“BREEDING AND SELECTION OF STRIPE RUST RESISTANT CULTIVARS”

G.M. WRIGHT and F.R. SANDERSON

Crop Research Division, DSIR, Lincoln

SUMMARY

For many years a number of European wheat cultivars with resistance to stripe rust have been included in the Lincoln crossing programme. During the first season of local infection, almost two-thirds of the wheat lines screened had a useful level of resistance; this was confirmed by observations made in England. Scoring of a few thousand plots of cultivars, F1, F3, and advanced generations has shown many factors of resistance. These are strongly inherited as not many two-parent crosses give simple Mendelian segregations in F3.

INTRODUCTION

The breeder's final objective, in the face of an important disease, is to produce cultivars that suffer no appreciable loss from attack by races already present, and which either inhibit the appearance of new races of the disease or remain tolerant when new races appear. As discussed below, the evaluation of resistance is complex because each specific combination of wheat genotype and rust race reacts in a way determined by infection conditions, plant age and temperature, among other things.

Durable resistance (Johnson 1981) and the best type of non-specific resistance (Line 1980) both apparently require a fairly high level of seedling susceptibility. Johnson's ideal resistant cultivar will have inherited its resistance from a parent that has long been widely grown and resistant, and will itself have been tested to ensure that it has no factor or combination of factors giving seedling resistance to any available race. Line's approach may be less successful in New Zealand than in the western U.S. He favours one of the "slow-rusting" types, as defined by controlled-temperature studies at various growth stages. The first of these is race-specific, with resistance to most U.S. races from seedling to the boot stage, and susceptibility from flowering time. The better type has seedling susceptibility to all races at any temperature, and adult-plant resistance at high temperatures.

This type of resistance has been effective in some U.S. cultivars for more than 20 years. In New Zealand's temperate maritime climate too much rust damage is likely in autumn wheat before the hot weather comes. Cultivar 'Gaines' has this type of resistance, and last season at Lincoln it was heavily rusted up to mid-October and classed as resistant late in November, after flowering.

Compared with the immune cultivar 'Bounty' which came into ear the same day, Gaines dropped from 58 to 44 mg in grain weight last season, while Bounty dropped from 59 to 52, suggesting that Gaines was affected by stripe rust as well as by the dry weather during grain filling.

The F1 and F3 data presented are from autumn-sown breeding plots at Lincoln, grown with no attempt at stripe rust control. The disease loss data is from spring-sown disease nursery plots at Gore.

Observations at Lincoln in the 1981-82 season

1. F1 plots.

Parent plots and 19 adjacent two-parent F1's were scored at about the early boot stage (late October) (Table 1). Plants were growing vigorously at 300 x 100 mm spacing. Plot reactions were recorded as

r — immune or light fleck e.g. Oroua

mr — moderate fleck e.g. Kopara

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ms — moderate infection e.g. Rongotea

s — heavy infection e.g. Takahe

vs — very severe infection e.g. Tiritea

There is a general tendency for F 1 scores to be better than the “average” of the parents.

TABLE 1: No. F 1 plots in each reaction class.

Reaction class	Scores of parent crosses									Total Lines
	r x s	r x vs	mr x ms	mr x s	mr x vs	ms x ms	ms x s	s x s	s x vs	
r	3	—	—	—	—	—	—	—	—	3
mr	—	—	2	—	1	—	2	—	—	5
ms	—	1	—	1	—	2	1	1	—	6
s	—	—	—	4*	—	—	—	—	1	5
										19

* mr parents from Nebraska.

2. F 3 plots from N.Z. F 2s

Thirteen two-parent crosses were classified by examining some 30 to 40 plants in an average of 39 F 3 plots per cross (Table 2). Scoring as above (seg = segregating into resistant and susceptible plants; r to ms or mr to ms etc.). Plots were machine-sown, with closer plant spacing than in the F 1 plots.

TABLE 2: Behaviour of 13 two-parent crosses in F 3.

Main types of F3 plots	Scores of parent crosses								
	r x mr	r x s	mr x mr	mr x ms	mr x s	ms x ms	ms x s	s x s	
r, seg, s	—	2 +	—	—	—	—	—	—	—
mr, some seg	—	—	1	—	—	—	—	—	—
mr, some ms	1*	—	—	—	1	—	—	—	—
seg	—	—	—	—	—	1	—	—	—
s, some seg	—	—	—	—	2	—	1	—	—
ms	—	—	—	1	—	—	—	—	—
s	—	—	—	—	1	—	—	—	2
Best plot in above crosses(es)	mr	r	r	mr	r	seg: r-mr	seg: mr-ms	seg: mr-ms	

* The “r x mr” cross produced 22 mr plots, 2 segregating mr-ms, 7 ms and 1s.

