

Annals Of Agric. Sc., Moshtohor,
Vol. 45(2): 597-606, (2007).

**COMPARATIVE STUDIES ON SLOW RUSTING IN CERTAIN
 EGYPTIAN WHEAT AS AFFECTED BY LEAF RUST
 BY**

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ABSTRACT

Four Egyptian wheat cvs viz. Giza-168, Sakha-93, Sids-1 and Giza-139 in comparison with a fast ruster i.e. Morocco gave evidence to their inclusion of slow rusting trait against leaf rust disease. Testing them for 2 seasons under greenhouse conditions and two other seasons under field conditions supported such finding. The tested cvs Revealed their ability to exhibit low pustules number, longer incubation period and latent period as compared with the local Giza-139 under field conditions. Relatively lower AUDPC, r-value and the higher weight of 1000 kw confirmed the presence of long lasting resistance in these cvs through out the two growing seasons 2003/04 and 2004/05.

INTRODUCTION

Wheat leaf rust incited by *Puccinia triticina* Ericks. & He in is one of the most dangerous diseases of wheat all over the world (Roelfs 1988). Recently, McIntoch, *et al.* 2005 described more than 60 leaf rust resistance genes and quantitative trait loci (QTLs) in wheat, many of them are race specific genes and several are used by breeders to develop new cultivars, that remain effective for short term and became ineffective thereafter. The recent example of breakdown of resistance afforded by the locus Lr 26 and Lr 9 in wheat against *P. triticina* (Aslam, 1996). Thus, it is necessary to search for more durable type of resistance. The partial resistance for wheat leaf rust is characterized in epidemiological sense by testing the component of disease cycle that affect the disease rate of increase. The long latent period was identified as important component of partial resistance (Parlevliet, 1989).

Some genes i.e. Lr 34 for adult-plant resistance have been associated with slow rusting and leaf tip necrosis (Singh 1992). Slow rusting genes are counted from a small group of leaf rust resistance genes such as Lr 34 (Martinez *et al.* 2001) and (Singh & Huertn-Espino, 2003). It was reported that Lr 34 is tightly linked with leaf tip necrosis (LTP) locus (Schnurbush *et al.*, 2004.).

The main objective of this work is to compare the phenomenon of slow rusting in certain Egyptian wheat cultivars in comparison with a cultivar Morocco

which is considered highly susceptible with leaf rust or fast rust. The study will throw high lights on the components of slow rusting through the agronomic and pathogen view points at both seedling and adult stages.

MATERIALS AND METHODS

The present work was carried out at the greenhouse of leaf rust research, at the Wheat Diseases Section, Plant Pathology Research Institute (PPRI), Agricultural Research Center (ARC), Giza, Egypt during the period 2003-2006.

Greenhouse studies.

Seeds of the Egyptian wheat (*Triticum aestivum* L.) cvs. viz. Giza-139, Giza-168, Sakha-93 and Sids-1 kindly obtained from Wheat Res. Sec. Field Crop Institute (FCI), ARC at Giza- Egypt. However, seeds of Morocco were kindly obtained from Prof. Dr. Willing, Sidney Univ. Australia (Personal communication). Meanwhile, urediniospores of races 77 and 149 solely as a source of inoculum were available at Wheat Diseases Research Section. The experiment was carried out in a completely randomized design with three replicates. These wheat cvs were sown in plastic pots (9 cm Θ). Each received 10 kernels, in a clay soil (all cultural practices were precisely applied), eight-day old seedlings were inoculated with either race 77 or 149. The inoculated seedlings were incubated in a moist chamber at (18 °C -20°C) overnight at darkness and transferred to the greenhouse benches, following the method adopted by (Tervet & Cassel, 1951) for rust inoculation. After disease onset, infection types (IT) were recorded following the scale proposed by Stakman *et al.* (1962). Latent period was estimated using the method proposed by Parlevliet (1975) who defined it by the time between inoculation and disease symptoms occurrence. Number of pustules/cm² was determined as described by (Parlevliet & Kuiper 1977).

