INHERITANCE OF RESISTANCE TO STRIPE RUST *Puccinia striiformis* IS CROSSES BETWEEN MONOGENIC LINES *Yr'S* AND EGYPTIAN CULTIVARS SUSCEPTIBLE

Abu Aly, A.A.M.; W.A. Youssief and A.A. Shahin*

Plant Disease Res. Dept, Sakha Agric. Res. Stn., Institute of Plant Pathology, ARC, Egypt

*** Correspondence author:**

Present address: Plant Diseases Dep., Sakha Agric. Res. Center, Kafr El-Sheikh, Egypt

E-mail: a.a.shahin@hotmail.com

ABSTRACT

Increased range of stripe rust *Puccinia striiformis tritici* [*Pst*] virulence on wheat *Triticum aestivum* L. in Egypt at last decades has required assemblage of a broad genetic base of resistance. The objective of this study to identify inheritance of *Yr17* and *Yr27* resistance to wheat stripe rust. Eight crosses between *Yr17*, *Yr27* and each of Giza 163, Gemmiza 3, Sids-6 and Sids-9, were performed. Results indicated that the four parents exhibited high susceptible reaction against stripe rust at seedling and adult stage. Breeding against stripe rust at seedling and adult stages proved that plant segregation indicated that F_1 plants of the eight testers having *Yr17* and *Yr27*, were resistant and exhibited low stripe rust reaction (0-1) at seedling stage and low stripe rust severity ranged between 0 and 5R at adult stage. The result of F_2 plants reaction exhibited wide range of stripe rust severity ranged between 0 and 60S but the direction was in the side resistance and this confirmed the results of F_1. This result confirmed the presence of resistant gene in the segregations of the resulted crosses and verified that a single dominant pair gene controls stripe rust resistance at adult stages.

Keywords: *Triticum aestivum*, stripe rust, *Yr's* genes, inheritance.

INTRODUCTION

Stripe rust, caused by *Puccinia striiformis* f. sp. *tritici*, is some of the most important disease of wheat in the world. In Egypt, stripe rust attacked most of the commercial wheat cultivars during 1968 to 1995, causing severe infection in North Delta area El-Daoudi *et al.* (1996). Stripe rust caused high loss in the production of most Egyptian wheat cultivar in the delta area during 1996/1997 growing seasons El-Daoudi, (1998). The inheritance of resistance to wheat stripe rust disease was studied for the first time by Biffen (1905) who showed its simple mode of inheritance, giving the first example for its successful application in breeding disease resistant varieties of field crops and economic plants. Youssef *et al*. (2007) and Shahin (2008) found that the inheritance of resistance to stripe rust was controlled by two complementary genes in the F_2 population of the crosses in seedling stage, they observed also no segregation on F_2 plants in adult stage.

The stripe rust disease can be controlled using fungicide application. However, breeding for resistance is considered to be the most conomical and

environmentally suitable to reduce degree of pollutions. It is considered the tradition way for transferring one or more resistance gene to a single wheat cultivar depending on filed or greenhouse screening with different races is better comparing with fungicide application, which is a very laborious and time consuming process.

Also, the objective of this study was to identify the stripe rust resistance gene in crosses of certain wheat population.

MATERIALS AND METHOD

Four wheat cultivars *i.e.* Giza 163, Gemmiza-3, Sids-6 and Sids-9 exhibited a wide range of variability in their susceptibility to stripe rust, while, the monogenic lines, *Yr17* and *Yr27* exhibited high level of resistance to stripe rust at adult stage McIntosh *et al*. (1995) and Shahin (2008). These parents were sown at Sakha Agric. Res. Stn. during 2004-2005 growing seasons in six rows each. All possible crosses among the four cultivars and monogenic lines *Yr's* genes) were conduced to produce the hybrid seed of the eight crosses. The resulted F_1 plants are represented as follow: *Yr17* × Giza 163, *Yr17* × Gemmiza-3, *Yr17* × Sids-6,*Yr17* × Sids 9, *Yr27* × Giza 163, *Yr27* × Gemmiza-3, *Yr27* × Sids-6 and *Yr27* × Sids-9, during 2005/2006 growing season, part of the eight F_1 hybrid seed was sown to produce the F_2 seed. The rest were left for the final experiment in the next season (2006/2007).

