

**Short Communication**

# Influence of After-ripening on Phytochrome Control of Seed Germination in Two Varieties of Lettuce (*Lactuca sativa* L.)<sup>1</sup>

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## ABSTRACT

The reversible photoreaction on seed germination of two varieties of lettuce differs remarkably not only with the variety but also with the germination temperature and the physiological conditions of seeds caused by after-ripening.

Grand Rapids showed reversible photoreaction at 25 C with 0 to 6 months and at 30 C with 5 to 6 months after-ripening. MSU 16 did not show any reversible photoreaction at 30 C with 0 to 6 months or at 25 C with 0 to 3 months after-ripening although they were completely reversible with 4 to 6 months after-ripening.

These two varieties of lettuce seeds, however, showed reversible photoreaction at 20 C when they were sown immediately after harvest or after 1 and 2 months after-ripening. The photoreversion decreased after the 4- to 6-month stage.

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It is wellknown that the typical phytochrome system is involved in the germination of photosensitive lettuce seeds (1). There is, however, considerable variation between different seed stocks, which depends largely on the history of the parent plant (7) and of the seeds after harvest (4, 12).

An analysis of the relationships between the temperature and the after-ripening of seeds in phytochrome-mediated germination was not made. We studied the functioning of the phytochrome system in lettuce seed germination at different temperatures, using the seeds of two varieties in 0 to 6 months after-ripening.

## MATERIALS AND METHODS

Lettuce plants (*Lactuca sativa* L. cv. Grand Rapids<sup>3</sup> and MSU 16<sup>4</sup>) were grown in the greenhouse of Fukushima University in 1977. Seeds were harvested from the mother plants about 20 days after anthesis. Harvested seeds were air-dried and kept in paper bags in a wooden box at room temperature (23 ± 2 C) until used. This storage constituted the after-ripening treatment.

Fifty seeds were sown on two layers of Toyo No. 3 filter paper

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<sup>3</sup> Original seeds were obtained from G. J. Ball.

<sup>4</sup> Original seeds were obtained from S. Honma, Michigan State University.

moistened with 1 ml distilled H<sub>2</sub>O in a 4-cm diameter Petri dish. The dishes then were wrapped with a light-proof paper, which was removed when irradiation was given. These dishes were placed in temperature-controlled chambers (±1 C).

R<sup>5</sup> (660 nm) and FR (730 nm) light were obtained by biological spectrograph (9) and light intensity at the level of seeds was adjusted to 3,000 ergs cm<sup>-2</sup> s<sup>-1</sup> for both R and FR.

The per cent germination was determined 48 h after sowing and is expressed as an average of four dishes ± the standard error.

## RESULTS

Seeds of both varieties of lettuce showed phytochrome control of germination at 20 C when they were sown immediately after harvest or with 1 and 2 months after-ripening (Table I). Their reversibility, however, began to decrease gradually with 2 to 3 months after-ripening. Neither Grand Rapids nor MSU 16 seeds showed any reversibility with after-ripening for 4 to 6 months. This is because both varieties germinated 88 to 76 % in darkness or under 5 min FR irradiation.

Grand Rapids seeds were completely reversible at 25 C with 0 to 6 months of after-ripening and at 30 C with 5 to 6 months of after-ripening (Table I). MSU 16 was completely reversible at 25 C with 4 to 6 months after-ripening.

Grand Rapids did not show any reversibility at 30 C with 0 to 4 months after-ripening and MSU 16 did not show it, either, at 25 C with 1 to 3 months after-ripening. This is because both varieties were dormant and were not induced to germinate by 5-min exposure to R light at each temperature.

## DISCUSSION

Grand Rapids seeds lose their thermal dormancy when after-ripened for 5 to 6 months. Early during thermal dormancy, they are photoreversible. Later, they lose photoreversibility and lose thermal dormancy. These losses occur during after-ripening and seeds become nondormant and germinate over a broad range of temperature in the dark. MSU 16 was more thermal dormant to begin with and was generally more dormant than Grand Rapids seeds throughout after-ripening.

The response of seeds toward R and FR light is influenced by germination temperature and other factors (2, 4, 6, 8, 11-14). Our data indicate that the function of phytochrome is influenced markedly not only by germination temperature but also by after-ripening.

The thermodormancy is typically attributed to a conversion of

<sup>5</sup> Abbreviations: R, red; FR, far red.

