Ann. Sci. For. (1989) 46 suppl., 228s-232s
Forest Tree Physiology, E. Dreyer *et al.*, eds.

The role of photoperiod and temperature in the induction and the release of dormancy in *Pinus sylvestris* L. seedlings

I. Dormling

Swedish University of Agricultural Sciences, Department of Forest Genetics, Stockholm, Sweden

Introduction

Scots pine (*Pinus sylvestris* L.) seedlings exhibit optimal development during their first growth period if given 25–20°C during the daytime and 15–10°C nighttime temperature. Optimal night length is 6–8 h, depending upon latitude of origin, 67–57°N. Longer as well as shorter nights bring about early bud set. Buds are formed sooner or later under all growing conditions (Dormling, 1975). The buds formed during short nights are not stable, however. Several flushes may occur if the night length is not prolonged.

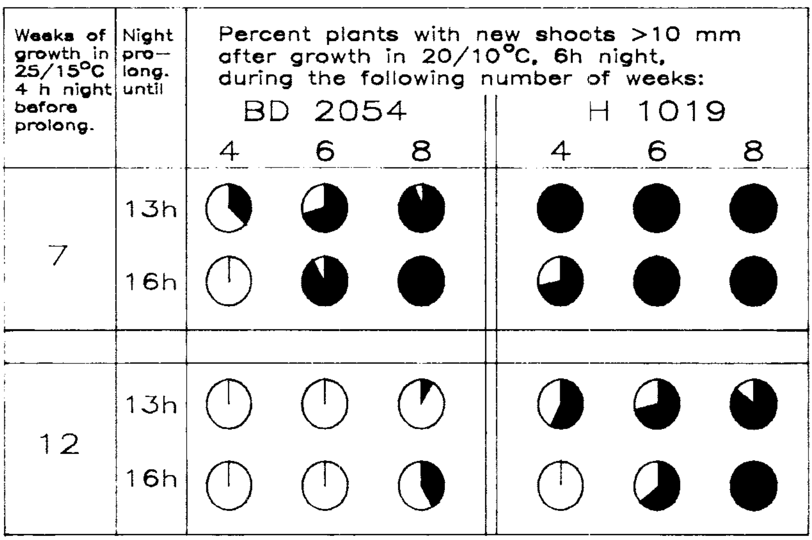

Fig. 1. BD 2064, 67°45'N, and H 1019, 57°25'N. Flushing rate in 2nd growth period. Night prolongation 1 h/wk in 25/5°C started at plant age 7 and 12 wk and stopped after the wk with 13 and 16 h, respectively. n = 16.

