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Abscission: Ethylene and Light Control[1]

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ABSTRACT

The role of ethylene in light control of leaf abscission im mung bean, *Vigna radiata* (L.) Wilczek cv Jumbo, cuttings was examined. While red light inhibits and far-red light promotes loss of break strength in abscission zones as compared with dark controls, changes in the rate of abscission could not be associated with changes in the rate of ethylene production. Reducing ethylene synthesis in tissue with aminoethoxyvinylglycine did not alter the effects of red or far-red light on abscission. Far-red light appeared to increase and red light appeared to decrease tissue sensitivity to ethylene.

Light affects the abscission of leaf, flower, and fruit tissue in several species (7, 10, 12, 13). Exposure of plant material to low levels of R[3] inhibits abscission and exposure to low levels of FR promotes abscission (6, 8, 10). Although the mechanism(s) by which light regulates the abscission process is unknown, available data suggest the involvement of plant hormones (6, 11).

The abscission inducing action of applied ethylene is well documented (1, 2) and most data also suggest that increases in endogenous synthesis and/or increases in sensitivity of tissue to ethylene may initiate the abscission process (2, 4). The importance of ethylene in abscission and the fact that light treatments may regulate ethylene production (3), suggest that control of ethylene production or action could be a component in the mechanisms by which light regulates abscission. This paper presents the results from a series of experiments to determine if light controls abscission through regulation of ethylene.

MATERIALS AND METHODS

Experimental plant cuttings were obtained from 8-d-old mung bean (*Vigna radiata* (L.) Wilczek cv Jumbo) seedlings (10). The cuttings, consisting of 5 cm of stem tissue with attached primary opposite leaves and apical bud, were inserted vertically (cut end down) into 1 dram vials (one cutting per vial) containing approximately 4 ml of distilled H_2O and exposed to light treatments in a controlled environmental chamber at 29 ± 1°C.

R and FR were produced by placing sheets of colored plastic between the light source and plant cuttings as previously described (10). Dark treatments were initiated by placing an opaque layer between the light source and the plant material. Irradiances (1200 mW m^{-2} for R and 1400 mW m^{-2} for FR) were measured with a J6512 irradiance probe on a Tektronic J16 digital photometer.

Abscission was measured using a recording abscissor (5, 10) to monitor the force (break strength) necessary to separate the leaf from the stem at the abscission zone. Reduced break strengths indicated a weakening of the cells of the abscission zones (5) and indicated the progress of the abscission process.

Ethylene production under light and dark conditions was studied by placing cuttings contained in vials into inverted 125 ml Erlenmeyer flasks capped with rubber serum stoppers for 12 h. Ethylene was measured by GC (1). Fresh weight of the cuttings and break strengths of the abscission zones were measured after determination of the ethylene level.

AVG was used to inhibit ethylene synthesis in plant tissue (14). Inverted cuttings were submerged into 10 mM AVG solution until the leaves, apical bud, and a portion of the upper stem tissue were covered and then placed under a vacuum of 0.03 bars for approximately 30 s. Preliminary results (data not presented) indicated that infiltration of AVG into the plant tissue by this procedure reduced ethylene production by 70 to 80% with minimal visible injury to leaves.

The sensitivity of abscission zones to ethylene under light and dark conditions was determined by monitoring abscission of cuttings maintained in a known ethylene environment. Immediately before the light treatments, cuttings were sealed into inverted 125 ml Erlenmeyer flasks and 10 μl/L exogenous ethylene was added to the gas phase. Break strengths were measured at 24 and 48 h after the start of the experiment. All flasks containing cuttings for the 48 h treatments were flushed with air at 24 h and reinjected with ethylene.

Each experiment was repeated a minimum of three times with 2 to 5 cuttings per replication.

RESULTS

Continuous exposure to R inhibited and continuous exposure to FR accelerated the loss of break strength in abscission zones of mung bean cuttings as compared with dark controls not treated with light (Fig. 1). R maintained the break strength of abscission zones at a level comparable to fresh cuttings (initial), while significant reductions in break strength of abscission zones were noted at 72 and 60 h after initiation of the light treatment on cuttings maintained in the dark and FR, respectively.