A cooperative experiment was conduced in a randomized complete block design with three replicates each contained two rows for each parent and F_1 well as 10 cm for each F_2. This performance was carried out to create uniform environmental conditions. The rows were 3 m long, 30 cm apart and seeds were sown 10 apart with in rows, therefore, each row contained 30 plants. Mixture of highly susceptible wheat cultivars were sown around the experiments as a spreader to disseminate the stripe rust uredinispores of the pathogen [*Pst*]. All regular cultural practices precisely applied during the growing seasons.

Pathogenicity test:

A. At seedling stage:

Ten pots for each of the parents and F_1 as well as 20 pots for each of F_2. Each pot contained 10 seed. Seedlings (8 days-old) of the parents, F_1 and F_2 were uniformly inoculated with the urediniospres of [*Pst*] which was used for inoculating all of the tested materials at seedlings stage in the greenhouse using the technique described by Johnson *et al.* (1972). Infection type data against the pathogen were recorded after approximately 18 days of inoculation according to scale described by McNeal *et al.* (1971).

The infection types *i.e.* 0, 1 and 2 were resistant; 3, 4 and 5 types, moderate resistant; 6 and 7 moderate susceptible and 8 and 9 high susceptible.

B. At adult stage:

In the adult tests under field condition was restricted in the spreader plants which were moistened and dusted with spore mixtures using the most prevalent stripe rust races in the area. The inoculum was mixed at the rate of

1:20 (urediniospores to talcum powder) (w.w). All materials were inoculated at booting stage according to the method adopted by Tervet and Cassel (1951). Data of stripe rust severity % were recorded on adult plants according to Peterson *et al.* (1948). To study inheritance of resistance, the F_2 plants were grouped into 10 categories depending on the percentage, for the disease severity and infection type under field condition. The disease severity (%) *i.e.* 0, 5R, 5MR, 20MR were considered as resistant phenotypes, while, 10MS, 10S, 30S, 40S, 50S and 70S were considered as the susceptible ones.

Statistical and genetic analyses, frequency distribution values, were estimated for each of parents, F_1 and F_2 populations for infection types in all of the tested crosses in respect.

To clarify, mode of inheritance of expected ratio of the phenotypes classes of the stripe rust, infection types were determined using χ^2 analysis according to the method of Steel and Torrire (1960).

RESULTS

The infection type frequency distribution and the disease severity class of the parents, F_1 and F_2 populations of each of the eight crosses were performed. Inoculation at seedling was accomplished by using race 230E158 and a mixture of the most prevalent races in the area at adult stage. Data presented in Table (1) showed that all of four parent exhibited high susceptible reaction, *Yr17*, *Yr27* and all F_1 plants tested at seedling exhibited high resistant reaction against physiologic race 230E158 ranged between (0 to 1), whereas, the results of F_2 of the eight crosses having *Yr17* and Yr27 exhibited a wide range of infection types ranged between 0-9 the segregated phenotypes were as follows, 88R:42S, 145R:45S, 85R:39S, 120R:47S, 155R:47S, 132R:52S, 151R:55S and 122R:55S for the crosses *Yr17* × Giza 163, *Yr17* × Gemmiza 3, Yr17 × Sids-6, *Yr17* × Sids-9, *Yr27* × Giza 163, *Yr27* × Gemmiza 3, *Yr27* × Sids-6 and *Yr27* × Sids-9, respectively, with expected ratio 3:1 for all. These results related that resistance was dominant over susceptibility in these crosses at seedling stage. At adult stage are shown in Table (2) all of four parents exhibited high susceptibility, where stripe rust severity (%) ranged between (50S-70S). Meanwhile, *Yr17* and *Yr27* was high resistant. As for F_1 plant of the eight tested crosses exhibited high resistance where their stripe rust severity (%) ranged between 0 and 5R these results revealed that resistance was dominant over susceptibility in these crosses in F_1 at adult stage.

The obtained results derived from F_2 of the eight tested crosses having resistance genes exhibited a wide range of reaction to stripe rust severity ranged between 0-70S the segregated phenotypes were as follow, 105R:40S, 125R:46S, 86R:36S, 96R:32S, 90R:37S, 103R:39S, 102R:38S, and 98R:47S, respectively, with expected ratio 3:1. This 3:1 ratio verified that single dominant gene pair control resistance and supported the fact that *Yr17* and *Yr27* carried the seedling and adult plant resistance gene and showed gene expression of resistance to stripe rust in all tested crosses at adult stage.

