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VIRULENCES AND PATHOGENICITY ASSOCIATIONS IN *PUCCINIA GRAMINIS* f. sp. *TRITICI* IN EGYPT DURING 1989/90 AND 1990/91 SEASONS

EL-DAOUDI, Y. H. , S. ABU EL- NAGA , IKHALS SHAFIK , FATEN K. EL-NASHAR, E. E. MOSTAFA AND M. M. O. KHALIFA

Plant Pathology Institue , Agrculyure Research Center Giza, Egypt .

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Abstract

Wheat stem rust survery during 1989/91 revealed the existence of 7 physiologic races i.e. 11,34,17,14,24,39 and 285 and 6 races i.e.11,11B , 15,17,24 and 34, respectively . Races,11,34,24 and 17 were the most frequent in both seasons .Virulence analysis of 96 and 78 stem rust single isolates on 12 wheat monogenic lines resulted in 37 and 41 virulence formulae during the two seasons , respectively . Most of the tested isolates were found virulent.

virulences were recorded to sr30 ,11, 8a ,24 and 37 (Tt-2) in 1989/90 and to sr 24 ,37 Gt,8a,30 and 11 in 1990/91 . Sr 9e,26 and to some extent sr27 proved their effectiveness against stem rust population during both seaons .

INTRODUCTION

Virulence has been recognized as a character controlled by a group of specific genes which may be influenced by those controlling pathogenicity (Waston 1970). A virulent physiologic race of a fungal pathogen is one which carries "virulence" genes

which enable it to attack a particular host genotype , whereas an avirulent race cannot attack this genotype (Russel 1987) . Many authors have studied this subject extensively (Green 1966, Johnson *et al* .1967, Watson and Luig 1968 and Abdel-Hak *et al* .1982).

Identification of physiologic races and determination of virulence genes are routinely carried out in Egypt (Abdel-Hak *et al.* 1982 & 1984 EL-Naga *et al.* 1990) The main objective was to survey and identify stem rust virulences and to determine pathognicity association coefficients that limit the effectiveness of gene pairs conditioning resistance against the stem rust pathogen populations.

MATERIALS AND METHODS

Stem rust samples were collected form commerical wheat cultivars from the farmers field and rust nurseries throughout the different governorates of Egypt during 1989/90 and 1990/91 growing seasons . Samples were isolated and propagated on "Little Club", a susceptible wheat variety. Inoculation, purification, incubation and race identification were carried out according to Stakman *et al.* (1962) in which inoculated seedlings were incubated in dew chamber for 24 hr and then in a greenhouse at 22° to 25°C. Infection type were scored on the primary leaf 12-14 days after inoculation . Infection types 0, 0;, 1, 2, 3 and 4 are immune, hypersensitive, resistant, moderately resistant, moderately susceptible and susceptible, respectively. One to three single isolated pustules were taken from each sample to form a total of 96 and 78 isolates of *Puccinia graminis* f. sp. *tritici* for 1989/90 and 1990/91, respectively. These isolates were also used for virulence analysis, using 12 monogenic wheat lines (Table1).

The virulence/avirulence formula suggested by Green (1965) was used to describe the tested isolates. The efficacy of Sr genes were determined according to their virulence frequencies (%). Pathogenicity association coefficients and virulence association coefficients were calculated using the equations proposed by Browder and Eversmeyer (1977) in which :

$$PAC_{A:B} = \frac{(\text{no. of isolates } A_A : A_B) + (\text{no. of isolates } V_A : V_B)}{\text{Total No . of isolates in samples}}$$

Table 1. Wheat monogenic lines (Sr's) used for virulence analysis .

No.	Sr gene	Cultivar or line
1	8 a	Cns / Red Egyptian
2	9 e	Vernstein
3	11	Line Ag
4	22	Mq*6 ST-RL 5244
5	24	Agent
6	25	Agatha
7	26	Eagle = Agropyron / Falcon
8	27	WRT 238-5
9	29	Pusa / Etoile de Choisy
10	30	BtSr 30 Wst
11	37 (Tr-2)	W 2691 SrT2
12	Gt	Gamut

$$VAC_{A:B} = \frac{\text{No. of isolates } V_A : V_B}{\text{Total No . of isolates in samples}}$$

where, PAC = Pathogenicity association cofficient
VAC = Virulence association coefficient
A = Avirulent V = Virulent
A and B = Vars.

RESULTS

The present study revealed the presence of collectively 7 physiologic races of

Table 2. Frequency % of physiologic races of *Puccinia graminis* f. sp. *tritici* during 1989/90 and 1990/91 growing seasons.

