Epidemiology and Specialization of Wheat and Oat Stem Rusts in Kenya in 1968

G. J. Green, J. W. Martens, and O. Ribeiro

First and second authors, formerly advisors for the Canadian International Development Agency-University of Manitoba Kenya Project, now Plant Pathologists, Canada Department of Agriculture, Research Station, 25 Dafoe Rd., Winnipeg 19, Manitoba; third author, formerly Agricultural Officer (Research), Plant Breeding Station, Njoro, Kenya, now Graduate Research Assistant, Department of Plant Pathology, University of West Virginia, Morgantown, West Virginia 26506.

E. J. Guthrie, Director, Plant Breeding Station, Njoro, Kenya, provided helpful advice, administrative assistance, and constructive suggestions on the manuscript. The authors are indebted to J. Knight of Njoro for the identification of many of the grasses on which rust was collected. P. J. Northwood of the Tanzania Ministry of Agriculture and Cooperatives, West Kilimanjaro, Tanzania, supplied many stem rust collections. T. R. Patel, S. D. Patel, and W. Odeke performed much of the technical work. Many of the rods used in epidemiological studies were sent to the Plant Breeding Station, Njoro, by R. W. Romig prior to January 1968.

Contribution No. 385, Canada Department of Agriculture, Research Station, Winnipeg. Published with approval of the Kenya Ministry of Agriculture, and the Director, Canadian International Development Agency-University of Manitoba Kenya Project.

Accepted for publication 15 September 1969.

ABSTRACT

Urediospores of *Puccinia graminis* and *P. recondita* were trapped at Njoro, Kenya, from February to December 1968. The initiation of rust development in the area can be explained by this inoculum. *Lolium multiflorum* was infected with rye stem rust, and *Agrostis producta, Dactylis glomerata,* and two unidentified grasses were infected with oat stem rust. No grass infected with wheat stem rust was found.

Using new sets of differential hosts and new systems of nomenclature, seven races of wheat stem rust and four races of oat stem rust were identified in East Africa in 1968. Wheat stem rust race EA5 predominated, presumably because it can attack the widely grown cultivar Romany. Oat stem rust race EA3 predominated. It attacks varieties carrying most of the identified resistance genes. There are good sources of resistance to wheat stem rust, but no commercial hexaploid oat variety is resistant to all races of stem rust. Phytopathology 60:309-314.

The history of wheat production in Kenya (1, 2, 8) has been mainly an account of attempts to control stem rust, *Puccinia graminis* Pers. f. sp. *tritici* Eriks. & E. Henn., by resistant varieties. Wheat stem rust has been studied at Njoro, Kenya, since 1927 (7). The appointment of a plant pathologist (E. J. Guthrie) in 1958 and the construction of an additional greenhouse in 1960 permitted an expansion of the program. The early workers found that the "standard" differential hosts (12) did not reveal important variation in the Kenya rust population, and they selected differentials mainly from local material. The number of hosts was increased from time to time, and from 1928 to 1957, races K1 to K19 were discovered (6). In 1958 the "standard" hosts were used to expand the genetic base of the investigations and to relate work in Kenya with that in other parts of the world. Other changes followed, and in 1964 the "standard" differentials, Little Club, Reliance, Kota, Einkorn, Vernal, and Khapli, and 10 hosts of local importance were regularly used. The six standard hosts retained were sufficient to identify the "standard" races (12), and virulence on one of the ten supplemental hosts was indicated by adding that host's number to the "standard" race number, e.g., 40/1/5/6.

W. F. Hanna continued the investigations in 1966 and 1967. He had difficulty identifying races because of variability in the reactions of the differential host varieties, presumably caused by changing environmental conditions.

The sources of resistance in the breeding program had changed by 1968. There was a need to relate race investigations to wheat breeding, and it was necessary to change again the methods of identifying races. This paper describes the system adopted and the results obtained with it.

Wheat is grown in localized areas from the Nile Valley of U.A.R. in the north to South Africa. If urediospores are transported throughout this enormous region, there is a large reservoir of inoculum and virulence genes, but if there is little or no exchange of inoculum, it may be possible to limit rust development in any one area by controlling agricultural practices. This has been attempted in Kenya, where barberry does not seem to function (7), by discouraging double-cropping (two crops a year) to decrease the movement of rust from one crop to the next.

