Title
Specific Changes in Leaf Characteristics of Two Bean Genotypes as Affected by Zn Efficiency

Authors
Hacisalihoglu, Gokhan
Lampley, Aja

Publication Date
2009-04-02

Peer reviewed

INTRODUCTION

Common bean (*Phaseolus vulgaris* L.) is grown around the world due to its multitude of uses as a legume crop species. It was domesticated in Mexico and South America around 5000 BC and utilized since then as a plant-based source of protein, iron, and fiber (Sauer, 1993).

Zinc (Zn) is one of the 17 essential nutrients required for plant growth. Therefore soil Zn deficiency can cause significant reductions in yield. Furthermore, Zn deficiency stress induces changes in plant metabolic processes such as cell division, photosynthesis, and protein synthesis (Marschner, 1995). However, certain bean genotypes evolved survival and reasonable yield strategies in Zn limited conditions. We refer to these strategies as Zn efficiency (ZE, Hacisalihoglu & Kochian, 2003). Several mechanisms have been proposed to explain ZE in plants. Early studies focused primarily on root uptake based mechanisms for ZE (Rengel et al., 1998). More recent studies showed evidence that ZE trait may be determined by shoot localized mechanisms in common beans (Hacisalihoglu et al., 2004).

The objective of this work was to investigate the effects of Zn deficiency stress on the physiological characteristics of leaves of common bean by studying chlorophyll content and leaf area parameters.

MATERIALS AND METHODS

Two common bean (*Phaseolus vulgaris* L. genotypes Calima and Jamapa) plants were grown under hydroponic conditions as described elsewhere (Hacisalihoglu et al., 2001). Briefly, 4-L plastic pots were filled with a hydroponic solution culture containing the following: 1 mM KNO_3, 1mM $Ca(NO_3)_2$, 0.05 mM $NH_4H_2PO_4$, 0.25 mM $MgSO_4$, 0.1 mM NH_4NO_3, 50 μM KCl, 12.5 μM H_3BO_3, 0.1 μM H_2MoO_4, 0.1 μM $NiSO_4$, 0.4 μM $MnSO_4$, 1.6 μM $CuSO_4$, 96μM $Fe(NO_3)_3$-H_3HEDTA, 1 pM $ZnSO_4$-H_3HEDTA and 2 mM MES at pH 6.0. Low-Zn grown (-Zn, treatment) and sufficient-Zn grown (+Zn, control) plants were analyzed at 9, 21, and 28 d after treatment for determination of leaf symptoms and parameters including chlorophyll content, leaf area, and shoot and root biomass.

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

Total leaf area was measured with a CI-202 portable area meter (CID, Inc., Camas, WA). Reported values are the mean data of total leaf area of three individual plants from low-Zn grown plants.

