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Inheritance of anthracnose resistance in common bean genotypes P.I. 207262 and AB 136

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ABSTRACT

Bean (*Phaseolus vulgaris*) lines P.I. 207262 and AB 136, both resistant to delta and kappa races of *Colletotrichum lindemuthianum*, were crossed with Michelite, Dark Red Kidney, and Perry Marrow, susceptible to both races, and with Cornell 49-242, resistant to delta and susceptible to kappa. F_1 and F_2 reactions demonstrated that P.I. 207262 carries duplicate dominant genes for resistance to the delta race; AB 136 carries a dominant gene. These resistance genes are independent of the *Are* gene from Cornell 49-242. With respect to the kappa race, F_1 and F_2 data showed that the resistance controlled by P.I. 207262 and by AB 136 depends on a single dominant gene. Complementary factors were involved with AB 136 resistance to the delta race and with P.I. 207262 resistance to kappa.

INTRODUCTION

Anthracnose of the common bean (*Phaseolus vulgaris* L.), caused by the fungus *Colletotrichum lindemuthianum* (Sacc. & Magn.) Scrib., is a seed-borne disease that can cause serious losses where (or when) humid weather with comparatively low temperature prevails. Although other control measures can be used, planting of resistant cultivars is the most useful one in Brazil, where a considerable proportion of bean growers are small farmers who employ a low technology level, which includes the use of their own seeds, no crop rotation, and no treatment with fungicide.

Breeding and selection of resistant cultivars is complicated by the existence of several strains or physiological races of the bean anthracnose organism (Oliari *et al.*, 1973; Menezes and Dianese, 1988). Sources of resistance to the different races have been found. Mastenbroek (1960) verified that Cornell 49-242, a Venezuelan black bean, carries a dominant gene (*Are*), which confers resistance to the races alpha, beta, gamma, delta, epsilon, zeta, eta, theta, lambda and mu (Chaves, 1980; Menezes and Dianese, 1988). Cornell 49-242 has been used in Brazilian common bean breeding programs for breeding anthracnose-resistant cultivars.

The kappa race was initially encountered in the State of Paraná (Menezes *et al.*, 1982), but it is now found in other states (Menezes and Dianese, 1988). The kappa race is able to overcome the resistance conferred by *Are*, and other sources of resistance have to be sought. Kappa constitutes a threat to bean crops in Brazil. The kappa-resistant lines, TO and P.I. 207262, were

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introduced, but they are susceptible to the zeta race (Menezes and Dianese, 1988). More recently, AB 136 was introduced as a source of resistance to the kappa race and all known Brazilian races of anthracnose (Menezes and Dianese, 1988; Balardin and Pastor-Corrales, 1990).

To facilitate the use of P.I. 207262 and AB 136 as sources of resistance to anthracnose, we investigated their mode of inheritance in relation to the delta and kappa races. It seems the delta race is the most common and widespread race in Brazil, after the alpha race (Menezes and Dianese, 1988).

MATERIAL AND METHODS

A monosporic culture of the kappa race of *C. lindemuthianum* was transferred to a test tube containing the medium proposed by Mathur *et al.* (1950) and incubated at 22°C for a period of eight to 10 days. After sporulation began, cultures of the pathogen were maintained at 5°C and used as stock culture for this study. Susceptible cultivars were inoculated at frequent intervals to test the pathogenicity of the cultures. The same procedure was utilized for the delta race.

AB 136 and P.I. 207262 (resistant to delta and kappa races) were crossed with Michelite, Dark Red Kidney, and Perry Marrow, all susceptible to both races, and Cornell 49-242, resistant to the delta race and susceptible to kappa race. Parents and F_1 and F_2 generations of each cross were grown in 30-cm diameter clay pots in a greenhouse where they were kept until the seedlings presented their first fully developed trifoliate leaves. They were then placed in a 100% humidity chamber at 22 ± 2°C, and inoculated.

Inoculation was performed with a hair brush, previously wetted in the spore suspension adjusted to 2 x 10^6 spores/ml with a hemocytometer. Inoculated plants were maintained in the humid chamber for 72 h at 20 ± 2°C with a 12-h photoperiod.

Host reactions were assessed visually eight to 10 days after inoculation. A 1-5 scale was used, where 1 = no disease symptoms; 2 = a few isolated small lesions on the mid and occasionally on the secondary veins of the leaf; 3 = many small lesions scattered on the mid and secondary veins, with collapse of the surrounding tissue; 4 = few to many large lesions scattered over the leaf blade, and 5 = many large coalescing lesions accompanied by tissue breakdown and chlorotic or abscissed leaflets. Lesion types 3, 4 and 5 were scored as susceptible (S), and types 1 and 2 as resistant (R). The observed phenotypic ratios of R to S plants were compared with theoretical ratios using the chi- square test.

RESULTS AND DISCUSSION

Delta race

In three crosses involving P.I. 207262 (Table I) the segregation ratio of 15R:1S in the F_2 populations is due to simultaneous and independent segregation at two loci, where either of the dominant alleles is capable of conferring resistance. Muhalet *et al.* (1981) also reported that duplicate dominant genes were responsible for the resistance to the delta race in some bean crosses. In addition, they found that the interaction of two dominant loci belonging to a complementary factor system was also capable of conferring a resistant reaction. In the cross P.I. 207262 x Cornell 49-242, the F_2 segregation ratio was 63R:1S, showing that three independent, dominant genes were involved, including *Are* from Cornell 49-242.

