This Week's Citation Classic

Kende H. Kinetinlike factors in the root exudate of sunflowers.
Proc. Nat. Acad. Sci. US 53:1302-7, 1965.
[Dept. Plant Physiology, Negev Institute for Arid Zone Research, Beersheva, Israel]

This paper describes evidence that at least two cytokinins are produced in the root of plants and are translocated to the shoot through the xylem. These cytokinins appear to fulfill the role of the 'root hormones' that have been postulated to regulate protein metabolism in leaves. [The *SCI*® indicates that this paper has been cited in over 175 publications since 1965.]

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"In 1963, I was working as a postdoctoral fellow in the group of Anton Lang at the California Institute of Technology. I had just accepted a position at the Negev Institute for Arid Zone Research in Israel and was casting around for ideas that might bridge my research interests in developmental plant biology and those of my future colleagues in plant-water relations and ion uptake. One of the most stimulating features of our academic life at Caltech was the weekly plant physiology journal club. At one of these sessions, Lang reported on a recent paper by Kulaeva[1] where evidence for the existence of a hereto hypothetical root factor was given.

"In 1939, Chibnall[2] had reported that the protein content of a detached leaf declined rapidly, leading to senescence and death of the organ. This process was reversed when adventitious roots developed on the petiole. Chibnall concluded that a hormone supplied by the root was necessary to maintain normal protein metabolism in the leaves. In 1957, Richmond and Lang[3] discovered that the plant growth regulator kinetin, a synthetic cytokinin, retarded senescence and protein loss in isolated leaves. Thus, Kulaeva's finding raised the question of whether Chibnall's hypothetical root hormone was a cytokinin. I decided immediately that hormonal relations between the root and the shoot would be my new research project at the Negev Institute. The possibility existed that environmental factors which affected the physiology of the root influenced developmental processes in the shoot via cytokinins.

"I joined the Negev Institute in the fall of 1963 eager to start my research on root hormones. Kulaeva's idea to assay xylem exudate of detopped plants for compounds that retarded chlorophyll loss in detached leaves had been an excellent one, but the effects she had observed were marginal. They had been obtained with unpurified and unconcentrated sap, and her bioassay was not specific for cytokinins. I concentrated and partially purified the xylem sap of sunflowers and set out to test whether it contained cytokinins, i.e., factors that induced cell divisions in plant tissue cultures. At that time, the Negev Institute neither possessed an autoclave nor facilities for sterile work. For the first experiments, I brought our pressure cooker from home to sterilize culture flasks and media. Later, we were allowed to use the autoclave at the Beersheva Hospital and, with time, the institute acquired its own autoclave. Using a tissue culture bioassay, I was able to show that the xylem exudate of sunflowers contained a cytokinin and that a second compound could be converted to an active cytokinin by acid hydrolysis. Indirect evidence indicated that these cytokinins were produced in the root.

"This paper has often been cited in the context of hormonal root-shoot relations, a topic reviewed by Torrey.[4] It established an important physiological function of cytokinins and described a case where a plant hormone was transported through the vascular system to play the role of a messenger between two distinct organs of a plant."

1. **Kulaeva O N.** The effect of roots on leaf metabolism in relation to the action of kinetin on leaves. *Sov. Plant Physiol.—Engl. Tr.* 9:182-9, 1962.
2. **Chibnall A C.** *Protein metabolism in the plant.* New Haven, CT: Yale University Press, 1939. 306 p.
3. **Richmond A E & Lang A.** Effect of kinetin on protein content and survival of detached *Xanthium* leaves. *Science* 125:650-1, 1957.
4. **Torrey J G.** Root hormones and plant growth. *Annu. Rev. Plant Physiol.* 27:435-59, 1976.

This Week's Citation Classic

Itai C & Vaadia Y. Kinetin-like activity in root exudate of water-stressed sunflower plants. *Physiologia Plantarum* 18:941-4, 1965.
[Dept. Plant Physiology, Negev Institute of Arid Zone Research, Beer Sheva, Israel]

Root exudate was chromatographed and bioassayed for cytokinin activity. Water stress decreased the level of activity in the exudate. The data support the hypothesis that modification of leaf metabolism in stressed plants may result from a decreased supply of cytokinin to the shoot. [The *SCI*® indicates that this paper has been cited in over 105 publications since 1965.]

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"In mid-1963, I joined the Negev Research Institute in Beer Sheva as a PhD student. At that time, Yoash Vaadia was engaged in forming a plant physiology group there and invited Hans Kende to work in it. The fact that the group was located in a desert research institute dictated the interest in plant response to this environment. The then recently established finding that plants adjust osmotically to drought[1] and salinity[2] shifted our efforts in finding the reasons for growth retardation due to water stress from physical parameters to metabolic ones. At the same time, Kende tried to prove that Chibnall's root factor is a cytokinin and indeed he found cytokinin present in root xylem exudate of sunflower plants.[3] From here, it was only one step to link the effects of water stress such as growth retardation and early senescence to reduction in the level of cytokinin in exudate of water-stressed plants. All of us got carried away by this working hypothesis and found in the literature more and more supporting evidence for it.

"The actual work was rather simple although our facilities were somewhat poor. As a matter of fact, Beer Sheva in those days was still more noted for its role in Abraham and Sarah's life and for its Bedouin camel market than for its scientific contributions. We were using an autoclave in a nearby hospital and constructed a primitive sterile hood to transfer the tissue needed for the bioassay. The only thing we enjoyed in ample supply was enthusiasm, and in retrospect this may account for rushing to publish those very preliminary data. In fact, the paper was rejected by a leading journal although not on the basis of its precocity but because of the editor's opinion that in view of the multitude of processes already known to be affected by water stress, reporting an additional one was not worth a publication. For us this paper served as a starting point. At that time, Aliza Benzioni, Amos Richmond, Moshe Tal, and Joseph Mizrahi joined the group; the original hypothesis was extended to include other environmental stresses such as those caused by salinity, high and low temperature or mineral deprivation, and other phytohormones as well (ABA). With time, other groups were attracted by this hypothesis and as a result of the joint effort our knowledge on the involvement of phytohormones in regulating plant response to environmental stress has been extended significantly as was reviewed recently.[4,5]

"This paper was probably cited since it is the first report on changes in phytohormones due to water stress and one of the few on the involvement of cytokinin."