DISCUSSION

Wheat (*Triticum astivum* L.) is one of the most important food crops in Egypt and all over the world. Stripe rust incited by *Puccinia striiformis f.sp. tritici* in particular, was a sporadic disease in Egypt before (1990). Most of the Egyptian cultivars exhibited considerable level of susceptibility, with few exception El-Dauodi *et al.* (1998). Studying eight crosses to stripe rust infection at seedling stage under greenhouse condition, the infection types of F_1 plants indicated that the eight tested crosses having *Yr17* and *Yr27* were resistant. As well as, F_2 segregation of crosses having *Yr17* and *Yr27* confirmed the results of F_1 and indicated that resistance was dominant over susceptibility. At adult stage *Yr17*, *Yr27* and its crosses with tested cvs. (F_1), exhibited high resistance. The rest of tested parents showed different degrees of susceptibility. Conversely F_2 segregations of crosses having *Yr17* and *Yr27* indicated that resistance was dominant over susceptibility. Also, results indicated that crosses fitted the expected ratio 3:1. This ratio verified that single dominant gene pair control stripe rust resistance and supported the F_1 result at seedling and adult stages.

This work could be usefully applicable in the breeding wheat program against rust disease in general and stripe rust in particular under Egyptian conditions.

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توريث المقاومة للصدأ الأصفر فى بعض الأقماح المصرية القابلة للإصابة

عبدالعزيز عبدالناصر محمد أبوعلى ، واصف عبدالصمد يوسف وعاطف عبدالفتاح

قسم بحوث أمراض النبات ـ محطة البحوث الزراعية بسخا ـ معهد بحوث أمراض النباتات ـ مركز البحوث الزراعية ـ مصر

يعتبر الصدأ الأصفر فى القمح المتسبب عن الفطر (يكسينا سترافورميس طراز تريتيسای) أكثر أمراض القمح خطورة فى مصر حيث تكرر ظهوره بحالة وبائية مسببا خسائر عالية فى المحصول بما أدى إلى إلغاء عدة أصناف تجارية ونظرا للزيادة المضطردة فى القدرة المرضية لسلالات هذا الفطر على إصابة نبات القمح فقد دعت الحاجة إلى البحث عن مصادر المقاومة لهذا المرض تحتوى على عوامل وراثية ذات تأثير واسع وفعال كان الهدف من هذه الدراسة هو التعرف على عوامل المقاومة الوراثية للصدأ الأصفر الموجودة فى *Yr27* ,*Yr17* ودورها فى الهجن المشتركة معها فى الأصناف المصرية لذلك تم التهجين بين الأصناف المختارة للحصول على الهجن الآتية : (*Yr17* × جيزه ١٦٣) ، (*Yr17* × جميزه ٣) ، (*Yr17* × سدس ٦) ، (*Yr17* × سدس ٩) ، (*Yr27* × جيزه ١٦٣) ، (*Yr27* × جميزه ٣) ، (*Yr27* × سدس ٦) ، (*Yr27* × سدس ٩). دلت النتائج على أن أصناف القمح المصرية فى طور البادرة والبلوغ كانت قابلة للإصابة بشدة بينما أكدت تجارب التربية ضد الصدأ الأصفر فى مرحلة البادرة والبلوغ تحت ظروف الصوبة والحقل أن نبات الجيل الأول للهجن التى تحتوى على *Yr17*, *Yr27* كانت كلها مقاومة. إذ أظهرت أقل نسبة إصابة والتى تراوحت بين الطرز المرضى (1-0) فى طور البادرة وأظهرت شدة الاصابة (0-5R) فى طور البلوغ .وقد أظهرت هذه النتائج أيضا أن صفة المقاومة سائدة على صفة القابلية للإصابة فى الجيل الأول كما أظهرت نتائج الجيل الثانى مدى واسع من رد فعل النبات لمرض الصدأ الأصفر والتى تراوحت بين الطرز المرضى (9-0) فى طور البادرة وشدة الاصابة (60S-0) فى طور البلوغ ولكن كان اتجاه المقاومة للمرض هو السائد على القابلية للإصابة فى ٨ هجن ومؤكدا نتائج الجيل الأول. وهذه الدراسة توضح أن السلالات احادية جين المقاومة Monogenic *Yr27*, *Yr17* يحتوى على جين المقاومة للصدأ الأصفر فى طور البادرة والبلوغ وكذلك الهجن التى تحتوى على *Yr27*, *Yr17* وقد تاكدت هذه النتيجة بنسبة ٣: ١. ويفيد هذا البحث تطبيقا فى عمليات التربية للمقاومة للأمراض بصفة عامة ولأصداء القمح بصفة خاصة.