Physiologic races	1989/90		1990/91	
	No. of isolates	Frequency %	No. of isolates	Frequency %
11	39	56.6	32	41.0
11 B	--	--	6	7.7
24	9	13.6	--	--
15	--	--	3	3.8
17	10	14.4	8	
24	9	13.6	4	5.1
34	27	39.1	25	6.4
39	1	1.4	--	--
285	1	1.4	--	--
Total No. of isolates	96		78	

Table 3. Virulence formulae of 37 stem rust isolated from 96 single pustules and their frequencies % during 1989/90 growing season.

Isolate No.	Avirulence / virulence *	Frequency %
1	9e,/	
2	9e, 26/	14.44
3	26, 27/	2.98
4	9e, 26, 27/	3.34
5	9e, 22, 26/	5.79
6	9e, 26, 29/	2.89
7	9e, 22, 25/	1.45
8	9e, 22, 26, 27/	2.89
9	9e, 22, 24, 26/	3.34
10	9e, 25, 26, 27/	3.34
11	9e, 26, 27, 29/	3.34
12	9e, 11, 27, 29/	1.45
13	9e, 22, 26, Gt/	1.45
14	9e, 26, 27, Gt/	1.45
15	9e, 22, 26, 29/	1.45
16	9e, 11, 22, 26, 27/	1.45
17	9e, 11, 22, 26, 29/	1.45
18	9e, 25, 26, 27, Gt/	5.79
19	9e, 24, 26, 27, Gt/	1.45
20	9e, 25, 26, 27, Gt/	1.45
21	9e, 26, 27, 29, Gt/	1.45
22	9e, 22, 26, 27, 29/	1.45
23	9e, 11, 22, 24, 26, 27/	1.45
24	9e, 22, 25, 26, 29, 37/	1.45
25	9e, 22, 26, 27, 29, Gt/	1.45
26	9e, 25, 26, 27, 30, Gt/	1.45
27	9e, 24, 26, 27, 29, Gt/	2.89
28	9e, 22, 24, 25, 26, 27, Gt/	1.45
29	8a, 9e, 22, 25, 26, 27, Gt/	2.89
30	8a, 9e, 22, 25, 26, 29, Gt/	1.45
31	8a, 9e, 26, 27, 29, 30, Gt/	1.45
32	9e, 11, 22, 25, 26, 27, 29/	1.45
33	8a, 9e, 22, 24, 25, 26, 27, Gt/	3.34
34	8a, 9e, 22, 25, 26, 27, 29, Gt/	1.45
35	8a, 9e, 22, 24, 25, 26, 27, 29, Gt/	1.45
36	8a, 9e, 11, 22, 24, 25, 27, 37, Gt/	1.45
37	8a, 9e, 11, 22, 24, 25, 26, 27, 29/	1.45

* Genes followed by a slash are the effective genes of resistance to the Egyptian wheat stem rust isolates.

Table 4. Virulence formulae of 41 stem rust isolates originated from 78 single pustules and their frequencies % during 1990/91.

Isolate No.	Avirulence / virulence *	Frequency %
1		
2	26/	3.75
3	9e, 26/	10.00
4	9e, 25/	6.25
5	26, 27/	1.25
6	8a, 26/	5.79
6	8a, 26/	3.25
7	25, 29/	1.25
8	27, 29/	1.45
9	29, 30/	3.25
10	22, 26/	1.25
11	9e, 11, 26/	1.25
12	9e, 26, 29/	5.00
13	9e, 26, 27/	7.50
14	11, 26, 27/	6.25
15	27, 29, Gt/	1.25
16	27, 29, 30/	3.75
17	22, 27, 29/	1.25
18	22, 26, 27/	1.25
19	9e, 24, 26/	2.50
20	9e, 22, 26/	1.25
21	9e, 22, 27/	.25
22	8a, 9e, 26/	1.25
23	9e, 25, 27/	2.50
24	9e, 24, 26/	1.25
25	26, 37, Gt/	1.25
26	9e, 22, 26, 27/	1.25
27	9e, 22, 26, 29/	1.25
28	8a, 9e, 11, 26/	3.75
29	25, 26, 27, 29/	3.75
30	9e, 11, 27, 29/	1.25
31	22, 26, 27, 29/	1.25
32	9e, 11, 24, 25, 29/	2.50
33	9e, 26, 27, 29, Gt/	1.25
34	9e, 22, 27, 29, 30/	1.25
35	8a, 9e, 26, 27, Gt/	1.25
36	9e, 22, 25, 26, 27/	1.25
37	8a, 9e, 22, 25, 26, 29/	1.25
38	9e, 11, 24, 26, 27, 29, 37/	1.25
39	8a, 9e, 11, 26, 27, 29, 37/	1.25
40	9e, 22, 26, 27, 29, 37, Gt/	1.25
41	9e, 11, 22, 25, 26, 27, 30, 37/	1.25

* Genes followed by a slash are the effective genes of resistance to the Egyptian wheat stem rust isolates.

