PLANT WATER STATUS IN DROUGHT-STRESSED COMMON BEAN UNDER DIFFERENTIAL RHIZOSPHERE CONFINEMENT

Rigoberto Rosales-Serna[1], Josué Kohashi-Shibata[1], Jorge A. Acosta-Gallegos[2], Carlos Trejo-López[1], Joaquín Ortiz-Cereceres[3] and James D. Kelly[4]

[1]Programa de Botánica. IRENAT. Colegio de Postgraduados. Montecillo, Edo. de México. MEXICO. C.P. 56230. e-mail: rigoberto_serna@yahoo.com. [2] Campo Experimental Bajío-INIFAP. Apdo. Postal 112. Celaya Gto. MEXICO. C.P. 38000. [3] IREGEP. Colegio de Postgraduados, Montecillo, Edo. de México. MEXICO. C.P. 56230. [4] Crop & Soil Sciences, Michigan State University, East Lansing, MI 48824.

Introduction. In Mexico dry bean (*Phaseolus vulgaris* L.) is mainly produced in regions that typically experience intermittent or terminal drought during the cropping season. Breeding for resistance to intermittent drought is the focus of improvement programs in the highlands and terminal drought in the lowland tropics. In addition to yield, other criteria for line selection under drought are needed. The importance of traits related to internal plant water status and turgidity maintenance and its effect on plant growth or survival is widely recognized (Karyudi and Fletcher, 2002). Inconsistent response on plant water status was observed possibly due to variations in root growth and its environmental interaction (Aiken and Smucker, 1996). The objective of the present work was to assess the effect of differential rhizosphere confinement on plant water status in genotypes of common bean grown under drought stress.

Material and Methods. An experiment was established under glasshouse conditions, in July 1st in 2002. Two drought-tolerant cultivars were included, G4523 (Determinate bush Type I) from the Nueva Granada race and Pinto Villa (Indeterminate prostate Type III) from the Durango race. The experiment was planted under a completely randomized factorial design with a split plot arrangement and four replications. The experimental unit consisted of one m length PVC tube. Tubes of three diameters were used (10, 15 and 20 cm) which were filled with 11, 25 and 36 kg of Haplic Feozem soil type, respectively. Tube segments were laid out in horizontal position, sealed in both extremes and a 6 cm groove was made in the upper part. Three 0.5 cm holes were drilled at the bottom to drain the excess water. Planting was made in order to allow plant emergence across the groove and a stand of 12 plants per unit was established.

Moisture treatments included irrigation (I) as a control, intermittent (ID) and terminal drought (TD). Under ID watering was suspended twice during the cycle. The first drying cycle was applied at 25 days after planting (DAP) and the second during the reproductive period (49 DAP). During the first drying period, soil moisture descended until the permanent wilting point was reached; thereafter, irrigation was applied. Two soil drying cycles were applied until the maturity or premature death of the plants, was observed. TD consisted of the definitive suspension of irrigation at 49 DAP. The control treatment was irrigated until physiological maturity in such a way that soil moisture was maintained above 80 %.

In each experimental unit, Relative Water Content (RWC) was determined at 06:00 and 14:00 h. Determinations were performed 12 days after drought treatment initiation (37 DAP) in a central leaflet of a young fully expanded leaf at basal and apical canopy positions. Leaflets were excised, covered with aluminum foil, stored in a portable freezer and taken to the laboratory. From each leaflet six discs, one cm in diameter, were punched and their fresh weight (FW) was determined. Thereafter, the discs were floated for four hours on de-mineralizated water at 25 °C under a photosynthetically active radiation of 15 μmol $m^{-2} s^{-1}$, supplied by fluorescent light. After this hydration process, the leaf portions were taken out, excess water was eliminated and then weighted (turgid weight; TW). The leaf discs were then oven-dried at 70 °C for 72 h to determine the dry weight (DW). RWC was estimated according to Matin *et al.* (1989). The remaining portions of the leaflets were used to determine osmotic potential (OP) with a 5520 Wescor Vapro Osmometer. Before determinations, plant tissue were covered with aluminum foil and frozen in liquid nitrogen. Leaf water potential (LWP) was also recorded, at the same hours and plant positions, with the pressure chamber technique.

