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FIELD TRIALS ON THE BEHAVIOUR OF WHEAT TO CERTAIN DISEASES

(RUSTS AND POWDERY MILDEWS)

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This paper was published in duplicated form by the two institutes in September 1974, in Italian, under the title 'Risultate delle Prove in Campo sul Comportamento dei Frumenti alle Malatti 1973-1974 (Ruggini e Oidio)'. It includes 39 pages of text and Tables. By permission of the authors, the English summary and Index of the groups of wheat included are reproduced below.

SUMMARY

Field trials on the resistance of over 400 varieties of Wheat to some of the most important parasites have been carried out at 12 locations in Italy in 1973-1974.

In general, the susceptibility of all "bread" and "durum" wheat varieties widely cultivated in Italy, to rusts and powdery mildew has been confirmed. On the other hand, some new varieties and advanced selections have shown to be very resistant.

Evidence has also been obtained concerning interesting sources of resistance to rusts and powdery mildew.

The results obtained have shown that:

(a) Valgerardo, Valselva, Wisconsin supremo, Timixin, Mexipack 69, and some Triticum timopheevi and T. monococcum lines were resistant to leaf rust, stem rust and powdery mildew;

(b) Belfuggito, Lambro, Creso, Valaniene, Valoriolo, Valgiorgio, Valsacco, Valfiora, Valnera, Valgrande, many Giorgio and Gerardo selections, ST 464, Gaza, Baladi 116, Baladi saidi, etc., among "durum" wheats, Era, Chris, Magnif mg, Super x, Yecora 70, Bonanza, Selkirk, etc., among "bread" wheats, were resistant to leaf rust and stem rust;

(c) Yuma, T. carthlicum, Wisconsin sel., C.I. 12632, Mendas, Hope, Minutola, Capp x F_3 Capp x Yuma, were resistant to stem rust and powdery mildew;

(d) Asosan, Purdue 57-52 A_1 P_2, Benhur, Lancer, Centurk, Gerardo 514, Gerardo 522, Gerardo 529, etc., were resistant to leaf rust and powdery mildew;

(e) Lakota, Wells, Leeds, Tito, Flamingos, Fr. K 58 NT II 50-35, were resistant to stem rust.

Other sources of resistance have also been found.

INDEX OF THE GROUPS OF WHEAT INCLUDED

I. Durum wheats

A. Currently cultivated in Italy.

B. New varieties.

C. Old varieties.

D. Argentine varieties.

E. Varieties from other origins.

II. Bread wheats

A. Currently cultivated and old varieties.

B. Italian wheats and wheats from other origins (Argentine).

III. Miscellaneous (several species)

IV. Differential varieties of Puccinia graminis tritici and lines and varieties which are carrying known resistant factors.

V. Idem. P. recondita.

VI. Idem. P. striiformis.

VII. Idem. Erysiphe graminis tritici.

VIII. New selections of durum wheat.

IX. New selections of bread wheat.

X. Varieties used as controls. Fortunato and Novosadska 1993 (susceptible to P. striiformis, P. recondita, P. graminis and E. graminis) and Victor (resistant to P. graminis and susceptible to P. recondita and E. graminis.

ON THE PRESENCE OF THE GENE SR 5 IN SOME EUROPEAN CULTIVARS

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Many European wheat cultivars show a reaction pattern to various wheat stem rust races identical or similar to that of line Sr 5 - Marquis. In an experiment with seven Canadian races (Bartoš et al. 1970) the reaction pattern of the following cultivars resembled that of line Sr 5 - Marquis: Bezostaya 1, Drauhofener Kolben, Farino, Gernot, Hybrid 80-3, Lassers Dickkopf, Primus, Rabe, Reichersberger Kolben, Stabil, Vrakuňská. The cultivar Admonter Früh differed only by showing additional resistance to one race. By genetic analysis of F_2 progenies of several crosses, the location of the gene for resistance at the Sr 5 locus was demonstrated in the cultivars Hybrid 80-3, Vrakuňská and Admonter Früh.

METHODS AND RESULTS

Two additional tests were carried out with seedlings of six Czechoslovak races in a collection of 200 cultivars or lines. Isolates of three races (1, 14, 21) avirulent and three (34, 56, 214) virulent to Sr 5 were used. The reactions of the majority of the resistant cultivars resembled those of line Sr 5-Marquis. The following cultivars were resistant (infection type 0) to races avirulent to Sr 5 and susceptible to at least one race virulent to SR5:

Aronde, Atys, Bartl, Bezostaya 1, Bezostaya rannaya, Bizel, Crystal, Kharkovskaya 63, Chebros, Dobrudza, Donetskaya 61, Festival, Francest, Geber, Gelpa, Ilyitchevka, Justin, Krasnodarskaya 46, Levent, Lutescens 32, Lutescens 39, Mironovskaya ulutchshenaya, Mojor, Odesskaya 51, Panis, Olt, Prestige, Provence 45-A-10, Reichersberger 42, Rembrandt, Robert, Topaze, Victor 1, Samos.

The majority of the cultivars mentioned above were susceptible to all races virulent to Sr 5. However, some of them showed additional resistance to single races virulent to Sr 5.

The economically very important cultivar Bezostaya 1, together with cultivars Bezostaya rannaya, Olt, Levent and Lutescens 32 were in the group possessing additional resistance to race 34 (Table 1).

