Physiologic Specialization and Epidemiology of Wheat Stem Rust in East Africa

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ABSTRACT

Nine new races of *Puccinia graminis tritici* were differentiated on new host cultivars in East Africa in 1969 and 1970. There was new virulence on wheat cultivars commonly grown in East Africa, and on cultivars used as sources of stem rust resistance. Most of the identified resistance genes are ineffective against East African races, but a good reservoir of resistance is available.

Similar races were found in Ethiopia, Kenya, and Tanzania, suggesting the exchange of or a common source of inoculum in the region. Spore traps at Njoro and Kitale in Kenya, and at Njombe in Tanzania, showed that airborne rust inoculum is present throughout the year. This is attributed to wide variations in cropping seasons in East Africa. No grass species were found which were susceptible to wheat stem rust.

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Additional key words: light-sensitive, temperature-sensitive, distribution of races.

In a previous report Green et al. (5) discussed physiologic specialization of wheat stem rust in Kenya. Using a set of nine differential wheat cultivars, ten races of *Puccinia graminis* Pers. f. sp. *tritici* Eriks. & E. Henn. were identified from collections made in 1966-68. There was no detectable variation in the races during this period. Studies of physiologic specialization were continued in 1969 and 1970, and the set of differential cultivars was modified to enable the identification of new races. The sources of stem rust resistance used in the breeding program (2) were also reviewed.

Earlier studies on epidemiology of stem rust in Kenya (5) were extended in 1969 and 1970. Rust spores were trapped in more locations, more grass species were investigated as possible hosts of wheat stem rust, and rust collections made in Ethiopia and Tanzania were identified as to race using the Njoro system to obtain a comparison of virulence in these areas.

MATERIALS AND METHODS.—*Rust survey*.—Wheat stem rust was collected from wheat in fields and trial plots throughout the wheat-growing areas of Kenya, in the West Kilimanjaro and Njombe regions of Tanzania, and in southern Ethiopia. Wild grasses infected with rust were collected in wheat-growing areas of Kenya and in a remote area of Kenya in a line from Maralal to Isiolo. The latter area consists primarily of thorn bush-grass vegetation, and the nearest wheat cultivation is about 75 miles away. Urediospores were scraped from infected plants with a sterile scalpel, and increased on the susceptible cultivar Florence Aurore. Urediospores were then suspended in a light paraffin oil, *Mobilsol 100* or *Bayol 35*, and sprayed onto seedling test plants. The inoculated plants were incubated 24 hr in a polythene chamber under high humidity, then placed on greenhouse benches. The mean daytime greenhouse light intensity was less than 1,000 ft-c, and the mean day-night temperature was 22 C. Infection types were scored about 15 days after inoculation. The method of race identification and nomenclature developed by Green et al. (5) was followed.

Spore trapping.—Airborne spores were trapped by the method of Roelfs et al. (6) at three locations; Njoro and Kitale in Kenya, and Njombe in Tanzania. In 1969, the Njoro trap was adjacent to the main experimental plot area; and in 1970, it was near late-sown increase plots and a commercial field of Bounty (stem-rust resistant, leaf-rust susceptible). The Kitale trap was located on the highest point of the National Agricultural Research Station, and the nearest wheat fields were about 15 miles away. The Njombe trap was in a 400 acre block of Romany (stem-rust susceptible, leaf-rust resistant) and Kenya Leopard (stem-rust resistant, leaf-rust susceptible). There were 70 cultivars grown in test plots within 5 miles of the trap. Njombe is an isolated, small, wheat-growing area in the southern highlands of Tanzania, and the nearest sizeable wheat-growing area is in West Kilimanjaro, 500 miles to the north.

The rods were exposed an average of 3.5 days at Njoro, and 7 days at Kitale and Njombe. The spore counts are expressed as the total number of spores averaged over a 2-week period.

