Zeitschrift: Saussurea : journal de la Société botanique de Genève
Herausgeber: Société botanique de Genève
Band: 14 (1983)

Artikel: Cotyledonary wounding and ethylene production in Bidens pilosus : effect of lithium
Autor: Desbiez, M. O. / Boyer, N. / Charnay, D.
DOI: https://doi.org/10.5169/seals-1099242

Cotyledonary wounding and ethylene production in Bidens pilosus. Effect of Lithium

M. O. DESBIEZ
N. BOYER
D. CHARNAY
&
THOMAS GASPAR

RÉSUMÉ

DESBIEZ, M., BOYER, N., CHARNAY, D. & T. GASPAR (1983). Lésion cotylédonaire et production d'éthylène chez Bidens pilosus. Effet du lithium. *Saussurea* 14: 113-119. En français résumé anglais.

Des piqûres, sur le cotylédon de jeunes plantes de *Bidens pilosus,* induisent un accroissement de l'émission d'éthylène et de la capacité de production d'éthylène à partir d'ACC (acide 1-aminocyclopropane-1-carboxylic) dans le cotylédon et dans l'hypocotyle adjacent, spécialement dans sa partie médiane. Il y a corrélation entre l'accroissement de la production d'éthylène, l'augmentation précédemment démontrée de l'activité peroxydasique et l'inhibition de la croissance de l'hypocotyle. Un prétraitement des plants au lithium empêche l'accroissement de l'émission d'éthylène par l'hypocotyle, mais pas par le cotylédon piqué. Cependant ce prétraitement n'empêche pas l'augmentation induite par les traumatismes de la capacité de production d'éthylène à partir de ACC dans les deux organes.

ABSTRACT

DESBIEZ, M., BOYER, N., CHARNAY, D. & T. GASPAR (1983). Cotyledonary wounding and ethylene production in Bidens pilosus. Effect of Lithium. *Saussurea* 14: 113-119. In English, French abstract.

Pricking one cotyledon of young *Bidens pilosus* plants induced an increase of ethylene emission and of ethylene production capacity from ACC (1-aminocyclopropane-1-carboxylic acid) by this cotyledon and by the adjacent hypocotyl,

CODEN: SAUSDH
ISSN: 0373-2525
14 113 (1983)

particularly in its middle portion. There was a correlation between the increase of ethylene production, the previously shown increase of peroxidase activity and the inhibition of hypocotyl growth. Pretreatment of the plants with lithium prevented the enhanced ethylene emission by the hypocotyl but not by the pricked cotyledon. It however did not counteract the wound-induced enhancement of ethylene production capacity from ACC in both organs.

Introduction

Pricking one cotyledon of young *Bidens pilosus* plants had been shown to induce rapid inhibition of hypocotyl growth, particularly in its middle portion. This inhibition was correlated with a rapid increase in activity of soluble peroxidases and interpreted as a peroxidase mediated decrease in auxin level (DESBIEZ & al., 1981). Pretreatment of the plants with lithium prevented the inhibition of elongation due to pricking as well as the peroxidase changes (DESBIEZ & al., 1981). The phenomenon was similar to previously described thigmomorphogenetic processes, in *Bryonia dioica* for instance (BOYER & al., 1979). There are several reports that ethylene production was increased by nonwounding physical stress (GOESCHEL & al., 1966; LEOPOLD & al., 1972; BANGERTH, 1974; HIRAKI & OTA, 1975; JAFFE & BIRO, 1977). A peroxidase, on the other hand, might be the factor mediating the conversion of ACC to ethylene (KONZE & KENDE, 1979; ROHWER & MÄDER, 1981; MACHACKOVA & ZMRHAL, 1981; VIOQUE & al., 1981; GASPAR & al., 1982). In this context we decided to investigate the effect of cotyledonary wounding on ethylene production by cotyledon and hypocotyl portions, in the absence and presence of ACC.