Table 1. Infection types after inoculation with stem rust

Cultivar	Race 21	214	56	14	1	34
Line Sr 5-Marquis	0	4	4	0	0	3-4
Bezostaya 1	0	3-4	3-4	0	0	1+
Bezost. rannaya	0	3	4	0	0	;1-2
Olt	0	3	3	0	0	2
Levent	0	4	3	0	0	1-2
Lutescens 32	0	3	3-4	0	0	1-2

Of this group, cultivar Lutescens 32 was crossed with the susceptible cultivars Cleo and Jubilar. Segregation for rust reaction to race 21 was studied in the field, where plants were classified as resistant or susceptible, and in one cross also in the greenhouse, where medium resistance was classified separately (Table 2).

Table 2. Segregation for stem rust reaction to race 21 in F_2 population

Cross	Number of plants: resistant	Number of plants: susceptible	Expected ratio	P
Cleo x Lutescens 32	376	83	13:3	0.80-0.50
Cleo x Lutescens 32	253 + 28*	62	12:1:3	0.50-0.20
Jubilar x Lutescens 32	97	18	13:3	0.50-0.20

* medium resistant plants - greenhouse classification

The segregation shows that the cultivar Lutescens 32 carries one dominant and one recessive gene for stem rust resistance effective to race 21.

DISCUSSION

The results indicate that the gene Sr 5 is probably very common in European wheat cultivars. Some of the cultivars possessing Sr 5 also carry additional genes for stem rust resistance as has been demonstrated previously in the cultivar Admonter Früh and as is presumed now for the cultivar Lutescens 32. Of the two genes determined in Lutescens 32, the dominant gene is probably Sr 5; the recessive one governs resistance to race 34.

Whereas the isolate of race 34 in our experiment was avirulent to Bezostaya 1, race 34 in Hungary is virulent to the same cultivar at the seedling stage (Bócsa, 1972). However, Bezostaya 1 remained resistant in Hungary under field conditions in the presence of race 34 and other races virulent to Bezostaya 1 at the seedling stage.

Our experiments and information by Bocsa suggest that the cultivar Bezostaya 1 probably possesses at least two genes (one of them Sr 5) for seedling resistance and other gene(s) for adult plant resistance to stem rust.

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A HISTORICAL ACCOUNT OF WHEAT RUST EPIDEMICS IN INDIA, AND THEIR SIGNIFICANCE

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Recent change in the wheat production technology of the under-developed nations of Asia, Africa and Latin America is sometimes referred to as the 'wheat revolution' or the 'green revolution'. This resulted in certain economic and political gains for India (Frankel, 1971). As a result of the widespread cultivation of varieties of similar genome a possible disease epidemic resulting in human calamity has been visualized by many (Paddock, 1970; Randal, 1970), as a number of plant pathogens reduce the yield potentials of the dwarf wheats in Asia and Africa (Saari & Wilcoxson, 1974).

While dicussing Puccinia graminis tritici race 15 B that caused severe stem rust epidemics during 1953 and 1954 in the USA, Paddock (1970) expressed the opinion that India was particularly vulnerable, and that if such an epidemic were to occur in India today, it would be disastrous. In view of this prediction, a need is felt for a probe into the historical records of wheat rust epidemics. Hence, an attempt was made to study the famines and epidemics recorded by the East India Company, by the British, and later by our own Government.

EARLY RECORDS

"Old and respectable landlords in the district of Jabalpur state that in Sumbut 1843 (A.D. 1786) wheat crops throughout the district were destroyed by the same calamity; and that the Saugor Government was obliged, not only to remit the revenue, but to provide a supply of wheat grain for almost every village by advances from the public treasury." So wrote Major Sleeman (1839), about the oldest known stem rust (blight) epidemic.

The next one to follow was the 1805 epidemic of Jabalpur. To a lesser extent stem rust occurred in the same district during 1827. During that year arable lands along the Narbada valley, in the Malwa tract and on the tableland of the Vindhya-Sathpur ranges experienced such a severe epidemic that farmers did not reap the amount of seed sown (Sleeman, 1839). He recorded that the old farmers of this region could recollect two recurrences of this calamity at an interval of twenty to forty years. During 1830, Sleeman had the blighted material identified as Uredo species. The description fits that of Puccinia graminis.

The repeated rust epidemics during 1828-29, 1831-32 and the poor crop in 1830-31 due to drought left no other alternative than to consume that year's bumper crop of Kisaree dal (Lathyrus sativus). As a result severe lathyrism occurred in Jabalpur-Saugor region, depriving half of their children of the use of their limbs below the waist (Sleeman, 1839).

CENTRAL INDIA

Col. K. Mackenzie reports that during 1887, his clothes got reddened with uredospores while walking through fields (Barclay, 1895). Severe rust epidemics occurred in the Central Provinces, in 1832 and 1879 (Anon, 1908): in this report the need to change the native susceptible wheat to exotic resistant ones was stressed. Prain (1897) noted the 'rust' epidemic of 1894-95 and similar ones in the preceding seasons. Strong sunshine is said to have checked the spread of 'rust' in Central India during 1897 (Anon, 1897).

Einkorn wheat, supposedly immune to black rust, had a severe attack of that rust in the hot weather of May 1907 (Howard, 1953). The year 1907 was not an epidemic year, but Sir Albert Howard observed severe rust on wheat grown by him at Pusa during May (wheat is normally harvested by March in that area). It appears that the then British India did not experience any rust epidemic during the thirties (Mehta, 1952).

