004 were released with the resistance genes Lr14a+ and Lr27+31 respectively (Herrera-Foessel *et al*., 2005). During 2008, a variant of BBG/BN acquired virulence for the Lr27+31 genes and the adult plant gene Lr12, consequently, Júpare C2001 and Banamichi C2004 became susceptible. This breed was designated as BBG/BP (Huerta-Espino *et al*., 2009).

During this same cycle at a very low frequency, the CBG/BP race was detected that beat Storlom's resistance and whose resistance is based on the Lr3 gene (Herrera-Foessel *et al*., 2005). The only difference between the CBG/BP and BBG/BP races is that the first one has virulence for the Lr3 gene, while the second one is virulent. The BBG/BN breed since its introduction in 2001, continues to evolve; however, Samayoa C2004 (Lr14a+) still maintains its resistance, but not Júpare C2001 and Banamichi C2004.

Currently, BBB/BN breeds with virulence for Mexicali C75, DW7276 and resistance genes Lr10, 23, 28 and 33, but avirulent in Altar C84 and Atil C2001, are kept in the leaf rust breed collection. The BBG/BN and BCG/BN races are virulent in Altar C84 and Atil C2001, but avirulent at Lr28. The BBG/BP race is virulent in addition to Altar C84 and Atil C2001, to Júpare C2001 and Banamichi C2004, but avirulent to Storlom; while CBG/BP is virulent in addition to Altar C84 and Atil C2001, to Júpare C2001, Banamichi C2004 and Storlom.

In order of complexity (more virulence genes) then we could place BBG/BN as the least complex followed by BCG/BN, BBG/BP and CBG/BP respectively. In order to obtain mono postular isolates or to increase leaf rust urediniospores, the use of susceptible varieties is recommended and if it is possible that the susceptibility is almost universal as is the case of the Morocco variety.

During the autumn-winter (A-W) wheat growing cycle 2008-2009, the CIMMYT crystal wheat improvement program was suggested to use the CBG/BP breed to make selection against this breed in the process of selecting resistant plants in the different segregating generations and especially for presenting a greater spectrum of virulence, this breed overcame the resistance of the Storlom variety during 2008 and appeared that same year along with BBG/BP, causing production losses in the south of Sonora of 40 million pesos as reported by Huerta-Espino *et al*., 2011, which is why it was considered important to make selection towards that breed.

However, satisfactory results were not obtained, these being attributed to the fact that the susceptible board that was used as a inoculum dispersant was not adequate or that the CBG/BP race possibly has adjustment problems or that the fact of having additional virulence to Lr3 does not It makes it fit to survive in the field and compete with other breeds of leaf rust such as BBG/BP. Therefore, the objective of the present study; it was to measure the proficiency of four breeds of leaf rust that preferentially attack crystalline wheats, including CBG/BP in greenhouse conditions.

Materials and methods

Obtaining single-insulated insulations

During the period of 2011-2014, samples of leaves with signs of rust of different crystalline wheat plants were collected in different farms in southern Sonora, noting the name of the variety, location of the site and the degree of severity of the disease, as well as the date they were collected. The samples were increased in the Atil C2001 variety and stored in the CIMMYT rust laboratory located in the experimental station of El Batán, State of Mexico, 19º 31' north latitude and 99º 53' west longitude, to carry out the study during the year 2015.

The spores of the leaf samples were collected using suction nozzles connected to a compressor and stored in gelatin capsules to preserve them in refrigeration, then all samples were increased, in seedlings of the Atil C2001 variety, for which they were planted in pots of 5 x 5 x 8 cm plastic to which a mixture of sterile soil and Peat Moss was added in a 60:40 ratio and sowing 15 seeds per pot. On the other hand, the Atil C2001 wheat variety is a genotype susceptible to the BBG/BN, BCG/BN, BBG/BP and CBG/BP breeds as well as Morocco. After five days after planting, all seedlings were treated with maleic acid (MH30®) to regulate their growth.

