INTERNATIONAL PATHOGENICITY SURVEY OF WHEAT LEAF RUST PATHOGEN AND SOURCES OF RESISTANCE

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Abstract

Boskovic, M. M. 1986. International pathogenicity survey of wheat leaf rust pathogen and sources of resistance. Arab J. Pl. Prot. 4: 135 - 128

The importance of international investigation of wheat rusts pathogens is emphasized and organisation of these works explained. A review of the main results with international survey of *Puccinia recondita tritici* related to several systems and host differentials is presented. Sources of resistance and survey systems are discussed. Parasite: host: environment interactions as a whole are very complex and new approach about P:H:E informations can best be conveyed in relation to host units. Our real goal is to know genetically to the maximum extent sources of resistance. New objectives and procedures in international survey of leaf rust fungus are explained. It is necessary to search for and document pathogenicity of *Puccinia recondita tritici* cultures useful in differentiating genetically different sources of resistance. Emphasis will be placed on sources of resistance and their usefulness rather than on description of pathogenicity of fungus populations.

Additional key words: wheat rusts, sources of resistance.

The Problem

For many years now leaf rust caused by *Puccinia recondita tritici* has posed a great problem in normal wheat production, as the most widespread wheat disease in the world.

Samborski and Peturson (25) reported reduction in yield of 58 percent at Winnipeg. Applying fungicides Conzales (14) found differences in yields between two varieties susceptible to leaf rust amounting to 28 - 34% in one year and 34 - 45% the following year. The trials conducted over a period of several years showed that the degree of susceptibility and tolerance of various wheat varieties have a considerable interference on the yield losses caused by leaf rust which varied between 5 - 45% (2).

Wheat rusts are a typical example of the indispensability of international cooperation dictated by the nature of a problem.

Long distance dissemination of the rust pathogens is a well-established phenomenon. Wind is a great uncontrolled carrier of inoculum. Uredospores of rust fungi are recognized as international travellers along the «wind-routes». Rust spores travel from Africa to Europe (17, 29), from Mexico to USA and Canada (27), from Australia to Newzealand (28), from China to Japan, and from Ethiopia to the Mediterranean region (16). In the Indian sub-continent rust spores make big jumps from the source areas to the plains (22, 23). Long distances are covered either in a single jump, or by a series of jumps which necessitates the build up of inoculum at each successive step. At high elevations, uredospores are exposed to certain adverse, lethal climatic conditions. Wheat rust uredospores cannot stand temperature extremes and ultraviolet radiation. However, despite these limitations, some uredospores are carried in viable state and cause infections thousands of kilometers away.

In order to find the best and the most suitable solutions for numerous problems of wheat rusts, it was necessary to establish an international cooperation within one broader epidemiological region. The importance and necessity of the cooperative international investigations of the wheat rusts was especially emphasized at the European and Mediterranean Cereal Rusts Conferences in Cambridge (1964), Oeiras / Portugal (1968), Praque / Czechoslovakia (1972), Interlaken / Switzerland (1976), Bari and Rome / Italy (1980) and Grignon / France (1984). The resolutions of the First International Congress of Plant Pathology, London, 1968, were passed recommending a worldwide survey of virulent genes in pathogen populations by means of lines monogenic for factors of resistance. The International Biological Program was realizing these recommendations with some help of European and Mediterranean Cereal Rust Foundation.

Cooperative research of yellow rust of wheat for Europe and some countries of Asia and Africa started in 1962 in Netherlands and Germany. Somewhat later, similar investigation of stem rust for such a broad area started in Portugal and finally of wheat leaf rust in Yugoslavia in 1966.

These investigations were primarily directed to the geographic distribution of physiologic races, the discovery of new races and testing sources of resistance. The greatest part of these research results was already published.