The 1946-47 epidemic of stem rust in Central India caused losses of 2 million tons of wheat (Gokhale, 1952). The estimated financial loss as a result of this pandemic and the 1948-49 crop failure due to the same disease in the southern districts of Bombay State, was about 50 million rupees (Gokhale et al., 1950). A stem rust epidemic is said to have occurred during 1956 in Bihar (Rao, 1972), but regarding this a reliable scientific report is lacking. With the initiation of the wheat diseases survey team, quantitative data on wheat rust are available from 1967 onwards. During this period, stem rust has never appeared as an epidemic, but in some years, it has been severe in isolated pockets of 10 km^2 (Swaminathan et al., 1967-1971; Joshi & Gera, 1973, 1974; Joshi et al., 1974).

NORTHERN INDIA

The earliest record of wheat 'rust' in the Indo-Gangetic plain seems to be that at Delhi noted by Smith (1843). Moreland (1906) recorded two damp seasons (1893-94 and 1894-95) as the 'worst rust' years at Allahabad, Jhansi and Banaras. Butler & Heyman (1906), while dealing with brown rust (*P. recondita tritici*) refers to Moreland (1906). This shows that the observation of the latter relate to brown rust. In the United Provinces, following the rust years of 1893-94 and 1894-95, severe drought occurred during 1895-96. This drought reduced the autumn crop yield by 3.33 million tons in the western districts of United Provinces and Northern Oudh, resulting in famine in 1896-7.

Damp weather and lack of sunshine during 1904-05, produced in parts of the Punjab "that grave disease of growing wheat known as rust" (Anon, 1905a). That year, the wheat crop also suffered frost injuries of up to 25-50% in the United Provinces, 10-15% in the Punjab and 65-70% in the sub-mountaneous regions of Gorakhpur. As a result, in United Provinces the estimated out-turn of 1,897,000 tons for 1904-05, was 41% less than that for 1903-04 and 24% and 12% below the average yields of the preceding five and ten years respectively (Anon, 1905b). About 5 million more acres were under wheat in United Provinces in 1904-05 than in 1903-04, but the national out-turn was 22% lower. "Frost and rust, however, did greater havoc with the crop" (Anon, 1905c).

During 1905-06 the United Provinces, which accounted for 33.4% of the total wheat area of British India, recorded a loss of 15% due to unprecedented drought (Anon, 1906). Crop loss due to rusts, followed by drought, resulted in a severe famine during 1906-07 in north Oudh and western districts of the United Provinces. It affected 66,000 square miles, having a population of 30 million (Hewett, 1908). Every province of the United Provinces recorded 'rust' during 1910-11, and the strong winds that blew at the time of ripening resulted in further crop damage (Anon, 1912). Between 1967 and 1974, brown and yellow rusts occurred each year, but only twice caused appreciable damage. Isolated epidemics of these two rusts, in combination, occurred in some pockets of western Uttar Pradesh during 1971-72. A pandemic of the same two rusts occurred during 1972-73 in western Uttar Pradesh, Haryana and the Punjab (Joshi et al., unpublished).

