Kasetsart J. (Nat. Sci.) Vol. 25 : 380 – 383 (1991)

Epidermal Conductance of Soybean Cultivars

Anek Chotiyarnwong[1]

ABSTRACT

Epidermal conductance, which my contribute to drought tolerance in crop plants, was measured in eleven soybean cultivars, including seven cultivars bred in Thailand. Significant variation in epidermal conductance was measured among the cultivars tested. Sukhothai 1, SJ. 4, Nakhonsawan 1 and CPAC 527-76 had low conductance. These cultivars might be potentially important in plant breeding program for improvement of drought tolerance in soybean.

INTRODUCTION

Food legumes are widely grown as a source of protein in semiarid and tropical regions, but production is often limited by large variation in the amount and distribution of rainfall. The water deficits that often occur influence various physiological processes associated with crop growth, development and economic yield (Begg and Turner, 1976). Sionit and Kramer (1977) reported that plants stressed during flower induction and flowering produced fewer flowers, pods and seeds than controls but stress during early pod formation caused the greatest reduction in number of pods and seeds at harvest. Seed yield was reduced most by stress during early pod formation and pod filling.

Sinclair and Ludlow (1986) indentified three phases in the response of plants to progressive drying of soil. During the first phase, water is freely available from the soil and the rate of water loss depends on environmental conditions around the shoot. Phase 2 begins when soil has dried to the extent that it cannot supply water at a rate sufficient to meet transpirational requirements. Stomata close and leaf conductance to water vapour declines in order to maintain plant water balance. Phase 3 commences when stomates are closed and continues until the 'critical' or lethal leaf relative water content is reached and leaves die. They proposed that the rate of loss of water per unit leaf area during phase 3 is controlled by the epidermal conductance of the leaves and the saturation deficit of the air. They showed that among four food legumes soybean (*Glycine max* (L.) Merr.) had the highest conductance, followed by black gram (*Vigna mungo* (L.) Hepper), cowpea (*Vigna unguiculata* (L.) Walp), and pigeon pea (*Cajanus cajan* (L.) Millsp.), and that high conductance was associated with a shorter survival time in phase 3.

Variation in epidermal conductance has been found among genotypes of rice (Yoshida and delos Reyes, 1976; O'Toole *et al.*, 1979), corn (Dube *et al.*, 1975) and soybean (Paje *et al.*, 1988). Epidermal conductance is a physiological trait which might well be utilized in plant breeding programs for improvement of drought resistance in crops, including soybean. Such a trait would have no "cost" in seasons with average or above average rainfall, but might be of considerable advantage in dry seasons, especially in areas with intermittent rainfall where plants need to survive until the next rain. The objective of this study was to determine the epidermal conductance of leaves of Thai soybean cultivars. Cultivars demonstrate low epidermal conductance will be used as the materials for further improvement of soybean lines for drought tolerance.

[1] Chiang Mai Field Crops Research Center, Chiang Mai 50290, Thailand.

MATERIALS AND METHODS

Seed of eleven soybean genotypes (Table 1) was sown in February 1989 in pots containing a soil/peat medium. The pots were located inside a glasshouse at the CSIRO Cunningham Laboratory, Brisbane, Australia, where they were well watered until sampling of plants at six weeks of age.

Determination of epidermal conductance

Epidermal conductance was calculated from the loss of fresh weight of detached leaves in a defined aerial environment, using a technique similar to that described by Paje *et al.* (1988). One leaflet from each plant was sampled each day until a total of five days (each comprising a terminal, left and right leaflet) was used. Leaflets were excised from the plants and kept in sealed plastic bags inside a styrofoam cooler while being transported to the laboratory. It was assumed that stomates fully closed during the 0.75 hour period during which leaves were transported in the darkened cooler to the laboratory.

The area of each leaflet was measured using a leaf area machine. Each leaflet was then weighed, without sealing the cut end, in a four-place pan balance (Mettler AE 100) which was interfaced with an Epson HX 20 microcomputer. After weighing, each leaflet was suspended in the air and subjected to a uniform constant aerial environment until the next weighing. The leaflets were weighed 15, 30, 45, 60, 75, 90, 120, 150, 180, 210, 270 and 330 minutes after the initial weighing. Environmental conditions in which leaflets were subjected to slow dehydration in the controlled environment room were: 25°C temperature, 85% relative humidity, 20 μmol $m^{-2}s^{-1}$ photon irradiance and 0.5 m^3s^{-1} air movement.

Typically, when leaves dehydrate under the above conditions there is a rapid loss of water during the first hour, followed by a uniform rate of loss up to the sixth hour (e.g. see Sinclair and Ludlow, 1986). A regression equation incorporating an exponential term and a linear term was calculated for each leaflet. The values of the coefficients for the linear period of water loss were obtained and used as estimates of the change in fresh weight with time. Epidermal conductance (g_e) was calculated using the formula of Sinclair and Ludlow (1986):

$$g_e = \frac{\Delta FW}{t} \times \frac{1}{A} \times \frac{1}{(e_l - e_a)}$$

where ΔFW is change in fresh weight (mg) over time t (min), A is the projected area of leaf (cm^2), and $(e_l - e_a)$ is the absolute humidity gradient between the leaf and the air in the room.

Table 1 Country of origin of eleven soybean cultivars grown for estimation of epidermal conductance of leaves.

