Egypt. J. Phytopathol., Vol. 38, No. 1-2, pp. 77-88 (2010)

Frequency of Virulence and Virulence Formula of Wheat Leaf Rust Races Identified in Egypt during 2004/05 - 2007/08

M. Nazim*; M.M. Aly; Ikhlas Shafik*** and Nagwa I. Abdel-Malek*****

* *Fac. of Agric., Minufiya Univ., Shibin El-Kom, Egypt.*
** *Fac. of Agric., Ain Shams Univ., Cairo, Egypt.*
*** *Plant Pathol. Res. Instit., ARC., Giza, Egypt.*

Wheat leaf rust is one of the major diseases on wheat in Egypt which appears annually in virulence of different frequencies. In this investigation, leaf rust samples were collected from different locations of Lower Egypt during four seasons (2003/04–2006/07). The single pustule method of isolation was followed for each sample. Rust data were recorded as infection types and virulence frequencies were determined against 20 *Lr* genes, in monogenic lines, and some Egyptian genotypes. Virulence frequencies were very high against *Lr's* 1, 2a, 2c, 3, 16, 26, 11, 30, 2b, 14b, 15 and 42, but were the lowest against *Lr's* 9, 24, 3ka, 10, 12, 18, 21 and 36 and also the cv. Gemmeiza 9. The physiologic races were identified according to their reactions on the 20 *Lr's* and virulence formula (virulence/avirulence) was recorded for each race. Shift, appearance and disappearance of the physiologic races were demonstrated. Race groups TT---, PT--- and FT--- were the most dominant being virulent mainly against *Lr's* 1, 2c, 3 and 9.

Keywords: Isogenic lines, leaf rust, *Puccinia triticina*, race groups, wheat, virulence frequency.

Leaf rust (*Puccinia triticina* Erikss.= *P. recondita* f.sp. *tritici*) is a common disease on wheat in all growing areas in Egypt. It annually appears at varying magnitudes in the different locations of the country. Nevertheless, it occurs at higher levels of disease severities in Lower Egypt than the other parts of the country (Abdel-Hak *et al.*, 1966 and Nazim *et al.*, 1976).

Generally, disease infection and development depend on the host response, pathogen virulence and the prevailing environmental conditions (Dyck and Johnston, 1983 and Eversmeyer and Kramer, 2000).

Under the Egyptian conditions, almost the local wheat genotypes are susceptible to leaf rust in terms of infection types (Nazim *et al.*, 1984). Moreover, the prevailing environmental conditions are highly suitable to the disease infection and development. Therefore, intensive care should be given to the prevailing virulences of the causal organism. However, it should be mentioned that the over summering of the causal organism urediniospores is doubtful and the main or the only source of inocula is from outside the country (Abdel-Hak *et al.*, 1966 and Saari, 1976), particularly in the absence of the alternate host (*Thalictrum* spp.), volunteer plants and/or stubs (Melchers, 1932 and Abdel-Hak *et al.*, 1966). The urediniospores which come into the country are usually found in different pathotypes which differ in their virulence and aggressiveness against the known genes for leaf rust resistance and also against the local genotypes which are different in their genetic makeup (Nazim *et al.*, 1983 and Nazim *et al.*, 1984).

Therefore, the aim of this investigation was to study the frequency of virulence against the leaf rust single genes for resistance and also against the local genotypes, to serve the national breeding programme for resistance.

Materials and Methods

Infected leaf specimens were collected from different wheat growing areas in Egypt during 2003/04-2006/07. Samples were obtained from the commercial fields as well as from wheat leaf rust trap nursery (WLRTN), from lines carrying known genes for leaf rust resistance (*Lr* s). Each specimen was transferred onto 8-9 day-old seedlings of the highly susceptible variety Giza 139 under greenhouse conditions.