Wheat is planted in Kenya at times chosen to make maximum use of rainfall while the crop is growing, yet have it ready for harvest during a dry period. In most of the wheat growing area, the long rains usually occur between March and August, the short rains during October and November. Dry conditions usually prevail from December to March. Most wheat is planted from March to June and harvested from August to January (Fig. 1). For each 300-m increase in altitude, there is a 15-day increase in the time wheat requires to mature. A small part of the crop is grown above 2,400 m, and a small acreage, on which rust inoculum can be produced, remains standing in January and February. Urediospores produced on this wheat could be in the air after the new crop at lower altitudes has emerged.

There is little published experimental work on the epidemiology of the cereal rusts in East Africa. A

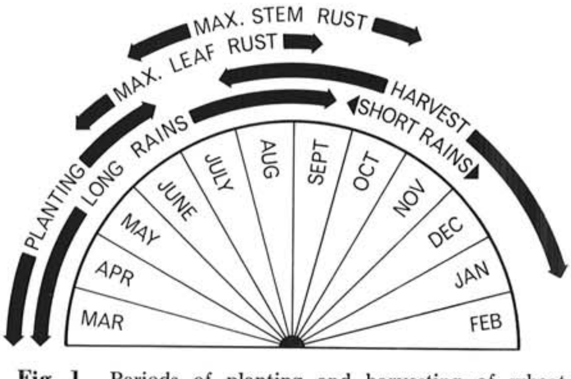

Fig. 1. Periods of planting and harvesting of wheat, rainfall, and maximum occurrence of airborne urediospores of leaf and stem rusts in Kenya.

spore-trapping program was initiated to determine whether or not air-borne inoculum, presumably originating on wheat, is present throughout the year at Njoro. A second source of primary inoculum is the wild grasses that abound in all parts of Kenya. If infected by the rusts of cereal crops, they would serve as sources of inoculum and as reservoirs of physiologic races. The results of a 1-year study of the stem rusts occurring on grasses are reported here.

Stem rust was unusually prevalent in 1968. Early planting was stimulated by early commencement of the long rains, and the weather during the growing period favored rust development. Consequently, the amount of air-borne rust inoculum was probably greater than in most years.

Ecological conditions in Kenya favor rust development. Most of the wheat-growing area is localized in the highlands (1,830 to 2,900 m) that straddle the equator west and north of Nairobi. The growing season extends over 12 months, temperatures range from 18 to 30 C, days are uniformly about 12.5 hr long, dews are heavy, and precipitation occurs frequently as showers during the main growing season. High resistance to all races is required to withstand the long attack.

Materials and Methods.—*Epidemiology*.—Spores were trapped by the method described by Roelfs et al. (10). Spore concentrations are expressed as the total number of spores counted on each tape. The spore trap was located at the Plant Breeding Station, Njoro, about 535 m from the greenhouses and irrigated plots, where small amounts of rust are usually present, and about 230 m from the main experimental plot area of the station. The greenhouses and irrigated plots are not regarded as important sources of spores, but the main plots that were sown at the time that farmers were planting their fields, and were artificially inoculated with wheat stem rust during the last week of June, probably contributed to the spore catch in July and August. The leaf rust spore counts probably include spores of the commonly occurring *Puccinia sorghi* Schw. which were not readily distinguishable from spores of *P. recondita* Rob. ex Desm.

Rust was collected on wild grasses growing in roadsides and fields throughout the wheat growing area of Kenya, and on grasses in the A. V. Bogdan grass and legume nursery at Kitale. Urediospores were scraped from pustules on the grass with a sterile scalpel and used to inoculate wheat, oats, rye, and barley. Only wheat and oats were inoculated when urediospores were scarce. The inoculated plants were incubated 24 hr in a polyethylene chamber, and were frequently sprayed with water. After incubation they were placed on the greenhouse bench, and infection was recorded 12-14 days later.

Physiologic specialization.—Stem rust was collected on wheat and oats in fields and in experimental plots. Urediospores scraped from leaves and stems with a sterile scalpel were used to inoculate seedling leaves of the susceptible wheat cultivar Florence Aurore or the susceptible oat cultivar Victory. The urediospores that developed were used to inoculate the differential host varieties, either by application with a sterile scalpel or by spraying in oil suspension. The plants were incubated 24 hr in a polyethylene chamber kept moist by frequent sprayings with water, after which they were placed on greenhouse benches. Infection types were recorded and races identified 12-14 days after inoculation.

Seed of most of the varieties used was from stocks at the Plant Breeding Station, Njoro, Kenya. Other varieties were from stocks at the Canada Department of Agriculture Research Station, Winnipeg.