Table 5. Virulence and frequency (%) for 96 and 78 isolates on 12 wheat monogenic lines in Egypt during 1989/90 and 1990/91 growing seasons.

Resistant gene Sr	Growing season 1989/90		Growing season 1990/91	
	No. of virulent isolates	Virulence %	No. of virulent isolates	Virulence %
8a	58	84.06	71	91.02
9e	2	2.90	34	43.35
11	61	88.40	67	85.89
22	39	65.50	60	76.92
24	55	79.70	78	100.00
25	47	68.10	70	89.74
26	8	11.60	21	26.92
27	29	42.03	44	56.41
29	47	68.10	52	66.66
30	67	97.10	68	87.18
37	55	79.70	73	93.58
Gt	46	66.70	72	92.31

Table 6. Pathogenicity association coefficient (PAC) and virulence association coefficient (VAC) between 11 gene pairs against rust urediospores during 1989/90 and 1990/91 grwoing seasons.

		Sr11		Sr22		Sr24		Sr25		Sr26		Sr27		Sr29		Sr30		Sr37		SrGt	
		PAC	VAC	PAC	VAC	PAC	VAC	PAC	VAC	PAC	VAC	PAC	VAC	PAC	VAC	PAC	VAC	PAC	VAC	PAC	VAC
9e	89/90	0.14	0.02	0.46	0.02	0.23	0.02	0.34	0.02	0.91	0.02	0.44	0.02	0.34	0.02	0.46	0.02	0.23	0.02	0.36	0.02
	90/91	0.52	0.43	0.66	0.43	0.43	0.43	0.54	0.43	1.17	0.27	0.87	0.34	0.76	0.43	0.56	0.43	0.50	0.43	0.51	0.43
11	89/90			0.68	0.56	0.91	0.74	0.80	0.62	0.23	0.11	0.54	0.42	0.79	0.68	0.91	0.88	0.91	0.79	0.78	0.66
	90/91			0.90	0.76	0.85	0.85	0.96	0.85	0.41	0.41	0.70	0.56	0.80	0.66	1.00	0.85	0.92	0.85	0.92	0.85
22	89/90					0.76	0.56	0.88	0.56	0.55	0.11	0.85	0.56	0.88	0.56	0.59	0.56	0.76	0.56	0.88	0.56
	90/91					0.76	0.76	0.87	0.76	0.50	0.27	0.79	0.56	0.89	0.66	0.89	0.66	0.93	0.93	0.84	0.76
24	89/90							0.88	0.60	0.32	0.11	0.62	0.20	0.88	0.68	0.82	0.79	0.88	0.68	0.86	0.66
	90/91							0.89	0.89	0.36	0.27	0.56	0.66	0.66	0.87	0.87	0.87	0.96	0.89	0.92	0.92
25	89/90									0.43	0.11	0.62	0.42	1.00	0.68	0.71	0.68	0.31	0.11	0.98	0.66
	90/91									0.37	0.72	0.66	0.77	0.76	0.66	0.97	0.87	0.33	0.26	0.85	0.26
26	89/90											0.69	0.11	0.43	0.11	0.14	0.11	0.32	0.11	0.45	0.11
	90/91											0.70	0.27	0.60	0.27	0.39	0.27	0.62	0.27	0.35	0.27
27	89/90													0.73	0.42	0.45	0.08	0.88	0.68	0.64	0.56
	90/91													0.89	0.56	0.69	0.56	0.91	0.66	0.91	0.66
29	89/90															0.71	0.68	0.88	0.68	1.01	0.68
	90/91															0.79	0.66	0.85	0.66	0.87	0.66
30	89/90																	0.88	0.68	0.86	0.66
	90/91																	0.99	0.92	0.94	0.87
37	89/90																			0.86	0.66
	90/91																			0.99	0.92

P. graminis tritici namely, 11, 34, 17, 14, 24 and 285 in 1989/90 and 6 races i.e. 11, 34, 11B, 17, 24 and 15 in 1990/91 .Races 11 and 34 were the most common (Table 2).

The virulence analysis 96 and 78 stem rust isolates revealed the presence of 37 and 41 virulence formulae during the two growing seasons , respectively , (Tables 3 and 4) .

High virulences and susceptibilities were observed with Sr's 30 , 11, 8 a, 24 and Tt-2 (37) in 1989/90 and with Sr.'s 24, Tt-2 (37), Gt+, 8a, 30 and 11 in 1990/91. Sr.'s 9e, 26 and 27 were the most effective resistance genes in Egypt (Table 5) .

