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Variation in virulence and resistance in the bean-bean rust pathosystem in Ecuador

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Abstract Twenty two *Uromyces appendiculatus* isolates were tested on 20 differential and 25 Ecuadorian *Phaseolus vulgaris* cultivars in the seedling stage. Based on the infection types 20 races could be discerned. The Ecuadorian cultivars differed greatly in their reaction to the isolates, from resistant to only one isolate ('Red Small Garden') to resistant to all isolates ('G2333'). The isolates showed a wide range of virulence to the Ecuadorian cultivars, from virulent to only two cultivars (isolate 13) to virulent to 21 cultivars (isolates 5 and 23).

Seven cultivars with a basically susceptible infection type appeared to differ greatly in quantitative resistance when tested in three consecutive crop cycles. The disease severities in percentage leaf area affected averaged over the three cycles ranged between 83.9% for 'Red Small Garden' and 13.1% for 'INIAP-414'.

Race-specific resistance does not seem an advisable breeding strategy, but the quantitative resistance offers a good alternative.

Keywords Common bean · Bean rust · Pathogenicity · *Phaseolus vulgaris* · Partial resistance · Quantitative resistance · Race · Race-specific resistance · *Uromyces appendiculatus* · Virulence

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Introduction

Three types of resistance of bean (*Phaseolus vulgaris*) cultivars to bean rust, caused by *Uromyces appendiculatus*, have been reported.

(i) Major gene resistance of the race-specific type is very common and many genes have been described (Carvallo et al., 1978; Meiners, 1981; Stavely, 1984; Grafton et al., 1985; Kardin & Groth, 1985; Sayler et al., 1995). They appear to interact with avirulence genes in the pathogen in a gene-for-gene way (Christ & Groth, 1979, 1982). The resistance genes are often expressed as a hypersensitive flecking or as an immunity reaction (Sayler et al., 1995) but in a few cases as a minute uredium reaction (Kolmer & Groth, 1984; Stavely, 1984). The pathogen populations are highly diverse consisting of many races (Ogle & Johnson, 1974; Carrijo et al., 1980; Stavely et al., 1989; Mora et al., 1992). Sexually reproducing populations of the rust appeared highly polymorphic for virulence. Much of the variation could not be explained by variation in corresponding host resistance genes (Groth & Roelfs, 1982). But asexual populations were not less diverse for

virulence than sexually reproducing populations (Groth et al., 1995).

(ii) Leaf pubescence in *P. vulgaris* has been associated with resistance to *U. appendiculatus* (Oviedo et al., 1990). Especially the size and density of the urediosori were reduced (Mmbaga & Steadman, 1992).

(iii) Cultivars differ in susceptibility (partial or quantitative resistance). The components of partial resistance, latent period, infection efficiency (receptivity), sporulation capacity, infectious period and pustule size differed among 15 Ethiopian cultivars. Latent period and infection efficiency were associated as well as sporulation capacity and pustule size, but no single parameter accounted for the partial resistance of any particular cultivar (Habtu & Zadoks, 1995). Urediospore production per leaflet and latent period were the best parameters for evaluating partial resistance as measured by the area under disease progress curve (Azevedo & Kushalappa, 1986). Receptivity, i.e. no. of uredia obtained per propagule applied, to *U. appendiculatus* varied greatly among cultivars (Groth & Urs, 1982; Torre et al., 1987). Significant differences in the susceptibility of 23 cultivars were found after natural infection by a single−pustule isolate of bean rust in field trials over three seasons. These differences were not correlated with differences in latent period or pustule size in primary leaves (Edington et al., 1994).

Ecuador has a long history of bean growing. It is close to or even part of the South American Centre of Diversity for this crop. This study was started to analyse the bean-bean rust pathosystem in Ecuador.

Materials and methods

Experiment 1

A large number of samples of bean rust were collected from most bean growing areas in Ecuador. Samples were collected and stored in paper bags. To produce a single uredium derived isolate from a sample, urediospores were removed from the leaves with a cotton plug and a diluted urediospore suspension was sprayed on 10 days old plantlets of Red Small Garden and INIAP-417. On a primary leaf with a low density of uredia, a single uredium was isolated before sporulation by cutting off the parts of the leaf with the other non-sporulating uredia. This was repeated three times per isolate.

Twenty two single uredium-derived isolates, each derived from a different sample, were compared on two series of cultivars; the differential series of 20 cultivars described by Stavely et al. (1989) and 25 Ecuadorian landrace-derived cultivars, advanced lines and released cultivars.

The seeds were sown in a greenhouse in pots of 10 cm diameter and a volume of about 200 ml. Per pot five seeds were planted and three seedlings were allowed to develop and were inoculated. Seedlings were grown in a greenhouse with an average temperature of 16.5°C and a relative humidity of 66%.

The inoculum, consisting of about 30.000 spores per ml of water with 0.1% Tween added, was sprayed over the plantlets in the primary leaf stage, 16 days after sowing. After inoculation the plantlets were kept overnight in a room at 15.7°C where the humidity was kept at 100% for 18 h.

The infection types (IT) were assessed according to the scale of Stavely et al. (1989) at 16 and 20 days after inoculation per seedling.

Assessment scale of Stavely et al. (1989):

1 = immunity
2 = necrotic spots without sporulation and less than 0.3 mm in diameter
2 + = necrotic spots without sporulation and 0.3–1 mm in diameter
2 ++ = necrotic spots without sporulation and 1–3 mm in diameter
3 = uredinia less than 0.3 mm in diameter
4 = uredinia 0.3–0.5 mm in diameter
5 = uredinia 0.5–0.8 mm in diameter
6 = uredinia over 0.8 mm in diameter

Several of the Ecuadorian cultivars showed some necrosis or chlorosis around pustules with an IT of 4 or higher. This is indicated by a superscript N or C.

Experiment 2

Seven cultivars with susceptible infection types (4–6) were compared in three successive field experiments, one in 1998 and two in consecutive seasons of 1999, in a complete block design with plots of four rows of 3.0 m length and 0.8 m apart with 3 replicates.