International Pathogenicity Survey of *Puccinia recondita tritici.*

From the very beginning of the leaf rust project standard differential varieties with differentiation of U.N. (Unified

Numeration) races proposed by Johnston (19) and Basile (1) were used. In the four year period, 1967 to 1970, 24 U.N. races were identified for 34 countries of Europe, Asia and Africa (3, 4). The leading one was U.N. race 3 with 42.29% of the total isolates. The second place was occupied by U.N. race 13 with 29.45% and then follow: U.N. race 17 (8.39%), U.N. race 8 (4.60%), U.N. race 6 (3.10%), U.N. race 9 (2.84%), U.N. race 2 (1.95%), U.N. race 10 (1.68%) and U.N. race 4 (1.35%). The other fifteen U.N. races have had less than one percent of the total isolates. In this period seventy five standard races were identified and proved variability potential of the pathogen. Some countries in Asia and Africa compared with the European part did not show much difference in composition and prevalence of races, which proved epidemiologic relation between regions.

In this period leaf rust nurseries were tested in the most European and Mediterranean countries of Asia and Africa as well as in some countries of Near and Middle East. The nurseries contained sources of resistance and the best results with leaf rust and other diseases had been reported (3).

Browder (10) first stated that the classic pathogenic race concept was inadequate and may, particulary in relation to breeding cultivars for specific resistance, be better served by other means. Information of parasite genotypes was conveyed only to the extent of one's knowledge of the genetic make-up of the hosts in the differential set. However, genes, not arbitrarily chosen gene combinations, are the functional, segregating units; genes for pathogenicity singly are the inherited units. Thus, a direct method was needed to relate information about genes for pathogenicity in parasite populations to genes for resistance in host plants and about gene association in both organisms.

Pathogenic race names were inadequate since the variation in *P. recondita* : *Triticum aestivum* system is so extensive that it would be impossible to describe and name all the races if all the existing variation was included in the taxonomic system (20).

International pathogenicity surveys from 1970 to 1974 had been accomplished by using near-isogenic wheat lines having different genes for low reactions (5).

Virulence frequencies are presented in table 1.

Very high virulence frequencies in the whole period have been found on the Lr10, Lr16 and Lr17 lines, while on Lr18 some lower percentage have been registered in 1972 and 1973. In the first two years also rather lower virulence frequencies can be observed on the Lr3B line. On the strong resistance genes Lr9 and Lr19 in each year only a few single susceptible reactions were found. More susceptible reactions in 1970 and 1971 have been registered on the variety Aghata possessing Lr 19, which was used in the first two years instead of single gene Lr 19 backcross line in variety Thatcher.

The virulence formulas identified in 1970 were 31, 1971 - 19, 1972 - 12, 1973 - 11 but in 1974 only 8 with almost complete susceptibility of all eight Lr lines by 92.30 per cent of the total isolates. The collections from 41 countries which have been analyzed in this period were sent mostly from Europe, Asia and Africa, and the number of countries varied in individual years, from 13 to 28. The adult plant reactions of these Lr lines in the nurseries were mostly susceptible. Some more resistance in several localities were registered only on Lr 18 line.

In a separate paper were illustrated in details for 1972 the considerable differences on the same basic Lr lines between the populations of *Puccinia recondita f. sp. tritici* of European-Mediterranean area, U.S.A. and Canada (6).

Virulence frequencies for each of the three samples are shown in table 2.

Table 1. Virulence frequencies to twelve near-isogenic wheat lines having different genes for low reactions to *Puccinia recondita* f. sp. *tritici* in 1970 - 1974 International pathogenicity surveys of the pathogen.

