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# Effect of Photoperiod on Endogenous Abscisic Acid in *Malus* and *Betula*<sup>1</sup>

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**Abstract.** Seedlings of *Malus hupehensis* Rehd., *M. domestica* Borkh. cv. Northern Spy and *Betula papyrifera* Marsh were grown under short and long photoperiods, with other environmental conditions being similar. *M. hupehensis* seedlings stopped elongation under short days (SD) and continued growth under long days (LD). There was no significant difference in abscisic acid (ABA) content in shoot tips taken from seedlings under either photoperiod. 'Northern Spy' seedlings ceased growth under SD, but neither did they grow vigorously under LD. Shoot tips of these seedlings were not significantly higher in ABA content when grown under SD. *Betula* seedlings discontinued elongation under short photoperiods, while LD promoted growth. *Betula* shoot tips from LD seedlings had more ABA than from seedlings grown under SD. These data do not support the hypothesis that SD causes cessation of shoot elongation by inducing a build up of ABA.

Abscisic acid originally came to be discovered because of its effect on abscission (5) and shoot development (1). In the latter role an inhibitor, later thought to be ABA, seemed to increase in shoot tips of *Acer pseudo-platanus* during SD and was suggested as being responsible for cessation of shoot elongation and formation of terminal buds under SD (2). More recently this theory has been questioned (3, 6, 7, 10). In this study we have examined changes in ABA in shoot tips of 2 *Malus* species, and *Betula papyrifera* growing under LD and SD.

**Plant material.** Seeds of *Malus hupehensis*, 'Northern Spy' apple and *Betula papyrifera* were planted in flats of Peatlite artificial soil mix and placed in growth chambers. Day/night photoperiods and temp were 16 hr (24°C) and 8 hr (18°C) respectively. Light intensity was about 250  $\mu$  einsteins/ $M^2$ /sec at plant level, and was provided by a mixture of fluorescent and incandescent lamps. The 2-months-old seedlings were divided into 2 groups and placed in LD and SD environments. Both groups received only 8 hr of

photosynthetic light daily, LD being obtained in 1 group by use of low intensity incandescent lamps during the second 8-hr photoperiod. At 0, 2, 8, 15 and 22 days after placing seedlings under LD and SD, 3 replications of 3 seedlings, each, were collected of each species. Shoot lengths, numbers of internodes, and fresh and dry (lyophilized) wt were recorded. Shoot tips (partially expanded and non-expanded leaves, apex, and associated

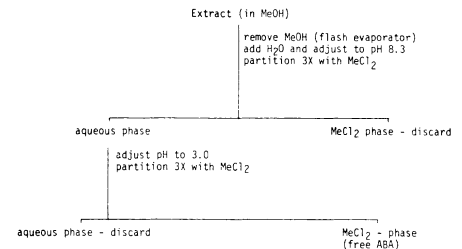


Fig. 1. Fractionation procedure for ABA. Equal volumes of each phase were used in partitions.

stem tissue) were analyzed for ABA.

**ABA analysis.** ABA was extracted by homogenizing the tissue in cold 80% methyl alcohol (MeOH), then centrifuging to separate particulate matter from the supernatant liquid. The pellet was resuspended and twice more extracted in a similar manner. The combined extracts were fractionated according to the scheme in Fig. 1. The methylene chloride (MeCl<sub>2</sub>) fraction containing the free ABA was analyzed by GLC (8, 9) employing 1% GE XE-60 liquid phase on Varaport 30, 100/120 mesh support, in a 4 mm x 2 meter glass column at 180°C.

**Malus hupehensis.** Shoots of this species stopped elongation under SD photoperiods and produced fewer internodes (Table 1). There was no signi-

Table 1. Effect of LD and SD on number of nodes and shoot length of seedlings of *Malus hupehensis*, 'Northern Spy', and *Betula papyrifera*.

Species	Collection day	No. nodes		Shoot length, cm	
		SD	LD	SD	LD
<i>Malus hupehensis</i>	0	14.6 ± 0.5 <sup>z</sup>	14.6 ± 0.5	23.2 ± 0.9	23.2 ± 0.9
	2	14.1 ± 0.2	15.3 ± 0.4	19.0 ± 0.7	24.8 ± 1.3
	8	16.4 ± 0.4	17.2 ± 0.5	17.7 ± 0.7	27.8 ± 1.4
	15	17.0 ± 0.8	22.1 ± 0.5	18.4 ± 1.2	33.1 ± 1.6
	22	18.2 ± 0.7	22.6 ± 0.8	16.9 ± 1.2	35.6 ± 2.2
Northern Spy	0	11.7 ± 0.3	11.7 ± 0.3	19.3 ± 0.5	19.3 ± 0.5
	2	13.1 ± 0.5	12.8 ± 0.4	20.3 ± 0.8	22.5 ± 1.3
	8	14.7 ± 0.6	15.2 ± 0.3	21.3 ± 1.6	29.3 ± 1.5
	15	16.6 ± 0.5	16.3 ± 0.5	22.2 ± 1.4	23.7 ± 1.4
	22	17.8 ± 0.7	16.6 ± 0.5	21.7 ± 1.2	24.2 ± 1.3
<i>Betula papyrifera</i>	0	5.3 ± 0.3	5.3 ± 0.3	7.5 ± 0.6	7.5 ± 0.6
	2	5.6 ± 0.2	5.1 ± 0.3	8.5 ± 0.5	11.0 ± 0.7
	8	8.6 ± 0.3	7.3 ± 0.3	13.0 ± 0.8	15.9 ± 1.0
	15	10.6 ± 0.3	10.1 ± 0.3	12.4 ± 0.8	15.2 ± 1.3
	22	9.9 ± 0.6	9.6 ± 0.5	12.9 ± 0.8	20.5 ± 1.6

<sup>z</sup>SE follows each mean.

