2319

PLANT BREEDING INSTITUTE — TRUMPINGTON
LIBRARY

CEREAL RUSTS BULLETIN

VOLUME 14 PART 1 1986

EDITED BY N.H. CHAMBERLAIN AND R. JOHNSON

PUBLISHED BY
THE EUROPEAN MEDITERRANEAN CEREAL RUSTS FOUNDATION

Cereal Rusts Bulletin Vol. 14, Part 1, 1986

CONTENTS

Cereal Rusts Bulletin Vol. 14, Part 1, 1986

INVENTORY OF ETHIOPIAN BARLEY LINES FOR RESISTANCE TO BARLEY LEAF RUST

BY

J.E. PARLEVLIET & J.G. MOSEMAN

Plant Breeding Department (IvP), Wageningen, The Netherlands.
Plant Genetics and Germplasm Institute, Beltsville, Maryland, USA.

SUMMARY

In 1982 a total of 244 Ethiopian spring barley accessions collected at about 150 locations in Ethiopia by G.A. Wiebe was evaluated for partial resistance to barley leaf rust, Puccinia hordei, at Wageningen. The partial resistance was compared with that of 'L94' (extremely susceptible) and 'Vada' (a fairly high level of partial resistance) in the greenhouse and in the field. In the greenhouse the relative latent period and infection frequency on each line was assessed in the seedling stage. The level of barley leaf rust in the field was evaluated in hill plots, one accession to a plot and 'L94' and 'Vada' repeated eight fold. The accessions ranged from the extreme susceptibility of 'L94' to the partial resistance of 'Vada' or possibly even beyond when these three parameters are considered jointly. The accessions with the highest partial resistance were PI 382372, PI 380321, PI 383119, PI 383120 and PI 383126.

INTRODUCTION

Barley leaf rust, caused by Puccinia hordei, is a world wide pathogen of barley. Major genic, hypersensitive type of resistance and polygenic, non-hypersensitive type of resistance both occur (Roane, 1962; Parlevliet, 1978). Major genic resistance is generally characterized by a lower reaction type, polygenic partial resistance is recognized by fewer and smaller uredosori of a basically susceptible (high) reaction type.

On the basis of reaction types, barley genotypes can be screened in the seedling stage for the two types of resistance. If the reaction type is not high, i.e. less than 8 or 9, it is not considered fully susceptible and a gene for hypersensitivity may be present. Among genotypes with a high, susceptible reaction type the latent period, infection frequency, and pustule size can be evaluated to obtain an impression of the level of partial resistance (Parlevliet, 1975). A susceptible reaction types does not necessarily indicate that major genes for hypersensitivity are absent. Major genes may be present, but not effective to the race or races used in the test.

Barley leaf rust is relatively unimportant in Western Europe because of the presence of partial resistance (Habgood and Clifford, 1981; Parlevliet et al., 1980). However, the genes for partial resistance in the cultivars tend to be the same (Parlevliet, 1978). Other polygenes controlling partial resistance would be very useful if the genes in those cultivars should become ineffective. Barley genotypes from outside Europe might carry partial resistance

based on such other genes. We tested Ethiopian barley accessions for partial resistance to Puccinia hordei in this study.

MATERIALS AND METHODS

We investigated a set of 280 barley accessions, compromising (1) 244 collections of barley made by G.E. Wiebe at about 150 sites in Ethiopia, (2) the cultivar Manchuria repeated 12 times and (3) the cultivars L94, Volla and Vada each repeated 8 times as controls. The latter three cultivars were included since they represent the range in susceptibility for barley leaf rust from extremely susceptible (L94) to a moderate degree of resistance (Vada).

About 3 g of seed of each accession was sown in a hill plot of 0.25 m in diameter on 30th March 1982 at Wageningen, The Netherlands. The hill plots were arranged in eight rows, with 37 hills to a row. The first and last hill of each row were guard hills sown with various barley cultivars. The centres of the hill plots were separated 0.75 m (within row) and 1.50 m (between rows). Plants within each hill plot were supported by a light plastic wheel type structure with spokes carried on a rod placed in the centre of the hill plot to prevent lodging. The wheel was raised on the rod during the growing season.

Rows of highly susceptible cultivar Akka were sown between the rows 1 and 2, 3 and 4, 5 and 6, 7 and 8, on both sides of the experiment, and in front of the rows 1 and 8 to ensure a barley leaf rust epidemic. The epidemic was initiated in the spreader rows in early May by planting sporulating seedlings in the spreader rows every 2 m. The barley leaf rust race used was 1-2-1.

Data were collected on the level of barley leaf rust using the scale of Parlevliet and van Ommeren (1975). Readings were taken on June 29 and on July 5. The mean of the two assessments was calculated. Earliness was evaluated on June 3 and 8 on a scale of 1 to 9, where each unit increase corresponded with approximaely 2½ days earlier heading. Tallness (length) of the plants was evaluated on a scale of 1 (very short) to 5 (very tall), where each unit increase corresponded to about 15 to 20 cm.

The 256 USDA accessions were evaluated in the seedling stage for two components of partial resistance, latent period and infection frequency. Six to eight seeds of each accession were sown and four emerged seedlings were kept to be inoculated one week after emergence with spores of race 1-2-1 and incubated according to the procedure described by Niks (1982). Ten accessions were sown in each box, together with 'L94' and 'Vada'. The latent period and infection frequency were evaluated according to Parlevliet (1975) and Parlevliet and Kuiper (1977), respectively.

The relative latent period (RLP) and relative infection frequency (RIF) were calculated by setting the observed values of 'L94' and 'Vada' at 100 and 125 (RLP) and 100 and 56 (RIF) respectively. Twelve days after inoculation the reaction type (RT) was assessed based on the 1 to 9 scale of McNeal et al. (1971). A RT of 8 or 9 was considered a susceptible or high reaction type or non-hypersensitive type. All other reaction types were assumed to be hypersensitive types of reaction.

The data from cultivar Manchuria were used to obtain an estimate of the experimental error. Manchuria was treated both in the field and in the greenhouse as one of the Ethiopian accessions, while

the other controls were known to the observers. The least significant difference values (Table 1) were calculated from the 12 'Manchuria' values.

RESULTS AND DISCUSSION

Partial resistance to barley leaf rust is most easily recognized in accessions with a susceptible reaction type. Most of the 25 accessions which had a RT lower than 8, had a RT of 7, and only five had RT's ranging from 3to 6 to race 1-2-1.

Partial resistance is the resistance to epidemnic development expressed as reduced levels of barley leaf rust in large fields. The three parameters evaluated are correlated with partial resistance. Latent period and infection frequency in the seedling stage and level of barley leaf rust in very small plots (with strong interplot interference) showed correlation coefficients, r, with partial resistance of 0.57, 0.76 and 0.95, respectively (Parlevliet and van Ommeren, 1975; Parlevliet and Kuiper, 1977). The three parameters were considered together to estimate the partial resistance of the Ethiopian lines since the error in the individual measurements was rather large (see L.S.D. in Table 1). For example, according to the seedling data accession PI 383034 was extremely susceptible with a RLP of 101 and a RIF of 108 (as 'L94'), but according to the field assessment the accession was fairly resistant with a score of 11 (as 'Vada'). Accession PI 382951 was fairly resistant in the greenhouse with a RLP of 121 and a RIF of 73, but its field assessment of 15½ suggested it is highly susceptible. Although these examples are extremes, they show that all available information should be used. Therefore, the accessions were ranked from most susceptible to most resistant by considering the three parameters jointly. Table 1 shows the four most susceptible and the five most resistant lines together with the check cultivars 'L94' and 'Vada'.

No accessions were significantly more susceptible than 'L94' (also an Ethiopian introduction) or more resistant than 'Vada', but the five accessions with a partial resistance similar to that of 'Vada' are of interest as the genes on which their partial resistance is based could be different from those of 'Vada' and from each other. Three of those accessions are relatively short, not taller than 'Vada'. Partial resistance appeared independently distributed among the two ear types of barley. Two-rowed and six-rowed genotypes were present among the partially resistant accessions and also among the susceptible accessions (Table 1).

The association of the three parameters is shown in Table 2. The Ethiopian accessions are grouped according to their relative latent period and the corresponding mean RLP, RIF and field assessments. The associations between the RLP and RIF and field assessment were good and fairly good, respectively.

There were associations between characteristics (Table 3). The correlation coefficient, r, between field assessment for barley leaf rust and earliness was 0.43, indicating that earlier accessions tended to be more susceptible. Tallness and the amount of barley leaf rust in the field were also correlated, r = -0.28, indicating that the shorter accessions were more susceptible. There also appeared to be a fairly strong association between tallness and earliness (Table 2), which may influence the other associations. Since the correlations

are low, they are not likely to interfere in the breeding process.

INTERPRETATIVE SUMMARY

Barley cultivars are needed that are resistant to the disease barley leaf rust which reduces barley production and quality of barley in most areas where barley is grown. Leaf rust resistant barley cultivars are available, but the genetic variation in genes conferring their resistance is limited. Therefore, new genes for resistance to the disease barley leaf rust should be identified.

We studied barley accessions collected in Ethiopia because they are known to be genetically diverse. We identified five accessions that are as resistant as the cultivar Vada which is one of the most resistant cultivars known.

The resistant accessions will be studied to verify that they have new and different resistance genes, and then they will be used to develop cultivars with new genes for resistance to the disease barley leaf rust. Barley production will be increased and stabilized by the reductions and losses in production and quality of barley in the United States and in other barley producing countries by the culivars derived with the new genes for resistance to the disease barley leaf rust.

REFERENCES

HABGOOD, R.M. AND B.C. CLIFFORD (1981). Breeding barley for disease resistance: the essence of compromise. In: Strategies for the control of cereal disease. Eds. J.F. Jenkyn and R.T. Plumb, Blackwell Scient. Publ., Oxford etc., 15-25.

MCNEAL, F.H., C.F. KONZAK, E.P. SMITH, W.S. TATE and T.S. RUSSELL (1971). A uniform system for recording and processing cereal research data. USDA Agr. Res. Serv. Wash. DC. ARS, 34-121: 42 pp.

NIKS, R.E. (1982). Early abortion of colonies of leaf rust, Puccinia hordei, in partially resistant barley seedlings. Canadian Journal of botany 60: 714-723.

PARLEVLIET, J.E. (1975). Partial resistant of barley to leaf rust, Puccinia hordei. I. Effect of cultivar and development stage on latent period. Euphytica 24: 21-27.

PARLEVLIET, J.E. (1978). Further evidence of polygenic inheritance of partial resistance in barley to leaf rust, Puccinia hordei. Euphytica 27: 369-379.

PARLEVLIET, J.E. and H.J. KUIPER (1977). Partial resistance of barley to leaf rust, Puccinia hordei. IV. Effect of cultivar and development stage on infection frequency. Euphytica 26: 249-255.

PARLEVLIET, J.E., W.H. LINDHOUT, A., VAN OMMEREN and H.J. KUIPER (1980). Level of partial resistance to leaf rust, Puccinia hordei, in West-European barley and how to select for it. Euphytica 29: 1-8.

PARLEVLIET, J.E. and A. VAN. OMMEREN (1975). Partial resistance of barley to leaf rust, Puccinia hordei. II. Relationship between field trials, micro plot tests and latent period. Euphytica 24: 293-303.

ROANE, C.W. (1962). Inheritance of reaction to Puccinia hordei in barley. I. Genes for resistance among North American race differentiating varieties. Phytopathology 52: 1288-1295.

TABLE 1 - The relative latent period, infection frequency, field assessment, earliness, ear type and plant length of two barley cultivars and nine Ethiopian accessions.

