SLOW-RUSTING RESISTANCE OF SOME EGYPTIAN WHEAT CULTIVARS TO LEAF RUST (*PUCCINIA RECONDITA*)

FATEN K. EL-NASHAR AND MASSARAT A. EL-GHAMRY

Plant Pathol. Res. Institute, Agricultural Research Center, Giza, Egypt.

(Manuscript received 5 October, 1998)

Abstract

Three components of partial or slow-rusting resistance, i.e. latent period, infection frequency and pustule size were measured in both seedling and adult stages for ten wheat cultivars including seven long-spike cvs. The slow-rusting cultivars had less infection frequency, longer latent period, smaller pustule size and less Area Under Disease Progress Curve (AUDPC). Accordingly, the ten cultivars can be classified into three groups i.e. fastrusting, moderate-rusting and slow-rusting and slow-rusting. Based on the obtained data, some wheat cultivars showed different behaviour at seedling and adult stages, while others showed the same behaviour at both stages. Slow-rusting cultivars at both stages were Sids1, Sids2 and Sids3. These cultivars can be included in the breeding program.

INTRODUCTION

For many years, wheat breeders have used hypersensitive resistance to develop cultivars resistant to rust fungi. The often ephemeral protection given by this type of resistance has prompted work in recent years on slow-rusting resistance, which may prove to be more durable. When *Puccinia recondita* Rob. ex. Desm. infects a slow-rusting wheat plant (*Triticum aestivum* L. em Thell), it takes longer time to produce uredia than on a fast-rusting plant (Shaner and Finney, 1980). Additionally, many infected slow-rusting wheat plants develop smaller uredia that produce fewer urediospores able to initate the next infection cycle, compared to fast-rusting wheats (Shaner *et al.*, 1978).

The main objective of this study was to determine three components of slow-rusting of some Egyptian wheat cultivars at both seedling and adult stages against two virulent isolates of Puccimia recondita under greenhouse conditions to serve in growing and breeding programs for rust resistance.

MATERIALS AND METHODS

Ten Egyptian wheat cultivars (*Triticum aestivum* L.), i.e. Sids 1, Sids 2,

Sids3, Sids 4, Sids 5, Sids 6, Sids7, Sids8, Sids9, and Sids10 (inculuding seve longspike cvs., from Sids4 to Sids 10) were used in this study. The Egyptian susceptible wheat cultivars "Gemmiza 1" was used as control.

The experiments were carried out under greenhouse conditions (20±2°C) on seedling and adult plant using two virulent physiologic races (Race 57 and race 77) of leaf rust (*Puccinia recondita*). Three components of slow-rusting resistance were measured in both stages.

Seeding stage test:

Seedling plants of the mentioned cultivars were grown in 5 inch clay pots in three replicates. Seedling (8 days old) were inoculated with two physiologic races of leaf rust, i.e. race 57 and race 77 and incubated in a moist chamber for 24 hours (Stakman *et al.*, 1962). The inoculated seedling were then kept kept under observations until disease reactions were obvious and clear for evaluation.

Adult stage test:

Each cultivar was grown outdoor in 25 inch clay pots in three replicates and received the proper irrigation and fertilization. At growth stage 10 of Feek's scale (Large, 1954), plants were transferred to the greenhouse and arranged at random in three replicates. Freshly collected urediospores of the two virulent physiologic races (race 57 and 77 of Puccinia recondita) were used as inoculum and mixed singly with talc powder at the rate of 1:25. Before inoculation, plants were irrigated, sprayed with water and uniformly dusted with spore-talc mixture using a baby cyclone (Tervet and Cassel, 1951). After inoculation, plants were then incubated in a moist chamber for 24 hours then transferred to green house benches.

Rust severity was assessed and recorded three times, at ten days intervals, using modified Cobb's scale (Peterson *et al.*, 1948) during the course of the disease eycle.

The Area Under Disease Progress Curve (AUDPC) was calculated using a simple formula adopted by Pandey *et al.* (1989)

$$AUDPC = D\ (1/2(Y_1+Y_K)+(Y_2+Y_3+\ldots\ldots\ldots\ Y_{K-1})$$

Y_1, Y_2 ..... YK are the k disease recordings at a constant interval of D days.

