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INHERITANCE AND THE GENETIC RELATIONSHIP OF RESISTANCE POSSESSED BY TWO KENYA WHEATS TO RACES OF *PUCCINIA GRAMINIS TRITICI.*

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Synopsis.

The results of genetic studies on the stem rust resistance of Kenya 744 and Kenya 117A are reported. Their resistance to race 222AB is inherited in a simple manner. The studies on the relationship of seedling and field reactions are made. In addition to the major gene for seedling resistance in these varieties modifying factors also appear to influence the field reaction. The resistance in the two varieties has been found to be allelic.

The use of more races of stem rust in inheritance studies reveals the presence of one more non-identical gene for stem rust resistance in each of these varieties.

A scheme is also presented for designating genes for stem rust resistance in Kenya wheats.

Introduction.

Wheats of Kenya origin have made important contributions to breeding programmes designed to evolve varieties resistant to stem rust. Three of these varieties, Kenya 743,[1] 744 and 745, have been widely used for this purpose in Australia (Watson and Waterhouse, 1949). Each of them was shown to have a diverse gene for resistance to stem rust (Watson, 1943; Watson and Waterhouse, 1945). The gene in Kenya 743 was rendered useless with the appearance of race 126B in 1942 (Watson and Waterhouse, 1949) and one in Kenya 745 became ineffective in 1948 with the appearance of races 222AB and 222BB (Waterhouse, 1952; Watson and Singh, 1952). The third gene present in Kenya 744 is still effective in giving protection to races of stem rust now prevalent in Australia and it has been incorporated into the commercial wheat varieties Festival and Dowerin (Single, 1952). Kenya 117A is another variety resistant to all races of stem rust in Australia and is being used by wheat breeders (Watson and Waterhouse, 1949; Single, 1952).

Kenya wheats have also been mentioned as important sources of resistance to stem rust in other countries. A report of the International Wheat Stem Rust Conference held at Winnipeg, Canada, in January, 1953, indicates the use being made of these wheats in U.S.A. and Canada. The main source of resistance to race 15B had been Kenya wheats and their derivatives (Ausemus et al., 1953) and Kenya 117A is being used to incorporate resistance to this race. In South America, too, Kenya wheats are reported to be among the most promising sources of resistance to stem rust (Vallega, 1951).

Review of Literature.

A review of literature on the inheritance of resistance in Kenya wheats is presented below.

Watson (1941) found that Kenya 744 and Kenya 745 each had a single dominant factor for seedling resistance to races 36 and 56 of stem rust and that the seedling and field reactions were highly correlated. He also reported that single factors which governed seedling resistance to race 17 in Kenya 744 and Kenya 745 were non-allelic. Watson (1943) later carried out more extensive studies on these Kenya wheats, and found that Kenya 745 had an additional factor for seedling resistance against some races and that the resistance of Kenya 744 to powdery mildew was governed by a single dominant factor inherited independently of the gene for stem rust resistance. He found also that a factor in Kenya 745 inherited independently of the one giving resistance to races 56 and 15 gave semi-resistance to a very virulent culture of race 15 from Brazil.

[1] Varieties carry the Sydney University Accession numbers.

Abbasi (1949) found that the resistance of Kenya RL 1373 to races 34 and 11 was governed by single factors which were loosely linked. Hasanain (1949) reported the resistance of certain Kenya wheats to *Puccinia graminis tritici* as a trigenic character.

Watson and Waterhouse (1949) studied several crosses involving Kenya varieties and classified these varieties into three groups represented by Kenya 743, Kenya 744, Kenya 745. These workers also reported that Kenya 117A which showed resistance to stem rust in Australia as well as to race 15B in U.S.A. was a variety distinct from Kenya 743, 744 and 745 and of considerable potential value as a source of resistance. Kenya 117A was found (Athwal, 1953) to have a single partially dominant factor for resistance to some races of Indian stem rust, and its resistance to race 42 was controlled by two factors.

Materials.

The object of this study was to learn the mode of inheritance of resistance to stem rust possessed by Kenya 744 and Kenya 117A 1347 and also to investigate the relationship between genes for resistance present in these varieties. The reactions of both the varieties were influenced by temperature and their range of reaction to different races is shown in Table 1. The more resistant reaction in each case was obtained at approximately 60–65°F and the less resistant at approximately 75–80°F.