RESULTS AND DISCUSSION.—*Physiologic specialization and sources of resistance*.—Since the report by Green et al. (5), nine new races, EA 11-19 (Table 1), have been isolated, three in 1969 and six in 1970. The previously used differentials (5) did not separate all the new races; hence, new cultivars were

TABLE 1. East African stem rust races, their virulence formulae, and "standard" race equivalents

East African race no.	Virulence formula,[a] resistant/susceptible	"Standard" race no.
1	1,2,5,7,8,15,22,23[b]/4,21	297
2	1,4,5,15,22/2,7,8,21,23	21
3	2,4,5,8,15,22/1,7,21,23	295
4	2,4,8,15,22/1,5,7,21,23	295
5	4,5,7,8,15,21,23/1,2,22	34
6	5,7,8,15,21/1,2,4,22,23	40
7	5,15,22/1,2,4,7,8,21,23	40
8	15,22/1,2,4,5,7,8,21,23	40
9	4,5,7,8,15,21/1,2,22,23	11
10	5,8,15,22/1,2,4,7,21,23	15
11	5,22/1,2,4,7,8,15,21,23	40
12	5,7,8,21/1,2,4,15,22,23	40
13	4,5,7,8,15,23/1,2,21,22	34
14	4,7,8,15,21/1,2,5,22,23	11
15	4,5,8,15,21/1,2,7,22,23	11
16	5,8,21/1,2,4,7,15,22,23	34
17	2,5,7,15,22/1,4,8,21,23	143
18	1,2,5,7,8,21,22,23/4,15	83
19	5,8,15/1,2,4,7,21,22,23	40

[a] Cultivars: 1 = Reliance; 2 = Kota; 4 = Vernal; 5 = H-441; 7 = Marquis-*Sr*11; 8 = Giza 144; 15 = C.I. 8154 X Fr^2; 21 = Renown selection containing *Sr*17; 22 = Iumillo; 23 = Kenora.

[b] May at times appear susceptible.

tested as differentials. New differentials included a selection from Renown carrying gene *Sr*17, Iumillo (a durum), C.I. 8154 X $Frocor^2$, and Kenora (Table 1). Races EA 1-10, previously described (5), were redefined using the new differentials, but the original designations have been retained. C.I. 8154 X Fr^2 separates EA 11 from EA 7, and EA 12 from EA 6. Kenora carried genes *Sr*9b and *Sr*15, and presumably *Sr*15 differentiates EA 5 and EA 9 (Table 4-B). Gene *Sr*15 appeared to be more stable in Kenora than in Norka; hence, Kenora was chosen as the differential. The cultivars SRPC 430/67, 1044 A.I.A.4, SRPC 527/67, Minnesota 3654/60, C.I. 8155, 87/65, Agatha, Romany, Wisconsin 245-II-50-17, and Bonny (Table 4-C) are normally included as supplemental "differentials" because of their importance as resistance sources (2). The EA races were also identified as to standard (7) races (Table 1).

The previously used differentials, Einkorn, Gala, and Sambtalia (SRPC 501/67) (5) were discarded because of variable reactions to several races. Environmental conditions appeared to be responsible for some of this variability (Table 2). The reactions of these cultivars were compared in a greenhouse (12:12 hr light:dark, mean day-night temperature 22 C, and mean daytime light intensity less than 1,000 ft-c) and in a growth cabinet with (i) 18:6 hr light:dark, temperature 18 C, light intensity 3,000 ft-c, and (ii) same as (i) except that light intensity was 700 ft-c. Einkorn was more susceptible to EA 2, 5, 8, and 9 in high light, and Sambtalia was more susceptible to races EA 2 and 8 in high light, but did not respond this way to races EA 5 and 9. Sambtalia thus appears to carry two genes, one light-sensitive gene conferring moderate resistance to EA 2 and 8, and one stable gene conferring high resistance to EA 5 and 9. Substituted single gene lines of Marquis carrying *Sr*6 and *Sr*13, and Norka carrying *Sr*15 were also included in the light study. Marquis-*Sr*13 appears to be light-sensitive, as it is more susceptible in the low temperature-high light growth cabinet conditions than in the higher temperature-low light greenhouse conditions. Norka-*Sr*15 appears to have temperature-sensitive resistance to EA 2 and 5. Resistance conferred by *Sr*15 is normally mesothetic, but this gene appeared more effective at lower temperature but high light. Marquis-*Sr*6 displayed its known temperature sensitivity (3) in reaction to EA 9, but showed stable, high resistance to EA 2. This indicates that Marquis-*Sr*6 may carry a second gene conferring the stable resistance to EA 2. Marquis-*Sr*11 remained stable under the varying conditions.