Results

Frequency of virulence:

Frequency of virulence of the causal organism " *Puccinia triticina* Erikss." of wheat leaf rust was studied using rust samples collected from lower Egypt during 2003/04 – 2006/07. The obtained cultures were tested in the following seasons (2004/05 – 2007/08). Virulence was tested against 20 monogenic lines for leaf rust resistance (Table 1) and also against selected wheat local varieties. Occurrence of virulence was estimated as virulent isolates to the total number of isolates for each wheat genotype.

a) Frequency of virulence to Lr's:

1) Occurrence of virulence in 2004/05:

The results presented in Table (3) showed different frequencies of virulence to the tested lines. The lowest values were found against *Lr* 9, *Lr* 21, *Lr* 24, *Lr* 10, *Lr* 36, and *Lr* 3ka, ranging from 19.58 to 36.08% in an ascending order. On the other hand, the highest occurrence of virulence was found against *Lr* 3, *Lr* 42, *Lr* 11, *Lr* 2a, *Lr* 15, *Lr* 30, *Lr* 16 and *Lr* 1, ranging 91.60 - 77.30% in a descending order. Whereas, the rest of lines showed moderate responses, as shown in Table (3).

2) Occurrence of virulence in 2005/06:

Results obtained revealed that *Lr* 9, *Lr* 21, *Lr* 36 and *Lr* 24 exhibited the lowest frequencies of virulence, being 25.0, 27.16, 27.71 and 36.14%, respectively. On the other hand, *Lr* 3, *Lr* 42, *Lr* 2c, *Lr* 15, *Lr* 30, *Lr* 16, *Lr* 14b, *Lr* 1, *Lr* 2b and *Lr* 26 arranged according to their virulence frequency, ranged from 93.01 to 73.8% (Table 3).

Table 1: [a]Pt-Code for the four differential sets in addition to a set of four lines for virulence survey for *Puccinia triticina* in Egypt

	Infection type [b] produced on near isogenic lines (*Lr* lines):			
Host set 1	1	2a	2c	3
Host set 2	9	16	24	26
Host set 3	3ka	11	17	30
Host set 4	10	18	21	2b
Host set 5*	14B	15	36	42
B	L	L	L	L
C	L	L	L	H
D	L	L	H	L
F	L	L	H	H
G	L	H	L	L
H	L	H	L	H
J	L	H	H	L
K	L	H	H	H
L	H	L	L	L
M	H	L	L	H
N	H	L	H	L
P	H	L	H	H
Q	H	H	L	L
R	H	H	L	H
S	H	H	H	L
T	H	H	H	H

[a] Pt-code consists of the designation for set 1 followed by that for set 2 , etc. For example, race MGBL; set 1 (M)-virulent to *Lr* 1, 3; set 2 (G)-virulent to *Lr* 16 ; set 3 (B)-avirulent; set 4 (L) virulent to *Lr* 10.

[b] L=low infection type (avirulent race); H = high infection type (virulent race).

* Nazim (1998), W4 (1998-2001, W4, ATUT - Minufiya Univ., Egypt).

Table 2: Infection types of leaf rust of wheat

Host response (class)	Infection * type	Disease symptom
Immune	0	No uredinia or other macroscopic sign of infection
Nearly immune	0;	No uredinia but hypersensitive necrotic or chlorotic flecks present
Very resistant	1	Small uredinia surrounded by necrosis
Moderately resistant	2	Small to medium uredinia surrounded by necrosis
Moderately susceptible	3	Medium sized uredinia that may be associated with chlorosis
Very susceptible	4	Large uredinia without chlorosis
Heterogeneous	X	Random distribution of variable sized uredinia on single leaf

* Infection types 0, 0; , 1 and 2 are considered as low infection types, whereas, infection types 3 and 4 are considered as high infection types (Johnston, 1961).

Table 3: Frequency of virulence of *Puccinia triticina* to 20 monogenic lines for leaf rust resistance during the following seasons

No.	*Lr* gene	Frequency of virulence (%) / season			
		2004/05	2005/06	2006/07	2007/08
1	*Lr* 1	77.30	75.00	65.50	89.20
2	*Lr* 2a	85.56	55.90	74.78	79.68
3	*Lr* 2c	85.40	89.10	76.40	81.50
4	*Lr* 3	91.60	93.10	84.00	93.80
5	*Lr* 9	19.58	25.00	25.21	23.07
6	*Lr* 16	77.30	80.90	73.90	96.90
7	*Lr* 24	31.95	36.14	27.73	30.96
8	*Lr* 26	74.20	73.80	73.10	86.10
9	*Lr* 3ka	36.08	40.47	31.09	35.38
10	*Lr* 11	86.20	48.19	50.42	46.15
11	*Lr* 17	46.87	40.24	68.90	53.84
12	*Lr* 30	77.30	82.01	73.90	96.09
13	*Lr* 10	32.97	37.03	42.37	44.16
14	*Lr* 18	41.23	48.19	71.10	80.00
15	*Lr* 21	25.77	27.16	28.81	21.53
16	*Lr* 2b	75.70	75.90	80.50	41.50
17	*Lr* 14b	73.10	77.30	84.00	98.40
18	*Lr* 15	82.40	86.90	78.90	89.20
19	*Lr* 36	36.00	27.71	30.25	32.30
20	*Lr* 42	89.60	92.70	72.60	86.10