When AB 136 was used as the resistant parent (Table I), the F_2 segregation ratio for three crosses was 57R:7S. This pattern of segregation could be explained by assuming independent transmission of genes at three loci, two of which behave as complementary factors. Thus, according to this explanation, AB 136 carries a dominant gene for resistance and one for the dominant complementary factors, while the susceptible parents carry the other dominant complementary factor. However, when AB 136 was crossed with Cornell 49-242 the F_2 segregation ratio was 15R:1S, i.e., two

Table I - F_1 and F_2 reactions and expected ratios of resistant (R) and susceptible (S) to the delta race in crosses of common bean cultivars.

Cross	F_1	F_2			
		No. of plants		Expected ratio	Probability
		R	S		
P.I. 207262 x Michelite	R	296	18	15:1	0.70
P.I. 207262 x D. Red Kidney	R	249	13	15:1	0.60
P.I. 207262 x Perry Marrow	R	267	17	15:1	0.85
P.I. 207262 x Cornell 49-242	R	314	8	63:1	0.18
AB 136 x Michelite	R	276	31	57:7	0.64
AB 136 x D. Red Kidney	R	234	34	57:7	0.64
AB 136 x Perry Marrow	R	180	29	57:7	0.17
AB 136 x Cornell 49-242	R	317	14	15:1	0.12

dominant and independent genes were involved, *Are* from Cornell 49-242 being one of them.

Kappa race

The crosses of P.I. 207262 with Michelite, Dark Red Kidney and Cornell 49-242 showed that resistance was dominant in F_1 and that the F_2 segregation ratio was 57R:7S (Table II). In the cross P.I. 207262 x Perry Marrow, the F_2 segregation ratio was different, i.e., 3R:1S. These results indicate the independent transmission of genes at 3 loci: P.I. 207262 carries a dominant gene and a dominant complementary factor, while Michelite, Dark Red Kidney, and Cornell 49-242 carry the other dominant complementary factor, which is not present in Perry Marrow.

The crosses involving AB 136 (Table II) indicate that it carries a dominant gene for resistance, hence the 3R:1S segregation ratio in F_2 populations.

Table II - F_1 and F_2 reactions and expected ratios of resistant (R) and susceptible (S) to the kappa race in crosses of common bean cultivars.

Cross	F_1	F_2			
		No. of plants		Expected ratio	Probability
		R	S		
P.I. 207262 x Michelite	R	246	37	57:7	0.25
P.I. 207262 x D. Red Kidney	R	347	39	57:7	0.60
P.I. 207262 x Perry Marrow	R	264	76	3:1	0.26
P.I. 207262 x Cornell 49-242	R	253	26	57:7	0.61
AB 136 x Michelite	R	220	85	3:1	0.24
AB 136 x D. Red Kidney	R	208	54	3:1	0.10
AB 136 x Perry Marrow	R	227	72	3:1	0.71
AB 136 x Cornell 49-242	R	236	73	3:1	0.58

Further remarks

Crossing with the resistant parents P.I. 207262 and AB 136 showed that common bean resistance to the delta and kappa races is controlled by a small number of major genes, one or two. The complementary factors can also be used in breeding programs, depending on the susceptible parent's genotype, when P.I. 207262 is used as a source of resistance to the kappa race and AB 136 as a source of resistance to the delta race. AB 136 should receive greater attention in Brazilian breeding programs because it is resistant to all races so far identified in the country (Schwartz *et al.*, 1982; Menezes and Dianese, 1988; Balardin and Pastor-Corrales, 1990), while P.I. 207262 is susceptible to zeta, a race that apparently is not widespread in Brazil (Menezes and Dianese, 1988).

The dominant nature of P.I. 207262 and AB 136 resistance and the small number of genes involved should make the transference of anthracnose resistance from both cultivars to new genotypes a relatively easy task. No attempt was made to test for allelism with known sources of resistance, but the results demonstrated that P.I. 207262 and AB 136 carry dominant genes for resistance to the delta race different from *Are*, the widely used gene from Cornell 49-242.

RESUMO

As linhagens de feijão (*Phaseolus vulgaris* L.) P.I. 207262 e AB 136, ambas resistentes às raças delta e capa de *Colletotrichum lindemuthianum* (Sacc. & Magn.) Scrib., fungo causador da antracnose, foram cruzadas com Michelite, Dark Red Kidney e Perry Marrow, suscetíveis a ambas as raças, e com Cornell 49-242, resistente à delta e suscetível à capa. As reações das gerações F_1 e F_2 demonstraram que P.I. 207262 carrega dois genes dominantes de resistência à raça delta, qualquer um dos quais é capaz de conferir resistência; AB 136 carrega um gene dominante. Esses genes de resistência à raça delta são independentes do gene *Are*, proveniente do cv. Cornell 49-242. Com relação à raça capa, a resistência condicionada por P.I. 207262 e AB 136 depende de um gene dominante. Fatores complementares estão envolvidos com a resistência de AB 136 à raça delta e com a resistência de P.I. 207262 à raça capa.

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