There have been some shifts in the prevalance of races EA 3-9 in Kenya from 1968 (5) to 1970 (Table 3). Race EA 5 has decreased from 66% of isolates in 1968 to 35% in 1970, probably due to the banning, in 1970, of the cultivar Romany, which was formerly

TABLE 2. Infection types[a] produced on some wheat cultivars by East African (EA) races of stem rust under greenhouse (GH)[b] and growth cabinet (GC)[c] conditions

	Stem rust race										
	EA 2			EA 5			EA 8			EA 9	
Cultivar	GH	GC(1)	GC(2)	GH	GC(1)	GC(2)	GH	GC(1)	GC(2)	GH	GC(1)
Marquis-*Sr*6	;1	;1		3+	3+		3+	3+		3	;2+
Marquis-*Sr*13	23−	3		23	23+		23−	3+		12	3
Norka (*Sr*15)	3±	;3		13	;2		3+	3+		3+	3+
Sambtalia	13	3+	0;	;1	;1	;	4−	4−	23+	;1−	;1−
Einkorn	12	33+	23−	12	3+	3−	2+	3+	23	13	3-3
Marquis-*Sr*11	4−	3+	4−	;1+	;1+	;1+	4−	4−	4−	;1+	;1+

[a] Resistant, ; to 1; moderate-resistant, 2; moderate-susceptible, 3; susceptible; 4.

[b] Greenhouse conditions: 12 hr light:dark, mean daytime light intensity less than 1,000 ft-c, mean day-night temperature 22 C.

[c] Growth cabinet conditions: (i) 18:6 hr light:dark, light intensity 3,000 ft-c, temperature 18 C. (ii) Same as (i) except light intensity 700 ft-c.

widely grown and is susceptible to race EA 5. Of the other predominating races, EA 7 has declined steadily from 17% in 1968 to 5% in 1970, and EA 4 has increased from 9 to 25%. The latter race has been important in Kenya because of its virulence on *Triticum timopheevi* Zhuk. resistance. Race EA 8, which has the widest range of virulence of the EA races, has remained at relatively low levels, and was not found in Ethiopia. Of the new races, EA 11 and 12 have become prominent in Tanzania, but not in Kenya. These races are virulent on C.I. 8154 X Fr^2, a cultivar released and grown commercially only in Tanzania. Races EA 13, 15, and 16 are important new races. EA 13 is a variant of EA 5, with moderate but new virulence on 1044 A.I.A.4, Minnesota 3654/60, 4148 A.I.E.3, and CD/1141/A.2, all of which are used as sources of resistance. This race has increased from less than 1% in 1969 to 11% in 1970. Races EA 15 and 16, isolated only in 1970, are virulent on Trophy, one of the most important wheat cultivars in East Africa, which prior to 1970 was resistant to stem rust. The number of collections of these races is disproportionately large because of larger numbers of collections made from Trophy. At present, races EA 17-19 do not appear important.

Although several new races are virulent on C.I. 8154 X Fr^2, this cultivar remains an important source of resistance, and when combined with resistance derived from *T. timopheevi* (H-441, Wis. 245-II-50-17), a broad range of resistance is provided. Although there is new virulence on a number of resistance sources, the developing patterns of virulence suggest that combinations of these should provide adequate resistance for the forseeable future.

