Reports

Effect of Kinetin on Formation of Red Pigment in Seedlings of Amaranthus retroflexus

Abstract. Kinetin induces formation of red pigment in seedlings of *Amaranthus retroflexus* in the dark. This effect is similar to the light-induced formation of pigment. Light and kinetin do not act in a simple additive way. The pigment is not an anthocyanin, and its formation is not affected by inhibitors of anthocyanin formation.

It has been thought that kinetin abolishes the light requirement of seeds (*1*). In other processes also a replacement of light requirement by kinetin has been reported (*2*). It has been shown since that lettuce seeds respond to kinetin [6-(aminofurfuryl)purine] by a large increase in their sensitivity toward light (*3*). The amount of light required to cause maximal germination is reduced in the presence of kinetin. It was of interest to determine whether other light-sensitive seeds show a similar response to kinetin. Seeds of *Amaranthus retroflexus* were selected since they are known to respond to light (*4*). The germination of *A. retroflexus* did not show any response to kinetin. At kinetin concentrations of $2 \times 10^{-4}M$, germination was somewhat inhibited and at lower concentrations there was no effect.

However, there was a difference in the appearance of seedlings from water-germinated as opposed to kinetin-germinated seeds. Seeds germinated in water in the dark gave colorless seedlings, while seeds germinated in solutions of kinetin, in the dark, under the same conditions contained a red pigment which was concentrated in the cotyledons. Seeds germinated in the light also contained a red pigment, which occurred chiefly in the hypocotyl. The pigment formed in the presence of kinetin in the dark and that formed in the light without kinetin appear to be the same, both in chemical reaction and also in their absorption spectra, both having absorption maxima at 2700 and 5400 A. Both are decomposed in hot dilute (0.5 percent) hydrochloric acid. The Chenopodiaceae and related families such as the Amaranthaceae are known to contain red pigments which differ from the anthocyanins and which are frequently referred to as "nitrogenous anthocyanins." The nature and chemical structure of these pigments is as yet unknown (*5*). The normal anthocyanins do not appear to occur in plants which contain the "nitrogenous anthocyanins."

The amount of red pigment formed in the seedlings was determined by extracting a definite number of seedlings, usually 50, with 5 ml of 20 percent ethanol. The seedlings were boiled for 2 minutes, cooled, and filtered, and the optical density of the extract was measured at 540 mμ.

Pigment formation was dependent on the kinetin concentration, being maximal at $10^{-4}M$ and decreasing at higher concentrations, and this concentration was used in subsequent experiments.

The formation of the pigment in the dark in the presence of kinetin was dependent on both temperature and time. At low temperatures the amount of pigment rose steadily with the length of time the seedlings were in the solution of kinetin, but at higher temperatures (26 and 37°C) the amount of pigment rose to a maximum and then fell again after about 90 to 130 hours. Pigment formation was more rapid at 26° and 37° than at 15° and 20°.

Light induced effects similar to those caused by kinetin, but the amount of pigment formed in the light was less than that formed in the presence of kinetin in the dark. In the light at 26°C the same rise and subsequent fall in the amount of pigment was observed as in the case of kinetin in the dark. However, in the presence of both light and kinetin at 26° this drop was not observed, the amount of pigment increasing steadily with time till 162 hours. The total amount of pigment formed was not greater in the light and kinetin after 162 hours than it was in kinetin alone, in the dark, after 120 hours. These results are shown in Table 1. Clearly the effects of kinetin and light are not simply additive. When both are operating, pigment formation is delayed. The level reached in kinetin and light after 162 hours is about the same as that reached in kinetin in the dark after 120 hours.

Compounds which have been shown to affect anthocyanin formation (*6*) were tested to see whether they had any effect on the formation of the pigment in *Amaranthus* seedlings. The results are shown in Table 2. It can be seen that the effects are far less marked than those observed for anthocyanin formation.

During attempts to study the effects of sugars, which might be precursors of the furfuryl group of kinetin, on pigment formation, it was necessary to apply mercuric chloride in order to prevent infection of the seedlings by fungi. It was observed that 50 parts of mercuric chloride per million alone caused a definite amount of pigment formation, although the amount was considerably less than that caused by kinetin. The sugars themselves (for example, arabinose) had no clear effect. Various purines, such as xanthine, uracil, and adenine, which are related to kinetin and might act similarly to kinetin, also did not induce pigment formation.

In conclusion, it may be said that kinetin appears to be very effective in inducing the formation of a red pigment, probably a nitrogenous anthocyanin, in *Amaranthus* seedlings. Although such enhanced pigment formation is not necessarily a specific effect, it seems likely that the action of kinetin here is related in some way to its more general effect on nitrogen metabolism (*7*). The latter is well known to be related to anthocyanin formation.

The joint effect of kinetin and light

Table 1. Amount of red pigment formed in *Amaranthus* seedlings with time under different conditions. (The intensity of pigment formation is given as optical density of a standard extract.) No pigment was formed in the dark.

Time from sowing (hr)	Pigment formation		
	In dark and kinetin ($10^{-4}M$)	In light	In light and kinetin ($10^{-4}M$)
48	0.030	0.030	0.030
72	.495	.190	.100
120	.630	.200	.245
144	.165	.265	.340
162	.095	.100	.595

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

Table 2. Effect of inhibitors on the formation of red pigment in *Amaranthus* seedlings.

