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

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## 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 METHODS

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 [*Psf*]. 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 [*Psf*] 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 $\chi^2$ 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.

**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 |

# 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

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يعتبر الصدأ الأصفر فى القمح المتسبب عن الفطر (بكسينا سترافورميس طراز تريتيساى) أكثر أمراض القمح خطورة في 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 إلي 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 *Yr17, Yr27* 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 (0-1) 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 (0-9) فى طور البادرة وشدة الاصابة (0-60S) 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.

**قام بتحكيم البحث**

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