



## Karrikins: A Novel Plant Growth Regulator

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Karrikins are a class of plant growth regulators that were discovered in the smoke of burning plant material. The name "Karrikin" is derived from the Australian Aboriginal word for smoke, "karrik." These compounds have attracted significant attention due to their potential applications in agriculture, particularly in promoting seed germination, enhancing plant growth, and improving crop yield under various environmental conditions.

### Discovery and Chemistry

Karrikins were first identified in the early 2000s during research on the effects of fire on seed germination. Wildfires are known to stimulate the germination of seeds in certain plant species, particularly those in fire-prone ecosystems. Researchers discovered that specific compounds in smoke, later identified as karrikins, were responsible for this effect.

Chemically, karrikins belong to a family of butenolide compounds. The most well-known karrikin is KAR1 (3-methyl-2H-furo[2,3-c]pyran-2-one), but other related compounds also exhibit biological activity.

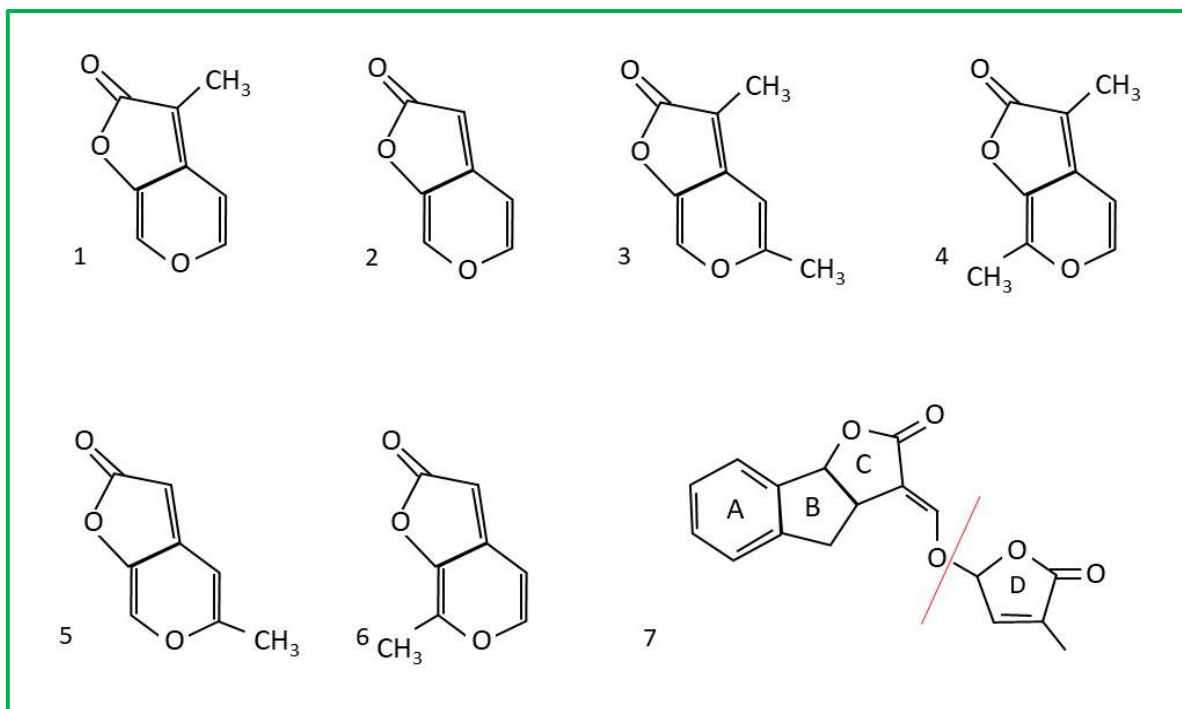
### Mechanism of Action

Karrikins influence plant growth and development by interacting with specific receptors in plant cells. The primary receptor for karrikins is the KAI2 protein, which is closely related to the receptor for strigolactones, another class of plant hormones. When karrikins bind to KAI2, they initiate a signaling cascade that affects gene expression, leading to various physiological responses.

