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Registration of Common Bacterial Blight, Rust and Bean Common Mosaic Resistant Great Northern Common Bean Germplasm Line ABC-Weihing

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ABSTRACT

Great northern common bean (*Phaseolus vulgaris* L.) germplasm line ABC-Weihing (Reg. No. GP-246, PI 647964) was developed by the University of Nebraska Agricultural Research Division in cooperation with USDA-ARS and released in 2006. This line, tested as NE1-05-4, was bred specifically for enhanced resistance to common bacterial blight (CBB), a major seed borne disease of common bean caused by the bacterium *Xanthomonas campestris* pv. *phaseoli* (Smith) Dye (*Xcp*). ABC-Weihing is a great northern BC₅F_{3,6} line obtained from five backcrosses ('Weihing'*5//Chase'/XAN 159). The first cross was made in spring 1997. Only BC_nF₁ plants resistant to *Xcp* isolates Dominican Republic DR-7 and Nebraska SC4A, as determined by multiple needle leaf inoculation tests in the greenhouse, were used for successive backcrossing. In addition to phenotypic selection for CBB resistance, marker-assisted selection for the resistant QTL-linked marker SU91 was conducted in the BC₁F₁, BC₂F₁, and ABC-Weihing. When inoculated with Nebraska *Xcp* strains in the field, ABC-Weihing exhibited resistance in both 2005 and 2006. ABC-Weihing has *Ur-3* and *Ur-6* genes for resistance to common bean rust and carries the single dominant hypersensitive *I* gene that provides resistance to all non-necrotic strains of the *Bean common mosaic virus* (BCMV). ABC-Weihing has bright white seed, blooms 45 d after planting, and is a midseason bean maturing 92 d after planting.

Great northern common bean (*Phaseolus vulgaris* L.) germplasm line ABC-Weihing (Reg. No. GP-246, PI 647964) was developed by the University of Nebraska Agricultural Research Division in cooperation with USDA-ARS and released in 2006. This line, tested as NE1-05-4, was bred specifically for enhanced resistance to common bacterial blight (CBB), a major seed-borne

disease of common bean caused by the bacteria *Xanthomonas campestris* pv. *phaseoli* (Smith) Dye [Syn. *X. axonopodis* pv. *phaseoli* (Smith) Vauretin et al.] (*Xcp*) and the brown-pigmented variant *X. campestris* pv. *phaseoli* var. *fuscans* (Burkholder) Starr & Burkholder [Syn. *X. axonopodis* pv. *phaseoli* var. *fuscans* (Burkholder) Vauterin et al. (*Xcpf*)]. ABC-Weihing is the first great northern to possess the XAN 159 (Miklas et al., 2003) source of CBB resistance.

ABC-Weihing is a great northern BC₅F_{3,6} line obtained from five backcrosses ('Weihing'*5//Chase'/XAN 159). XAN 159 was developed by the International Center for Tropical Agriculture (CIAT) for CBB resistance by selection from the interspecific cross 'UI 114' pinto/PI 319441//PI 319443 (*P. acutifolius* A. Gray)/'Masterpiece' made by Thomas and Waines (1984). XAN 159 was estimated to have up to five QTL (quantitative trait loci) for resistance to CBB (Eskridge and Coyne, 1996) and is susceptible to rust and *Bean common mosaic virus* (BCMV). Chase is a pinto cultivar derived from a cross between a great northern breeding line, GN-WM-84-17, and a pinto breeding line, P-WM-84-45, from the University of Nebraska dry-bean breeding program. Chase pinto has the *Ur-3* rust resistance gene and moderate resistance to CBB and brown spot (caused by *Pseudomonas syringae* pv. *syringae* van Hall) (Coyne et al., 1994). Weihing is a great northern cultivar derived from a cross between two great northern breeding lines from the University of Nebraska dry-bean breeding program, NE 6-91-115 and NE6-91-73. Weihing has the *Ur-3* and *Ur-6* rust-resistance genes with partial avoidance to white

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Abbreviations: BCMV, *Bean common mosaic virus*; BCMNV, *Bean common mosaic necrosis virus*; CBB, common bacterial blight; QTL, quantitative trait loci; *Xcp*, *Xanthomonas campestris*.