Lr Line	Virulence frequencies by years				
	1970	1971	1972	1973	1974
LR 1/TC. Centenario/	53.26	32.35	97.24	100.00	100.00
LR 2A/TC. Webster/	52.34	32.35	96.35	98.59	98.35
LR 2D/PL Loros/	99.34	77.75	100.00	97.18	99.45
LR 3A/TC. Democrat/	90.46	94.11	100.00	98.59	98.35
LR 10/TC. Exchange/	99.21	99.81	100.00	85.91	100.00
LR 16/TC. Exchange/	98.30	99.81	87.88	87.88	100.00
LR 17/TC. Kl. Lucero/	94.12	100.00	99.81	100.00	98.90
LR 18/TC. Africa 43/	99.47	96.13	77.19	66.90	96.70
LR 3B/TC. Aniversario/	64.05	43.35	93.98	78.84	99.09
LR 14b/TC. M. Escobar/	99.85	99.76	98.83	91.61	100.00
LR 9/TC./	01.39	00.23	00.58	00.00	00.00
LR 19/TC./	19.16	03.49	00.97	00.64	00.00

Table 2. A comparison of virulence frequencies to nine near isogenic wheat lines having different genes for low reaction to *Puccinia recondita* f. sp. *tritici* in samples of *P. recondita* taken in European-Mediterranean countries, the United States, and Canada in 1972.

Line name	Line no.	Virulence frequency in sample from:		
		Europe[a]	United States[b]	Canada[c]
LR 1 (TC)	RL 6003	97.2	34.6	6.5
LR 2A (TC)	RL 6000	96.4	17.3	2.4
LR 2D (PL)	RL 6001	100.0	26.8	11.2
LR 3A (TC)	RL 6002	100.0	89.4	96.4
LR 10 (TC)	RL 6004	100.0	67.6	46.7
LR 16 (TC)	RL 6005	87.9	5.0	4.7
LR 17 (TC)	RL 6008	99.8	15.4	5.9
LR 18 (TC)	RL 6009	77.2	4.5	23.1
LR 3B (TC)	RL 6007	94.0	11.1	- -

(a) Data from 545 isolates collected in 24 European and Mediterranean countries.
(b) Data from 809 isolates collected in 32 States.
(c) Data from Samborski,D.J. 1972. Leaf rust of wheat in Canada in 1972. Can. Plant Dis. Surv. 52: 168 - 170.

Pathogenicity of *Puccinia recondita tritici* to nine near-isogenic lines of *Triticum aestivum* was determined by assaying samples from 24 European and Mediterranean countries, and 32 States of the United States in 1972. These lines carried *Lr 1*, *Lr 2A*, *Lr 2D*, *Lr 3A*, *Lr 10*, *Lr 16*, *Lr 17*, *Lr 18*, or *Lr 3B*. Data from these studies were compared with each other and with data from a similar study made in Canada the same year in which eight of the same nine lines were used. Virulence frequencies to all the lines were very high in the European-Mediterranean sample, whereas virulence frequencies were high to only two of the lines in the samples from the United States and Canada. Sixty-three percent of the 545 isolates in the European-Mediterranean sample had combined virulence to all eight of the lines, but none of the isolates from the United States or Canada had virulence to more than seven of the lines. These data indicate that the host lines used are of limited value in survey studies of pathogenicity in the European-Mediterranean countries. These lines have no value to plant breeding for leaf rust resistance in the European-Mediterranean countries; however, there is value in knowing of pathogenicity to them in epidemiological studies.

After this period it was essential to include some other experimental differential wheat lines in international survey. Two sets each with ten experimental host differentials were established and used for 1977 and 1978. The first set contained differentials with insufficiently known genetical background. In the second one most of the lines were better known genetically. These lines were selected from material received and recommended by Australian scientists (personal communication). The results were reported (7).

Total virulence frequencies of *Puccinia recondita* f. sp. *tritici*. in the seedling stage and field reactions in the nurseries on the first set of those differentials are presented for two years in Table 3.

The wheat lines or varieties listed in the table have been selected after several years of preliminary testing. Only the first variety Arthur was replaced for 1978 with Arthur 71. It is known that Agent has the Lr 24 gene for which there were low virulence frequencies and statisfactory field reactions. For field data of the nurseries it should be mentioned that severity of leaf rust was higher in 1978 than in 1979. Differential nursery reactions (D) with average MS or S reponse but with low severity could be valid but where the average susceptibility was of high severity would not be reliable. This is because high severity would be more likely to fluctuate with time even though the variety might be completely susceptible to all races.