Cultivar or accession	Relative		Field assessment [1]	Earliness	Ear type [2]	Length
	Latent period	Infection frequency				
L94	100	100	15½	9	2	4
Vada	125	56	11	4	2	3
PI 382802	102	116	15½	4	6	4
PI 382814	102	122	15½	4	6	4
PI 383007	102	98	15½	8	6	4
PI 382663	102	105	15½	5	2	4
PI 382372	127	32	11	4	2	4
PI 383126	120	43	11½	4	6	3
PI 383021	123	55	10	4	6	5
PI 383120	129	48	10½	4	6	3
PI 383119	119	43	9	3	2(int)[3]	3
L.S.D. (P=0.05)	7.8	28.5	2.1	1.1	-	0.3

[1]) Each unit increase on this scale represents approximately a doubling of the amount of barley leaf rust; a 9 representing 0.5%, a 15 about 25% leaf area affected.

[2]) represents two-rowed (2) and six-rowed (6) barley respectively.

[3]) intermediate, suggesting two-rowed ears.

TABLE 2 - Partial resistance to barley leaf rust, of Ethiopian barley accessions grouped according to their relative latent period (RLP), mean relative latent period and infection frequency and mean field assessment.

Group	Range of RLP	n	Mean relative		Mean field assessment
			latent period	Infection frequency	
1	106	52	102.5	88.2	14.0
2	106-110	85	108.0	84.0	13.4
3	111-115	67	112.8	73.8	13.7
4	116-120	52	117.9	62.1	13.5
5	120	25	127.7	55.8	12.2

TABLE 3 - Partial resistance to barley leaf rust of Ethiopian barley accessions and of two barley cultivars grouped according to plant length, mean earliness and field assessment.

Group	Plant length	n	Earliness	Field assessment
A	2	18	7.2	13.8
B	3	78	6.7	13.9
C	4	101	5.8	13.3
D	5	31	4.4	12.6
L94	4	7	9	15½
Vada	3	7	4	11

Cereal Rusts Bulletin Vol. 14, Part 1, 1986

RESISTANCE TO YELLOW RUST (PUCCINIA STRIIFORMIS WESTEND.) IN TRITICUM AESTIVUM SSP. SPELTA.

BY

G.H.J. KEMA[1], A.C. ZEVEN[2], R.W. STUBBS[1]

1) Research Institute for Plant Protection (IPO), Wageningen
2) Department of Plant Breeding (IVP), Agricultural University, Wageningen.

INTRODUCTION

A project which involved an analysis of genes of resistance to yellow rust in Dutch breeding material (Kema et al., 1984) was carried out at the IPO from 1980 until 1984. Accessions of Triticum aestivum spp. spelta to T. spelta) originating mainly from locations in Europe were included in this investigation. They are part of the 'Wageningse Triticinae Collectie' (WTC) maintained by the second author at the Department of Plant Breeding of the Agricultural University at Wageningen. Turkensteen (1968) had previously screened the WTC with Puccinia striiformis using eight Dutch races and occasionally one race from Chile and one race from the Lebanon. He obtained two remarkable results: (1) T. spelta entries in particular showed resistance to the races used and (2) no differential reactions occurred. This led Zeven et al. (1968) to the conclusion that T. spelta could be a possible source of race-non-specific resistance to yellow rust. Since this investigation was carried out the virulence of the pathogen increased in the Dutch as well as in the foreign populations (Stubbs, 1985). In the period 1968-1986 a world-wide collection of yellow rust isolates was established. It was wondered whether T. spelta would exhibit the same type of resistance against a much broader virulence spectrum of the pathogen. If so, the accessions could probably be utilized as an additional source of variation of genes for resistance against yellow rust. However, before the practical application of such a source it should be known whether resistance in T. spelta is based on genes for resistance identical with the gene in T. spelta var. album : Yr_5. Stubbs (1968) produced mutants of P. striiformis which gave intermediate infection types on T. spelta var. album. Unfortunately these mutants were lost during preservation. Moreover, it is doubtful whether reliable results could be obtained with such a mutant. Recently virulence for Yr_5 was reported by Nagarajan (1983) but unfortunately this isolate is not available for research. Performing a diallel crossing program was then considered to be the only method left to investigate the genetics of resistance against yellow rust in T. spelta. Therefore, after intensive screening of T. spelta accessions with many isolates of yellow rust, a half-diallel crossing program was executed with some of the resistant T. spelta accessions. The analysis of this program was interrupted by the detection of virulence for Yr_5 in Australia (Wellings, 1984). This contribution deals with the results obtained with that virulence and with other isolates of yellow rust.

MATERIALS AND METHODS

From the original collection of 55 entries, 24 T. spelta accessions (18 resistant and six susceptible accessions ; Table 1) were inoculated in the seedling stage with 13 Dutch races and 36 foreign yellow rust isolates. The Dutch races represented a wide range of virulence genes. They are compatible with the described resistance genes (with exception of those in cv. Spaldings Prolific, cv. Moro and cv. Compair) and with most of their two-gene combinations. The foreign isolates represented also a wide range of virulence genes prevailing in the different regions in the world (Table 2). Virulence for the resistance of cv Spaldings Prolific, cv Moro and cv Compair was available is those isolates. They include also an isolate (83049) from Saudi-Arabia virulent on the universal resistant T. dicoccoides sel. G-25 (Stubbs, 1984). This isolate is interesting because crossing experiments indicated that the resistance of T. dicoccoides sel G-25 is monogenic and different from Yr_5 Amitai et al., in preparation). The emphasis was on the isolates from the Middle-East and Asia because this region is believed to be the primary centre of origin of primitive hexaploid wheats (Zeven and de Wet, 1982). Later research included an isolate (85060) from Australia with virulence for T. spelta var. album. This isolate was identified as 360E137A (Wellings, 1984) using the nomenclature described by Johnson et al., 1972. Standard procedures were used for sowing, inoculation, incubation, growth conditions and assessments (Kema et al., 1984).

RESULTS

Table 1 presents the results obtained with the races mentioned in table 2 with exception of the race from Australia. It is obvious that none of the changes in virulence in the yellow rust populations resulted in compatible reactions with the resistant T. spelta entries. Table 3 shows the results obtained from inoculations with eight races including race 360E137A (isolate 85060, Australia). Nearly all resistant entries showed compatible reactions with this isolate, T. spelta 45 differentiates the Afghan isolates, T. spelta 57 is susceptible to one isolate from Iran (78098).

DISCUSSION

The compatible reactions of most entries with race 360E137A from Australia indicate that their resistance could be controlled by the gene in T. spelta var. album (Yr_5). As already mentioned T. spelta 45 differentiates the Afghan isolates and T. spelta 57 is susceptible to one isolate from Iran (78098). This implies that T. spelta 45 and T. spelta 57 carry genes different from Yr_5. Thus, from these data the presence of at least three different genes for resistance, viz. Yr_5 and the genes in the entries 45 and 57, is concluded. This conclusion is contradictory to the one of Zeven et al. (1968). Their suggestion that the high degree of resistance could be controlled by race-non-specific genes is confusing because the interpretation of this type of resistance has changed since that time. T. spelta entries may possess genes influencing the rate of development of an epidemic. At present however, no indications for it have been found.

In the study of Zeven et al. (1968) differential reaction patterns did not occur i.e. lines tested were either resistant to all races or susceptible to all races. In the present work they were only rarely observed. This indicates that virulence for resistance genes in resistant lines of T. spelta is very rare. Therefore, the appearance of a race with virulence for Yr_5 in Australia is remarkable and hard to explain, particularly because yellow rust was first introduced into Australia only in 1979 (O'Brien et al., 1980). Since that time the physiologic specialization was comparable to that in Europe. Although yellow rust is endemic in Europe and the physiologic specialization there was studied intensively since 1957 (Zadoks, 1961) virulence for Yr_5 was never observed.

One might tend to conclude that most of the resistant T. spelta entries have a common origin. Material obtained from different botanical gardens might be identical because of possible exchange. Although the material is very uniform in resistance against yellow rust, difference in Rf_{tim} - and Ne-genotypes (Zeven and De Wet, 1982; Tahir et al., 1968) indicate that such a conclusion cannot be drawn.

The half-diallel crossing program was performed to analyse the genetical background of the resistance in some of the entries. Preliminary results obtained with the progenies of this program showed that the resistance of the entries used is most probably not based on different genes. The data presented here strongly confirm these results. However, in the crosses with the susceptible check segregations were not always clearly monogenic. Therefore this work will continue to confirm the results which are now available. Furthermore it will be investigated whether the resistance of T. spelta 57 is monogenic and possibly allelic with Yr_5.

ACKNOWLEDGEMENTS

Spores of the Australian race 360E137A were kindly provided by C.R. Wellings of the Plant Breeding Institute of the University of Sydney. Samples of seed were kindly provided by J. Waninge of the Department of Plant Breeding, Agricultural University, Wagneningen. Thanks are due to C.H. van Silfhout, R.A. Daamen and A. Tempel for critically reading the manuscript.

REFERENCES

AMITAI, Z.K., VAN SILFHOUT, C.H., and GRAMA, ADRIANA. (in preparation). An undescribed gene for resistance to Puccinia striiformis in Triticum dicoccoides sel. G-25.

JOHNSON, R., STUBBS, R.W., FUCHS, E., and CHAMBERLAIN, N.H. (1972). Nomenclature for physiologic races of Puccinia striiformis infecting wheat. Trans. Br. Mycol. Soc. 58 (3), pp. 475-480.

KEMA, G.H.J., VAN SILFHOUT, C.H. AND STUBBS, R.W. (1984). Analysis of resistance to yellow rust (Puccinia striiformis Westend. f. sp. tritici) in Dutch wheats. Proc. 6th Eur. Mediterr. Cereal Rusts Conf., 1984, pp 75-79.

NAGARAJAN, S. (1983). "Annual Report 1983." Indian Agric. Res. Inst., Regional Station, Flowerdale, Simla.

O'BRIEN, L., BROWN, J.S., YOUNG, R.M. and PASCOE T. (1980). Occurrence and distribution of wheat stripe rust in Victoria and

susceptibility of commercial wheat cultivars. Australias. Plant Pathol, 9, pp. 14.

STUBBS, R.W. (1968). Artificial mutation in the study of the relationship between races of yellow rust of wheat. Proc. 2nd Cereal Rust Conf., 1968, pp. 60-62.

STUBBS, R.W. (1984). "Annual Report 1984", pp. 67-68. Research Inst. for Plant Prot. (IPO), Wageningen, The Netherlands.

STUBBS, R.W. (1985). Stripe Rust. In : "The Cereal Rusts", 2, Eds A.P. Roelfs and W.R. Bushnell. Acad. Press, pp. 61-101.

TAHIR, Ch. M., and TSUNEWAKI, K. (1968). Monosomic analysis of Triticum spelta var. duhamelianum, a fetility restorer for T. timopheevi cytoplasm. Jap. Jour. of Gen. 44, No. 1, pp. 1-9.

TURKENSTEEN, L.J. (1968). Onderzoek naar resistentie tegen Puccinia striiformis (Westend.) in Triticum species. Ingenieurverslag Plantenveredeling. Wageningen. Not published.

WELLINGS, C.R. (1984). "Annual Report 1984," pp. 24-25. Plant Breed. Inst., University of Sydney, Sydney, Australia.

ZADOKS, J.C. (1961). Yellow rust on wheat. Studies in epidemiology and physiologic specialization. Tijdschr. Plantenziekten 67, pp. 69-256.

ZEVEN, A.C., TURKENSTEEN, L.J. and STUBBS, R.W. (1968). Spelt (T. spelta L.) as a possible source of race-non-specific resistance to yellow rust (Puccinia striiformis West.). Euphytica 17, pp. 381-384.

