

THE EUROPEAN MEDITERRANEAN CEREAL RUSTS FOUNDATION
PUBLISHED BY

EDITED BY N. H. CHAMBERLAIN

VOLUME 12 PART 1 1984

CEREAL RUSTS BULLETIN

PLANT BREEDING INSTITUTE - CASTLE HILL
LEICESTER

5/10

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VIRULENCE OF Puccinia recondita ON WHEAT IN PAKISTAN

BY

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SUMMARY

Fifty three isolates of Puccinia recondita Rob. ex. Desm. f. sp. tritici were tested on 27 backcross lines and hosts, each near isogenic for resistance. Host lines carrying genes Lr19, Lr24, Lr28 were resistant to all the isolates.

High virulence on the host genes Lr16, Lr2c, Lr1, Lr14a and Lr18 was probably due to the presence of these genes singly or in combinations in most of the wheat cultivars commercially grown in Pakistan. A possible influence of directional selection in the rust pathogen was envisaged to overcome resistance of these genes.

The high proportion of parasite cultures showing an increased frequency in virulence on most of the other genes for resistance, used in the study, could be due to an accumulation of unnecessary genes for virulence carried by P. recondita f. sp. tritici populations prevalent in Pakistan. An increase in the frequency of virulence on host gene Lr9 is attributed to a change in the occurrence of virulence on this gene in the last few years.

INTRODUCTION

Leaf rust of wheat (Triticum aestivum L. em. Thell.) caused by Puccinia recondita Rob. ex. Desm. f. sp. tritici, is economically the most important disease on spring wheat cultivars predominantly grown in Pakistan. Extensive acreages of commercial wheats, planted with susceptible

Field isolates of *P.recondita* f. sp. *tritici* from several present and past commercial wheat cultivars and some old types. Fifty three pure isolates of *P.recondita* were established and increased in the greenhouse on a susceptible cultivar 'Morocco' W1103, using techniques described by Browder (1971). The isolates were stored in the liquid nitrogen tank (Minnesota Valley engineering company, St. Paul, model BT 31) for use when required. Sets consisting of 5 to 10 seeds of each of 27 single gene lines and a susceptible check were planted in 22.5 cm clay pots in the greenhouse. The 27 backcross lines, each near isogenic for low reaction to *P.recondita* f. sp. *tritici* and kindly supplied by Prof. Dr. Glen D. Stalter of the North Dakota State University, Fargo, U.S.A.; carried the single genes Lr 1, Lr 2a, Lr 2b, Lr 2c, Lr 3, Lr 3ka, Lr 9, Lr 10, Lr 11, Lr 14a, Lr 14b, Lr 15, Lr 16, Lr 17, Lr 18, Lr 19, Lr 20, Lr 21, Lr 23, Lr 24, (as 'Agent', CI 13523), Lr 25 (as

MATERIALS AND METHODS

cultivars were responsible for the 1978 leaf rust epidemic in Pakistan. The identification of the physiologic races of *P.recondita* f. sp. *tritici*, through the use of an internationally accepted set of standard differential cultivars (Johnston & Mains, 1932), has not been found to provide the information needed for practical utilization in the wheat breeding programmes. Therefore, emphasis has been focussed on the use of single gene lines in the wheat breeding programmes by several workers (Samborski, 1968; Loegering & Browder, 1971; Browder, 1980; Stalter et al, 1982). It was therefore considered necessary to use single gene lines for assaying the virulence pattern demonstrated by the populations of *P.recondita* f. sp. *tritici*, prevalent in Pakistan. Such information on the virulence data could provide knowledge about the effective host genes, and their usefulness in wheat breeding programmes.

'Transec', CI 14189), Lr 27, Lr 28, Lr 29, Lr 30 ('Terenzio', RL 6049) and Lr 31 (as 'Sabieki 12') respectively. Inoculation techniques described by Browder (1971), were used. Each inoculated set was sprayed with 1 ml Tween 20 (Polyoxyethylene Sorbitan monolaurate, ICI, inc.), in 99 ml water and incubated in a growth room at 19±2 C for 24 h at approximately 100% relative humidity. At the end of the incubation period, the inoculated sets were moved to the greenhouse for rust to develop. Observations on the development of rust were made 10 to 12 days later following the scale adopted by Johnston & Mains (1932). Isolates of *P.recondita* f.sp. *tritici* producing resistant infection types (0, 1 or 2) were classified as avirulent while those producing susceptible infection types (3 and 4) as virulent. The frequency of each corresponding gene for virulence in the parasite population was determined.

RESULTS AND DISCUSSION

The 53 isolates of *P.recondita* f. sp. *tritici* demonstrated a range of virulence. The frequency of virulence was high on most of the Lr genes (table 1). However, none of the cultures tested in 1982, could attack host lines carrying genes Lr 19, Lr 24 and Lr 28 and only one isolate could attack gene Lr 25.

Behaviour of the host genes Lr 11, Lr 15, Lr 25, Lr 27, Lr 28, Lr 29, Lr 30 and Lr 31, against the populations of *P.recondita* f. sp. *tritici* prevalent in Pakistan, is reported for the first time.

High virulence of the parasite cultures for the host genes Lr 16, Lr 2c, Lr 1, Lr 14b, Lr 20, Lr 14a and Lr 18 is probably due to the presence of these genes, singly or in combination, in most of the existing commercial wheat cultivars (pers. comm.). Browder & Eversmeyer (1977) also observed that high frequency of virulence in the parasite population for lines with specific genes for resistance may indicate the presence of those specific host genes in the commercially grown cultivars. High virulence of the parasite cultures on lines with specific genes for resistance, as

found in this study, also suggests a tendency for directional selection in the pathogen, in overcoming the resistance conferred by these genes in the commercial cultivars of Pakistan. Failure of the parasite cultures to attack host lines with genes Lr 19, Lr 24 and Lr 28, demonstrates the complete effectiveness of these genes against the existing populations of *P.recondita* f. sp. *tritici*, prevalent in Pakistan. Almost no virulence on Lr 25 and the ability of relatively few parasite cultures to attack gene Lr 29, also makes both of these genes effective. Therefore, these five genes should be considered useful for incorporating effective resistance in the future wheat cultivars of Pakistan. In addition, adult plant resistance of lines with genes Lr 19, Lr 24, Lr 25 and Lr 28, as observed in Pakistan, further signifies the critical value of these genes in seedling plus adult plant resistance incorporation in the breeding programmes.

