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Short communication

Red and far-red reversible photoreactions on seed germination of *Cucumis sativa*

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The effects of red and far-red light in seed germination of *Cucumis sativa* differs markedly with the degree of seed ripening and the variety of seed; reciprocal hybrids are clearly maternal.

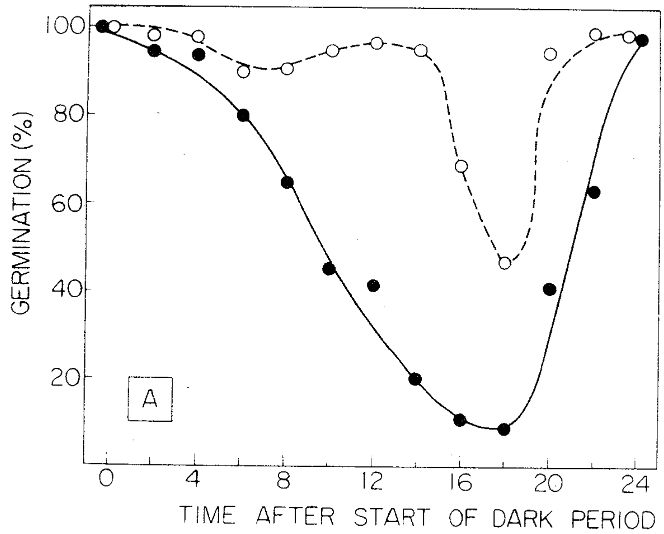
The germination of light-sensitive seeds has been shown to be controlled by a reversible photoreaction. It was first reported that red radiation stimulates the germination of seeds and far-red radiation inhibits the action of red light (*1*). The response of seeds toward these types of light is also influenced by temperature and other factors (*2, 3*).

The present experiments were performed to find the effect of red and far-red light on seed germination using two varieties of cucumber and their reciprocal hybrids.

The two strains of cucumber (*Cucumis sativa* L. cv. Karihafushinari and Aofushinari) were grown at an experimental farm of Fukushima University in 1968. Seeds were harvested from fruits 40 and 50 days after artificial intra- or inter-varietal pollination of flowers which were selected from a specified position on a main stem (these seeds are referred to as groups *a* and *b*, respectively). Seeds were air-dried and stored for three months in a dry condition in a paper bag in a wooden box at room temperature. Seeds to be tested were disseminated on two layers of filter paper in a Petri dish 6 cm in diameter and moistened with 2 ml distilled water. Then, the dishes were wrapped with light-tight paper, which was removed when the seeds were irradiated. These dishes were placed in temperature-controlled chambers (25±0.2°C).

Red light was provided by a combination of red colored fluorescent tubes (Toshiba) and a red plastic filter (Nagahama Jushi No. 311). Far-red light was obtained from 4 infra-red lamps (Toshiba medical lamp 100 v 125 w) and blue plastic filters (Nagahama Jushi No. 351), between which 4 Petri dishes containing distilled water 10 cm deep were inserted. The light intensity at the level of seeds was adjusted to 8.0×10^3 ergs·cm^{-2}·sec^{-1} for both red and far-red. One-hr of far-red light interruption was given at different times during the 24-hr dark period after sowing.

Four dishes containing 25 seeds, each were used for each treatment, and the germination percentages were counted 26 or 28 hr after sowing.



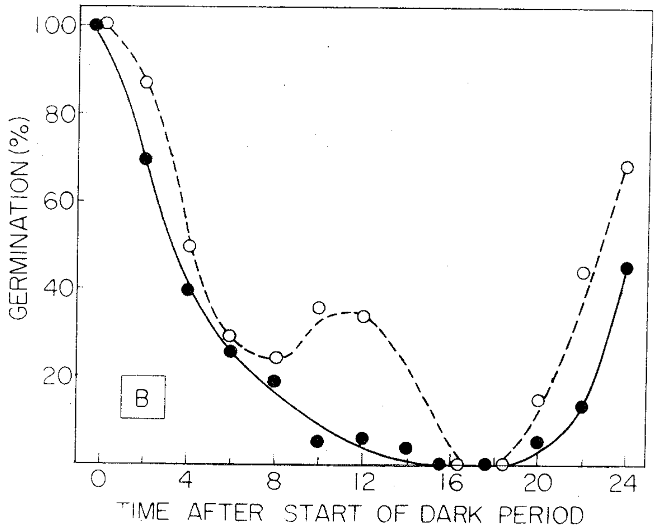


Fig. 1. Effective phase of suppression by far-red irradiation in germination of cucumber seeds.
A: Karihafushinari, B: Aofushinari.
●: Group *a* seeds, ●: Group *b* seeds.