ZEVEN, A.C. and DE WET, J.M.J. (1982). Dictionary of cultivated plants and their regions of diversity, excluding most ornamentals, forest trees and lower plants. Pudoc, Wageningen, The Netherlands, pp. 263.

TABLE 1 - *Triticum spelta* entries of the Triticinae collection at Wageningen and their reactions to yellow rust [1].

Entry	Addition	Origin	Resistance to yellow rust A[2]	B[3]
2	Line 10	Belgium	S	S
3	Line 24	Belgium	S	S
5[4]	var. *album* 'Weisser Kolben'	Germany; via exp. station Koln coll. nr. T 114	R	R
6	'Weisser Grannenspelz'	Germany (WDR)	S	-
7	'Schwarzer Bart'	Germany (WDR)	S	-
8[4]	var. *duhamelianum* 'Roter Sommerspelz'	Germany (WDR)	R	R
9[4]		Hungary; via botanical garden, Szeged	R	R
10		United Kingdom; via botanical garden, Chelsea	R	R
11	'Minster in Westfalen'	Germany; botanical garden (WDR)	R	R
12		Hungary	S	S
13		? ; via Reading (UK) coll. nr. 174	S	-
15		? ; via Chelsea (UK)	S	-
16		? ; via Foundation for Plant Breeding (NL)	S	-
17		Germany ; botanical garden, Hamburg	R	R
18		France ; botanical garden, Dijon	R	R
19		Czecho-Slovakia ; botanical garden, Tabor	R	R
20		? ; via Tabor	S	-
21		? ; via Turin (I)	S	-
22		? ; via Turin	R	R
23	var. *saharense* 'Sahara I'	North Africa, Sahara oasis	S	-
24	'Lohnauer Sommerspelz'	Germany	S	S
25	'Elsenegger'	Switzerland, Lausanne	S	-
26	'Neuegg Weisshorn'	Switzerland, Lausanne	S	-

contd..

TABLE 1 CONTINUED

27	'Oberkulmer Rothorn'	Switzerland, Lausanne	S	-
28	Line 73	Belgium, via Gembloux	S	-
29	'Brauner Winter Grannen'	? ; via Gatersleben H Tr 1786/63	S	-
30	var. arduinii	? ; via Toulouse (F) coll. nr. 2223/65	S	-
31	var. duhamelianum 'Steiners Roter Tiroler Dinkel'	Austria ; via Gatersleben H Tri 3775/62	S	-
32	var. duhamelianum 'Hattig Niederwill'	Switzerland ; via Gatersleben H Tri 4656/6 Ox	S	-
33		? ; via Belgium	S	-
34	var. duhamelianum 'Brauner Spelz aus Schettlenz	Germany ; via Gatersleben H Tri 4684/6 Ox	S	-
35	var. album 'Spelz aus Tzari Brod'	Bulgaria ; via Gatersleben A Tri 474	R	R
36	var. album 'Vogelers Dinkel Weiss'	Germany ; via Gatersleben H S 312/63	S	S
37		? ; via Sofia (BUL)	S	-
38		? ; via Haun	S	-
39		? ; via Toulouse	S	-
40	var. duhamelianum	? ; via Toulouse	S	-
41	var. duhamelianum	?	S	-
42	mutica	? ; via botanical garden, Modena (I)	R	R
43		? ; via botanical garden, Bremen (WDR)	R	R
44		? ; via botanical garden, Bonn (WDR)	S	-
45		? ; via botanical garden, Nancy (F)	S	*[5]
46		? ; via botanical garden, Grignon (F)	R	R
47		? ; via botanical garden, Strasbourg (F)	R	R
48	var. coeruleum	? ; via Toulouse	S	-
49		?	R	-
50[4]		? ; via botanical garden, Cluj (ROM)	R	R
51	var. arduinii	? ; via Modena	S	-
52		? ; via Modena	S	-

contd.

TABLE 1 CONTINUED

53	var. coeruleum	? ; via Cluj	S	-
54	'Spelt uit Hoosterhof'	Belgium ; via Foundation for Plant Breeding (NL)	S	-
55	'Braunlander Spelz'	Germany	S	-
57[6]	Iran 415 'bearded'	Iran ; near Shahr Kard, 2000 m.	R	R
58[4,6]	Iran 417 a	Iran ; near Shahr Kard, 2060 m.	R	R
	var. album	? ; stored and multiplied at IPO, resistant check	R	R

1 Excluding isolate 85060 from Australia.
2 Data derived from Turkensteed (1968).
3 Data from the present study.
4 Resisant entry which is included in the half-diallel program.
5 Differential reaction (see table 3).
6 Entries collected by Kuckuck, Hannover.

TABLE 2 - Isolates of P. striiformis which have been used in screening T. spelta entries. Isolates which have been used in earlier[1] work are underlined.

Country	Isolate[2]	Race[3]	Country	Isolate	Race	Country	Isolate	Race
Afghanistan	72078	102E 0	Iran	73160	66E 16	The Netherlands	77694	105E137
	79054	6E 16		78093	98E 1		78510	106E139
	81065	39E150		78098	2E 16		78568	232E137
Algeria	80093	41E136	Israel	77142	2E 0		78627	234E139
Australia	85060	360E137A⁻		85026	?		80567	43E138
Chile	65001	32E 64	Kenya	75147	38E 16		81526	104E 41
	74210	108E173		80022	38E 22		?	104E 9
	82049	108E205	Lebanon	?	6E 16		?	36E132
China	82015	15E158	The Netherlands	58700	36E132		?	33E 96
Colombia	74176	12E132		59791	32E128	Nepal	80054	4E 16
Ecuador	81038	?		60018	32E 0	Pakistan	75059	77E 0
	81047	66E 0		61009	32E 0	Peru	81035	104E 9
Egypt	75080	82E 16		61023	40E136	Saudi-Arabia	83049	6E 16
India	76033	66E 0		66043	37E132	Tanzania	80100	2E 16
Irak	77167	82E 16		66049	37E132	Tunisia	76078	6E 16
	78046	6E 16		68009	39E134	Turkey	73077	6E 16
	78048	2E 16		72078	108E141		75115	6E 20
	78065	70E 16		77168	41E168		75582	6E 16
				77689	169E136	Switzerland	77631	32E 64

1 Derived from Zeven et al. (1968)
2 The first two digits of an isolate number represent the year of collection, the three latter digits represent an IPO-sequence number.
3 For description of the race codes see Johnson et al. (1972)

TABLE 3 - Differential reactions of seedlings of T. spelta entries with isolates of yellow rust from five regions.

	Regions							
		Iran		Afghanistan		Switzer-land	Saudi-Arabia	Australia
	Isolates							
	73160	78098	78093	79054	72078	77631	83049	85060
	Races							
Entries	66E16	2E16	98E1	6E16R^{-1}	102E0	32E64	6E16R^{+1}	360E137^{-1}
5	1-2[2]	1	2	1	1	2	1	9
8	1-2	1-2	1-2	1	1	1-2	1	9
9	1	1-2	2	1	1	2	1-2	9
10	1	1	1-2	1	1	1-2	1	9
11	1-2	1	1	1	1-2	1	1	9
17	1	1	1-2	1	1	1-2	1	8
18	1	1	1	1	1-2	1	1	8
19	1	1	1	1	1-2	1-2	1	8
22	1	1-2	1	1	1	1-2	1	8
35	1	1	1	1	1	1	1	8
42	1	1	1-2	1	1-2	1-2	1	8
43	1-2	1-2	1-2	1	2	1-2	1-2	8
45	9	9	9	4	2	9	7-8	8
46	1-2	1	1	1	1-2	1	1	7
47	1-2	1	1	1	1-2	1	1	8
50	1	1	1	1	1-2	1	1	8
57	-	7	1	-	1	-	2	1
58	1-2	1	1	1	1-2	1	1	8
album	1	1	1	1	1	1	1	8

[1] R^{-} and R^{+} indicate avirulence and virulence on cv. Rusalka, respectively, A^{-} indicates avirulence on cv. Anza.
[2] Data according 0-9 scale.

Cereal Rusts Bulletin Vol. 14, Part 1, 1986

EVOLUTION OF VARIANTS OF RACE 21 OF PUCCINIA GRAMINIS f. sp. TRITICI IN INDIA

BY

P. BAHADUR

Indian Agricultural Research Institute, Regional Station, Flowerdale, Shimla-2, India.

Pathogenicity surveys of Puccinia graminis f. sp. tritici over the past fifty years in India reveal that variants of existing races are produced as a response to the cultivation of resistant genotypes (Bahadur, 1984). The pathogen also accumulated in a sequence virulence genes corresponding to the incorporation of resistance genes in the host in Australia (Luig and Watson, 1970). Until 1980, variation in pathogenicity of P. graminis f. sp. tritici in India was determined using the system of Stakman and Levine (1922) and subsequently that of Bahadur et al. (1985). The latter system permitted speculation on the possible evolutionary trend of the race 21 group of races.

During wheat rusts pathogenicity survey, race 21 of P. graminis f. sp. tritici, was detected in 1934 from the cultivar C 518 from Lyallpur, Pakistan (Mehta, 1940). This virulence was at a low frequency prior to the cultivation of varieties of NP 700 series. After the cultivation of two Australian varieties Ridley and Gabo in the Northern Himalayan and Southern Nilgiri and Pulney hills respectively the frequency increased further. During 1946-55, race 21 constituted about 45% of the total sampled population (Fig. 1). Both Ridley and Gabo possess stem rust resistance gene Sr11 and after their cultivation, two variants of race 21 namely 21A and 21A-1 were identified. The first variant was collected in 1956 from Yalta (Sr11) in Northern India and the second 21A-1 in 1958 from Charter (Sr11+?) at Wellington (South India). Subsequently, Yalta and Charter were incorporated as additional differentials (Prasada and Sreekantiah, 1956). Susceptibility of both Yalta and Charter to race 21A-1 indicates an additional factor for stem rust resistance in Charter. Subsequently between 1956 and 1965 the average frequency of races 21A and 21A-1 increased from 3 to 24% and from 2 to 7% respectively with a corresponding decrease in the frequency of race 21 due to cultivation of wheats such as NP 770, NO 809 and Ridley. The two former cultivars became susceptible to race 21A and the last one to both races 21A and 21A-1 in Northern India. Variant race 21A is virulents on Sr11 and race 21A-1 on Sr8 and Sr11 in set A, and both on Kota (Sr28+) in set B (Bahadur et al. 1985).

After the cultivation of dwarf wheats such as Kalyansona and Sonalika, the frequency of race 21 again increased from 10-30% during 1965-70 to 50-60% during 1975-80 (Fig. 1). During 1982, field samples identified as race 21 and the type culture of race 21 identified by Mehta were tested on the new differentials. A significant difference in pathogenicity of the two types of race 21 was observed on isogenic lines though cultures are indistinguishable on the standard

differentials of Stakman and Levine. The field isolates were virulent on Sr9b and Sr30 (Set A), while the type culture 21 was avirulent. This indicates that at some stage a minor variation in race 21 occurred unnoticed on standard differentials. The new variant is named as 21A-2. Stem rust resistance gene Sr9b was used for breeding wheat, while there is no mention of Sr30 in Indian literature.

In 1954 race 17 (Joshi et al. 1960) was recorded from RS-6 (Barley) and the average frequency varied from 2-7% between 1955-80. Possibly race 21 became virulent on Sr21 and thus resulted in race 17. However, Sr21 has not been used in India to increase the level of resistance in the wheat varieties.