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Table 1. Reaction to selected races of the bean rust pathogen (*Uromyces appendiculatus*) of the great northern common bean germplasm line ABC-Weihing and other bean cultivars containing rust resistance genes. These races are used for the detection of certain bean rust-resistance genes.

Common Bean Cultivar	Resistance Gene	Rust Reaction [†] to selected races of bean rust pathogen							
		41	44	47	49	53	67	73	108
ABC-Weihing	(<i>Ur-3</i> & <i>Ur-6</i>)	2,2 ⁺	2 ⁺ ,2	2,2 ⁺	5,4,6	2,2 ⁺	5,4	2	2,2 ⁺
Aurora	(<i>Ur-3</i>)	2,2 ⁺	4,5,6	4,5,6	5,4,6	2,2 ⁺	4,5,6	5,6	2,2 ⁺
Golden Gate Wax	(<i>Ur-6</i>)	2 ⁺ ,2 ⁺⁺	2 ⁺ ,2	2,2 ⁺	4,5	4,5	4,5	2	5,4
Other Checks									
Pinto 114		5,6	5,6	4,5	4,5	4,5	5,6	4,5	5,6
Early Gallatin	(<i>Ur-4</i>)	4,5	2 ⁺ ,2	4,3	2 ⁺ ,2	4,5	4,5	2 ⁺ ,2	2 ⁺ ,2
PI 181996	(<i>Ur-11</i>)	f2,3	f2,3	f2,3	f2,3	f2,3	f2,3	f2,3	5,6,4
Weihing	(<i>Ur-3</i> & <i>Ur-6</i>)	2,2 ⁺	2 ⁺ ,2	2,2 ⁺	5,6	2,2 ⁺	5,4	2	2,2 ⁺

[†]Rust resistant reactions: 2 = Necrotic spots without sporulation, also known as hypersensitive reaction (HR). 2 = necrotic spots less than 0.3 mm diameter, 2⁺ = necrotic spots 0.3- 1 mm diameter, 2⁺⁺ = necrotic spots 1-3 mm diameter; f2 = faint chlorotic spots without sporulation; 3 = Small Uredinia (sporulating pustule) less than 0.3 mm diameter; and Rust susceptible reactions: Large Uredinia: 4 = Uredinia 0.3-0.5 mm diameter, 5 = Large uredinia 0.5-0.8 mm diameter, 6 = very large uredinia larger than 0.8 mm diameter.

mold due to upright and porous plant architecture, which gives resistance across U.S. dry bean production areas, and resistance to the halo blight pathogen [*Pseudomonas syringae* pv. *phaseolicola* (Burkholder) Young et al.] observed in Nebraska (Coyne et al., 2000). Weihing also has excellent seed quality and possesses the *I* gene for resistance to BCMV. The ABC-Weihing breeding line will be useful for improving resistance to common bacterial blight in great northern and pinto bean market classes while maintaining rust and bean common mosaic resistance, seed quality, and yield potential.

Methods

ABC-Weihing is a great northern BC₅F_{3,6} line obtained from five backcrosses (Weihing*5//Chase/XAN 159). Because there was incompatibility between Weihing and XAN 159 due to the lethality alleles *DL1* and *DL2*, advanced backcross resistant lines from the cross Chase/XAN 159 (Mutlu et al., 2005) were used as a donor parent to transfer *Xcp* resistance to the recurrent great northern parent Weihing.

The first cross was made in spring 1997. Only BC_nF₁ plants resistant to *Xcp* isolates Dominican Republic DR-7 and Nebraska SC4A, as determined by multiple needle leaf inoculation tests in the greenhouse (Andrus 1948), were used for successive backcrossing. In addition to phenotypic selection for CBB resistance, marker-assisted selection for the resistant QTL-linked marker SU91 was conducted in the BC₁F₁ and BC₂F₁.

A single DNA sample was extracted from an individual leaf disk punched from a newly opened trifoliate leaf using a modified (Afanador et al., 1993) 'mini-prep' procedure, and assayed for the presence of CBB resistance-linked markers. The PCR protocol for amplification of the SCAR marker SU91 linked with a major resistance QTL derived from XAN 159 was as described by Pedraza et al. (1997), 34 cycles of 10s at 94°C, 40s at 58°C, and 120s at 72°C; followed by one cycle of 5 min at 72°C. The band was visualized on 1.4% agarose gels containing ethidium bromide (0.5 µg mL⁻¹) for 5 h at 3V cm⁻¹ constant voltage.