Three components of slow-rusting resistance were measured as follows:

1. Latent period (LP):

Latent period was measured according to Parlevliet (1975) by counting the number of visible pustules on marked leaves daily until no more pustules appeared. From these data, time between inoculation and "50% of the pustule just visible" was estimated.

2. Infection frequency (IF):

The number of pustule per unit leaf area cm2 (2.0x0.5 cm) on the upper side of the leaves were counted as described by Parlevliet and Kuiper (1977).

3. Pustule size (PS):

Pustule size was measured using the light microscope magnification (100X) with a micrometer. Leaves were sampled 25 days after inoculation and bioled in a mixture of lactophenol and ethanol solution (1:2, V/V) for 3 minutes for fixation. The length (L) and width (W) of 10 randomly chosen pustule per one leaf were measured.

Pustule size was estimated using the following formula suggested by Broers (1989) as follows:

Pustule size = $1/4 \times \pi \times L \times W$ ($\pi = 3.14$ or $\frac{22}{7}$)

Data were statistically analyzed (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Increased awarness of the short-lived nature of most immume-type resistance to plant disease has led to greater interst in other forms of resistance. Resistance expressed as a slow development of disease caused by the rust fungi has been found in the cereals and it has been called slow-rusting (Ohm and Shaner, 1976). The rapid loss of race specific resistance to cereal rusts encouraged plant breeders to seek more stable forms of resistance such as "slow-rusting"(Caldwell *et al.*, 1970 and Simons, 1972).

Slow-rusting involves one or more of the following restrictions on the pathogen, longer latent period, fewer and smaller pustules (Sztejenberg and Wahl, 1976). Thus, three components of slow-rusting were determined for ten susceptible wheat cultivars to define those with partial resistance in the seedling and adult stage (Table , 1 and 2).

At seedling stage:

The ten wheat cultivars used in this study differed in the components of slow-rusting as shown in Table (1). Data showed that significant differences were observed between the two races (Race 57 and 77) concerning latent period and pustule size, while in infection frequency no significant difference was recorded. In most cases, race 77 was more aggressive than race 57 which has short latent period, more infection frequency and larger pustule size with different cultivars. These results confirmed the results reported Sherif (1983), Abdou *et al.*, (1989) and Sherif *et al.*, (1990) who showed that race 77 was more aggressive and had vast range of virulence than race 57. Statistical analysis also proved that there was significant difference between each cv. and the control (Gemmiza 1) in each component.

Based on the data, the slow-rusting cultivars have a longer latent period, less infection frequency and smaller pustule size. Thus, the tested wheat cultivars can be classified into three groups according to the component of partial resistance. (1) Fast-rusting cultivars (compatible with all three components) i.e. Sids5, Sids7, Sids8, Sids9, and Sids10; (2) Moderate-rusting cultivars i.e. Sids4 and Sids6 and (3) slow-rusting cultivars (incompatible with all three components) i.e. Sids1, Sids2 and Sids3.

Different studies have shown that the slow-rusting trait is heritable and can be generally effective in reducing losses (Cox and Wilcoxson, 1982 and Sally and Sharp, 1988).

At adult stage:

The data presented in Table (2) show that the ten tested wheat cultivars could also be classified to the three groups i.e. Fast; moderate and slow-rusting cultivars. Sids1, Sids2, and Sids3 show longer latent period, less infection frequency and limited pustule size, these cultivars can be regarded as slow-rusting cultivars. On the other hand, the cvs. Sids6, Sids8, Sids9 and Sids10 are moderate rusting cultivars. The remaining cultivars Sids4, Sids5 and Sids7 were fast rusting cultivars.

Based on the obtained data, some wheat cultivars showed different behaviour at seedling and adult stage, while others showed the same behaviour at both stages. Slow-rusting cultivars at both stages were Sids1, Sids2 and Sids3. Results, also proved that the seven tested long-spike cultivars are grouped as moderate or fast-rusting cvs. in both stages, according to the measurments of the three components of partial resistance.