Similar information on the effectiveness of some of these genes has been also reported by different workers. Barcello & Sello (Pers. comm.), have reported on the effectiveness of host genes Lr 19, Lr 24 and Lr 25 in Brazil. Samborski (1980) and Stalter et al (1982) also indicate that resistance conferred by Lr 19 is effective in North America. Finally, gene Lr 28 has been also found to confer resistance against the prevalent races of leaf rust in Australia (McIntosh, Pers.comm.).

A small proportion of the parasite cultures in the present study, were found to attack host gene Lr 9, which implies a change taking place towards an increase in virulence on this gene in Pakistan. Recent observations in the field and seedling tests, supported by previous information (Smith & Kilpatrick, 1978) confirms the present findings. Occurrence of virulence demonstrated by a majority of the isolates of *P.recondita* f. sp. *tritici* on most of the other genes used in the study (table 1), could be due to an accumulation of unnecessary genes for virulence operating in the parasite populations of Pakistan. In such a situation, the strategy proposed by Mackey (1981) on gene accumulation, in the wheat cultivars rather than gene diversification,

could be considered promising in improving the wheat breeding programmes for rust resistance in Pakistan.

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Table 1: Virulence of 53 isolates of *Puccinia recondita* f. sp. *tritici* on backcross lines containing single genes for resistance to wheat leaf rust in Pakistan during 1982.

Resis- No. of virulent isolates	Total Percent		Kara- Bahawal- Faisal- Islam- Murree			
	virulent isolates	isolates	chi	pur	abad	abad
Lr 16	6	96.2	11	51	22	3
Lr 2c	4	92.5	10	49	23	3
Lr 1	5	92.5	10	49	22	3
Lr 14b	5	90.6	10	48	22	3
Lr 20	6	90.6	10	48	20	3
Lr 14a	5	86.8	10	46	21	3
Lr 17	6	86.8	10	46	19	3
Lr 23	4	86.8	9	46	22	3
Lr 18	5	84.9	7	45	22	3
Lr 2b	5	83.0	8	44	21	2
Lr 30	5	77.4	8	41	18	2
Lr 21	5	77.4	10	41	16	3
Lr 11	4	75.5	10	40	19	1
Lr 2a	5	73.6	5	39	19	2
Lr 10	3	69.8	10	37	18	2
Lr 31	3	56.6	3	30	15	3
Lr 3	4	52.8	2	28	12	2
Lr 3ka	3	47.2	2	25	12	1
Lr 15	5	45.3	1	24	12	2
Lr 27	1	43.4	6	23	10	2
Lr 9	2	26.4	2	14	7	1
Lr 29	0	9.4	0	5	2	1
Lr 25	0	1.9	0	1	0	0
Lr 19	0	0.0	0	0	0	0
Lr 24	0	0.0	0	0	0	0
Lr 28	0	0.0	0	0	0	0

RESISTANCE OF OATS TO CROWN RUST IN CENTRAL EUROPE

BY

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INTRODUCTION

Present day experience with cultivation of cereals indicates that high and stable grain yields can be achieved only in those cultivars in which economically important characters and disease resistance are combined. In oats, in particular, crown rust and stem rust have been shown to be of importance in central Europe (Sebesta, 1971, Sebesta and Kryzaneck 1975, Sebesta et al. 1972). The paper deals with pathogenic variation in crown rust of oats in central Europe, actual and potential donors of resistance and current strategies used in rust resistance breeding of oats in Czechoslovakia.

MATERIALS AND METHODS

Crown rust samples were collected from European Oat Disease Nursery (EODN) (Sebesta and Zwatz, 1980); farm fields of cultivated oats; wild oats (*Avena fatua* L.). The virulence analyses of crown rust on standard differentials (Simons and Michel, 1964) and/or PC-isolines (Fleischmann and Baker 1971, Simons et al. 1978, Sebesta and Harder 1983) with *A. sterilis* L. resistance genes were carried out in the seedling stage. On the PC-isolines, the rust isolates were differentiated into virulence/avirulence combinations using the formula method of Green (1965). As a criterion of the breeding importance, the percent of the total number of isolates from each country which showed

According to the reactions of nine \overline{PC} -isolines of cv. Pendek, the standard races might be grouped into 17 pathotypes, possessing none or up to five virulence genes in relation to $\overline{A. sterilis}$ resistance genes (Table 2). In the years 1977-1979, in Austria, Czechoslovakia and Poland using 12 \overline{PC} -isolines 13, 22 and 18 virulence combinations were isolated respectively. In 1980, in Austria and Czechoslovakia, using 14 \overline{PC} -isolines, 7 and 12 virulence

are of continuing great importance. For resistance breeding, combinations of the resistance in Landhafer and Victoria, incorporated into cvs. Dodge and Garland (Clinton x Hawkeye-Victoria) and presently being transferred into several Czechoslovak lines of oats, $\overline{byzantina}$ was overcome by 8 races.

Of the standard resistance types, the most effective were $\overline{Trispernia}$, C.I.7008 ($\overline{A. byzantina}$), Bondvic, C.I.7009 ($\overline{A. sativa}$), Landhafer, C.I.7005 ($\overline{A. byzantina}$) and Santa Fe, C.I.7006 ($\overline{A. byzantina}$), being attacked only by three or four virulent races. The resistance of Victoria, C.I.7002 ($\overline{A. byzantina}$) was overcome by 8 races.

Of the standard resistance types, the most effective were $\overline{Trispernia}$, C.I.7008 ($\overline{A. byzantina}$), Bondvic, C.I.7009 ($\overline{A. sativa}$), Landhafer, C.I.7005 ($\overline{A. byzantina}$) and Santa Fe, C.I.7006 ($\overline{A. byzantina}$), being attacked only by three or four virulent races. The resistance of Victoria, C.I.7002 ($\overline{A. byzantina}$) was overcome by 8 races. inoculum at least cannot be excluded. importance in the European context as partial exchange of that have occurred in Israel (Dinor, 1973), may be of in Poland (Mazaraki, 1977). Also the large number of races standard differentials. Similarly, high variation was found virulence in crown rust in central Europe based on the more common than the others. There is a high variation of races were identified and races 228, 231, 240 and 265 were during this period. In Austria, in the years 1970-1976, 10 standard races of $\overline{P. coronata avenae}$ were identified (Table 1). In Czechoslovakia, races 228, 239, 240 and 265 prevailed in Czechoslovakia and Austria in the years 1965-76, 25

RESULTS AND DISCUSSION

Investigations of inheritance of resistance in the chosen oats were conducted in both seedling and adult plant stages by methods described (Sebesta 1977, 1979). Harder 1983). virulence on each of the \overline{PC} -gene lines was taken (Sebesta and

combinations were isolated, respectively (Sebesta and Harder, 1983). In 1981, using 18 Pc resistance genes of *A. sterilis*, two virulence combinations were isolated from the GDR crown rust population that possessed virulence on lines carrying genes Pc 35, Pc 38, Pc 40, Pc 45, Pc 47, Pc 48, Pc 54, Pc 62 and Pc 63.