TABLE 1.

Range of Reaction of Two Kenya Varieties to Races of Stem Rust.

Variety.	Reaction to Stem Rust Races.												
	126	126B	222AB	222BB	15	15C	21	34	38	40	122	24	21K
Kenya 744 ..	R-SR	R-SR	R-SR	R-SR	R-S	R-S	R-SR	SR-S	R-SR	SR-S	S	S	S
Kenya 117A ..	R-SR	R-SR	R-SR	R-SR	R-SR	R-SR	R-SR	R-SR	R-SR	R-SR	R-SR	R-SR	S

R = resistant ; SR = semi-resistant ; S = susceptible.

Races 15, 21, 34, 38, 40, 122 and 24 of stem rust gave standard reactions on the differential set recorded by Stakman and Levine (1938). Race 15C differs from race 15 in its ability to attack Yalta, and 21K differs from 21 in its ability to attack Kenya 117A.

In the field Kenya 744 and Kenya 117A are highly resistant to a collection of the common Australian rusts, viz. races 126, 126B, 222AB and 222BB.

Kenya 744 is an early variety with white chaff, red grain and is half awned. It is probably identical with a variety known elsewhere as Kenya Standard. Kenya 117A is a later maturing variety with white chaff, red grain and tip awned. It has a high degree of resistance under Australian conditions. This variety is of some interest also in that it shows the usual compatibility with Khapli Emmer (Waterhouse, 1952). However, it appears to differ in its behaviour to stem rust from a collection of Kenya 117A imported from U.S.A. As far as is known the pedigree of Kenya 744 and Kenya 117A 1347 is A 8 V.12.D(L) × Marquis and BF 4.2D.30.B.2(L) respectively.

Federation 107 and Chinese White 1806 were used as susceptible parents in crosses with Kenya varieties. Chinese White was susceptible to all the races used in inheritance studies while Federation showed only partial resistance to race 38 at low temperatures, 60–65°F. The tests on crosses involving Federation were carried out at reasonably high temperatures against race 38, 70–75°F.

Methods.

Inheritance of resistance was studied in the F_1, F_2, F_3 and F_4 generations of crosses of Kenya 744 and Kenya 117A with a susceptible variety. Race 222AB was first used in the glasshouse to study the mode of inheritance and later the relationship between the four races, 126, 126B, 222AB and 222BB, was found from the breeding behaviour of F_3

and F_4 families. After testing with race 222AB, F_2 seedlings of the crosses Federation x Kenya 744 and Federation x Kenya 117A were transplanted in the field. F_3 progenies of these plants were studied as seedlings with race 222AB to check the F_2 classifications. F_3 lines of these crosses were also grown in the field and classified for stem rust reaction to mixed inoculum of the above four races. It was thus possible to correlate the seedling and adult plant reactions.

F_2s of the crosses Federation x Kenya 744 and Chinese White x Kenya 744 when tested with stem rust race 222AB were also classified for reaction to powdery mildew to confirm the earlier results of Watson (1943).

F_1s and F_2s of the cross Kenya 744 x Kenya 117A and its reciprocal were studied with race 222AB in the glasshouse. The seedlings were then transplanted in the field and notes for stem rust reaction were taken on mature plants. Some of the plants were again tested with race 222AB in the F_3 generation to confirm F_2 results.

In addition to the Australian races of stem rust, race 38 from the United States and race 122 from Kenya were used to get more information on gene relationship and the number of genetic factors for resistance in these varieties.

The following classes were used to record stem rust reaction in the seedling and mature plant stage.

Seedling reactions: Resistant (R) —; and 1; Semi-resistant (SR)—2, 3^c; Intermediate (Int.)—3^c; Segregating (Seg.)—F_3 or F_4 line consisting of Resistant or Semi-resistant and susceptible plants; Susceptible—3 and 4.

Field reaction: Resistant (R)—Almost free from rust; Moderately Resistant (R)—15 to 25% of the area of stem was infected; Semi-Resistant (SR)—25–40% of the stem was infected; Intermediate (Int.)—40–60% of the stem was infected; Segregating (Seg.)—Lines consisting of resistant and susceptible plants; Susceptible (S)—The plants were heavily infected like the susceptible parents.