Materials and methods

1. Plant material, growing conditions and treatment

Young plants of *Bidens pilosus* L. (var. *radiatus*) were raised from seed (achenes) in Petri dishes (darkness, 22°C) on filter paper and dilute nutrient solution, as used previously (DESBIEZ & THELLIER, 1978). Plantlets with 15 mm-long hypocotyls were selected at day 4 and placed in lots of 40 in glass hemolysis tubes containing the same solution for 24 hours. From that time, they were kept in a controlled environment room (9 hours light daily at 24 W m^{-2}; 22°C; 60% humidity). At day 5, they were transferred either to deionized water or to a LiCl (50 µm) solution. There is no effect of lithium on seedling growth between days

5 and 6 (DESBIEZ & al., 1981). At day 6, four prickings with a needle were given to one cotyledon, on the middle vascular bundle, one hour before sampling.

2. Ethylene production and measurement

Seven mm-long segments of top, middle and bottom portions of hypocotyls or pricked cotyledons were cut and set (30 pieces) on filter paper sheet (45 mm diameter) imbibed with distilled water or with an ACC (2 µm) solution in a glass bottle (121 cm^3) hermetically sealed with a butyl plug and placed in the controlled environment room. Three samples of 1 cm^3 air were withdrawn from the bottles with a syringue after 1 to 24 hours depending on the presence of ACC and the volume of ethylene produced. Gas chromatography of ethylene was according to the technique used by DUBUCK & al. (1978). A stainless steel column (3 m × 1.5 mm) filled with Porapak R (80-100 Mesh) was used for the analyses. Column, injector and FID temperatures were 60, 90 and 90°C respectively. The electrometer sensitivity was 1×10^{-12} A/mV. N_2 was used as carrier gas (55 cm^3/min).

Each set of experiments was repeated at least four times.

Results and discussion

Ethylene production by *Bidens* cotyledons or hypocotyls portions in the absence of ACC was rather weak and necessitated a relatively long incubation period of the material to be significantly measured. Results from Tables 1 and 2, however, clearly indicated that pricking induced a stimulation of the gas production in both types of tissues: 46% in the cotyledons and from 20 up to 40% in the hypocotyl where the middle portion appeared the most reactive. Measurement of ethylene production in the presence of ACC also revealed a general higher capacity in the pricked plants except in the bottom portion of the hypocotyl. An increasing gradient of ethylene production (in the absence of ACC) and of capacity of ethylene production (in the presence of ACC) was exhibited from the bottom to the top of the hypocotyl.

Pretreatment of the plants with lithium did not significantly modify the ethylene production by cotyledons and hypocotyls of the control plants (Tables 1 and 2), nor did it affect the increased production by the wounded cotyledon (Table 1). Lithium however suppressed the increased ethylene production by hypocotyls of the pricked plants (Table 2). The pricking-induced increase in ethylene production capacity (from ACC) was not counteracted by lithium neither in the cotyledon (Table 1) nor in the hypocotyl (Table 2).

The previously shown enhancement of ethylene production in mechanically stressed plants thus was repeated in the wounded *Bidens* cotyledons as well as in the unwounded hypocotyls. Along the hypocotyl the increase of ethylene production was greatest in the middle portion, the same region which we previously had shown the most inhibitied in growth and had the highest stimulation of peroxidase activity (DESBIEZ & al., 1981). This relationship between the increase in peroxidase activity and ethylene production lends support to the idea of a peroxidase involvement in the conversion of ACC to ethylene (see introduction). An additional argument to this hypothesis is that lithium suppresses both phenomenons. Stimulation of ethylene production in the presence of exogenously supplied ACC on the other hand would indicate that endogenous ACC in *Bidens* was rate limiting in ethylene production. A peroxidase mediated lowering of the IAA (indoleacetic acid) level in the middle portion of the hypocotyl (see DESBIEZ & al., 1981) would normally reduce the ACC level through a regulating effect of the auxin on ACC synthase (ADAMS & YANG, 1981). However this concept in not in agreement with the observed increase in ethylene production in the central portion of the hypocotyl. On the other hand the wound-induced increase of peroxidase could readily account for the enhancement of ethylene production capacity from ACC (KONZE & KENDE, 1979; MACHACKOVA & ZMRHAL, 1981; ROHWER & MÄDER, 1981; VIOQUE & al., 1981; GASPAR & al., 1982). Further comparisons of auxin, ACC and ACC-synthase will be necessary to decide whether there is a causal link between their levels, ethylene production and growth inhibition observed in this material. We note that the IAA-mediated ethylene production by roots can be inhibited without suppressing the auxin effect on growth (DUBUCQ & al., 1978).