Cultivar	Country of origin
SJ.1	Thailand
SJ.2	Thailand
SJ.4	Thailand
SJ.5	Thailand
Nakhonsawan 1 (NS 1)	Thailand
Chiang Mai 60 (CM 60)	Thailand
Sukhothai 1 (SK 1)	Thailand
UFV 80-96 (CPI101100)	Brasil
G 2120 (CPI101117)	Indonesia via Taiwan
P 46	Australia
CPAC 527-76 (CPI90992B)	Brasil

RESULTS AND DISCUSSION

Epidermal conductivity estimates (Table 2) were in the range 0.260 to 0.438 mm s^{-1}, which is comparable with the range of 0.248 to 0.577 reported for experiment 2 of Paje *et al.* (1988), but greater than the values (0.12 to 0.17) for soybean found by Sinclair and Ludlow (1986). Sinclair and Ludlow measured epidermal conductance in plants grown outdoors where they were subjected to higher air temperatures, irradiances and saturation deficits. These conditions would normally be expected to reduce epidermal conductance, because plants grown outdoors have thicker cuticle than those grown in controlled environments (Wilson *et al.,* 1980).

There was no significant difference between leaflets, the mean epidermal conductance of left, right and terminal leaflets being 0.324, 0.324 and 0.322 mm s^{-1}, respectively. Across genotypes, Spearman's rank order correlation coefficients (Daniel 1978) between leaflets were very high:

Between left and right leaflets: r_s = 0.927**
Between left and terminal leaflets: r_s = 0.873**
Between right and terminal leaflets: r_s = 0.936**

This result indicates that any of the leaflets may be used to estimate epidermal conductance.

There were significant differences between cultivars in term of epidermal conductance (Table 2). Most of the Thai cultivars had low epidermal conductance. However, there were no significant different from that of CPAC 527-76, the line previously identified by Paje *et al.* (1988), which have one of the lowest values of epidermal conductance among 74 cultivars tested. The results obtained in this experiment also confirm the relatively low epidermal conductance of Nakhonsawan 1 and SJ.4, which were included among the lines tested by Paje *et al.* (1988). The older Thai cultivar, SJ.1, and a high value of epidermal conductance while SJ.2 and SJ.5 had intermediate values of epidermal conductance compared to SJ.4 and Nakornsawan 1.

When selection for drought tolerance is carried out in the field, using seed yield produced

Table 2 Mean epidermal conductance of soybean leaves: left (LL), right (RL) and terminal (TL) leaflets, and leaf means.

Cultivar	Epidermal conductance mm s^{-1})			
	LL	RL	TL	Leaf mean
SK 1	0.260	0.265	0.272	0.265 a[1]
SJ. 4	0.275	0.275	0.270	0.267 a
NS 1	0.271	0.290	0.296	0.285 a
CPAC 527-76	0.277	0.296	0.297	0.290 a
MC 60	0.296	0.308	0.306	0.303 ab
SJ. 5	0.306	0.312	0.295	0.305 ab
SJ. 2	0.336	0.349	0.333	0.340 bc
UFV 80-96	0.350	0.333	0.344	0.342 bc
P46	0.322	0.368	0.368	0.353 c
G 2120	0.438	0.377	0.378	0.398 d
SJ. 1	0.435	0.405	0.387	0.409 d
Mean	0.324	0.324	0.322	0.323
LSD (5%)				0.044

[1] Values followed by the same letter are not significantly different ($P_{0.05}$)

under stress conditions as the selection criterion, it is not possible to identify the contribution of different drought resistance strategies to the yield performance of lines. For example, some lines may have been earlier maturing and completed their life cycle before drought stress imposed an effect on seed development. Alternatively, some lines, may have had moderate rate of water requirement during their growth due to the less leaf area development than others. These would tend to reduce the severity of stress during podfill. Low epidermal conductance is another strategy for coping with stress and is particularly important in aiding survival during periods of intermittent drought or extending survival, therefore, it would allowed the continuation of yield component during the terminal drought. Judging from the result of this experiment, it can be conclusively stated that low epidermal conductance is one of the mechanism contributing to drought tolerance in most Thai soybean cultivars.

Acknowledgements: This research was conducted at the CSIRO Cunningham Laboratory, Brisbance, during a visit under the auspices of ACIAR Project 8405. The author wishes to thank Drs B.C. Imrie and R.J. Lawn for their guidance, and also Ms Leanne Abberton for technical assistance.

LITERATURE CITED

Begg, J.E. and N.C. Turner. 1976. Crop water deficits. Adv. Agron. 28 : 161-217.

Daniel, W.W., 1978. Applied Nonparametric Statistics. Houghton Mifflin Co., Boston. U.S.A.

Dube, P.A., K.R. Stevenson, G.W. Thertell and R.B. Hunter. 1975. Effect of water stress on leaf transpiration, transpiration rates in the dark and cuticular resistance to water vapour diffusion of corn inbreds. Can. J. Plant Sci. 55 : 565-572.

O'Toole, J.C., R.T. Cruz and J.N. Seiber. 1979. Epicuticular wax and cuticular resistance in rice. Physiol. Plant 47 : 239-244.

Paje, M.C.M., M.M. Ludlow and R.J. Lawn. 1988. Variation among soybean (*Glycine max* (L.) Merr.) accessions in epidermal conductance of leaves. J. Agric. Res. 39 : 363-373.

Sinclair, T.R. and M.M. Ludlow. 1986. Influence of soil water supply on the plant water balance of four tropical grain legumes. Aust. J. Plant Physiol. 13 : 329-341.

Sionit, N. and P.J. Kramer. 1977. Effect of water during different stages of growth of soybean. Agron. J. 60 : 274-278.

Wilson, J.R., M.M. Ludlow, M.J. Fisher and E.D. Schulze. 1980. Adaptation to water stress of leaf water relations of four tropical forage species. Aust. J. Plant Physiol. 7 : 207-220.

Yoshida, S. and E. delos Reyes. 1976. Leaf cuticular resistance of rice varieties. Soil Sci. Plant Nutrit. 22 : 95-98.