As indicated in Table 3, resistance genes Pc 39, Pc 48, Pc 50 and Pc 55 were shown to be the most effective in Europe.

In addition, genes Pc 58 and Pc 59 were indicated in a limited number of tests to be highly effective against Austrian, Czechoslovak, Lithuanian, Polish and Yugoslav isolates of oat crown rust. Gene Pc 61 was overcome only sporadically by isolates from Austria, Czechoslovakia and Poland. Gene Pc 38 was only moderately effective, except that it seemed to be of potential use in the Federal Republic of Germany, Switzerland, southern Italy or Yugoslavia (Sebesta and Harder 1983). Gene Pc 39 was widely effective with the exception of moderate virulence in Italy and Yugoslavia. Up to now, no strains of crown rust have been isolated that overcome the Pc 38 + Pc 39 gene combination (Sebesta and Harder 1983, Sebesta 1975, 1977, 1979, Sebesta and Zhukova 1980).

The strategy of incorporating multigenic resistance has been accepted in breeding for resistance to both oat crown and stem rusts (Sebesta 1979). For crown rust resistance breeding, the type of resistance of cvs. Garland and Dodge seem to be of long term great importance. This resistance was transferred into several Czechoslovak advanced yielding lines of oats that at the present time are intensively used in breeding programmes. The resistance of Garland or Dodge cvs. has been effective against all the races with the exception of race 264. Our genetic analyses indicated that cvs. Garland (Dodge) contain at least three genes for crown rust resistance.

As demonstrated, these genes are non-allelic with Pc 39 and Pc 50 genes thus enlarging their effectiveness against all of strains of *P. coronata avenae* in central Europe that have been identified up to now.

- It is assumed that in the near future the combinations of the other highly effective \overline{Pc} genes as well as the genes newly transferred as well as the genes newly transferred from $\overline{A. sterilis}$ (Table 4) will be widely used in resistance breeding (Sebesta et al. 1982).
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Table 1

The incidence of crown rust in Czechoslovakia and Austria in the years 1965 to 1976 (Figures express the number of localities at which a race was isolated, + = an occurrence only is noted).

Race	Origin	63	66	67	68	69	70	71	72	73	74	75	76
201	CS	1	1	1	1	1	1	1	1	2	3		
202	CS	1	1	1	1	1	1	1	1	2	3		
203	CS			1									
211	CS				4					2			
213	CS				1								
214(?)	CS		1	1	1								
216	CS			1	2								
228	A												
228	CS		10	3	5	4	2	7	4	9	3	4	1
229	CS		3	2	4	2	1	2		1	1	1	1
230	G									+	2	1	1
230	CS									+	2	1	1
231	A	1	7	3	1	5	3	9	1	2	3	+	3
231	CS												
232	CS												
234	A	1											
234	CS												
235	A												
235	CS												
235	A			3			5						
238	A			2									
238	CS												
239	A	4	6	6	6	6	10	2	2	2	1	7	2
239	CS												
240	A												
240	CS	5	15	5	9	6	13	1	1	6	1	1	2
259	CS												
263	A												
263	CS												
264	CS												
265	A												
265	CS												
274	CS		3	2	7	11			21	3	2	4	2
282	CS	1											
294	A												
294	CS												
CS1	CS												

A = Race isolated from the Austrian population
 CS = Race isolated from the Czechoslovak population
 G = Race isolated from the Greek population

Table 2

Virulence genes in the central European populations of *P. coronata* Avenue in relation to the nine genes transferred from *a. sterilis* L.

Pathotype	Race	Virulence gene combination	Number of virulence genes
1	228/C.4		0
2	228/C.2		2
	228/C.3		1
	229	VPC 35	1
	239/C.1		1
	239/C.3		1
	240/C.1		1
3	228/C.1	VPC38	1
	239/C.2		1
4	232	VPC 35, VPC 38	2
	240/C.2		2
5	211	VPC 45, VPC 47	2
6	235	VPC 35, VPC 38, VPC 45	3
7	213	VPC 40, VPC 45, VPC 47	3
8	265/O.1	VPC 35, VPC 45, VPC 46, VPC 47	4
9	214(?)	VPC 35, VPC 45, VPC 47	4
		VPC 48	4
10	265/C.2	VPC 45, VPC 47, VPC 47, VPC 48	4
11	234	VPC 45, VPC 46, VPC 47, VPC 48	4
12	202	VPC 40, VPC 45, VPC 46	4
	264		4
	274	VPC 47	4
	294		4
13	201/C.2	VPC 35, VPC 40, VPC 45, VPC 47	4
14	230	VPC 40, VPC 45, VPC 47	4
	259		4
15	282	VPC 35, VPC 45, VPC 46, VPC 47, VPC 48	4
16	201/C.1	VPC 35, VPC 40, VPC 45, VPC 46, VPC 47	5
17	238/C.2	VPC 35, VPC 40, VPC 45, VPC 47, VPC 48	5

Percentage of isolates of Puccinia Coronata avenae with virulence on lines of Avena sativa with specific genes (Pc) for crown rust resistance.