A change in avirulence of race 21 on Kubanka and Acme (Sr9g) possibly resulted in race 194 which was identified in 1945. During the maintenance of single spore cultures of races 75 and 21A-1 colour mutant on Agra local wheat, a change in the pathogenicity leading to avirulence on Kubanka and Acme was noted. A new race 226 originated from race 75 (Singh et al. 1969) and the other 194 CM from 21A-1CM. Such behaviour on Sr9g has also been observed in Australia (Watson and Luig, 1963). During induced mutation studies, progressive changes in the pathogen on plants with Sr6 and Sr30 and changes from avirulence to virulence on plants with Sr5, Sr9e and Sr21 were observed (Luig, 1978).

Studies in India reveal that variants of race 21 arose as a consequence of widespread cultivation of improved wheats. Variant 21A acquired virulence for Sr11, 21A-1 for Sr11+? and 21A-2 for Sr9b.

ACKNOWLEDGEMENTS

Thanks are due to the Head of the Division of Mycology and Plant Pathology, IARI., New Delhi and the Head of the Regional Station, Flowerdale, Simla for providing necessary facilities.

REFERENCES

BAHADUR, P. 1984. Effect of complex resistance on the dynamics and evolution of Puccina graminis (Pers.) f. sp. tritici Erikss. & Henn. in India during last 50 years (1931-80). Tropical Plant Pathology, 1 : 73-101.

BAHADUR, P., S. NAGARAJAN and S.K. NAYAR. 1985. A proposed system of virulence designation in India. 2. Puccinia graminis tritici. Indian Acad. Sci. 95: 29-33.

JOSHI, L.M., SWARUP, G., SREEKANTIAH, K.R. and VASUDEVA, R.S. 1960. Race 17 of brown rust of wheat: a new record for India. Indian Phytopath. 13: 183.

LUIG, N.H. 1978. Mutation studies in Puccinia graminis tritici. Proc. 5th Wheat Gen. Symp. (S. Ramanujam ed.) Indian Soc. Gen. Pl. Breed. New Delhi 533-39.

LUIG, N.H. and WATSON, I.A. 1970. The effect of complex genetic resistance in wheat on the variability of Puccinia graminis f. sp. tritici. Proc. Linn. Soc. New South Wales. 95, 22-42.

MEHTA, K.C. 1940. Further studies on cereal rusts in India. Indian Counc. of agric. Res. Monogr. 14: 1-224.

PRASADA, R. and SREEKANTIAH, K.R. 1956. Identification of biotypes within physiologic races of wheat stem rust. Indian Phytopath. 2: 209-11.

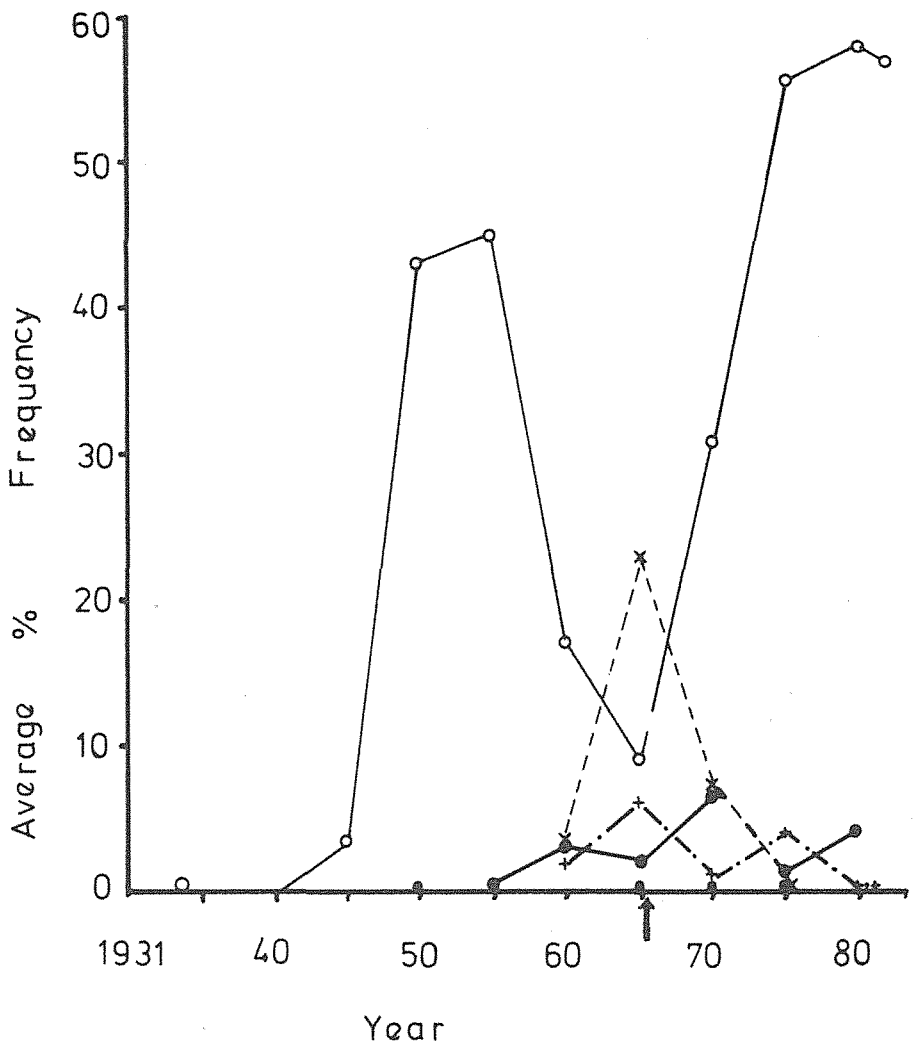
SINGH, S.D., MISRA, D.P. and AHMED, S.T. 1969. A pathogenic mutation in race 75 of Puccinia graminis var. tritici. Indian Phytopath. 22: 519-21.

STAKMAN, E.C. and LEVINE, M.N. 1922. The determination of biologic forms of Puccinia graminis on Triticum sp. Minn. Agr. Exp. Sta. Tech. Bull. 8: 1-10.

WATSON, I.A. and LUIG, N.H. 1963. The classification of Puccinia graminis var. tritici in relation to breeding resistant varieties. Proc. Linn. Soc. N.S.W. 88: 235-38.

Fig. 1 Shows the changes in average percent frequency of variants of race 21 during 50 years.

Symbols o_____o, x_____x, o_____o, o_____o and +_____._____+, depicts race 21 (arrow indicates probably year of exchange in virulence but detected in 1982 - 21A-2), 21A, 194, 17 and 21A-1.



Cereal Rusts Bulletin Vol. 14, Part 1, 1986

RESISTANCE TO BRITISH RACES OF PUCCINIA STRIIFORMIS IN THE DIFFERENTIAL WHEAT CULTIVARS HEINES KOLBEN AND HEINES PEKO.

BY

R. JOHNSON, A.J. TAYLOR & G.M.B. SMITH

Plant Breeding Institute, Cambridge CB2 2LQ, England.

SUMMARY

The two spring wheat cultivars Heines Kolben and Heines Peko are part of an internationally used set of cultivars for differentiating races of Puccinia striiformis. It has been suggested that both cultivars possess the gene Yr6 and that Heines Peko also possesses the gene Yr2. Heines Peko is much more resistant than Heines Kolben to races possessing pathogenicity for Yr6 but lacking pathogenicity for Yr2. Despite this difference our data show that both are more susceptible as seedlings and in field nurseries to races possessing pathogenicity for both Yr6 and Yr2 than to races possessing pathogenicity for Yr6 but not Yr2. It is postulated that Yr2 is present in Heines Kolben, in a genetic background that inhibits its expression in seedlings.

INTRODUCTION

The wheat cultivar Heines Kolben (Kolben) is one of the parents of Heines Peko (Peko) and both are of spring habit. Zadoks (1961) classified Kolben and Peko as possessing a common gene 'B' for resistance to yellow rust caused by Puccinia striiformis West.. Macer (1966) proposed the name Yr6 for the gene in Peko and later (Macer, 1975) suggested that the same gene was present also in Kolben. Labrum (1980) presented data from crosses between Kolben and Peko supporting this suggestion and indicating that Yr6 was carried on chromosome 7B. On the basis of tests with races of P. striiformis, Chamberlain (1973) proposed that Peko also carried another gene, probably Yr2, originally reported in the cultivar Heines VII (Lupton & Macer, 1962). Labrum (1980) reported difficulty in establishing this from crosses of Peko with Heines VII due to weak expression of resistance to a race with pathogenicity for Yr6 but not Yr2. She also experienced difficulty in identifying the chromosome carrying the gene thought to be Yr2 from Peko using monosomic analysis, but with the help of chromosome counts in the progeny of monosomic plants tentatively assigned it also to chromosome 7B.

Peko and Kolben are both used as differential cultivars in a system proposed for classification of races of P. striiformis (Johnson et al., 1972). This system has been in regular use at the Plant Breeding Institute and the reactions of both cultivars to many races of P. striiformis have been observed. In 1986 both cultivars were included in race nurseries in the field. Typical examples of the data are reported here.

MATERIALS AND METHODS

Seedlings of differential wheat cultivars were grown in 8 cm plastic plant pots in potting soil until the first leaf was fully expanded and the second leaf partly emerged. Each pot contained about 8 seedlings of a single cultivar. The seedlings were sprayed with distilled water containing Tween 20 as a wetting agent (one drop from a glass rod per litre of water) and dusted with urediospores of P. striiformis dispersed in sterilised talc. The plants were then resprayed and placed in humid chambers at 10°C for 24 h to encourage infection. They were then returned to the glasshouse or growth cabinet and were scored for infection type after 12 to 14 days. Infection types were recorded on a 00 to 4 scale where 00 represents a small chlorotic fleck without sporulation, 0 a larger chlorotic fleck without sporulation and 1 to 4 represent increasing amounts of sporulation and decreasing amounts of chlorosis. Plus (+) was added to indicate a slightly higher (more susceptible) infection type than average for the class and minus (-) was added to indicate a slightly lower infection type. The races of P. striiformis used were as shown in the data.

In field tests the cultivars were sown in short rows with a Hege 90 drill and were adjacent to a yellow rust susceptible cultivar (Vuka) used to spread the rust. Plots with a set of cultivars and the associated susceptible cultivar were infected with a single isolate of P. striiformis by spraying the rows of the susceptible cultivar with urediospores dispersed in a light mineral oil (BP odourless kerosene) in March 1986 using an ultra low volume sprayer ('Herbie', Micron Sprayers Ltd.). Each set of cultivars for testing together with its associated susceptible cultivar was surrounded by a 2 m barrier of a mixture of wheat and rye resistant to yellow rust to reduce cross-contamination. The plots were scored for percentage leaf area infected with rust according to a modified Cobb Scale.

RESULTS

The results given in Table 1 for infection types on seedlings are characteristic and have been observed in many tests with these races and with other races possessing equivalent pathogenicity for the genes Yr2 and Yr6. Although Peko is clearly more resistant than Kolben with race 108 E9 it is also apparent that Kolben and Peko are both more susceptible to the races carrying pathogencity for both Yr2 and Yr6.

Two features are evident in the data from the race nurseries (Table 1). One is that Peko is more resistant at post-seedling stages to races 45 E140 and 109 E141 than Kolben. The second is that both Peko and Kolben are more susceptible to the races with pathogenicity for Yr2 and Yr6 than to those with pathogenicity for either of these genes separately. Unfortunately the race lacking pathogenicity for both genes was not used in the field nurseries because it was not important for the main purposes of the tests. It should be noted that infection in nurseries with races possessing pathogenicity for Yr2 or Yr6 separately may be partly due to contamination with the races possessing pathogenicity for both genes (Johnson & Taylor, 1978). Thus the data cannot be used to indicate the effectiveness of resistance due to Yr2 or Yr6 in adult plants.