No significant differences in ethylene production between R and dark treated cuttings were observed prior to initiation of abscission by the dark treated material (Fig. 2). Significantly higher levels of ethylene production did occur initially in cuttings treated with FR as compared with cuttings in R and dark, but ethylene production returned to the level of dark controls 12 to 24 h prior to any reductions in break strength of the abscission zones.

AVG reduced ethylene production by cuttings as compared with nontreated and water treated tissue (Table I). At 3 d after

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[3] Abbreviations: R, red light; FR, far-red light; AVG, aminoethoxyvinylglycine.

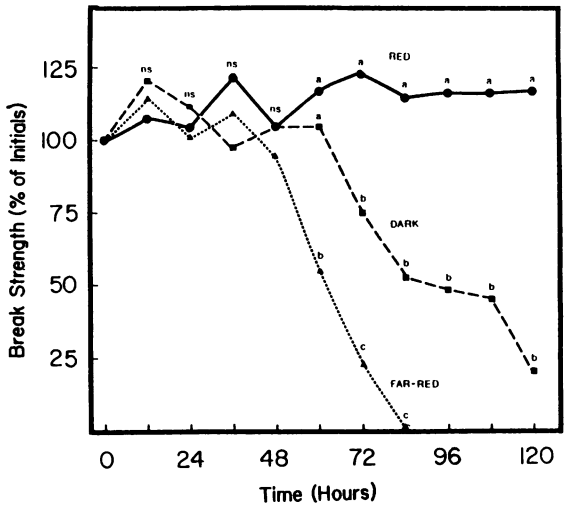

FIG. 1. Light and abscission in mung bean cuttings. Means of three replicates of two cuttings each. Means with same letter within individual time periods are not significantly different according to Duncan's NMRT (5% level).

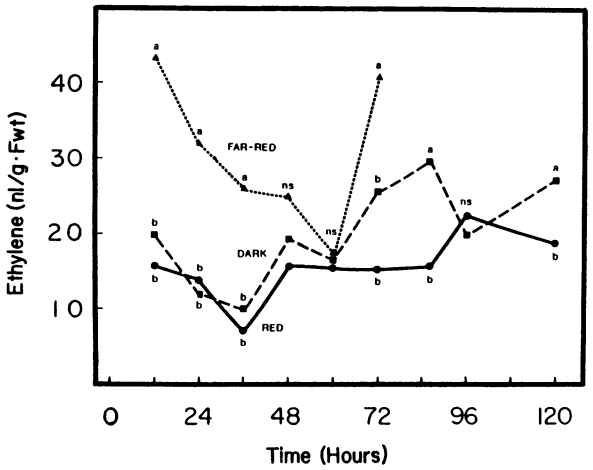

FIG. 2. Effect of R and FR on the production of ethylene in mung bean cuttings. Means of three replicates of two cuttings each. Means with same letter within individual time periods are not significantly different according to Duncan's NMRT (5% level).

treatment, ethylene production in AVG infiltrated cuttings was approximately 30% of the ethylene production from control cuttings not treated with AVG. Ethylene production in cuttings treated with AVG and exposed to FR was reduced to the level of ethylene production by cuttings exposed to R or kept in the dark. Reduced ethylene production with AVG treatments had no effect on abscission as the break strength of abscission zones was the same in AVG, water, and nontreated controls at both 3 and 5 d after initation of the light and AVG treatments.

The loss of break strength in abscission zones treated with various concentrations of ethylene was influenced by treatment of cuttings with R or FR (Fig. 3). After a 24 h ethylene treatment there was an increased loss of break strength in cuttings exposed to FR, but no observable changes in break strength of dark or R treated cuttings. R maintained break strength in abscission zones of cuttings treated for 48 h with 0.1 and 1 μl/L ethylene but not in those treated with 10 μl/L.

DISCUSSION

Previous reports (6, 8–10) have indicated that R inhibits and FR promotes leaf abscission as compared with plant samples

Table I. *Effect of Light and AVG on Ethylene Production and Abscission*

AVG (10 mM) or distilled H_2O was vacuum infiltrated into tissue at 0.03 bars for approximately 30 s.