Source: Sebesta and Harder (1983)

Host resistance (Pc) gene	COUNTRY OR REGION*										
	A	CS	D	DK	I/S	P	PL	SU/L	SU	TG	YU
avirulent	2.5	5.8	23.0	3.4	0.0	8.9	0.0	0.0	5.3	21.4	0.0
Pc 35 ^b	42.5	40.6	7.6	41.4	77.8	57.8	17.2	38.5	89.5	0.0	14.3
Pc 38 ^b	35.0	27.5	3.8	34.5	0.0	35.6	48.3	69.2	26.3	0.0	0.0
Pc 39 ^b	0.0	8.6	0.0	0.0	22.2	8.9	0.0	0.0	0.0	0.0	14.2
Pc 40 ^b	40.0	23.2	50.0	31.0	77.8	31.1	62.1	30.8	42.1	35.7	100.0
Pc 45 ^b	30.0	33.3	17.3	13.8	100.0	26.7	65.5	0.0	31.6	42.8	100.0
Pc 46 ^b	22.5	23.2	7.7	6.9	66.7	24.4	65.5	0.0	0.0	21.4	85.7
Pc 47 ^b	32.5	27.5	38.5	0.0	100.0	20.0	96.6	0.0	31.6	35.7	100.0
Pc 48 ^b	2.5	26.1	0.0	6.9	22.2	8.9	3.4	0.0	0.0	0.0	0.0
Pc 50 ^b	0.0	0.0	1.9	3.4	0.0	0.0	37.9	23.0	0.0	7.1	0.0
Pc 54 ^b	20.0	28.9	9.6	0.0	88.9	24.4	89.7	0.0	15.8	21.4	71.4
Pc 55 ^b	5.0	0.0	0.0	0.0	0.0	6.7	0.0	7.7	0.0	0.0	25.6
Pc 56 ^b	0.0	5.8	5.8	20.7	11.1	20.7	75.9	38.5	15.8	0.0	0.0
Pc 58 ^c	-	-	0.0	0.0	0.0	-	0.0	-	-	0.0	0.0
Pc 59 ^c	-	-	0.0	0.0	0.0	-	0.0	-	-	0.0	-
Pc 60 ^c	-	-	5.8	0.0	66.7	-	10.3	-	-	0.0	-
Pc 61 ^c	-	-	7.7	0.0	66.7	-	10.3	-	-	0.0	-
Pc 62 ^c	0.0	0.0	11.5	0.0	0.0	0.0	62.1	-	-	28.6	-
Pc 63 ^c	50.0	34.8	3.8	31.0	0.0	70.0	0.0	-	-	0.0	-

* Austria (A), Czechoslovakia (CS), Fed. Rep. Germany (D), Denmark (DK), Italy/South (I/S), Poland (P), Portugal (PL), Soviet Union/Lithuania (SU/L), Soviet Union/various regions (SU), Switzerland (TG), Yugoslavia (YU).

^b - data from A, CS are from 1977-1980, P from 1977, 1978, 1980, SU/L, YU from 1979, SU from 1978, D, DK, I, PL, TG from 1980.

^c - data are from 1980.

Oat species with resistance to crown rust revealed in screening tests.

* resistant also to oat powdery mildew

Oat species	Source
A. ludoviciana Dur.	France - Poland
A. ludoviciana Dur.	Iran - Poland
A. ludoviciana Dur.	Israel - Poland
A. ludoviciana Dur.	Greece - Poland
A. macrocarpa Koench.	Portugal - Poland
A. sterilis L.	Greece - Poland
A. sterilis L. CAV 1094	Iraq - Poland
A. sterilis L. CAV 1964	Algeria - Poland
A. sterilis L. CAV 1986	Algeria - Poland
A. sterilis L. CAV 1993	Crete - Poland
A. sterilis L. CAV 2648*	Algeria - Poland
A. sterilis L. CAV 2669	Algeria - Poland
A. sterilis L. CAV 2673	Poland
A. strigosa Schreb., Miestnyj*	Poland
A. strigosa Schreb., glabrata*	USA - Poland
A. sterilis CAV 1339 K 503	USSR (Leningrad)
A. sterilis L. CAV 1340 K 504	USSR (Leningrad)
A. sterilis L. CAV 1438 K 553	USSR (Leningrad)
A. sterilis L. CAV 1445 K 557	USSR (Leningrad)
A. sterilis L. CAV 1959 K 648	USSR (Leningrad)
A. sterilis L. CAV 1979 K 657	USSR (Leningrad)
A. sterilis L. CAV 2946 K 685	USSR (Leningrad)
A. sterilis L. CAV 3150 K 767	USSR (Leningrad)

At present, in breeding programmes, attention is being given to the use of non-specific resistance of hosts against pathogens, especially where the use of specific resistance is limited. During ontogenetic development most intervarietal variability of partial resistance is attained by the young flag leaf (Parlevliet, 1975; Parlevliet and Van Omeron, 1975). In field evaluations it is necessary to make a range of observations in order to understand the relationship

INTRODUCTION

The number of developed uredia of brown rust of barley, *Puccinia hordei* Oth was assessed at 3 and 4-day intervals in a selected set of ten Czechoslovak and Dutch spring barley cultivars. The induced epidemic of the pathogen was evaluated on flag leaves in field conditions. The criterion for cultivar resistance evaluation was the area under disease progress curve (AUDPC) computed by two different methods (Bevington, 1969, Wilcoxson et al., 1975). The use of both methods is possible in breeding material evaluation. The method by Wilcoxson et al. (1975) was simple, not demanding tedious mathematical elaboration, and was shown to be more precise than the one by Bevington (1969).

SUMMARY

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BY

COMPARISON OF TWO METHODS FOR COMPUTING AREA
UNDER DISEASE PROGRESS CURVE (AUDPC)

between host and pathogen as pointed out by Van der Plank (1963). If we know the development of a disease, it is possible to calculate the AUDPC. In such a way it is possible to quantify resistance essential for further use of the material in breeding programmes.

MATERIALS AND METHODS

In 1980 and 1981 the infection of brown rust of barley, (*Puccinia hordei*) was recorded on inoculated field plots of 10 selected Czechoslovak and Dutch spring barley cultivars. Each plot was 3 - 75cm long rows. In order to reduce interplot interference the barley line CB-S 119, with specific resistance to barley brown rust conditioned by the Pa3-gene, was sown between the plots. Each cultivar was replicated four times in a completely randomized block. Spring barley Koral with resistance to powdery mildew (MAL3) and high susceptibility to brown rust, was sown around the experiment and inoculated using water-uredospore suspension of a local barley brown rust population at the beginning of tillering. At earing a set of 3 uniformly developed stems was selected in each cultivar. The level of barley rust infection was thus assessed on 112 flag leaves by counting uredia. Assessments on flag leaves of the labelled stems was performed at 3 and 4-day intervals from the first appearance of uredia to ripening. The total quantity of uredia was calculated and expressed on leaf area unity.