DISCUSSION

The classification of an isolate of P. striiformis as race 108 E9 under the system proposed by Johnson et al. (1972) indicates that it possesses pathogenicity for Kolben but not for Peko. As indicated, the correlation of this pattern with the lack of pathogenicity for Yr2 led to the suggestion that Peko possessed Yr2 but that this did not appear to be present in Kolben. The data of Table 1 showing the different reactions of Peko and Kolben to race 108 E9, which possesses pathogenicity for Yr6 but not Yr2, appear to support this conclusion. However, the other data in Table 1 indicate that Kolben is slightly more susceptible at the seedling stage and markedly more susceptible in the field to races that possess combined pathogenicity for Yr2 and Yr6 than to race 108 E9. It is therefore postulated that Kolben possesses Yr2 as well as Yr6 but in a genetic background that inhibits its expression in seedlings. The evidence from the field trial indicates that Peko possesses resistance greater than that of Kolben at the post-seedling stages and it is possible that the genes associated with this resistance enhance the expression of Yr2 in Peko compared with its weak expression in Kolben. Difficulties experienced by Labrum (1980) in testing for allelism of the gene thought to be Yr2 in Peko with Yr2 in Heines VII could relate to the variable expression of Yr2 in different genetic backgrounds. The same type of variation combined with partial recessiveness of Yr2 probably caused the difficulties experienced by Labrum (1980) in detecting the chromosome carrying the gene thought to be Yr2 in Peko.

REFERENCES

CHAMBERLAIN, N.H. 1973. Some aspects of the physiologic specialization of Puccinia striiformis causing yellow rust of wheat. Ph.D. Thesis, University of Reading.

JOHNSON, R. & TAYLOR, A.J. 1978. Yellow Rust of Wheat. Annual Report of the Plant Breeding Institute for 1977. pp. 119-121.

JOHNSON, R., STUBBS, R.W., FUCHS, E. & CHAMBERLAIN, N.H. 1972. Nomenclature for physiologic races of Puccinia striiformis infecting wheat. Transactions of the British Mycological Society 58: 475-480.

LABRUM, K.E. 1980. The location of Yr2 and Yr6, genes conferring resistance to yellow rust. Proceedings of the Fifth European and Mediterranean Cereal Rusts Conference, Bari, Italy, 1980. pp 41-45.

LUPTON, F.G.H. & MACER, R.C.F. 1962. Inheritance of resistance to yellow rust (Puccinia striiformis Erikks. and Henn.) in seven varieties of wheat. Transactions of the British Mycological Society 45: 21-45.

MACER, R.C.F. 1966. The formal and monosomic genetic analysis of stripe rust (Puccinia striiformis) resistance in wheat. Proceedings of the 2nd International Wheat Genetics Symposium, Lund, Sweden 1963. Hereditas, Supplement 2: 137-142.

MACER, R.C.F. 1975. Plant Pathology in a changing world. Transactions of the British Mycological Society 65: 351-367.

ZADOKS, J.C. 1961. Yellow rust of wheat: studies in epidemiology. Tijdschrift over Plantenziekten 67: 69-256.

TABLE 1 Infection types on seedlings of wheat cultivars infected with races of P. striiformis and percentage leaf areas infected in field plots of 20 June 1986.

Race	Pathogenicty for		seedlings		field nurseries[1]	
			cultivar			
	Yr2	Yr6	Peko	Kolben	Peko	Kolben
40 E8	-	-	ON[2]	ON	*	*
108 E9	-	+	On	3 - 3+	12.5	22.5
41 E136	+	-	1N - 2N	1N - 2N	12.5	27.5
104 E137	+	-	2⁻N - 3⁻N	1N - 2N	15.0	25.0
45 E140	+	+	4	4	32.5	62.5
109 E141	+	+	4	4	40.0	77.0

[1] Means of two replicates
[2] N = necrosis associated with infection
* Not tested in field nursery

Cereal Rusts Bulletin Vol. 14, Part 1, 1986

EXPRESSION OF 3 AG TRANSLOCATIONS IN WHEAT FOR LEAF RUST RESISTANCE AT SEEDLING AND ADULT PLANT STAGES OF PLANT GROWTH IN DIFFERENT BACKGROUNDS.

BY

R.N. SAWHNEY AND J.B. SHARMA

Division of Genetics
Indian Agriculture Research Institute,
New Delhi-110 012, India

INTRODUCTION

Rust resistance studies on the spontaneously translocated Agropyron derivative, Agent, have shown this resistance to be highly effective to Indian populations of the stem rust and leaf rust pathogens when tested at both seedling and adult plant stages (Sawhney and Goel, 1981; Sawhney and Goel, 1983; Sawhney et al., 1982a; Sawhney et al. 1982b). The two resistances, attributed to genes designated Sr_{24} and Lr_{24} are inherited together as part of the alien chromosome sector (McIntosh et al., 1977). This resistance is reported to be associated with red seed colour which apparently was also inherited from Agropyron (McIntosh, 1976). Since white grained wheats are preferred by Indian consumers, this valuable red seeded source of resistance could not be exploited for commercial purposes. A number of alien transfer lines involving the 3 Ag source chromosome were produced by Dr. E.R. Sears (Sears, 1973). Two of these, 3D/Ag#3 and 3D/Ag#14, were reported to produce white seeded rust resistant progenies (McIntosh, 1976). In an effort to develop improved stocks deriving resistance from 3D/Ag#3 and 3D/Ag#14, Dr. R.A. McIntosh, University of Sydney, succeeded in transferring this resistance to a number of lines including two selections of TR 380, one selection of TR 538 and to Condor selection (WW 31). This communication reports the responses of different white seeded stocks possessing 3 Ag translocations as seedlings and adult plants against Indian populations of the leaf rust pathogen.

MATERIALS AND METHODS

Source host genotypes possessing certain 3 Ag translocations in Chinese Spring background and other stocks deriving resistance from source genotypes 3D/Ag#3 and 3D/Ag#14 in the background of TR 380.14, TR 380.16, TR 548, Condor Sel (WW 31) and the carrier parents were evaluated against eight Indian leaf rust races/biotypes (12,12B,77,77A,104,104A,104B and 162) at the seedling stage. Standard procedures for the inoculation of seedlings were followed and the infection types were recorded after 15-20 days of inoculations according to the scale devised by Stakeman et al. 1962. All this material was also tested for the adult plant resistance to leaf rust at Delhi, Gurdaspur, and Wellington from 1983-85. The nurseries were artificially inoculated with mixtures of several races of leaf rust pathogen at Delhi and Gurdaspur (Punjab). At Wellington (Nilgiri

Hills-Tamil Nadu) where severe natural epidemics occur regularly, tests were made under natural infection of high intensity. Adult plant reactions for severity and response to leaf rust were recorded according to the scale described by Loegering (1959).

Seeds of the material used in the study were initially obtained from Dr. R.A. McIntosh, University of Sydney, Australia, and initial inoculum of the races was obtained from IARI Regional Station, Shimla, where races are being maintained as single spore cultures.

RESULTS AND DISCUSSION

Table 1 gives the seedling data of various host genotypes when tested against eight races of leaf rust individually.

While the source lines showed resistance of variable infection types, three of the other stocks deriving resistance from 3Ag translocations ($\underline{Lr_{24}}$) produced '0' IT (low infection) to all the eight races. Among the source lines, 3D/Ag#14 was observed to be more effective than 3D/Ag#3.

Based upon the pathogenicity and non-pathogenicity tests of single gene lines for leaf rust resistance and the host genotypes without $\underline{Lr_{24}}$ (Carrier lines), it was inferred that both TR 380.16 and TR 548 carry a leaf rust resistance gene $\underline{Lr_1}$. The additional resistance in TR 380.14 to races 77,77A,104 and 104A suggested that this genotype carries at least one additional gene providing resistance to four of the important Indian races of leaf rust.

The increased level of resistance in TR 380.14*7/3Ag#14, TR 380.16*7/3Ag#3 and TR 548*7/3Ag#3 in contrast to the source 3Ag translocation lines was accounted for as due to additive or complementary interaction between $\underline{Lr_{24}}$ and the other resistance genes, postulated in the recipient parents. However, it was not possible to differentiate the effects of different recipient parents. The infection spectra produced on Condor Sel*7/3Ag#3 was identical to that of 3D/Ag#3 which supports our results because Condor Sel (WW 31) was not postulated to carry any resistance gene against the races tested.

Table 2 gives leaf rust resistance at the adult plant stage of growth at different locations over the years. Among the source lines, 3D/Ag#14 was observed to be more effective than 3D/Ag#3, a behaviour similar to that observed for seedling resistance. Of the various other stocks possessing 3Ag translocations, TR 380.14*7/3Ag#14 was completely effective and the level of resistance was comparable to that produced on the source line 3D/Ag#14. Two of the other stocks TR 380.16*7/3Ag#3 and TR 548*7/3Ag#3 were observed to have either better or comparable resistance to that produced on the source line, 3D/Ag#3. The increased level of resistance in TR 380.16*7/3Ag#3 at Wellington (1984-85) in contrast to TR 548*7/3Ag#3 could be explained because even the recipient parent (TR 380.16) was observed to produce infection of very low intensity of 5S in contrast to 40S on TR 548. Another stock with 3Ag#3 translocation, Condor Sel*7/3Ag#3 was however, observed to possess a low level of resistance in contrast to the source line. This behaviour could be explained because of either decreased level of expression of genes for resistance when transferred to different backgrounds (Dyck and Samborski, 1974) or because of the decreased expression of resistance at the adult plant stage of the resistance observed in the seedlings. (Sawhney et al., 1982b). Our seedling tests, however, do not support the first possibility. In

support of the second possibility also the source lines should have shown less effectiveness at the adult plant stge. However, the high degree of resistance found in the source lines at the adult plant stage could be due to combined effect of Lr_{24} resistance and adult plant resistance observed in our earlier studies to be present in Chinese Spring, a carrier line of 3Ag translocations in the source lines.

The high degree of resistance in TR 380.14*7/3Ag#14 both at the seedling and adult plant suggests that among the host genotypes carrying Lr_{24}, TR 380/14*7/3Ag#14 should be of great importance for use in breeding programmes. The host genotype, besides being completely resistant both as seedlings and adult plants, possibly carry Lr_{24}, Lr_1 and an unknown gene imparting resistance to leaf rust. With appropriate procedures for the identification of different genes for resistance it would be possible to develop multigene cultivars deriving different resistance genes in a single genotype which will provide not only complete protection to leaf rust but should be additionally useful to prolong the effective life of the Lr_{24} gene for resistance. The leaf rust resistance of Lr_{24} is so far reported to be universally effective.

ACKNOWLEDGEMENTS

Our gratitude to Dr R.A. McIntosh, University of Sydney for supply of the nucleus seed material; to Drs. S. Nagarajan and S.K. Nayar for supply of inoculum of the races and for help in confirming a few results at the seedling stage.

REFERENCES

Dyck, P.L. and Samborski, D.J. (1974). Inheritance of virulence on Puccinia recondita on alleles at the Lr_2 locus for resistance in wheat, Can. J. Genet. Cytol. 16: 323-332.

Loegering, W.Q. (1959). Model of recording cereal rust data. USDA Intern. Spring Wheat Rust Nursery.

McIntosh, R.A. (1976). Genetics of wheat rusts since Farrer. Farrer Memorial Oration 1976. J. Austral. Inst. Agric. Sci. 42(4): 203-216.

McIntosh, R.A., Dyck, P.L. and Green, G.J. (1977). Inheritance of leaf rust and stem rust resistance in wheat cultivars Agent and Agatha. Aust. J. Agric. Res. 28: 37-45.

Sawhney, R.N. and Goel, L.B. (1981). Race specific interactions between wheat genotypes and Indian cultures of stem rust. Theor. Appl. Genet. 60: 161-166.