TABLE 2.

Reaction of F_2s of the Cross Federation x Kenya 744 to Powdery Mildew and Stem Rust Race 222AB.

	Reaction to Race 222AB.		
	Resistant to Semi-resistant.	Susceptible.	Total.
Reaction to mildew:			
Resistant	216	80	296
Susceptible	69	19	88
Total	285	99	384

P value for 3 : 1 ratio for stem rust reaction lies between 0·70 and 0·80.—P value for 3 : 1 ratio for mildew reaction lies between 0·30 and 0·50.—P value for independence test lies between 0·30 and 0·50.

EXPERIMENTAL RESULTS.

Inheritance of the resistance of Kenya 744.

Glasshouse studies with race 222AB.—8 F_1 seedlings of the cross Federation x Kenya 744 were tested with race 222AB and the resistance was found to be dominant.

F_2s of this cross and of the cross Chinese White x Kenya 744 were inoculated with race 222AB. After incubation the pots were allowed to stand near wheat plants infected with powdery mildew. Mildew infection did not interfere unduly with the rust reactions and it was quite possible to take observations on stem rust and mildew simultaneously. The data are presented in Tables 2 and 3. Federation and Chinese White were susceptible to stem rust race 222AB and mildew, whilst Kenya 744 was resistant.

From data in Tables 2 and 3, it can be concluded that a single dominant factor in Kenya 744 controlled seedling resistance to race 222AB. The resistance to powdery mildew which was monogenic did not show any association with stem rust resistance.

F_2 plants of the cross Federation × Kenya 744 representing resistant and susceptible classes in Table 2, were transplanted in the field. Their F_2 reactions are compared in Table 4 with the breeding behaviour of F_3 families when tested with the same race of stem rust.

TABLE 3.

Reaction of F_2s of the Cross Chinese White × Kenya 744 to Powdery Mildew and Stem Rust Race 222AB.

	Reaction to Race 222AB.		
	Resistant to Semi-resistant.	Susceptible.	Total.
Reaction to mildew :			
Resistant	504	163	667
Susceptible	170	49	219
Total	674	212	886

P value for 3 : 1 ration for stem rust reaction lies between 0·30 and 0·50.—P value for 3 : 1 ratio for mildew reaction lies between 0·80 and 0·90.—P value for independence test lies between 0·50 and 0·70.

The breeding behaviour of F_3 families in Table 4 shows that five out of 112 F_2 plants were wrongly classified. P value for the agreement of F_3 data with a 1:2:1 ratio is rather low because a relatively high proportion of resistant F_2 plants gave progenies which were homozygous for resistance. If the resistant and segregating F_3 families are grouped together the data (83:29) agree well with 3:1 ratio (P 0·80–0·90).

TABLE 4.

The Breeding Behaviour of F_3 Families from the Cross Federation × Kenya 744 Raised from F_2 Plants Tested and Transplanted in the Field.

	F_3 Classification with Race 222AB.			
	Resistant to Semi-resistant.	Segregating.	Susceptible.	Total.
F_2 reactions with race 222AB :				
Resistant to semi-resistant	38	41	1	80
Susceptible	—	4	28	32
Total	38	45	29	112

P value for 1 : 2 : 1 ratio = 0·05–0·10.

Additional information on the inheritance of resistance to race 222AB was obtained from tests with a random sample of 158 F_3 lines of the cross Federation × Kenya 744. Forty-four lines were homozygous for resistance or semi-resistance, 71 segregated and 43 were homozygous susceptible. The data agree with a 1:2:1 ratio (P 0·30–0·50). The numbers of resistant and susceptible plants were found in the 71 segregating lines as well as in the 45 segregating lines of Table 4. A total of 116 lines consisted of 2045 plants of which 1480 were resistant to semi-resistant, 43 intermediate and 522 susceptible. If the intermediate plants are grouped with the resistant class, the P value for the goodness of fit to 3:1 ratio lies between 0·50 and 0·70.

Field Studies.—F_1 plants of the cross Federation × Kenya 744 showed slight development of rust in the field and they were classed as moderately resistant. Kenya 744 showed complete freedom from stem rust and Federation was susceptible.