In order to obtain monopostular isolates, from each of the collected samples, inoculations were made in the seedlings of Atil C2001 of eight days of age, this was carried out by suspending the urediniospores in mineral oil (Sotrol® 170; Chevron Phillips Chemical Company, The Woodlands, Texas, United States), sprinkling on the leaf blade. The inoculated seedlings were allowed to dry

for a period of 20 min. and then they were passed to a spray chamber with a temperature of 20-24 °C for 16 h and sprayed 100%. After this period the inoculated seedlings were moved to a greenhouse whose temperature fluctuated between 20-24 °C.

Seedlings that contained each of the isolates were placed in individual plastic cages in order to avoid contamination of the isolates. Eight days after the inoculation, when the uredines were visible but before they broke the epidermis of the leaf, three to four uredines isolated on different leaves were identified and when more than one uredine was present, with scissors they were removed some to leave a single uredine per leaf, this is equivalent to monosporic cultures in water-agar of other fungi, but in obligate parasites such as rust; monopostular isolates are made in living plants.

When the uredines reached their maximum growth, which occurred 15 days after inoculation, the urediniospores of each of the four uredines were collected separately, which gave rise to four particular isolates. Each isolation was identified and stored in gelatin capsules and these were kept refrigerated at a temperature of -5 °C. All monopostular isolates obtained were increased by Atil C2001 to have enough spores to inoculate differential lines.

Identification of physiological races

For the identification of physiological races, a set of 20 differential lines was used, arranged in five sets of four differentials each as indicated in Table 1. In addition to the 20 differentials; 28 other wheat and crystalline wheat genotypes were planted that allow differentiating the four races as indicated in Table 2.

Table 1. Codes used for the designation of physiological races of *P. triticina* E.

Code	Differential set (North America)												Differentials set (Mexico)							
	1				2				3				4				5			
	1	2a	2c	3	9	16	24	26	3ka	11	17	30	3bg	13	15	18	10	19	23	27+31
B	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
C	R	R	R	S	R	R	R	S	R	R	R	S	R	R	R	S	R	R	R	S
D	R	R	S	R	R	R	S	R	R	R	S	R	R	R	S	R	R	R	S	R
F	R	R	S	S	R	R	S	S	R	R	S	S	R	R	S	S	R	R	S	S
G	R	S	R	R	R	S	R	R	R	S	R	R	R	S	R	R	R	S	R	R
H	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S
J	R	S	S	R	R	S	S	R	R	S	S	R	R	S	S	R	R	S	S	R
K	R	S	S	S	R	S	S	S	R	S	S	S	R	S	S	S	R	S	S	S
L	S	R	R	R	S	R	R	R	S	R	R	R	S	R	R	R	S	R	R	R
M	S	R	R	S	S	R	R	S	S	R	R	S	S	R	R	S	S	R	R	S
N	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R
P	S	R	S	S	S	R	S	S	S	R	S	S	S	R	S	S	S	R	S	S
Q	S	S	R	R	S	S	R	R	S	S	R	R	S	S	R	R	S	S	R	R
R	S	S	R	S	S	S	R	S	S	S	R	S	S	S	R	S	S	S	R	S
S	S	S	S	R	S	S	S	R	S	S	S	R	S	S	S	R	S	S	S	R
T	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S

R= resistant; S= susceptible.

Table 2. Lines and testers used as differentials that include hard wheats.