FIGURE - 1

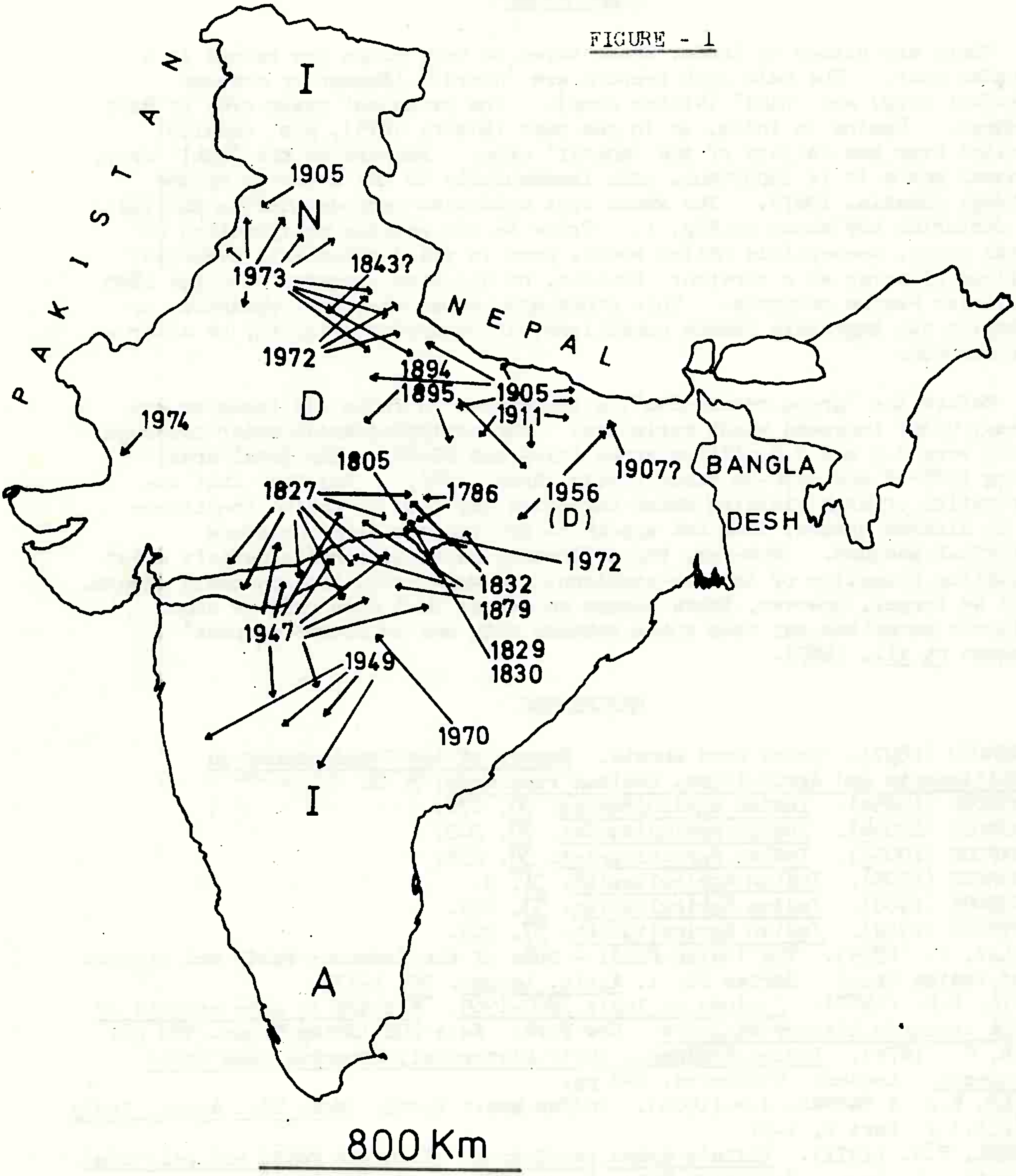

Fig. 1. Ends of the dark lines indicate the area where wheat rusts appeared or created an epidemic in India during 1786-1974. The case where documents are not sufficient to classify into either is denoted as (D), and ? stands for disease appearance.

CONCLUSIONS

There are places in India, where three or more crops are raised in a calendar year. The main crop seasons are 'Kharif' (Summer or monsoon dependent crop) and 'Rabi' (Winter crop). The principal grain crop of Rabi is wheat. Famine in India, as in the past (Blair, 1874), has usually resulted from the failure of the 'Kharif' crop. Failure of the 'Rabi' crop, in areas where it is important, adds immeasurably to the severity of the distress (Bhatia, 1967). The wheat rust epidemics recorded during the last two centuries are shown in Fig. 1. Prior to the genetic manipulation of cereal crops, susceptible native wheat, poor in yield potential, occupied millions of acres at a stretch: however, no disaster comparable to the 1845 A.D. Irish Famine occurred. This study also shows that rust epidemics or pandemics can aggravate famine conditions, if occurring prior to, or after a poor monsoon.

Before the "green revolution", a large area in India and Pakistan was already under improved wheat varieties. The estimated areas under improved wheats were 2.9 and 7.9 million acres (11.9 and 22.4% of the total area) during 1926-27 and 1938-39 respectively (Anon, 1945). The fear that the cultivation of high yielding dwarf varieties may lead to famine conditions due to disease attack, does not appear to get support from the above historical account. However, the delicately balanced surplus/deficit wheat production situation of the sub-continent may get upset if a pandemic occurs. "Lest we forget, however, there always in danger that stem rust or other insidious parasites may make sneak attacks with new or secret weapons" (Stakman et al., 1967).

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PRESENCE OF WHEAT RUST UREDOSPORES OVER THE ROHTANG PASS (3,954 m) IN THE INTERIOR OF THE HIMALAYAS

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Wheat is a winter crop in India, and is grown from October to May, the exact dates depending upon the location. In the hills of northern India and in the outer Himalayas, wheat is grown up to 3,000 m. At such high elevations crop maturity is delayed until June. However, there are valleys in the inner Himalayas, where the snow clears only by April. One such valley is the Lahaul and Spiti valley of the Himachal Pradesh in the North Western Himalayas. The Lahaul valley is surrounded by perpetually snow covered, inaccessible mountain ranges, broken at places by passes at heights mainly exceeding 4,000 m. In the south, Lahaul valley is connected by the Rohtang pass (3,954 m) to the Kulu valley of the outer Himalayas (Fig. 1). In the Lahaul valley, wheat is