Two hundred and sixty-eight F_3 lines of the Federation × Kenya 744 cross were also grown in the field. All the four Australian races of stem rust were present and the lines were classified as resistant to moderately resistant, segregating and susceptible. Table 5 contains the data on the F_3 lines.

TABLE 5.

Classification of F_3 Lines of the Cross Federation × Kenya 744 for Their Reaction to Stem Rust in the Field.

	Reaction to Stem Rust in the Field.				
	Resistant.	Resistant to Moderately Resistant.	Segregating.	Susceptible.	Total.
Parents ..	Kenya 744	—	—	Federation	—
F_3 lines ..	—	78	134	56	268

P value for 1 : 2 : 1 ratio lies between 0·10 and 0·20.

The field data also indicate the presence of a single major factor for resistance in Kenya 744. The resistance was partially dominant and appears to be influenced by modifying genes. Since 744 is a very early variety escapes can probably account for the larger number of resistant lines as compared to the susceptible ones. Of the 268 lines 151 were tested in the glasshouse with race 222AB and Table 6 shows relationship between the seedling and field reaction which is fairly satisfactory.

TABLE 6.

Relationship of the Seedling Reaction of Federation × Kenya 744 F_3 Lines to Their Reaction in the Field.

	Seedling Reaction to Race 222AB.			
	Resistant to Semi-resistant.	Segregating.	Susceptible.	Total.
Reaction to Races 126, 126B, 222AB, 222BB in the field :				
Resistant to moderately resistant	41	6	—	47
Segregating R & S, or R- & S. .	4	56	10	70
Susceptible	—	4	30	34
Total	45	66	40	151

Relationship between races.—F_3 lines of the cross Federation × Kenya 744, with known reactions to race 222AB, were tested in the F_4 generation against races 126, 126B and 222BB. Twenty-nine lines which were homozygous resistant to race 222AB, bred true for their resistance against the other three races. Another 22 F_3 lines homozygous susceptible to race 222AB also showed the same breeding behaviour against the other races. From this it can be concluded that the same gene in Kenya 744 was responsible for resistance to the four races of stem rust.

Studies with race 38.—Preliminary tests made on F_3 lines of the cross Federation × Kenya 744 did not show strong correlation between reactions to race 38 and race 222AB. F_2s of the cross Chinese White × Kenya 744 were tested with race 38 to study the mode of inheritance of resistance. The data in Table 7 show that Kenya 744 has two factors for resistance to race 38. One of these factors appears to be only partially dominant. The plants showing an intermediate type of reaction were grouped with the resistant and semi-resistant class when interpreting the data. The goodness of fit was not very satisfactory, probably because some of the plants classified as intermediate for their reaction to race 38 are genotypically susceptible. The data on F_4 lines included in the same table confirm the presence of two factors in Kenya 744.

TABLE 7.

Reactions of F_2s of the Cross Chinese White × Kenya 744, and F_4s of the Cross Federation × Kenya 744 to Stem Rust Race 38.

	Reactions to Race 38.				
	Resistant to Semi-resistant.	Intermediate.	Segregating.	Susceptible.	Total.
Parents of F_2s	Kenya 744	—	—	Chinese White	—
Chinese White × Kenya 744 F_2s	708	36	—	36	780
Parents of F_4s	Kenya 744	—	—	Federation	—
Federation × Kenya 744 F_4s ..	55	—	68	6	129

P value for 15 : 1 ratio for F_2 data lies between 0·05 and 0·10.—P value for 7 : 8 : 1 ratio for F_4 data lies between 0·50 and 0·70.

The reactions of 178 randomly selected F_3 and F_4 lines of Federation × Kenya 744 cross to race 38 and race 222AB are compared in Table 8.

These data show that one of the two factors in Kenya 744 which give resistance to race 38, is the same as the one giving resistance against race 222AB. Figures within brackets in Table 8 indicate the lines which show reactions not expected on the basis of this hypothesis. This is a minor discrepancy and could happen by chance. If the three families showing the unexpected behaviour are disregarded, the reactions of the rest of the lines (51:24:57:8:27:8) can be fitted with expected ratio of 4:2:6:1:2:1 on the basis of preceding hypothesis. The P value for the goodness of fit lies between 0·30 and 0·50 which is fairly satisfactory.

