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in

Chataigner J. (ed.).
Maladies du riz en région méditerranéenne et les possibilités d'amélioration de sa résistance

Montpellier : CIHEAM
Cahiers Options Méditerranéennes; n. 15(3)

1997
pages 87-93

The present status of resistance to rice blast disease caused by *Pyricularia oryzae* under Egyptian conditions

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Abstract. Commercial cultivars and promising lines were evaluated against blast disease under different test conditions, i.e. blast nursery test for seedling reaction, multilocation test for adult plant reaction and greenhouse test for seedling reaction against individual isolates of *Pyricularia oryzae.* In addition, international differential varieties and Japanese differential varieties were also included for race identification studies and level of single genes for blast resistance. Common races of *Pyricularia oryzae* in the Nile Valley in 1989-1993 were identified. The most prevalent race groups were IC, ID and IG with 28%, 27% and 16% occurrence respectively. IE and IF race groups were detected in 1992 and 1993 seasons, while the IB race group was found in the 1993 season. Multilocation test for the promising lines under natural infection conditions show that some entries were resistant at all locations, others were susceptible at most of the locations. However, some entries resistant in one season became susceptible at only few number of locations, as GZ 4120-205-2 (two locations) and Giza 175 (3 locations) in the second season. The greenhouse test revealed that some entries were resistant to the tested isolates in both the 1991 and 1992 seasons. Other entries including the Japonica type commercial cvs. were susceptible to most of the tested isolates. GZ 4120-205-2 and Giza 175 were compatible to 1-3 isolates in the two seasons of 1991 and 1992. While GZ 3766-38-1-1 was compatible to 2 isolates in 1991 and became susceptible to 16 isolates in the 1992 season.

The level of resistance of each of Pi-genes in the Japanese differential varieties indicated that Pi-a, Pi-k^s and Pi-ta were low in its effects against the tested isolates with 20%, 31% and 45% resistance respectively. While, Pi-m, Pi-K and Pi-b showed higher levels of resistance as 80%, 86% and 90% respectively.

The area of the susceptible Japonica types old commercial cvs., i.e. Giza 171 and Giza 172, decreased from 77.6% in 1989 to 58% in 1993. And the area of the Indica rice cvs. IR 28 and Giza 181, resistant to the prevalent races, decreased from 13.8% to 5.4% in the same period while the area of Giza 176, as a new Japonica cv., increased from 2.8% in 1989 to 32.1% in 1993. This led to the reduction in the fungicide treated area from 15.4% in 1989 to 5.7% in 1993 with an increase in the national yield average from 6.5 t/ha in 1989 to 7.72 t/ha in 1993 .

I – Introduction

Rice blast disease is the most important rice disease in Egypt as it is many other countries (Balal, 1984; Ou, 1985). Breeding for resistance is the most economical way within the integrated disease management strategy. However, the breakdown of major gene resistance of the new cultivars is known to occur as the area of the cultivar increased. A new cultivar is known to remain resistant for a period of time between 2 and 6 years (Kiyosawa, 1965). However, the appearance of new virulent races and their build up makes it possible for the breakdown of resistance of such new cultivars. The rice blast fungus *Pyricularia oryzae* cav. is known to be highly variable. Many investigators studied the physiological specialization of the fungus in many countries (Atkins, 1962; Goto et al., 1964; Padmanabhan et al., 1970; Abdel-Hak, 1981; Yamada,1985; Kamel et al., 1986).

In Japan, Yamasaki and Kiyosawa (1966), using seven stable strains of the fungus, classified Japanese varieties into five groups. In further tests, with more varieties, Kiyosawa (1974) found 12 groups. In 1976, a new Japanese set of differential varieties was chosen, with each variety having a single resistance gene (Yamada et al., 1976).

In Africa, Notteghem (1981) observed that virulent strains existed for all the identified genes of vertical resistance, and most of the strains possessed unnecessary virulence genes for their survival. Two varieties were resistant on the research station but appeared to be very susceptible when grown in seed production farms. It is probable that varieties with vertical resistance genes remain resistant at a few locations where varietal trials are carried out. Virulent races exist at a low rate, the variety may encounter them only when cultivated over large areas. He added that this may be the cause of many break downs in Africa. In Egypt, El-Kazzaz (1973) identified 5 races from 10 isolate as IB-47, IC-17, IF-3, IH-1 and II-d. Abdel-Hak (1981) identified ten races as IA-5, IA-15, IB-6, IB-55, IC-5, ID-5, ID-6, IE-1, IE-2, IF-1 and IG-1 from the 1977 season samples.

