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Virulent Race Overcome Wheat Stem Rust Resistance Gene *Sr27* in Egypt

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Triticale is an excellent source of resistance to wheat stem rust, caused by *Puccinia graminis* f.sp. *tritici*. Stem rust historically is one of the most destructive diseases of wheat (*Triticum aestivum* L.) worldwide. Deployment of resistant genotypes successfully prevented rust epidemics over the past several decades. This is primarily due to the on-going incorporation of effective stem rust resistance genes into new wheat breeding materials; this may place the pathogen under great selection pressure. Although *Sr27* has little effect on the commercial wheat production, it has a major impact on the commercial triticale cultivars. In Egypt, high levels of stem rust infection were observed on wheat cultivar (Cooring) which carrying *Sr27* grown at Gemmiza Research Station during May 2015. Samples collected from rusted stems of wheat cultivar (Cooring) were cut and artificially inoculated on primary leaves of 8-day-old seedlings of highly susceptible wheat Cv. Morocco. Four single pustules were collected and race analysis was done. Results showed that out of the four identified races, race QQQCM was the most virulent one on wheat seedling carrying *Sr27* with infection type (4), whereas the rest of races were a virulent to *Sr27*. This race (QQQCM) first time to appear in Egypt from previous identified races. Regarding to the performance of 20 stem rust resistant genes at seedling stage, (*Sr* 9e,7b,8a,9g,30,17,9a,9d,10,31and *Sr38*) were resistant to race QQQCM, meanwhile the rest *Sr*s were susceptible.

Keywords: *Puccinia graminis* f.sp. *tritici*, resistant genes, stem rust, *Triticum aestivum* L. and wheat.

Stem rust of wheat caused by the fungus *Puccinia graminis* Pers. f.sp. *tritici* Eriks. & E.Henn. is the most destructive disease on wheat worldwide. Successful control of the disease over three decades through the use of genetic resistance has resulted in a sharp decline in research activity in recent years (El-Daoudi, *et al.*, 1995). Occurrence of new races in a geographic/ epidemiologic regions can be attributed to the migration from an outside such as spread of race TTKS, in East Africa commonly known as Ug99 to anther countries (Singh *et al.*, 2006). Wheat stem rust resistant gene *Sr27* (3A.3R translocation) is one of the most important gene possess resistant to stem rust especially in triticale, whereas virulence on *Sr27* is rare. Acosta (1962) and Harder *et al.* (1972) isolated an east African culture virulent on Pembina line with *Sr27*. McIntosh (1983) showed that isolates of *P. graminis* f.sp. *tritici* from triticale cv. Coorong were virulent on wheat seedlings with *Sr27*. The results were accepted as evidence that the resistance gene in Coorong and many other triticale lines developed in Mexico was *Sr27*. Virulence on triticale genotypes with *Sr27* was found in South Africa in 1988. Smith and Le Roux (1992) and McIntosh (1983) stated that *Sr27* occurred at high frequency in lines present in

nurseries distributed from CIMMYT and gave warning of genetic vulnerability. The value of adult plant resistance in protecting wheat genotypes against such virulent stem rust races could be achieved by combining many genes of resistance in single genotypes that conferred high level of generalized resistance against the pathogens. In this respect, Brennan and Murray (1988) stated that a breeding program should develop rust resistant cultivars conditioned with resistance genes (both race- specific and race- nonspecific resistance). The inheritance of adult plant resistance has often been considered as a complex, but there is an evidence also that it is oligogenic **(**Barcellos *et al*., 2000**).** The identification of genes conferring stem rust adult plant resistance would be a significant step towards a good control of such disease (Manninger *et al*., 1998; Nazim *et al*., 2001 and Mousa *et al*., 2004).

The objective of this study was to identify and characterize the new race that overcome the resistant gene *Sr27* which governing the resistance in triticale.

Materials and Methods

Collected samples from the infected wheat genotypes Coorong carrying *Sr27* were used to identify physiologic race(s) that overcome the resistance of *Sr27*. The collected samples (rusted stems) were kept in glassine envelopes (8 x 15 cm). Rust samples, were left at room temperature for 24 hours to remove the humidity in the samples. After that samples were preserved in dissector in fridge until usage. The infected specimens were transferred to the very susceptible wheat cv. Morocco. The method of inoculation was carried out as described by Stakman *et al*. (1962)**.** Eight days old seedlings were sprayed with an atomizer in the inoculation chambers with water then inoculated by shaking and brushing rusted materials over the plants and sprayed gently again with water in order to induce "dew" on the plant. Finally, the inoculated plants were kept in damp chambers for 24 hours to allow the rust spores to germinate and cause infection. Inoculated plants were transferred and placed on benches in the greenhouse and kept for 14 day. After developing the rust symptoms, four single pustules were separately isolated from the sample and inoculated again on very susceptible wheat cultivar seedlings Morocco to obtain enough urediospores to inoculate the differential sets.