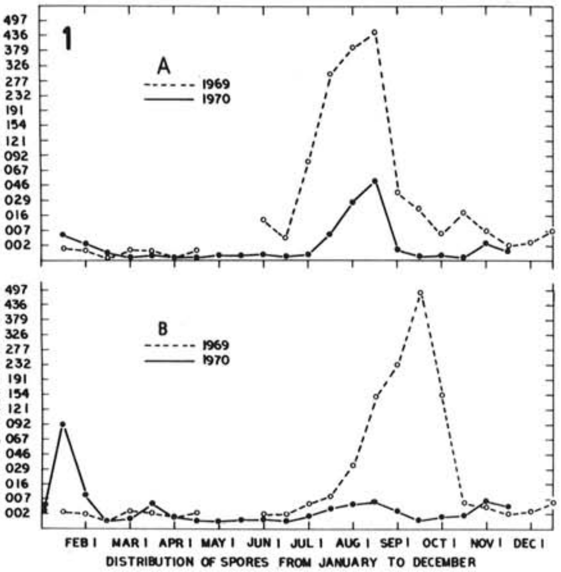
The rust population in East Africa has evolved virulence patterns that are somewhat different from those in North America. In 1969, cultivars carrying genes *Sr*6, *Sr*8, *Sr*9a, *Sr*13, and *Sr*15 conferred resistance to most isolates in Canada, and *Sr*6 was effective against more races than any other gene (4). In Kenya, *Sr*6 is effective against EA 1, 2, and 9, all minor races, *Sr*8 is effective only against EA 18 (4% of isolates in 1970), and *Sr*9a and *Sr*9b are ineffective against all EA races. Gene *Sr*13 confers broad but unstable resistance, and *Sr*15 is notable for its effectiveness against EA 5, which is diminishing in prevalence. Alternately, Marquis-*Sr*11 is effective against 52% of all isolates in Kenya and Tanzania in 1970, as compared to 11% in Canada. The remaining identified resistance genes are generally less effective in East Africa than in Canada.

The reactions of Marquis-*Sr*6 and Norka (*Sr*15) to EA 5 previously reported (5) do not coincide with those in the present study (Table 4-B), and could not be repeated under a range of environments in a large number of trials. Marquis-*Sr*6 is now considered to be susceptible, and Norka (*Sr*15) has intermediate resistance to EA 5. Races EA 5 and 9 are poorly differentiated by Einkorn (5), Marquis-*Sr*6, and cultivars carrying *Sr*15, all of which are unstable under Njoro conditions. These races may be biotypes of each other, accounting for some of the variance of results.

Little is known of the sources of variation of stem rust in East Africa. There is circumstantial evidence that some variation is due to somatic recombination of existing virulence. Race EA 14 was isolated from a nursery which had been inoculated with a mixture of races EA 2-8. A comparison of the virulence of EA 4 and 5 on Kota, H-441, Marquis-*Sr*11, Iumillo,

TABLE 3. East African (EA) wheat stem rust races in Kenya, Tanzania, and Ethiopia in 1969 and 1970, and their distribution

EA race designation	Kenya				Tanzania				Ethiopia	
	1969		1970		1969		1970		1970	
	No.	%	No.	%	No.	%	No.	%	No.	%
2	3	2.0								
3	1	0.7	1	0.4			1	2.4		
4	19	12.7	59	24.7	13	29.0	5	11.9		
5	90	60.0	83	34.7	11	24.0	9	21.4	13	59.0
6	2	1.3	4	1.7						
7	17	11.3	11	4.6	5	11.0	2	4.8	7	32.0
8	14	9.3	16	6.7	5	11.0				
9			2	0.8					2	9.0
10	1	0.7	1	0.4						
11	2	1.3			7	16.0	6	14.2		
12					4	9.0	11	26.2		
13	1	0.7	26	10.9			1	2.4		
14			1	0.4						
15			27	11.3			1	2.4		
16			1	0.4			5	11.9		
17							1	2.4		
18			4	1.7						
19			3	1.3						
Total	150	100	239	100	45	100	42	100	22	100