Gen Lr	Variety or cross	Tester	Type of infection*
2a	Tc*6/Webster	RL6016	;1
2c	Tc*6/Carina	RL6019	;11+
12	Exchange/6*Tc	RL6011	X(RPA)^{y}
14a	Selkirk/6*Tc	RL6013	X
14b	Tc*6/María Escobar	RL6006	;X
20	Thew	W203	;X
25	Transec	RL6084	0;
27+31+10+	Gatcher**	W3720	X^{-}
28	CS2D-2M	CS2D-2M	0;
29	Tc*6/CS7AG#11	RL6080	;1
32	Tetra Canthatch/T.tauschii	RL5497-1	2
33	Tc*6/PI58548	RL6057	22+
36	E84018	E84018	;
13	WL711	WL711	X
23 +	Gaza	Gaza	;
Lr3	Storlom	Storlom	0
LrNd	ND line	ND line	0;
72	Altar C84	Altar C84	0;
27+31+72	Banamichi	Banamichi	X
27+31+72	Júpare C2001	Jupare C2001	X
14a+	Samayoa C2004	Samayoa C2004	X
LrCam	Cirno C2008	Cirno C2008	;
27+31	Inquilab	Inquilab	X
61	Guayacan INIA	Guayacan INIA	X

RPA= adult plant resistance; *= the type of infection are based on the 0-4 scale (Roelfs *et al*., 1992), which indicate 0= no uredinia present, no ureninia, chlorotic or necrotic freckles; 1= small uredinias surrounded by necrosis; 2= small or medium-sized uredinias surrounded by chlorosis or necrosis; X= uredinias of variable size distributed randomly on a single leaf. **= gatcher has an additional unidentified gene. The four races are virulent in the differentials with the genes Lr14b, 20, 22a, 22b and 33 and avirulent in the differentials that have the resistance genes Lr1, 2b, 3ka, 3bg, 9, 15, 16, 17, 18, 19, 21, 24, 25, 26, 29, 30, 32 and 36.

The nomenclature for the designation of races is based on the proposal by Long and Kolmer (1989) and modified by Singh (1991). In this system, if the differential wheat genotype is resistant, it is inferred that the pathogen is virulent to this particular resistance gene that the differential line possesses, but if the differential is susceptible, it is inferred that the pathogen possesses virulence for this particular gene.

Thus, each race is designated using five consonants of the English alphabet, and each of the letters represents in coded form the response of four mono-gene differentials. A diagonal is used to separate the response of the differentials used in North America (Long and Kolmer, 1989) from the differentials used in Mexico (Singh, 1991). In all cases, the 0-4 scale described by Roelfs *et al*. (1992).

Competency tests and identification of physiological races

Leaf rust breeds that attack crystalline wheats, previously identified as: BBG/BN and BCG/BN (Singh *et al*., 2004); BBG/BP and CBG/BP (Huerta-Espino *et al*., 2009, 2010) multiplied separately in Atil C2001 (variety susceptible to these four races) to obtain fresh inoculum and thus ensure 100% germination, following the methodology described above in obtaining monopostular isolates, but the urediniospores in this case were collected in mass. When the uredinias or pustules were sporulating to the maximum, 1 mg of urediniospores of each race was collected and mixed proportionally and uniformly to obtain a mixture of the four races.

Seedlings of eight days of wheat genotypes: Atil C2001, RL6005, Morocco, Samayoa C2004 and Júpare C2001, were inoculated with the mixture of urediniospores that contained the four races. When the signs of the disease were visible and the urediniospores had the maximum sporulation, urediniospores of each of the genotypes were collected to inoculate eight-day-old seedlings of the five genotypes, giving rise to 25 combinations between genotypes and including among themselves.

This process of inoculating and collecting urediniospores in mass was repeated for three successive generations in the 25 combinations that were collected in bulk (CM3) and from each of the 25 combinations four monopostular isolates (AMP) were obtained, which originated 100 isolates. The 100 isolates were increased in the Morocco variety as it is a more susceptible genotype than Atil C2001, which allowed to obtain enough inoculum and proceed to the identification of races.

A total of 125 sets of differentials were planted; 25 of them were inoculated with the mass compound (CM3) of the four races and the remaining 100 with each of the isolates obtained from the four individual pustules of each of the 25 combinations that were obtained after three successive generations in varieties with different levels of resistance (CM3).