1. **Slatyer R O.** Effects of several osmotic substrates on the water relationships of tomato. *Aust. J. Biol. Sci.* 14:519-40, 1961.
2. **Bernstein L.** Osmotic adjustment of plants to saline media. II. Dynamic phase. *Amer. J. Bot.* 50:360-70, 1963.
3. **Kende H.** Preservation of chlorophyll in leaf sections by substances obtained from root exudate. *Science* 145:1066-7, 1964.
4. **Itai C & Benzioni A.** Water stress and hormonal response. (Lange O L, Kappen L & Schulze E D, eds.) *Water and plant life: problems and modern approaches.* Berlin: Springer-Verlag, 1976. p. 223-42.
5. **Vaadia Y.** Plant hormones and water stress. *Phil. Trans. Roy. Soc. London B* 273:513-22, 1976.

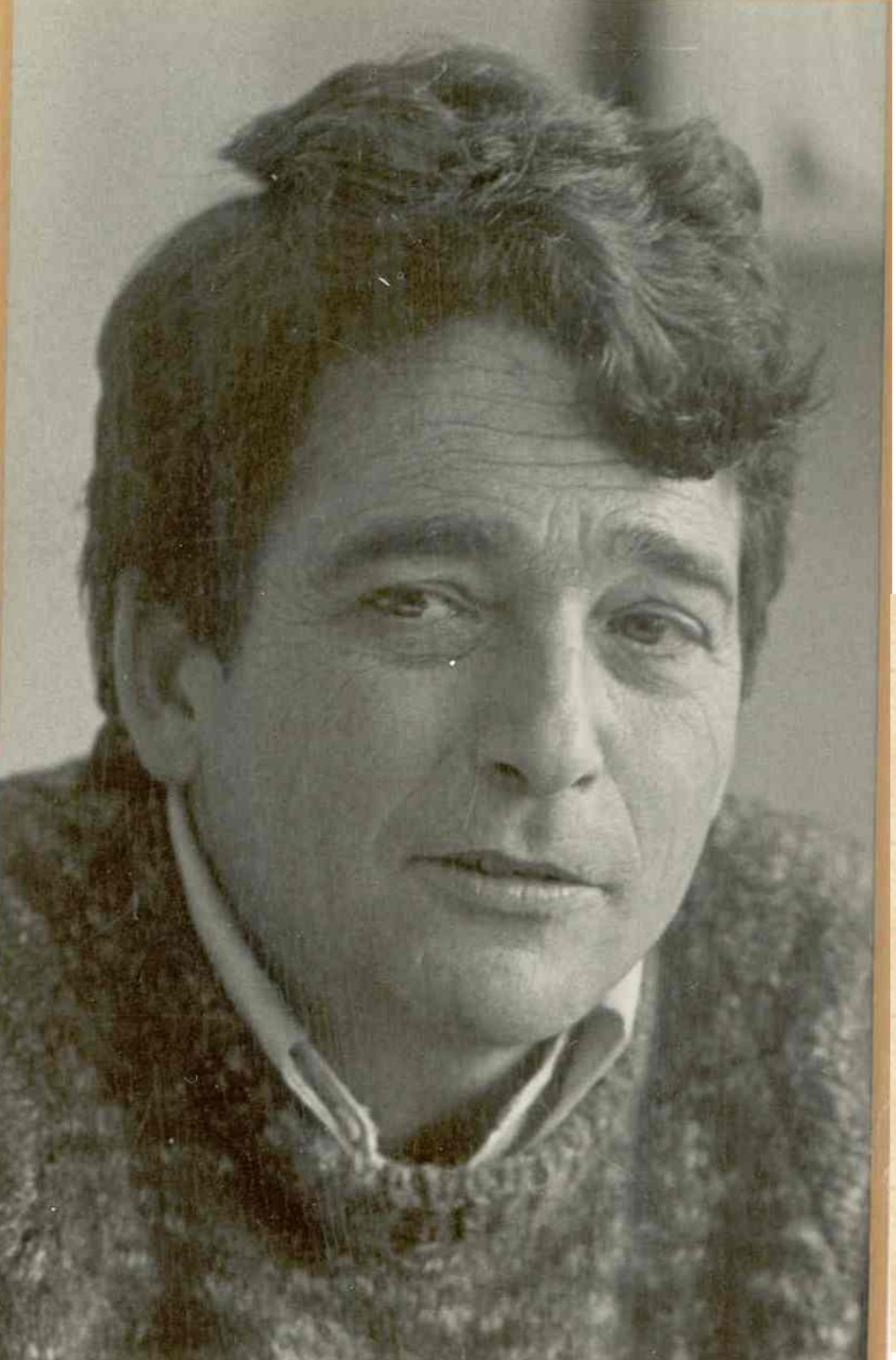
Moshe Tal's research tomato mutant

FLACCA **Sprayed with ABA**

Wilty mutant *FLACCA*

Jojoba three years old plantation with new clones
with Professor Aliza Benzioni in Hatzerim

The wooden tower the first in the world to carry the semipermeable membrane for water desalination on Bregman campus BGU. Developed the sixties by the late Professor Syndy Loeb.



Yoash Vaadia opens scientific meeting in Beer Sheva1966