

## BRIEF COMMUNICATION

## Effects of capsaicin on plant growth

H. KATO-NOGUCHI\* and Y. TANAKA

*Department of Biochemistry and Food Science, Faculty of Agriculture, Kagawa University, Miki, Kagawa 761-0795, Japan*

## Abstract

Capsaicin, a possible allelochemical, caused growth inhibition of roots and shoots of alfalfa (*Medicago sativa*), cress (*Lepidium sativum*), lettuce (*Lactuca sativa*), crabgrass (*Digitaria sanguinalis*), timothy (*Phleum pratense*) and ryegrass (*Lolium multiflorum*), and suppressed their germination. Increasing the dose of capsaicin increased the inhibition. The concentrations for 50 % inhibition of the root growth were 2.7, 0.32, 2.1, 0.27, 0.29 and 0.57 mM for alfalfa, cress, lettuce, crabgrass, timothy and ryegrass, respectively, and the concentrations for 50 % inhibition of the shoot growth were 17, 0.87, 6.7, 2.3, 1.4 and 6.2 mM for alfalfa, cress, lettuce, crabgrass, timothy and ryegrass, respectively. Germination percentage was inhibited 50 % at the concentrations 82, 88, 68, 4.8, 22 and 11 mM for alfalfa, cress, lettuce, crabgrass, timothy and ryegrass, respectively. Thus, effectiveness of capsaicin on the plant growth differed with species and targets, and suggests that capsaicin may act as an allelochemical to other plants.

*Additional key words:* alfalfa, allelopathy, *Capsicum annuum*, crabgrass, cress, germination inhibitor, growth inhibitor, lettuce, phytotoxicity, ryegrass, timothy.

Capsaicin, a primary pungent principle contained in a variety of *Capsicum* spp. such as chili pepper, red pepper and cayenne pepper, is an amide derivative of vanillylamine and 8-methylnon-*trans*-6-enolic acid (Ochoa-Alejo and Salgado-Garaciglia 1992). Capsaicin has a number of pharmacological and physiological effects on mammals (Surh and Lee 1995, Abdel-Salam *et al.* 1997), however, the physiological role of capsaicin in plants is not clear and only limited information is available in the literature with regard to its effectiveness on plant growth (Cho *et al.* 1992). Thus, in the present research, the effects of capsaicin on germination and growth of six plant species were determined.

Capsaicin, obtained from *Nacalai Chemicals* (Kyoto, Japan), was dissolved in methanol, added to a sheet of filter paper (No. 2; *Toyo Ltd*, Tokyo, Japan) in a 5.5-cm Petri dish, and dried. After evaporation of methanol, the filter paper in Petri dish was moistened with 2 cm<sup>3</sup> of 0.05 % (v/v) aqueous *Tween 20*. The concentrations of capsaicin in the bioassay were 0, 0.01, 0.03, 0.1, 0.3, 1, 3, 10, 30, 100 mM. Fifty seeds of alfalfa (*Medicago sativa* L.),

cress (*Lepidium sativum* L.), lettuce (*Lactuca sativa* L.), crabgrass (*Digitaria sanguinalis* L.), timothy (*Phleum pratense* L.), and ryegrass (*Lolium multiflorum* Lam.) were separately arranged on the filter paper and allowed to germinate in the dark at 25 °C for 24 h (alfalfa, cress, lettuce) or 60 h (crabgrass, ryegrass, timothy). Then, the germination percentage was calculated by reference to that of control seeds treated with plain solution (Kato-Noguchi 2001).

