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ORIGIN OF NEW RACES IN WHEAT RUSTS IN THE ABSENCE OF ALTERNATE HOSTS AND ITS IMPACT ON BREEDING RESISTANT VARIETIES

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SUMMARY

In India, where alternate hosts of wheat rusts are non-functional, means other than hybridization must account for new races. In a study of the phenomenon of somatic recombinations in stem and leaf rusts, new races have been obtained from mixtures of race 15CM with 14 and 17 of stem rust and races 107 CM with 17 and 63 of leaf rust.

The possibility of introduction of inoculum of races from neighboring countries is suggested, and the significance of the appearnace ofnew races in breeding for rust resistance discussed.

The main source of origin of new physiologic races in wheat rusts is hybridization. But in India, although the alternate hosts, *Berberis* and *Thalictrum*, are non-functional (MEHTA, 1940; PRASADA, 1947), new races have been picked up from time to time. Consequently, mechanisms other than hybridization (heterokaryosis, somatic hybridization, mutation, etc.) may be responsible for the origin of new races. These have received great attention in recent years in USA and Australia. In India very little work has been done on these aspects. Observations on mutations in races 14 and 15 of *Puccinia graminis tritici* and race 107 of *P. recondita*, and on vegetative recombinations are reported here.

MUTATION

A mutant of race 14 of *P. graminis tritici* which appeared in the type culture on cultivar Little Club is primarily a colour mutant, but it also shows minor differences from the parent race in virulence on Marquis and Kota.

Two pathogenic mutants were obtained in race 15 of *P. graminis tritici* by inoculating the seedlings of wheat cultivar Lee, which is resistant to this race. One orange-coloured and one normal pustule were observed. Both the resulting mutant cultures are more virulent on "Lee" than the parent race, but on the standard differential hosts they produce similar reactions (SHARMA and PRASADA, 1966).

In race 107 of *P. recondita* a light-yellow-coloured pustule was observed in the greenhouse cultures which produced infection types similar to those of the parent race 107 on the standard differential hosts.

VEGETATIVE RECOMBINATION

Stem Rust

Single uredospore cultures of standard races 15CM (orange mutant), 14, 17, 21, 24, 42, and 117 (all red), were used in six different mixtures, all including 15 CM. Seedlings of Reliance or Kota or of both were inoculated with each mixture.

As the orange 15 CM is highly virulent on both Reliance and Kota, the red races 14, 24, 42 and 117 are avirulent on both the cultivars, and races 17 and 21 are avirulent only on Reliance, normally no red, susceptible-type pustule could be expected on either cultivar where the red component was avirulent. Hence any red, susceptible pustule appearing unexpectedly on Reliance or Kota was isolated as a possible recombinant and increased on seedlings of a susceptible wheat; and each culture was inoculated four to six times on a set of 25 wheat cultivars including the differential hosts.

Table 1. Infection types[1] of parent stem-rust races 15CM (orange) and 14 (red) and of recombinants obtained by mixing them

Wheat	Parent Races		Recombinant races							
cultivar	15CM	14	1[2]	2[2]	3	4	5	6	7[2]	8
Little Club	4	4	4	4	4	4	4	4	4	4
Marquis	4	0;-2	4	4	4	0;-2	4	4	4	4
Reliance	4	0;	0;	0;	4	0;	4	0;	4	4
Kota	4	0;-2	0;	4	4	0;-1	4	4	4	4
Arnautka	4	4	4	4	4	4	4	4	4	4
Mindum	4	4	4	4	4	4	4	4	4	4
Spelmar	4	4	4	4	4	4	4	4	4	4
Kubanka	4	4	4	2	4	4	4	4	4	4
Acme	4	4	0;-2	0;	4	4	4	4	4	4
Einkorn	4	4	0;	0;	4	4	4	3	0;	0;
Vernal	4	0;	0;	0;	0;	0;	4	0;	0;	0;
Khapli	0;-1	0;-1	0;	0;-1	0;-1	0;-1	0;-1	0;-2	0;	0;
Charter	4	0;	0;	0;	4	0;	4	0;	0;	0;
Yalta	4	0;	0;	0;	4	0;	4	0;	0;	0;
E535	4	0;	0;	0;	4	0;	4	0;	0;	0;
Selkirk	4	2	3	3	4	2	4	0;-2	4	0;
Agra Local	4	4	4	4	4	4	4	4	4	4
Resembles standard race number					11	14	15-C	17	34 (R-1)	34 (R-2)

[1]According to notation of STAKMAN and LEVINE (1922). [2]Previously undescribed.

