USING SPECIFIC RACES OF THE COMMON BEAN RUST PATHOGEN TO DETECT RESISTANCE GENES IN *Phaseolus vulgaris*

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Host resistance is the most effective method of managing the rust disease of dry and snap beans (8). Some cultural practices and fungicides provide supplementary but less effective means of bean rust management (3). However, accomplishing effective and durable resistance to the rust pathogen in common bean is difficult. The causal agent of bean rust, *Uromyces appendiculatus*, is known to have abundant diversity for virulence (1). A multitude of races of the rust fungus have been identified in many bean-producing regions of the world (2, 4, 6, 8). Ninety races of the bean rust fungus have been isolated, identified and maintained in storage at Beltsville since 1980 by J. R. Stavely (7). Many of these races are from the United States but some are also from Africa, Asia, Europe, Central America and the Caribbean. Races of *U. appendiculatus* are differentiated by the characteristic symptoms or reaction grade that they elicit on each of a set of 19 differential cultivars. Correspondingly, several rust resistance genes, including *Ur-3*, *Ur-4*, *Ur-5*, *Ur-6*, *Ur-7*, and other uncharacterized and unnamed genes, have been identified in common bean. More recently, *Ur-11*, which provides resistance to 89 of the 90 races maintained at Beltsville, was identified and incorporated alongside other rust resistance in dry and snap bean cultivars with multiple rust resistance genes (7).

Molecular markers and specific races of the rust pathogen can be utilized to identify bean plants with one or more rust resistance genes. This is particularly important when developing beans with multiple rust resistance genes. While the prospective value of molecular markers in marker assisted selection of beans with rust resistance genes is immense, at present some of the molecular markers available are not fully reliable. Using specific races of the bean rust pathogen in multiple individual race inoculations provides a reliable means of detecting rust resistance genes. Stavely selected races of *U. appendiculatus* that produced proven reactions in the presence of the rust resistance gene of choice. Race 47 was used for detecting *Ur*-6, race 53 for *Ur-3*, race 67 for identifying *Ur-11*, and race 49 to detect presence of *Ur-4* with *Ur-11*. Additionally, races 41, 44, 73, and 108, were used for confirmation (Table 1). It is important to take into account that *Ur-3* and *Ur-6* are epistatic to Ur-11 for all the races controlled by them and *Ur-11*.

The presence of *Ur-3* results in a grade 2 type of reaction when inoculated with race 53 and with most races that *Ur-3* controls. This reaction is epistatic to the grade 3,2 produced by bean plants with *Ur-11* when these are inoculated with race 53 or with the other races controlled by *Ur-3*. Thus, race 53 elicits a different type of resistant reaction in bean plants with *Ur-3* than in plants with *Ur-11*. Since race 53 is not controlled by Ur-3 or Ur-6, this race can be used for detecting *Ur-3* (Table 1). Likewise, the resistant reaction elicited by race 47 in plants with *Ur-6* is epistatic to the resistant reaction produced by plants with *Ur-11*. Additionally, race 47 is not controlled by *Ur-3* or *Ur-4*; thus, race 47 can used to detect Ur-6. Race 67, which is controlled only by Ur-11 but not by *Ur-3*, *-4*, or *–6*, can be used to detect *Ur-11*. Ur-4 produces a type 2 of reaction to race 49 in absence of other resistance genes. Plants with Ur-11 without Ur-4 produce a 3,2 reaction. If Ur-4 and Ur-11 are present a faint chlorotic reaction results. Thus race 49 can used to detect Ur-4 with Ur-11.

Table 1. Using selected, specific, races of the bean rust fungus in multiple, individual inoculations of bean cultivars to identify presence of certain rust resistance genes

Bean Cultivar	Resistance Gene	Reaction[a] to *Uromyces appendiculatus* Race							
		41	44	47	49	53	67	73	108
Aurora	*Ur-3*	2,2+	5,4	4,5	5,4	2,2+	4,5	5,6	2,2+
E. Gallatin	*Ur-4*	4,5	2+, 2	4,3	2+, 2	4,5	4,5	2,2+	2,2+
G. G. Wax	*Ur-6*	2+,2++	2+, 2	2,2+	4,5	4,5	4,5	2	5,4
PI 181990	*Ur-11*	3,2	3,2	3,2	3,2	3,2	3,2	3,2	5,6,4
Ur-4 & Ur-11					f 2				
Gene identified →				*Ur-6*	*Ur-4 & Ur-11*	*Ur-3*	*Ur-11*		

[a]Standard bean rust grading scale: 1 = Immune, no visible symptoms. 2, 2+, 2 ++, 2 +++ = Highly Resistant; Necrotic Spots without sporulation and less than 0.3 mm, 0.3 – 1,0 mm, 1.0 – 3.0mm, and greater than 3.0 mm in diameter, respectively. 3 = Resistant; Uredinia - Sporulating lesions - less than 0.3mm in diameter. 4 = Moderately Resistant; Uredinia 0.3-0.5mm in diameter. 5 = Moderately Susceptible; uredinia 0.5-0.8 mm in diameter. 6 = Susceptible; Uredinia larger than 0.8mm in diameter.

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