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BRIEF COMMUNICATION

Water relations of *Capsicum* genotypes under water stress

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Abstract

Pepper species and cultivars, *Capsicum annuum* cv. Bell Boy, *C. annuum* cv. Kulai and *C. frutescens* cv. Padi, differing in drought tolerance were investigated for their water relations, stomatal responses and abscisic acid (ABA) content during water stress. *C. frutescens* cv. Padi exhibited a greater osmotic adjustment than *C. annuum* cultivars. Stomatal conductance of cv. Bell Boy was more sensitive to water stress than that of cvs. Kulai and Padi. In all pepper genotypes, stomatal closure was triggered in the absence of a large decrease in leaf water status. ABA content in xylem sap and leaf was higher in *C. annuum* cultivars compared to *C. frutescens* cv. Padi.

Additional key words: abscisic acid, osmotic potential, pepper, pressure potential, stomatal conductance, water potential.

Plants growing in agricultural ecosystems are generally hindered from expressing their full genetic potential for production by environmental stresses. One of the environmental stresses that is crucial for the productivity of crop is drought and the important adaptation of plants to drought is the increase in the concentration of intracellular solutes which facilitate the maintenance of cell pressure potential. There is evidence that osmotic adjustment may differ in different genotypes (*e.g.* Johnson *et al.* 1990, Singh *et al.* 1990).

Stomatal closure in drying soil coincides with leaf internal water stress, but there are many reports on stomatal closure triggered in the absence of the change in leaf

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water status (Blum *et al.* 1991, Correia and Pereira 1994). The evidence of a non-hydraulic root-to-shoot signalling the effect of soil drying has been repeatedly proven under conditions of a gradual depletion in soil moisture content (Trejo and Davies 1991, Khalil and Grace 1993, Jackson *et al.* 1995). There are, however, contradictory reports on the nature of the chemical signal involves in this root to shoot communication (Davies and Lakso 1978, Munns and King 1988, Zhang and Davies 1987, Trejo and Davies 1991).

Abscisic acid (ABA) increases in plants during drought stress. However, few studies has compared stress induced increase in ABA in tolerant and sensitive pepper cultivars. Berkowitz and Rabin (1988) showed that ABA used as antitranspirant affected water relations and yield of transplanted pepper plants. The present study was undertaken to investigate water relations, stomatal sensitivity and accumulation of ABA in xylem of three pepper cultivars subjected to water stress.

Three different pepper genotypes used for this work were the *Capsicum annuum* cv. Kulai, *Capsicum annuum* cv. Bell Boy (sweet pepper) and *Capsicum frutescens* cv. Padi. The seedlings were grown in a controlled environment cabinet at 22 - 25 °C (day) or 18 °C (night), relative humidity of 48 - 56 % and photoperiod of 14 h with photon flux density of 320 μmol m^{-2} s^{-1}. The seedlings were grown in pots containing 2.1 dm^3 of *John Innes* compost mixture *No 2*. Once plants reached 5 - 6 leaf stage, a group of plants remained unwatered and the other plants were watered daily. Over the following 6 d, measurements of water, osmotic and pressure potentials, stomatal conductance, xylem sap ABA, and soil water content were made 4 h after the beginning of light period.

Stomatal conductance was determined on the abaxial surface of the youngest fully expanding leaves, using a diffusion porometer (*AP-4, Delta-T Devices*, Cambridge, UK). Leaf water potential was measured using a pressure chamber (*PMS, Soil Moisture Equipment*, Santa Barbara, USA) on the adjacent leaves used for stomatal conductance measurements on each sampling day. These leaves were then inserted