Cultivar resistance was characterized by computing AUDPC. Two methods were used:

1. Equilibration of experimentally determined points by Bevington (1969) by means of curve equation

$$(1) \quad y = a \cdot b^x$$

with following computation of area (A) defined by equilibrated curve of disease progress and by x axis. This was accomplished by integration of equation (1) with a formula, as follows:

$$(2) \quad A = a \cdot b^x = a \cdot \log e (b^x)^n - b^2 o) \quad \log b$$

Absolute and relative values of both years individually, and average values of the two years, computed by the above methods were compared using Wilcoxon's rank test. In view of the fact, that the determined data are equilibrated by the Bevington's method, (1969), whereas the second method adds up the truly measured values, the method by Wilcoxon et al. was taken as the base for comparison. Both positive and negative differences were determined in the area values computed by Bevington but these differences were in all cases insignificant. For that reason, only tables for average values of both years are given (tables 1 and 2), along with results of individual years as additional information. Results of both methods were subjected to variance analysis for bi-factorial experiment from which high significance for factor "cultivar" followed (at $\alpha = 0.01$, tables 3 and 4). Average area values under disease progress curve of

RESULTS

Results of evaluation by both methods are interpreted by unity of leaf infection in time ($u \cdot cm^{-2} \cdot d^{-1}$).

$$A = \frac{1}{k} \int_t^{\frac{1}{2}} (s_i + s_{i-1}) \quad (4)$$

resulting form of equation would be:
 were multiplied by time (t) where t is time interval. The (3) with the first method, the individual time intervals in order to be able to compare results using equation

s_i - infection value at the end of respective time interval
 s_{i-1} - infection value at the beginning of respective time interval.

$$A = \frac{1}{k} \int_t^{\frac{1}{2}} (s_i + s_{i-1}) \quad (3)$$

where
 Wilcoxon et al by equation:
 2. AUPC calculation using Simpson's theorem by

x_n - end of time interval
 x_0 - beginning of time interval
 a, b - equation parameters

where

individual cultivars were evaluated further using Tukey's test of minimal differences. The significance of differences for both methods is given in tables 5 and 6.

CONCLUSION

It is possible to use equation exponential curve (1) for equilibration of determined data in order to compute AUDPC. Positive and negative deviations in area values are insignificant. This method is not convenient even under conditions of high infection pressure for the graphic interpretation of infection development, especially in its second half. In the method by Wilcoxson et al. (1975) the area is computed in direct dependence on measured values. Therefore it is conditioned by use of convenient scales for infection evaluation, which with sufficient accuracy reflects the dynamics of heat-pathogen relation. Both methods can be used for evaluation of breeding materials. The method by Wilcoxson et al. is simple, not demanding tedious mathematical elaboration and it was shown to be more precise (compare table 5 and 6). Non elimination of experimental error is a disadvantage of both methods. The first method is less precise but enables equilibration of infection values during the observations. The second method can be held as more precise for area estimation, but it does not follow the course of infection continuously in the whole period of its development.

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Table 1: Absolute differences between average 2-year results of area values obtained by two different methods, and with year results as additional information

Cultivar	Method by Bevington		Method by Wilcoxon et al.		Differences between the methods	
	1980	1981 Mean	1980	1981 Mean	Difference	rank + difference -
Vada	49	102	51	111	+5	4
Julia	114	88	126	98	+11	8
Minerva	130	173	141	181	+9	5
ST 6984	227	189	241	196	+10	6.5
Zefir	199	280	203	281	+2	3
Opal	277	213	277	211	-1	1.5
Mars	195	310	208	296	-	-
Spartan	384	249	357	239	-18	9
Safir	561	425	552	433	-1	1.5
Krystal	460	552	470	562	+10	6.5
					Rank	55
					Rank	33
						12

$$T_p \ 0.01 < T_p \ 0.05 = 6 < T_{emp} = 12$$

Table 2: Relative differences between 2-year results of area values obtained by two different methods, and with year results as additional information.

Cultivar	Method by Bevington		Method by Wilcoxon et al.		Differences between the methods				
	1980	1981	1980	1981	difference	+ difference -			
Vada	8.7	24.0	15.4	9.2	25.6	16.5	+1.1	4	4
Julia	20.3	20.7	20.5	22.8	22.6	22.8	+2.3	7.5	7.5
Minerva	23.2	40.7	30.8	25.5	41.8	32.7	+1.9	5	5
ST 6984	40.5	44.5	42.2	43.7	45.3	44.3	+2.1	6	6
Zefir	35.5	65.9	48.7	36.8	64.9	49.2	+0.5	3	3
Opal	49.4	50.1	49.7	50.2	48.7	49.6	-0.1	1.5	1.5
Mars	34.8	72.9	51.1	37.7	68.4	51.2	+0.1	1.5	1.5
Spartan	68.4	58.6	64.1	64.7	55.2	60.2	-3.5	9	9
Satir	100.0	100.0	100.0	100.0	100.0	100.0	-	-	-
Krystal	82.0	129.9	102.6	85.1	129.8	104.9	+2.3	7.5	7.5
								Rank	Rank
								34.5	10.5

T_p 0.01 T_p 0.05 = 6 T_{emp} = 10.5

Table 3: Variance analysis of results obtained by Bevington's method

Source of variance	DF	MSQ	F	S
Cultivars	9	42 774,0	10.15++	
Years	1	11.2	0.003	
Error	9	4 212.4		64.9
Total	19			

$F_{tab} 0.01 = 6.54$

Table 4: Variance analysis of results obtained by Wilcoxon et al.

Source of variance	DF	MSQ	F	S
Cultivars	9	41 582.1	11.94++	
Years	1	16.5	0.005	
Error	9	3 483.8		59.02
Total	19			

$F_{tab} 0.01 = 6.54$

Table 5: Significance of differences between cultivars, evaluated by Bevington

	Va	Ju	Mi	ST	Ze	Op	Ma	Sp	Sa	Kr
Vada	-							xx	xx	xx
Julia	-						x	xx	xx	xx
Minerva				-				xx	xx	xx
ST 6984				-				xx	xx	xx
Zefir				-				xx	xx	xx
Opel				-				xx	xx	xx
Mars				-				xx	xx	xx
Spartan							-			x
Safir										-
Krystal										-

D_{MIN} - Tukey test - $\alpha = 0.05$
 $\alpha = 0.01$

Table 6: Significance of differences between cultivars, evaluated by Wilcoxon et al.