TABLE 8.

Distribution of 178 Lines of the Cross Federation × Kenya 744 for Their Reaction to Race 38 and Race 222AB.

	Reaction to Race 38.			
	Resistant to Semi-resistant.	Segregating.	Susceptible.	Total.
Reaction to race 222AB :				
Resistant to semi-resistant	51	(2)	—	53
Segregating	24	57	(1)	82
Susceptible	8	27	8	43
Total	83	86	9	178

It is of some interest to find the presence of two factors in Kenya 744 against race 38. Only one of them is effective against Australian rusts. Several other varieties, for example, Bencubbin, Ford, Gular and Mentana, which are susceptible to stem rust in Australia show resistance to race 38. Work is in hand at present to relate the resistance of these varieties to race 38 with that of Kenya 744.

Inheritance of the resistance of Kenya 117A.

Glasshouse studies with race 222AB.—6 F_1 plants of the cross Federation × Kenya 117A were tested with race 222AB and were found to be almost as resistant as Kenya 117A.

Athwal (1953) reported that reactions of F_2 segregates from crosses involving Kenya 117A were difficult to read and the heterozygous plants showed an intermediate type of reaction. With race 222AB, however, the segregation was clear cut and heterozygous F_2 plants were indistinguishable in their reactions from homozygous plants. The data on F_2s, F_3s and F_4s of the cross Federation × Kenya 117A are presented in Table 9.

TABLE 9.

Reactions of F_2s, F_3s and F_4s of the Cross Federation × Kenya 117A to Race 222AB.

	Reactions to Race 222AB.			
	Resistant or Semi-resistant.	Segregating.	Susceptible.	Total.
	Kenya 117A	—	Federation	—
F_2s	407	—	138	545
F_3s	24	49	23	96
F_4s	15	45	22	82

P value for 3 : 1 ratio for the F_2 data lies between 0·80 and 0·90.—P value for 1 : 2 : 1 ratio for the F_3 data lies between 0·95 and 0·98.—P value for 1 : 2 : 1 ratio for the F_4 data lies between 0·30 and 0·50.

F_2 data indicate the presence of a single dominant factor for seedling resistance in Kenya 117A.

The breeding behaviour of F_3 and F_4 lines confirms the conclusion drawn from F_2 data.

TABLE 10.

The Breeding Behaviour of the Progenies of F_2 Plants of the Cross Federation × Kenya 117A Tested and Transplanted in the Field.

	Seedling Reactions of F_3 Families to Race 222AB.			
	Resistant or Semi-resistant.	Segregating.	Susceptible.	Total.
F_2 seedling reactions to race 222AB :				
Resistant to semi-resistant	15	26	—	41
Susceptible	—	—	11	11
Total	15	26	11	52

P value for 1 : 2 : 1 ratio for F_3 reactions lies between 0·70 and 0·80.

Some F_2 seedlings from the resistant and susceptible classes were transplanted in the field. Their progenies were again tested with race 222AB to confirm the accuracy of F_2 classification. The breeding behaviour of F_3 families is correlated with the F_2 reactions in Table 10.

As the resistance of Kenya 117A is dominant, the progenies of resistant F_2 plants were either homozygous resistant or segregating, whilst all the susceptible F_2 plants bred true in the F_3 generation. The F_3 test showed the correctness of the F_2 classification.

In Tables 9 and 10, 75 segregating F_3 lines of the cross Federation × Kenya 117A consisted of 1375 plants of which 1009 were resistant to semi-resistant, 7 intermediate and 359 susceptible. By grouping the intermediate plants with the resistant ones, the data agree with 3:1 ratio with a P value of 0·30–0·50.

Field Studies.—F_1 plants of the cross Federation × Kenya 117A were only moderately resistant in the field whereas Kenya 117A maintained its full resistance. One hundred and sixty F_3 lines of the same cross were also grown and tested in the field for rust reaction to a mixture of four races of stem rust. The infection was good and Federation was severely rusted. The F_3 lines were more difficult to classify and the segregation was not as clear cut as expected on the basis of a single dominant factor. Only 11 out of 160 F_3 lines approximated to the resistance of Kenya 117A. Some lines showed a range of reaction from resistance to moderate resistance and semi-resistance. Among the lines which segregated for resistance and semi-resistance were some that were difficult to separate from lines segregating for resistance and susceptibility. Likewise certain lines segregating for semi-resistance and susceptibility were hard to separate from homozygous susceptible lines. In such cases both the alternative classifications were recorded. The field reaction of F_3 lines are given in Table 11 and are compared with the seedling reaction against race 222AB.