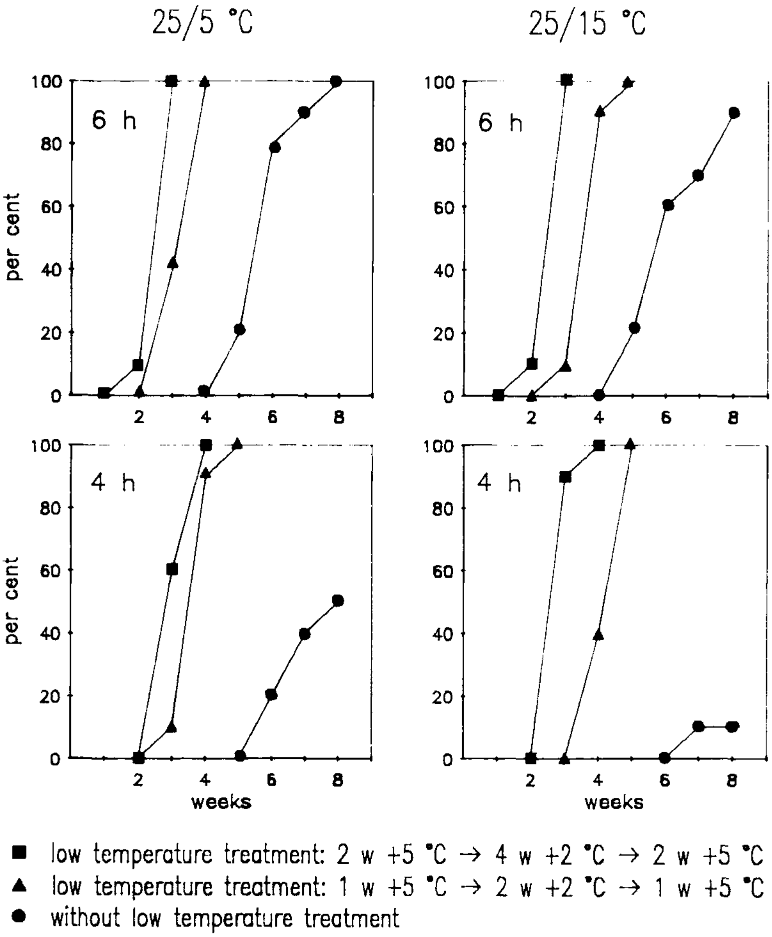

Fig. 2. W 4107, 60°41'N. Flushing rate in 2nd growth period. Plants raised in 25/15°C with 6 and 4 h nights. Night prolongation in 25/5°C and 25/15°C. Dormancy breaking treatment at 8, 4 and 0 wk. *n* = 10.

There are indications that Scots pine buds do not overwinter in a stage of true dormancy (Dormling *et al.*, 1977; Kupila-Ahvenniemi, 1985). Seedlings exposed to long nights for 4–7 wk produce buds that flush readily after exposure to growing conditions. More than 20 cycles with long nights completely change the growth habit from the juvenile stage with primary needles to the stage with needle fascicles = secondary needles (Dormling *et al.*, 1977; Dormling, 1986). The normal winter dormancy of Scots pine, however, includes a rest phase which is broken by exposure to cold (Romberger, 1963). The necessity to fulfill the chilling requirement to break winter dormancy in Scots pine has been stressed (*e.g.*, Wareing, 1951; Vegis, 1965; Sarvas, 1974).

In the following, I will use the working definition of dormancy proposed by Lang (1987): "Dormancy is the temporary sus-

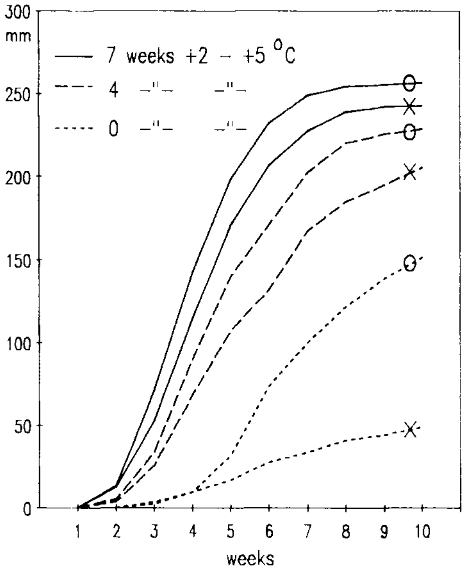

Fig. 3. H 1019, 57°25'N. Height development in 2nd growth period in 20/10°C with 18/6 h day/night. First growth period: 13 wk in 25/15°C in 16/8 h day/night, night prolongation 1 h/wk until 16 h night with day/night temperature in 8/16 h of —o— 25/5°C, —x— 25/15°C. Low temperature treatment at 7, 4 and 0 wk. *n* = 10.

pension of visible growth of any plant structure containing a meristem." True dormancy, *i.e.*, a stage in which growth is not possible even under the most favorable conditions, may not exist (Vegis, 1965). For that reason, deep dormancy will be used as the definition of the most dormant stage obtained. There are no strict borderlines to phases before and after deep dormancy. Early and late phases of dormancy are characterized as quiescence: dormancy imposed by the external environment (Romberger, 1963).