	Va	Ju	Mi	ST	Ze	Op	Ma	Sp	Sa	Kr
Vada	-						x	xx	xx	xx
Julia	-							x	xx	xx
Minerva				-				xx	xx	xx
ST 6984				-				xx	xx	xx
Zefir				-				xx	xx	xx
Opel				-				xx	xx	xx
Mars				-				xx	xx	xx
Spartan								-	x	xx
Safir										-
Krystal										-

D_{MIN} - Tukey test - $\alpha = 0.05$
 $\alpha = 0.01$

PHYSIOLOGIC RACES OF Puccinia recondita ROB. ISOLATED
FROM WHEAT IN THE PROVINCES OF CONTINENTAL PORTUGAL

BY

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This report groups the results of Puccinia recondita surveys in continental Portugal obtained between 1959 and 1981.

The wheat varieties used for physiologic race identification were the international standard differentials plus three supplemental varieties.

The results of annual surveys of physiologic races between 1959-1971 were reported by Freitas (1966, 1968, 1972) and by Freitas e Freitas (1976, 1978). From 1972 to 1981 the results were reported by Freitas (1983).

Cultures isolated from samples obtained in the Portuguese Continental Provinces were identified and the physiologic race frequencies were calculated for each Province and for the country as a whole. (Table 1).

Wheat is mainly cultivated in the southern part of the country and particularly in Alto Alentejo and Baixo Alentejo. In the northern provinces the wheat fields are small and infrequent in distribution. The frequency of the different samples and races of P. recondita reflects the distribution of the wheat crop in Portugal. For example, only 25% of the total samples came from the northern and central part of the country.

Some of the infrequent races isolated in the southern part of the country are not detected in some northern provinces. Race 11A was the most frequent race in each

province followed by one of races: 57, 58A, 58C, 68, 75. The most frequent races detected showed generally only small differences in frequency between the provinces. The results obtained during the same period for the country as a whole, as well as those for 1959-1971 (Freitas, 1982) are basically similar.

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Table 1 - Physiologic race frequencies per Provinces and for the country as a whole (%)

Physiologic races Provinces	1A	1B	1C	11A	11B	11C	11D	11E	11F	14	15A	15B	20	57	58A	58B	58C	58D	68	75	84	87	107	131	
Minho	3.4	3.4	-	49.4	3.4	-	-	2.3	1.1	2.3	4.6	1.1	-	2.3	6.9	-	6.9	1.1	4.6	2.3	1.1	-	2.3	1.1	
Tras- es Montes e Alto Douro	1.8	-	1.8	38.2	-	-	-	-	1.8	-	7.3	-	-	5.5	1.8	-	7.3	-	12.7	12.7	-	-	-	3.6	5.5
Douro Litoral	4.1	-	1.4	41.1	1.4	-	-	-	6.8	-	5.5	1.4	-	5.5	12.3	2.7	6.8	-	2.7	2.7	1.4	1.4	1.4	1.4	1.4
Beira Litoral	1.3	1.3	1.3	61.3	-	0.7	2.0	-	2.7	-	2.7	1.3	0.7	7.3	0.7	-	7.3	-	2.0	2.0	0.7	-	1.3	3.3	
Beira Alta	5.3	1.8	1.8	49.1	-	1.8	-	-	-	-	1.8	1.8	1.8	3.5	5.3	-	1.8	-	5.3	17.5	-	-	-	1.8	
Beira Baixa	1.5	-	-	61.8	-	-	-	-	4.4	-	1.5	1.5	-	7.4	5.9	-	2.9	-	4.4	4.4	-	1.5	2.9	-	
Estremadura	1.1	2.0	0.5	44.4	1.6	0.3	1.4	-	4.3	0.3	2.2	0.7	1.4	2.9	9.1	1.3	4.8	0.3	7.5	9.1	1.3	0.3	0.9	2.0	
Ribatejo	0.9	1.8	-	48.2	-	0.9	0.9	-	2.7	-	1.8	0.9	0.9	5.4	7.1	0.9	5.4	-	3.6	8.9	1.8	-	0.9	7.1	
Alto Alentejo	4.1	0.5	-	45.9	0.5	3.6	1.0	1.5	1.5	1.5	2.6	0.5	0.5	6.2	6.2	1.5	6.7	-	5.7	1.5	3.1	0.5	2.6	2.1	
Baixo Alentejo	3.8	2.4	0.3	42.1	0.7	1.4	2.1	0.3	3.1	0.3	2.1	0.3	1.4	6.2	8.9	0.3	9.2	0.3	2.1	6.2	1.7	1.0	1.4	2.4	
Algarve	2.8	1.5	0.9	41.3	4.3	1.9	1.1	0.2	3.4	0.4	3.2	0.6	1.5	6.6	6.0	1.3	5.6	-	5.1	5.1	1.7	0.4	2.6	2.4	
Country	2.5	1.6	0.6	45.6	1.7	1.2	1.2	0.3	3.3	0.5	2.7	0.8	1.1	5.2	7.1	0.9	6.1	0.2	5.2	6.3	1.5	0.5	1.7	2.5	

Yellow rust (*Puccinia striiformis* West.) causes considerable yield loss in wheat and barley in north-western India and in the Nilgiri Hills of Tamil Nadu. Over the years a number of pathogenic forms have been identified different from each other. During 1981-1982, a large number of samples were collected from Haryana, Punjab and the plains of West Uttar Pradesh, Himachal Pradesh and Jammu & Kashmir and established on susceptible Kathia local. To identify the type of virulence, urediospore dustings were inoculated on set O, A and B and are ascribed a value following binary notation and decanary value (Nagarajan et al. unpublished). Some reactions did not agree with the previously identified virulences. Susceptible pustules were re-isolated onto Kathia from Chinese 166 possessing $\overline{YR 1}$ and *Sonalika* which is resistant to all virulences except 102S102 or I (Sharma, et al., 1973). These isolates when re-inoculated on the O, A and B set produced identical reaction to the original isolate. It is deduced that this isolate is a new virulence and is given a value of 47S102 or K, following the new system of identification. This isolate produces susceptible reactions on Chinese 166 ($\overline{YR 1}$) and Vilmorin ($\overline{YR 3}$) and resistant reactions on Suwon x Omar. All previously identified wheat yellow rust races occurring in India are virulent on Suwon x Omar. Reactions of this new isolate and other important virulence combinations known to occur are given in Table 1. During 1981-1982 when this virulence was identified, it represented 21% of the total sampled population and during

OCURRENCE OF A NEW VIRULENCE, 47S102 OF PUCCINIA STRIIFORMIS
WEST., IN INDIA DURING CROP YEAR, 1982
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1982-83 was identified in the north-western states and in the Nilgiri Hills of Tamil Nadu. During that year virulence 47S102 represented 15% of the samples analysed. A close watch of this virulence will be kept, as it is a potential threat.

