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Short communication

The relationship between growth inhibition and ethylene production by mechanical stimulation in *Lilium longiflorum*

Yoshiaki Hiraki[1] and Yasuo Ota[2]

[1] Chiba Agricultural Experiment Station, Chiba, Chiba 280-02, Japan and
[2] National Institute of Agricultural Sciences, Konosu, Saitama 365, Japan

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When *Lilium longiflorum* plants were stimulated mechanically by lightly stroking the leaf blades with a dusting bush daily, stem elongation was significantly inhibited in an epinastic response. The mechanical stimulation increased ethylene production and resulted in reduced plant height. Thus, ethylene may play an important role in thigmomorphogenesis.

The reports by Neel and Harris (*1*, *2*) on the motion-induced inhibition of growth in *Liquidambar* and *Zea mays* seedlings suggested that a hormonal mechanism may be involved in this response. A similar growth inhibition was reported for *Cucurbita melopepo* in which the growth of the petioles and shoots were retarded when they were rubbed or shaken, the young tissue being the most sensitive (*3*). Jaffe (*4*) found that when young plants of *Hordeum vulgare, Bryonia dioica, Cucumis sativus, Phaseolus vulgaris, Mimosa pudica,* and *Ricinus communis* were rubbed once or twice daily with the fingers, their stem elongation was significantly retarded. He suggested that this response of plants to mechanical stimulation may be called thigmomorphogenesis, and that it represents an adaptation designed to protect plants from physical stress. Matsukawa and Kashiwagi (*5*) found that when *Lilium longiflorum, L. longiflorum* var. *albomarginatum* and *L. speciosum* were subjected to daily gentle stroking of leaves by fingers or a dusting brush for 70 days, their growth was reduced to 50–75% of the unstimulated controls and the diameter of the stem was increased in an epinastic response.

Goeschel et al. (*6*) have reported that ethylene production was increased by nonwounding physical stress and that ethylene acts as an endogenous growth regulator, decreasing elongation and increasing the diameter in response to increasing increments of stress. Leopold et al. (*7*) reported that imposing stress on branches of *Pinus strobus, Pyrus malus* and *Prunus persica* trees by tying them in arcs resulted in an increase in the ethylene content of the internal atmospheres of the stressed branches.

This report presents evidence showing that mechanically stimulated *Lilium longiflorum* plants produced a greater quantity of ethylene and the plant growth

