PHYSIOLOGIA PLANTARUM, VOL. 21. 1968, 759–764

The Effect of Limitation in Light During the Rest Period On Leaf Bud Break of the Peach (*Prunus persica*)

By

A. Erez, S. Lavee and R. M. Samish

The Volcani Institute of Agricultural Research, Bet Dagan, Israel

(Received September 27, 1968)

Abstract

Reduction in the amount of light supplied during the mid-rest period caused a better leaf bud opening in the peach as compared with natural winter daylight; this includes darkness, short photoperiod and reduced light intensity. The quantitative nature of this light effect was shown. The role of light as a factor regulating dormancy is discussed.

Introduction

The effect of the photoperiod on bud opening of deciduous dormant trees was examined by Kramer (8), Olmsted (10) and, more extensively, by Wareing (13). In all these investigations long day was found to enhance bud opening as compared with the natural photoperiod. We could find no information in the literature on the effect of a long dark period during rest in deciduous woody plants.

In our investigations leafless dormant peach shoots were found to be sensitive to light. More so, light was found to be obligatory for leaf bud opening (5). This report deals with the effect of light during the main rest period.

Materials and Methods

The experimental material consisted of excised shoots of the last growth season, or of one or two-year-old peach plants (*Prunus persica*). Shoots, 50 cm long with a basal diameter of 6–8 mm, were collected from the orchard in autumn and shortened to 40 cm, by removing the distal portion. They were placed vertically under a polyethylene-covered frame with their bases in moist vermiculite, and held at 6°C.

Table 1. *Daily, maximum and minimum temperature means for the months January and February during the years of outdoor experiments at Bet Dagan, Israel* (9).

Year	Temperature mean, °C		
	daily	max.	min.
1964	11.60	16.85	6.40
1965	12.50	17.95	7.05
1966	13.05	19.45	6.65
1967	11.65	17.10	6.25

Humidity was kept high during the cold period. With whole plants, one- and two-year old grafted saplings were used. One-year-old plants were taken from the nursery in autumn and transferred to 20 l tin containers. Two-year-old plants were grown during the second season in the containers after they had been severely pruned in spring. For the indoor experiment, only one-year-old plants were used, while for the outdoor experiment both ages were used. Indoors, in the constant temperature rooms, chilling was maintained at 6°C. Light was supplied by cool white fluorescent tubes at an intensity of about 700 lux at the average height of the plants. Excised shoots were kept under continuous light, where as potted plants were subjected to an 8-hour photoperiod. After the chilling period both shoots and whole plants were forced at 23°C under a 16-hour photoperiod, the former with their bases newly cut and submerged in water.

Outdoor conditions were those of Bet Dagan (Israel) at 32°N with a minimum day length of 10 hours, reaching 11.5 hours by the end of February. Mean temperature values for the winter months during the four years of the experiment are presented in Table 1. The winter of 1963–64 and 1966–67 were colder than the other two, as is emphasized by the relatively low mean minimum and daily temperatures, resulting in a better bud opening in these years.

Darkness was achieved by means of a black cloth-covered construction which allowed less than 1 lux to penetrate. Heavy shade was achieved by jute cloth cover. All treatments were protected by a shed against direct sun irradiation in order to avoid heating but for the 1964 season, when the control was left unprotected. Incident radiation as measured by a Kipp & Zonen Solarimeter, type CM 2, on a clear day (April 17), was in erg. cm^{-2} s^{-1} units: 69.10^4 in the open, 18.10^3 under the overall shade and 19.10^2 under the heavy shade.

Treatments were terminated at the end of February or the beginning of March, at which time all plants were kept under natural light and temperature conditions.

Each treatment was performed on 12 shoots or six whole plants. Results are reported as per cent of buds which opened. Statistical significance was expressed as LSD.

Results

The effect of light during the chilling period was first tested with one-year-old Elberta shoots collected on Jan. 17, 1963 and chilled additionally for 26 days. Leaf bud burst after 18 forcing days was determined. On the light-chilled shoots 30.7 per cent of the buds opened while on the dark-chilled

Table 2. *The effect of dark and light preconditioning on lateral and terminal leaf bud opening on one-year-old Redhaven plants.* — Chilling period: 50 days at 6°C; forcing period: 19 days at 23°C.

