Evaluation of Cadmium Response as a Tool for Zinc Efficiency Detection in Common Bean (Phaseolus vulgaris)

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Growing Zn-efficient common beans (Phaseolus vulgaris L.) in low-Zn soils is a cost-effective solution to Zn deficiency stress. Hydroponic experiments were conducted to investigate the responses of two bean genotypes (‘Calima’ and ‘Jamapa’) to Cd. Bean seedlings were grown in chelate buffer nutrient solution with increasing Cd concentrations (0, 1, 2.5, 5, 10, and 25 µM). Toxic Cd concentrations inhibited the growth of seedlings as early as 5 d. A concentration of 5 µM Cd appeared to be the threshold value for separating tolerant and susceptible lines. The results showed that tolerance to Cd toxicity was significantly correlated with Zn efficiency trait in bean. Overall, cv. Calima was highly resistant, while cv. Jamapa was very susceptible to Cd stress. The susceptible cv. Jamapa displayed decreased shoot length, chlorophyll content, and IR temperatures when grown at 5 µM Cd. Data in this study demonstrated that Cd tolerance permitted the discrimination of Zn-efficient and Zn-inefficient bean lines. Therefore, measurement of Cd response may provide a useful indirect criterion for screening of Zn efficiency in bean.

Materials and Methods

Two contrasting genotypes of common bean, ‘Calima’ and ‘Jamapa’, were evaluated in hydroponics experiments with a protocol described previously (Hacisalihoglu et al., 2004). Briefly, 4-L plastic pots were filled with a hydroponic solution culture containing the following: 1 mM KNO₃, 1 mM Ca(NO₃)₂, 0.05 mM NH₄H₂PO₄, 0.25 mM MgSO₄, 0.1 mM NH₄NO₃, 50 mM KCl, 12.5 mM H₂BO₃, 0.1 mM H₂MoO₄, 0.1 mM NiSO₄, 0.4 mM MnSO₄, 1.6 mM CuSO₄, 96 mM Fe(NO₃)₃·H₂OEDTA, 1 mM ZnSO₄·H₂OEDTA, and 2 mM MES at pH 6.0.

Cadmium (0, 1, 2.5, 5, and 10 µM) was added to solutions as CdSO₄. Plants were analyzed for determination of leaf symptoms and parameters including chlorophyll content and leaf IR temperatures.

Leaf IR temperatures were measured from 1100 to 1200 HR using a handheld IR thermometer (Fisher Scientific, Suwanee, GA). Reported IR values were the average of 10 leaves.

Leaf chlorophyll content was determined non-destructively with a Minolta SPAD-502 meter (Spectrum Tech., Plainfield, IL). Reported SPAD readings were the mean of 10 leaves from low-Zn grown plants.

Results and Discussion

In a previous study, it has been showed that ‘Calima’ is very Zn efficient and ‘Jamapa’ is a highly Zn-inefficient bean genotype (Hacisalihoglu et al., 2005). Plant growth in ‘Jamapa’ was severely inhibited at 5 d after Cd application compared with the non-treated control (Fig. 1). A significant effect of genotypes to Cd response was recorded (Fig. 1). Cd toxicity symptoms such as chlorosis and necrosis on leaves appeared as early as 5 d after treatment (Fig. 1). Visual symptoms were more severe with increased Cd concentration. There were significant differences between two common bean genotypes at 5 µM Cd concentration compared with all other concentrations. No significant changes in growth occurred in non-treated control plants.

The data for average leaf IR temperatures are listed in Fig. 2. There were moderately significant differences in leaf IR temperatures between the two genotypes. Under 5 µM Cd concentration, genotype ‘Calima’ exhibited 25% lower IR temperatures compared with genotype ‘Jamapa’ (Fig. 2). There was no significant differ-
ence in IR temperatures between the two genotypes subjected to no Cd treatment (control) (Fig. 2).

Leaf chlorophyll content (SPAD unit) was significantly decreased with increasing Cd concentration in both genotypes (Fig. 3). Overall, genotype Calima exhibited 4-fold (at 10 µM Cd) and 16% (5 µM Cd) higher content compared with genotype ‘Jamapa’ at 5 d after treatment (Fig. 3). There was no significant difference in chlorophyll content between two genotypes subjected to no Cd (control) (Fig. 3). This was in consistent with previous findings showing that Cd inhibited growth and decreased chlorophyll content of young barley plants (Vassilev et al., 1998).

In this study, response to Cd stress was tested as a new method for screening bean genotypes for Zn efficiency. The results showed marked increase in IR temperatures and decrease in chlorophyll content with increasing Cd concentration. This was in agreement with previous findings in common beans (Hacisalihoglu and Lampley, 2009). Cd response technique was able to segregate high and low Zn efficient common bean genotypes. There is a need for further research in the use of Cd response technique for potential practical applications.

**Literature Cited**


