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Marrè E. Effects of fusicoccin and hormones on plant cell membrane activities: observations and hypotheses. (Marrè E & Ciferri O, eds.) *Regulation of cell membrane activities in plants*. Amsterdam: North-Holland, 1977. p. 185-202.
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Growth stimulation by fusicoccin as well as by the natural hormone auxin is associated with the activation of ATP-dependent electrogenic H^+ extrusion. It was proposed that some important physiological effects of plant hormones depend on the regulation of the activity of the plasma-membrane proton pump. [The *SCI*® indicates that this paper has been cited in over 150 publications.]

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Ever since I began my scientific career as a plant biologist, my interest has centered on the integration of functions in living organisms. I was thus attracted to the problem of the mode of action of hormones, as yet a quite open and major challenge to plant physiologists. The research in this field, at various levels from molecular to organismic, thus became the main focus of work for me and for the group of younger collaborators working in our laboratory at the University of Milan.

In 1970 a new, potentially promising approach to the mechanism of hormone action was introduced by the observation that the fungal toxin fusicoccin, discovered by Antonio Graniti[1] and chemically identified by Alessandro Ballio,[2] was able to mimic on a much enlarged scale the growth-promoting activity of auxin. We thought that this characteristic of fusicoccin might be used to understand at least part of the mechanism of growth regulation by the natural hormones.[3]

At about the same time, work by various groups of plant physiologists was making it clear that lowering the pH in the extracellular space can induce growth effects similar to those of auxin, presumably by increasing cell-wall plasticity (wall loosening). This suggested that at least part of auxin's action might be mediated by the stimulation of acid secretion (acid growth theory).[4]

In 1973, using fusicoccin as a tool, we were able to give a direct experimental demonstration of the validity of this hypothesis, by showing that both the strong effect of fusicoccin and the relatively smaller one of auxin on growth by cell enlargement were accompanied by—and apparently depended on—a parallel stimulation of H^+ extrusion.[3] An analysis of fusicoccin and of auxin-induced H^+ extrusion showed that it was associated with a hyperpolarization of the electric potential and an increase of the K^+ uptake rate and that it was mediated by the activation of an ATP-driven proton pump at the plasma membrane.[5,6]

The work in the following years and through today extended and generalized these early observations and significantly contributed to the knowledge of the nature of the electrogenic H^+ pump, its role in the secondary active transport of solutes, its regulation by intra- and extracellular pH and by the transmembrane electric potential, and its involvement in the action of auxin, of brassinosteroids, and, quite probably, of the natural inhibiting hormone abscisic acid. In recent years the recognition of the important role of the H^+ pump in the control of intracellular pH has led to a series of investigations on cytosolic pH regulation of a large area of metabolism, with probable important physiological consequences.[7,8]

The interest of plant physiologists in this line of research and in these results is documented by the large number of citations the paper has received. A highly gratifying acknowledgment came in 1983 with the awarding of the Charles Reid Barnes Award of the American Society of Plant Physiologists to me, the senior investigator of our group.

1. **Graniti A.** Azione della fusicoccina tossina prodotta da *Fusicoccum amygdali* del. sul bilancio ibrico di piantine recise di pomodoro. *Phytopathol. Mediterr.* 5:146, 1966.
2. **Ballio A.** Fusicoccin: structure activity relationships. (Marre E & Ciferri O, eds.) *Regulation of cell membrane activities in plants*. Amsterdam: North-Holland, 1977. p. 217-23.
3. **Marrè E, Lado P, Rasi-Caldogno F & Colombo R.** Correlation between cell enlargement in pea internode segments and decrease in the pH of the medium of incubation. I. Effects of fusicoccin, natural and synthetic auxins and mannitol. *Plant Sci. Lett.* 1:179-84, 1973. (Cited 125 times.)
4. **Rayle D L & Cleland R E.** Control of cell enlargement by hydrogen ions. *Curr. Topics Biol.* 11:187-211, 1977. (Cited 105 times.)
5. **Marrè E.** Fusicoccin: a tool in plant physiology. *Annu. Rev. Plant Physiol.* 30:273-88, 1979. (Cited 290 times.)
6. **Rasi-Caldogno F, De Michelis M I, Pugliarello M C & Marrè E.** H^+ pumping driven by the plasma membrane ATPase in membrane vesicles from radish: stimulation by fusicoccin. *Plant Physiol.* 28:121-5, 1986.
7. **Marrè M T, Romani G, Bellando M & Marrè E.** Stimulation of weak acid uptake and increase in cell sap pH as an evidence for fusicoccin- and K^+-induced cytosol alkalinization. *Plant Physiol.* 82:316-23, 1986.
8. **Marrè E, Beffagna N & Romani G.** Potassium transport and the regulation of intracellular pH in *Elodea densa* leaves. *Botanica Acta* 101:17-23, 1987.

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