In USA, Marchetti (1994) mentioned that races IB-54, ID-13, IG-1 and IH-1 were the most common; all the cultivars grown in the 1950s and 1960s were compatible with at least one of those pathotypes. He added that, in the last 30 years, the Pi-K^h and Pi-ta^2 genes have been introduced into US rice cultivars; already present with Pi-z, Pi-i, Pi-a and Pi-K^s genes. The most effective of these against US pathotypes of *P. grisea* are Pi-ta^2, Pi-K^h and Pi-z. The objective of this study is to evaluate promising lines and commercial cultivar to the races of *P. oryzae* in Egypt in the period of 1989-1993. Levels of resistance of single genes in Japanese differential varieties were also evaluated.

II – Materials and methods

1. Blast nursery test

Promising lines were evaluated for seedling reaction under blast nursery test. Seedbeds were prepared, manure fertilizer was added during land preparation (20 m^2/ha). Each entry was planted in 5 rows of 50 cm long and 15 cm apart, with cv. Giza 159 as a susceptible check from each side of the bed and alternatively after the five rows of each tested entry. Sowing date was during the first week of July in both the 1991 and 1992 seasons. The test was replicated two times in three different locations, i.e. Sakha (Kafr El-Sheikh), Gemmiza (Gharbia) and Zarzora (Beheira). Natural infection was developed and the plants were scored 30-45 days after sowing, using the (0-9) scale of IRRI (1980).

2. Multilocation test (Trap varieties)

Promising lines, commercial cultivars and selected single resistance gene varieties were evaluated for leaf blast infection at tillering stage, at 15-20 locations distributed in the 6 rice growing governorates in the 1991 and 1992 seasons. Seedlings of 25-30 days old were transplanted in rows 20x20 cm between hills and rows, at each location, with three rows, 3 m long and 40 cm between each entry. Transplanting was done during the second half of June in each season. Nitrogen fertilizer was added at the recommended rate, 40 kg N/feddan (1 ha = 2.38 fed.). Two rows of the susceptible check cv. Giza 159 was transplanted from each side of the tested entries. Plants were left for natural infection.

Leaf blast infection was scored according to the standard evaluation system for rice (IRRI, 1980). Two scores were recorded during the vegetative growth stage. The first was done in the last week of July, about 30 days after transplanting (DAT) and the second at 60 DAT.

3. Greenhouse test

Promising lines were evaluated in the 1991 and 1992 seasons. In addition, international differential varieties (Atkins et al., 1967) and ten Japanese differential varieties (Yamada et al., 1976) were also evaluated in the period 1989-1993. Plastic trays (30x20x12 cm) were partially filled with fine soil, 5 g ammonium sulphate were added to each tray. Each tray was planted with 16 entries, with Giza 159 in the middle and at the two ends of the tray as a susceptible check variety. Plants were inoculated at 3-4 weeks after sowing. Single isolates were purified and grown on rice-glucose-agar medium for spore production (50 g rice grain, 100 g rice husk, 15 g glucose, 20 g agar/1000 l/water). Two hundred ml of spore suspension was prepared from each isolate adjusted to 105 spores/ml. Twenty five isolates each season were inoculated, each isolate was sprayed using electrical spray gun. Plants were left under cages for 24 hours, then cages were removed. Plants were moved to the incubation room supplied with automatic system for temperature adjustment, between 25-30°C; relative humidity was maintained at about 100% by fine sprinklers. Seven days after inoculation, typical blast lesions appeared and scored using the 0-9 scale.