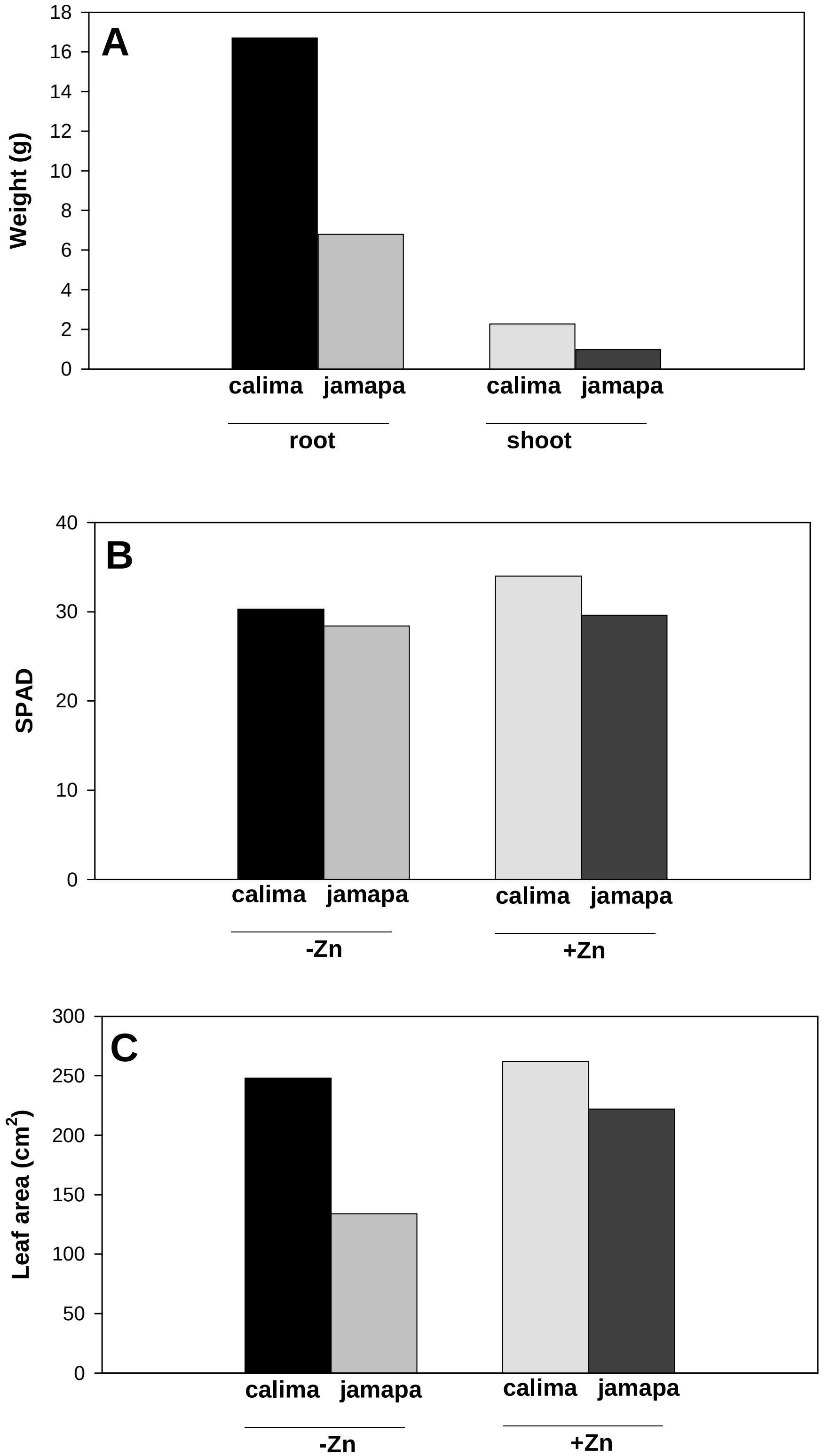

Figure 1. Comparison of two common bean genotypes ‘Calima’ and ‘Jamapa’ for final (28 d) shoot and root biomass at –Zn (A); SPAD Chlorophyll content for –Zn and +Zn (B); and total leaf area for –Zn and +Zn (C).

RESULTS AND DISCUSSION

As expected, Zn deficiency symptoms, including shortening of internodes and chlorotic leaves, appeared as early as 21 d in low-Zn grown plants. Under Zn deficiency, genotype Calima showed no symptoms compared with Zn-inefficient genotype 'Jamapa'. This is in agreement with earlier findings in beans (Hacisalihoglu et al., 2004).

Both shoot and root biomass were significantly reduced under Zn deficiency stress. Overall, there was a 41% (shoot) and 44% (root) increase in final fresh weights of genotype 'Calima' as compared to 'Jamapa' (Fig. 1A).

Overall the genotype 'Calima' displayed 7% (in –Zn) and 15% (in +Zn) higher chlorophyll (SPAD) values as compared to genotype 'Jamapa' at 9 d after treatment (Fig. 1B). In this study, SPAD readings did not successfully explain the variability in ZE before the typical deficiency symptoms appeared.

Zn deficiency significantly decreased total leaf area, especially for inefficient genotype 'Jamapa'. Zn-efficient genotype 'Calima' displayed 18% (in +Zn) and 85% (in –Zn) greater leaf area as compared with inefficient genotype 'Jamapa' (Fig. 1C).

In summary, our present results indicate that Zn deficiency decreases total leaf area as early as 9 d after treatment. From these results, it can be concluded that greater leaf area can correlate with the ZE trait in common beans and can be used as an early indicator of Zn deficiency stress in plants. However, there is a need for future research in the use of leaf area as a practical technique to detect Zn deficiency in the field before the symptoms appear.

ACKNOWLEDGEMENTS

This research was supported by U.S. Department of Agriculture Center of Excellence grant to G.Hacisalihoglu. We thank E. Vallejos (University of Florida) for the original source of seeds.

REFERENCES

Hacisalihoglu G, Hart JJ, Vallejos CE, Kochian LV, The Role of Shoot-Localized Processes in the Mechanism of Zn Efficiency in Common Bean. Planta. 2004; 218:704-711.

Hacisalihoglu G. and Kochian LV, How Do Some Plants Tolerate Low Levels of Soil Zinc? Mechanisms of Zinc Efficiency in Crop Plants. New Phytologist. 2003; 159:341-350.

Hacisalihoglu G, Hart JJ, Kochian LV, High and Low Affinity Zn Transport Systems and Their Possible Role in Zn Efficiency in Bread Wheat. Plant Physiology. 2001; 125: 456-463.

Marschner H, Mineral Nutrition of Higher Plants. 1995; Academic Press, New York, NY.

Rengel Z, Romheld V, and Marschner H, Uptake of Zn and Fe by wheat genotypes differing in tolerance to Zn deficiency. J. Plant Physiol. 1998; 152: 433-438.

Sauer JD, Historical Geography of Crop Plants. 1993; CRC Press, B. Raton, FL.