Results and Discussion.—*Airborne spores*.—Urediospores of stem rust and leaf rust were caught during nearly every trapping period (Table 1). Small numbers of spores were caught until early June. The leaf rust counts were maximum from June to September, and stem rust counts were maximum from July to mid-October. Spore courts were minimum during March, April, and May. These results are correlated with crop development in Kenya (Fig. 1). A large part of the crop is planted during April and May. Early planted crops begin to head in May. Heading continues on later sown crops with the majority being headed by July. The increase in the number of leaf rust spores caught during June would result from leaf rust development during tillering, and the increase of stem rust during late June and July corresponds to the development of stem rust during and after heading.

The most important feature of the spore trap results is the presence of spores throughout the period of the study. The severe rust epidemic that developed in fields of susceptible varieties in 1968 can be attributed to early infections caused by this airborne inoculum and favorable weather for rust development. Further studies at several locations are necessary to establish whether the same sequence of events occurs regularly, but it appears that the production of highly resistant varieties for East Africa would have a cumulative effect on rust development by restricting the amount of primary inoculum.

Native grasses as hosts.—One hundred and thirteen rust collections were made on native and introduced grasses: *Agrostis producta* Pilger-5, *Andropogon abyssinicus* R. Br. ex Fresen-1, *Anthephora hochstetteri* Nees-1, *Bothriochloa glabra* (Roxb.) A. Camus-1, *B.*

TABLE 1. Numbers of stem rust and leaf rust urediospores caught on rods exposed at Njoro, Kenya in 1968

Date		Stem rust	Leaf rust
Feb.	24-28	13	0
	28-March 4	19	4
March	4-7	0	0
	7-11		
	11-14	7	4
	14-17	1	3
	17-22	2	0
	22-26	2	0
	26-28	34	19
	28-April 1	16	22
April	1-4	4	12
	4-8	14	6
	8-11	2	5
	11-16	0	0
	16-18	1	1
	18-22	0	3
	22-26	0	2
	26-30	0	0
	30-May 4		
May	4-7	0	0
	7-9	0	3
	9-13	0	2
	13-17	2	0
	17-21	2	7
	21-23	2	7
	23-27	0	0
	27-30	5	11
	30-June 3	4	16
June	3-7	3	23
	7-10	5	19
	10-14	82	47
	14-17	14	21
	17-20	21	19
	20-24	12	18
	24-27		16
	27-July 1	95	158
July	1-4	82	75
	4-8	56	66
	8-12	40	66
	12-15	142	172
	15-18	58	46
	18-22	74	62
	22-25	66	78
	25-29	34	52
	29-Aug. 1	68	108
Aug.	1-6	77	64
	6-9	220	143
	9-12	257	279
	12-15	247	86
	15-19	235	78
	19-22	274	34
	22-26	141	30
	26-29	174	34
	29-Sept. 2	196	26
Sept.	2-5	829	41
	5-9	928	43
	9-12	1412	52
	12-16	1487	49
	16-19	1452	48
	19-23	1387	18
	23-26	1433	23
	26-30	1423	16
	30-Oct. 3	1262	16
Oct.	3-7	1226	14
	7-10	258	15
	10-14	148	12
	14-17	122	8
	17-21	116	6

TABLE 1. (*Continued*)

Date		Stem rust	Leaf rust
Oct.	21-24	12	3
	24-28	15	0
	28-31	12	1
	31-Nov. 4	14	6
Nov.	4-7	11	3
	7-11	16	0
	11-14	13	0
	14-18	12	0
	18-22	9	2
	22-25	6	0
	25-28	4	0
	28-Dec. 5	0	0
Dec.	5-9	5	2
	9-13	4	0
	13-16	3	0
	16-19		
	19-21	16	21
	21-23	14	10
	23-27	18	25
	27-30	41	19

insculpta A. Camus-1, *Brachiaria brizantha* Stapf-1, *B. ruziziensis* Germain and Evrard-1, *B. serrata* (Spreng.) Stapf-1, *Cenchrus ciliaris* L.-1, *C. setigerus* Vahl-1, *Chloris amethystea* Hochst.-2, *C. gayana* Kunth.-2, *Cymbopogon giganteus* Chiov.-1, *Dactylis glomerata* L.-5, *Dicanthium papillosum* (Hochst. ex A. Rich.) Stapf-1, *Digitaria gazensis* Rendle.-3, *D. macroblephara* (Hack.) Stapf-1, *D. nodosa* Parl.-1, *D. pentzii* Stent-1, *D. rivae* (Chiov.) Stapf-1, *D. scalarum* Chi-1, *Eragrostis heteromera* Stapf-1, *E. kiwuensis* Jedw.-3, *E. racemosa* Steud.-6, *E. superba* Peyr.-1, *E. tenuifolia* Hochst. ex A. Rich.-1, *Festuca* spp. L.-1, *Helictotrichon*