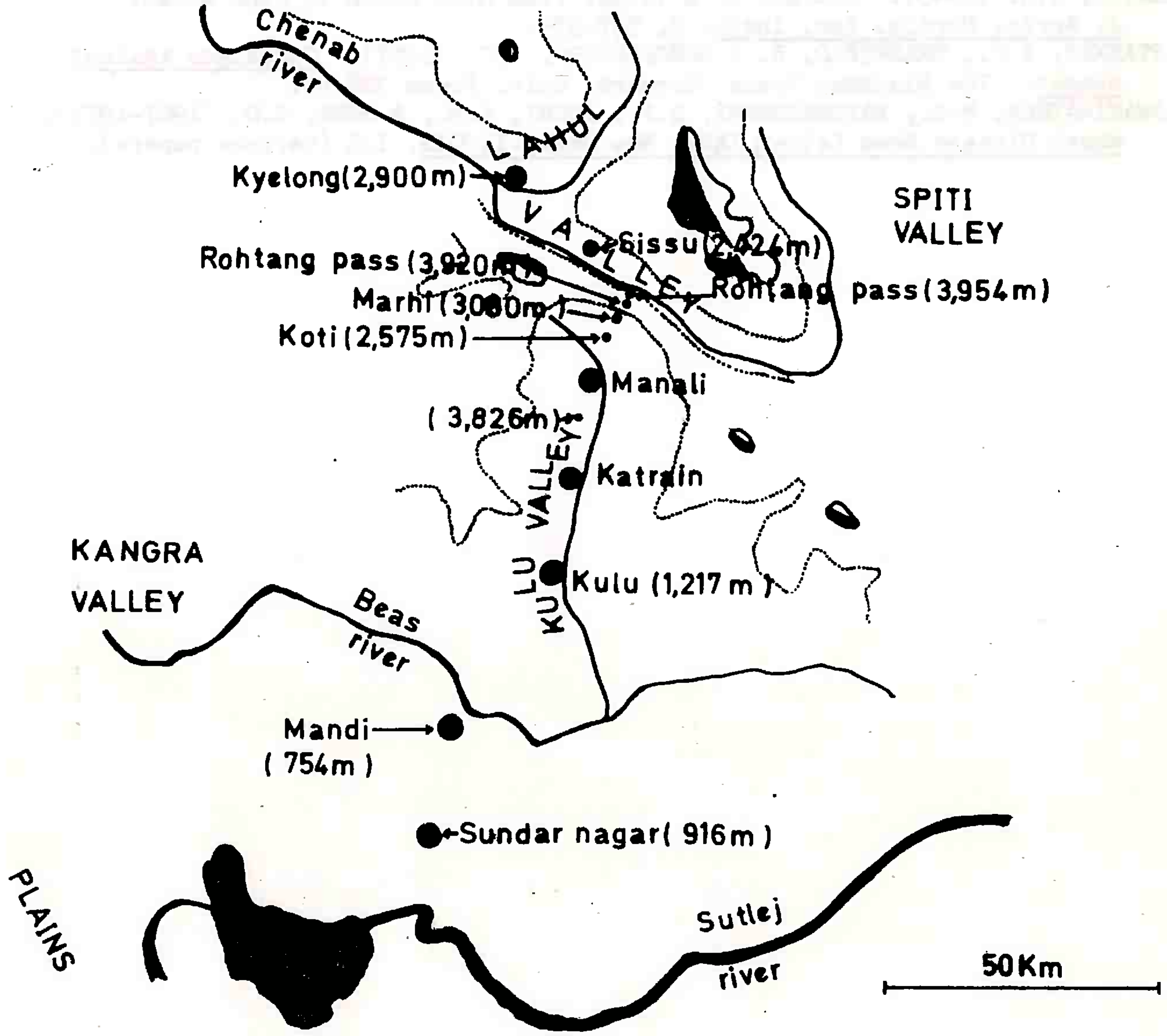

Fig. 1. The geographical location of the Kulu, Lahaul and Spiti valleys and other places referred in the text. The area within the dotted line denotes high mountains of over 3,696 m. The black and white shade denotes perpetual snow and peaks above 5,544 m. Note that the Lahaul valley is very narrow when compared to the Kulu valley.

grown as a summer crop from May to September/October. It remains free from rust infection till mid July, when yellow rust starts appearing.

Mehta (1940) has stated that the rust survives in the summer months in the Himalayas either on self sown or volunteer plants or on a regular crop. Joshi (1957) has suggested that strong winds from the Kulu valley passing over the Rohtang pass enable inter-valley exchange of rust inoculum between Kulu and Lahaul-Spiti to take place.

A survey of these hills and valleys was undertaken between 12-20 July 1974. Rod samplers (Roelfs et al. 1968) were exposed at Marhi (3,080 m), Rohtang Pass (3,920 m) on the Kulu side of the Pass and also on the other side of the Pass (3,954 m) and over a wheat field in the Spiti valley at Sissu (2,424 m). The period of exposure in each case was 48 h, between 14-16 July. During this period at Koti (2,575 m) in the Kulu valley wheat was nearly ripe, with traces of infection of black, brown and yellow rusts. However, the wheat crop at Khokhsar, Sissu, Tandi and Kyelong in the Lahaul valley which was in stages from tillering to flowering was free from infection.

Microscopic examination of rod samples from Sissu and the site in the Rohtang Pass facing the Lahaul valley, did not reveal the presence of any wheat rust spore in the air. However, rods exposed at Marhi facing the Kulu valley trapped one uredospore of black rust, one of brown and two of yellow on a 1.57 cm^2 area of trapping surface. At the site in the Rohtang Pass facing the Kulu valley (3,924 m) one uredospore of black rust, one of yellow and two of brown were trapped per unit area. The speed over the Rohtang Pass on 17 June, 1973 around 10.30 a.m. was approximately 30 km/h.

The horizontal distance in a straight line between Marhi and Koti is less than 4-6 km though their elevations are very different. The presence of inoculum in air samples over the Rohtang Pass, the occurrence of rust at Koti, and its complete absence in the Lahaul valley even 60-70 days after sowing, strongly suggest the possible exchange of inoculum between the two valleys as was visualised by Joshi (1957).

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PHYSIOLOGIC RACES OF OAT CROWN AND STEM RUST IN ITALY, 1974

BY D. SISTO, G. CARIELLO, M. PARADIES AND P. TARANTINI*

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A preliminary survey of physiologic races of crown and stem rust of oats, carried out in Italy in 1974, resulted in the identification of nine races of *Puccinia coronata avenae* (263, 264, 265, 276, 325, 384, 385, 409 and 410) and of five races of *P. graminis avenae* (76, 77, 80, It.3^n and It.6^n). Races 264, 325 and 410, and race 80 were, respectively, the most prevalent.

INTRODUCTION

Oats are widespread in Italy as green forage and, on more than 300,000 ha, as a grain crop.

