Relationship Between Genes Controlling Resistance to *Fusarium* and *Thielaviopsis* Root Rots in Beans[1]

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Abstract. Previous reports suggest similarity between *Fusarium* and *Thielaviopsis* root rot resistances in beans (*Phaseolus vulgaris* L.), with regard to both source and nature of resistance. This study was conducted to determine the relationship between the genes controlling resistance to the 2 pathogens. The susceptible cultivar 'Redkote' was crossed with bean lines 2114-12 and P.I. 203958 (N203), both of which have resistance to *Fusarium* and *Thielaviopsis*. Four populations of F_6 lines were separately developed. Two populations were derived from 'Redkote' x 2114-12; one was selected for resistance to *Fusarium* and the second for resistance to *Thielaviopsis*. Similarily, a *Fusarium*-resistant and also a *Thielaviopsis*-resistant population of F_6 lines were derived from 'Redkote' x N203. Two additional populations of F_4 plants, one resistant to *Fusarium* and one resistant to *Thielaviopsis*, were derived from the backcross [('Redkote' x 2114-12, F_2) x 'Redkote']. The F_6 and F_4 lines developed for resistance to *Fusarium* or to *Thielaviopsis* were subsequently tested for resistance to the other pathogen. The data indicate that genes controlling resistance to *Fusarium* and *Thielaviopsis* are different and non-linked.

Previous reports indicated that *Phaseolus vulgaris* L. lines 2114-12 and P.I. 203958 (N203), and *Phaseolus coccineus* L. ('Scarlet Runner') are all resistant to dry root rot caused by *F. solani* [Mart.] Appel and Wr. f. sp. *phaseoli* [Burk.] Snyd. and Hans. and to the black root rot caused by *T. basicola* (Berk. and Br.) (1,2,3,5). Resistance to *Fusarium* was shown to be controlled by 4-6 genes with additive action (1) and resistance to *Thielaviopsis* by approximately 3 genes with additive action (2). Resistance of *P. coccineus* to both pathogens was reported to be regulated by the production of 2 phytoalexins (3). This study was conducted to determine relationships between the genes controlling resistance to *Fusarium* and those controlling resistance to *Thielaviopsis*.

Materials and Methods

From crosses reported previously (1, 2) between the susceptible cultivar 'Redkote' and the *Fusarium* and *Thielaviopsis* root rot resistant lines 2114-12 and N203, 4 groups of F_6 lines, were selected. From the cross 'Redkote' x 2114-12, one group was screened and selected from the F_2 through the F_5 generation for resistance to *Fusarium*, and a second group was similarily screened and selected for resistance to *Thielaviopsis*. Another *Fusarium*-resistant and another *Thielaviopsis*-resistant group, making 4 F_6 groups in total, were simultaneously selected from the cross 'Redkote' x N203. Selection in all generations of the original and backcross populations was based on both individual plant and progeny performances. The backcrosses were to 'Redkote', using selected *Fusarium*-resistant F_2 plants and selected *Thielaviopsis*-resistant F_2 plants from the cross 'Redkote' x 2114-12. By selection in the F_2 and F_3 generations from these backcrosses, a group of F_4 lines with resistance to *Fusarium* and a second group with resistance to *Thielaviopsis* were identified. For each of the 4 F_6 and 2 F_4 groups, the available seeds were divided into 2 lots. One lot was then tested against *Fusarium* and the other against *Thielaviopsis*. Each tested lot included 5 to 21 plants. All tests were conducted in the greenhouse using testing and evaluation procedures previously reported (1).

Results and Discussion

Eleven F_6 lines developed for resistance to *Fusarium* were all partially to moderately resistant to *Thielaviopsis*, and 5 F_6 lines developed for resistance to *Thielaviopsis* were all partially to moderately resistant to *Fusarium* (Fig. 1). Six F_4 lines from the backcross to 'Redkote' that were selected for resistance to *Fusarium* were all found to be moderately to partially susceptible to *Thielaviopsis*, and 10 F_4 lines selected for resistance to *Thielaviopsis* were all moderately to partially susceptible to *Fusarium* (Fig. 2).

The results are as expected for independent and non-linked genes; i.e. because of the number of genes conditioning resistance (1,2) there is a high probability that a given F_2 plant will carry some genes for resistance to both pathogens. Continuous selection for resistance to one pathogen will not influence the frequency of genes for resistance to the other pathogen; this frequency will be determined by chance segregation. With independence of the genes conditioning resistance to *Fusarium* and to *Thielaviopsis*, the lines should carry, as they did, lower and varied levels of resistance against the pathogen for which screening was not practiced. The F_4 lines of the backcross to 'Redkote' had more opportunity to receive, from 'Redkote', genes for susceptibility to both pathogens. Only the resistance genes that were screened and selected for, the genes for resistance against *Fusarium* or alternatively against *Thielaviopsis*, remained in high enough frequency to give moderate to high levels of resistance. Independence of the genes controlling *Fusarium* and *Thielaviopsis* resistances is further indicated in that breeding lines 2051-02 and 2136-04 are highly resistant to *Fusarium* (4) but susceptible to *Thielaviopsis* [5].

These results indicate that the genes controlling resistances to *F. solani* f. *phaseoli* and to *T. basicola* are different and non-linked. They support previous reports indicating a difference in the genetics and inheritance of *Fusarium* and *Thielaviopsis* resistance (1, 2). They appear not to support evidence that the physiological basis of resistance is regulated by the same 2 phytoalexins for both pathogens (3). It is possible however, that the phytoalexins may be produced by alternate genetic pathways and that the genes controlling enzymatic steps of the synthesis of the phytoalexins by the different pathways are activated by different stimuli, i.e., by either *Fusarium* or by *Thielaviopsis*. Pierre (3) showed that different fungi induced different quantities of the 2 phytoalexins in different bean lines,

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including N203 and 2114-12, and that more phytoalexin was induced in resistant than susceptible cultivars.