Field experiments

This experiment was carried out at the experimental farm of Sakha Res. Sta. during the two seasons (2003/04 and 2004/05) to evaluate 4 Egyptian wheat cvs only. A split plot design was adequate for this experiment since the main plots were represented by the Egyptian cvs. within each block, however the subplots represented the treatments i.e. Artificial inoculation, chemical protection (sumi-8), flag leaf removal and natural infection. The experimental unit consisted of a pair of rows with 3 m long and 30cm apart, each row was seeded with 5 g of each wheat cv, 100cm was left between blocks and around them as an alley. The experiment was surrounded with a belt of wheat of the highly susceptible cvs. i.e. *Triticum spelta saharences* and Little Club, such belt served as a spreader for the disease. When the spreader plants were 50% infected, the genotypes were scored three times for rust severity using "Modified Cobb's" scale (Peterson *et al.* 1948) at weekly intervals.

Disease severity (DS) was recorded four times during the two successive seasons, expressed as percentage coverage of leaves with rust pustules according the scale of Peterson *et al.*, (1948). Plant reaction (Infection type) expressed in five types as described by Stakman *et al.*, (1962). Area under disease progress

curve (AUDPC) was estimated to compare different responses of the tested cultivars (Pandey *et al.*, 1989) using the following equation:

$$\text{AUDPC} = D [1/2 (Y_1 + Y_k) + Y_2 + Y_3 + \dots + Y_{(k-1)}]$$

Where: D = Time intervals, Y₁ = first disease reading and Y_k = last disease recording

Rate of disease increase (r-value) as a function of time was also estimated to determine the ability of the tested cultivars to slow down the development of leaf rust infection during the epidemic under field conditions. It was calculated from the different rust scores as a severity of leaf rust infection at the time of rust appearance and every seven days thereafter. Rate of leaf rust increase (r-value) was estimated using the following formula of Van der Plank, (1963):

$$r\text{-value} = \frac{1}{t_2 - t_1} \left(\log_e \frac{X_2}{1 - X_2} - \log_e \frac{X_1}{1 - X_1} \right)$$

Where: X₁ = the proportion of the susceptible infected tissue (DS) at date t₁, X₂ = the proportion of the susceptible infected tissue (DS) at date t₂ and t₂ - t₁ = the interval in days between these dates. Statistical analysis was down according to Snedecor and Cochran(1960).

RESULTS

1-Evaluation of some wheat cvs to leaf rust infection at seedling stage:

Regarding the components of slow rusting duration, Data in Table (1) reveal the performance of 3 of local wheat cvs. [Giza-168, Sakha-93 and Sids-1] in comparison with (2) susceptible ones [local wheat cv. Giza-139 and Morocco] as affected by inoculation with either of races of *P. triticina* at seedling stage (Table and Fig. 1). These data indicated that the two cvs. Giza-168 and Sakha-93 exhibited relatively high incubation period (IP) followed by Sids-1 that came in the second rank. On the other hand, the two fast ruster i.e. Giza-139 and Morocco exhibited the same lower value of IP (7 day) when inoculated with race 77 of *P. triticina*. A similar trend was observed between cvs., since, the IP was more higher, but the cv. Sids-1 exhibited lower value. The fast ruster exhibited no change when inoculated with race 149, where data also revealed that race 149 exhibited higher mean of IP than that of race 77. The total mean of cultivar run in the same trend.

Regarding the latent period LP, data in the Table (1) & Fig (2) revealed that cv. Giza-168 showed the longest LP when inoculated with either of the two races followed by cv. Sakha-93 with race 77. However, Giza-139, Sids-1 and Morocco exhibited the same value of LP with race 77. The situation seems quite different with race 149, since Sids-1 and Sakha-93 exhibited the same LP value. Meanwhile, Morocco exhibited higher LP than them. Also, the mean of LP was longer with race 77 than its value with race 149. Generally the highest mean of LP was recorded with Giza-168 followed by Giza-139 and Morocco, however Sids-1 and Sakha-93 were the least in such value.

Table (1): Incubation period, latent period and number of urediniospores pustules/cm² of partial resistance in five wheat cultivars inoculated with either race 77 or 149 of *Puccinia triticina*, in seedling stage.