The different lithium effects on cotyledon and hypocotyl were very interesting. They might indicate that a distinction has to be made between a wounding effect (pricking at the cotyledon level) and the mechanically induced thigmomorphogenetic process itself (inhibition of growth of the untouched hypocotyl). These effects could also mean that lithium only acted on the transfer and/or translation of a message (in the hypocotyl) but did not interfere with the storage of sensory information (in the cotyledon). Indeed evidence has been presented both for such a storage of sensory information and for a translocatable thigmomorphogenetic factor induced by mechanical perturbation (ERNER & al., 1980; JAFFE & SHOTWELL, 1980). Quite similar results were obtained by KAREGE & al. (1982) who showed that lithium, which had no effect on the peroxidase response in directly irradiated leaves, prevented the transmission of the signal to darkened leaves. The fact that in *Bidens* hypocotyl lithium suppressed mechanically induced ethylene production but not the enhancement of ethylene production capacity from ACC indicates that part of the cotyledon pricking message can be transmitted to the

hypocotyl even in the presence of this ion. This could also mean that several factors, differently influenced by lithium, are parts of this message.

	Without ACC (24 h)	*With Acc (1 h)*
Control –Li	14.2 ± 2.0	9.7 ± 2.3
Control +Li	12.3 ± 1.9	10.0 ± 1.2
Pricked –Li	20.7 ± 1.8 (+46%)	17.9 ± 1.8 (+85%)
Pricked +Li	19.0 ± 4.1 (+54%)	19.5 ± 4.7 (+95%)

Table 1. – Effect of pricking on ethylene production (arbitrary units: 16 arbitrary units = 0.1 µl l^{-1}) by cotyledons, in the absence and the presence of ACC. Plants have been or have not been pretreated with lithium.

	–Li Without ACC (24 h)	*–Li With Acc (1 h)*
Control		
Top	6.6 ± 0.8	40.6 ± 8.2
Middle	6.0 ± 1.2	23.7 ± 5.5
Bottom	5.5 ± 1.2	15.1 ± 2.6
Pricked		
Top	8.5 ± 2.1 (+29%)	55.7 ± 9.4 (+37%)
Middle	8.4 ± 0.7 (+40%)	28.7 ± 4.9 (+21%)
Bottom	6.6 ± 0.8 (+20%)	14.1 ± 4.4 (–7%)

	+Li Without ACC (24 h)	*+Li With Acc (1 h)*
Control		
Top	6.0 ± 1.1	43.4 ± 7.9
Middle	5.5 ± 0.5	22.8 ± 6.5
Bottom	5.6 ± 0.8	13.8 ± 2.1
Pricked		
Top	5.9 ± 0.7 (–1%)	60.2 ± 8.6 (+39%)
Middle	5.7 ± 1.0 (+4%)	29.6 ± 4.3 (+30%)
Bottom	5.8 ± 0.9 (+4%)	14.8 ± 3.3 (+7%)

Table 2. – Ethylene production (arbitrary units) in top (5 mm), middle (5 mm), and remaining basal portion of hypocotyls of lithium treated and untreated *Bidens* plants in response to cotyledon wounding.

ACKNOWLEDGEMENTS

The research was partly supported by the French CNRS (LA 45, RCP 474) and by the Belgian FRFC (grant 2.9009).

