

Characterization of the Blunt Leaf Apex (*bla*) Trait in Cucumber

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Abstract. A further characterization of the cucumber (*Cucumis sativus* L.) mutant ‘Wisconsin SMR-18’ *bla* (blunt leaf apex) revealed a new character associated with the previously described leaf phenotype. The attachment of the blade to the petiole of *bla* plants is flat across, as opposed to the cordate or indented attachment in the wild-type ‘Wisconsin SMR-18’ plants. The new character (truncate leaf base) was easier to score and becomes distinctive earlier in development than previously described leaf apex characters. It was expressed consistently in homozygous *bla* plants. Segregation analysis of 1159 F₂ seedlings arising from self-pollinated ‘Wisconsin SMR-18’ × ‘Wisconsin SMR-18’ *bla* F₁ plants suggested that the leaf base and leaf apex character were controlled by a single locus or two tightly linked ones with a maximum distance between the two of 0.03 cM. In a field study of growth and fitness characteristics, the two genotypes did not differ significantly for flower or fruit count. The similar flowering and fruiting characteristics, along with the reliable early occurring truncate character, likely will make the two genotypes useful for pollination and gene movement studies.

Numerous genes have been described in cucumber (Pierce and Wehner, 1987, 1990). Among these, nine are associated with distinctive leaf morphologies (Vakalounakis, 1992). Leaf morphological mutations can be useful as markers for hybrid production and for pollination, genetic, and linkage studies. We have been using the recessive *bla* (blunt leaf apex) mutant as a marker trait to monitor pollen-mediated gene flow from donor (wild type) to recipient (*bla bla*) populations (Hokanson et al., 1994). The *bla* mutant was first described by Robinson (1987) as a recessive seedling marker trait that arose from a mutagenized ‘Wisconsin SMR-18’ cucumber population. Individuals expressing the trait were reported to have a rounded leaf apex, rather than the pointed leaf apex typical of wild-type ‘Wisconsin SMR-18’. Seeds of the *bla* mutant originally were provided by R. Robinson (New York Agricultural Expt. Station, Cornell Univ., Geneva). Seed increases were performed by hand-pollinations in the greenhouse and by field pollinations in bee-proof cages.

In the process of working with the mutant, we found that expression of the leaf apex trait was variable. The phenotypes observed for

‘Wisconsin SMR-18’ *bla* plants in the greenhouse ranged from leaves exhibiting extremely rounded leaf apices with reduced lobing and serration, as originally described by Robinson (1987), to leaves with nearly pointed apices, and sufficient lobing and serration to blur the distinction between *bla* and wild type (Fig. 1A). The lobing and serration traits were variable. The wild-type ‘Wisconsin SMR-18’ also exhibited variable characteristics in the first true leaf. In a test seedling population, the apex of the first true leaf was blunt in 9 of 33 wild-type ‘Wisconsin SMR-18’ plants.

In our study, we describe a second characteristic associated with the leaf genotype, a flat or truncate leaf base. The attachment of the blade to the petiole of *bla* plants is flat across, rather than indented or cordate (Fig. 1A and B). This trait was evident in the second and all subsequent true leaves. The truncate leaf base was consistently expressed in homozygous *bla* plants (Fig. 1A). Regardless of leaf shape (i.e., apex, serration and lobing), if the first two leaves had truncate leaf bases, the plants always had the *bla* phenotype at maturity. Progeny of self-pollinated *bla* plants always exhibited the mutant phenotype. Although the first true leaves of some wild-type ‘Wisconsin SMR-18’ plants (seven of 33) had truncate leaf bases, all subsequent leaves had cordate leaf bases and pointed leaf apices. Similarly, heterozygotes clearly exhibited the dominant cordate leaf base (Fig. 1C).

To verify that the truncate leaf base trait was due to the presence of the *bla* mutation rather than a mutation at a separate locus, we self-pollinated flowers on 11 ‘Wisconsin SMR-18’/‘Wisconsin SMR-18’ *bla* F₁ plants. All 11 of these F₁ plants exhibited the dominant cordate leaf base and wild-type leaf apex. We evaluated 1159 seedlings arising from 16 fruit from the 11 F₁ plants. Seedlings were assessed at the first, second, and third leaf stage for leaf

base and leaf apex characters (Table 1). At the first leaf stage, ≈10% of the wild-type individuals resembled the mutant either for the shape of the leaf apex, the leaf base, or both; the apex was more variable than the base. When the second and third leaves were scored, both the leaf base and apex characters segregated in the expected 3:1 ratios for a recessive, single-gene trait. From the second leaf on, there was complete correlation between the two traits; no recombinants (blunt leaf apex associated with cordate leaf base or acute leaf apex with truncate base) were present among the 1159 F₂ seedlings. These results suggest that the leaf base and leaf apex characters were controlled by a single locus or two tightly linked ones (maximum distance 0.03 cM; product ratio method). Because expression of the *bla* and wild-type phenotypes was more vari-