This new virulence 47S102 is the most virulent pathotype recorded so far, and is able to infect Yr 1, Yr 2, Yr 3, Yr 6, Yr 7, Yr 8, Sonalika and Kalyansona. It is avirulent on Yr 5 and Yr 9. Incorporating either of these genes in the wheat varieties of north-western India will produce resistance. Of the 186 entries representing various wheat improvement programmes that were evaluated for seedling resistance against 47S102, the following were resistant.

CPAN 1827, HD 2135, HD 2190, HD 2309, HD 2310,
HD 2314, HD 2315, HD 2323, HU 741, J 340, JMJ 78-4,
JMJ 78-5, K 7835 and K 7903.

These lines, if they possess good agronomic and quality characters can be considered for widespread cultivation, if not, at best can be used as donor lines for incorporating resistance. We thank the authorities of the Indian Agricultural Research Institute (IARI), New Delhi for the facilities and funding. Shri Mukesh Srivastava and Shri Prem Singh rendered valuable technical assistance.

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Table 1 continued

Viru-Chinese Iee Heines Vilmorin Moro Strubes Suwon x
 lence 166 (Yr 7) Kolben (Yr 3) (Yr 10) Dickkopf Omar
 (Yr 1)

Set A

New	4	4	4	4	4	4	4	4	4
47S102 (K)	4	4	4	4	4	4	4	4	0;-1
Old									
102S102 (I)	0;	4	4	4	0;-2	0;	4	4	4
70S64 (20A)	0;	4	4	2-4	0;	0;	0;-3	4	4
67S4(31)	4	4	4	0;-2	0;	0;	0;	4	4
66S64-1 (38A)	0;	4	4	0;	0;	0;	0;	4	4

Table 1 continued

Viru-Hybrid Heines Compar T.spelta Reibsel Sonalika Kalyan-
 lence 46 VII album (Yr 8) (Yr 9) sona
 (Yr4b) (Yr2) (Yr5)

Set B

New	4	4	4	4	4	4	4	4	4
47S102 (K)	0;	4	4	4	0;	0;	4	4	4
Old									
102S102 (I)	0;	4	4	4	0;	0;	4	4	4
70S64 (20A)	0;-2	0;	0;	0;	0;	0;	0;	4	4
67S4 (31)	0;	0;	0;	0;-3	0;	0;	0;	0;	0;
66S64-1 (38A)	0;	0;	0;	0;	0;	0;	0;	4	4

Stem rust of wheat, *Puccinia graminis* f.sp. *tritici* (Pres.), Erikss and Henn, has been extensively studied by many workers throughout the world (Stakman & Harrar, 1957). In the Sudan this disease is presently under control with resistant varieties (Baghdadi, 1983). About 325 physiological races and biotypes of *Puccinia graminis* have been identified throughout the world (Stakman et al., 1962 and Stewart, 1970). Dissemination of stem rust races from one country to another by wind is well known (Ogilvie & Thorpe, 1961). Therefore, in the Sudan resistant varieties may become infected with new physiological races introduced from neighbouring countries. Abdel-Hak (1959) and Abdel-Hak et al. (1966) identified 16 physiological races of stem rust from Egypt and Near East countries throughout the area. Abdel-Hak et al. (1966) emphasized that the identification of wheat stem rust physiological races was of increasing importance, because of their role in breeding of resistance varieties.

The paper reports the results of the survey of races and detection of new races in the Sudan and neighbouring countries.

INTRODUCTION

A survey carried out between 1970-1974 in 6 localities of the main wheat growing areas, showed that stem rust was found only in Khashm El Girba district. Stem rust samples were identified as 7 different physiological races. Race 21 was the most prevalent race during the survey. Races 222, 34, 186 and 194 were identified for the first time in the Sudan.

SUMMARY

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BY
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IN THE SUDAN IN 1970/74
PHYSIOLOGICAL RACES OF WHEAT STEM RUST

MATERIALS AND METHODS

During the season 1970-1971 and 1971-1972, at the Egyptian Trap Nursery, 30 wheat and barley varieties were sown in mid November at 6 localities viz: Gurier and Hudeiba Northern Province, Shambat Khartoum Province, Wad Medani Gezira province, Khashm El Girba, Kassala Province and Jebel Marra Datur Province. These represent the main wheat growing areas in the country.

In 1972-1973 and 1973-1974, forty-eight new Egyptian Trap Nurseries (42 wheat, 3 barley and 3 oat varieties) were sown in mid November, at Heiba, Shambat, Wad Medani, Khashm El Girba and Jebel Marra.

Each entry was sown in a one-metre long row. The nursery was surrounded with a border of the variety Baladi "Local", highly susceptible to stem rust to act as spreader.

In 1970-1971 and 1971-1972, stem rust was observed only in Khashm El Girba district. Infection began on the spreader and then on the Trap Nursery infecting 7 and 9 varieties each season respectively. During 1972-1974, again the infection was observed in Khashm El Girba only, on the spreader and then on the Trap Nursery infecting 10 and 17 varieties each season respectively. The infection in each season appeared between mid January and mid February. Samples were collected on 20-23 February and sent to Giza - Egypt and Elvas - Portugal for identification of physiologic races. Between 1970 and 1974, stem rust specimens collected from the "Trap Nursery" at Khashm El Girba district, 7 physiologic races were identified (Table I).

RESULTS

Table 1

Season	No. rusted varieties	Races identified
1970-71	7	21, 222
1971-72	9	2, 75
1972-73	10	21, 34
1973-74	17	21, 17, 186, 194, 75

Race 21 was found to be the most prevalent during the period. Races 222, 34, 186 and 194 were identified for the first time in the Sudan.

DISCUSSION

During the survey infections of stem rust were observed only in Khashm El Girba district. Possibly because warm humid weather prevailing in this district during January - February favoured stem rust development. Abdel-Hak et al (1966) reported that stem rust of wheat developed under similar climatic conditions.