TABLE 11.

Reaction of F_3 Lines of the Cross Federation × Kenya 117A in the Field and Their Relationship with the Seedling Reactions Against Race 222AB.

	Field Reaction to Mixed Races.						
	R.	R to R- or R to SR.	R and SR or R and S.	Seg.	SR and S or S.	S.	Total.
Seedling reaction to race 222AB :							
Resistant to semi-resistant	11	12	13	3	—	—	39
Segregating	—	—	10	63	15	1	89
Susceptible	—	—	—	—	8	24	32
Total	11	12	23	66	23	25	160

In cases when two alternative field reactions are given for F_3 lines in Table 11, efforts were later made to find out the more probable ones. Of the 23 lines under the class R & SR or R & S, 17 were recorded as R to SR and 6 as segregating, and of the 23 lines under the class SR & S or S, 13 were recorded as susceptible and 10 as segregating. Taking the more probable reactions, 160 F_3 lines in the field can be classified as 11 resistant, 29 resistant to semi-resistant, 82 segregating and 38 susceptible. If the resistant and semi-resistant lines are treated as one class, the field data will fit 1:2:1 ratio with a P value of 0·90–0·95. The field reaction of F_3 lines can be best explained by the presence of one main modifying factor and probably some minor genes which reduce the effectiveness of the gene for resistance in Kenya 117A in the mature plant stage. Except for the modifying factors, the seedling and the field reactions appear to show satisfactory correlation.

Table 11 shows that the resistant F_3 lines, which all appear to be identical for their reaction in the seedling stage and are almost as highly resistant as Kenya 117A, show graded resistance in the field. Approximately $\frac{1}{4}$ of the resistant and semi-resistant lines in the field or $\frac{1}{16}$ of all the lines are almost as resistant as Kenya 117A. This is expected on the basis of the preceding explanation where one main modifying factor prevents the gene for rust resistance in Kenya 117A showing its full resistance in the field.

Clark and Smith (1935) reported the presence of modifying factors as it was difficult to obtain lines with as complete freedom from rust as the Hope and H-44 parents. Athwal (1953) reported modifying genes in crosses of Federation with Kenya 117A. Modifying factors probably also affect the field reaction of Kenya 744 as expressed earlier in this paper.

In backcrossing programmes carried out at Sydney University to incorporate the resistance of Kenya 117A into commercially desirable wheat varieties, it was found rather difficult to recover the full resistance of Kenya 117A. F_3 lines from the successive backcrosses were necessary to insure that the complete resistance was present. Modifying factors can thus influence the breeding programme. If the full resistance is not obtained after the first backcross then it probably will not be recovered subsequently.

TABLE 12.

Reactions of F_2s and F_4s of the Cross Federation × Kenya 117A Against Race 38.

	Reactions to Race 38.				
	Resistant to Semi-resistant.	Intermediate.	Segregating.	Susceptible.	Total.
	Kenya 117A	—	—	Federation	—
F_2s	236	13	—	12	261
F_4s	69	—	90	9	168

Relationship between races.—Selected F_4 lines of the cross Federation × Kenya 117A were tested with races 126, 126B, 222AB and 222BB. All the 26 lines which were resistant and 25 lines which were susceptible to race 222AB behaved similarly with the other three races. Of the 12 lines which segregated with race 222AB as well as 126 and 222BB, 10 were found to be segregating against race 126B; one of the remaining two lines was resistant and the other susceptible. From the data it appears that the same gene in Kenya 117A gives resistance to all the races of stem rust in Australia.

TABLE 13.

Numbers of F_4 Lines of the Cross Federation × Kenya 117A Observed and Expected in Various Classes when Inoculated with Two Races of Rust.