Materials and Methods

Seedlings of Scots pine of different Swedish origins were raised in the Stockholm Phytotron. Day temperature was 25°C, night temperature 15°C, night length as indicated in the figure legends. Night prolongation with 1 h per wk in different temperature regimes was used as a dormancy inducing treatment. Seedlings were grown in pots with mineral wool as a substrate and watered daily with a low concentration nutrient solution: 2L 6513, 100 mg N/l (Ingestad, 1979). Light was provided by Osram HQI lamps, irradiance *ca* 80 $W \cdot m^{-2}$ (400–700 nm) at plant level. The air humidity was 75% RH.

Results and Discussion

Fig. 1 illustrates that seedling age at the start of night prolongation, 7 or 12 wk, played an important role in the possibility of the buds to attain a deeper stage of dormancy. Only the 12 wk old plants of northern origin had no flushing buds after 6 wk under growing conditions. These seedlings had their most dormant buds after 13 h nights. They lost some dormancy during the further prolongation to 16 h.

Short night length, 4 h, during growth made the seedlings more dormant after night prolongation for more than the 6 h night – the optimal one for height growth (Fig. 2). The same was true for the higher temperature 25/15°C compared with 25/5°C. Dormancy breaking treatments of 8 and 4 wk had a dramatic influence, hastening the flushing rate, especially in the plants with lowest degree of dormancy. In Fig. 3 the same reactions to temperature and break of dormancy are illustrated by height increment curves for seedlings of southern origin.

Seedlings which had relatively short nights, 6 h, during the first growth period produced in the 2nd period stems with long distances between the needle fascicles = long stem units (Fig. 4). The 8 h seedlings had a denser appearance. Independent of the initial night length, plants given the longest dormancy breaking treatment had the longest shoots in the 2nd growth period. This was not accompanied by longer stem units, however. Instead the plants formed more stem units.

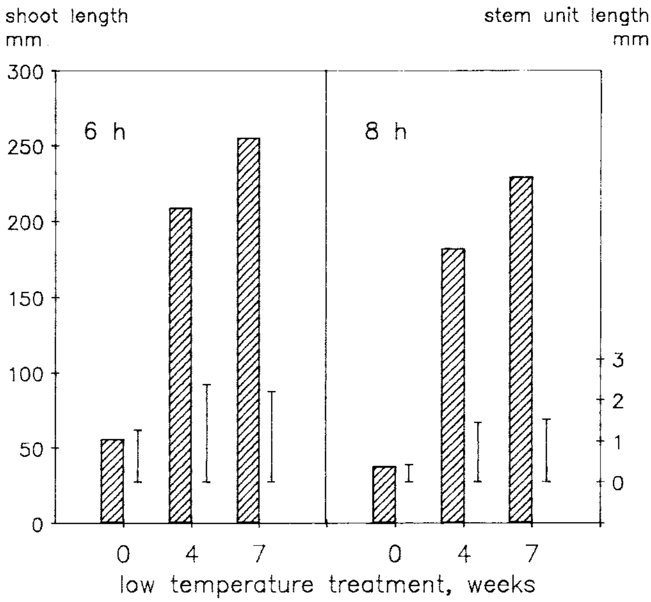

Fig. 4. W 4009, 61°19'N. Height increment and stem unit length after 10 wk in 2nd growth period as in Fig. 3. Plants raised in 25/15°C with 6 and 8 h nights. Night prolongation 1 h/wk until 16 h. Break of dormancy in 0, 4 and 7 wk $n = 10$.

Conclusions

All conditions provided during seedling development may influence its later degree of bud dormancy. Deepest dormancy is reached after a long growth period with short night followed by night prolongation with high temperature. Low temperature, +2 to +5°C, is effective in breaking dormancy of any stage. The deeper the dormancy, the longer the time needed for a complete break.

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