Tobari 66 contains two weak genes Lr 1 and Lr 20 and may be some other resistance genes. These genes in mutual interactions are quite differentially valuable in the seedling stage, followed by good field reactions. In Canada for the first time in 1977 some virulent cultures were found on Tobari 66 (26). Waldron with several known genes (Lr 1, 2A, 10) and Jaral have shown good results, but for the second one there was an increased virulence frequency in 1978 although it retained still satisfactory field reactions.

In the countries from which collections were received in both years the parasite populations were different by years. In both years 18 countries were the same but 12 were different for 1977, and 11 for 1978.

Virulence for the wheat lines ND - 138 - 1 × Pa[5] and Gabo 56 × Backa[6] was at quite high frequencies and was indicated by differential nursery reactions with medium or high severity. Two other lines, Purdue 5119 × Bo - 5[6] and NS - 4R were better in both growth stages.

Table 3. Virulence frequencies of *Puccinia recondita* f. sp. *tritici* on ten experimental wheat lines in 1977 and 1978 international pathogenicity surveys, and average field reactions in the nurseries

Diff. variety/line	Total vir. frequencies in 1977	Average reactions * in nurseries, 1978	Total vir. frequencies in 1978	Average reaction in nurseries, 1979
Arthur (77), Arthur 71 (78)	54.17	*D(R,S – L. sev.)	11.11	R
Agent (Lr 24)	0.83	D(R,MS – L. sev.)	18.80	R
Tobari 66 (Lr 1,20)	68.33	–	50.43	R
Waldron (Lr 1,2A, 10)	11.67	D (R,S – L. sev.)	9.40	R
Jaral	11.67	–	72.65	D (R,MS – L. sev.)
ND-138- 1 × Pa[5] (Yu)	77.60	D (R,MS – M. sev.)	53.85	D (R,MS, S – M. sev.)
Gabo 56 Backa[6] (YU)	69.17	D (R,S – H. sev.)	68.38	D (R,S – M. sev.)
Purdue 5119 × Bo – 5[6] (YU)	35.00	–	14.50	D (R,MS – Tr.)
NS – 4R (Yu)	15.83	D (R,S – H. sev.)	9.40	D (R,S – L. sev.)
Kavkaz	87.50	–	27.35	D (R,S – H. sev.)
Number of virulence formulae	46		44	

D: differential reactions in different nurseries; R: resistant; MS: moderately susceptible; S: susceptible; L: low; M: medium; H: high – severity; Tr.: trace

Virulence analyses (Collections from countries)

1977 and 1978		Only 1977		Only 1978	
Algeria	Yemen	Belgium	Jordan	Equador	Italy
Austria	Kenya	Bulgaria	Luxemburg	Spain	Madagaskar
Bangladesh	Nepal	China	Paraguay	Upper Volta	Mexico
Chile	Pakistan	Cyprus	Saudi Arabia	Greece	Portugal
East Germany	Poland	Czechoslovakia	Tanzania	Iraq	Turkey
Egypt	Switzerland	Holland	West Germany	Iran	
Etiopia	Thayland				
France	Zambia				
India	Yugoslavia				

Table 4. Virulence frequencies of *Puccinia recondita* f. sp. *tritici* on second ten experimental wheat lines in 1977 and 1978 International pathogenicity surveys and average field reactions in the nurseries

Diff. variety/line		Total vir. frequencies in 1977	Total vir. frequencies in 1978	Average reactions in nurseries, 1979
CS/KF 1A	Lr 10	2.50	35.10	D (R,MS – L. sev.)
Kenya 1483	Lr 15	99.17	76.90	D (R,S – H. sev.)
Thew	Lr 20	52.20	99.20	D (R,S – H. sev) SEG.
Tc[6] × Lr. 21	Lr 21	99.17	89.70	R – MR
Tc[6] × Lee	Lr 23	13.33	64.90	D (R,MS – M. sev.)
Agent, CI 13523	Lr 24	0.83	18.80	R
Transec	Lr 25	5.83	61.60	D (R,S – H. sev.) SEG
Tobari 66	Lr 1,20	68.33	50.40	R
Waldron	Lr 1,2A,10	11.67	9.40	R
CS/KF 7D		59.17	85.40	R