Table 1. Three components of partial resistance in ten wheat cultivars, including seven long-spike cvs., in addtion cv. "Gemmiza1" as control, inoculated with race 57 and 77 of *Puccinia recondita* in the seedling stage .

N	Cultivars	Latent period (day)			Infection frequency*			Pustule size (m m^2)		
		Race 57	Race 77	Mean	Race 57	Race 77	Mean	Race 57	Race 77	Mean
1	Sids 1	13.67	12.67	13.17	3.33	3.67	3.50	0.100	0.111	0.106
2	Sids 2	11.33	12.67	12.00	2.00	3.67	2.83	0.113	0.132	0.123
3	Sids 3	11.33	11.33	11.33	2.00	5.00	3.50	0.135	0.212	0.174
4	Sids 4	9.67	9.67	9.67	4.67	6.00	5.33	0.199	0.163	0.181
5	Sids 5	9.67	9.00	9.33	10.33	4.67	7.50	0.168	0.227	0.198
6	Sids 6	10.33	9.33	9.83	3.33	6.00	4.67	0.199	0.133	0.166
7	Sids 7	9.67	10.00	9.83	11.00	11.67	11.33	0.210	0.221	0.216
8	Sids 8	10.00	9.33	9.67	9.67	16.00	12.83	0.148	0.243	0.196
9	Sids 9	10.00	9.33	9.67	17.00	9.67	13.33	0.182	0.283	0.232
10	Sids 10	10.33	9.33	9.83	7.00	12.33	9.67	0.172	0.285	0.229
	Gemmiza1 (control)	9.67	9.00	9.33	20.33	20.67	20.50	0.318	0.351	0.334
Races mean		10.52	10.15		8.242	9.03		0.177	0.215	
L. S. D. at 5 %										
For Races (A)			0.274			N. S**			0.020	
For cultivars (B)			0.642			3.996			0.046	
A X B			0.908			5.652			0.065	

* Infection frequency = No. of pustule/cm^2/Leaf area

** N.S. = Not significant.

Table 2. Three components of partial resistance in ten wheat cultivars, including seven long-spike cvs., in addtion cv. "Gemmiza1" as control, inoculated with race 57 and 77 of *Puccinia recondita* in the adult stage .

N	Cultivars	Latent period (day)			Infection frequency*			Pustule size (m m^2)		
		Race 57	Race 77	Mean	Race 57	Race 77	Mean	Race 57	Race 77	Mean
1	Sids 1	14.00	13.67	13.83	6.00	4.00	5.00	0.125	0.150	0.137
2	Sids 2	13.67	14.00	13.83	3.33	2.00	2.67	0.119	0.138	0.129
3	Sids 3	13.67	14.00	13.83	5.00	1.00	3.00	0.159	0.215	0.187
4	Sids 4	13.00	12.33	12.67	21.33	16.33	18.83	0.203	0.242	0.223
5	Sids 5	12.67	12.33	12.50	9.67	22.00	15.83	0.206	0.321	0.264
6	Sids 6	13.67	12.33	13.00	4.00	13.67	8.83	0.204	0.209	0.207
7	Sids 7	13.00	12.33	12.67	11.67	15.33	13.50	0.221	0.299	0.260
8	Sids 8	13.67	12.33	13.00	3.67	15.33	9.50	0.182	0.250	0.216
9	Sids 9	12.67	12.00	12.33	11.33	6.67	9.00	0.185	0.251	0.218
10	Sids 10	13.00	12.33	12.67	6.00	8.00	7.00	0.152	0.263	0.208
	Gemmiza1 (control)	12.33	12.00	12.17	24.00	23.67	23.83	0.330	0.391	0.361
Races mean		13.214	12.697		9.636	11.636		0.190	0.248	
L. S. D. 5 %										
For Races (A)			0.294			1.777			0.018	
For cultivars (B)			0.688			4.168			0.042	
A X B			N. S**			5.895			0.059	

* Infection frequency = No. of pustule/cm^2/Leaf area

** N.S. = Not significant.

The slow development of the disease due to the components studied support the concept of partial resistance.