No	Cultivars	Incubation period (day)			Latent period (day)			No. of Urediospore pustules / cm ²		
		Race 77	Race 149	Mean	Race 77	Race 149	Mean	Race 77	Race 149	Mean
1	Giza-139	7.00	7.00	7.00	8.00	8.67	8.34	34.67	81.67	58.17
2	Giza-168	7.67	8.00	7.84	9.00	9.00	9.00	12.00	6.33	9.17
3	Sakha-93	7.67	8.00	7.84	8.33	8.00	8.17	27.67	24.67	26.17
4	Sids-1	7.66	7.33	7.49	8.00	8.00	8.00	13.00	22.67	17.84
5	Morocco	7.00	7.00	7.00	8.00	8.33	8.17	42.33	61.33	51.80
	Mean	7.4	7.466	7.434	8.266	8.4	8.336	25.93	39.33	32.63

Concerning the number of pustules/cm², data in Table (1) and Fig. (3) indicate that the highest number of pustules was recorded on Giza-139 inoculated with race 149 followed by Morocco inoculated with races 77 and 149. On other hand, the least number of pustules was recorded on cv. Giza-168 inoculated with races 77 and 149 followed by cvs Sids-1 and Sakha-93. It could be also concluded that the tested cvs. exhibited less number of pustules/ cm² with race 77 as compared with race 149.

2-Evaluation of some wheat cvs to leaf rust infection under field conditions:

(a) During 2003/04:

As for rust severity (RS), data in Table (2) indicate that the four tested wheat cvs were differed in their reaction to leaf rust infection with differing the treatments. In this respect, the highest, RS was recorded in infected plots of Giza-139 and Sids-1 which inoculated artificially with mixture of races 77 and 149. Also, the RS was high on Sids-1 and Giza-139 in non-infected and flag leaf removed treatments. On the other hand, The least RS was recorded on Giza-168 and Skha-93 which protected with sumi-8 fungicide. It is clear also from the obtained results that there were clear significant differences between test wheat cvs and treatments.

Regarding AUDPC, during season 2003/04, data indicated that the highest AUDPC was recorded on cvs Giza-139 and sids-1 in artificially infected plots followed by non-infected plots of same cvs. While, the flag leaf removed treatment came in the third rank. On the other hand, the least AUDPC was recorded on all protected cvs with clear significant differences between the tested wheat cvs in relation to different treatments.

Concerning r-value during season 2003/04 data received clear significant differences between tested cvs in relation to the different treatments. In this respect, the highest r-value was recorded on Sids-1 in artificially infected and non-infected treatments. Mean while, the least r-value was recorded on Giza-168 in protected treatments. Also, the cvs Giza-139, Sakha-93 and Giza-168 revealed moderately r-value in infected, flag leaf removal and non-infected treatments.

Table (2): Rust severity, r-value, AUDPC and 1000 kernel weight of four tested Egyptian wheat cvs under field conditions during season 2003/04.

Wheat cultivars	Rust severity				AUDPC*				r-value				1000-Kernel weight			
	Protected	Art. Infected	Flag Leaf	N. infection	Protected	Infected	Flag Leaf	N. infection	Protected	Infected	Flag Leaf	N. infection	Protected	Infected	Flag Leaf	N. infection
Giza 139	10.75	72.5	40.3	40.5	88.38	590.6	406.9	472.5	0.028	0.066	0.087	0.093	44.130	39.380	36.780	41.14
Sids-1	9	72.5	57.3	57.5	105	511.9	336.0	476	0.031	0.171	0.013	0.153	44.760	40.970	37.460	42.2
Sakha-93	8.75	27.5	32.2	32.5	105.9	219.6	259.0	140.9	0.034	0.075	0.065	0.055	40.240	37.700	35.200	38.1
Giza-168	3.5	17.5	25.2	25.0	71.75	112.0	91.0	305.4	0.006	0.056	0.025	0.103	40.600	37.460	33.080	38.63

LSD at 5%
for CVS x T

15.50

181.08

0.02

2.698

Protected = sprayed with sumi-8 fungicide.

Art. Infected = infected with mixture of leaf rust races 77 and 149.

Flag Leaf = removal flag leaf.

AUDPC = area under disease progress curve.

r-value = rate of disease increase.

N. infection = natural infection.

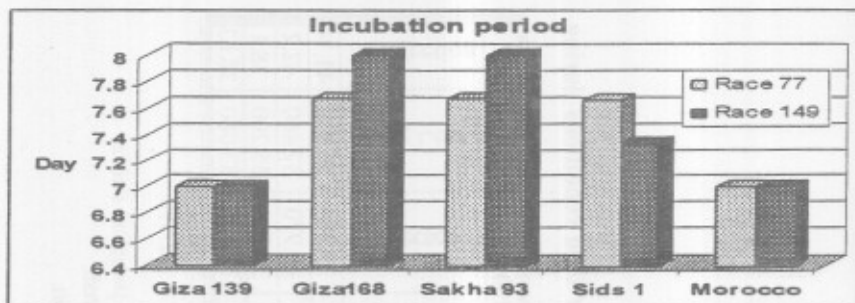


Fig. (1): Incubation period of leaf rust races 77 and 149 on different wheat cvs.