III – Results and discussion

1. Reaction to leaf blast infection under different test conditions

Results in Table 1 indicated that the tested entries were in three groups. The first one included the resistant entries to leaf blast infection at seedling stage (blast nursery test and greenhouse test) and at tillering stage (multilocation test). This group has the indica type cvs. Giza 181, IR 28, IR 19743-40-2-3, GZ 1368 S-5-4 and ECIA 31-104. The second group showed susceptible entries under different test conditions. Some entries in this group were Japonica commercial rice cvs. as Giza 171, Giza 172, Giza 176 and the susceptible check cv. Giza 159. However, some entries were found resistant at one test but susceptible at the other(s). This is the third group with Giza 175 (IxJ rice cv.), showing resistant reaction at blast nursery test in the two seasons 1991 and 1992, but susceptible reaction to 1 and 3 isolates in the greenhouse test in the two seasons respectively. While, multilocation test showed resistant reactions in the 1991 season at all locations, and susceptible reactions in 3 locations in 1992 (Table 1). This group also included Pi No. 4, BL-1 and GZ 4120-205-2. Sehly et al. (1990), found that Giza 175, IR 19743-46-2-3 and GZ 2175-5-6 (Giza 176) were generally resistant with few type 4 lesions on some plants in blast nursery test at Sakha and Gemmiza. While Giza 171 and Giza 172 were susceptible at both locations. However, under greenhouse test Giza 171 and Giza 172 in addition to the susceptible check variety Giza 159 were susceptible to 20 tested isolates; Reiho was susceptible to 19 isolates; Giza 175 was susceptible to 2 isolates only. They added that, the promising line GZ 2175-5-6 (released now as Giza 176) was susceptible to one isolate identified as ID-13 and collected from Meet Sweed (Dakahlia) in the 1987 season. Marchetti (1994) mentioned that a new pathodeme (Sensu Robinson, 1976) provides an additional selection pressure favoring those pathotypes that are compatible with it. Pathotypes which can infect the new pathodeme increase in prevalence to the point that they are detectable. Thus, we have a “new” race.

Some entries showed susceptible reaction in the blast nursery test but proved resistant at multilocation test, as GZ 3766-36-1-1, but the greenhouse test indicated that the number of susceptible reactions of this entry against individual isolates was increased from 2 isolates in 1991 to 16 isolates in 1992 (Table 1). The virulent races in the 1991 season to this entry were ID-5 and ID-15. However, most of the identified races were compatible with it in 1992. The compatible races to Giza 175 was IC-3 in 1991 and IC-17, ID-13 and IF-1 in 1992.

2. Reaction to leaf blast infection at seedling and tillering stages

Results in Table 3 indicated that some entries as Giza 171 and Giza 172 had higher leaf blast scores (6-8) at seedling stage compared with lower ones (4-5) at tillering stage. This may be explained as an effect of adult plant resistance observed by other investigators (El-Kazzaz et al., 1990; Roumen et al., 1992).

3. Common races of *Pyricularia oryzae* in the 1989-1993 seasons

The eight international differential varieties were inoculated with 20-25 isolates annually in the period 1989-1993, along with the tested promising lines. Results in Table 2 show that the common race groups in the Nile delta in this period were IC, ID, IG-1 and IH-1 with 28%, 27%, 16% and 13% occurrence for each group respectively, as a mean for the five years. In addition, IE-5 and IF-1 were identified in 1992 and 1993 seasons; while IB race group was identified in the 1993 season (Table 2).

The common races in each season indicated that in the IC race group the race IC-25 was isolated from samples collected in the 1989 and 1990 seasons; IC-29 in 1989, 1990 and 1993 seasons; IC-21 in 1990 and 1991 seasons; IC-17 in 1990, 1992 and 1993 seasons; IC-3 in 1991 and 1992 seasons; IC-13 in 1991 and 1992 seasons; each of IC-1, IC-11 and IC-31 was isolated once in 1991, 1992 and 1993 seasons, respectively (Table 2). While, in the ID race groups ID-5 was isolated from samples of 1989, 1991 and 1992 seasons; ID-13 in 1990, 1991 and 1992 seasons; ID-15 in 1990 and 1991 seasons; in addition to ID-11 in 1993 season (Table 2). Five different races in the IB race group were also found in 1993 season. This is in addition to the IG-1 and IH-1 races as presented in Table 2. Earlier studies in Egypt indicated the presence of different race groups and different races in each race group (El-Kazzaz, 1973; Abdel-Hak, 1981; El-Refaei et al., 1986 and Sehly et al., 1990). Marchetti (1994) observed that race IE- 1 became more common in US rice cultivars since 1991. He added that one might speculate that the emergence of IE-1 is an example of improved fitness through the loss of unnecessary virulence.

Table 1. Evaluation of promising lines, commercial cvs., and some Japanese differential varieties to leaf blast infection under different test conditions in 1991 and 1992 seasons