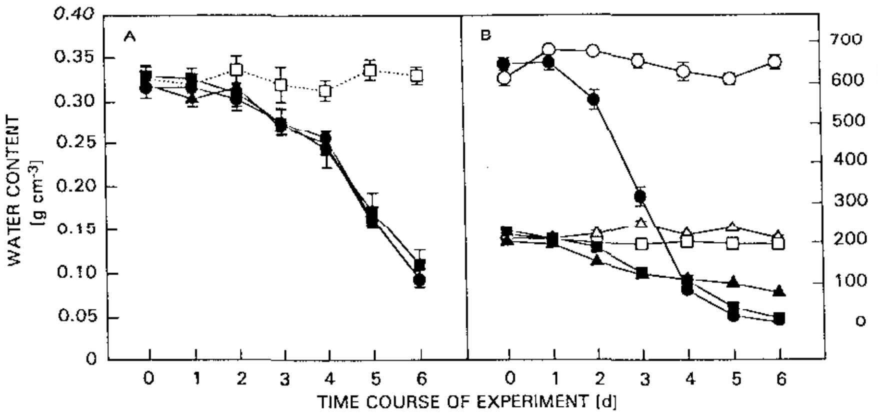

Fig. 1. Bulk soil water content (*A*) and stomatal conductance (*B*) during development of water stress (control plants - *open symbols*, stressed plants - *closed symbols*) in three pepper cultivars (cv. Bell Boy - *circles*, cv. Kulai - *triangles*, cv. Padi - *squares*); means of 4 - 5 replications, *bars* represent S.E.

into 10 cm^3 syringe and immediately placed in liquid nitrogen before storage in a deep freezer at -20 °C for 5 d before determination of osmotic potential using a vapour pressure osmometer. Pressure potential was calculated from the difference between water and osmotic potential. At each harvest, the plant was cut at 1 cm above soil surface and the cut stump enclosed in the polythene bag was immediately placed in a pressure chamber. The extruded sap was collected in a capillary tubing and transferred to Eppendorf vials, and then frozen in liquid nitrogen. Analysis of xylem sap and leaf ABA was carried out using a radioimmunassay protocol (Quarrie *et al.* 1988). Soil was sampled in each 3 cm depth of the soil column and soil water content was determined after oven drying at 80 °C for 48 h. On each occasion, plants were chosen at random and four different plants were used for determining each parameter.