Infection types (IT) were scored after 14 days using the 0-4 scale of Stakman *et al*. (1962). Infection types were categorized as either being Low (resistant 0, 0; 1 and 2) or High (susceptible 3 and 4). The differential host series consisted of wheat rust monogenic lines, arranged in five subsets (Table 1). Races were assigned using the international Pgt-code as suggested by Roelfs and Martens (1988).

Results

Race analysis from the infected wheat triticale Cooring (Fig. 1and 2) showed that four races were identified based on their reaction on 20 differential sets listed on Table (1). Most of the identified races varied in their virulence on stem rust resistance gene *Sr27*, this indicated a high level of variation both in quantity and virulence spectrum. The obtained data (Table 2 and 3), revealed that the identified races possess different infection types on *Sr27* ranged from (0, to 4). Race QQQCM

Fig. 1. Infected wheat triticale Cooring with Sr27 at Gemmiza Research Station-during May 2015.

Fig. 2. Virulent race overcome wheat stem rust resistance gene Sr27 in Egypt.

was the virulent one on *Sr27* which gave susceptible reaction with infection type (4), meanwhile the rest races showed a virulent infection types (0,-1-2). On the other hand, race KKBBB was less aggressive on the differential sets which overcome the resistance of six stem rust resistant genes (*Sr 21, 9e, 7b, 6, 8a* and *Sr* 9g). Races TTMCC and BCPPL were intermediate in their effect on the resistant genes.

Table 1. Pgt-code races of *Puccinia graminis* f.sp. *tritici*

Subset	Infection types produced on host lines with *Sr*				
	1	*5*	*21*	*9e*	*7b*
	2	*11*	*6*	*8a*	*9g*
	3	*36*	*9b*	*30*	*17*
	4	*9a*	*9d*	*10*	*Tmp*
	5	*24*	*31*	*38*	*MCN*
Pgt-code	B	Low	Low	Low	Low
	C	Low	Low	Low	High
	D	Low	Low	High	Low
	F	Low	Low	High	High
	G	Low	High	Low	Low
	H	Low	High	Low	High
	J	Low	High	High	Low
	K	Low	High	High	High
	L	High	Low	Low	Low
	M	High	Low	Low	High
	N	High	Low	High	Low
	P	High	Low	High	High
	Q	High	High	Low	Low
	R	High	High	Low	High
	S	High	High	High	Low
	T	High	High	High	High

Table 2. Infection type produced on Sr27 with the identified races

No.	Race	I.T	No.	Race	I.T
1	QQQCM	4	3	BCPPL	2
2	TTMCC	0	4	KKBBB	1

Concerning a virulence/virulence formulae of data presented in Table (4) race QQQCM was the virulent one on Sr27 and nine stem rust resistant genes, *i.e*. (Sr5,21,11,6,36,9b, TMP, 24 and SrMcN). On the other hand race KKBBB was less aggressive on stem rust resistant genes which showed virulence on six stem rust resistant genes (Sr21, 9e, 7b, 6, 8a and 9g), meanwhile it was a virulent on Sr27. Races TTMCC and BCPPL were a virulent on Sr27and virulent on different stem rust resistant genes.

Effectiveness of stem rust resistant genes was assessed. Sr31 and Sr38 were completely effective to all identified races whereas Sr9g, Sr36 and SrTMP were the least effective.