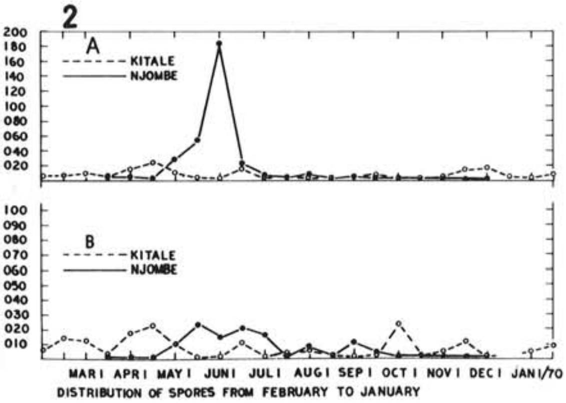


Fig. 1-3. 1) Counts of airborne leaf rust (A) and stem rust (B) spores at Njoro in 1969 and 1970. **2)** Counts of airborne leaf rust (A) and stem rust (B) spores at Njombe and Kitale in 1970. **3)** The areas of wheat cultivation in East Africa and the usual periods of rust susceptibility in each area.

Romany, Wisconsin 245-II-50-17, and 1183 L.I.C. (Table 4-A, C), suggest that these two races could have hybridized somatically to produce EA 14. Similarly, EA 19 may be a recombination of EA 5 and 7. The importance of somatic recombination is further suggested because there is extended mycelial proximity due to a longer growing season in the short equatorial day. Moreover, there are susceptible hosts available throughout most of the year (Fig. 3), and an alternate sexual host is not known to be functional in East Africa. However, these conditions also increase the probability of mutations.

Epidemiology.—In a study of grass species as possible hosts of wheat stem rust, 164 collections of rust-infected grasses were made, none of which were proved as positive hosts. Although, in a few cases, isolations supposedly made from grasses were virulent on wheat, reinfection of the original grass hosts with the same isolates was unsuccessful. Occasionally, type-2 infections resulted on very young grass seedlings, but these pustules disappeared and the same plants could not be reinfected. Grass species investigated in addition to those previously reported (5) were *Aristida adoensis* Hoechst, *Botriochloa pertusa* A. Camus, *Eragrostis chalcantha* Trin., *Eulalia polyneura* Stapf., *Exotheca* spp., *Helictotrichon* spp., *Lolium temulentum* L., *Panicum coloratum* Linn., *Panicum maximum* Jacq., and *Themeda triandra* Forsk. The descriptions of Edwards & Bogdan (1) were used to identify the grasses. The surveys to date indicate that grass species are not important in the epidemiology of wheat stem rust in East Africa. However, large grassland areas remain unsurveyed, and it is possible that grass species may play some role.

At Njoro, stem and leaf rust spores were caught throughout the year in 1969 and 1970 (Fig. 1-A, B). The leaf rust counts were maximum from late June to late August, and the stem rust counts were maximum from late July to early October. The maximum spore counts are correlated with the main periods of rust

TABLE 4. Infection types[a] produced on (A) differential cultivars; (B) cultivars with substituted genes for stem rust resistance; and (C) cultivars used as sources of resistance, by East African (EA) stem rust races