REFERENCES

ADAMS, D. O. & S. F. YANG (1981). Ethylene the gaseous plant hormone: mechanism and regulation of biosynthesis. *Trends Biochem. Sci.* 6: 161-164.

BANGERTH, F. (1974). Interaktionen von Auxin und Äthylen bei der thigmotropen Bewegung der Ranken von Cucumis sativus. *Planta* 117: 329-338.

BOYER, N., B. CHAPELLE & T. GASPAR (1979). Lithium inhibition of the thigmomorphogenetic response in Bryonia dioica. *Plant Physiol.* 63: 1215-1216.

DESBIEZ, M. O., N. BOYER & T. GASPAR (1981). Hypocotyl growth and peroxidases of Bidens pilosus. Effect of cotyledonary prickings and lithium pretreatment. *Plant Physiol.* 68: 41-43.

& M. THELLIER (1978). Contrôle ionique de la manifestation d'un rythme nycthéméral de préséance entre bourgeons axillaires. *Physiol. Vég.* 16: 785-798.

DUBUCQ, M. M. HOFINGER & T. GASPAR (1978). Auxin-controlled root growth and ethylene production. *Plant Cell and Environment* 1: 151-153.

ERNER, Y., R. BIRO & M. J. JAFFE (1980). Thigmomorphogenesis: evidence for a translocatable thigmomorphogenetic factor induced by mechanical perturbation of beans (Phaseolus vulgaris). *Physiol. Plant.* 50: 21-25.

GASPAR, T., C. PENEL, T. THORPE & H. GREPPIN (1970-1980). *A survey of their biochemical and physiological roles in higher plants.* Université de Genève, Centre de botanique. 324 pp.

GOESCHEL, J. D., L. RAPPAPORT & H. K. PRATT (1966). Ethylene as a factor regulating the growth of pea epicotyls subjected to physical stress. *Plant Physiol.* 4: 877-884.

HIRAKI, Y. & Y. OTA (1975). The relationship between growth inhibition and ethylene production by mechanical stimulation in Lilium longiflorum. *Plant Cell Physiol.* 16: 185-189.

JAFFE, M. J. & R. BIRO (1977). Thigmomorphogenesis: the role of ethylene in wind induced growth retardation. *In:* The Proceedings of the Fourth Annual Meeting of the Plant Growth Regulator Working Group. *Hot Springs, Ark.:* 118-124.

- & M. SHOTWELL (1980). Physiological studies on pea tendrils. XI. Storage of tactile sensory information prior to the blue light activation effect. *Physiol. Plant.* 50: 78-82.

KAREGE, F., C. PENEL & H. GREPPIN (1982). Rapid correlation between the leaves of spinach and the photocontrol of a peroxidase activity. *Plant Physiol.* 69: 437-444.

KONZE, J. R. & H. KENDE (1979). Ethylene formation from 1-aminocyclopropane-1-carboxylic acid in homogenates of etiolated pea seedlings. *Planta* 146: 293-301.

LEOPOLD, A. C., K. M. BROWN & F. H. EMERSON (1972). Ethylene in the wood of stressed trees. *Hort. Sci.* 7: 175.

MACHACKOVA, I. & Z. ZMRHAL (1981). Is peroxidase involved in ethylene biosynthesis? *Physiol. Plant.* 53: 479-482.

ROHWER, F. & M. MÄDER (1981). The role of peroxidase in ethylene formation from 1-aminocyclopropane-1-carboxylic acid. *Z. Pflanzenphysiol.* 104: 363-372.

VIOQUE, A., M. A. ALBI & B. VIOQUE (1981). Role of IAA-oxidase in the formation of ethylene from 1-aminocyclopropane-1-carboxylic acid. *Phytochem.* 20: 1473-1475.

Addresses of the autors: M. O. D., N. B., D. C.: Laboratoire de phytomorphogenèse, 4, rue Ledru, F-63 038 Clermont-Ferrand Cédex.

T. G.: Hormonologie fondamentale et appliquée, Institut de botanique, B 22, Université de Liège, Sart Tilman, B-4000 Liège.