Data in table (6) show that, the pathogenicity and virulence association coefficients through the gene combination, Sr 9e/Sr 26, Sr 9e/Sr 27 and Sr26/Sr27 were the most effective with low PAC and VAC or nearly equal values of PAC and VAC (Table 6).

DISCUSSION

The results showed that some of the present races were previously identified by Abdel-Hak *et al.* (1928) in Egypt and other Near East countries. These findings substantiate the assumption of inoculum transmission between countries and their role in the induction of rust epidemics. Thus , studying rust movement , identifing physiologic races and exchanging breeding materials are considered to be amply justified . Fluctuations in the populations of cereal rusts will be minimized by encouraging the cultivars that show a broad genetic base of resistance which is comprised of specific and/or non specific resistance (Waston 1970) .

In Egypt, Sr genes 6, 11, 9e, 22, 24, 26 and 27 were effective against stem rust during 1950-1960 (Abdel -Hak et al 1982). EL-Daoudi *et al* . (1987) found that Sr24, SrGt, Sr29, Sr26, SrSr27, Sr36 (Tt$_2$1) and Sr9e were effective against stem rust population at both seedling and adult stages. Abu El-Naga *et al.* (1990) indicated that genes Sr9e, Sr27, Sr26, Sr8a, and Sr24 were effective during 1987/88; while SrGt, Sr26, Sr9e, Sr27, Sr22 and Sr36 were effective during

1988/89 .

These results indicated a high frequency of virulence to Sr30, Sr11, Sr8a, Sr24 and Sr37 . This may be due to the existence of these resistance genes in the commerical varieties from which the tested isolates were collected . Genes Sr9e, Sr26 and Sr27 were effective against stem rust pathogen population during the two seasons tested .A breeder can combine several resistance of few effective gene pairs i.e. Sr 26/Sr27 and Sr27/Sr9e and Sr9e/Sr26 . These gene pairs are advantageous to the breeder . This data reflect current virvulences in the pathogen population in Egypt which may change with time and change in their corresponding resistance genes.

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عدوانية بعض السلالات ومعاملات الإرتباط المرضيه للفطر *Puccinia graminis* f. sp. tritici المسبب لمرض صدأ الساق الأسود في القمح بمصر في الموسمين ١٩٩٠/١٩٨٩ ، ١٩٩١/١٩٩٠

يوسف حسين الداودي ، صلاح عبد الحميد أبو النجا ، إخلاص شفيق ،
فاتن النشار ، السيد الدسوقي مصطفي ، محمد عمر خليفه

قسم أمراض الحبوب – معهد بحوث أمراض النباتات – مركز البحوث الزراعيه – الجيزه

دل الحصر الخاص بمرض صدأ الساق الأسود في القمح خلال موسم ١٩٩٠/١٩٨٩ و ١٩٩١/١٩٩٠ علي وجود سبع سلالات فسيولوجيه لهذا المرض وهي ١١، ٣٤، ١٧، ١٤، ٢٤، ٣٩، ٢٨٥ وست سلالات فسيولوجيه وهي ١١، ١١ب، ١٥، ١٧، ٢٤، ٣٤ في كلا الموسمين علي التوالي.

وكانت السلالات ١١، ٣٤، ٢٤، ١٧ هي الأكثر شيوعاً خلال الموسمين. وقد دل اختبار ٩٦ ، ٧٨ عزله فرديه من فطر صدأ الساق الأسود علي ١٢ سلاله قمح أحاديه الجين monogenic lines علي وجود ٣٧ ، ٤١ صيغه خاصه بالشده المرضيه أو العدوانيه Virulence لهذه العزلات المختبره في كلا الموسمين علي الترتيب وقد لوحظ أن أغلب العزلات المختبره كانت أكثر عدوانيه more virulent .

وقد سجلت درجات عاليه من العدوانيه للعزلات المختبره علي الجينات 11, 8, 24, 37 (Tt-2), Sr30 في موسم ١٩٩٠/١٩٨٩ والجينات Tt 2, 24, 30, 8, Gt+ في موسم ١٩٩١/١٩٩٠ – بينما أثبتت الجينات Sr 9e, Sr 26 وإلي حد ما Sr 27 كفاءتها كجينات مقاومه ضد عشائر جرايم الصدأ الأسود خلال الموسمين. ومن منطلق تقدير معامل الإرتباط المرضي بمفهومه الواسع بين الجينات المختبره وكذلك معامل الإرتباط العدواني أثبتت الإرتباطات الجينيه 26/27 , 9e/27 , 9e/26 كفاءتها كأزواج جينات متوفره ضد عشائر الجراثيم اليوريديه لفطر الساق الأسود علي مدي الموسمين تحت الظروف المصريه.