Table 1. Germination of Lettuce Seed after Exposure to R (5 min) and FR (5 min) Radiation in Sequence Irradiation was given 8 h after beginning of the dark period.

cv.	Temperature	Irradiation	Germination Following After-ripening for Months:						
			0	1	2	3	4	5	6
	C		%						
Grand Rapids	20	Dark	78 ± 2	82 ± 3	89 ± 4	86 ± 3	85 ± 1	83 ± 2	88 ± 1
		R	95 ± 1	92 ± 1	93 ± 2	93 ± 1	94 ± 1	90 ± 1	92 ± 1
		FR	12 ± 2	19 ± 2	29 ± 3	37 ± 2	88 ± 4	80 ± 2	86 ± 3
		R-FR	16 ± 2	25 ± 3	32 ± 2	41 ± 3	79 ± 3	76 ± 4	81 ± 3
		R-FR-R	94 ± 2	90 ± 2	93 ± 1	96 ± 2	97 ± 1	91 ± 3	90 ± 2
	25	Dark	1 ± 1	0	5 ± 1	1 ± 1	25 ± 3	28 ± 3	43 ± 3
		R	76 ± 3	67 ± 3	89 ± 2	76 ± 2	78 ± 3	88 ± 1	86 ± 2
		FR	0	2 ± 1	0	2 ± 1	8 ± 2	4 ± 1	3 ± 1
		R-FR	0	0	0	0	4 ± 1	7 ± 1	5 ± 2
		R-FR-R	81 ± 3	81 ± 3	84 ± 2	79 ± 2	82 ± 3	91 ± 3	89 ± 2
	30	Dark	0	0	0	0	0	0	0
		R	0	0	0	0	0	45 ± 2	66 ± 2
		FR	0	0	0	0	0	0	0
		R-FR	0	0	0	0	0	3 ± 1	2 ± 1
		R-FR-R	0	0	0	0	0	51 ± 2	67 ± 2
MSU 16	20	Dark	28 ± 1	36 ± 2	53 ± 2	72 ± 2	83 ± 2	86 ± 2	87 ± 1
		R	50 ± 2	82 ± 2	80 ± 2	87 ± 2	90 ± 2	90 ± 1	89 ± 2
		FR	0	15 ± 1	24 ± 2	33 ± 2	86 ± 3	83 ± 3	84 ± 2
		R-FR	0	24 ± 2	23 ± 2	38 ± 2	84 ± 2	85 ± 3	86 ± 2
		R-FR-R	66 ± 2	89 ± 2	79 ± 2	84 ± 2	85 ± 1	90 ± 2	96 ± 1
	25	Dark	0	0	0	0	11 ± 1	8 ± 1	11 ± 1
		R	0	0	7 ± 1	2 ± 1	73 ± 2	68 ± 2	74 ± 2
		FR	0	0	0	0	1 ± 1	0	4 ± 1
		R-FR	0	0	0	0	2 ± 1	0	0
		R-FR-R	0	0	2 ± 1	9 ± 1	65 ± 2	68 ± 1	83 ± 1

active form to inactive form of phytochrome (5, 11). Ikuma and Thimann (6) reported that low temperature stimulated lettuce seed germination at a point other than that controlled by phytochrome. The light requirement in thermodynamically dormant lettuce seeds is a conditional response to the incubation at high temperature (3). Negm *et al.* (10) suggested that the failure of lettuce seed germination at high temperature is not due to a direct effect on the phytochrome system but, rather, to some other blocks. Takeba and Matsubara (13) also explained that the germination of lettuce seeds is regulated not only by the phytochrome system but also by the thermolabile factor. Danielson and Toole (2) reported that high temperature imposes a block to germination beyond that of the active form of phytochrome.

The failure of germination induction by a brief (5-min) exposure to R light at high (25 C in MSU 16 and 30 C in Grand Rapids seeds) temperature in the initial stage of after-ripening may occur, either because the active form of phytochrome cannot function to induce germination or because there are blocks other than a direct inactivation of phytochrome system itself. The failure of germination inhibition by a brief (5-min) exposure to FR light at low (20 C) temperature in both varieties of seeds with 4 to 6 months after-ripening may occur, either because the inactive form of phytochrome cannot function to inhibit germination or because there are factors other than a direct activation of phytochrome itself.

Our experiments have clearly shown that the range of temperature and R light requirement for germination induction or the range of temperature and FR light requirement for germination inhibition changed with the physiological conditions of the seeds.

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