Sawhney, R.N., Goel, L.B. and Mathur, H.C. (1982a). Adult plant responses of specific genes resistant to leaf rust against Indian population of leaf rust pathogen. Z. Pflanzenzüchtung, 89: 222-228.

Sawhney, R.N., Goel, L.B. and Mathur, H.C. (1982b). Adult plant responses in wheat of specific genes resistant to Indian populations of the stem rust pathogen. Sabrao J., 14(2): 131-136.

Sawhney, R.N. and Goel, L.B. (1983). Effectiveness of newly described leaf rust resistance genes against Indian cultures of standard races and biotypes of leaf rust in wheat. Wheat Inf. Serv., 56: 34-36.

Sears, E.R. (1973). Agropyron - wheat tranfers induced by homoeologous pairing. Proc. 4th Internat. Wheat Genetics

symposium, Missouri Agr. Exp. Sta. Columbia, No. 191-199.
Stakman, E.C., Stewart, D.M. and Loegering, W.Q. (1962). Identification of Physiological races of Puccinia graminis var. tritici. USDA Agric. Res. Serv. No. E617 (Rev.) 53 pp.

Table 1 - Seedling reactions of host-genotypes with and without Lr_{24} (3Ag translocations) when tested with eight races of leaf rust pathogen.

Genotype	Races								Postulated Lr genes
	12	12B	77	77A	104	104A	104B	162	
3D/Ag#3	0;	0;-1	0;-1	0;	0;-1	0;-1	0;-1	0;	Lr_{24}
3D/Ag#14	0;	0;-1	0;	0;	0;	0;-1	0;	0;	Lr_{24}
TR 380.14	0;	0;	0;-1	0;-1	0;-1	0;-1	4	0;	Lr_1+
TR 380/14*7/3Ag#14	0	0	0	0	0	0	0	0	Lr_{24}+
TR 380.16	0;	0;	4	4	4	4	4	0;	Lr_1
TR 380.16*7/3Ag#3	0	0	0	0	0	0	0	0	Lr_{24}+
TR 548	0;	0;	4	4	4	4	4	0;	Lr_1
TR 548*7/3AG#3	0	0	0	0	0	0	0	0	Lr_{24}+
Condor Sel (WW 31)	4	4	4	4	4	4	4	4	-
Condor Sel*7/Ag#3	0;	0;-1	0;-1	0;	0;-1	0;-1	0;-1	0;	Lr_{24}

Table 2 - Adult plant leaf rust responses of host genotypes with and without 3Ag translocations

Genotype	Rust intensity				
	1983 (summer)	1983-84 (rabi)	1984-85 (rabi)		
	Wellington	Delhi	Delhi	Wellington	Gurdaspur
3D/Ag#3	-	0	TR	TS	0
3D/Ag#14	-	0	0	0	0
TR 380.14	TX	30S	5MR	30S	40S
TR 380/14*7/3Ag#14	0	0	0	0	0
TR 380.16	50X	20S	60S	5S	10S
TR 380.16*7/3Ag#3	0	0	TR	TR	F
TR 548	60S	30S	-	40S	20S
TR 548*7/3AG#3	0	0	-	TS	0
Condor Sel (WW 31)	50S	30S	40S	10S	20S
Condor Sel*7/Ag#3	5X	0	TR	TS	5S

Cereal Rusts Bulletin Vol. 14, Part 1, 1986

ON THE ECOLOGY OF THE BROWN RUST OF COUCH GRASS, PUCCINIA PERSISTENS VAR. PERSISTENS, IN BOHEMIA

BY

Z. URBAN and J. MARKOVA

Department of Cryptogamic Botany, Charles University, Praha, Czechoslovakia

The taxonomy of the brown rust of couch grass and other allied species in Bohemia and Moravia was treated in some previous papers (Ondrackova and Urban 1972, Markova 1976, Markova and Urban 1977). Their ecological and evolutionary characters give evidence of their common origin and that the brown rust of wheat is closely related with them; according to this we proposed following classification: Puccinia persistens Plow. subsp. persistens var. persistens and P. persistens subsp. persistens var. triticina (Eriks.) Urban et Markova.

Beginning in 1977 we made ecological observations concerning the overwintering of the couch grass rust in the neighbourhood of Jicin (75 km NE from Praha) and Praha. At Jicin the locality was a broad grassy field border which was more or less regularly cut from spring to late autumn. At Praha we made observations in some clover and Alfalfa fields.

The origin and evolution of couch grass rust foci depend on the yearly course of biotic and all other environmental conditions. Among the biotic conditions the most serious appears powdery mildew (Erysiphe graminis DC. = Blumeria graminis (DC.)Speer.

Regular observation at Jicin gave evidence that winter periods in 1979 and 1980 were unfavourable for rust overwintering; for a long time there were low temperatures which were very conducive for the rapid mass development of the powdery mildew but suppressive for rust. Temperatures more conducive to rust occurred at the beginning of the winter period 1981 but the first four months of 1982 were very cold with temperatures below the average for many years; at some favourable places and at Jicin the couch grass rust was able to survive but it could not develop massively and spread.

The spring 1983 was very favourable for rusts with respect to temperature and precipitation; the figures of both factors were above the average for many years. Consequently, in the grassy wheat field border (cv. Mironovska 808) at Jicin as early as in May 14 not less than 3 massively infested rust foci were present. A month later, June 18, we collected 7 urediospore samples from cv. Mironovska 808; two of them were identified as Puccinia persistens var. persistens, viz. the brown rust of couch grass.

The urediospores of both rust varieties mentioned can be differentiated as follows:

var. persistens - Yellowish spore wall layer is 1.0 - 1.25(1.5) m thick whereas in

var. triticina - deep yellowish brown spore wall layer is (1.5) 1.75 - 2.0 m thick.

Inoculation experiments were carried out by Ing. P. Bartos, Dr Sci. in the Research Institute for Plant Production, Praha-Ruzyne, with urediospores collected on June 25 from Agropyron repens (L.) P.B. at Jicin. The reaction type on Agropyron repens was middle to high susceptible; one of collected samples produced a resistant type of reaction with sporulation on cv. Little Club (unfortunately cv. Mironovska 808 was not available in the test). More detailed information concerning these observations is published in Czechoslovakian (Urban and Markova 1985).

It seems that this is the first report on the occurrence of the brown rust of couch grass on hexaploid wheat in Middle Europe. This cross infection could be favoured by the new, broadly used recent technology in preparing large amounts of green and stored fodder and thus providing conditions for massive overwintering and spread of the couch grass rust. According to our previous experiments (Ondrackova and Urban 1972, Markova 1976 and unpublished results) Puccinia persistens var. persistens in Czechoslovakia can parasitize diploid and tetraploid wild as well as cultivated wheats and also rye. The rust resistance genes in many hexaploid wheats have their origin in these wild and cultivated wheats in rye. Therefore in the future it is possible that some populations of the couch grass could overcome the resistance of some hexaploid wheat cultivars and cause severe infections.

The recent technology of wheat cultivation and other agricultural products brings serious changes in our civilized country environment. Artificial manure is applied more and more. This is the reason that, on field borders and uncultivated land, exuberant and vigorous vegetation occurs in which the most frequent plant is Agropyron repens. This stubborn weed grows not only on uncultivated places but immediately in fodder plantations (clover and alfalfa fields) and on their border. The mowing machines cut the culms and leaves periodically so that further new leaf blades emerge and provide a substrate for massive urediospore reproduction and spread. Thus the recent methods of fodder management prepares many suitable ecotopes in which couch grass rust can overwinter as uredia or dicaryotic mycelium.

REFERENCES

MARKOVA, J. 1976. K. poznani hnede rzi pyru v CSR.1. Ces. Mykol. 30: 90-105.

MARKOVA, J., URBAN, Z. 1977. K. poznani hnede rzi pyru v CSR.2. Ces. Mykol. 31: 72-80.

ONDRACKOVA, J., URBAN, Z. 1972. K. poznani hnede rzi pyrove, Puccinia perplexans Plow. var. triticina (Eriks.) Urban f.sp. persistens v Cechach. Ces. Mykol. 26: 9-22.

URBAN, Z., MARKOVA, J. 1985. Ekologie rzi pyrove, Puccinia persistens var. persistens, v Cechach. Ces. Mykol. 39: 225-233.

Cereal Rusts Bulletin Vol. 14, Part 1, 1986

VIRULENCE FACTORS OF PUCCINIA GRAMINIS F.SP. TRITICI IDENTIFIED IN ITALY IN 1984 (1).

LUCIANA CORAZZA

Istituto Sperimentale per la Patologia Vegetale, Rome

SUMMARY

In 1984, the environmental conditions favoured stem rust epidemics in Italy. According to the avirulence/virulence formulae of the biotypes identified and the field behaviour of standard differential varieties and isogenic lines, the effectiveness of Sr 21 and Sr 22 derived from Triticum monococcum L. and that conferred by the genes for resistance of T. dicoccum varieties Khapli and Vernal was shown. A less degree of protection (against 50% of isolates) was conferred by Sr 11. Several durum wheat cultivars, including 'Creso' and 'Valnova', demonstrated a good level of resistance to the virulence factors of Puccinia graminis f.sp. tritici, when inoculated at seedling stage with seven biotypes under controlled conditions.

The most widespread cultivars of bread wheat and ten cultivars of barley were shown to be highly susceptible.

Among Agropyron, spp. tested, A. sibiricum had a higher level of resistance to this rust. The other cultivars of grasses tested (Lolium perenne, L. multiflorum, Dactylis glomerata) were resistant, despite the fact that variants of wheat stem rust were repeatedly isolated from their wild relatives.

INTRODUCTION

In 1984, the environmental conditions favoured epidemics of Puccinia graminis Pers. f.sp. tritici Eriks. et Henn. in Italy and many samples of this rust were collected in different agroclimatic conditions, both from durum and bread wheat varieties (Corazza and Basile, 1985).

Since this pathogen showed high variability in recent years as well as a trend to accumulate factors of virulence (Corazza and Basile, 1983), natural populations of wheat stem rust were analysed to identify the most frequent biotypes and for their potential hazard to cultivated cereals.

MATERIALS AND METHODS

Biotypes of the physiologic races most frequent in this year (Corazza and Basile, 1985) were identified and their formulae were elaborated according to their virulence or avirulence reaction in the greenhouse, under standardized conditions, on seedlings of fifteen isogenic and near-isogenic lines, carrying the following genes for resistance : Sr5,Sr6,Sr7b,Sr9a,Sr9b,Sr11,Sr13,Sr14,Sr22,Sr23,Sr25, Sr30,Sr32,SrTt-1,SrTt-2.

(1) Research work supported by CNR, Italy. Special grant I.P.R.A. - Sub project 1, Paper N. 939.

Seven biotypes, namely R. 11 b1, b2, R. 21 b1, b2, b3, R. 34 b1, R. 276 b1, were inoculated on seedlings of twenty-five durum wheat cultivars, thirty-five bread wheat cultivars, ten barley cultivars and several forage grasses, all potential hosts of this rust.

The field response and severity, according to the modified Cobb's scale, were recorded on standard differential varieties, isogenic and near-isogenic lines in three different environmental conditions : Porano(Terni), Monterotondo (Roma), Vitulazio (Caserta). In the field trials were employed isogenic and near-isogenic lines carrying the following genes for resistance: Sr1,Sr5,Sr6,Sr7b,Sr8, Sr9a,Sr9b,Sr9e,Sr9g,Sr10,Sr11,Sr13,Sr14,Sr15,Sr17,Sr22,Sr23,Sr25, Sr26,Sr27,Sr29,Sr30,Sr32,SrTt-1,SrTt-2,SrTmp.

RESULTS AND DISCUSSION

Within the physiologic race 21 six different biotypes were identified (Table 1); in particular, R.21 b 1, isolated from the six-rowed barley 'Ogra', was found to have virulence factors active against all the res-genes tested, except Sr 22. This gene, transferred from Triticum monococcum (Kerber and Dyck, 1973), was effective against all the variants identified during this year.