	EA race number																		
Cultivar	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
A																			
Reliance											3+	4	4	4–	4–	4–	4–	4–	4–
Kota											3+	4	4	4–	4–	4–	12	0;	4–
Vernal											4	4	;1	;1–	;1–	4–	4–	4–	4–
H-441	0;										;1	;1	;1	3+	0;	0;	0;	0;	;1
Marquis-*Sr*11	0;										4	;1	12	0;	3+	3+	;1	;1	4
Giza 144	0;										3+	0;	;1	0;	23	12	1	;1–	1
Renown with *Sr*17	4–	3+	4–	3+	;1+	;1	3	3+	;1	3+	4–	;1	4–	;1	2	2	4–	;1	3+
Iumillo	0;	0;	;1–	0;	3+	4	;1–	0;	3+	;1–	;1–	4	3+	3+	3+	4–	;1	;1	4–
C. I. 8154 X Frocor[2]	3										3±	3±	;1	0;	0;	3	;1	3+	2±
Kenora (*Sr*9b, *Sr*15)	3	3+	3	4	;12+	3	3+	4	3	3+	3+	4–	3	3	3	4–	3+	0;	4–
B																			
Marquis-*Sr*1										4	3+	3+	3+	0;	23		3+	4–	4–
Marquis-*Sr*5										4–	4–	4–	4	3	4–	3+	4–	4–	4–
Marquis-*Sr*6					3+					4	4	4–	4–	3	4–	3	4–	4–	4–
Marquis-*Sr*7a										4	4–	3	4	3	3	3	3+		23
Marquis-*Sr*7b											3+	3	3	3+	3	3	3	1	4–
Marquis-*Sr*8										3+	3+	4–	3+	4–	4–		3	;1	4–
Marquis-*Sr*9a										4–	3+	3+	3+	3+	3+	3	4–	4–	4–
Marquis-*Sr*9b										3	4–	3+	3+	3+	3+	3	3	3+	4–
Marquis-*Sr*10									4–	4–	4–	4–	3+	3+	3+	3+	1	23	;1
Marquis-*Sr*13	23	12+	23	23+	12+	;–3	1-3	23	;–3	;2+	23	1-3	23		;2		;2	;1	23
Marquis-*Sr*14	3	4	3+	4–	3	4–	4	4	4	4–	4–	4–	4–	3+	4–	3	4–	4-	3
Norka (*Sr*15)					X–				4–	4–	4–	4–	X	3+	3+	3+	4–	4–	3+
Marquis-*Sr*16		4		3+	3		4–							4–	3+		3+	4–	4–
C																			
SRPC 430/67											;1	12	2	;1	12	;1			
1044 A.I.A.4											;2	0;	3±[b]	0;	0;	0;	0;	0	3
SRPC 527/67[d]											0;	;1	;1	0;	0;	;1	;1–	0;	0;
Wisconsin 245-Bonza[3]											1	0	0;	3+[b]	;1	0;			
Minnesota 3654/60											12	0;	3±[b]	;1	0;	0;	X	0;	1
C.I. 8155											;2	;1	0;	0;	0;	0;	0;	23	0;
WRT 238.5 X Pb[5]											;1	12	;1	4–[b]	;1	0;			
4148 A.I.E.3											;1	0;	3+[b]	0;	23–	0;			
Lee-Mida-Bonza[2]											;1	0;	;1	;1	4–[b]	4–[b]			
Conley											3	;1	;1	0;	3+	3			
1198 A.2.A.2											0;	0;	0;	2	0;	0;			
Hope[c]											3	3+	3+	23	1	12			
87/65											;1	;1	;1	0;	0;	;1	;1	12	;1
Kenya Page[c]											;1	0;	3+	;1–	3	12			
Justin (C.I. 13462)											3	;1	;1	;1–	3[b]	3+[b]			
Trophy											;3–	;1	;1	;1	3+[b]	4[b]			
Bonny											;1	;1	;1	0;	3+[b]	4[b]	0;	0	1
Agent[e]											;1	;1	1	1	12	23–			
H44-24[c]											3+	3+	3+	3+	3+	3+			
Africa Mayo[c]											2	1	3+	1	0;	12			
Wis. 245-Supreme 51											;1	;1	12	3+[b]	;1	0;			
CD/1141/A.2											0;	0;	3[b]	4–[b]	3+[b]	0			
Gabo-Gamenya											;1	0;	0;	23	0;	0;			
Kenya Hunter											;1	0;		0;	0;	0			
Kenya Leopard											;1	0;	0;	0;	0;	0;			
Tobari 66											3	0;	;1	0;	3+	4–			
Wis. 245-II-50-17											0;	0	0;	3	0	0	0;	0	0
SRPC 408/67											3	;1	3+	;1	12	;1			
Mentor											;1	0;	0;	;1	0;	0;			
Kenya Cheetah											;1–	0;	0;	0;	0;	0			
1203 D.I.S.I.											0;	;1–	;1–	4–[b]	3[b]	0;			
Romany											2±	23	3±	3+	3+	3+			
1183 L.1.C.											0;	0;	;1–	3+	0;	0;			
South Africa 43											3	3+	3+	3+	3+	3+			
Agatha[e]											12	23–	2						
T4											0;	2	2						