D: differential reactions in different nurseries; R: resistant; MR: moderately resistant; MS: moderately susceptible; S: susceptible; L: low; M: medium; H: high-severity; SEG: segregation.

Kavkaz should have two unclassified resistance genes (18). Maybe these genes would be valuable only when combined. Using these ten differential cultivars it was possible to identify 46 virulence formulae for 1977 and 44 for 1978.

In table 4 are presented the results with another set of differential lines.

The first essential in a study of variation in pathogen virulence is to establish the most effective set of differential genes. It will be most useful to have a wide selection of isolated, identified genes that can be manipulated to produce different kinds of resistance as required. Simultaneously testing both the lines with single genes and with several genes for resistance leads to a more complete analysis of the population. After preliminary testing of some single gene lines and other resistant material provided and recommended by Australian colleagues, those of selected ones were included in the second experimental differential set. Several of the already used differentials in the first set with one or more known resistance genes were included in the second one, in order to have more complete composition of the known effective genes for the analysed population. The first seven lines carry the known genes Lr 10, 15, 20, 21, 23, 24 and 25. The next two as already explained, have a combination of weak single genes. In the last line CS/ KF 7D probably another resistance gene or genes are involved.

The diversity of total virulence frequencies in the table on these ten lines is quite evident. Increased virulence frequencies in 1978 were expressed on the lines with Lr genes 10, 20, 23, 25 and the line CS/KF 7D. Of these only Lr 10 and CS/KF 7D had good field resistance in the nurseries. The greater resistance of Lr 10 (CS/KF 1A) than of Lr 10 in the line TC × Exchange (RL 6004 «L» line) is remarkable.

Lr 21 showed good field resistance and the others were already explained. High segregation was noted in Thew and Transec. Identified virulence formulae were 27, in 1977 and 41 in 1978.

The named Lr genes have been shown to occur on 13 different chromosomes, in all 3 common wheat genomes. As it was shown Lr genes and their corresponding genes for pathogenicity are the basis for storing and retrieving information about specificity in the *P. recondita*: Triticum system. Browder (11) summarized information on thirty five genes for low reaction to *Puccinia recondita tritici* (Lr genes), origin, chromosome location, characteristic low infection types, relative environmental sensitivity, synonymy and reference host lines and cultures. Five Lr genes, Lr 12, Lr 13, Lr 22 a, Lr 22 b, and Lr 26 can be detected only by inoculating adult plants with an avirulent culture. Post-infection temperature influences the expression of all Lr genes; but some, Lr 11, Lr 12, Lr 13, Lr 14 a and Lr 18 are especially sensitive to high temperatures.

The value of Lr genes is ultimately to control leaf rust by manipulating Lr gene frequency in commercially grown wheat cultivars through breeding methods. Meanwhile, it is evident from knowledge of the gene-for -gene relationship that Lr genes protect plants from portions of parasite populations having the corresponding Lp genes. On the other hand in the last years some national surveys and other testing have shown good resistance specially in adult stage among Lr lines mostly only by Lr 9, 25, 28, Lr 19 and Lr 24 (9, 13, 24).

Sources of Resistance and New International Survey Approach

The narrow effective genetic base within Lr Lines particulary for breeding for resistance have stimulated breeding for new efficient genetic combinations transvered in one wheat backround.

Years ago we have started screening an extensive wheat germplasm for genetically different sources of resistance to be included into a scheme of recurrent selection aimed at the development of diverse resistances. Last three years, the progenies of these crosses were screened for resistance to a number of tipical cultures of *Puccinia recondita tritici* in order to gain knowledge of their genetic constitution of the resistance. The recurrent parents Princ and Starke were backcrossed two times with the donors.