TABLE 2. Key, formulas, formula numbers, and "standard" race numbers for races of wheat stem rust in Kenya

Key	Virulence formula	Formula number	"Standard" race number
Reliance resistant			
Kota resistant	1,2/3,4	EA1	297
Kota susceptible	1,3,4,5,6,9/2,7,8	EA2	21/1/6/7/8
Reliance susceptible			
Kota resistant			
H441 resistant	2,4,5,6,8,9/1,3,7	EA3	295/-
H441 susceptible	2,4,6,8,9/1,3,5,7	EA4	295/1/3/4
Kota susceptible			
Einkorn resistant			
Vernal resistant	3,4,5,7,8,9/1,2,6	EA5	34/2/5/7/8
Vernal susceptible			
H441 resistant			
Gala resistant	3,5,6,7,8,9/1,2,4	EA6	40/2
Gala susceptible	3,5/1,2,4,6,7,8,9	EA7	40/1/5/6
H441 susceptible	3/1,2,4,5,6,7,8,9	EA8	40/1/3/4/5/6
Einkorn susceptible			
Vernal resistant	4,5,6,7,8,9/1,2,3	EA9	11/2/7
Vernal susceptible	5,6,8/1,2,3,4,7,9	EA10	15/1-10

Table 3. Infection types produced on differential host varieties by races of wheat stem rust

Differential variety	Physiologic race 297 EA1	21/1/6/7/8 EA2	295/- EA3	295/1/3/4 EA4	34/2/5/7/8 EA5	40/2 EA6	40/1/5/6 EA7	40/1/3/4/5/6 EA8	11/2/7 EA9	15/1-10 EA10
1 Reliance	0	0	3	3	4—	4	4	4	3+	4—
2 Kota	0;	3+	0;	0;	4—	4	4	4	3+	4—
3 Einkorn	3+	2	3+	3+	2	2	2	2	3	3+
4 Vernal	3+	1	2—	2—	2—	4	4—	4	1+	4
5 H441		0;1	0; to 2	3	0;	0;1	0;1	3	0;1	0;1
6 Gala		1	1	1	4	1	4	4	1	1?
7 *Sr11* (in Marquis)		4	3	3+	1	1	4	4	0;1	4
8 Giza 144		4	2	2	0;	0;	3+	4	0;	2
9 501/67		2	0;	0;	0;1	0; to 2	4	4	0;1	3+
10 Romany		2	2	2	2+, 3+[a]	2	2	2	1+	2
11 87/65		1	0;1	2	1	1	1	1+	0;1	1
12 430/67		1	2	2	1+	2	2	1+	1+	1
13 1044 A.I.A.4		0	0	0;	2	0;1	0; to 2	0; to 2	0;	1
14 527/67		1	0;	0;	0;1	0;1	0;1	0;1	0;1—	1
15 C.I. 8154 × Fr^2		0;	1	0;1	0;1	0; to 2	0; to 2	0; to 2	0;	0; to 2
16 Agatha		3—	2	2	2	2	2	2	2+	2
17 C.I. 8155		0;	0;	1	0;	0;	0; to 2	0;	0;	0;
18 Minn. 3654/60		0;	2	2	0;1	0;1	2	2	0;1	2
19 Wis. 245 × II-50-17		0	0	3	0;	0	;1—	3+	0;	0;
20 4148 A.I.E.3		;	;	1 to 3	3	1	3	1 to 3	1+	

[a] The infection type on Romany varied from 2+ to 3+ in different tests.

cartilagineum C. E. Hubbard-1, *Heteropogon contortus* (L.) P. Beauv. ex Roem & Schult.-1, *Hyparrhenia collina* Stapf-1, *H. diplandra* (Hack.) Stapf-1, *H. filipendula* Stapf-1, *H. hirta* Stapf-2, *H. lintonii* Stapf-1, *H. pilgerana* C. E. Hubbard-2, *Ischaemum brachyatherum* Fenzl.-1, *Lolium multiflorum* Lam-5, *L. perenne* L.-2, *Pennisetum dowsonii* Stapf and Hubbard-1, *P. massaicum* Stapf-1, *P. polystachyon* Schult.-1, *P. trachyphyiium* Pilger-1, *Poa leptoclada* Hochst. ex A. Rich.-7, *Rhychelytrum* spp. Nees-1, *Sehima nervosum* Stapf-1, *Setaria spendida* Stapf-1, *Setaria* spp. Beauv.-1, *Sporobolus fimbriatus* Nees-1, *S. pyramidalis* Beauv.-2, *Tricholaena eichingeri* (Nez) Stapf and Hubbard-1, and 30 unidentified specimens. The number following the species designates the number of rust collections from each grass.