Fig. 1 shows that the maximum suppression of germination is seen when far-red light is given about 16 to 18 hr after the beginning of the dark period. But the degree of suppression differs markedly with the variety of cucumbers and the endogenous physiological condition of the seeds, caused by the degree of ripening. Suppressive effects were more remarkable in seeds of Aofushinari than in those of Karihafushinari, and in seeds of group *b* rather than in those of group *a* for both varieties.

Various lengths of exposure to far-red light were then given 18 hr after the beginning of the dark period to determine the necessary dosage for the suppression of seed germination. Fig. 2 shows that a 30-min exposure to far-red light is enough to inhibit germination. This suppressive effect was more remarkable in seeds of Aofushinari than in those of Karihafushinari.

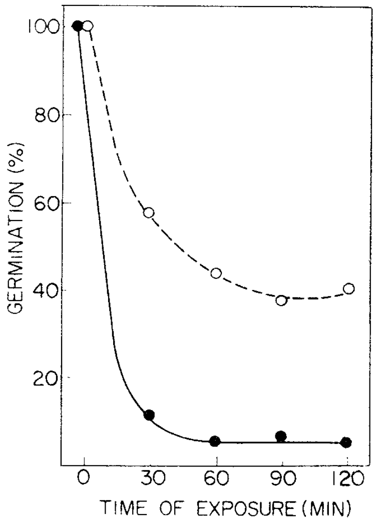


Fig. 2. Suppression by far-red irradiation.
○ : Karihafushinari, ● : Aofushinari.

Table 1
Germination of seeds after exposure to far-red (1 hr) and red (30 min) radiation in sequence

Irradiation	Percent of germination	
	a seeds	*b* seeds
Dark control	100	98
R	96	88
FR	54	22
FR+R	80	78
FR+R+FR	36	26
FR+R+FR+R	82	60

Variety: Karihafushinari. Irradiation was given 18 hr after the beginning of the dark period.

The next experiment was designed to ascertain whether the germination response would depend solely upon the last of a sequence of exposures to red and far-red radiation. Table 1 shows that the action of far-red versus red radiation seems to be completely reversible; for if far-red irradiation is given after exposure to red light, a far-red effect is obtained. In fact, germination can be repeatedly controlled by alternating red and far-red light, and the subsequent response is always to the last kind of radiation given. The response of seeds for controls repeated by alternating red and far-red light is more effective in seeds of group *b* than in those of group *a*.

In another experiment, seeds of these two local varieties and their hybrids which were harvested from fruits 40 days after artificial intra- or inter-varietal pollination, were exposed to far-red radiation for 1 hr 10 or 18 hr after the beginning of the dark period and again placed in the dark.

Table. 2 shows that seeds of the local variety, Aofushinari, were suppressed more by exposure to far-red light than were those of Karihafushinari. The suppres-

Table 2

Suppressive effects by far-red irradiation on seed germination in two local varieties of cucumber, and their reciprocal hybrids

Seed parent		Pollen parent	Percent of germination (a)	(b)
Karihafushinari	×	Karihafushinari	100	74
Aofushinari	×	Aofushinari	4	5
Karihafushinari	×	Aofushinari	96	64
Aofushinari	×	Karihafushinari	6	3

(a) One-hr far-red light was given 10 hr after the beginning of the dark period.
(b) One-hr far-red light was given 18 hr after the beginning of the dark period.

sive effect of far-red radiation on the seeds was clearly seen to be maternal for reciprocal hybrids between the varieties.

Interconvertible photoreactions may be involved in the light action mediated by phytochrome (*1*). But the physiological action of phytochrome-P_r and -P_{fr}, and the relation between the physiological responses and optically detectable phytochrome contents in plant organisms are still obscure (*4*). MANCINELLI and HENDRICKS (*5*) reported that dark germinating tomato seeds can be inhibited by exposure to far-red light. They concluded that the diminution of P_{fr} from minimal exposure to red is accompanied by the disappearence of some endogenous factor (presumably a hormone).

The genetics of seed germinability or dormancy have also received some study. PINNELL (*6*) recognized that the maternal parent was of rather great importance in determining seedling stands in both single crosses and double crosses, and postulated that the nature of the endosperm may be responsible for that portion of inheritance directly related to the maternal parent in the ability of corn seed to germinate in wet field soil at low temperatures. HARPER and McNAUGHTON (*7*) reported that the proportion of dormant seed from reciprocal hybrids in the papaver species indicates a maternal predominance in determining seed dormancy.

The present experiments show that light sensitivity for germination differs remarkably with the degree of seed ripening and the variety of cucumber, and that reciprocal hybrids are clearly maternal. But these experiments do not affirm whether this phenomenon is due to cytoplasmic inheritance or to predetermination in the egg-cytoplasm by a gene of the maternal parent, because we have not yet been able to examine the influence of seed coat endosperm and the embryo on light sensitivity for germination.

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