Several species of wild oats are common all over the country as weeds in fields, in pasture land, along railways, etc.

Crown rust (*Puccinia coronata* Corda var. *avenae* Fraser ex Led.), stem rust (*Puccinia graminis* Pers. f. sp. *avenae* (Eriks. & E. Henn) and mildew (*Erysiphe graminis* DC. f. sp. *avenae* Em. Marchal) are the most common fungal parasites of oats in Italy. They are present in all the year round on volunteer plants and on wild oats.

In Italy, very little has been done on oat breeding in general and even less on disease resistance. Therefore a survey of pathogenicity on this host genus of crown and stem rust populations has been started, and will be expanded in future years so as to get a fair idea of the behaviour of these rusts and of their variations in Italy, for subsequent breeding work.

MATERIALS AND METHODS

In 1974, 115 samples of *P. coronata avenae* and 21 of *P. graminis avenae* were collected on cultivated, volunteer and wild oats in different regions of Italy.

These samples were initially increased on very susceptible varieties, i.e. *P. coronata* on 'Markton' and *P. graminis* on 'Marvellous'. Then each sample was transferred on the differential varieties to determine its reactions. Several monosoric isolations (Vallega 1942, 1944) were evaluated to confirm the determination of the races. The work was conducted in the greenhouse, where the temperature was maintained between 20 and 25°C.

The following differential varieties, suggested respectively by Simons & Murphy (1955) and Stewart & Roberts (1970), were used:

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* The authors wish to thank Dr. J. Vallega for guidance and assistance, and Prof. A. Ciccarone for encouragement and advice.

P. coronata avenae		P. graminis avenae	
1 - Anthony	(C.I.2143)	1 - Minrus	(C.I.2144)
2 - Victoria	(C.I.2401)	2 - Richland	(C.I. 787)
3 - Appler	(C.I.1815)	3 - Joanette	(C.I.2660)
4 - Bond	(C.I.2733)	4 - Rodney	(C.I.6661)
5 - Landhafer	(C.I.3522)	8 - Eagle^{2}xC.I.4023	(C.I.8111)
6 - Santa Fè	(C.I.4519)	9 - Santa Fè Sel.	(C.I.5844)
7 - Ukraine	(C.I.3259)	Sa - Saia	(C.I.4639)
8 - Trispermia	(C.I.4009)		
9 - Bondovic	(C.I.5401)		
10 - Saia	(C.I.4639)		

RESULTS AND CONCLUSIONS

As a result of rust screening in 1974, nine physiologic races of P. coronata avenae and five races of P. graminis avenae were identified in Italy.

(a) - Puccinia coronata avenae. Races found in 1974 were the following: 263, 264, 265, 276, 325, 384, 409 and 410. Races 263, 264, 265, 276 and 325 had previously been described in Italy by Zitelli & Vallega (1968), who had also found races 348, 277, 286, 202, 203, 448, 375, 262 and 347 during the period 1961-1965. Races 384, 409, 410 are new for Italy.

All races isolated in 1974 are virulent on Appler, Bond, Landhafer, Santa Fe, Trispermia and Bondovic. Races 409 and 264, which exhibited the widest spectrum of virulence, attack all the differential hosts except Ukraine and Saia, respectively.

The scale of sampling was not large enough to allow definitive conclusions about the frequency and geographical distribution of races to be drawn. However, races 264, 325 and 410 were met most frequently (Table 1).

Table 1. Frequency and geographical distribution of physiologic races of P. coronata avenae isolated in Italy, 1974.

Region	Number of times each race was isolated									Total number of isolations	Number of Races
	263	264	265	276	325	384	385	409	410		
Abruzzi	-	2	-	2	2	4	2	-	5	17	6
Apulia	-	4	-	-	-	-	3	-	3	10	3
Basilicata	-	2	-	-	-	-	-	-	-	2	1
Calabria	-	6	-	1	4	-	-	-	2	13	4
Campania	3	2	1	-	2	-	2	1	2	13	7
Emilia-Romagna	-	2	1	-	5	1	3	-	2	14	6
Latium	-	-	-	-	-	-	1	1	2	4	3
Lombardy	-	1	-	-	3	-	-	-	3	7	3
Marches	3	-	-	-	2	-	-	-	-	5	2
Sardinia	1	-	1	-	3	-	-	-	-	5	3
Sicily	-	2	-	-	1	-	-	1	2	6	4
Tuscany	3	1	-	-	3	-	-	-	1	8	4
Umbria	1	2	-	-	-	-	-	-	1	4	3
Veneto	-	2	-	1	1	-	1	-	2	7	5
Total for each race:											
No.	11	26	3	4	26	5	12	3	25	115	9
%	9.6	22.6	2.6	3.5	22.6	4.3	10.4	2.6	21.7		

All races found in Italy in 1974 have been already identified in other countries of the Mediterranean Basin (Wahl & Schreiter, 1953; Wahl, 1959; Kostic, 1964; Santiago, 1968; Sebesta, 1972; Dinoor, 1973; Salazar & Martinez, 1973).

(b) - Puccinia graminis avenae. Races 76, 77, 80, It.3^n[1] (=2,3,4,8,Sa/1.9)[1] and It.6^n(=4,Sa/1,2,3,8,9), have been isolated in Italy in 1974. They are all different from those identified during the period 1961-66 by Zitelli & Vallega (1968). It.3^n and It.6^n are such according to the old classification of Levine and Smith, but by the use of the additional differentials, a "New race number" must be given, according to the key proposed by Stewart and Roberts (1970).