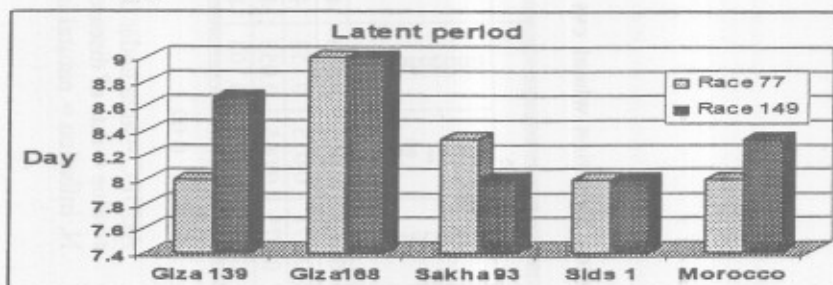


Fig. (2): Latent period of leaf rust races 77 and 149 on different wheat cvs.

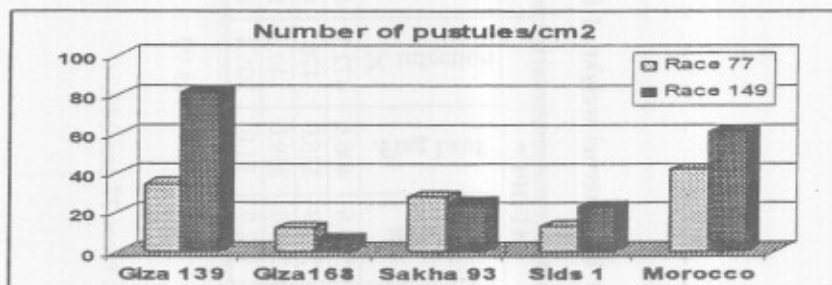


Fig. (3): Number of urediniospores pustules/ cm² of leaf rust races 77 and 149 on different wheat cvs.

On the other hand, significant differences were recorded between tested wheat cvs during season 2003/04 in relation to different treatments regarding 1000 kernel weight. In this respect, the highest of 1000 kernel weight were recorded on Sids-1 in all treatments. However, the highest weight of 1000 kernel weight was recorded on protected Sids-1 and Giza-139. Mean while, the least weight was recorded on Giza-168 and Sakha-93 in almost treatment.

(b) During 2004/05:

As for rust severity (RS), data in Table (3) indicate that the four tested wheat cvs were differed in their reaction to leaf rust infection with differing the treatments. In this respect, the highest, RS was recorded in infected plots of Giza-139 and Sids-1

which inoculated artificially with mixture of races 77 and 149 and other treatments. On the other hand, The least RS was recorded on Giza-168 and Sakha-93 which protected with sumi-8 fungicide. It is clear also from the obtained results that there were clear significant differences between test wheat cvs and treatments.

Regarding AUDPC, during season 2004/05, data indicated that the highest AUDPC was recorded on cvs Giza-139 and sids-1 in artificially infected plots followed by non-infected plots of same cvs. While, the flag leaf removed treatment came in the third rank. On the other hand, the least AUDPC was recorded on all protected cvs with clear significant differences between the tested wheat cvs in relation to different treatments.

Concerning r-value during season 2004/05 data received clear significant differences between tested cvs in relation to the different treatments. In this respect, the highest r-value was recorded on Giza-139 in artificially infected and non-infected treatments. Mean while, the least r-value was recorded on Giza-168 in protected treatments. Also, the cvs Giza-139, Sakha-93 and Giza-168 revealed moderately r-value in infected, flag leaf removal and non-infected treatments.

On the other hand, significant differences were recorded between tested wheat cvs during season 2003/04 in relation to different treatments regarding 1000 kernel weight. In this respect, the highest of 1000 kernel weight were recorded on Sids-1 in all treatments. Mean while, the least weight was recorded on Giza-168 and Sakha-93 in flag leaf removal treatment.