With respect to the other res-genes, according to the pathogenicity formula of the biotypes identified, Sr11 was effective against 50% of the isolates, while Sr7b, Sr25, Sr32 demonstrated a certain degree of effectiveness towards the most frequent variants of stem rust isolated in 1984.

The analysis of field behaviour of standard differential varieties, isogenic and near-isogenic lines in different environmental conditions (Table 2) showed the high degree of resistance of the T. dicoccum varieties Khapli and Vernal and of the T. monococcum Einkorn with respect to the rust genotypes present within the natural populations.

Also in the field conditions the isogenic line carrying Sr 22 was the only one effective.

It is relevant to note the presence, in the italian population of stem rust, of factors of virulence able to overcome resistance of Sr 26 and Sr 27.

Pathogenicity on Sr 26 (Eagle) was identified in Italy since 1980 (Siniscalco et al., 1981) and, more recently, in 1985. In the same year, in several locations of Italy was noted the presence of factors of virulence able to overcome the Sr 27 resistance, derived from rye (Zitelli et al., 1985). It would be interesting to isolate the biotypes able to attack these genes.

The analysis of seedling reaction, in greenhouse, with respect to seven biotypes identified within four different variants of the pathogen, indicated a wider presence of resistance factors in durum wheat cultivars than in bread wheat cultivars (Table 3). 'Ciano', 'Creso', 'Filippo', 'Sansone', 'Tito' and 'Valnova', among the durum wheat cultivars and 'Concordia' and 'Gisella', among the bread wheats, possessed a good resistance level.

The ten cultivars of barley were highly susceptible (Table 4).

Among the Agropyron spp., A. sibiricum showed a higher level of resistance to this rust. All the other cultivated grasses were resistant to the artificial infection, despite the fact that variants

of wheat stem rust were repeatedly isolated in recent years from their wild relatives (Basile, 1972; Sibilia and Basile, 1959, 1961a, 1961b).

CONCLUSIONS

The analysis carried out in 1984 revealed the presence, in Italian populations of Puccinia graminis f.sp. tritici, of factors of virulence able to multiply on a great number of cultivars.

Some of the most widespread durum wheat cultivars, some of which were recently released, such as 'Creso' and 'Valnova', showed a high level of resistance; nevertheless they were susceptible to some of the biotypes used for the screening. The resistance of the cultivars Karel and Sansone, previously pointed out (Siniscalco et al., 1983), were confirmed.

With respect to the bread wheat cultivars, which are generally more susceptible to this rust than durum wheat varieties (Corazza and Basile, 1984), the most widespread and recently released cultivars were susceptible to the biotypes used for the analysis.

Barley was confirmed as susceptible to this pathogen, which is able to cause damage under field conditions (Corazza, 1984b, 1985).

Genes for resistance derived from Triticum monococcum and T. dicoccum demonstrated to be effective.

The susceptibility of the most widespread cultivars of wheat indicates the need of appropriate approaches to control this highly variable pathogen.

Some of the possible measures of control could be:

- selection of early varieties, in order to 'escape' the infection in the field;
- the avoidance of late sowing, especially in environments more favourable to this rust;
- use of forms of partial resistance (Parlevliet, 1979);
- introduction of genes for resistance derived from wild or related species (Knott and Dvorak, 1976);
- introduction of more genetic diversity in our cultivars, since most of them have similar genetic background (Bozzini, 1984);
- cultivation of multilines, some of which were recently analyzed in Italy (Corazza, 1984a).

ACKNOWLEDGEMENTS

Grateful thanks are expressed to Dr A. McIntosh (Sydney, Australia) and to Dr A.P. Roelfs (Minnesota, U.S.A.) for kindly supplying the seeds of isogenic lines. I am very indebted to Dr P. Tedeschi, Director of Istituto per lo Studio dei problemi agronomici dell'irrigazione nel Mezzogiorno (C.N.R.) and to Dr F. Cannata, Director of Istituto per l'Agroselvicoltura (C.N.R.) for the realization of the field trials in Vitulazio (Caserta) and Porano (Terni) respectively.

LITERATURE CITED

BASILE, R., 1972. Segnalazione di due razze fisiologiche di Puccinia graminis var. tritici identificate da piante di Lolium perenne L. e Avena barbata raccolte nel Lazio durante l'anno 1969. Annali Istituto Sperimentale Patologia Vegetale, 3, 21-23.

BOZZINI, A. 1983. Cos 'e che non va nella granicoltura italiana. L'Informatore Agrario, 48, 28440-28442.

CORAZZA, L. 1984a. Prospettive sull'uso de varieta multilinee di frumento tenero in Italia. L'Informatore Agrario, 10 35, 43-46.

CORAZZA, L. 1984b. Varieta di orzo a confronto per la resistenza alle principali crittogamme parassite. L'Informatore Agrario, 40, 33, 63-66.

CORAZZA, L. 1985. Il comportamento in campo di varieta di orzo nei confronti dei parassiti fungini nel 1984-85. L'Informatore Agrario, 41, 34, 69-71.

CORAZZA, L., R. BASILE 1983. Le ruggini del frumento in Italia nel 1982 ed identificazione di alcune razze fisiologiche di Puccinia recondita Rob. ex Desm. f.sp. tritici Eriks. et Henn. e di Puccinia graminis Pers. f.sp. tritici Eriks. et Henn. Annali Istituto Sperimentale Patologia Vegetale, 8, 39-46.

CORAZZA, L., R. BASILE 1984. Evoluzione razziale della Puccinia graminis Pers. f.sp. tritici Eriks. et Henn. su alcune varieta di frumento tenero e duro coltivate in Italia (1953-1983). Annali Istituto Sperimentale Patologia Vegetale, 9, 141-152.

CORAZZA, L., R. BASILE 1985. Andamento delle ruggini del frumento in Italia nel 1983 e 1984 ed identificazione di alcune razze di Puccinia recondita f.sp. tritici e di Puccinia graminis f.sp tritici. Annali Istituto Sperimentale Patologia Vegetale, 10.

KERBER, E.R., P.L. DYCK 1973. Inheritance of stem rust resistance transferred from diploid wheat (Triticum monococcum) to tetraploid and hexaploid wheat and chromosome location of the gene involved. Canadian Journal genetic Cytology, 15, 397-409.

KNOTT, D.R., J. DVORAK 1976. Alien germplasm as a source of resistance to diseases. Annual Review Phytopathology, 14, 203-222.

PARLEVLIET, J.E. 1979. Components of resistance that reduce the rate of epidemic development. Annual Review of Phytopathology 17, 203-222.

SIBILIA, C., R. BASILE 1959. Graminacee spontanee attaccate da ruggini, raccolte in Italia nel 1959. Bollettino Stazione di Patologia Vegetale, 17, 117-126.

SIBILIA, C., R. BASILE 1961a. Quelques races physiologiques de rouille noire sur graminees spontanees en Italie en 1960. II Coloquio Europeo sobre la roya de les Cereales, Madrid.

SIBILIA, C., R. BASILE, 1961b. Contributo alla conoscenza delle razze fisiologiche di Puccinia graminia var. tritici isolate da Graminacee spontanee raccolte in Italia nel 1961. Bollettino Stazione di Patologia Vegetale, 9, 153-156.

SINISCALCO, A., C. CARIDDI, F. CASULLI, F. TOMMASI, H. PARADIES, V. PIGLIONICA, D. SISTO, A. CICCARONE, R. BASILE, L. CORAZZA and R. NALLI 1981. Risultati delle prove di campo eseguite nel 1979-80 e 1980-81 sul comportamento di frumenti verso ruggini ed altri parassiti. Bollettino informativo no. 7, 105 pp.

SINISCALCO, A., F. TOMMASI, F. CASULLI, 1983. Brevi note sul comportamento di alcuni frumenti duri e teneri nei confronti di sette isolati di Puccinia graminis f.sp. tritici. Phytopathologia Mediterranea, 22, 171-176.

ZITELLI, G., M. PASQUINI, E. BIANCOLATTE, V. CECCHI, M. VALLI, 1985. Risultati delle prove eseguite nel 1984-85 Sul comportamento in campo di frumenti duri e teneri nei confronti delle malattie fungine. L'Informatore Agrario, 37, XL1, 69-78.

TABLE 1 - Biotypes and related avirulence/virulence formulae of some physiologic races of *Puccinia graminis* f.sp. *tritici* isolated in Italy in 1984.

Race	biotype	avirulence/virulence for *Sr* genes
11	b 1	7b,22,25,32/5,6,9a,9b,11,13,14,23,30,Tt-1,Tt-2
11	b 2	7b,9a,22/ 5,6,9b,11,13,14,23,25,30,32,Tt-1,Tt-2
21	b 1	22/5,6,7b,9a,9b,11,13,14,23,25,30,32,Tt-1,Tt-2
21	b 2	11,22/5,6,7b,9a,9b,13,14,23,25,30,32,Tt-1,Tt-2
21	b 3	22/ 5,6,7b,9a,9b,11,13,14,23,25,30,32,Tt-1,Tt-2
21	b 4	11,22,32/5,6,7b,9a,9b,13,14,23,25,30,Tt-1,Tt-2
21	b 5	22,25/5,6,7b,9a,9b,11,13,14,23,30,32,Tt-1,Tt-2
21	b 6	11,13,22,32,Tt-1/5,6,7b,9a,9b,14,23,25,30,Tt-2
34	b 1	22,25,30/5,6,7b,9a,9b,11,13,14,23,32,Tt-1,Tt-2
34	b 2	7b,11,22,25/5,6,9a,9b,13,14,23,30,32,Tt-1,Tt-2
34	b 3	9a,11,22,32/5,6,7b,9b,13,14,23,25,30,Tt-1,Tt-2
34	b 4	7b,9a,11,13,14,22,25,30,Tt-1,Tt-2,32/5,6,9b,23
107	b 1	7b,22,32/5,6,9a,9b,11,13,14,23,25,30,Tt-1,Tt-2
135	b 1	7b,22,25,32,Tt-1,Tt-2/5,6,9a,9b,11,13,14,23,30
277	b 1	11,22,Tt-1/5,6,7b,9a,9b,13,14,23,25,30,32,Tt-2
293	b 1	11,22,32,Tt-1/5,6,7b,9a,9b,13,14,23,25,30,Tt-2

TABLE 2 - Field reaction of standard differential varieties, isogenic and near-isogenic lines carrying known res-genes for Puccinia graminis f.sp. tritici as recorded in three different locations.