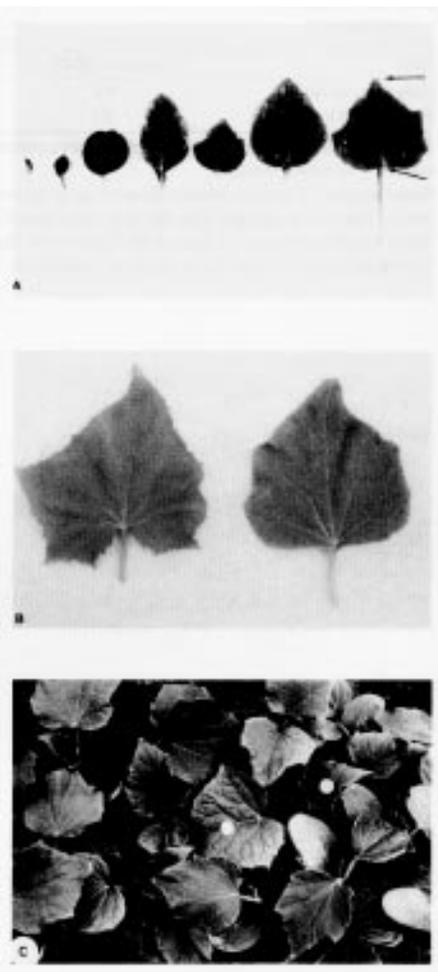


Fig. 1. *Bla* phenotypes. (A) Variation in leaf shape for first true leaves of ‘Wisconsin SMR-18’ *bla*. Arrows indicate a ‘Wisconsin SMR-18’ *bla* individual with a first leaf with an acute apex and truncate leaf base. (B) Leaf phenotypes for (left) ‘Wisconsin SMR-18’ and (right) ‘Wisconsin SMR-18’ *bla*. Note the indented or cordate leaf base for the ‘Wisconsin SMR-18’ leaf on the left and the truncate base for ‘Wisconsin SMR-18’ *bla* on the right. (C) Progeny from an open-pollinated ‘Wisconsin SMR-18’ *bla* plant. White dots indicate wild-type ‘Wisconsin SMR-18’ leaves originating from a heterozygous seedling (an outcrossing event). Note other leaves have the recessive truncate leaf base.

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able for the first leaf than for later leaves, these traits must be scored no earlier than the second true leaf.

Furthermore, to analyze the utility of this mutation, the *bla* mutant also was studied for growth and fitness characteristics in the field

using a randomized complete-block design with four replications. The two genotypes did not differ significantly for number of flowers or fruit (Table 2). Similar flowering and fruiting characteristics between the two genotypes should allow for pollination and gene move-

ment studies to be accomplished without bias due to diminished reproductive performance of one of the genotypes.

The occurrence of the truncate leaf base character increases the usefulness of the *bla* mutant for screening large seedling populations, especially in the early seedling stage. Although both characters (blunt apex and truncate base) are reliable in later stages of development, the leaf base character becomes distinctive and consistent sooner in development than does the leaf apex.

Table 1. Test for cosegregation of blunt leaf apex and cordate leaf base.

Leaf position	Wild apex/ wild base	Wild apex/ truncate base	Blunt apex/ wild base	Blunt apex/ truncate base	Apex (wild : blunt)	Base (wild : truncate)
1	769	4	61	325	773:386 $\chi^2 = 42.9^{***,z}$	820:329 $\chi^2 = 7.09^{**},z$
2	859	0	0	300	859:300 $\chi^2 = 0.48$	859:300 $\chi^2 = 0.48$
3	861	0	0	298	861:298 $\chi^2 = 0.31$	861:298 $\chi^2 = 0.31$

^zChi-square test for an expected 3:1 segregation ratio for the individual characters blunt apex or truncate base.

^{**}, ^{***}Significant for one degree of freedom at $P \leq 0.01$ and 0.001 , respectively.

Table 2. Comparison of flowering and fruiting of 'Wisconsin SMR-18' and 'Wisconsin SMR-18' *bla* genotypes.^z

Trait	Wisconsin SMR-18	Wisconsin SMR-18 <i>bla</i>	MS _{tr} /MS _{Error}
Male flowers/plant ^y	49	42	35.9/61.0 ^{ns}
Total fruit/plot ^x	10	9	2.2/1.1 ^{ns}

^zFour replicate plots, five plants per plot, three central plants scored per plot. Plants were spaced 0.5 m within rows, 1.5 m between rows.

^yTotal number of open staminate flowers per plant summed over three observation dates (6, 14, and 28 Aug. 1992). The two genotypes also did not differ significantly for number of female flowers.

^xTotal number of fruit (≥ 5 cm) on the vine on 30 Sept. 1992.

^{ns}Nonsignificant F value for analysis of variance at $P > 0.05$.

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