

# THE *Bct-1* LOCUS FOR RESISTANCE TO BEET CURLY TOP VIRUS IS ASSOCIATED WITH QUANTITATIVE RESISTANCE TO BEAN DWARF MOSAIC VIRUS IN COMMON BEAN

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Host resistance provides effective control of some diseases induced by geminiviruses in common bean (*Phaseolus vulgaris*). A recessive gene *bgm-1* conditions resistance to *Bean golden yellow mosaic virus* (BGYMV) and is located on linkage group B3 near the *bc-1<sup>2</sup>* gene for resistance to *Bean common mosaic virus* (Blair et al., 2007). The dominant *Bct-1* gene conditions resistance to *Beet curly top virus* (BCTV) and is located on linkage group B7 (Larsen and Miklas, 2003) in the vicinity of a QTL for resistance to BGYMV (Miklas et al., 1996; 2000). These genomic associations of host resistances to different geminiviruses, and between a geminivirus and a potyvirus as in the first example, suggest presence of individual resistance genes with broad effect against multiple virus species and/or presence of resistance gene clusters formed from gene duplication events with subsequent divergence for specific resistance against different viruses. We sought to examine the effect of the *Bct* gene that conditions resistance to BCTV (curtovirus) against another distinct geminivirus, *Bean dwarf mosaic virus* (BDMV), a begomovirus.

Ninety-four F<sub>5:7</sub> RILs (Moncayo/Primo) were previously characterized for reaction to BCTV across three disease field nurseries (Larsen and Miklas, 2003). Sixty-seven RILs had *Bct-1* gene and resistance to BCTV and 27 RILs lacked the gene and were susceptible to BCTV. Reaction to BDMV was determined by sap-inoculation in a growth chamber. Sixteen plants of each RIL and the parents Primo and Moncayo were mechanically inoculated with BDMV. Primary leaves of 10 to 14-day-old plants were dusted with celite and rubbed with infected tissue ground by mortar and pestle in 0.1 M potassium phosphate buffer (pH 8.0). Symptoms were rated using a disease severity index (DSI) of 1 to 4 approximately 21 DAI, where 1 = no obvious symptoms, 2 = mild: only mosaic on young leaves and no stunted growth, 3 = moderate: leaf curling, mosaic and dwarfing beginning at the 2nd to 3rd trifoliolate stage and stunted plant growth, and 4 = severe: leaf curling, mosaic and dwarfing beginning at the 1st trifoliolate stage and severely stunted growth. Viral DNA was detected by PCR in plants rated 2, 3, and 4.

Uniform disease reaction for the parents was observed (Table 1). Moncayo with resistance to BCTV had complete resistance to BDMV, and Primo susceptible to BCTV was completely susceptible to BDMV. The F<sub>1</sub> population was resistant to BDMV indicating dominant inheritance. The RILs expressed a quantitative disease reaction to BDMV (Table 1). The RILs with *Bct-1* had plants with a DSI mostly rated 1 or 2 for BDMV reaction with a mean DSI of 1.42 (Table 2). RILs without *Bct-1* had plants mostly rated 3 and 4 for BDMV with a mean of 3.07. Generally, RILs scoring <2.0 for BDMV reaction also possessed BCTV resistance, and RILs scoring > 2.0 were susceptible to BCTV. Six RILs had a weak association between BDMV and BCTV reactions. *Bct-1* explains 69.6% of the phenotypic variation for reaction to BDMV based single factor ANOVA.

Seo et al. (2004) demonstrated that germplasm of Andean origin was susceptible to BDMV, whereas most Middle American (MA) germplasm was resistant. The pinto bean Othello (Race Durango) possessed a dominant gene *Bdm* which conditioned qualitative resistance to BDMV. Most snap

beans originate from the Andean gene pool, and many possess genes purposely introgressed from the MA gene pool. Moncayo is a snap bean with resistance to BCTV due to transfer of *Bct-1* from the MA gene pool. In summary, *Bct-1* or a closely linked gene confers quantitative resistance to BDMV. This quantitative resistance to BDMV is different from the qualitative resistance conferred by the *Bdm* gene. The genomic location of *Bdm* is unknown. Resistance to BCTV, BDMV, and BGYMV is associated on linkage group B7.

## REFERENCES

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**Table 1.** Quantitative BDMV reaction for a subset of RILs (Moncayo/Primo).

RIL	Plants inoculated	DSI=1	DSI=2	DSI=3	DSI=4	Mean DSI	BCTV rxn
	No.	Number of plants				1 to 4	
Sample of co-segregation between BDMV reaction and <i>Bct-1</i> gene observed for most RILs							
MP-1	16	7	8	1		1.6	R
MP-4	14		5	4	5	3.0	S
MP-5	12	7	4	1		1.5	R
MP-6	10			6	4	3.4	S
MP-11	15	14	1			1.1	R
Few RILs with weak association between BDMV reaction and <i>Bct-1</i> gene							
MP-19	14		11	3		2.2	R
MP-30	8	4		2	2	2.3	S
MP-75	14	5	5	4		1.9	R
MP-77	7	4		3		1.9	S

**Table 2.** Summary of BDMV disease reaction for RILs grouped based on R and S reaction to BCTV.

		Average BDMV reaction (on a per line basis)					
Group	Total RILs	Avg. Inoculated	DSI-1	DSI-2	DSI-3	DSI-4	Mean DSI rating
	No.	Number of plants					1 to 4
R to BCTV - <i>Bct</i>	67	13.4	8.7	3.9	0.6	0.2	1.4
S to BCTV - <i>bct</i>	27	12.4	0.8	1.3	5.9	4.4	3.1