Treatment	Sampling Time			
	3 d		5 d	
	Ethylene	Break strength	Ethylene	Break strength
	nl/g fresh wt	*% of initials*	*nl/g fresh wt*	*% of initials*
R control	15 ± 3	115 ± 5	19 ± 3	115 ± 15
R + AVG	4 ± 2	117 ± 12	10 ± 5	103 ± 16
R + H_2O	12 ± 1	127 ± 5	18 ± 3	110 ± 18
Dark control	27 ± 11	55 ± 9	70 ± 14	15 ± 4
Dark + AVG	7 ± 2	64 ± 10	18 ± 3	21 ± 5
Dark + H_2O	21 ± 8	70 ± 7	27 ± 1	25 ± 5
FR control	42 ± 10.0	29 ± 5		
FR + AVG	12 ± 2.4	26 ± 6		
FR + H_2O	25 ± 6	38 ± 5		

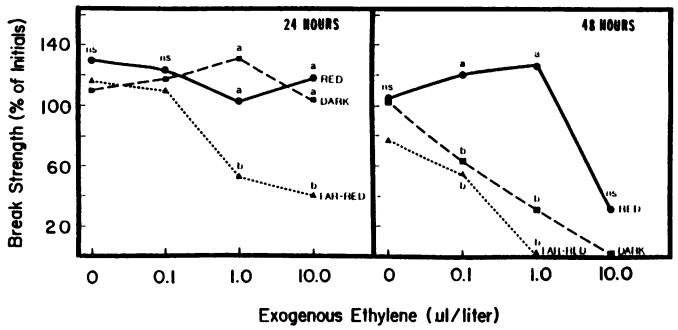

FIG. 3. Effect of R and FR on the sensitivity of leaf abscission zones to ethylene. Means of three replicates of two cuttings each. Means with same letter within individual ethylene treatments are not significantly different according to Duncan's NMRT (5% level).

maintained in the dark. Our results confirmed these observations and indicated that neither the abscission inhibiting nor promoting activity of R or FR, respectively, appeared to be mediated through the plant hormone ethylene.

While FR increased ethylene production in cuttings for the first 36 h of treatment, significant reductions in break strength of abscission zones on cuttings in FR were not observed until 24 h later. There were no significant differences in ethylene production between dark and R treated cuttings until after decreases in break strength of abscission zones on cuttings in the dark had already been measured. Neither ethylene production nor break strength of abscission zones changed in cuttings exposed to continuous R over the 120 h observation period.

Further evidence for the lack of an association between ethylene production and light control of abscission was exemplified by studies with AVG. Reducing the rate of ethylene production with AVG did not alter the effects of either R or FR on the abscission process. The break strength of abscission zones in cuttings treated with AVG and R was the same as the initial break strength throughout the 5 d experimental period even though ethylene production was reduced by 40 to 60%. A reduction in break strength was still observed in cuttings treated with AVG and FR even though ethylene production was reduced to less than 30% of FR controls and to less than 50% of dark controls.

However, light did alter the physiological response of abscission zones to ethylene. R reduced and FR increased the sensitivity of the tissue to ethylene. While no loss of break strength was

noted at 24 h in the abscission zones of dark controls treated with ethylene, a reduction in the break strength was observed in cuttings treated with FR and ethylene at concentrations of 1 and 10 μl/L. The break strength of abscission zones on cuttings exposed to R was not reduced by treatment with 0.1 and 1 μl/L ethylene for 48 h even though the break strength of abscission zones on dark controls treated with these concentrations of ethylene was reduced. An ethylene concentration of 10 μl/L overcame the R inhibition of abscission. These results support those of Curtis (9) who demonstrated that ethrel-induced abscission in mung beans could be partially inhibited by treatment of the tissue with white fluorescent light.

In summary, our data indicates that R does not inhibit abscission by decreasing ethylene production. In addition, we suggest that increased ethylene production is not necessary for promotion of abscission by FR. Light apparently does affect the sensitivity of the abscission process in mung bean cuttings to ethylene.

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