For further experiment, seeds of alfalfa, cress, crabgrass, lettuce, timothy and ryegrass were sown on the filter paper and allowed to germinate in the dark at 25 °C for 12 h (alfalfa, cress, lettuce) or 48 h (ryegrass, timothy, crabgrass). Capsaicin was dissolved and added to a sheet of filter paper in 3.5-cm Petri dish and the filter paper was moistened with 0.8 cm<sup>3</sup> of 0.05 % (v/v) aqueous *Tween 20* as described above. Then, 10 germinated seeds of test plants were arranged on the filter paper and allowed to grow in the dark at 25 °C for 48 h. The shoot and root lengths of the seedlings were measured, and the percentage length of the seedlings was calculated by

Received 10 June 2002, accepted 4 September 2002.

Abbreviations: I<sub>50</sub> - concentration required for 50 % inhibition in the assay.

\* Corresponding author; fax: (+81) 87 8913086, e-mail: hisashi@ag.kagawa-u.ac.jp

reference to that of the control plants treated with plain solution. All experiments were repeated three times in completely randomized block designs.

Capsaicin suppressed germination of lettuce seeds, and inhibited growth of their roots and shoots at concentrations greater than 3, 0.1 and 0.3 mM, respectively, with the most marked inhibition being achieved on the root growth (Fig. 1). When the percentage inhibition was plotted against the logarithm of the concentrations of capsaicin, the response curves of the germination, root growth and shoot growth were linear between 10 and 60 %, 10 and 80 % and 10 and 85 % inhibition, respectively. The effectiveness on the germination was weak and complete response curve was not obtained. The concentrations required for 50 % inhibition in the assay (defined as  $I_{50}$ ) were 68, 2.1 and 6.7 mM for the germination, root growth and shoot growth, respectively, as interpolated from the response curves. Comparing  $I_{50}$  values, the inhibitory effect of capsaicin on the root and shoot growth was 26- and 10-fold greater than that on the germination, respectively.

The effects of capsaicin on root and shoot growth, and germination of all test species were examined and  $I_{50}$  values were determined from the concentration-response curves as described above (Table 1). Capsaicin

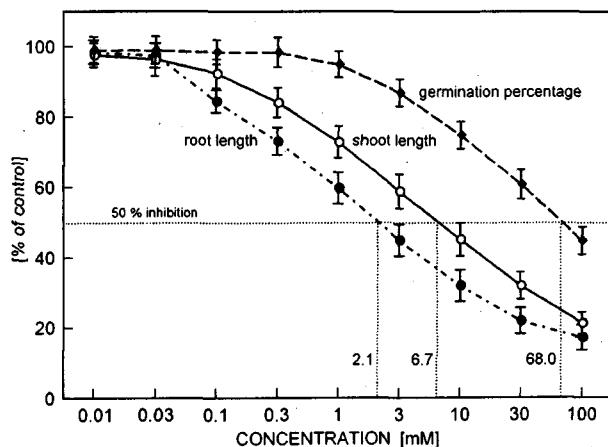


Fig. 1. Effects of capsaicin on root and shoot growth, and germination of lettuce. Means  $\pm$  S.E. from three replicates (50 seeds each for determination of germination, and 10 plants each for determination of root and shoot growth). Germination rate of control plants was  $91 \pm 7.3\%$ , and length of control plants was  $18.6 \pm 1.1$  and  $6.9 \pm 0.33$  mm for roots and shoots, respectively.

## References

Abdel-Salam, O., Szolcsányi, J., Mózsik, G.: Capsaicin and the stomach. A review of experimental and clinical data. - *J. Physiol.* **91**: 151-171, 1997.  
 Cho, K.-J., Park, K.-S., Tang, C.-S.: Allelopathic potential of red-pepper (*Capsicum annuum* L.) fruit. - *Res. Rep. rural Develop. Admin. Suweon* **34**: 18-23, 1992.

Table 1.  $I_{50}$  values [mM] of capsaicin for root and shoot growth, and germination of test plants. Means  $\pm$  S.E. from three replicates (10 plants each for determination of root and shoot growth, and 50 seeds each for determination of germination).