3) Occurrence of virulence in 2006/07:

Virulence frequency against *Lr* 9, *Lr* 24, *Lr* 21, *Lr* 36 and *Lr* 3ka were the lowest, *i.e.* 25.21, 27.73, 28.81, 30.25 and 31.09%, respectively. While, virulence to *Lr* 1, *Lr2a*, *Lr* 2c, *Lr* 3, *Lr* 16, *Lr* 26, *Lr* 17, *Lr* 30, *Lr* 18, *Lr* 2b, *Lr* 14 b, *Lr* 15 and *Lr* 42 were the highest frequencies, being 65.5, 74.78, 76.4, 84.0, 73.9, 73.1, 68.9, 73.9, 71.1, 80.5, 84.0, 78.9 and 72.6%, respectively, (Table 3).

4) Occurrence of virulence in 2007/08:

The results given in Table (3) show different frequencies of virulence to the tested *Lr* genes in terms of infection types. The least frequencies were found to *Lr* 21, (21.53%) and *Lr* 9 (23.07 %). On the other hand, 80 % or more of the isolates were virulent to *Lr* 1 , *Lr* 2 c , *Lr* 3 , *Lr* 16 , *Lr* 26 , *Lr* 30 , *Lr* 18 , *Lr* 14 b , *Lr* 15 and *Lr* 42 , while the rest of *Lr* genes showed different responses.

Dramatic shift in frequency of virulence to *Lr* 2a, *Lr* 16, *Lr* 11, *Lr* 17, *Lr* 18 and *Lr* 2 b was found, whereas *Lr* 1, *Lr* 2c, *Lr* 3, *Lr* 9, *Lr* 24, *Lr* 26, *Lr* 3 ka, *Lr* 30, *Lr* 10, *Lr* 21, *Lr* 14b, *Lr* 15, *Lr* 36 and *Lr* 42 were almost stable showing light shifts in their frequencies of virulence during the period of study. Moreover, no absolute resistance was noticed within the tested monogenic lines. The occurrence of virulences to *Lr* 9 and *Lr* 21 was the lowest, while, virulences to *Lr* 24 and *Lr* 36 were relatively moderate during the whole period of study.

b) Frequency of virulence to local wheat genotypes:

Occurrence of virulence was also estimated as percentage of virulent occurrence against the local wheat cultivars to the total number of the tested isolates.

1) Occurrence of virulence in 2004/05:

Data presented in Table (4) show that the lowest frequencies of virulence (18.50 and 29.33%) were found to wheat cultivars Gemmeiza 9 and Sakha 93, respectively. Relatively moderate frequencies (31.50, 31.90, 32.20, 37.14, 37.50, 37.90 and 47.90%) occurred to the wheat cultivars Sakha 94, Gemmeiza 10, Sids 10, Sakha 61, Gemmeiza 7, Sids 1 and Sids 9, respectively. Relatively higher frequencies occurred to other cultivars, *i.e.* Giza 164 (52.0%), Giza 170 (54.70%), Sakha 8 (55.60%), Sids 6 (57.20%), Sids 8 (61.40%) and Giza 168 (64.20%). Moreover, the highest frequencies (79.78, 72.16, 71.80 and 76.00%) occurred to the wheat cvs. Giza 160, Sakha 69, Sids 7 and Sids 11, respectively.