Concn. of inhibitor (*M*)	Light	Dark and kinetin
	Catechol	
10^{-3}	Slight inhibition	50% inhibition
	Thiouracil	
10^{-5}	Slight stimulation	Slight inhibition
10^{-4}	No germination	No germination

might be explained as follows. In the presence of both kinetin and light, processes leading to pigment destruction predominate initially. Later, pigment formation exceeds pigment destruction, and the amount of red pigment rises. This might be due to the slow formation in the light of pigment precursors, which are converted to the red pigment in the presence of kinetin (*8*).

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References and Notes

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7. K. Mothes and L. Engelbrecht, *Proc. Intern. Botan. Congr., 9th Congr.* (1959), vol. 2, p. 173.
8. This report is part of a thesis submitted to the Hebrew University by one of us (E.B.).

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Behavior and Beliefs during the Recent Volcanic Eruption at Kapoho, Hawaii

Abstract. The recent volcanic eruption at Kapoho, Hawaii, resulted in rituals and offerings to the Hawaiian Volcano Goddess, Pele.

In 1955, a volcanic eruption occurred in the populated Puna District of East Hawaii. This renewal of volcanic activity followed a period of quiescence lasting well over 100 years. During the 3 months of intermittent volcanic action there was no loss of life, but damage to property and crops was extensive. On 13 January 1960, eruption resumed near the village of Kapoho for the second time in 5 years. The resulting emergency was preceded by a sharp increase in the frequency and magnitude of earthquakes. More than 250 individuals left their homes prior to and during the first night of the eruption. One hundred and one individuals were relocated to the Red Cross disaster shelter. The remaining evacuees were sheltered by relatives or friends, or by means of house rentals. Most transportable belongings were removed during the first two days.

On the fifth day of the eruption, the first dike was built to contain or divert the lava from the Warm Springs recreation area, which was destroyed the following day. A series of earthen dikes were constructed with bulldozers during the following weeks. The lava circumvented, overran, filtered under, or pushed aside each of the dikes. Numerous buildings in the path of the flow were destroyed. It was suggested that the flow might be diverted by bombing with military aircraft. The major landowner in the area emphatically refused to give permission.

During the 15th and 16th days, most of the village of Kapoho was covered by the lava. The destruction of Kapoho was almost complete as of the first week in February.

Since the initial day of the emergency, periodic observations have been made of the behavior patterns of the evacuees and others at the site of the eruption and in the evacuation center. Concurrently, a questionnaire is being administered to most of the evacuees and to a control group in a similar rural community that is quite distant from any volcanic activity. Responses are sought to questions concerning "security seeking" behavior, communication of the state of emergency, self-reliance, manner of relocation, and so forth. The questionnaire interview is being conducted by a group of students of the Hilo Campus, in English, local pidgin English, Japanese, Korean, and three Filipino dialects. A photographic account of the behavior is also being made.

A number of behavioral scientists entertain the working hypothesis that in times of stress and uncertainty, many individuals seek security in supernatural beliefs, rituals, and related behavior. One of the objectives of our research is to measure this phenomenon as it is occurring in the unique cultural environment of Hawaii. The study is seeking to establish the relationship between the current observations of "security seeking" behavior and other variables such as ethnic group membership, degree of acculturation, level of education, and previous experience under stress, such as the conditions of social disorganization in the 1955 eruption.

One unusually interesting class of "security seeking" behavior emerges consistently during Hawaiian eruptions: rituals and offerings are made to the Hawaiian Volcano Goddess, Pele. Pictorial records have been made with or without permission from the individual performing the ritual. Permission to take the picture in Fig. 1 was granted. This picture shows a Hawaiian language chant to Pele being read by a Chinese-Hawaiian. The traditional offerings of breadfruit, bananas, pork, and tobacco are at his feet. The Western influence is manifested by the Christmas gift wrapping and green ribbon for the box of offerings to Pele. The throwing of the offerings upon the lava flow was accompanied by the singing of a Chinese song.

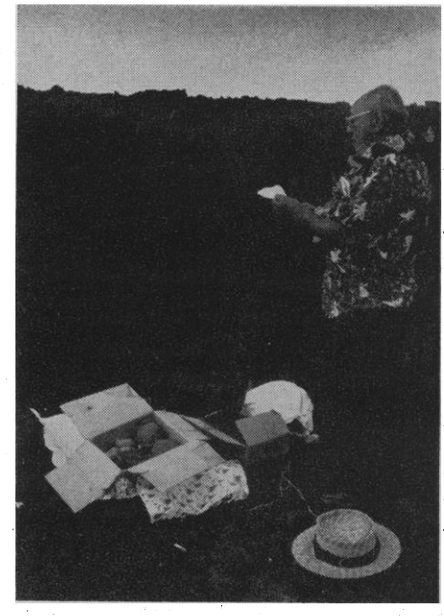

Fig. 1. A Chinese-Hawaiian stands next to the lava flow reading a chant to the Volcano Goddess Pele. Note the Christmas gift wrapping around the offerings.

Preliminary data indicate that this behavior and especially the related be-

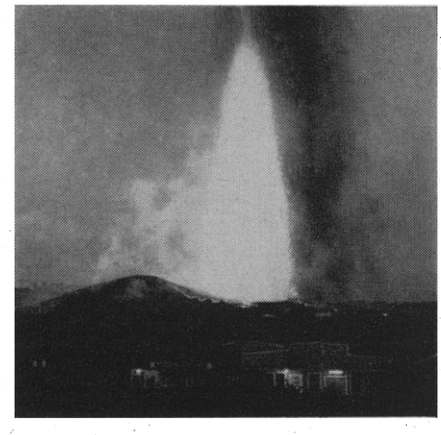

Fig. 2. The immense lava fountain is shown behind the main street of the village of Kapoho. [Hilo Tribune Herald]