Entry	Blast nursery test*		Multilocation test				Greenhouse test			
			1991		1992		1991		1992	
	1991	1992	R1	S2	R	S	No. of V. Isolates	Virulent isolates	No. of V. isolates	Virulent isolates
1) Giza 181	1-2	1-2	23	0	15	0	0	0	0	0
2) IR 28	1	1	23	0	15	0	0	0	0	0
3) IR 19743-40-2-3	1-2	1-2	23	0	15	0	0	0	0	0
4) GZ 1368 S-5-4	1-2	1-2	23	0	15	0	0	0	0	0
5) ECIA 31-104	1-2	- **	23	0	-	-	0	0	-	-
6) GZ 4120-205-2	1-3	2-4	23	0	13	2	1(5%)	IC-3	2(10%)	IC-1,IC-13
7) Giza 175	2-3	2	23	0	12	3	1(5%)	IC-3	3(15%)	IC-17,ID-13,IF-1
8) GZ 3766-38-1-1	2-4	2-7	23	0	-	-	2(10%)	ID-5, ID-15	16(80%)	Most races
9) GZ 4565-5-6	4-6	4-8	-	-	-	-	16(80%)	Most races	18(90%)	Most races
10) GZ 4565-S-10	4-6	4-7	-	-	13	2	17(85%)	Most races	18(90%)	Most races
11) Toride 1 (Pi-Z)	2-4	4-5	19	4	-	-	3(15%)	ID-5,13,15	10(50%)	50% of races
12) Kanto 51 (Pi-k)	1-2	2-4	23	0	-	-	3(15%)	IC-3,13,ID-5	4(20%)	IC 1,IG 1,IE7
13) Tsuyake (Pi-m)	2	2	-	-	-	-	2(10%)	IC-3, 21	3(15%)	IC 17, IE 7,II
14) Pi No. 4 (Pi-ta)	1-2	2	23	0	-	-	4(20%)	ID-13,15	7(35%)	Many races
15) BL 1 (Pi-b)	1-2	1-2	23	0	-	-	3(15%)	IC 3, ID-15	4(20%)	IE5, ID15
16) Giza 176	4-6	5-9	9	14	0	15	21(84%)	Most races	20(80%)	Most races
17) Giza 171	5-6	6-8	2	21	0	15	23(92%)	Most races	22(88%)	Most races
18) Giza 172	5-7	5-8	1	22	0	15	23(92%)	Most races	22(88%)	Most races
19) Reiho	4-6	5-8	10	13	3	12	19(76%)	Most races	-	-
20) Giza 159	5-7	6-9	0	23	0	15	25(100%)	All races	25(100%)	All races

* = Blast nursery score is the range of three locations, i.e., Sakha, Gemmiza and Zarzora
** = Not tested
1, 2 = No. of resistant and susceptible reactions at the test locations

Table 2. Common races of *Pyricularia oryzae* isolated from Nile delta of Egypt in the period 1989-1993

Race group	Percentage of isolation					Mean
	1989	1990	1991	1992	1993	%
IB	-	-	-	-	30	6
IC	20	40	15	30	35	28
ID	10	55	40	25	5	27
IG-1	35	-	20	20	5	16
IH-1	25	5	25	5	5	13
IE-5	-	-	-	5	10	3
IF-1	-	-	-	5	10	3
II	10	-	-	10	-	4
Common races in each group:						
IB	-	-	-	-	IB 11,17,23,27,29	-
IC	IC 25,29	IC 17,21,25,29	IC-3,13,21	IC-1,3,4,13,17	IC-11,17,27,29,31	-
ID	ID-5	ID-13,15	ID-5,13,15	ID-5,13	ID11	-

Table 3. Leaf blast reaction score development on some entries under blast nursery test and multilocation test

Entry	Blast nursery score* Sakha 1992	Multilocation score** 30 DAT	60 DAT
1) Giza 171	6 - 8	4	5
2) Giza 172	7 - 8	4	5
3) Giza 176	5 - 9	5	6
4) Reiho	6 - 8	4	7
5) Toride 1	4 - 5	2	4
6) GZ4120-205-2	2 - 4	2	(4)
7) GZ 4565-5-10	4 - 8	4	5
8) Giza 175	2	2 (4)[1]	(4)
9) Giza 159	6 - 9	5	7
10) Nabatat Asmar	4	4	(4)

* Range of 2 replicates at Sakha.
** The highest score in the tested locations at which the entry was susceptible.

Table 4. Levels of resistance of Japanese differential varieties to Egyptian isolates of *Pyricularia oryzae* in the period 1989-1993

Differential variety		Marker gene	% of resistance 1988	1989	1991	1992	1993	Mean %
		Code	Pi-					
1) Shin 2	1	k^s	10	40	50	35	20	31
2) Aichi Asahi	2	a	0	40	15	15	30	20
3) Ishihikari Shiroke	4	i	30	60	80	70	25	53
4) Kanto 51	10	k	100	90	85	80	70	85
5) Tsuyake	20	m	60	90	90	85	75	80
6) Fukunishiki	40	z	100	70	80	75	50	75
7) Yashiromuchi	100	ta	25	50	25	50	75	45
8) Pi No. 4	200	ta^2	35	60	80	65	40	56
9) Toride 1	400	z^t	100	100	85	50	45	70
10) BL 1	-	b	100	100	85	80	80	89

