Quantitative Method to Screen for Resistance to Bean Common Mosaic

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Bean common mosaic epidemics occurred frequently in the United States in the early 1900's but have been sporadic since the development of resistant cultivars in the 1930s. Currently, control is achieved through seed certification programs and resistant cultivars. The most economical control will be to develop cultivars with durable resistance by pyramiding the *I* gene with *bc* genes. Plant breeders have focused on incorporating durable resistance into breeding lines and commercial cultivars, but resistant phenotypes are difficult and expensive to evaluate because of epistatic interactions and the influence of environmental factors. The quickest way to select for resistant lines is to use marker assisted selection. However, not all the *bc* genes have markers, some markers are background specific or give unreliable results, and not all breeding programs have this technology available. Genetic and plant breeding material are still screened with strains of BCMV and BCMNV using the classical qualitative approach based on symptom development associated with systemic virus movement. This classical approach is problematic when a continuum of symptom expression exists, such as in the case of separating partially resistant material from resistant and susceptible material. Thus, a system that generates numbers suitable for statistical analysis and does not rely solely on subjective ratings and variable symptom expression would be useful. The objective of this study was to establish a quantitative rating system through characterizing resistance to the NL3 strain of BCMNV in recombinant inbred lines (RILs) derived from a cross between pinto bean cultivars Olathe and Sierra. These RILs have also been utilized in research work to establish RAPD markers for *bc-u* and *bc-l²* (J. Amer. Hort. Soc. 124(6):644-648, 1999).

A quantitative method to screen common bean (*Phaseolus vulgaris* L.) plants for resistance to bean common mosaic virus (BCMV) and bean common mosaic necrosis virus (BCMNV) is described in Table 1. In developing the quantitative method four parameters were assessed: symptoms associated with systemic virus movement, plant vigor, virus titer (i.e., ELISA values), and plant dry weight. Based on these parameters, two rating systems (V and VV rating) were established. To evaluate the usefulness of this quantitative approach, 55 recombinant inbred lines (RILs) from a Sierra X Olathe cross were inoculated with the NL3 strain of BCMNV. All the RILs were susceptible in some degree to the NL3 strain of BCMNV, since 25 RILs exhibited very susceptible reactions and 30 RILs expressed partially resistant reactions (Figure 1). The ratio of RILs in these phenotypic groups fit a 1 susceptible: 1 partially resistant ratio ($\chi^2 = 0.454$, P = 0.500) indicating the response is associated with 1 gene. With the classical qualitative approach based only on symptom expression, the RILs were difficult to separate into phenotypic groups because of a continuum of responses. By plotting percent reduction in either the V or VV rating versus the ELISA absorbance values, the RILs could be clearly separated into different phenotypic groups. This quantitative system should be particularly useful for the evaluation of the independent action of *bc* genes (most genes will not express full resistance without the *bc-u* gene present) and the discovery of new genes associated with partial resistance.

Table 1. Description of rating systems used to evaluate the responses of bean plants to inoculation with the NL3 strain of bean common mosaic necrosis virus.

Rating scale	Description of symptoms for	
	V rating	VV rating[a]
10	Healthy plant	0% LAR, and/or 0% PHR
9	Slight chlorotic spots or general chlorosis	5-10% LAR, and/or PHR
8	Chlorotic spots or ring spots or vein clearing	20% LAR, and/or PHR
7	Spotty veinal necrosis or local lesions or questionable mosaic	30% LAR, and/or PHR
6	Spotty mosaic or vein banding	40% LAR, and/or PHR
5	Mosaic or vein banding on half of plant or widespread veinal necrosis	50% LAR, and/or PHR
4	Mosaic throughout plant	60% LAR, and/or PHR
3	Strong mosaic	70% LAR, and/or PHR
2	Strong mosaic plus slight systemic necrosis	80% LAR, and/or PHR
1	Strong systemic necrosis (black root) but plant not dead	90% LAR, and/or PHR
0	Dead plant	Dead plant

[a] VV rating includes the symptoms described under the V rating but also allows for separation based on stunting. The criteria (V rating, leaf area reduction = LAR, and/or plant height reduction = PHR) with the lowest corresponding value on the rating scale was given precedence in establishing the value from 0 to 10 that was assigned.
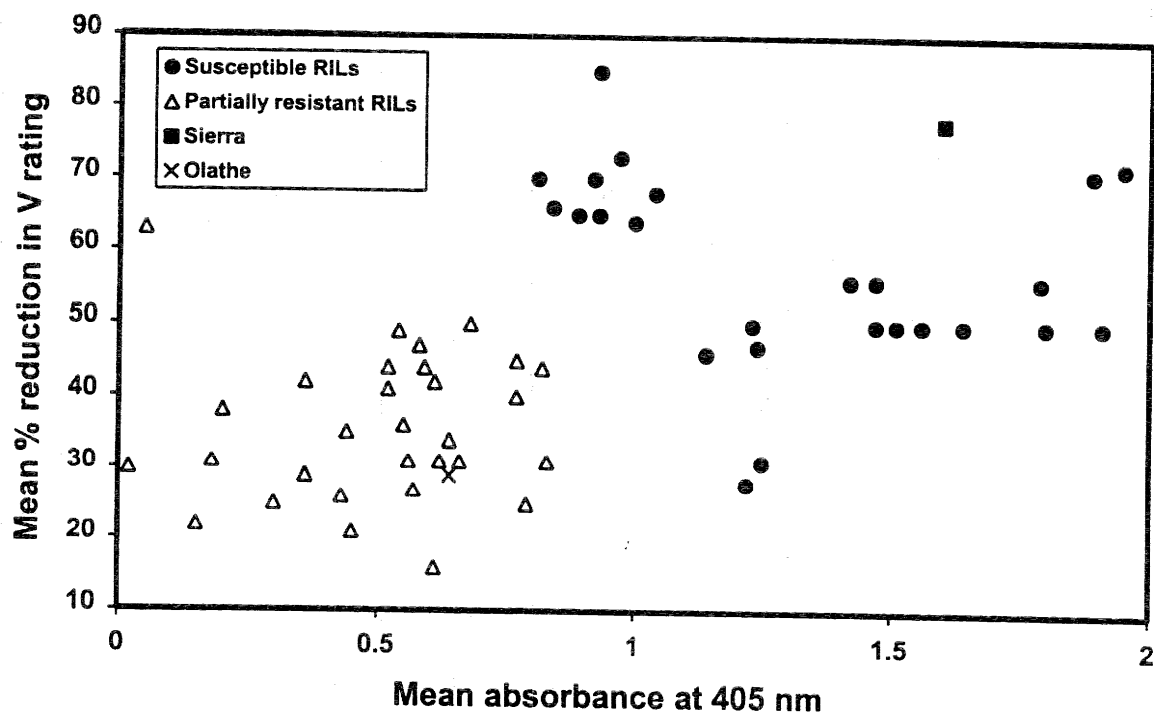

Figure 1. Summary of disease reaction data from inoculation of the NL3 strain of BCMNV onto 55 recombinant inbred lines (RILs) from an Olathe (moderately resistant parent; *bc-u bc-u bc-1^2 bc-1^2*) X Sierra (susceptible parent; *Bc-u Bc-u Bc-1 Bc-1*) cross. The RILs and parents are compared based on ELISA absorbance values and V rating (disease rating based on symptoms; Table 1). Percent reduction was established by comparing inoculated plants with check plants.