Table 4: Frequency of virulence of *Puccinia triticina* to Egyptian wheat varieties during the following seasons

No.	Variety	Frequency of virulence (%) / season			
		2004 / 05	2005 / 06	2006/07	2007/08
1	Giza 160	79.78	91.66	-	-
2	Giza 164	52.00	52.30	67.80	-
3	Giza 168	64.20	67.80	72.00	20.30
4	Giza 170	54.70	63.70	52.60	-
5	Gem. 7	37.50	35.70	54.20	-
6	Gem. 9	18.50	22.60	35.50	18.40
7	Gem. 10	31.90	33.30	43.20	7.60
8	Sakha 8	55.60	60.70	68.60	-
9	Sakha 61	37.14	84.50	79.80	-
10	Sakha 69	72.16	84.50	88.90	-
11	Sakha 93	29.33	88.00	75.40	-
12	Sakha 94	31.50	47.40	65.20	9.20
13	Sids 1	37.90	64.60	73.10	-
14	Sids 6	57.20	-	-	-
15	Sids 7	71.80	-	-	-
16	Sids 8	61.40	-	-	-
17	Sids9	47.90	-	-	-
18	Sids 10	32.20	-	-	-
19	Sids 11	76.00	75.00	71.50	-
20	Sids 12	-	63.00	60.50	-
21	Sohag 3	-	56.20	40.50	-
22	Sohag 1	-	35.30	24.30	-
23	Baniswief 1	-	82.70	62.30	-

2) Occurrence of virulence in 2005/06:

Data presented in Table (4) indicate that the lowest frequencies of virulence (22.6, 33.3, 35.7 and 35.3%) were detected to the wheat cvs. Gemmeiza 9, Gemmeiza 10, Gemmeiza 7 and Sohag 1, respectively. Higher frequencies occurred to the cvs. Giza 164, Giza 168, Giza 170, Sakha 8, Sakha 94, Sids 1, Sids 11, Sids 12 and Sohag 3, being 52.3, 67.8, 63.7, 60.7, 47.4, 64.6, 75.0, 63.0 and 52.2%, respectively. On the other hand, highest frequencies of virulence (91.66, 84.50, 84.50, 88.00 and 82.70%) were found to the wheat cvs. Giza 160, Sakha 61, Sakha 69, Sakha 93 and Baniswief 1, respectively.

3) Occurrence of virulence in 2006/07:

The lowest frequencies, *i.e.* 24.3, 35.5 and 43.2% were found to the wheat cvs. Baniswief 1, Gemmeiza 9 and Gemmeiza 10, respectively. Whereas, the highest frequencies (79.8, 88.9 and 75.4%) were found to the wheat cvs. Sakha 61, Sakha 69 and Sakha 93, respectively (Table 4).

4) Occurrence of virulence in 2007/08:

The results obtained in the fourth growing season showed that cvs. Gemmeiza 10 and Sakha 94 had low frequencies of virulence being, 7.6 and 9.2%, respectively, followed by cv. Gemmeiza 9 (18.4%) and cv. Giza 168 (20.3%).

From the results presented in Table (4), it was noticed that different virulence frequencies were found during the period of study. Occurrence of virulence to cvs. Gemmeiza 9 and Gemmeiza 10 was more stable, whereas, virulence to cvs. Giza 168 and Sakha 94 exhibited higher frequencies in the first three seasons, then declined in the fourth season.

Physiologic races and virulence formula:

Physiologic races of *P. triticina* were identified as major race groups showing different virulence formula (Table 5). Race group T- - - - was the most dominant race group (40.0, 36.8, 27.4 and 19.9%), followed by race group P - - - - (24.4, 13.7, 19.9 and 53.7%); race group F - - - - (6.1, 4.7, 5.0 and 4.6%); race group B - - - - (4.1, 4.7, 1.6% , -) and race group C - - - - (3.0, 1.2 % , - , - ,). Race groups TR - - - and TP - - - occurred in lower percentages in the first three seasons and disappeared in the fourth season. On the other hand, race groups PL - - - , PQ - - - , PM - - - and PP - - - , in addition to race group FQ - - - and BB - - - disappeared in the fourth season. Whereas, race group CT - - - disappeared in the last two seasons of the study. Moreover, race group TT - - - (27.8, 25.0, 22.6 & 18.4%) appeared in lower percentage of isolation in the fourth season, but race group PT - - - (12.3, 3.5, 11.7 & 47.6%) appeared in higher percentage in this season, reflecting shift in their occurrence in the fourth season of the study (2007 / 08). Moreover, virulence formula of the identified race groups, indicated that *Lr*'s 2c, 3 and 9 were almost inactive against all identified races during the period of study (Table 5). Meanwhile, *Lr*'s 1, 16, 24 and 26 were active against certain identified races and inactive against others.