In Khashm El Girba the symptoms of the disease were observed between mid January and mid February. This is in agreement with Khalifa's observation (Khalifa, 1964-65). During the survey, 7 races of wheat stem rust namely 17, 21, 34, 75, 186, 194 and 222 were identified from Khashm El Girba district, compared to 24 physiologic races from Egypt and Near East countries (Abdel-Hak, 1959, Abdel-Hak et al, 1966, and Abdel-Hak & Kamel, 1971). Of the 24 physiologic races identified by Abdel-Hak et al from Near East countries 8 races occurred in Khashm El Girba (Khalifa, 1964-65). In addition 4 new races, 34, 186, 194 and 222 are reported in this paper for the first time.

These results show a very close similarity in prevalence and distribution of the physiologic races of wheat stem rust between the Sudan and all the Near East countries. Such a similarity exists in the European countries (Santiago, 1957 & 1962 and Ogilvie & Thorpe, 1961)

Thanks are due to Dr A M Kamel, "Cereal Diseases Research Division Giza, Egypt", for supplying the Egyptian Trap Nursery and helping in identifying the physiologic races and Eng. Maris Julia Antunes, Head of Plant Breeding Research Station, Elavs, Portugal, for the identification of the physiologic races. Also thanks to Dr D A Dafalla, Khashm El Girba Reseach Station, Agric. Res. Corporation for his co-operation.

ACKNOWLEDGEMENTS

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MONITORING A NEW VIRULENCE 75G5 OF STEM RUST OF WHEAT
IN INDIA DURING 1982, AND SOURCES OF RESISTANCE

BY

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The cultivation of dwarf wheats resulted in the evolution of variants of the existing races identified on standard and supplementary set of differentials (Stakman et al., 1962). In 1982, the system of virulence analysis was changed to one with isogenic lines or lines with known genes similar to that for yellow rust (Johnson et al., 1972). The new system consists of 3 sets of differentials O, A and B. The O set includes the commercial cultivars, set A isogenic stem rust resistant lines able to differentiate pathogen variability in India and set B a condensed set of standard and supplementary differentials. The virulences are named according to decanary values in set A and B, while set O shows the behaviour of commercial cultivars (Bahadur et al., 1983). The letter 'G' which separates the values of set A and B denotes the virulence to be that of *Puccinia graminis* tritici. The varieties, isogenic lines in sets O, A and B are as follows:

Set O	Set A	Set B
Agra Local	Sr 13	Marquis
WL 711	Sr 9b	Einkorn
Sonalika	Sr 11	Kota
LOK-1	Sr 28	Reliance
Sr 24	Sr 8	Charter
Bijga yellow	Sr 9e	Khapli
NI 5439	Sr 30	
Nilgiri	Sr 7t-2	
Barley local		

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In 1982, a new variant 75G5 (21A-2) of stem rust was detected on isogenic lines included in set A. On tall wheats possessing SR 11. Variant 21A (old name) affected Ridley in Northern India and was isolated in 1956 while 20G21 (21A-1) that infects Gabo, Gaza etc was identified in 1958 from a sample collected from South India. With the introduction of dwarf wheats the frequency of variants 21A and 20G21 (21A-1) declined and were rarely detected after 1973, whereas virulence 9G5(21) after showing a decline around 1967 became dominant (Bahadur, 1983). The details of the reaction of these virulences are given in Table 1.

Virulence 9G5(21), first detected in 1934 (Mehta, 1940) is able to infect two of the genes in set A and B. After the incorporation of race-specific resistance in wheat cultivars, variant 20G21(21A-1) acquired virulence for SR 8 and SR 11, and 75G5(21A-2) for SR 9b and SR 30. The additional virulence acquired by 75G5(21A-2) indicates a response by the pathogen to changes in resistant varieties.

The following wheat lines possess seedling resistance to all the variants discussed here: CPAN 1796, DWR 5023, HD 2135, HD 2281, HD 2320, HD 2327, HD 2329, HD 4502, Jairaj, PWB-34, Raj 1555, Raj 1972, VL 421, WH 283 and WH 331. Among the isogenic lines, SR 24, SR 25, SR 26, SR 27 and SR Pt-2 are also resistant to 9G5(21), 20G21(21A-1) and 75G5(21A-2).

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WHEAT LEAF RUST EPIDEMICS IN CZECHOSLOVAKIA IN 1983

BY

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Leaf rust of wheat occurs every year in Czechoslovakia, however, heavy outbreaks are rare. In 1983 leaf rust was widespread in all wheat growing regions of the country. It started to spread earlier than in other years mainly due to successful overwintering on leaves of winter wheat. High temperatures in late spring and in summer favoured the development of leaf rust. Despite the considerable severity of the leaf rust epidemic, losses in yield in susceptible cultivars were estimated to be only up to 10%.

The total of 74 leaf rust samples (single-pustule isolates) from 30 places was tested on the standard differentials and on the cultivars grown in Czechoslovakia. Race 61, virulent on Lr 26 predominated (48%), followed by race 61 avirulent on Lr 26 (32%), race 14 virulent on Lr 26 (16%), race 14 avirulent on Lr 16 (3%) and race 63 avirulent on Lr 26 (1%).

Avirulence on Lr 26 is of significance because almost one third of Czechoslovak commercial winter wheat cultivars (Amika, Iris, Istra, Sabina and Solaris) possess Lr 26. Avirulence of races 14 and 63 on Lr 3 is also important, for many cultivars, grown in Czechoslovakia have this gene (Ilyitshovka, Mironovaskaya, Yubileyaya, Mironovskaya 808, Juna, Odra; Amika and Istra possess both Lr 3 and Lr 26).

In Czechoslovakia, race 77 virulent on Lr 26 was predominant until 1979. Since 1980 race 61 became predominant. Initially race 61 was avirulent on Lr 26, but since 1982 isolates virulent on Lr 26 predominated. It is deduced that race 61 originated from race 14 by a single mutation and achieved virulence on Lr 26 by another single mutation. A similar trend was observed in races 14 and 77 in the last decades. Isolates virulent on Lr 26

predominated in a few years over avirulent isolates of the corresponding race.

Papers, short notes on topics such as Pathogen Virulence, surveys, Breeding for resistance, Sources of resistance, control of cereal rusts, Techniques or any subject of possible interest are required for the Bulletin to maintain its function of rapid dissemination of rust information.

Papers - typed double spaced should be sent to me at the following address -

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