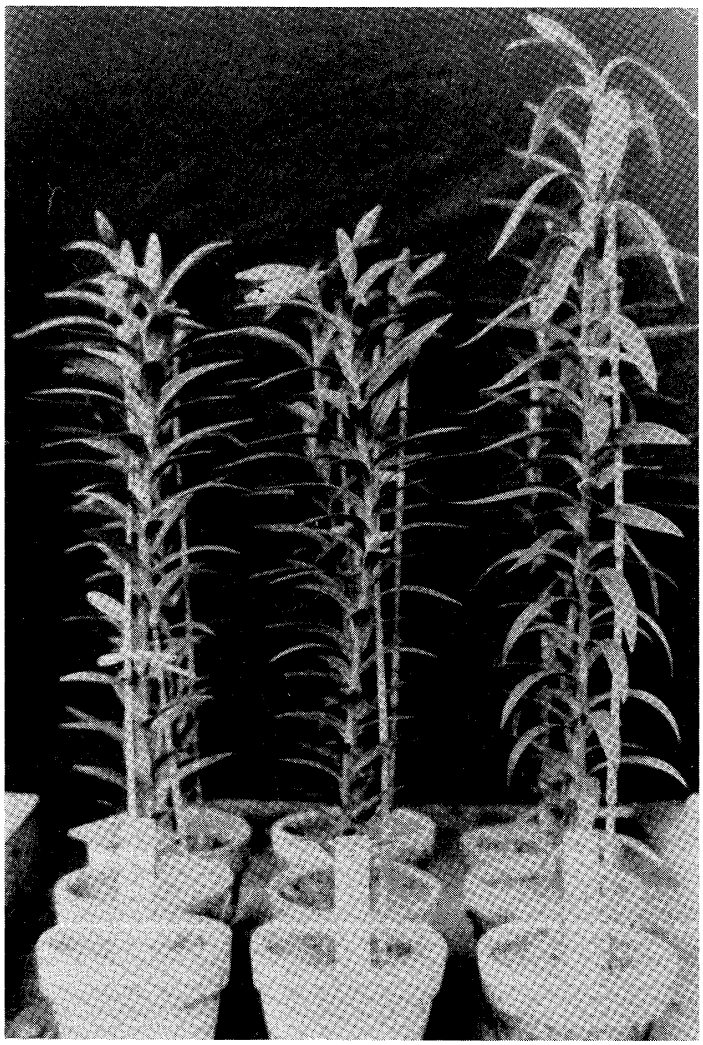

Fig. 1. *Effect of mechanical stimulation on the growth of* Lilium longiflorum. The control plant on the right was untreated, the top of the center plant covered with a 4 g vinyl net, and the plant on the left was stroked with a dusting brush.

Table 1 *Effects of mechanical stimulation on the growth of* Lilium longiflorum

Plot	Plant height (cm)			No. of leaves			Fresh weight of shoots (g)
	Start	End	Increment	Start	End	Increment	End
Control	60.4±4.0	83.5±4.3	24.6±1.8	55.0±3.5	62.0±2.0	7.0±2.0	91.0±4.5
Stroking	58.0±2.8	71.1±2.0	13.1±3.0	53.3±2.0	57.3±1.5	4.0±1.0	72.9±2.8
Covering	57.1±3.0	69.3±3.5	12.2±1.0	53.8±2.5	58.2±1.5	4.3±1.0	73.2±2.5

Mechanical stimulation was given either by stroking using a dusting brush or by covering with a vinyl net for 22 days. Data presented are the average of six plants with standard error.

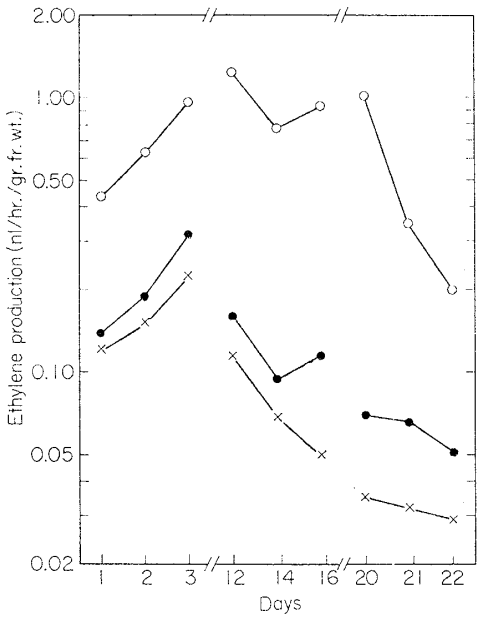

Fig. 2. *Effect of mechanical stimulation on ethylene production in* Lilium longiflorum. Test plants were sealed in a 0.55 m^3 vinyl chamber for a certain period, and then ethylene production was measured. ×, control; ●, stroked; ○, covered.

was significantly reduced. Moreover, application of ethylene at 0.1 ppm or more greatly inhibited the growth of *Lilium longiflorum*.

Lilium longiflorum (c.v. teppoyuri) plants used in these experiments were grown in a greenhouse under a temperature regime of 24.1°C (day)–12.6°C (night).

The rubbing stimulation involved light stroking of the leaf blades by a dusting brush three times back and forth five times daily (at 8.30, 10, 12 a.m. and 3, 4.30 p.m.) or covering the plant top with a 4 g vinyl net (9 mesh, 20×20 cm) during the experiment period of 22 days. Three plants from each plot were sealed in a 0.55 m^3 vinyl chamber during the night at 5 p.m. to 8.30 a.m., and ethylene produced from the plants was collected in 9-cm Petri dishes containing 10 ml of mercuric perchlorate (0.25 M HgO in 2.0 M $HClO_4$). In order to release ethylene from the mercuric perchlorate solution, 5 ml of the solution was transferred into a 10-ml graduated centrifuge tube and this tube was stoppered with a silicone rubber stopper. The tube was evacuated and 4 M LiCl was introduced through a hypodermic needle until the gas space in the tube reached 7 ml. Air was then freely introduced into the tube through the needle up to atmospheric pressure. The gas sample was withdrawn with a syringe by water exchange and injected into a gas chromatographic apparatus. Ethylene was determined with a flame ionization gas chromatograph, Hitachi 063, equipped with a Porapak Q column (60–80 mesh) at 100°C.