Bud type	% of open buds after chilling in		
	dark	light	LSD $P = 0.05$
lateral	57.5	42.4	10.1
terminal	99.0	95.2	N.S.

shoots bud burst reached 65.5 per cent. This difference was significant at the $P = 0.01$ level (LSD 20.9). The chilling in the dark considerably increased leaf bud opening as compared to that in the light.

In order to examine this effect on intact plants, one-year-old potted Redhaven plants were placed on January 6 in conditions similar to the above, but light was given in an 8-hour photoperiod. After 50 days the plants were transferred to forcing conditions. The per cent of terminal and lateral bud opening after 19 forcing days is shown in Table 2. The intact plants reacted to light similarly to what was shown for the excised shoots. Leaf bud opening was better after chilling in the dark. Even with the terminal buds, where bud burst was close to 100 per cent, darkness had a slight advantage in promoting bud opening.

This effect of darkness during chilling was tested outdoors as compared with local conditions over a three-year period. One-year-old Elberta plants were used in 1964, two-year-old ones in 1965, and one-year-old Redhaven plants in 1966. The opening of the leaf buds after dark and natural day light preconditioning is shown in Table 3. With both varieties, ages and bud types, bud opening was markedly better when dark-preconditioned. The effect of darkness was particularly marked when only a small portion of the buds had opened under natural light conditions.

The question arose as to what would be the effect of reducing light intensity and duration, as compared to total darkness, and whether this factor

Table 3. *The effect of winter darkening on leaf bud opening on peach plants.* — Darkening period: Jan. 29—Mar. 2, 1964; Feb. 8—Mar. 7, 1965; Jan. 3—Feb. 27, 1966; recorded on Apr. 7, 1964; Apr. 17, 1965; May 15, 1966 resp. L = lateral; T = terminal.

Season	Peach variety	Bud type	% of open buds after winter preconditioning in		
			natural day light	dark	LSD $P = 0.05$
1964	Elberta	L	14.0	52.8	15.1
		T	2.0	36.1	8.5
1965	Elberta	L	12.0	21.4	14.3
		T	10.7	41.9	29.9
1966	Redhaven ..	L	6.3	19.3	12.1
		T	65.0	87.0	24.0

Table 4. *The effect of different light conditions on leaf bud opening of the Redhaven peach.* — Period of light treatments, Jan. 2—Feb. 26, 1967.

Light treatment	Total daily incident radiation 10^7 erg cm^{-2}	% of open buds after winter preconditioning			
		Laterals		Terminals	
		April 10	April 16	April 10	April 16
Darkness	0	36.4	54.5	78.5	97.7
Heavy shade	7.1–7.8	45.3	65.7	79.3	95.8
1 hour daily	2.0	26.9	58.8	65.8	94.3
4 hours „	7.9	31.5	56.4	42.8	61.0
10 1/2—11 1/2 hours daily (natural)	69.0–76.0	14.7	43.2	0	46.0
LSD (P = 0.05)	—	27.2	23.1	26.5	28.0

is of a photoperiodic nature. Two-year-old Redhaven plants were subjected to 0, 1 and 4 hours of daily illumination as compared with full natural day light, and under reduced intensity. The different light conditions were imposed during the period from January to February 26, when all plants remained under natural light conditions under light shade. The amount of bud opening is shown in Table 4.

The effect of limited light conditions was more pronounced with terminal than with lateral buds, with which most differences were not significant, although a distinct trend developed, parallel to the significant differences in terminal bud opening. All treatments increased bud opening over natural light conditions. Heavy shade with a light intensity of approximately 1/10th of daylight caused the largest amount of bud opening, which was similar to that in the dark treatment. The four-hour daily illumination caused a significantly lower terminal bud opening than the other treatments with limited light.

Discussion

In our previous paper (5) we showed the effect of light on peach bud opening when it was supplied shortly before sprouting. In this paper we show a different effect of light when applied during main rest. As against the photoperiodic nature of pre-emergence illumination, the negative mid-rest light effect on bud opening proved to be of a quantitative nature. A similar behavior toward light was reported by Posner and Hillman (12) in the case of the germination of seeds of *Lemna perpusilla* 6746 which germinated only in light; nevertheless, a dark pre-treatment was found to enhance germination considerably.