	Reaction to Race 222AB.			
	Resistant to Semi-resistant.	Segregating.	Susceptible.	Total.
Reaction to race 38 :				
Resistant to semi-resistant	39 (40·5)	26 (20·25)	5 (10·125)	70 (70·875)
Segregating	—	65 (60·75)	18 (20·25)	83 (81·0)
Susceptible	—	—	9 (10·125)	9 (10·125)
Total	39 (40·5)	91 (81·0)	32 (40·5)	162

Studies with race 38.—Federation × Kenya 117A F_2s were tested with race 38. Table 12 contains the data on F_2s and also a random sample of F_4 lines of this cross.

If 13 F_2 plants showing intermediate type of reaction are grouped with the resistant class, the data will give a satisfactory fit to 15:1 ratio with a P value of nearly 0·30. The F_4 data agree with 7:8:1 ratio with a P value of 0·50–0·70. Thus it appears that Kenya 117A also has two factors for resistance to race 38.

Reactions of 162 F_4 families of the cross Federation × Kenya 117A to races 38 and 222AB are compared in Table 13.

In Table 13 all the lines that were resistant to race 222AB gave the same reaction against race 38. Of the lines that were segregating and susceptible with race 222AB, some bred true for resistance against race 38. It shows that one of the two factors in Kenya 117A for resistance to race 38 is the same as the one giving resistance to race 222AB and the other is independent of it. The figures within brackets in Table 13 indicate the number of lines expected on the basis of this hypothesis. The observed agrees with the expected with a P value of 0·30–0·50.

Studies on the genetic relationship of the resistance of two Kenya wheats.

F_1s of a cross between Kenya 744 and Kenya 117A were tested with race 222AB in the glasshouse. All the plants were as resistant as the parents in the seedling stage and nearly as resistant in the field. F_1s of a reciprocal cross also behaved in the same manner.

In the F_2 generation 1036 plants of the cross Kenya 744 × Kenya 117A and 380 plants of the reciprocal cross were tested with race 222AB in the glasshouse, but no susceptible segregate was found. Both the crosses showed segregation for mildew reaction.

TABLE 14.

Reactions of Kenya 744 × Kenya 117A F_2s and Federation × Kenya 117A F_4s to Race 122.

Cross and Generation.	Reactions to Race 122.			
	Resistant to Semi-resistant.	Segregating.	Susceptible.	Total.
	Kenya 117A	—	Kenya 744	—
Kenya 744 × Kenya 117A F_2..	355	—	123	478
	Kenya 117A	—	Federation	—
Federation × Kenya 117A F_4..	37	93	35	165

P value for 3 : 1 ratio for the F_2 data lies between 0·70 and 0·80.—P value for 1 : 2 : 1 ratio for the F_4 data lies between 0·20 and 0·30.

Of the 1036 F_2 plants, 343 were transplanted in the field and their reactions to stem rust were recorded under conditions of heavy infection. The plants segregated for awn and other morphological characters. Whereas in the glasshouse the resistant reaction of all the plants was equal to the parents, in the field some plants showed moderate to semi-resistant and even intermediate type of reaction. A considerable amount of rust developed on the plants giving intermediate type of reaction but no fully susceptible plant was observed. The two parents maintained their resistance. Of the 343 F_2 plants in the field, 319 were as resistant or nearly as resistant as parents, 15 showed moderate to semi-resistance and 9 plants were intermediate for their reaction to stem rust. One hundred and thirty-one plants representing different field reaction (117 resistant, 10 moderately to semi-resistant and 4 intermediate) were harvested and their progenies tested with race 222AB in the seedling stage. All the 131 F_3 families bred true for resistance and they were all identical in their breeding behaviour in the seedling stage. The explanation for this is that the genes for resistance to race 222AB and consequently other Australian races are allelic in Kenya 744 and Kenya 117A. Modifying factors which are capable of influencing the field reaction of the two Kenya varieties are probably non-allelic.

As the gene for resistance to race 222AB in Kenya 744 and in Kenya 117A also gives resistance to race 38 no segregation for resistance to this race is expected in crosses between these two varieties. Such tests therefore will reveal nothing about the relationship of the second gene each of these wheats appears to possess against race 38. The reactions to different races of stem rust in Table 1, however, show that the two above varieties have at least one non-identical gene for rust resistance.