Short Communication

Role of Boron in the Far-Red Delay of Nyctinastic Closure of Albizia Pinnules

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ABSTRACT

Boron has been found to be necessary for the delaying action of 710 nanometer irradiation on the nyctinastic closing of Albizia julibrissin pinnules. It is effective only over a narrow micromolar range. In contrast, the delaying action of 470 nanometer irradiation on closure is inhibited by boron. The effect of boron on leaflet closing occurs rapidly. Boron is suggested to be involved in a phytochrome action that precedes and is required for a delaying effect on pinnule closing subsequently induced by an unknown far-red absorbing pigment.

In a previous paper (9), I have shown that certain wavelengths of far-red radiation, such as 710 and 730 nm, delayed the nyctinastic closing of Albizia julibrissin pinnules. After the investigation was completed, pinnules harvested from the same Albizia plants gave less or no response to 710 nm irradiation. Because the plants had been growing in the same pots for 6 or more months, I thought that the plants could be under some mineral nutrient stress. (Among 21 plants, only one was slightly chlorotic.) Testing of several important major and minor nutrient elements showed that only boron restored the ability of the leaflets to respond to 710 nm irradiation.

MATERIALS AND METHODS

The Albizia julibrissin plants used were those left over from a previous investigation (9), and were grown in a greenhouse. Materials and procedures were essentially the same as used in that investigation. Leaves were harvested in the morning and brought into the laboratory. Pinnules of 8 cm length (measured from tip) were placed in vials containing 5 ml of solutions of different nutrient salts (KH2PO4, MgSO4, CaCl2, FeSO4, CuSO4, MnCl2, and ZnCl2) and boric acid at various concentrations. The pinnules were exposed to two 40-w Sylvania Gro-Lux lamps (400 ft-c) for at least 2 h before use. One pinnule of a pair always served as a dark control (10 min) during the irradiation of the other. Both pinnules received the same concentration of a chemical. A pinnule was irradiated on the ventral surface for 10 min with a horizontal beam of the following photon fluence rate: 43.6 μmol/m²·s at 710 nm, and 5.3 μmol/m²·s at 470 nm. Following a dark or light treatment, the angles of six pinnules (fourth to ninth from tip) were measured rapidly and their means calculated. Each experiment was repeated eight or more times with consistent results.

RESULTS

Because the following chemicals are without any effect over a wide range in concentration (0.1 μM to 1 mM), the results with them are not reported: KH2PO4, MgSO4, CaCl2, FeSO4, CuSO4, MnCl2, and ZnCl2. Only boric acid over the concentrations given in Figure 1, from a typical experiment, restores the ability of 710 nm irradiation to delay closing. (Replicate experiments show small variations, so of less than 2 degrees for the angles of six pinnules of a pinna.) Best responses with B are obtained when KCl (100 μM) is included. KCl alone is without any effect. It can be seen that B is effective only over a narrow μM range. However, B

FIG. 1. Responses of Albizia pinnules, during 10 min nyctinastic closure, to increasing B concentration when irradiated at 710 and 470 nm. Pinnula in various concentrations of H3BO3 and 100 μM KCl. Values above zero indicate a delay in closing compared to dark control.
reduces the ability of the blue light (470 nm) to retard leaflet closing.

The response of pinnules to the treatment time with B is presented in Figure 2. The treatment time is defined as the number of minutes a pinna is incubated in 1.5 μM H₂BO₃ and 100 μM KCl in white light before a 10-min irradiation at 710 nm. The results obtained show a relatively fast effect of B on the closing of pinnules during irradiation with 710 nm.

**DISCUSSION**

A few years ago, I (8) reported that B is necessary for a phytochrome-mediated bioelectric response that is likely to involve changes in membrane properties. The results of this study showing the requirement for B in the far-red delay of pinnule closing also suggest that B is involved in some action on the membrane, since leaflet movements in Albizia and Samanea have been shown to involve potassium ion fluxes (5) and bioelectric potential changes (2). A 710 nm irradiation with B present may reduce K⁺ efflux (or increase K⁺ influx) in extensor cells of a pulvinus and thus reduce leaflet closing. Similar results can be seen in the paper by Rothbejerano and Itai (3) in which B has been shown to enhance stomatal opening of B-deficient Commelina communis epidermis. Other data for the involvement of B in ion fluxes have been published (1, 6). These early indications of boron deficiency suggest that a primary role of B is the maintenance of some membrane property.

In addition to B, other elements might also be necessary for leaflet movements (4, 10).

A previous study (9) has shown that the far-red delay of nyctinastic closure of Albizia pinnules is probably due to some action of phytochrome that enables a subsequent dose of far-red radiation absorbed by an unknown photoreceptor to bring about some change in the membrane that delays closing. It is possible that B is also necessary for the phytochrome action resulting from its small A of 710 nm radiation. If so, this would be another bit of evidence for a key role for B in phytochrome action (8). Unreported experiments show that B does not enable 750 to 760 nm radiation to retard closing, nor does it affect dark-induced closing.

The result of B in reducing the delaying effect of 470 nm irradiation on leaflet closure might be due to the action of B (with 470 nm irradiation) decreasing K⁺ efflux from (or increasing K⁺ influx into) flexor cells, thus increasing leaflet closing. If so, it is probable that B could also play a role in some membrane changes induced by blue light. Blue light is postulated by Satter and Galston (5) to act on the flexor or dorsal cells of a pulvinus.

In Figure 2, the data show that B becomes effective within a short time—a significant effect is seen after 10 min of pretreatment. If the diffusion time from the cut end of a pinna to the pulvini of a pinnule pair is considered, the effect of B on the closing of pinnules in far-red light probably occurs within a few min. Previous reports (1, 7, 8) also indicate a fast response of cells to added B.

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**LITERATURE CITED**