The backcrosses were analysed for the presence of resistance genes in them by two cultures of the parasite (Boskovic and Momcilovic, 1984). Even from the same crosses genetically different resistances were obtained. Eighteen donors were used, selected, and numbered from International rusts nurseries.

Comparative testing using different cultures of the crossing progenies and 26 Lr. lines were performed. Only different progeny lines numbered 66, 77, 5, 143, 172 438 and 496 with the same reaction pattern of homozygous high resistance with Lr 19 were selected and crossed with Lr 9, Lr 19 and Lr 24 to see if these genes are eventually present in these hybrid lines. Their F – 2 progenies, together with the parental components and a susceptible control were screened for reaction to a *Puccinia recondita tritici* culture. The results are presented in table 5 (9).

The resistance frequency above 0.75 was quite prominent indicating that hybrids possess more than one pair of resistance genes. The only exception was the hybrid 66/1× Lr 9 coming from the non-homogenity of Lr 9. It was also quite evident that the resistance donors used do not possess either one of the three Lr genes (Lr 9, Lr 19 and Lr 24). The effects of the donors resistance were complemental, dominant or recessive genes. These produced high resistance by recombining the known or unknown weak resistance genes. The hybrids will continue to be screened by several parasite's cultures to select new genetic resistances in the lines possessing different combinations of donor's genes and Lr 9, Lr 19 and Lr 24.

More than ten years ago Day (15) suggested that in studies of pathogenic specialization the most important information is the frequency of certain critical virulence genes in the pathogen population, as well as a combination of virulence genes.

Table 5. The frequencies of resistant plants in F_2 of the crosses between six sources of leaf rust resistance with Lr 9, Lr 19 and Lr 24.

Expected res. genotype

Crosses	N° of plants	R	S	f (R)	Expected f (R)	P	From Lr	From Lines
66/1 Lr 9	181	110	71	0.60				
66/1 Lr 19	182	138	44	0.76	0.77	0.75 – 0.90	A – OR	bbcc
66/1 Lr 24	169	141	28	0.38	0.89	0.05 – 0.01	A – OR	B – C –
66/2 Lr 9	155	125	30	0.80	0.77	0.25 – 0.50	A – OR	bbcc
66/2 Lr 19	143	125	18	0.87	0.89	0.90 – 0.75	A – OR	B – C –
77 Lr 9	118	102	16	0.86	0.89	0.50 – 0.25	A – OR	B – C –
77 Lr 19	129	108	21	0.84	0.89	0.10	A – OR	B – C –
77 Lr 24	150	125	25	0.83	0.89	0.05 – 0.01	A – OR	B – C –
5 Lr 9	137	133	4	0.97	0.94	0.10 – 0.05	A – OR	B –
5 Lr 19	101	92	9	0.91	0.94	0.25 – 0.10	A – OR	B –
5 Lr 24	176	136	40	0.77	0.81	0.25 – 0.10	A – OR	bb
143 Lr 9	199	163	37	0.81	0.77	0.05 – 0.01	A – OR	bbcc
143 Lr 19	83	79	4	0.95	0.89	0.05 – 0.01	A – OR	B – C –
143 Lr 24	140	128	12	0.91	0.89	0.50 – 0.25	A – OR	B – C –
438 Lr 9	71	67	4	0.94	0.89	0.10 – 0.25	A – OR	B – C –
438 Lr 19	140	131	9	0.94	0.89	0.10 – 0.25	A – OR	B – C –
438 Lr 24	167	159	8	0.95	0.89	0.05 – 0.01	A – OR	B – C –
496 Lr 9	155	142	13	0.91	0.89	0.50 – 0.25	A – OR	B – C –
496 Lr 19	134	116	18	0.87	0.89	0.50 – 0.25	A – OR	B – C –

These ideas suggested that a population genetics approach to the study of pathogenic specialization may be more useful than a taxonomic approach. The major objective of pathogenicity surveys should be to adequately describe pathogen populations, so that the informations can be used effectively in breeding programs rather than attempting to name all the variants present in the fungal population.