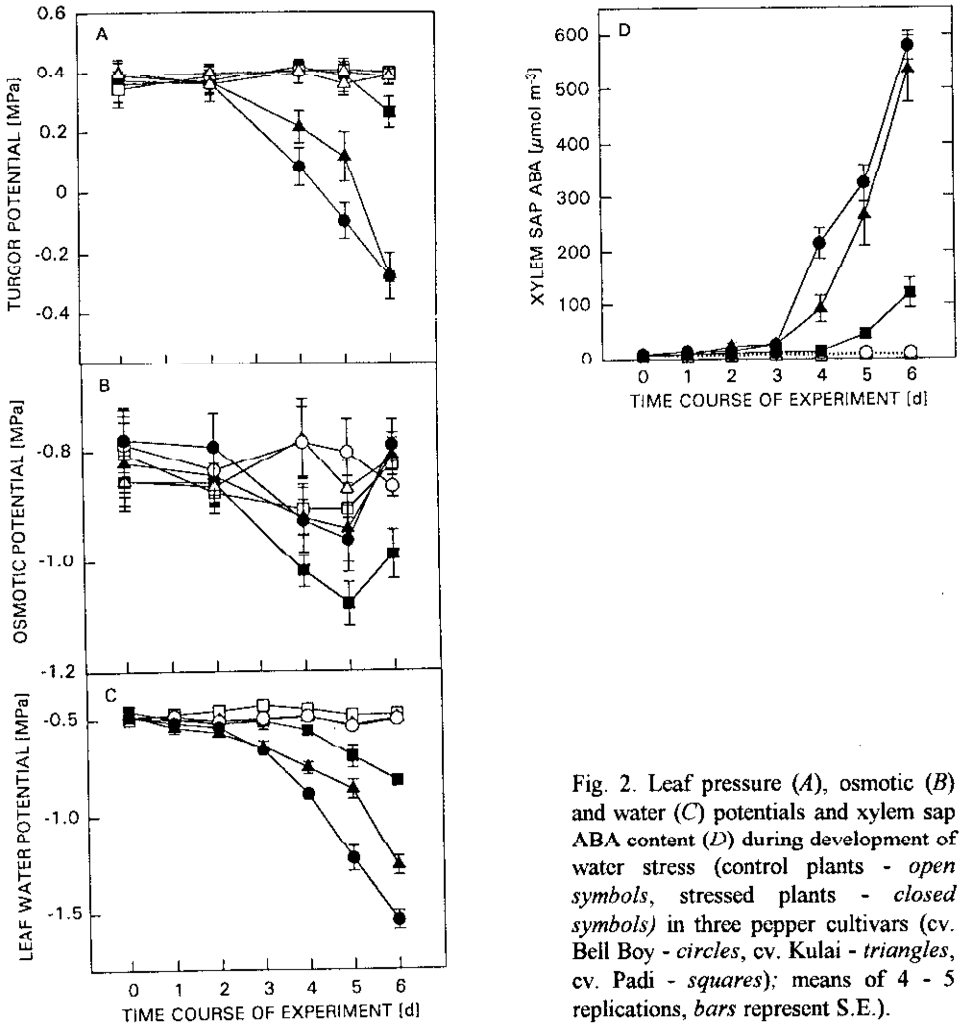

Fig. 2. Leaf pressure (*A*), osmotic (*B*) and water (*C*) potentials and xylem sap ABA content (*D*) during development of water stress (control plants - *open symbols*, stressed plants - *closed symbols)* in three pepper cultivars (cv. Bell Boy - *circles*, cv. Kulai - *triangles*, cv. Padi - *squares*); means of 4 - 5 replications, *bars* represent S.E.).

Soil moisture content decreased with time of withholding water (Fig. 1*A*). Mean soil moisture content under water stress was 0.1 g cm^{-3} when experiment terminated. Withholding water from the root system reduced stomatal conductance on all pepper genotypes (Fig 1*B*). *C. annuum* cv. Bell Boy exhibited higher stomatal conductance than cv. Kulai or cv. Padi under well watered conditions. However, once watering was stopped, stomatal conductance of cv. Bell Boy was reduced after 2 d and was 50 % lower than that of control after 3 d. Stomatal conductances of *C. annuum* cv. Kulai and *C. frutescens* cv. Padi were reduced slightly in these days.

A reduction in leaf water potential was only observed after 3 d in all *C. annuum* cultivars. In addition, leaf water potential was reduced at a slower rate compared to the stomatal conductance, especially at the earlier phase of water stress. The results agreed with those observed in many other experiments reported earlier (Zhang and Davies 1987, Trejo and Davies 1991 and Jackson *et al.* 1995). Schulze (1994) indicated that the response of stomata to a root signal may be regarded as a feedforward response, in which roots in dry soil produce a chemical signal to reduce water loss even before plant experiences plant internal water stress.

Leaf water potential declined rapidly from -0.60 MPa (day 3) to a minimum of -1.55 and -1.2 MPa (day 6) in cvs. Bell Boy and Kulai, respectively. Cv. Padi maintained leaf water potential less than -1.0 MPa under water stress conditions throughout the experiment (Fig. 2*C*). When plants were subjected to water stress, the osmotic potential decreased (Fig. 2*B*). The variations in the water and osmotic potentials resulted also in different pressure potentials in individual genotypes: cv. Padi maintained a greater pressure potential compared to *C. annuum* cultivars under water stress conditions (Fig. 2*A*). The negative values of pressure potential observed may indicate that plants were in wilting stage as water stress progressing.

C. frutescens cv. Padi exhibited a greater capacity of osmotic adjustment than both *C. annuum* cultivars. The results confirmed the nature of which this cultivar being cultivated without irrigation requirement. The sensitive response to water stress in *C. annuum* cv. Bell Boy (a sweet bell pepper) agreed with those observed by Aloni *et al.* (1991).

The differences between pepper genotypes in xylem sap ABA contents were accentuated with duration of water stress. The content of xylem sap ABA was 100 µmol m^{-3} higher in cv. Bell Boy than in cv. Kulai on day 4. Thereafter, xylem sap ABA in cv. Bell Boy increased progressively reaching a maximum values on day 6. Xylem sap ABA in cv. Kulai responded similarly. The content of xylem sap ABA in *C. frutescens* cv. Padi remained the lowest throughout the whole experimental period (Fig. 2*D*) . This differences in ABA concentration between species/cultivars were shown to be dependent of the leaf water status on each species/cultivars. The large differences in ABA content between cvs. Bell Boy or Kulai and Padi was overall, due to a lesser reduction in leaf water potential as observed from day 4 in cv. Padi. There were enough evidence for a role for ABA in chemical signalling between root to shoots in droughted plants (Jackson 1993, Davies *et al.* 1994) .The present study, however, was unable to show a large increase in ABA until day 4 of water stress to account a large decrease in stomatal conductance by all the cultivars studied.

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