Table (1): Evaluation of crosses of the four cvs. having resistant *Yr's*) genes against stripe rust infection using race 230E158 at seedling stage, under controlled condition at Sakha during 2007.

Crosses and parents		Plants No.	Infection type											Phenotypes		Effected Ratio	X^2
			0	0;	1	2	3	4	5	6	7	8	9	R	S		
Yr_{17} x Giza 163	P_1	80	80														
	P_2	80											80				
	F_1	30	62														
	F_2	130	50	38						25	14	3		88	42	3:1	3.70
Yr_{17} x Gemmiza 3	P_1	80		80													
	P_2	80										80					
	F_1	30		30													
	F_2	190	60	50	30	5				15	15	12	3	145	45	3: 1	0.17
Yr_{17} x Sids 6	P_1	30															
	P_2	80											80				
	F_1	30			30												
	F_2	124	30	25	10	20					8	12	19	85	39	3: 1	2.75
Yr_{17} x Sids 9	P_1	80		80													
	P_2	80											80				
	F_1	25			25												
	F_2	167	30	20	30	18	22				7	20	20	120	47	3: 1	0.88
Yr_{27} x Giza 163	P_1	80			80												
	P_2	80											80				
	F_1	35			35												
	F_2	202	35	20	55	23	22				5	15	27	155	47	3: 1	0.32
Yr_{27} x Gemmiza 3	P_1	80															
	P_2	80										80					
	F_1	28		28													
	F_2	184	60	40	12	9	11			11	9	11	21	132	52	3: 1	1.04
Yr_{27} x Sids 6	P_1	80			80												
	P_2	80											80				
	F_1	35			35												
	F_2	206	21	38	22	45	25			10	8	22	15	151	55	3: 1	0.31
Yr_{27} x Sids 9	P_1	80			80												
	P_2	80											80				
	F_1	30			30												
	F_2	177	20	12	40	50				5	5	15	30	122	55	3: 1	3.48

Table (2): Evaluation of crosses of the four wheat cvs. having resistant genes (*Yr's*) against stripe rust infection using a mixture races at adult stage at the Sakha experimental farm, during 2006/2007.

Crosses and parents		Plants No.	Infection type										Phenotypes		Effected Ratio	X^2
			0	5R	5MR	20MR	10M	10S	30S	40S	50S	70S	R	S		
Yr_{17} x Giza 163	P_1	80	80													
	P_2	80										80				
	F_1	40		40												
	F_2	145	40	38	27		21	9	10				105	40	3:1	0.51
Yr_{17} x Gemmiza 3	P_1	80	80													
	P_2	80									80					
	F_1	52	52													
	F_2	171	65	42	18		26	15	5				125	46	3: 1	0.32
Yr_{17} x Sids 6	P_1	80	80													
	P_2	80										80				
	F_1	46		46												
	F_2	122		50	16	20			16	10	10		86	36	3: 1	1.32
Yr_{17} x Sids 9	P_1	80	80													
	P_2	80										80				
	F_1	45		45												
	F_2	126		40	46	10		10			20		96	32	3: 1	0.09
Yr_{27} x Giza 163	P_1	80	80													
	P_2	80										80				
	F_1	40		40												
	F_2	127		30	35	25	16	11		4	6		90	37	3: 1	1.15
Yr_{27} x Gemmiza 3	P_1	80	80													
	P_2	80									8					
	F_1	35		35												
	F_2	142	60	23	20		19	15			5		103	39	3: 1	0.46
Yr_{27} x Sids 6	P_1	80	80													
	P_2	80			40							80				
	F_1	40	12		30											
	F_2	140		40		20				15	7	16	102	38	3: 1	0.34
Yr_{27} x Sids 9	P_1	80	80													
	P_2	80										80				
	F_1	45		45												
	F_2	145	18	20	35	25				20	11	16	98	47	3: 1	1.02