Results and Discussion. Inconsistent data were observed for all the evaluated traits, in most of the plant position and sampling hour combinations. Therefore, more experimental units, moisture treatments or contrasting cultivars were needed due to a dynamism registered on plant water status. Pinto Villa showed the highest values for RWC in all the evaluated conditions, perhaps due to its plant traits as the lower stomatal index in the adaxial surface, in comparison with susceptible cultivars (Aguirre *et al.*, 1999). Under drought at 06:00 h, G4523 exhibited a consistent reduction in RWC according to a decrease in tube diameter (Figure 1). Results showed larger effects in G4523 due to the reduction in soil volume available to roots, in comparison to Pinto Villa. Similar results were observed at 14:00 h, in which a 60 % reduction in RWC was registered in G4523. That value seems to be lethal for G4523, since turgidity was not regained in some plants, after irrigation.

Values for OP showed similar trends from those observed for RWC. G4523 exhibited constant increments in OP according to the reduction in tube diameter at 6:00 and 14:00 h. A positive and significant relationship was observed for RWC and OP, for both varieties across moisture treatments and tube diameters. Regression values were higher at the predawn readings. Results suggest that increments in OP are needed to maintain high RWC values or that the reduction in cellular water content promoted increments in cell solutes (Hopkins, 1999), since reductions in osmotic potential seems to be related to a decrease in RWC. Variable responses were observed for LWP in both cultivars. Pinto Villa showed the lowest values for LWP at both plant positions and reading hours. This trait in combination with high values for RWC and a lower decrease in OP suggest that this cultivar maintained an adequate internal water status.

Conclusions. Variations in rhizosphere confinement caused differential responses for plant water status among dry bean cultivars. A combination of shoot traits allows drought tolerant cultivars to maintain an adequate internal water status as reductions of osmotic and leaf water potential occur. Differences in plant water status were observed between basal and apical plant positions, across tube diameters and moisture treatments.

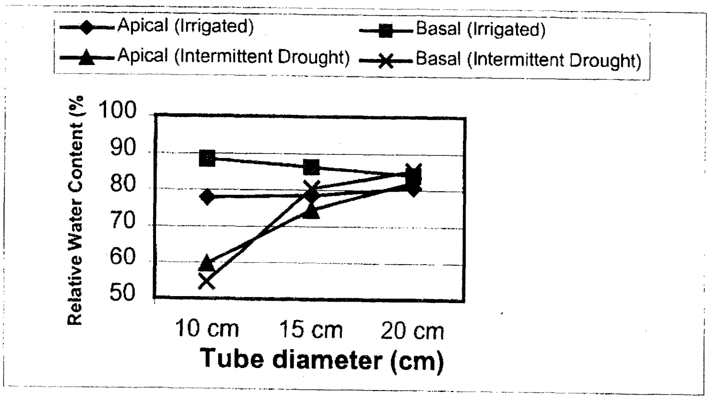

Figure 1. Relative water content observed for G4523 at 06:00 h in different tube diameters and moisture conditions.

References

Aguirre, J.F., L. Ruiz P., J. Kohashi S., C. Trejo L., and J. Acosta G. 1999. Morphological observations in the leaf surface of *Phaseolus vulgaris* L. and their possible relationship to stomatal response. Annu. Rep. of Bean Imp. Coop. 42:75-76.

Aiken, R.M. and A.J.M. Smucker. 1996. Root system regulation of whole plant growth. Annu. Rev. Phytopathol. 34: 325-346.

Hopkins, W.G. 1999. Introduction to plant physiology. 2nd. Ed. John Wiley & Sons. N.Y. p. 457.

Karyudi, and R.J. Fletcher. 2002. Osmoregulative capacity in birdseed millet under conditions of water stress. I. Variation in *Setaria italica* and *Panicum miliaceum*. Euphytica 125: 337-348.

Matin, M.A., J.H. Brown, and H. Ferguson. 1989. Leaf water potential, relative water content, and diffusive resistance as screening techniques for drought resistance in barley. Agron. Jour. 81: 100-105.