The competitive ability between races was determined by the frequency with which each of the four races was identified, under the assumption that there is no competitive difference between them or if it exists, it will be reflected by a higher frequency in those with greater competitive ability compared with the less frequent and therefore with less competitive ability, under the conditions of work.

Results and discussion

After inoculating the 25 differentials with the urediniospores from the mass compound (M3) of each genotype, no difference was observed between them. However, it is important to note that it was not possible to make an adequate breed identification, since the key differentials in this case, Lr3, Lr26, Lr27+31 presented the two possible types of infection (resistance and susceptibility reaction), which He indicated that at least two races were represented in each of the 25 mixtures.

The 100 isolates test allowed to identify the four races with which the study began. The results are listed in Table 3 grouped by the variety in which the three generations of asexual reproduction were obtained in succession. When grouping the four races, it was determined that the CBG/BP race was the most common, followed by BBG/BP and BBG/BN, the race that was identified less frequently was the BCG/BN race as illustrated in the Tables 3 and 4.

Table 3. Frequency of races identified in each of the combinations masal compound-monopostular isolation.

No. of masal compound	CM combination- Monopostular insulation	Races identified (%)			
		CBG/ BP	BBG/ BP	BBG/ BN	BCG/ BN
1	Morocco-Morocco	3	0	0	1
2	Morocco-Jupare	2	1	1	0
3	Morocco-Atil	2	1	1	0
4	Morocco-Samayoa	4	0	0	0
5	Morocco-RL6005	2	2	0	0
6	Júpare- Morocco	3	1	0	0
7	Júpare-Jupare	4	0	0	0
8	Júpare-Atil	2	1	1	0
9	Júpare-Samayoa	2	1	1	0
10	Júpare-RL6005	2	1	1	0
11	Atil-Morocco	2	1	1	0
12	Atil-Júpare	3	1	0	0
13	Atil-Atil	1	1	2	0
14	Atil-Samayoa	0	4	0	0
15	Atil-RL6005	2	2	0	0
16	Samayoa-Morocco	0	2	2	0
17	Samayoa-Júpare	2	2	0	0
18	Samayoa-Atil	2	2	0	0
19	Samayoa-Samayoa	1	0	3	0
20	Samayoa-RL6005	1	3	0	0
21	RL6005-Morocco	1	2	0	1
22	RL6005-Júpare	3	1	0	0
23	RL6005-Atil	0	2	2	0
24	RL6005-Samayoa	0	2	2	0
25	RL6005-RL6005	2	1	1	0
Total (%)		46	34	18	2

When the frequency of identified races was compared from the variety where the monopostular isolates were obtained with the frequency of identified races based on where the mass multiplications were made, differences were observed not in the total of races, but in the individual frequency of these (Table 4).

Table 4. Frequency of hard wheat races identified in each of the mass compounds by variety.

Compound mass (CM)	Races identified (%)			
	CBG/BP	BBG/BP	BBG/BN	BCG/BN
Morocco	13	4	2	1
Júpare C2001	13	4	3	0
Atil C2001	8	9	3	0
Samayoa C2004	6	9	5	0
RL6005	6	8	5	1
Total (%)	46	34	18	2

When the isolates were multiplied in a particular genotype and in this same monopostular isolates were made, only the four races with which the study began in Morocco and RL6005 were identified. The presence of three races in the Atil-Atil and RL6005-RL6005 combination was observed, two races in the Morocco-Morocco and Samayoa-Samayoa combinations and only one race in the Jupare-Jupare combination (Table 5). In this case, the most frequent breed was CBG/BP, followed by BBG/BN and BBG/BP and the least frequent was BCG/BN (Table 5).

Table 5. Frequency of hard wheat breeds identified based on the variety where the monopostular isolation was performed.