Their pathogenic behaviour is as follows: It.2^n (=1,2,4,8,9,Sa/3), It.8^n (=1,4,8,9,Sa/2,3), It.11^n (=1,3,4,8,9,Sa/2) and 72 (=4,9,Sa/1,2,3,8).

All races found in 1974 are avirulent to Rodney (Pg4) and Saia (Sa) but virulent on Santa Fè Sel. C.I.5844 (pg9).

The race with the widest spectrum of virulence with respect to the differentials we utilised proved to be It.6^n, which was avirulent to Rodney and Saia only. This is very similar to race 72, previously found in Italy (Vallega & Zitelli, 1964; Zitelli & Vallega, 1968), in Canada (where it is known as 6F), in Sweden (where it is known as 6B) and in Israel (where it is known as 6). However It.6^n has shown, in addition, virulence to Santa Fe Sel. C.I.5844.

Race 80 was isolated twelve times on twenty samples collected in six regions of Italy (Abruzzi, Campania, Emilia-Romagna, Molise, Apulia and Sicily); 3^n was identified three times; 76, 77 and 6^n were detected twice.

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(1) The formula indicates avirulence and virulence towards the set of differential varieties suggested by Stewart and Roberts (1970).

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DEPOSITION OF PUCCINIA STRIIFORMIS UREDOSPORES ON ADULT WHEAT PLANTS IN LABORATORY EXPERIMENTS

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The effects of inherited differences in growth habit of adult winter wheat plants on the deposition of Puccinia striiformis West. uredospores on the leaves, were studied in three laboratory experiments. The object of the experiments was to find if an erect growth habit could contribute to disease escape of adult plants through decreased spore deposition.

MATERIALS AND METHODS

The following winter wheat varieties were used in one or more of the experiments:-

Maris Widgeon (experiment 1))	fairly prostrate flag leaves
Cappelle-Desprez (experiment 2))	
Little Joss (experiments 2 and 3))	
Holdfast (experiments 1 and 2)	fairly erect flag leaves
W1343 (experiments 1, 2 and 3)	an eligulate wheat with very erect flag leaves

Seedlings in small peat pots were vernalised at 6-10°C with a daylength of 14 h. They were then transplanted into 11.5 cm diameter plastic pots containing sterilised potting compost and were maintained in a spore-proofed glasshouse until the ligule of the flag leaf of the first tiller was just visible. Because the varieties grew and matured at different rates, sowing dates were adjusted so that plants of the different varieties were at the same growth stage at the time of inoculation.

In all three experiments, at least four plants of each variety were randomly arranged on a platform at the base of a spore settling tower 226 cm high and 68 cm in diameter. Uredospores of a mixture of four races of P. striiformis, namely 40 E8 (2B), 41 E136 (58C), 104 E137 (3/55D) and 104 E9 (3/55 Opal), were blown into the top of the tower and were allowed to settle on the plants below for approximately 15 min. The flag leaf, and in experiments 2 and 3 the adjacent leaves also, were detached from the stem of each tiller of the experimental plants for examination of the leaf surface under the microscope. Precautions were taken to avoid shaking uredospores from the inoculated leaves although previous experiments (Russell, unpublished data) had shown that P. striiformis uredospores are not easily dislodged from wheat leaves.

The detached leaves were cut into three segments (designated tip, middle and base in this paper) of approximately equal length. Individual segments were then sandwiched between two glass microscope slides, held together at each end with adhesive plastic tape. This enabled the segments to be flattened without disturbing the uredospores on the leaf surface. Both surfaces of each segments were examined under the microscope at a magnification

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of X100, using transmitted light. This method permitted the identification and counting of P. striiformis uredospores, which are heavily pigmented. The mean number of uredospores in ten randomly selected fields of view using the low power of the microscope, was recorded for both surfaces of all segments of each variety.

RESULTS

In experiment 1, significantly more uredospores were found on flag leaves of Maris Widgeon than on those of either Holdfast or W1343 (Table 1). Differences between leaf part means were also significant ($P < 0.01$); there were most spores on the abaxial surface of the middle segment and least on the abaxial base segment in each variety. Spore deposition differences between different parts of the leaf surface were much larger in W1343 than in Maris Widgeon.

Table 1. Mean numbers of P. striiformis uredospores observed per 10 microscope fields of view on flag leaves of three winter wheat varieties in experiment 1.

	Adaxial surface			Abaxial surface			Variety means S.E. ± 8.0 (L.S.D. 16.6)
	Base	Middle	Tip	Base	Middle	Tip	
W1343	4.5	12.4	14.8	11.2	68.2	28.8	23.3
Maris Widgeon	55.4	45.3	44.6	50.4	57.4	34.3	47.9
Holdfast	27.0	24.2	25.0	7.3	61.4	38.4	30.6
Leaf part means S.E. ± 10.5 (L.S.D. 20.6)	29.0	27.3	28.1	23.0	62.4	33.8	

In experiment 2, significantly fewer spores were found on flag leaves of W1343 than on those of Cappelle-Desprez (Table 2). Varietal differences on the adjacent leaf 2 were small and insignificant. In Cappelle-Desprez there were significantly more spores on the flag leaf than on leaf 2; a similar trend was observed in Little Joss and Holdfast but not in W1343. Differences between leaf part means were highly significant ($P < 0.001$) and, as in experiment 1, most spores were found on the middle segment of the abaxial surface and least on the abaxial base segment.