Species	Germination	Root	Shoot
Alfalfa	$82.0 \pm 5.7$	$2.70 \pm 0.15$	$17.00 \pm 1.10$
Cress	$88.0 \pm 6.8$	$0.32 \pm 0.02$	$0.87 \pm 0.05$
Lettuce	$68.0 \pm 5.9$	$2.10 \pm 0.13$	$6.70 \pm 0.41$
Crabgrass	$4.8 \pm 0.2$	$0.27 \pm 0.01$	$2.30 \pm 0.17$
Timothy	$22.0 \pm 1.8$	$0.29 \pm 0.01$	$1.40 \pm 0.01$
Ryegrass	$11.0 \pm 0.9$	$0.57 \pm 0.03$	$6.20 \pm 0.39$

concentration-dependently inhibited the germination, root and shoot growth of all species although its effectiveness differed with species and targets. In all bioassays, the  $I_{50}$  values of the root growth were smallest, followed in order by the shoot growth and the germination, confirming that the root growth was the most inhibited. Additionally, capsaicin was much more effective on the germination of monocotyledonous species (crabgrass, timothy and ryegrass) than that of dicotyledonous species (alfalfa, cress and lettuce). The difference between dicotyledonous and monocotyledonous species was less clear in shoot and root growth than in germination percentage.

It was found that many secondary metabolite are released into the environment, either as exudation from living plant tissues or by decomposition of plant material under certain conditions (Rice 1984, Putnam 1988, Einhelling 1996). These findings together with the occurrence of capsaicin in *Capsicum* plants (Leete and Louden 1968, Iwai *et al.* 1979) and its effectiveness on growth (Fig. 1 and Table 1) suggest that capsaicin may act as an allelochemical of pepper to neighboring or successional plants after being released into the environment by the decomposition of the plants in the soil or by the exudation from their roots.

Controlling weeds through allelopathy is one strategy to reduce synthetic chemical herbicide dependency in the present weed management systems (Rice 1984, Putnam 1988). It has also been shown that certain plant residues and extracts may function as weed suppressive agents (Putnam 1988, Einhellig 1996, Kato-Noguchi 2001, Kato-Noguchi and Ino 2001). Thus, it is possible that the pepper itself may be important as a weed suppressive agent.

Einhellig, F.A.: Interactions involving allelopathy in cropping systems. - *Agron. J.* **88**: 886-893, 1996.  
 Iwai, K., Suzuki, T., Fujiwake, H.: Formation and accumulation of pungent principle of hot pepper fruits, capsaicin and its analogs in *Capsicum annuum* var. *annuum* cv. Karayatsubusa at different growth stages after flowering. - *Agr.*

Biol. Chem. **43**: 2493-2498, 1979.

Leete, E., Louden, C.L.: Biosynthesis of capsaicin and dihydrocapsaicin in *Capsicum frutescens*. - J. amer. chem. Soc. **90**: 6837-6841, 1968.

Kato-Noguchi, H.: Assessment of the alleopathic potential of *Ageratum conyzoides*. - Biol. Plant. **44**: 309-311, 2001.

Kato-Noguchi, H., Ino, T.: Assesment of alleopathic potential of root exudates of rice seedlings. - Biol. Plant. **44**: 635-638, 2001.

Ochoa-Alejo, N., Salgado-Garaciglia, R.: Phenylalanine ammonia-lyase activity and capsaicin-precursor compounds in *p*-fluorophenylalanine-resistant and -sensitive variant cells of chili pepper (*Capsicum annuum*). - Physiol. Plant. **85**: 173-179, 1992.

Putnam, A.R.: Allelochemicals from plants as herbicides. - Weed Technol. **2**: 510-518, 1988.

Rice, E.L.: Allelopathy. 2<sup>nd</sup> Ed. - Academic Press, Orlando 1984.

Surh, Y.-J., Lee, S.S.: Capsaicin, a double-edged sword: toxicity, metabolism, and chemopreventive potential. - Life Sci. **56**: 1845-1855, 1995.