Table 5: Virulence and Virulence formula of *Puccinia triticina* Erikss

Race group *	Virulence formula	Isolation (%)/year**			
		2004/05	2005/06	2006/07	2007/08
TT---	*Lr* 1,2a,2c,3,9,16,24,26	27.8	25.0	22.6	18.4
TS---	*Lr* 1,2a,2c,3,9,16,24	4.1	4.7	1.6	1.5
TR---	*Lr* 1,2a,2c,3,9,16,26	5.1	5.9	1.6	-
TP---	*Lr* 1,2a,2c,3,9,24,26	3.0	1.2	1.6	-
T----	----------------	40.0%	36.8%	27.4%	19.9%
PT---	*Lr* 1,2c,3;9,16,24,26	12.3	3.5	11.7	47.6
PL---	*Lr* 1,2c,3,9	1.0	13.0	0.8	-
PS---	*Lr* 1,2c,3,9,16,24	1.0	1.2	-	4.6
PQ---	*Lr* 1,2c,3,9,16	3.0	3.5	0.8	-
PM---	*Lr* 1,2c,3,9,26	2.0	1.2	0.8	-
PR---	*Lr* 1,2c,3,9,16,26	4.1	8.3	3.3	1.5
PP---	*Lr* 1,2c,3,9,24,26	1.0	1.2	2.5	-
P----	----------------	24.4%	13.7%	19.9%	53.7%
FT---	*Lr* 2c,3,9,16,24,26	4.1	3.5	4.2	4.6
FQ---	*Lr* 2c,3,9,16	2.0	1.2	0.8	-
F----	----------------	6.1%	4.7%	5.0%	4.6%
BB---	----------------	4.1	4.7	1.6	-
CT---	*Lr* 3,9,16,24,26	3.0	1.2	-	-

* Other race groups recorded frequency less than 1%.

** Samples were collected in Egypt during 2003/04-2006/07 and tested during the abovementioned seasons.

Discussion

Leaf rust of wheat, in particular, has been the main cause of eliminating many cultivars, *e.g.* cvs. Giza 139, Mexipak 69, Super X, Chenab 70 and Giza 160, because of their susceptibility under field conditions. Moreover, some wheat cultivars were discarded very shortly after their release such as cvs. Giza 139 and Giza 160 (Gomaa, 1978 and Nazim *et al.*, 1990). The failure of such genotypes was mainly due to the dynamic nature in population of the causal organism which produces virulences able to breakdown their resistance.

Generally, new races of leaf rust develop by mutation (Park *et al.*, 2002); heterokaryosis (Kolmer, 1992); recombination (McIntosh, 1992 and Park *et al.*, 1999); migration (Park *et al.*, 1995) and selection of virulence against resistance of the grown wheat varieties in the region (Kolmer, 2005).

The change occurring in virulence of leaf rust population is mostly influenced by new varieties with known or unknown resistance genes and also by a biotic factor, *e.g.* temperature and rainfall (Nazim and Clifford, 1983 and Manninger, 2001).

It was previously reported by Melchers (1932) and Abdel-Hak *et al.* (1966) that the alternate host (*Thalictrum* spp.) could not be found in Egypt and that the urediniospores cannot survive in the summer in Egypt due to the high temperature (Nazim *et al.*, 2003 and Abd EL-Malek, 2003) indicating that the initial inoculum comes from external sources (Abdel-Hak *et al.*, 1966; Saari, 1976 and Nazim *et al.*, 2003).

McVey *et al.* (2004) indicated that wheat leaf rust population in Egypt is made of a great diversity. Moreover, field observations in Egypt showed that the absence of alternate host, volunteer plants and stubs confirm that the source of initial inoculum usually comes from the neighbouring countries, carried by the prevailing winds. Therefore, the present work was concerned with the diversity in population of the causal organism and the frequency of the different virulences. Also this work included greenhouse studies to estimate the frequency of virulences of the causal organism against a set of 20 monogenic lines and some wheat cultivars in order to study the shifts in virulence in the different seasons. Evaluation of the effectiveness of *Lr* genes was included to serve the national breeding programs for leaf rust resistance.