[a] Resistant, ; to 1; moderate-resistant, 2; moderate-susceptible, 3; and susceptible, 4. Infections somewhat greater than the "type" are indicated by "+"; those somewhat less, by "–". Combined types, e.g., 1-3, indicate the range of infection types (1 to 3) produced by a single race on a given cultivar. X = Mesothetic reactions. Data for races EA 1-10 have been published elsewhere (4, 5).

[b] New virulence.

[c] Have adult or suspected adult resistance.

[d] *Aegellops speltoides* and *A. ovata* derivative, may also carry resistance from *Agropyron*.

[e] *Agropyron elongatum* derivative.

attack (Fig. 3). The main periods of rust attack in Fig. 3 are those considered "normal", but planting time is at the discretion of the farmer, and there is considerable variation. In 1970, the spore counts at Njoro were lower than in 1969, and this correlates with a lighter rust epidemic. At Kitale, spores were also caught throughout the year, but there were no clearly discernible peaks of spore counts (Fig. 2). Considerable acreages of wheat are grown both east and west of Kitale, and fields of Romany 30 miles east were heavily infected in August. However, the distances appear too great to yield clear peaks in numbers of airborne spores at the trap location.

The Njombe trap (Fig. 2) revealed an increase of leaf rust spores during May and June, and a slight rise in stem rust spores from May to July. Although Romany is susceptible to the prevalent race EA 5, only small pockets of stem rust infection were found in the field of Romany adjacent to the trap. A field of Romany 10 miles from the trap attained a moderate level of stem rust infection during May and June, the time at which the number of airborne spores began to increase. The field of Kenya Leopard showed little leaf rust, but a field of Africa Mayo a short distance away was heavily rusted. At Njombe, airborne spores were nearly nonexistent in the out-of-season period. This low level of primary inoculum correlates with light stem rust infection in Romany, if we assume that conditions for rust development were favorable. The nearest wheat-growing area to Njombe is West Kilimanjaro, 500 miles to the north, and much of the intervening country is dry savanna. At West Kilimanjaro, there is some wheat susceptible to rust attack at most times of the year (Fig. 3), and it is possible that some of the inoculum produced here reaches Njombe. The wheat-growing areas of Kenya and northern Tanzania are also well isolated from wheat cultivation in Ethiopia (Fig. 3). However, wheat is grown at some locations in Kenya at most times of the year, cropping seasons cover a wide range of dates, and it is likely that wheat crops in various stages of maturity provide the higher levels of background inoculum at Njoro and Kitale. Oat stem rust and rye stem rust are common in Kenya, and these crops combined with infected grasses may also contribute to the stem rust counts. Also, maize rust spores may have confused leaf rust counts. Double cropping, or the growing of two crops per season, has been discouraged in the past to reduce the amount of rust inoculum. This occurred in a period when large numbers of cultivars were recommended to farmers, but the mean level of rust resistance was low. The use of cultivars with broader and higher levels of resistance should reduce the inoculum load, and double cropping would not be a factor. Alternately, there is some evidence of inoculum exchange between Tanzania, Kenya, and Ethiopia, or perhaps a common source of inoculum (Table 3). Of 22 stem rust collections made in Ethiopia, 13 were EA 5, 7 were EA 7, and 2 were EA 9; this is similar to the predominant race distribution in Kenya and Tanzania.

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