Table 3. Infection types of twenty differential lines in addition to *Sr*27 inoculated with four single pustules

Set	*Sr* genes	Infection type / Single pustules			
		1	2	3	4
Set 1					
1	*Sr5*	H	H	L	L
2	*Sr21*	H	H	L	H
3	*Sr9e*	L	H	L	H
4	*Sr7b*	L	H	L	H
Set 2					
1	*Sr11*	H	H	L	L
2	*Sr6*	H	H	L	H
3	*Sr8a*	L	H	L	H
4	*Sr9g*	L	H	H	H
Set 3					
1	*Sr36*	H	H	H	L
2	*Sr9b*	H	L	L	L
3	*Sr30*	L	L	H	L
4	*Sr17*	L	H	H	L
Set 4					
1	*Sr9a*	L	L	H	L
2	*Sr9d*	L	L	L	L
3	*Sr10*	L	L	H	L
4	*SrTMP*	H	H	H	L
Set 5					
1	*Sr24*	H	L	H	L
2	*Sr31*	L	L	L	L
3	*Sr38*	L	L	L	L
4	*SrMcN*	H	H	L	L
	Sr 27	H	L	L	L
Race		QQQCM	TTMCC	BCPPL	KKBBB

Table 4. A virulence/Virulence pattern of identified races

No.	Race	Avirulence / Virulence genes
1	QQQCM	Sr9e,7b,8a,9g,30,17,9a,9d,10,31,38/
2	TTMCC	Sr9b,30, 9a,9d, 10,24,31,38,27/
3	BCPPL	Sr5, 21, 9e, 7b; 11, 6, 8a, Sr9b,9d,31,38,McN,27/
4	KKBBB	Sr5,11,36,9b,30,17,9a,9d,10,TMP,24, 31,38,McN,27/

Discussion

Wheat stem rust is the most important disease of wheat all over the world. The pathogen is able to produce new races that can attack previously resistant varieties and develop rapidly under optimal environmental conditions which results in a serious yield loss. Hence, monitoring the disease and its races is of great importance for sustainable wheat management programs. Race analysis of samples collected from wheat triticale (Cooring) which carrying *Sr27*, revealed that race QQQCM was the virulent one on *Sr27*, meanwhile the rest races were a virulent. Race QQQCM showed high infection type (4) on some important stem rust genes, *i.e. Sr36, Sr24* and *SrMcN*. In this respect, McIntosh (1983) stated that isolates of *Puccinia graminis* f.sp. *tritici* from triticale cv. Coorong were virulent on wheat seedlings with *Sr27*. Also, they found that *Sr27* occurred at high frequency in lines present in nurseries distributed from CIMMYT. Olivera *et al*. (2013) reported that three South African *P. graminis* f.sp. *tritici* isolates UVPgt53, UVPgt56 and UVPgt57 were virulent on *Sr27*. They stated that these isolates were virulent on 8 stem rust resistant genes Sr8a, 9a, 9b, 9d, 9g, 10, 11and McN.

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سلالة شديدة القدرة المرضية كسرت جين المقاومة (*Sr 27*) لصدأ الساق فى القمح بمصر

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يعتبر قمح التريتيكال مصدر جيد من مصادر المقاومة لصدأ الساق المتسبب عن الفطر بكسينيا جرامينيز تريتيسای. صدأ الساق فى القمح من اكثر امراض القمح خطورة على مستوى العالم . استخدمت الاصناف المقاومة بنجاح لتقليل الاوبئه بصدا الساق لفترة طويله.وهذا راجع الى ادخال جينات المقاومة الفعالة فى الاصناف الجديدة. على الرغم من ان جين المقاومة (*Sr 27*) له دور قليل فى الاصناف التجارية الا ان له دور مهم فى اقماح التريتيكال. فى مصر، سجلت شدة اصابة عالية بمحطة بحوث الجميزة على الصنف كورنج والذى يحمل جين المقاومة (*Sr 27*) فى شهر مايو ٢٠١٥. العينات التى تم جمعها من الصنف كورنج تم عمل عدوى بها لبادرات الصنف الحساس موروكو فى عمر ٨ يوم. اربعة بثرات فردية اخذت لعمل تعريف السلالات. اوضحت نتائج تعريف السلالات ان السلاله (QQQCM) كان لها القدرة على كسر مقاومة الجين (*Sr 27*) بطراز اصابة ٤ ،بينما باقى السلالات كانت ضعيفه القدرة المرضيه ولم تكسر مقاومة الجين. هذه السلاله كانت لاول مرة تظهر فى مصر من نتائج تعريف السلالات السابقة . فيما يخص كفاءة الجينات فى طور البادرة كانت الجينات (*Sr 9e, 7b,* *8a, 9g, 30, 17, 9a, 9d, 10, 31* and *38*) هى المقاومة للسلاله (QQQCM) بينما باقى الجينات كانت حساسة للاصابة.