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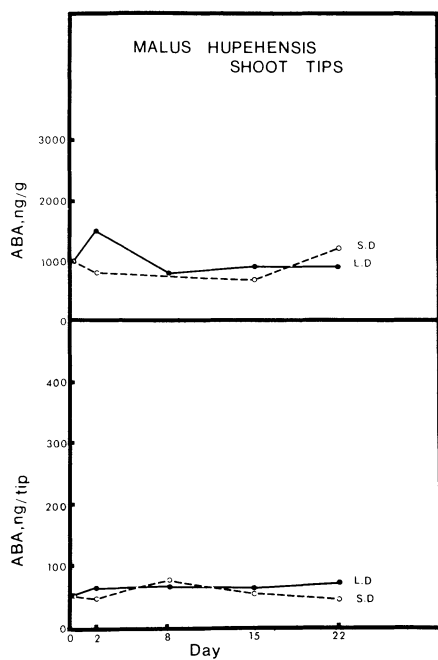


Fig. 2. ABA content of shoot tips of *M. hupehensis* exposed to SD and LD photoperiods.

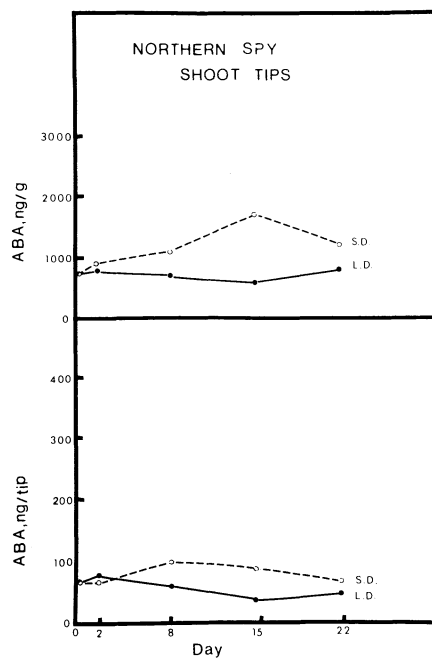


Fig. 3. ABA content of shoot tips of 'Northern Spy' exposed to SD and LD photoperiods.

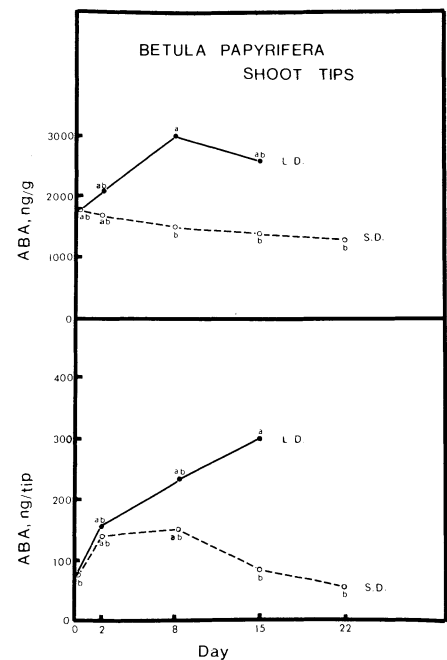


Fig. 4. ABA content of shoot tips of *Betula papyrifera* exposed to SD and LD photoperiods. Means followed by the same letter are not significantly different at 5% level (HSD test).

ficant difference in ABA content in shoot tips of plants grown under the 2 light regimes (Fig. 2).

'Northern Spy'. These seedlings ceased growth under SD, but neither did they grow vigorously under LD (Table 1). Internode numbers were equal in the 2 light regimes. Photoperiod length had no effect on ABA content in shoot tips (Fig. 3).

*Betula papyrifera*. *Betula* shoots continued elongation under LD but ceased growth under SD treatment (Table 1). The no. of internodes was equal in SD and LD but internode length was greater in LD treated shoots. Shoot tips from LD plants collected on day 15 contained more ABA than shoot tips collected on days 15 and 22 from seedlings grown under SD treatment (Fig. 4).

Our results are in agreement with those of others who report that SD do not lead to increased amounts of ABA in shoots (3, 10, 11). The results argue against the theory (2) that SD induce cessation of shoot elongation by causing ABA accumulation. In fact, just the opposite occurred in *Betula*, where more ABA was found in LD shoots.

Others have also reported higher ABA content under LD (3, 10, 11).

Not only does it appear that ABA content is not regulated by photoperiod, but it is questionable whether ABA plays a primary role in control of shoot elongation. Exogenous applications of ABA to intact plants are not always effective in inhibiting shoot growth (4, 6), and the fact that the highest ABA concn has been reported in the actively growing shoot tip itself (3, 7, 10), casts doubt on a major role for this substance in shoot elongation.

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