Monopostular insulation	Race identified and frequency (num. = %)			
	CBG/BP	BBG/BP	BBG/BN	BCG/BN
Morocco	9	6	3	2
Júpare C2001	14	5	1	0
Atil C2001	7	7	6	0
Samayoa C2004	7	7	6	0
RL6005	9	9	2	0
Total	46	34	18	2

On the other hand, it was observed that when the races were increased separately in Atil C2001, they continued to thrive, but when the mixing was done the competitive ability of the races was manifested, and in the Atil C2001 genotype the race was not recovered (BCG/BN) with less competitive ability.

Authors such as Matens (1973) indicate that there are differences in the competitive ability between races of phytopathogenic fungi and the ability to survive in mixtures of races varies considerably; studies of Watson and Singh (1952) with *Puccinia graminis* f. sp. *tritici* and Leonard (1969), with *P*. *graminis* f. sp. *Avenae*

They indicated that simple races in mixtures were more predominant than more complex races in terms of virulence genes. However, Katsuya and Green (1967); Osoro and Green (1976) in studies with mixed wheat stem rust races could not establish a clear relationship between survival and race complexity.

In studies with fungal breed mixtures, in the greenhouse, it has been reported that some races tend to dominate when inoculated into susceptible genotypes. Watson (1942) found that race 34 of stem rust was always maintained and even increased in frequency, but race 147 was always removed from the mix after several successive generations in a susceptible genotype. Race 34 differs from race 147 in that 34 is virulent to Sr9d and virulent to Sr9e, while race 147 is virulent to Sr9d, but virulent to Sr9e (Stakman *et al*., 1962).

Similar results have been reported in *P. graminis* f. sp. *tritici* (Browder, 1965; Katsuya and Green, 1967; Watson and Luig, 1968) and in *P. graminis* (Irish, 1950), *Phytopthora infestans* (Thurston, 1961), *Tilletia caries* and *T. foetida* (Rodenhiser and Holton, 1953). In the mixture of races of *Colletotricum graminicola* with differences in their virulence range and inoculated in sorghum plants under greenhouse conditions for five and six successive generations.

It is found that isolation with the smallest range of virulence prevailed over more complex isolates and there were differences in the ability to survive in the races (Casela *et al*., 2001); Watson (1958) concluded that *P. graminis* races with greater number of virulence genes were unable to remain in the population in susceptible genotypes in relation to races with fewer virulence genes.

Similar results were reported by Black (1952) in *P. infestans* and Flor (1956) in *Melanpsora lini*. On the other hand, many researchers believe that races with a greater number of virulence genes are the least competitive and do not survive when grown in susceptible genotypes and indicate that there is a negative correlation in the ability to survive and the number of virulence genes in a given race, including Vander plank (1968) believes that unnecessary virulence reduces the ability to survive and can prevent highly virulent breeds from being abundant in the field. Such could be the case of the BCG/BN breed that has unnecessary virulence for Lr26 (Huerta-Espino *et al*., 2006). There is evidence that certain factors such as temperature and inoculum density determine that certain races of *P. graminis* survive in competition or not.

As of 2001, when the BBG/BN breed that overcame the resistance of Altar C84 and Atil C2001 was identified in Mexico, the majority of single-leaf leaf rust isolates from crystalline wheat samples were made in the Atil C2001 variety. Undoubtedly, with this, other possible virulent breeds in Atil C2001 or Altar C84 were eliminated, consequently the frequency with which BBB/BN was identified, which is the breed prior to 2001 and typical of crystalline wheats was much lower (Bárcenas-Santana *et al*., 2015).

To avoid the above; it was determined that all monopostular leaf rust isolates regardless of their origin should be performed in the susceptible variety Morocco. In the present study, in addition to indicating the dominance of a particular breed that could have a greater competitive ability, it also allowed measuring the effect of the genotype where field samples are multiplied and the effect of the genotype where monopostular isolates are performed.