Concerning susceptible wheat cultivars presented in Table (3), the mean rust serverity and AUDPC are recorded. Generally, rust severity was higher with race 77 compared with race 57. The ten wheat cultivars showed different rust severities against the two rust races. The three wheat cvs. Sids1, Sids2 and Sids3 had lower rust severity (Tr.s) for races 57 and 77. Regarding AUDPC, data showed that AUDPC was higher in cvs. inoculated with racc 77 than with race 57. On the other hand, cv. Gemmiza 1 was higher in AUDPC than other cvs. Also, cvs Sids1, Sids2 and Sids3 (slow-rusting varieties) showed lower AUDPC for the two races. Johnson and Wilcoxon (1980) reviewed the use of the AUDPC in the epidemiological studies and concluded that since AUDPC, indicated in a single value; both severity of the disease and the rate at which the disease or pathogen increased during the crop season, should find wide application in plant disease studies.

Accordingly, it is interesting to note that cultivars having good levels of incoplete or partial resistance are able to slow-down rust development through longer latent period, lower disease severity, lower infection frequency, restricted pustule size and lower AUDPC. Also, identification of stages of pathogenesis at which slow-rusting is expressed can help breeders in combining genotypes with partial resistance to increase the level of this resistance.

Table 3. Mean of leaf rust severity and Area Under Disease Progress Curve (AUDPC) of ten wheat cultivars including seven longspike cvs. in addition to cv. "Gemmiza 1" as control, inoculated with race 57 and 77 of *P.recondita* in the adult stage.

No.	Cultivars	Mean of rust severity		AUDPC	
		Race 57	Race 77	Race 57	Race 77
1	Sids 1	Tr.s	Tr.s	34	38
2	Sids 2	Tr.s	Tr.s	34	34
3	Sids 3	Tr.s	Tr.s	40	40
4	Sids 4	20 s	40 s	225	320
5	Sids 5	30 s	50 s	325	450
6	Sids 6	10 s	20 s	125	175
7	Sids 7	30 s	40 s	400	450
8	Sids 8	15 s	20 s	150	225
9	Sids 9	10 s	10 s	110	175
10	Sids 10	5 s	10 s	85	110
	Gemmiza 1 (control)	50 s	60 s	475	550

REFERENCES

1. Abdou, Y.A., S. Sherif and Ahlam M.Gowily. 1989. Biochemical composition of germinating urediospores of some physiologic races of wheat leaf rust in relation to its aggressiveness Desert Inst. Bull., A.R.E., 39, Suppl., pp 545-559.

2. Broers, L.H.M. 1989. Influence of development stage and host genotype on three components of partial resistance to leaf rust in spring wheat. Euphytical, 44:187-195.

3. Caldwell, R.M., J.J.Roberts and Z.Eyal. 1970. General resistance ("slow-rusting") to *Puccinia recondita* f.sp. *Tritic* in winter and spring wheats. Phytopathology, 60:1287.

4. Cox, D.J., and R.D. Wilocxson. 1982. The relationship of Sr6 gene to slow rusting in wheat. Phytopathology, 72:178-181.

5. Gomex, K.A. and A.A. Gomez. 1984. Statistical procedures for Agricultural Research. John Wiley & Sons. USA.

6. Johnson, D.A. and R.D. Wilcoxon. 1980. A table of area under disease progress curves. Technical Bulletin, Texas Agricultural Experiment Station.

7. Large, E.C. 1954. Growth stages in cereals. Illustration of the Feek's scale. Plant Pathology, 3:128-129.

8. Ohm, H.W., and G.E. Shaner. 1976. Three components of slow leaf-rusting at different growth stages in wheat. Phytopathology, 66:1356-1360.

9. Pandey H.N., T.C.M. Menon and M.V. Rao. 1989. A simple formula for calculating Area Under Disease Progress Curve. Rachis, 8 (2): 38-39.

10. Parlevliet, J.E. 1975. Partial resistance of barley to leaf rust, *Puccinia hordei.* I. Effect of cultivars and development stage on latent period. Euphytica, 24:21-27.