The Japanese differential varieties, each with a single major gene for blast resistance, were evaluated under greenhouse condition against 20 single isolates in each season in the period 1988 to 1993, except the 1990 season. Results in Table 4 indicated that Pi-a in Aichi Asahi, Pi-K^s in Shin 2 and Pi-ta in Yashiro mochi showed lower level of resistance, as 20%, 31% and 45% resistance respectively as a mean of the five years. While, moderate level of resistance was observed with Pi-i in Ishikari shiroke, and Pi-ta^2 in Pi No. 4 with an average of 53% and 56% resistance in the 5 years. However Pi-Z in Fukunishiki and its allele Pi-Z^t in Toride 1 were completely resistant in 1988 but its level of resistance was decreased in time to be 50% and 45% in 1993. In the other hand, the levels of resistance of Pi-K in Kanto 51, Pi-m in Tsuyake and Pi-b in BL-1 were still as high as 85%, 80% and 89% as an average of 5 years (Table 4).

Marchetti and Abdel-Hak (1985) stated that Giza 171 and Giza 172 have the resistance gene Pi-k^s; while Reiho has the gene Pi-ta^2. Previous studies in Egypt indicated the presence of common races able to attack both Pi-ks and Pi-ta^2 (Sehly et al., 1990).

4. Relationship between cultivated area with different rice cvs. virulent races and fungicide treated area

Results in Table 5 show that the area with old commercial cvs. Giza 171 and Giza 172 (Japonica type cvs.) were decreased from 77.6% of the total rice area in 1989 to 58% in 1993. The virulent races of these two cvs. were decreased from 100% to 80% in the same period. The area of the two commercial rice cvs., IR 28 and Giza 181 (Indica type), was decreased from 13.8% in 1989 to 5.4% in 1993. No virulent isolates were detected for both cvs. in the 5 years of 1989-1993. The Indica x Japonica rice cv. Giza

175 was cultivated in about 5.8% of the rice area in 1989 with 10% virulent isolates decreased to 2.4% area in 1993 and 20% of the isolates were virulent to it. However, the rice area of the Japonica high yielding rice cv. Giza 176 was increased from 2.8% in 1989 to 32.1% in 1993 with corresponding increase in the virulent isolates from 10% in 1989 to 85% in 1993 season (Table 5).

Fungicide treated area for rice blast control in the period 1989 to 1993 is presented in Table 5. In the 1989 season, the treated area was 15.4% decreased to 5.7% in 1993. Trycyclazole and ediphenphose were the most common fungicides used for rice blast control in Egypt in this period. The national yield average of Egyptian rice cultivars was increased from 6.5 T/ha to 7.72 T/ha in the 1989 and 1993 respectively.

Table 5. Percent increment in cultivated area with the newly released rice cvs., percent of virulent isolates and treated area with fungicides for blast control in Egypt in 1989-1993

Season	*Commercial cvs.*						*Newly released cvs.*						Total	%	*Area ***		National yield
	Giza 171, 172 (Japonica)			IR 28, Giza 181 (Indica)			Giza 175 (J x I)			Giza 176 (Japonica)					Treated	%	
	Area *	%	V.I %	Area	%	V.I %	Area	%	V.I. %	Area	%	V.I. %					T/ha
1989	320.5	77.6	100	56.7	13.8	0	23.9	5.8	10	11.2	2.8	10	413	100	63.5	15.4	6.50
1990	342.7	69.0	100	48.7	11.0	0	31.5	7.0	5	54.2	13.0	30	437	100	46.0	10.5	7.28
1991	287.0	65.0	90	32.3	8.0	0	10.5	2.0	5	105.4	24.0	84	445	99	28.4	6.4	7.52
1992	322.0	62.0	90	28.6	5.6	0	13.0	3.0	12	136.9	27.0	80	511	98	33.8	6.6	7.66
1993	333.0	58.0	80	26.9	5.4	0	12.2	2.4	20	161.8	32.1	85	539	98	30.7	5.7	7.72
Mean	**321.0**	**66.3**	**92**	**38.6**	**8.8**	**0**	**18.2**	**4.0**	**10.4**	**93.9**	**19.8**	**57.8**	**469**	**99**	**40.5**	**8.9**	**7.34**

* V.I. = Virulent isolates %.
* Area in 1000 ha (one ha = 2.38 feddan).
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