Close to these ideas is our new objective in international pathogenicity survey of *P. recondita tritici* – to provide genetically diverse sources of resistance to wheat leaf rust for use in European – Mediterranean regions – to search for and document pathogenicity of *P. recondita tritici* cultures useful in differentiating sources of resistances. Emphasis will be placed on sources of resistance and their usefulness rather than on description of pathogenicity of fungus populations.

Regional Field nurseries approach will involve testing of a uniform set of winter and spring wheat lines genetically different and highly resistant to *P. recondita tritici*. This set will be exposed to the naturally occuring pathogen populations at many sites of the Eur-Med. regions. The materials in these nurseries will also provide a basis for collecting uredial cultures which are virulent to some or all of the wheat lines. These cultures will then be used in further greenhouse and laboratory studies of the genetic relationships of the sources of resistance and to search for other sources of resistance. The cultures to be used will be selected in such a way as to maximize probability of showing genotypic differences in the wheat lines.

In this study logic analysis of infection – type data, aegricorpus phenotypes which indicate aegricorpus, parasite and host genotypes will be applied according to Loegering (21). Browder's (12) considerations of the parasite: host: environment specificity will be included in the methods of analysis. Ultimately we manipulate the host; then information about P: H: E systems can best be conveyed in relation to host units.

Emphasis in data analysis would be on reporting useful sources of resistance and indications that given sources of resistance are different.

When virulence to a given line is found and confirmed by greenhouse tests, that line will be removed from the field nursery and replaced by another line with potential value.

This procedure is based on the concept of maximizing the number of sources of resistance to be studied.

It is assumed that once virulent cultures are available, these cultures can be used to separate that line from other sources of resistance.

Analysis of infection-type data will be done to distinguish between sources of resistance and to evaluate the usefulness of the different sources of resistance in various places of the Europ.-Med. regions.

الملخص

بوسكوفتش، م. م. 1986 . المسح الدولي لباثولوجية مسبب مرض صدأ الأوراق (الصدأ البرتقالي) ومصادر المقاومة في القمح . مجلة وقاية النبات العربية 4 : 128 - 135

جرى في المقالة التأكيد على أهمية الدراسات الدولية لأصداء القمح وأوضحت عملية تنظيم هذه الدراسات وقدمت كمثال النتائج المهمة للمسح الدولي على المسبب المرضي لصدأ الأوراق *(Puccinia recondita tritici)* وعلاقة هذه النتائج بالبرامج المتعددة التي تقوم بهذه الدراسات وكذلك استعمال أصناف القمح المعرفة (المفرقة) لسلالات المسبب المرضي بالإضافة إلى مصادر المقاومة في النبات والمستعملة من قبل تلك البرامج . إن العلاقة، المسبب المرضي : العائل : عوامل البيئة ككل هي علاقة مركبة وإن أحدث الطرق لتوضيح هذه العلاقة هي وحدة العائل والتي جرى شرحها والتركيز عليها في المقالة . كذلك أوضحت في هذه الدراسة الأهداف والطرق المستعملة في المسح الدولي لمسبب مرض صدأ الأوراق، نظراً لأن الهدف الرئيسي من الدراسة يتركز على معرفة التركيبة لأكبر حد ممكن لمصادر المقاومة . ونجد من الضروري تعريف عزلات المسبب المرضي وتوثيق باتولوجيتها، إذ إنها المفتاح الرئيسي في التباين الوراثي لمصادر المقاومة المختلفة في العائل، وعدم الاكتفاء بوصف باتولوجية مجموعة المسبب المرضي .

كلمات مفتاحية : أصداء القمح، مصادر المقاومة .

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