11. Parlevliet, J.E., and H.J. Kuiper. 1977. Partial resistance of barley to leaf rust. *Puccinia hordei* IV-Effect of cultivars and devlopment stage on infection frequency. Euphytica, 26: 249-255.

12. Peterson, R.F., A.B. Campbell and A.E. Hanna. 1948. A diagramatic scale for estimating rust intensity on leaves and stems of cereals. Can.J. Res. 26:496-500.

13. Sally, B.K. and E.L. Sharp. 1988. Selection and evaluation of three spring wheats with slow-rusting resistance to *Puccinia graminis* f.sp *tritici.* Plant Disease, 72:413-415.

14. Shaner, G., H.W. Ohm and R.E. Finney. 1978. Responcse of susceptible and slow leaf-rusting wheats to infection by *Puccinia recondita.* Phytopathodogy, 68:471-475.

15. Shaner, and R.E. Finney. 1980. New sources of slow Leaf-rusting resistance in wheat. Phytopathology, 70: 1183-1186.

16. Sherif, S. 1983. Studies on the virulence of some physiological races of leaf rust of wheat in Egypt. Ph.D. Thesis, Faculty of Agric. Cairo Universily 167 p.

17. Sherif, S., Y.H. El-Daoudi, Massarat El-Ghamry and r.A. Rizk. 1992. Pathogenicity associations and population shifts of *Puccinia recondita* f.sp. *Tritici* in Egypt during 1989-1991. Zagazig. J. Agric. Res., 19, (1): 227-241.

18. Simons, M.D. 1972. Polygenic resistance to plant disease and its use in breeding resistant cultivars. J. Environ. Oual., 1: 232-240.

19. Stakman, E.C., D.M. Stewart and W.Q Loegering. 1962. Indentification of physiologic races of Puccinia graminis var. tritici. U.S. Dep. Agric. Bur. Entomol. Plant Quarantine Bull. E. 617 (revised) 53 pp.

20. Sztejenbery, A., and I. Wahl. 1976. Mechanisms and stability of slow stem rusting resistance in Avena sterilis. Phytopathology, 66:74-80.

21. Tervet, I. and R.C. Cassel. 1951. The use of cyclone separation in race identification of cereal rusts. Phytopathogy, 41: 282-285.

المقاومة في بعض أصناف القمح المصرية لصدأ الأوراق عن طريق بطء التصدؤ

فاتن النشار، مسرات الغمري

قسم بحوث أمراض الحبوب – معهد بحوث أمراض النبات – مركز البحوث الزراعية – الجيزة .

أستخدمت في هذه الدراسة عشرة أصناف من القمح المصرية وهي من سدس ١ حتي سدس ١٠ وكان الهدف هو دراسة صفة المقاومة الجزئية أو الصدأ البطيء لهذه الأصناف في طوري، البادرة والبلوغ وذلك من خلال ٣ مقاييس لهذه الصفة هي فترة الحضانة – عدد البثرات في وحدة المساحة وحجم البثرة. الأصناف بطيئة الصدأ تزيد من فترة الحضانة للصدأ وكذلك تحد من عدد البترات في وحده المساحة ومن حجم البثرة إلي جانب الأقلال من شدة الأصابة بالصدأ والمساحة الواقعة تحت منحني تقدم المرضي. تبعا لذلك أمكن تقسيم الأصناف المختبرة إلي ثلاثة مجموعات وهي أصناف سريعة للصدأ وأصناف متوسطة للصدأ وأصناف بطئية للصدأ. وقد تبين من النتائج أن بعض أصناف القمح المختبرة تسلك سلوك في طور البادرة يختلف عن سلوكها في طور البلوغ والبعض الأخر من الأصناف يسلك نفس السلوك في كلا الطورين. ولقد أمكن التوصل إلي ثلاثة أصناف تحمل صفة المقاومة الجزئية أو الصدأ البطئ في كلا الطورين وهي الأصناف سدس ١، وسدس٢، وسدس٣ حيث يمكن أدخال هذه الأصناف في برنامج التربية للمقاومة.