Recombinants were isolated from only two mixtures, viz. 15CM with 14 and 15CM with 17. As a result of mixing races 15CM and 14, eight races and biotypes were isolated, of which three were previously undescribed. From the combination of races 15CM and 17, six races and biotypes were identified, of which three were new and previously undescribed (Tables 1 and 2).

Table 2. Infection types of parent stem-rust races 15CM (orange) and 17 (red) and of recombinants obtained from mixing them

Wheat cultivar	Parent races		Recombinant races					
	15CM	17	1[1]	2[1]	3	4[1]	5	6
Little Club	4	4	2	0;-2	4	4	4	4
Marquis	4	4	4	3	4	4	4	4
Reliance	4	0;	4	3	4	4	4	0;
Kota	4	4	3	3	4	4	4	4
Arnautka	4	4	4	4	4	4	4	4
Mindum	4	4	4	4	4	4	4	4
Spelmar	4	4	4	3	4	4	4	4
Kubanka	4	4	3	4	4	4	4	4
Acme	4	4	3	3	3	4	4	4
Einkorn	4	3-4	0;	0;	0;	4	4	4
Vernal	4	0;	2-3	3	4	4	4	0;
Khapli	0;-1	0;	0;-2	0;-1	0;-1	0;-1	0;-1	0;
Charter	4	0;	0;	0;	0;	4	4	0;
Yalta	4	0;	0;	0;	0;	4	4	0;
E535	4	0;	4	4	0;	0;-2	4	0;
Agra Local	4	4	4	4	4	4	4	4
Resembles standard race number					40	15 biotype	15-C	17

[1]Previously undescribed.

Recombinant races which produced infection types on standard differentials similar to those of earlier known races were compared with type cultures of these latter on additional wheat cultivars. No difference could be observed except in the isolates of race 34 (R-1 and R-2 in Table 1). Some recombinant isolates were typical of the type culture of that race, while others were different from it on wheat cultivars Selkirk and Golden Ball, and from race 34-A on Charter, Yalta, and Bowie.

Leaf Rust

Race 107CM (yellow), a mutant from race 107, was mixed with the uredospores of other normal orange-coloured races 16, 17, 63 and 21, separately, and inoculated on the seedlings of 8 differential varieties (JOHNSON and MAINS, 1932) in separate experiments. All these four races are avirulent on most of the differentials, and only one or two cultivars are susceptible to them. Race 107CM is highly virulent on 5 cultivars (Carina, Brevit, Webster, Loros and Hussar). From these cultivars, if the other race of the mixture was avirulent, all normal-orange, susceptible-type pustules produced were isolated and increased on the seedlings of a highly susceptible wheat, and inoculated 4-5 times on the set of differential hosts.

Table 3. Infection types[1] produced by parent leaf-rust races 107CM and 17 and their somatic recombinants on the differential hosts

Varieties	Parent races		Recombinant race						
	107CM	17	1[2]	2	3	4[2]	5[2]	6	7
Malakof	0	4	4	0	0	0	0	0	0
Carina	4	0	0	4	3	0	0	3-4	4
Brevit	4	0	1-2	4	4	4	4	3-4	4
Webster	4	0	0	4	3	0	0	0-1	4
Loros	4	0	0	3	4	0	0	2-3	4
Mediterranean	0-1	0	0	0	0	0	0	0-1	3
Hussar	3-4	4	3	0	3	4	0	0-1	4
Democrat	0-1	0	3	0	0-1	0	0	0-1	4
Agra Local	4	4	4	4	4	4	4	4	4
Resembles international race no.			52	106	107	120	123	131	162

[1]JOHNSTON and MAINS (1932). [2]Previously undescribed from India.

The mixture of race 107CM with 17 produced seven races (three of them new to India), and the mixture with 63 produced six races (two of them previously undescribed and two others new for **India**). The other two mixtures did not produce any new races (Tables 3 and 4).