The exact mechanisms by which karrikins promote seed germination and growth are still under investigation, but they are known to mimic certain natural growth regulators, triggering processes that enhance seedling vigor and growth.

### Chemical Properties of Karrikins

The structure of KARs is very similar to phytohormones strigolactones (SLs). Butenolide ring of KARs and lactone D ring of SLs are closely related. The KARs structure combines a six-membered pyran ring with a five-membered butenolide ring. The differences between the six known KARs are based on methyl substitutions (Figure 1). These KARs are described as KAR1 to KAR6. Only C, H, and O are present in the two-ring structures of KARs. The pure KARs have a melting point of 118–119°C, and they are the substances of crystalline character. KARs can be quickly dissolved in organic solvents and mildly in water.



**Figure 1. The known chemical structures of karrikin family representatives and strigolactone analog GR24. 1. KAR<sub>1</sub> 2. KAR<sub>2</sub>. 3. KAR<sub>3</sub>, 4 KAR<sub>4</sub>, 5. KAR<sub>5</sub>, 6. KAR<sub>6</sub>, 7. Strigolactone analog GR-24, the red line separates a lactone D ring, which is similar to the KARs butenolide ring.**

KARs relate to SLs because they share a specific type of lactone known as a butenolide fused to a pyran ring with the systematic name 3-methyl-2H-furo[2,3-c]pyran-2-one. The plant-made signaling compounds SLs are synthesized from carotenoids. To date, the structure of at least 20 different naturally occurring SLs has been characterized. In contrast, KAR molecules are not produced by the plant itself but are formed by heating or combustion of carbohydrates, such as cellulose. Various SL analogs abbreviated as GR have been synthesized, of which GR24 is the most active and widely used in SL research. Even though just six KARs so far showed physiological activity in plants, almost 50 analogs of KAR<sub>1</sub> with different substitutions have been synthesized.

### Applications in Agriculture

**Seed Germination:** Karrikins have been shown to stimulate the germination of seeds, particularly in species that are difficult to germinate or have long dormancy periods. This property makes karrikins valuable for improving the germination rates of crops, especially under suboptimal conditions.

**Seedling Growth:** Beyond germination, karrikins can enhance the early growth stages of seedlings, leading to stronger and more resilient plants. This is particularly beneficial in agricultural settings where early seedling vigor can significantly impact crop yield.

**Stress Tolerance:** Karrikins may help plants cope with environmental stresses such as drought, salinity, and poor soil conditions. By promoting better root growth and more efficient water and nutrient uptake, karrikins can improve plant resilience in challenging environments.

**Weed Management:** Karrikins' ability to stimulate seed germination is also being explored for use in weed management. By inducing the germination of weed seeds before crop planting, farmers can potentially reduce the weed seed bank in the soil, making subsequent weed control easier.

## Current Research and Challenges

While karrikins hold great promise, their application in agriculture is still in the early stages. Key areas of ongoing research include:

**Understanding Karrikin Pathways:** More research is needed to fully elucidate the signaling pathways and molecular mechanisms by which karrikins exert their effects.

**Formulation and Application:** Developing effective formulations and delivery methods for karrikins in agricultural settings is crucial. Ensuring stability, consistency, and ease of application will be important for commercial use.

**Crop-Specific Effects:** The response to karrikins can vary among different plant species and even among different cultivars. Understanding these variations is essential for optimizing karrikin use in diverse agricultural systems.

## Future Prospects

As research progresses, karrikins could become an important tool in sustainable agriculture. Their ability to enhance seed germination, improve crop resilience, and potentially reduce reliance on chemical inputs aligns with the goals of modern farming practices. If successful, karrikins could contribute to increasing agricultural productivity and food security, particularly in regions facing environmental challenges.

## Conclusion

Karrikins represent an exciting frontier in plant science and agriculture. Their novel mode of action and potential applications in enhancing plant growth, stress tolerance, and weed management make them a promising addition to the arsenal of tools available to farmers. Continued research and development will be key to unlocking their full potential and integrating them into practical agricultural systems.