It would be expected that the four races with which the study began would recover at the same frequency assuming that all four have the same competitive ability and that the wheat genotypes used in the study do not exert a selection pressure allowing the infection of one(s) race(s), but not

of another(s). Coincidentally, the races that were identified in the highest proportion are the most recently identified CBG/BP and BBG/BP races identified in 2008 (Huerta-Espino *et al*., 2009) and consequently those with the most virulence genes compared to BBG/BN and BCG/BN identified in 2001 (Singh *et al*., 2004) and that have fewer virulence genes.

The frequency with which CBG/BP was identified with additional virulence to Lr3 compared to BBG/BP would suggest that additional virulence on Lr3 also brings with it greater competitive ability, which at the same time acquired virulence for the complementary genes Lr27+31 in comparison with the BBG/BN race that can be considered as the base race or original race. Under this criterion, the BCG/BN race should have greater competitive ability than the BBG/BN race when acquiring virulence at Lr26; however, in the present study, it was the race identified less frequently.

One possible explanation is that Lr26 is a resistance gene from rye and although it was common in flour wheat grown in Mexico for a while, including Seri M82 and Bacanora T88 (Singh, 1993), it has never been present in wheat varieties crystalline released in Mexico, although there are crystalline genotypes with this resistance gene (Mujeeb-Kazi *et al*., 1996). It may also be because acquiring virulence for Lr26, lost its competitive ability as is the case of stem rust race 147 when acquiring virulence for Sr9e, lost virulence for Sr9d (Watson, 1942) and its competitive ability.

The BBG/BP race in order to cause the epidemic in Júpare C2001 and Banamichi C2004 in commercial wheat fields in Sonora during the 2007-2008 cycle had to have additional virulence for Lr27+31 adaptations to the conditions of the South of Sonora (Huerta-Espino *et al*., 2009, 2010). CBG/BP on the other hand overcame Storlom resistance although it is not a commercial variety, it is used extensively in the breeding program and possibly went through the same adaptation mechanism as BBG/BP.

The greater competitive ability of BBG/BP and CBG/BP with a greater number of virulence genes than the BBG/BN and BCG/BN races with a lower number of virulence genes is consistent with that reported by Watson and Luig (1968) who showed that under greenhouse conditions, regardless of the initial proportions of competing races, races with a greater number of virulence genes were the most predominant after four successive generations of urediniospores, one generation more than in the present study.

In the same way, Brown and Sharp (1969) reported that yellow rust races of wheat with the highest number of virulence genes (more complex) predominated in competition, regardless of the proportion of each type in the breed mix; however, less complex races prevailed, although at a low rate after seven successive generations of urediniospores.

There are however two clear trends; in the races identified in 2001 (BBG/BN and BCG/BN) the unnecessary virulence for Lr26 is apparently negative in terms of competition, while in the races identified in 2008 the additional virulence for Lr3 in the CBG/BP race, confers greater competitive ability.

Conclusions

In the present study it was possible to identify that there are differences in the competitive ability of the four races involved in the study and these differences are influenced both by the genotype where the inoculum was multiplied by three successive generations (CM mass compound) and by the genotype where monopostular isolates were made.

The CBG/BP breed was the most frequent and competitive and identified in the CM collections of Júpare and Morocco, as well as in obtaining the AMP and even in the Júpare-Júpare and Morocco-Morocco combinations in the CM-AMP relationship. In the case of Júpare this dominance could be attributed to the presence of the complementary genes Lr27+31 that determines the resistance of Júpare and that these genes were the ones that the pathogen had to overcome in order to cause the epidemic in both Júpare and Banamichi and in the case of Morocco, only the competence ability of the breed is demonstrated when there are no resistance genes.

The four races with which the study began were only recovered when the CM was performed in the susceptible variety Morocco and also when the monopostular isolates were made in this same variety, which suggests that to avoid eliminating races with low competitive ability or races new with different virulence capabilities both at the beginning of sample purification and obtaining monopostular isolates should be done in the Morocco variety.

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