Table 1 and Fig. 1 show that the stem length, number of leaves and fresh weight of plants stimulated mechanically by both stroking and covering, were significantly less than those of control plants, and the stem diameter had increased in an epinastic response. Moreover, the ethylene production of mechanically stimulated plants was greater than those of comparable control plants (Fig. 2).

Since ethylene may play a role in thigmomorphogenesis, the next experiment was conducted to study the effect of ethylene application on the growth and developemnt of *Lilium longiflorum* plants. Six plants of about 25 cm height were sealed

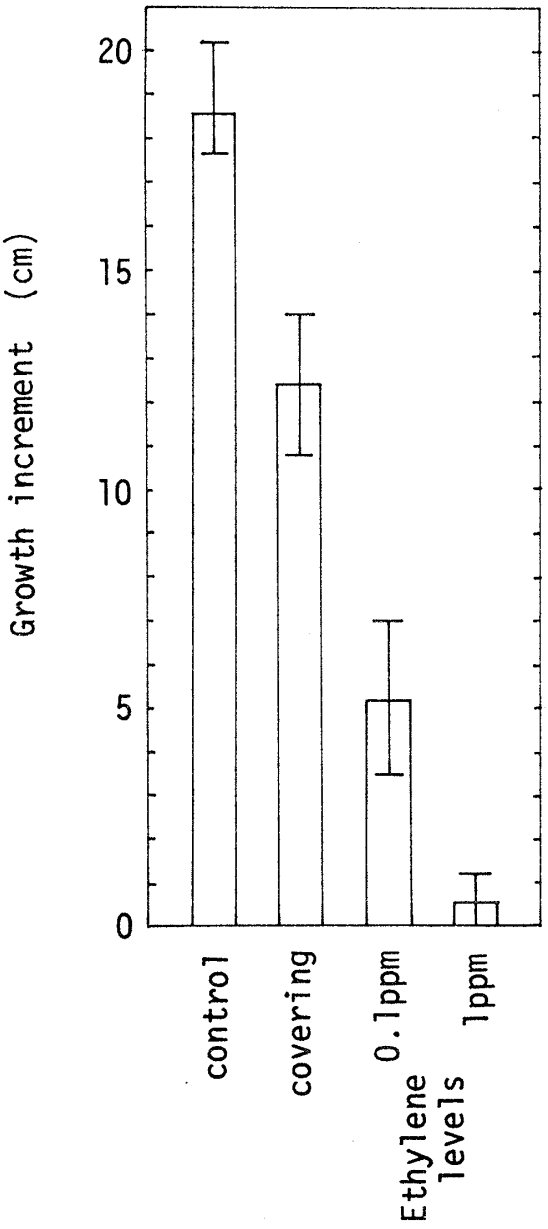

Fig. 3. *Effect of ethylene application on the growth of* Lilium longiflorum. Growth increment shows the difference in plant height at the start and end of the experiment. The vertical lines indicate the standard errors.

in a 0.55 m^3 vinyl chamber and ethylene was applied through the vinyl film with a gas-tight syringe. Ethylene levels in the chamber were adjusted at 0, 0.1 and 1.0 ppm during the experiment for 16 days. For comparison with the ethylene application plots, a mechanical stimulation plot was also added.

Ethylene applied plants had their growth greatly retarded showing an epinasty similar to the mechanically stimulated plants, and the stem elongation was completely inhibited by treatment with 1 ppm ethylene (Fig. 3 and 4). However, when ethylene was removed from the atmosphere or the mechanical stimulation was stopped, these plant recovered from the growth retardation, and flowered normally at the same date as the controls.

The results presented here support strongly the view that the modification

Fig. 4. *Effect of ethylene application on growth of* Lilium longiflorum. The plants on the right, center and left had 1, 0.1 and 0 ppm ethylene applied, respectively.

of plant growth and development brought about by mechanical stimulation may be mediated by ethylene (*4*). Thus, ethylene may play an important role in thigmomorphogenesis.

References

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