Line or variety	gene	location		
		Roma	Caserta	Terni
'Little Club'	SrLC	80VS*	80S	50S
'Marquis'	Sr7b,18,19,20	80VS	80S	40S
'Reliance'	Sr5,Sr16,Sr7b,Sr18	70VS	70VS	50S
'Kota'	Sr7b,18,20,28,+	10MS	70VS	60S
'Arnautka'	Sr9d,+	10MS	70VS	40S
'Mindum'	Sr9d,+	30MS	70VS	10S
'Spelmar'	Sr9d,+	10MS	70VS	80S
'Kubanka'	Sr9g,+	10MS	60S	40S
'Acme'	Sr9g,+	20MS	40MS	10MS
'Einkorn'	Sr21,+	0	0	0
'Vernal'	Sr9c	0	0	0
'Khapli'	Sr7a,13,14,+	0	0	0
Marquis[10] 1.1.7.6.	Sr1	60S	60S	20MS
I Sr 5-Ra (CI 14159)	Sr5	30S	70VS	20MS
I Sr 6-Ra (CI 14163)	Sr6	50S	50S	10MS
Kenya 117 A Marquis[10] 2.1.1.3.	Sr7	40S	50S	20MS
I Sr 7b - Ra (CI 14165)	Sr7b	30S	20MS	30MS
I Sr 8 - Ra (CI 14167)	Sr8	40S	70VS	60S
I Sr 9a - Ra (CI 14169)	Sr9a	70VS	20MS	70VS
W 2691 Sr 9b (CI 17386)	Sr9b	50S	80VS	70VS
Vernstein (W3196)	Sr9e	10MS	50S	40S
II 71 - 331	Sr9g	70VS	80VS	80VS
W 2691 Sr 10 (CI 17388)	Sr10	70VS	80VS	80VS
I Sr 11 - Ra (CI 14164)	Sr11	20MS	20MS	TR
W 2691 Sr 13 (CI 17387)	Sr13	30MS	80VS	30MS
Line A W 3673	Sr14	20MS	80VS	80VS
Sr 15 Line AB	Sr15	30MS	80VS	30MS
Fed x Ren.	Sr17	20MS	70S	10MS
S W Sr 22 T.B.	Sr22	0	20MR	TR
Exchange	Sr23	10MS	80VS	TR
LC Sr 25 Ars	Sr25	10MS	20MS	0
Eagle (PI 365582)	Sr26	10MS	50S	50S
W 2691 Sr 27	Sr27	20MS	70VS	70VS
RL 6046	Sr29	20MS	50S	TR
Bt Sr 30 Wst (PI 442897)	Sr30	10MS	40MS	0
Cns Sr 23 A.s.	Sr32	TR	40MS	0
W 2691 Sr Tt-1 (CI 17385)	SrTt-1	20MS	50MS	40MS
W 2691 Sr Tt-2 (PI 442915)	SrTt-2	10MS	50S	40S
Mi 30	SrTmp	10MS	50S	0

* VS = very susceptible
S = susceptible
MS = moderately susceptible
MR = moderately resistant
TR = trace

TABLE 3 - Susceptibility (S) or resistance (R) of several durum and bread wheat varieties when inoculated with different biotypes of Puccinia graminis f.sp. tritici under standardized controlled conditions at seedling stage.

Races	R 11		R 21			R 34	R 276
biotypes	b1	b2	b1	b2	b3	b1	b1
Durum wheats							
Appulo	S	S	S	S	S	S	S
Athena	R	S	S	S	S	S	S
Berillo	S	S	S	S	S	S	S
Bitia	R	S	S	S	S	S	S
Capeiti 8	S	S	S	S	S	S	S
Capelli	S	S	S	S	S	S	S
Ciano	S	R	R	S	R	R	R
Creso	R	R	R	S	R	S	R
Filippo	R	R	R	R	S	R	R
Gabbiano	R	R	R	R	R	R	R
Grifoni B52	S	S	S	S	S	S	S
Hymera	S	S	S	S	S	S	S
Karel	S	S	S	S	R	S	S
Kid	R	R	R	R	R	R	S
Isa	R	S	S	S	S	S	S
Murgia	S	R	S	S	S	S	S
Orsini	R	R	S	R	R	R	S
Polesine	R	S	S	R	R	S	S
Produra	R	R	S	S	S	S	S
Sansone	R	R	R	R	R	R	R
Tito	R	S	R	R	R	R	S
Trinakria	S	R	S	S	S	S	S
Valforte	S	S	R	R	R	R	S
Valgerardo	S	S	R	R	S	R	S
Valnova	S	R	R	R	S	R	R

continued.

PLANT BREEDING INSTITUTE – CASTLE HILL LIBRARY

Table 3 continued

Races	R 11		R 21			R 34	R 276
biotypes	b1	b2	b1	b2	b3	b1	b1
Bread wheats							
Adria	S	S	S	S	S	S	S
Aurelio	S	S	S	S	S	S	S
Abano	S	S	S	S	S	S	S
Amika	S	S	S	S	S	S	S
Centauro	S	S	S	R/S	S	R/S	S
Chiarano	S	S	S	S	S	S	S
Claudia	S	S	S	S	S	S	S
Concordia	R/S	S	R/S	R/S	R/S	R/S	R/S
Costantino	S	S	S	S	S	S	S
David	S	S	S	S	S	S	S
Etruria	S	S	S	S	S	S	S
Gala	S	S	R/S	R/S	R/S	S	S
Gallo	S	S	S	S	S	S	S
Gemini	S	S	S	S	S	S	S
Gisella	R/S	R/S	R/S	S	S	R/S	R/S
Gladio	S	S	S	S	S	S	S
Granarolo	S	S	S	S	S	S	S
Iris	S	R/S	S	S	S	R/S	S
Irnerio	S	S	S	S	S	S	S
Lario	S	S	S	S	S	S	S
Leoprado	S	S	S	S	S	S	S
Livio	S	S	S	S	S	S	S
Loreto	S	S	S	S	S	S	S
Manital	S	S	S	S	S	S	S
Mec	S	S	S	S	S	S	S
Oderzo	S	S	S	S	S	S	S
Orso	S	S	S	S	S	S	S
Pandas	S	S	S	S	S	S	S
Salgemma	S	S	S	S	S	S	S
Saliente	S	S	S	S	S	S	S
Salmone	S	S	S	S	S	S	S
Saul	S	S	S	S	S	S	S
Tivoli	S	S	S	S	S	S	S
Tommaso	S	S	S	S	S	S	S
Valle d'Oro	S	S	S	S	S	S	S

TABLE 4 - Susceptibility (S) or resistance (R) of barley and forage grasses at seedling stage under standardized controlled conditions, to biotypes of Puccinia graminis f.sp. tritici.

Races	R 11		R 21			R 34	R 276
biotypes	b1	b2	b1	b2	b3	b1	b1
Two-rowed barleys							
Alpha	S	S	S	S	S	S	S
Aramir	S	S	S	S	S	S	S
Arda	S	S	S	S	S	S	S
Havila	S	S	S	S	S	S	S
Igri	S	S	S	S	S	S	S
Six-rowed barleys							
Barberousse	S	S	S	S	S	S	S
Eldorado	S	S	S	S	S	S	S
Gerbel	S	S	S	S	S	S	S
Robur	S	S	S	S	S	S	S
Thibaut	S	S	S	S	S	S	S
Forage grasses							
Agropyron sibiricum	S	S	R	R	R	R	-
Agropyron elongatum (var. Large)	S	S	S	S	S	S	-
Agropyron desertorum	S	S	S	S	S	S	-
Lolium perenne (var. Trani)	R	R	R	R	R	R	-
Lolium perenne (var. Mirvar)	R	R	R	R	R	R	-
Lolium multiflorum (var. Prego)	R	R	R	R	R	R	-
Lolium multiflorum (var. Turgo)	R	R	R	R	R	R	-
Dactylis glomerata (var. Jesper)	R	R	R	R	R	R	-

Cereal Rusts Bulletin Vol. 14, Part 1, 1986

OBITUARY

Professor Irvine A. Watson, 1914-1986

Emeritus Professor Irvine A. Watson, distinguished for research on pathogenic variation in wheat rust fungi and for the breeding of rust resistant varieties of wheat, died on 1 March 1986.

He was born in 1914 and grew up on the family property near Parkes, New South Wales. He was educated at Hurlstone Agricultural High School, and entered the University of Sydney in 1933. He graduated Bachelor of Science in Agriculture with First Class Honours in 1938 and was awarded the Thomas Lawrence Pawlett Scholarship by the University of Sydney for PhD studies at the University of Minnesota. His PhD on genetic aspects of resistance to Puccinia graminis f.sp. tritici was awarded in 1941.

Watson was appointed as an Assistant Lecturer in the Unversity of Sydney in 1938. He was promoted to Lecturer, then Senior Lecturer and, in 1955, to Associate Professor of Genetics and Plant Breeding. In 1962 he was appointed to the Chair of Agricultural Botany, a position which he held until his retirement in 1977. Watson also held the appointment of Director of the Plant Breeding Institute of the University of Sydney (1974-1977).

Watson's research expanded upon the studies of his predecessor, Professor W.L. Waterhouse. Watson aimed to understand the biology and genetic variability of wheat rust pathogens and to apply this knowledge in the production of rust resistant wheat cultivars. He began before Flor revealed the inheritance of pathogenicity in the flax rust fungus and proposed the gene:for:gene hypothesis for pathogen/plant relationships. Watson's research on the stem rust pathogen established the roles of mutation and somatic hybridization as mechanisms of pathogenic variation in Australia. His work is documented in approximately 60 research papers, many of which appeared in the Proceedings of the Linnean Society of NSW.

Watson realised the need for continual and comprehensive monitoring of variation in the pathogen population by means of pathotype surveys. Because the only genetic markers for use in epidemiological and population studies were those relating to pathogenicity, he believed in monitoring pathogenicity on the maximum number of host differentials. He realised that only some of the variation was relevant to the resistance genes being deployed in commercial cultivars. The resulting knowledge of pathogenicity was then used to record the spread of new pathotypes throughtout Australasia. Unique systems of pathotype designation were employed. Using the survey procedures, new variants were identified as putative mutants from pre-existing pathotypes, as somatic hybrids and, rarely, as introductions from outside the geographical region. The last clearly documented instance of an introduced variant of P. graminis tritici occurred in 1968. The origin of this variant was deduced to have been southern Africa on the bases of knowledge of patterns of pathogenicity, comparisons of cultures and meteorology. Watson believed that a global cataloguing of pathogenicity phenotypes would provide a data base for epidemiological studies and be of great value in selecting the combination in wheat of appropriate resistance genes

for particular geographical areas. The initial steps in obtaining the required information were undertaken in the early 1970s with the International Gene Virulence Survey for P. graminis tritici, the results of which were published by his colleague N.H. Luig in 1983.

The second aspect of Watson's research was his ability to apply his knowledge of pathology to the breeding of hard prime quality and rust resistant bread wheats. Gabo, released in 1945, was undoubtedly the most successful wheat produced in collaboration with Professor Waterhouse; others were Kendee (1946), Saga (1951) and Koda (1955). Gamenya (1960) and Mengavi (1960) were backcross derivatives of Gabo. With the introduction of the system of wheat research levies paid by producers and matching funding from government in the late 1950s, Watson began to guide the development of the wheat rust research and wheat breeding teams located at Castle Hill and Narrabri, respectively, as separate sections of the Plant Breeding Institute (PBI) which he established in 1974. The group of cultivars, Mendos (1964), Gamut (1965), Timgalen (1967), Gatcher (1969), Songlen (1975), Timson (1975) and Shortim (1977) were produced in collaboration with the team at Narrabri. Recently released PBI wheat cultivars, Sunkota (1981), Suneca (1982) and Sunstar (1983) must be attributed, in part, to him.

Watson served for many years on both the Wheat Industry Research Committee and the Wheat Industry Research Council. His advice was much sought by rural industries in Australia.

Many honours were conferred upon Irvine Watson. They included Commander of the Most Excellent Order of the British Empire (1977), Farrer Memorial Medal (1958), E.C. Stakman Medal of the University of Minnesota (1966), Commemorative Medal of the International Maize and Wheat Improvement Centre (1971), and the James Cook Medal of Contribution to Human Welfare (1975). He was a Fellow of many learned Societies: the Australian Institute of Agricultural Science, the Australian Academy of Science, Foundation Fellow of the Australian Academy of Technological Sciences, and Foreign Member of the Soviet Academy of Agricultural Sciences. A measure of the high esteem of the Faculty of Agriculture, University of Sydney, was the award to Professor Watson of the degree of Doctor of Science in Agriculture in honoris causa, one of only two such awards ever to have been made.

Professor Watson was a gentleman in every meaning of the word and he will be remembered with respect and with affection. He is survived by his wife, Loma, and a son and two daughters.