From the results obtained during the four seasons (2004/05 - 2007/08), it was found that the occurrence of virulence frequencies against *Lr* 9, *Lr* 21 and *Lr* 24 were very low but against *Lr* 3 ka , *Lr* 36 and *Lr* 10 were relatively moderate. Shifts in virulence frequency were noticed with *Lr* 2a, *Lr* 16, *Lr* 11, *Lr* 17, *Lr* 18 and *Lr* 26 against the tested isolates. No shifts occurred with *Lr* 's 1, 2c, 3, 3ka, 9, 24, 26, 30, 10, 21. 14b, 15, 36 and 42. Thus, *Lr* 9, *Lr* 21 and *Lr* 24 were the most effective genes, followed by *Lr* 3 ka, *Lr* 10 and *Lr* 36. Similar results were reported by Nazim *et al.* (1976); Nazim *et al.* (1983); Sherif *et al.* (1996) and Imbaby and Ageez (1998).

Concerning the occurrence of virulence against the tested wheat varieties, results showed different virulence frequencies during the period of study due to the different prevailing races and environmental conditions, as well as the genetic makeup of the different genotypes. However, cv. Gemmeiza 9 showed moderate virulence frequency during the four seasons, whereas, cvs. Gemmeiza 10 and Sakha 94 gave moderate occurrence of virulence in the first three seasons, but lower in the fourth one, reflecting a shift in their reactions.

Generally, the use of wheat genotypes with genetic resistance to leaf rust is the most practical method of controlling the disease. Meanwhile, the use of genotypes with specific genes for resistance selects pathotypes that have virulence to the resistance genes (Manninger, 2001; Long *et al.*, 2002 and Kolmer and Ordoñez, 2007).

McVey *et al.* (2004) suggested that the use of resistance genes in Egypt has had a strong selective effect on virulence in the pathogen population during the same season. Also, Kolmer *et al.* (2005) stated that the use of wheat cultivars with leaf rust seedling resistance genes has selected leaf rust phenotypes with resistance to genes *Lr* 9, *Lr* 16, *Lr* 17, *Lr* 24 and *Lr* 26 in the United States in 2003.

The physiologic races of *P. triticina* that were identified as major race groups showed different virulence formula during the four seasons (2005–2008). Race group T - - - - was the most dominant race; followed by race group P - - - - , race group F - - - - , race group B - - - - and race group C - - - - . Race groups TR - - - and TP - - - occurred in lower percentages in the first three seasons and disappeared in the fourth season. On the other hand, race groups PL- - -, PQ- - -, PM- - -and PP- - - in addition to race group FQ - - - and race group BB - - - disappeared in the fourth season. Race group CT - - - disappeared in the last two seasons of the study (2006/07–2007/08). Moreover, race group TT - - - showed low percentage of isolation and race group PT - - - showed higher percentage of isolation, reflecting a shift in their occurrence in the fourth season (2007/08).

The difference in virulence appearance and / or disappearance depends on the source of inocula carried to Egypt by northern winds (Nazim *et al.*, 1976).

Concerning virulence formula of the identified race groups, it was noticed that *Lr 2c, Lr 3* and *Lr 9* were inactive against all identified races during the period of study, whereas, *Lr 1, Lr 16, Lr 24 and Lr 26* were active against certain races and inactive against others.

Shifts in physiologic specialization between leaf rust and resistance genes probably reflect the use of certain *Lr* genes in wheat cultivars (Watkins, 2001). Thus, wheat varieties should be supplied by effective genes for leaf rust resistance to avoid any expected epidemics.

References

Abdel-Hak, T.; Kamel, A.H.; Keddis, Sofia and Shafik, Ikhlas. 1966. Epidemiology of wheat rusts in the U.A.R. (Egypt). Min. Agric. Plant Port. Dep. Cereal Diseases Res. Div. Tech. Bull. No.1 : pp. 1-46.

Abd EL-Malek, Nagwa I. 2003. Study the effect of environmental factors on the viability of rust urediniospores of wheat rusts. M.Sc. Thesis, Dept. of Agric. Science. Institute of Environmental Studies and Research. Ain Shams University, 2003.

Dyck, P.L. and Johnston, R. 1983. Temperature sensitivity of genes for resistance in wheat to *Puccinia recondita*. *Can. J. Plant Pathol.*, **5:** 229-234.