Table 4. Infection types produced by parent leaf-rust races 107CM and 63 and their somatic recombinants on the differential hosts

Varieties	Parent races		Recombinant races					
	107CM	63	1[1]	2[1]	3[1]	4[1]	5	6
Malakof	0	0	4	4	0	4	0	0
Carina	4	1-2	0	2-3	3	4	4	4
Brevit	4	2-3	4	3	4	4	4	4
Webster	4	0-1	0	0	0-1	0	4	0-2
Loros	4	1-2	2	0	4	2-3	3	2-3
Mediterranean	0-1	1-2	0	0	3	0	0-1	0-1
Hussar	3-4	0	4	4	3	4	3	0-1
Democrat	0-1	1-2	0	0	4	0	0-2	0-2
Agra Local	4	4	4	4	4	4	4	4
Resembles international race no.					12	49	107	131

[1]Previously undescribed from India.

DISCUSSION

The present studies confirm the results of earlier workers (NELSON, WILCOXSON, and CHRISTENSEN, 1955; WATSON, 1957; WATSON and LUIG, 1958, 1962; BRIDGMON, 1959; ELLINGBOE, 1961; VAKILI and CALDWELL, 1957; LITTLE and MANNERS, 1967) that new races and biotypes can be produced when mixtures of uredospores of known races of rusts are inoculated onto seedlings of different wheat cultivars, and also demonstrate that production of recombinants depends on the races used in the mixtures and the host variety on which the mixture is cultured. Some combinations on certain wheats readily produce recombinants, while others do so rarely or not at all. Negative results do not necessarily prove that nuclear exchange or parasexualism had not occurred in such cases. There might have been reassortment of nuclei, etc., without any immediate pathogenic change, or if there was any such change it did not show itself. These considerations may also explain the early failures to demonstrate new somatic hybrids from mixtures of races.

The present results can not be explained entirely by a simple nuclear reassortment as suggested by NELSON, *et al.* (1955), as six to eight races have been isolated from the mixtures of two races involving only four nuclei. Perhaps something of the nature of parasexualism is involved. Careful cytological studies would throw further light on this little-understood process.

This type of asexual origin of new races is of major importance for India, where the alternate host is not involved in the life cycle. An enormous number of hyphal and mycelial fusions must occur in nature and in nurseries during the screening of wheat varieties and their crosses for resistance, and new races found in India during recent years may have originated by this process as well as through introductions from neighboring countries.

Table 5 shows the prevalence of physiologic races in neighboring West-Asian and near-African countries. There is a remarkable similarity in stem-rust race-flora. Races 11, 14, 17, 21, 24 and 19 occur extensively over the entire region; races 15, 117, and 122 have been found in several countries; while races 34, 40, 42, and 194 occur in only a few of them. Race 19 is similar to Indian race 17. In a study of wind trajectories in relation to spore showers and rust appearance, MEHTA (1952) observed that winds frequently blow into India from Pakistan, Afghanistan, Iran and Nepal, suggesting dissemination of uredospores from those countries.

The significance of changes in race flora of a country is of particular interest to the plant breeder for obvious reasons. Much basic research is needed to learn the limits in virulence that are imposed on a given race by its genes, and to determine the compatibility between different races for combination and reassortment of characters in the vegetative phase. The role of alternate hosts in neighboring countries should be determined by observation and experimentation. Any change in the race flora of those countries would have its impact in India, since dissemination of uredospores from those places appears to be taking place. In most cases, the break-down of wheat varieties has been found to be due to changes in race population, and so this information is vital for every rust-resistance breeding program.

Table 5. Physiologic races *Puccinia graminis* var. *tritici* reported from India in relation to their prevalence in West-Asian and near-African countries.

Races	Ind	Ken	UAR	Syr	Pak	Tun	Iran	Eth	Tur	Sud	Leb.	Iraq	Jor	Lib
11	+	+	+	+		+			+		+	+		+
14	+	+	+	+	+	+	+	+	+	+	+		+	+
15	+	+		+	+		+					+		
17	+	+	+	+	+	+	+	+	+	+	+	+	+	+
21	+	+	+	+	+	+	+	+	+	+	+		+	+
24	+	+	+	+	+	+	+	+	+	+	+	+	+	+
34	+			+	+			+						
40	+	+			+									
42	+	+	+											
117	+	+	+				+		+	+				
122	+	+	+	+		+								
194	+		+											
19		+	+	+	+	+	+	+		+	+	+	+	+

Names abbreviated: India, Kenya, Syria, Pakistan, Tunisia, Ethiopia, Turkey, Sudan, Lebanon, Jordan, Libya.

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