DISCUSSION

Wheat leaf rust incited by *Puccinia triticina* Ericks. & Her n. is one of the most dangerous diseases of wheat all over the world (Roelfs *et al.* 1992). at seedling stage. The obtained results gave evidence to the presence of relatively lower rust severity, longer IP, LP and number of pustules/cm². These parameters were often more or less common in cvs. Giza-168, Sakha-93 and Sids-1. The reverse was recorded with Morocco and Giza-139. These results run in the same trend with those of (El-Daoudi *et al.* 1983, Parlevliet 1989, EL-Shamy and Mousa 2001). The obtained result also revealed that the two leaf rust races i.e. 77 and 149 exhibited quite similar effect on the tested wheat cvs regarding these parameters with a few tendency to virulence with race 149. The mean value of such parameter exhibited by the cultivars confirmed such conclusion. This finding would give us the ground to say that cvs. Giza-168 and to some extent Sakha-93 may exhibited the component of slow rusting at seedling stage. Similar results were reported by (Kuhn *et al.* 1978 Martinez *et al.* 2001, Singh and Huerta-Espino. 2003).

As regard to the evaluation of wheat cvs at adult stage the obtained results indicated the presence of varied values of significance in slow rusting component in most of treatments, but no significance was observed in rust severity, r-value, AUDPC except for 1000 k.w. under the stress of chemical protection. This result seemed to be logic (Kolmer 1996, Singh 1992, Schnurbusch *et al.* 2004).

It could be concluded herein that flag leaf removal has a profound effect on agronomic characters and may overcome the other treatments.

Table (3): Rust severity, r-value, AUDPC and 1000 kernel weight of four tested Egyptian wheat cvs under field conditions during season 2004/05.

Wheat cultivars	Rust severity				AUDPC				r-value				1000-Kernel weight			
	Protected	Art. Infected	Flag Leaf	N. infection	Protected	Infected	Flag Leaf	N. infection	Protected	Infected	Flag Leaf	N. infection	Protected	Infected	Flag Leaf	N. infection
Giza-139	17.5	75.0	42.2	42.5	136.5	800.6	394.6	356.1	0.081	0.152	0.128	0.129	41.420	38.880	35.600	40
Sids-1	9.5	50.0	62.2	62.5	105.9	420.9	562.6	525.9	0.031	0.144	0.129	0.171	45.220	43.500	36.820	42.43
Sakha-93	7.5	35.0	16.0	16.25	99.75	369.3	248.5	175.9	0.03	0.134	0.1	0.072	40.620	39.270	35.780	39.03
Giza-168	4.75	16.25	9.5	9.5	79.63	149.6	132.1	99.75	0.015	0.072	0.056	0.047	42.050	40.200	35.220	40.47

LSD at 5%
for CVS x T

13.50

138.66

1.29

1.06

Protected = sprayed with sumi-8 fungicide.

Art. Infected = infected with mixture of leaf rust races 77 and 149.

Flag Leaf = removal flag leaf.

AUDPC = area under disease progress curve.

r-value = rate of disease increase.

N. infection = natural infection.

The obtained results confirmed the presence of significance in cvs regarding the components of slow rusting i.e. r-value, rust severity and 1000 K.W. These results run in the same line with those of (Martinez *et al.* 2001, Qing *et al.* 2005) who suggested that the slow-rusting might have a similar mechanism with the low infection who type resistance of race specificity, but with lower intensity.

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دراسة مقارنة على التطور البطيء لصدأ الأوراق في بعض أصناف القمح المصرية

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في دراسة مقارنة لمدى انتشار مرض صدأ أوراق القمح لمدة موسمين تحت ظروف الصوبة بين أربعة أصناف مصرية: 'جيزة 139'، جيزة 168، وسخا 93، سدس 1 مع الصنف 'موروكو' سريع الإصابة بالصدأ، وتمت المقارنة في الحقل للأصناف المصرية فقط. أظهرت نتائج الأصناف لتقدير مكونات التطور البطيء لصدأ الأوراق بكل من طوري البادرة والحقل أن الأصناف: جيزة 168، وسخا 93، سدس 1 لديها صفة التطور البطيء لزيادة المرض. حيث يتكشف عليها أقل عدد من البثرات في وحدة المساحة، وأطول فترة حضانة مقارنة بالصنف المحلي جيزة 139 والصنف موروكو.

وفيد هذا البحث في طرق المقاومة للأصداء ببرامج التربية للقمح وبرنامج أمراض القمح.