+ Both “r x s” crosses produced r, segregating, and s plots in roughly equal numbers. All crosses produced at least one fully susceptible plot.

3. F 3 plots from U.K. F 2s

These crosses were made by W.B. Griffin at PBI, Cambridge and differ from the above F3's in that the F2 plants providing the seed for the plots were selected at PBI for stripe rust resistance and other characters by P.D. Hadfield and the scoring at Lincoln was done late in November 1981, at or approaching anthesis, giving a genuine “mature plant” reaction (Table 3).

These results show that screening in England was very effective, and that at least three loci differentiate Bounty and Talent from the other parents, as all crosses included several plots segregating within the resistant range. In the resistant-susceptible range of

segregation, fully susceptible plants were noted in each of the Talent crosses; in one, two, and nine plots respectively. However in the Bounty crosses only one plant, in a Bounty x Oroua plot, was classed as fully susceptible, and presumably was growing in the wrong plot.

Chi-square tests support the following statements:

No differences between the Bounty crosses ($p=0.60$)

Talent crosses different from Bounty crosses ($p=0.00002$)

Talent x Rongotea different from other Talent crosses ($p=0.013$).

TABLE 3: Classification of F 3 plots from U.K. F 2s.

Cross		r, mr, r-mr	seg: (r-s)	ms, ms-s	Total plots
Bounty (r)	x Karamu (r)	33	9	-	42
	x Oroua (r)	33	5	-	38
	x Kopara (mr)	30	6	-	36
	x Takahe (s)	28	8	1	37
Talent (r)	x Brigand (mr?)	17	13	2	32
	x Kopara (mr)	7	6	-	13
	x Rongotea (ms)	5	20	-	25

Disease nursery, Gore

The disease nursery was sown as 6 row plots, 1.5 m long. Each plot consisted of two cultivars each of two rows, with the outside rows sown with the highly susceptible cultivar Tiritea.

Stripe rust was recorded on the flag leaf as percent area infected and distinguished as a resistant (if no, or poor sporulation) or a susceptible reaction. The distinction between a resistant or susceptible reaction is not apparent from the data presented in Fig. 1. Thus, in this situation of a very high disease pressure, Oroua with a 30R reaction appears to be more severely affected than Kopara with the 15S reaction. The naturally lighter grain weight of Oroua also supports the apparently higher susceptibility of Oroua. This cultivar variation in grain weight is also demonstrated by Rongotea where both the Rongotea lines weighed more than the predicted value: the data in Fig. 1 demonstrates the effects of stripe rust on the CRD cultivars. Those cultivars with good resistance, Whakanui, Konini, and Kopara were reduced in yield by 7%. The moderately susceptible cultivars Rongotea, Takahe, by 18% and the highly susceptible cultivar Tiritea by 39%. Because of leaf flecking under the severe disease pressure and the natural tendency of Oroua to produce lighter grain, the resistance of Oroua is not demonstrated by this data.

DISCUSSION

There was no attempt to control stripe rust by seed treatment or spraying, and cultivars such as Kopara with apparent resistance were reduced in yield by approximately 40% under the conditions of severe infection followed by draught at Lincoln. At Gore the loss in Kopara was only 7%. As more than a third of the wheat plots in the area were sowing freely the inoculum load was very heavy for a long period. For 1982-83 most seed has been treated with triadimenol and the proportion of susceptible plots will be very much lower.

New high-quality rust-resistant selections are in National List trials already. A high proportion of the material in the spring wheat breeding programmes also shows adequate resistance. The selection and adoption of new resistant cultivars means that in future the disease should cost less to control.

Fig. 1: Correlation between Kernal weight and the percentage of the flag leaf infected by stripe rust.

The graph demonstrates the varying degrees of resistance exhibited by the New Zealand cultivars.

WH = Whakonui	resistant
KN = Konini	moderately resistant
KP = Kopara	moderately resistant
HI = Hilgendorf	moderately resistant
RO = Rongotea	moderately susceptible
TA = Takahe	moderately susceptible
TI = Tiritea	highly susceptible
OR = Oroua	

Oroua, because of the very high disease pressures within the trial, the 30% leaf flecking with no sporulation, recorded as 30 R, appears more susceptible than Kopara, with 15% of the leaf infected and active sporulation, recorded as 15 S. this is accentuated by lower than average kernal weight of Oroua.

Regression equation $Y = 44.0 - 0.201 x$

The standard deviation of Y about the regression line is $S = 4.528$

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