Three collections from *Lolium multiflorum* infected rye, four from *Agrostis producta,* three from *Dactylis glomerata,* and two from unidentified grasses infected oats. Eight of the oat stem rust cultures were identified as race EA3 and one as EA4.

None of the collections clearly infected wheat, but one collection from *Eragrostis racemosa,* one from *Helictotrichon cartilagineum,* and three from *Poa leptoclada* produced a few pustules on wheat that appeared to be contaminants.

Certain grasses are hosts of rye stem rust, *P. graminis* Pers. f. sp. *secalis* Eriks. & E. Henn., and oat stem rust, *P. graminis* Pers. f. sp. *avenae* Eriks. & E. Henn., but no evidence was obtained that any of the grasses studied are hosts of wheat stem rust. Despite the lack of evidence that grasses growing in the areas in which the collections were made provide important amounts of primary inoculum of wheat stem rust, extensive studies of the vast grassland areas of East Africa are needed before generalized conclusions can be drawn. It would be surprising if none of the numerous species of grass in the region are susceptible to wheat stem rust. If susceptible species are found, their epidemiological importance will require investigation.

Races of wheat stem rust.—The main races were differentiated on wheat cultivars Reliance, Kota, Einkorn, and Vernal of the "standard" differential hosts (12), and on H441 and Gala used at Njoro. In addition, cultivars Marquis^6-*Sr11* from Canada and Giza 144 and 501/67 from seed stocks at Njoro were useful. These varieties were numbered 1 to 9, and an additional 11 varieties (Table 3) were chosen because of their importance as sources of resistance and their diverse origins.

The system of nomenclature used to designate races appears in Table 2. It resembles the method previously described by Green (4). In the table the "standard" races are those described by Stakman et al. (12). The formulas consist of a numerator showing the numbers of the resistant differential hosts and a denominator of the susceptible hosts. Only nine hosts are used in the formulas, because these hosts separate all the races found. The infection types produced on the differential hosts by the nine races appear in Table 3.

Resistance genes identified in Canada with North American races of stem rust (5) were tested to the Kenya races. The infection types produced on the lines of Marquis with single substituted resistance genes (Table 4) show that the identified genes are largely ineffective against Kenya races. However, it is evident from the reactions in Table 3 that there are unidentified resistance genes effective against the Kenya races.

Race EA5 (34/2/5/7/8) was the most common race in 1968 (Table 5). There are excellent sources of resistance to this race, and many of the recommended varieties are resistant to it, but the widely grown cultivar Romany is susceptible and frequently is severely infected. Romany seems to be a major factor in the prevalence of race EA5. Varieties with resistance from *Triticum timopheevi* Zhuk. are susceptible to races EA4 and EA8, and contribute to their prevalence. Races EA3, EA6, and EA9 are not threatening, and presumably manage to survive on varieties not highly resistant to them.

The 1968 wheat stem rust data do not indicate an abundance of races in Kenya, and W. F. Hanna (*unpublished data*) confirmed that the same races had been present for the 3-year period. There had been distinct changes in races in earlier years. Race EA4 that became common in 1966, and seems to have been present in trace amounts as early as 1964, damaged varieties with resistance from *T. timopheevi.* Similar changes must be anticipated in the future, but in view of the range of resistance available (3), we expect that sources of resistance to new races will be available.

Races of oat stem rust.—A new system of nomenclature for races of oat stem rust similar to that used for wheat stem rust was developed (Table 6). Race

TABLE 4. Infection types produced on backcross lines of Marquis wheat with substituted genes for rust resistance by races of stem rust in Kenya

Race	Substituted rust resistance gene									
	Sr1	*Sr5*	*Sr6*	*Sr7*	*Sr8*	*Sr9a*	*Sr9b*	*Sr10*	*Sr11*	*Sr15*[a]
EA1	4	0	0;1	0;2[CN]	2−	3+	2	3+	1	3+
EA2	3	0	0;1	4	3+	3+	3+	3+	4	4
EA3	4	4	3+[c]	4	3+	3+	3+	3+[c]	3+	3+
EA4	4	3+	3+	3+	3+	4−	4	3+	3+	4
EA5	3	4−	0;1	4	4	4	4	4	1	3+
EA6	4	4	4	3	4	4	3+	3+	1	4
EA7	4	4	4	4	4	4	3	4	4	4
EA8	4	4	3+	4	3+	3+	3+	3+	3+	3+
EA9	3+	3+	0;2	3+	4	4	3			

[a] Not in Marquis.