Eversmeyer, M.G. and Kramer, C.L. 2000. Epidemiology of wheat leaf and stem rusts in the Central Grait Plains of the U.S.A. *Ann. Rev. Phytopathol.*, **38:** 491-513.

Gomaa, A.S.A. 1978. Report on the Egyptian wheat varieties and their development, Egyptian Soc. of Genetics Science, Cairo.

Imbaby, I.A. and Ageez, A.A. 1998. Virulence patterns of *Puccinia recondita* f.sp. *tritici* in Egypt. *Egypt. J. Phytopathol.*, **26:** 121-130.

Johnston, C.O. 1961. Sixth revision of international register of physiologic races of the leaf rust of wheat "*Puccinia recondita*". Report. Supplement. **92:** 19-30.

Kolmer, J.A. 1992. Effect of sexual recombination in two population of the wheat leaf rust fungus *Puccinia recondita. Can. J. Bot.*, **70:** 359-363.

Kolmer, J.A. 2005. Tracking wheat rust on a continental scale. *Oxford, U.K: EL Sevier. Curr. Opin. Plant Biol.*, **8:** 441-449.

Kolmer, J.A. and Ordoñez, M.E. 2007. Genetic differentiation of *Puccinia triticina* populations in Central Asia and the Caucuses. USDA–ARS. Cereal Disease Laboratory and Dept. of Plant Pathology, Univ. of Minnesota, St. Paul 55108. (C.f. *Amer. Phytopathol. Soc.*, **97** (9): 1141).

Kolmer, J.A.; Long, D.L. and Huges, M.E. 2005. Physiologic specialization of *Puccinia triticina* on wheat in the United States in 2003. *Plant Dis.*, **89 (11):** 1201-1206.

Long, D.L.; Leonard, K.J. and Hughes, M.E. 2002. Virulence of wheat leaf rust in the United States in 1999. *Plant Dis.*, **86:** 15-19.

Manninger, K. 2001. Occurrence and virulence of wheat leaf rust in Hungary. Plant Prot. Institute, Hungarian Acad. of Sciences, H. 1525 Budapest, P.O. Box 102, Hungary.

McIntosh, R.A. 1992. Close genetic linkage of genes conferring adult-plant resistance to leaf and stripe rust in wheat. *Plant Pathol.*, **41:** 523-527.

McVey, D.V.; Nazim, M.; Leonard, K.J. and Long, D.L. 2004. Patterns of virulence diversity in *Puccinia triticina* on wheat in Egypt and United States in 1998-2000. *Plant Dis.*, **88:** 271-279.

Melchers, L.E. 1932. Plant disease problems in Egypt. *Trans. Kansas Acad. Sci.*, **35:** 39-61.

Nazim, M. 1998. Report of the research project ATUT, W4 (1998 – 2001) Linked project between Minufiya University and Minnesota University (USDA), The Cereal Disease Lab. (1997-2001).

Nazim, M. and Clifford, B.C. 1983. Effect of temperature on the interaction between *Puccinia recondita* f.sp. *tritici* and *Triticum aestivum*. *Minufiya J. Agric. Res.*, **7:** 69-83.

Nazim, M.; El-Shehedi, A.A.; El-Basyouni, S.Z. and Abdel-Hak, T.M. 1976. The relative effectiveness of wheat leaf rust resistance genes in seedling and adult stages. 2nd Cong. Egypt. Phytopathol. Soc., pp. 627-641.

Nazim, M.; Abdou, Y.A. and Sherif, S. 1983. Virulence survey and population shift of *Puccinia recondita* f.sp. *tritici* in Egypt. *Appl. Microbiol. Soc. Cairo,* **3:** 29-41.

Nazim, M.; Abdou, Y.A.; El-Shehedi, A.A.; EL-Daoudi Y.H. and EL-Rayes, F. 1984. Estimation of loss in grain yield of two wheat varieties caused by leaf rust using single tillers. *Minufiya, J. Agric. Res.*, **8:** 53-65.

Nazim, M.; El-Shanawani, M.Z. and Boulot, O. 1990. Partial resistance to leaf rust in some Egyptian wheat cultivars. Proc. of the 6th Cong. of Egypt. Phytopathol. Soc., **1:** 77-97.