CBB screening was performed in the field in 2005 and 2006 at the West Central Research and Extension Center, North Platte, NE. At flowering, plants were sprayed with a bacterial suspension of 3 × 10⁷ cfu mL⁻¹ of Nebraskan *Xcp* strains SC-

4A and LB-2 using a backpack sprayer (Schuster and Coyne, 1981). The plants were evaluated 14 d after inoculation using a 1-9 scale, where 1 = immune and 9 = very susceptible (CIAT, 1987). Reactions from 1 to 4 were considered resistant and from 5 to 9 susceptible.

The NL3 strain of *Bean common mosaic necrosis virus* (BCMNV) was used to screen bean lines for resistance to both BCMV and BCMNV. Plants were mechanically inoculated at the primary leaf stage with infected source tissue macerated in 50 mM potassium phosphate (pH 7.4) containing 10 mM sodium sulfite. Disease reaction was obtained 14 d after inoculation.

Rust was evaluated in greenhouse facilities at Beltsville, MD, in 2004

using the rust, *Uromyces appendiculatus* (Pers.:Pers) Unger, races 41, 44, 47, 49, 53, 67, 73, and 108. 'Pinto UI 114', 'Aurora' (*Ur-3*), and Weihing (*Ur-3*, *Ur-6*) were used as very susceptible, intermediate, and resistant checks, respectively. A rust evaluation scale that considers pustule size and intensity of infection was used (Stavelly et al., 1983). Pustule size was evaluated on a 1 to 6 scale. When several pustule grades were present, they were recorded in order of predominance with the most prevalent type listed first (Table 1).

Characteristics

A high level of CBB resistance was confirmed in ABC-Weihing by presence of the previously developed SCAR marker SU91 (Pedraza et al., 1997), tightly linked with a QTL from XAN 159. Reaction of ABC-Weihing to *Xcp* was consistent across two years at the West Central Research and Extension Center, North Platte, NE, where field disease ratings of 3.6 and 2.0 were recorded in 2005 and 2006, respectively. ABC-Weihing had a reaction similar to XAN 159 which was rated 3.5 and 2.0 in the same trials. Conversely, the susceptible great northern 'Matterhorn' (Kelly et al., 1999) scored 5.7 and 9.0 in 2005 and 2006, respectively.

Inoculation of ABC-Weihing with races 41, 44, 47, 49, 53, 67, 73, and 108 under greenhouse conditions at Beltsville, MD in 2004 provided evidence for the presence of *Ur-3* and *Ur-6* genes for resistance to common bean rust (Table 1). Based on top necrosis reaction to the NL-3 strain of BCMNV, it was determined that ABC-Weihing carries the single dominant hypersensitive *I* gene that provides resistance to all non-necrotic strains of BCMV, but is hypersensitive to the temperature-dependent necrosis-inducing strains of BCMV and to the temperature-independent necrosis inducing strains of BCMNV. ABC-Weihing has the same partial avoidance to white mold [*Sclerotinia sclerotiorum* (Lib.) de Bary] as Weihing due to its semi-upright and porous plant architecture in field nurseries.

ABC-Weihing exhibits a semi-upright Type 2b indeterminate growth habit. Plants averaged 57 cm in height during 2005 with excellent lodging resistance. ABC-Weihing has white flowers and blooms 45 d after planting. ABC-Weihing is a midseason bean maturing 92 d after planting and ranging in maturity from 90 to 94 d.

Seed size for ABC-Weihing (34.5 g 100 seeds⁻¹) was slightly larger than Matterhorn (33.9 g 100 seeds⁻¹), in 2005 in the Mid-West Regional Performance Nursery (MRPN) grown across four locations: Carrington, ND; Saginaw, MI; Mitchell, NE; and Fort Collins, CO. For the same nursery ABC-Weihing (2079 kg ha⁻¹) had similar yield to Matterhorn (2112 kg ha⁻¹). The seed coat of ABC-Weihing is bright white.

Availability

A limited quantity of seed is available from C.A. Urrea (currea2@unl.edu). We ask that appropriate recognition of source be given when this germplasm contributes to the development of a new cultivar.

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