In experiment 3, where spore deposition was compared on the flag leaf and leaves 2 and 3 of W1343 and Little Joss, there were significant differences in number of uredospores found between variety/leaf means ($P < 0.01$). Most spores were observed on the flag leaf and least on leaf 3 (Table 3). There were significantly fewer spores on flag leaves of W1343 than on those of Little Joss and a similar trend was observed on leaf 2 but not on leaf 3. As in the other experiments, differences between leaf parts were highly significant ($P < 0.001$), most spores again being found on the middle segment and least on the base segment of the abaxial surface.

Table 2. Mean numbers of *P. striiformis* uredospores observed per 10 fields of view on flag and adjacent leaves of four winter wheat varieties in experiment 2.

		Adaxial surface			Abaxial surface			Variety/leaf means S.E. ± 12.7 (L.S.D. 26.4)
		Base	Middle	Tip	Base	Middle	Tip	
W1343								
	flag	1.0	6.5	12.5	30.8	45.0	23.0	19.8
	leaf 2	5.8	11.3	10.5	8.3	59.5	20.3	19.3
Little Joss								
	flag	49.8	4.2	10.0	5.5	128.2	41.2	39.8
	leaf 2	24.5	11.3	19.2	3.3	26.2	68.0	25.4
Cappelle-Desprez								
	flag	44.2	44.8	51.8	16.0	135.8	29.2	53.6
	leaf 2	29.2	16.0	11.8	1.5	35.3	10.5	17.4
Holdfast								
	flag	47.5	61.5	36.0	26.8	3.8	29.5	34.2
	leaf 2	19.8	4.0	3.5	4.2	31.2	30.0	15.5
Leaf part means S.E. ± 11.1 (L.S.D. 21.9)		27.7	20.0	19.4	12.0	58.1	31.5	

Table 3. Mean numbers of *P. striiformis* uredospores observed per 10 fields of view on flag leaf and leaves 2 and 3 on W1343 and Little Joss in experiment 3.

		Adaxial surface			Abaxial surface			Variety/leaf means S.E. ± 4.8 (L.S.D. 10.7)
		Base	Middle	Tip	Base	Middle	Tip	
W1343								
	flag	2.4	11.4	4.7	10.7	33.7	31.7	15.7
	leaf 2	3.0	13.7	1.4	5.0	13.7	21.0	9.6
	leaf 3	0.4	14.0	7.4	4.0	5.4	7.7	6.5
Little Joss								
	flag	54.3	9.3	11.7	5.4	74.0	51.4	34.3
	leaf 2	21.3	22.4	23.3	3.3	31.3	6.0	18.0
	leaf 3	13.3	21.3	8.4	0.7	2.1	15.7	10.2
Leaf part mean S.E. ± 5.3 (L.S.D. 10.5)		15.8	15.4	9.5	4.9	26.7	22.2	

For differences within Table S.E. = 12.7 (L.S.D. = 25.7)

DISCUSSION

These experiments have shown that, under controlled inoculation conditions, fewer *P. striiformis* uredospores were deposited on flag leaves of the eligulate wheat, W1343, than on Cappelle-Desprez, Maris Widgeon or Little Joss. In experiment 1, and in two other experiments which did not include W1343 (Russell, unpublished data), spore deposition was less on flag leaves of Holdfast than on those of Cappelle-Desprez or Little Joss. The flag leaves of W1343, and to a smaller extent those of Holdfast, are more erect than those of the other varieties examined.

The highest concentration of uredospores was consistently found on the abaxial surface of the middle segment of the leaf and the lowest on the abaxial surface of the base segment. Several leaves of each variety were examined in an attempt to explain these differences in spore deposition between different parts of the leaf surface. It was found that, as expected, the base of the abaxial surface always faced downwards and was not therefore exposed directly to the settling of uredospores in relatively still air. The lamina was often twisted, however, in such a way that the middle segment of the abaxial surface was uppermost and exposed to spore settling. The tip of the adaxial surface was usually uppermost but was often pendulous in varieties with prostrate leaves. This may explain why fewer spores were found on the tip than on the middle segment.

These experiments have shown that an erect growth habit can contribute to disease escape by reducing deposition of _P. striiformis_ uredospores on the leaves. An erect growth habit may therefore be a character which is capable of exploitation by the plant breeder, in conjunction with other forms of inherited resistance to yellow rust (Russell & Hudson, 1973), in the production of disease-resistant wheat varieties. An inherited tendency for low spore deposition on the adaxial leaf surface, particularly the distal parts, where the highest percentage germination of _P. striiformis_ uredospores has been shown to occur (Russell, 1975), would be particularly advantageous.

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A CORRECTION

The following corrections should be made to the article 'A Character Designation of the Host in Host-parasite systems and a representation of the corresponding genes', by A.P.do Carmo e Freitas, in Vol. 2, Part 2 (pp 33-38) of this Bulletin, to correct errors in the original manuscript.

1. Page 33, fourth line from the bottom should read:

   The specific host character needs to include low (R -) and high (rr) ..

2. Page 34, lines 18-20 should read:

   "Hmn:P" will represent an allele for pathogenicity n at the locus m with reference to a specific host: parasite association (symbols H and P). The corresponding gene for receptivity will be represented by "Pmn:H".

EDITORIAL NOTE

Owing to a printing error, the cover of Vol. 3, Part 1 was labelled 'Volume 3, Part 2'. Each of the articles had the correct part number incorporated in its heading.

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