Nazim, M.; Ali, M.M.; Imbaby, I.A. and Abd El-Malek, Nagwa I. 2003. Viability of rust urediniospores stored at different temperatures and produced on different wheat genotypes. *J. Environ. Sci.*, 7 (3): 911-934.

Park, R.F.; Burdon, J.J. and McIntosh, R.A. 1995. Studies in the origin, spread and evolution of an important group of *Puccinia recondita* f.sp. *tritici* pathotypes in Australia. *Eur. J. Plant Pathol.*, **101:** 613-622.

Park, R.F.; Burdon, J.J. and Jahoor, A. 1999. Evidence for somatic hybridization in nature in *Puccinia recondita* f.sp. *tritici*, the leaf rust pathogen of wheat. *Mycol. Res.*, **103:** 715-723.

Park, R.F.; Bariana, H.S.; Weltings, C.R. and Wallwork, H. 2002. Detection and occurrence of a new pathotype of *Puccinia triticina* with virulence for Lr 24 in Australia. *Aust. J. Agric. Res.*, **53:** 1069-1076.

Saari, E.E. 1976. Long distance transportation and expansion of wheat rusts. *J. Turk. Phytopathol.*, **5:** 7-12.

Sherif, S.; Shafik, Ikhlas; Imbaby, I.A.; Alaa El-Dein, Omayma; Tammam, A. and Mostafa, M.A. 1996. Virulence survey of leaf rust of wheat caused by *Puccinia recondita* f.sp. *tritici*, in Egypt in 1994/95. Proceeding du Symposium Régional sur les Maladies des Céréale et des Légumineuses Alimentaires., Rabat, Moroco, pp. 173-178.

Watkins, J.E.; Schimelfenig, J.; Buenziger, P.S. and Eskridge, K.M. 2001. Virulence of *Puccinia triticina* on wheat in Nebraska during 1997 and 1998. *Plant Dis.*, **85** (2): 159-164.

(Received 17/03/2010;
in revised form 12/05/2010)

تكرار ظهور السلالات الممرضة ومعادلة القدرة المرضية لمرض صدأ أوراق القمح وتعريف السلالات الفسيولوجية للفطر المسبب في مصر خلال الفترة ٢٠٠٤/٢٠٠٥ ــ ٢٠٠٧/ ٢٠٠٨

محمد نظيم* ، مديح محمد علي** ، إخلاص شفيق*** ،
نجوه ابراهيم عبد الملك***
* كلية الزراعة-جامعة المنوفية
** كلية الزراعة-جامعة عين شمس
*** معهد بحوث أمراض النباتات ــمركز البحوث الزراعية-الجيزة.

يعتبر مرض صدأ أوراق القمح من الأمراض الرئيسية فى مصر والذى يظهر سنويا بدرجات مختلفة من التكرار للسلالات الممرضة – وفى هذا البحث جمعت عينات أوراق القمح المصابة بالمرض من جهات متفرقة من الوجة البحرى خلال أربعه مواسم ٢٠٠٣/٢٠٠٤ ــ ٢٠٠٦/ ٢٠٠٧.

وقد تم عزل السلالات الممرضة بإتباع طريقة البثرة الفردية – وأخذت بيانات الصدأ بطريقة طرز الإصابة ضد عشرين سلالة قمح حاملة لجينات فردية للمقاومة وكذلك بعض أصناف القمح المحلية – وقد تم تسجيل المعادلة المرضية لكل سلالة مع تسجيل غياب وظهور السلالات الفسيولوجية والتغير فى ظهور هذه السلالات ونسب عزلها. وقد سجلت أعلى نسب للإصابة على سلالات القمح الحاملة لجينات المقاومة المفردة أرقام 1, 2a, 2c, 3, 16, 26, 11, 30, 2b, 14b, 15, 42 بينما كانت السلالات بأرقام 36, 21, 18, 12, 10, 3ka, 24, 9, 5 والصنف جميزة ٩ أقلها فى نسب الإصابة. وكانت مجاميع السلالات الفسيولوجية ---TT و---PT و---FT أكثر السلالات سيادة و قدرة على إصابة سلالات القمح الحاملة لجينات المقاومة الفردية بأرقام 9 ,3 ,2c ,1.