We have shown that a quantitative decrease in light during mid-rest increased the subsequent opening of vegetative buds of the peach. This would seem to explain the observations by horticulturists (3, 15) that shade, cloudiness and fog improved the breaking of dormancy. Chandler (3) and others (4, 14, 15) have related this effect to temperature exclusively, but it may very well be due to the reduction of light, or both factors acting simultaneously.

Furthermore, it is of interest that enhancing effects of both reduced illumination in winter and of long-day conditions during the pre-bud burst stage in spring, correspond to the light conditions prevailing in high latitudes. There the tree is exposed to short days with reduced light intensity during winter and to long days in spring, especially, as sprouting is delayed by low spring temperature. Our results provide experimental proof for the observation of Bennett (1) who suggested that "... light may have in winter a retarding influence and become a stimulating factor in spring and summer ...".

Thus it is postulated that during main rest the dormant tree is affected by changes in light duration and intensity in addition to and apart from temperature. The mechanism of the effect of limitation of light during the chilling period on bud opening, might be explained hypothetically on a promoter-inhibitor basis: the decrease of inhibitors, as well as the increase of promoters.

The role of photo-oxidation in auxin destruction has been demonstrated by Galston and Hand (6). Gibberellin A-5 was found to be more active in etiolated than in illuminated pea tissue (7). Since, in the dormant bud both, auxin (2) and gibberellin (11) are believed to control the resuming of growth, it is suggested that higher activity of these growth regulators might be one of the results of reduced light exposure.

This work was supported by grant No. FG-Is-105 of the United States Department of Agriculture, for project No. A10-CR-8.

Contribution from The Volcani Institute of Agricultural Research (National and University Inst. Agric.), Bet Dagan, Israel. 1967 series, No. 1229-E.

References

1. Bennett, J. P.: Temperature and bud rest period. Effect of temperature and exposure on the rest period of deciduous plant leaf buds investigated. — Calif. Agr. 4: 11, 13, 15, 16. 1950.
2. Blommaert, K. L. J.: The significance of auxins and growth inhibiting substances in relation to winter dormancy in the peach tree. — Bull. S. Afr. J. Agric. Sci. No. 268. 1955.
3. Chandler, W. H.: Deciduous Orchards. — Lea & Febiger, Philadelphia. 1942.
4. — & Brown, D. S.: Deciduous orchards in California winters. — Circ. Calif. Agric. Ext. Serv. No. 179. 1951.
5. Erez, A. Samish, R. M. & Lavee, S.: The role of light in leaf and flower bud break of the peach (Prunus persica). — Physiol. Plant. 19: 650–659. 1966.
6. Galston, A. W. & Hand, M. E.: Studies on the physiology of light action. I. Auxin and the light inhibition of growth. — Am. J. Bot. 36: 85–94. 1949.
7. Kende, H. & Lang, A.: Gibberellins and light inhibition of stem growth in peas. — Plant Physiol. 39: 435–440. 1964.
8. Kramer, P. J.: Effect of variation in length of day on growth and dormancy of trees. — *Ibid.* 11: 127–138. 1936.
9. Monthly Weather Report: Israel Meteorological Service. Series b/W. January–February 1964–1967.
10. Olmsted, C. E.: Experiments on photoperiodism, dormancy, leaf age and abscission in sugar maple. — Bot. Gaz. 112: 365–393. 1951.
11. Philips, I. D. J.: Some interaction of gibberellic acid with naringenin (5,7,4′-trihydroxyflavanone) in the control of dormancy and growth. — J. Exp. Bot. 13: 213–226. 1962.

12. Posner, H. B. & Hillman, W. S.: Aseptical production, collection and germination of seeds of Lemna perpusilla. — Physiol. Plant. 15: 700–708. 1962.
13. Wareing, P. F.: Growth studies in woody species. Photoperiodism in dormant buds of Fagus sylvatica L. — *Ibid.* 6: 692–706. 1953.
14. Weinberger, J. H.: Effect of high temperature during the breaking of the rest of Sullivan Elberta peach buds. — Proc. Am. Soc. Hort. Sci. 63: 157–162. 1954.
15. Weldon, G. P.: Fifteen years study of delayed foliation of deciduous fruit trees in Southern California. — Monthly Bull. Calif. Dept. Agric. 23: 160–181. 1934.