TABLE 5. Physiologic races of *Puccinia graminis* f. sp. *tritici* collected on wheat in East Africa in 1968

Formula no.	Equivalent "standard" race	No. isolates
EA3	295/1-	4
EA4	295/1/3/4	19
EA5	34/2/5/7/8	137
EA6	40/2	6
EA7	40/1/5/6	35
EA8	40/1/3/4/5/6	5
EA9	11/2/7	2
Total		208

TABLE 6. Physiologic races of *Puccinia graminis* f. sp. *avenae* isolated from grasses, wild oats, and cultivated oats in Kenya in 1968

Formula no.	Virulence formula effective/ineffective host genes[a]	No. isolates
EA1	3,9/1,2,4,8	15
EA2	4,9/1,2,3,8	1
EA3	9/1,2,4,3,8	62
EA4	/1,2,3,4,8,9	5
Total		83

[a] For gene nomenclature see (11).

EA3, that predominated in 1968, can attack seedlings of varieties with all resistance genes excepting *pg9*. The prevalence of virulent races such as EA1, EA3, and EA4 is difficult to explain. Oats are grown on small localized acreages, and the varieties in use have shifted, but as the kinds of resistance they carried is uncertain, the nature of the selection pressure that favored widely virulent races in unknown. Grasses probably play an important part in the severe rusting of oats whenever they are grown in Kenya, but the effect of grasses on the virulence of races is not known. Although the adult plant resistance conferred by resistance gene *pg11* (9) was effective in the field in 1968, breeding stem rust-resistant oats for Kenya appears to be a much more difficult problem than breeding stem rust-resistant wheat.

LITERATURE CITED

1. DIXON, G. E. 1960. A review of wheat breeding in Kenya. Euphytica 9:209-221.
2. DOWSON, W. J. 1919. Wheat in East Africa. Dep. Agr., Nairobi, B.E.A. Bull. No. 4.
3. EVANS, L. E., J. W. MARTENS, G. J. GREEN, & E. A. HURD. 1969. Sources of resistance to wheat stem rust in Kenya. Can. J. Plant Sci. (in press)
4. GREEN, G. J. 1965. Stem rust of wheat, rye and barley in Canada in 1964. Can. Plant Dis. Surv. 45:23-29.
5. GREEN, G. J., D. R. KNOTT, I. A. WATSON, & A. T. PUGSLEY. 1960. Seedling reaction to stem rust of lines of Marquis wheat with substituted genes for rust resistance. Can. J. Plant Sci. 40:524-538.
6. GUTHRIE, E. J. 1959. Work on cereal rusts in Kenya. A paper presented to the Sixth FAO Meeting on wheat and barley breeding in the Near East. Ankara, Turkey.
7. GUTHRIE, E. J. 1966. Investigation into physiologic specialization in wheat stem rust. Information bulletin on the near east wheat and barley improvement project. Vol. III, p. 15-20. FAO Near East Regional Office, Cairo, UAR.
8. LATHBURY, R. J. 1947. The development of wheat varieties in Kenya. Emp. J. Exp. Agric. 15:177-188.
9. MCKENZIE, R. I. H., & J. W. MARTENS. 1968. Inheritance in the oat strain C.I. 3034 of adult plant resistance to race C10 of stem rust. Crop Science 8: 625-627.
10. ROELFS, A. P., V. A. DIRKS, & R. W. ROMIG. 1968. A comparison of rod and slide samplers used in cereal rust epidemiology. Phytopathology 58:1150-1154.
11. SIMONS, M. D., F. J. ZILLINSKY, & N. F. JENSEN. 1966. A standardized system of nomenclature for genes governing characters of oats. U.S.D.A. ARS 34-85, 22 p.
12. STAKMAN, E. C., D. M. STEWART, & W. Q. Loegering. 1962. Identification of physiologic races of *Puccinia graminis* var. *tritici*. U.S.D.A. ARS Bull. E617 (Rev.), 53 p.