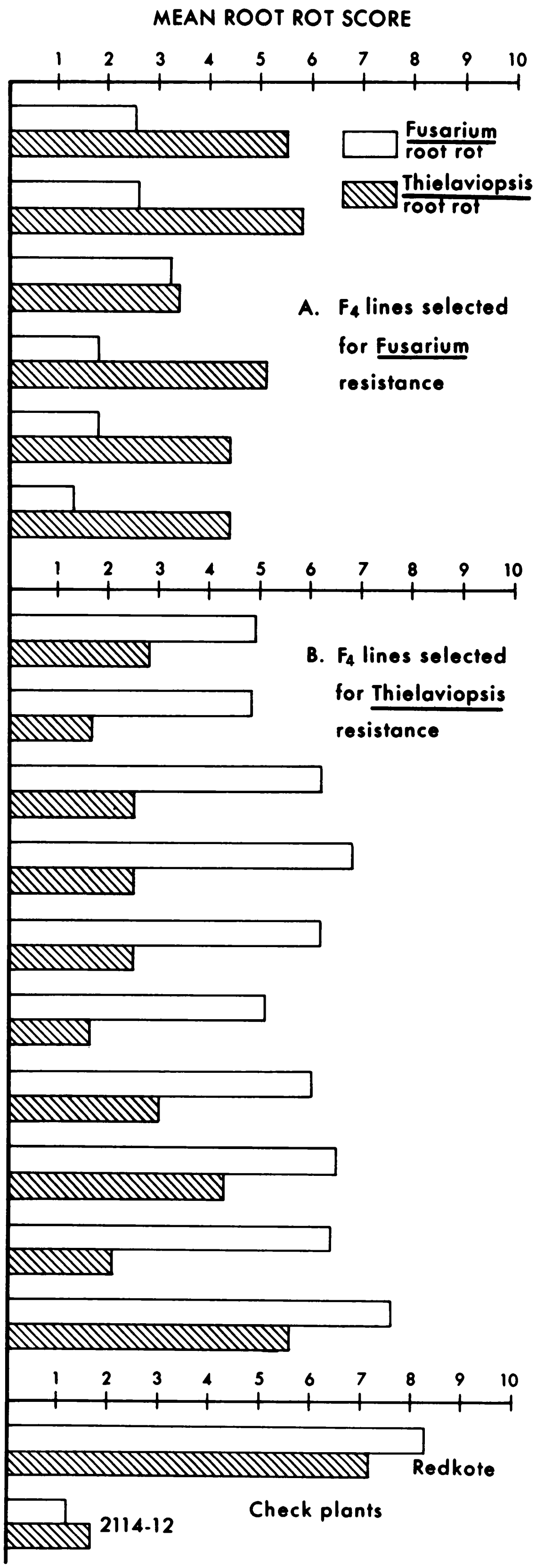

Fig. 2. Fusarium and *Thielaviopsis* root rot mean scores of F_4 lines of the cross 'Redkote'^{2} x 2114-12 that were selected for *Fusarium* or for *Thielaviopsis* resistance.

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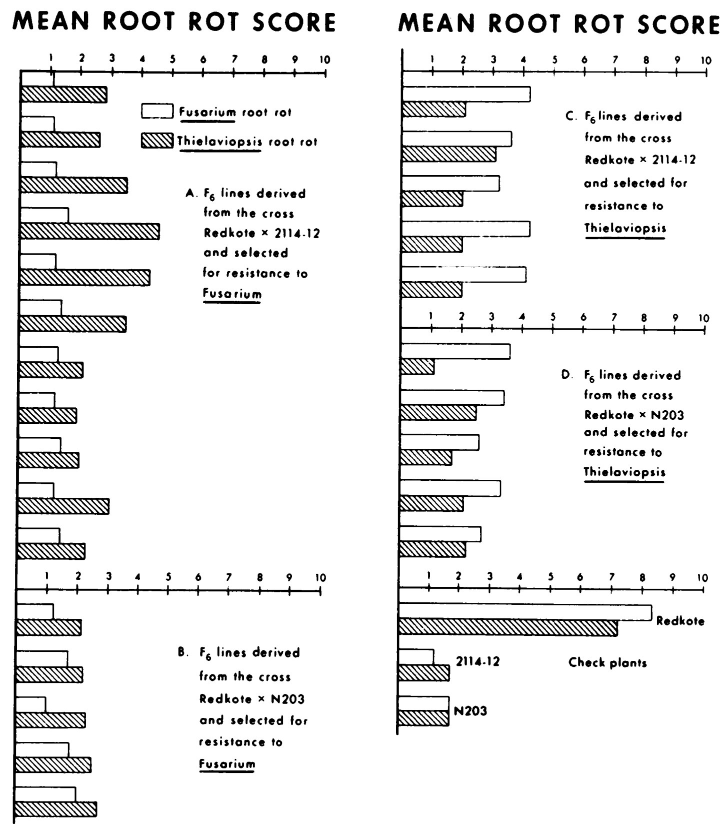

Fig. 1. Fusarium and *Thielaviopsis* root rot mean scores of F_6 lines of the crosses 'Redkote' x 2114-12 and 'Redkote' x N203 that were selected for *Fusarium* or for *Thielaviopsis* resistance.