

Contribution to the Knowledge of the Ecology of Growth Termination in Spruce Seedlings of Norwegian and Central-European Provenances

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Introduction

It is well known that daylength and temperature are among the most important factors controlling the yearly alternation of active growth and dormancy in trees. Numerous experiments have established the fact that most trees of a northern climate respond to long days with prolonged growth, and to short days with early termination of growth and entrance of dormancy. Tests also indicate that the time of growth-cessation is greatly influenced by temperature, but information on this effect is rather vague.

In an attempt to learn more about the influence of temperature upon growth termination, and its importance in this matter compared to that of photoperiod, experiments with seedlings of Norway spruce were started at The Forest Research Institute of West Norway. This paper is a preliminary account of such an experiment. A more detailed report will be published by STEIN MAGNESEN*).

Methods

The test material consisted of six provenances of Norway spruce (*Picea abies* [L.]). Of these, five were of Central European origin (Lat. 47°–49° N), and the sixth of West Norwegian (Lat. 60° N), the latter thus representing local seed source. Seeds were sown in soil-filled pots, and kept in growth chambers for nearly six months. Owing to uneven germination, there were mostly 40–100 seedlings pr. provenance pr. treatment.

In most photoperiodic tests, at least the laboratory tests, daylength and temperature have been kept constant throughout the period of testing. An exception was the nursery experiments by ROBAK (1962), in which seedlings were grown under natural temperature conditions, and the artificial daylength varied through the growth season. However, in the experiment described in this paper, both temperature and daylength were made subject to con-

trolled variation during the entire time of testing, imitating natural conditions. In cooperation with the firm Termaks, Bergen, the Research Institute had developed an apparatus in which conditions of temperature and light could be controlled in sufficient accordance with our wishes.

The artificial light source in each chamber was made up from 8 white fluorescent tubes and one 15-W incandescent bulb. This arrangement provided a light intensity of about 5500 lux during the whole photoperiod. As it is known that plants respond photoperiodically to light of low intensity, daylength was defined as the time between sunrise and sunset, with addition of civil twilight. The lights were programmed by means of time clocks. These were readjusted every five days, approximately imitating the natural daylength conditions existing at 48° N and 60° N. The latitudes were chosen for being where the seeds originated.

The seedlings were simultaneously grown under two different temperature conditions, representing a warm and a cool growth season in West Norway. Temperature data were actually taken from thermograph records, dating from 1955 and 1962. To maintain the desired temperatures in the growth chambers, these are fitted with cam-operated temperature controllers. The instruments allow temperature to be varied continuously throughout the day. However, the daily program will automatically repeat itself, and in an effort to imitate natural conditions the process cams were also changed every five days during the experiment. In this way temperature varied in the course of the day, and through the growth season as well. The two photoperiod programmes and the two temperature programmes were combined to make four different treatments.

In West-Norwegian nurseries seeds are usually sown in May. Consequently, the treatments imitated temperature and daylight conditions existing during a period of the year starting with May and ending with November.

*) Publ. Meddel. Vestl. Forstl. Forsøksst. No. 48, 1969.

Table 1. — Length of time, in days, between sowing and appearance of the first terminal buds. Results from tests with different light intensities are compared. The provenances are: No. 00/47 Lankowitz, Austria, lat. 47° N, alt. 500 m. No. 00/48 Sassellen-Bartholomäberg, Austria, lat. 47° N, alt. 1250–1400 m. No. 00/78 Bayerischer Wald, Germany, lat. 49° N, alt. below 1100 m. No. 00/79 Zwiesel-Ost, B.W. Germany, lat. 49° N, alt. above 1100 m. No. 33 Toplita, Rumania, lat. 47° N, alt. 800–900 m. No. A-1283 Voss, West Norway, lat. 60° N, alt. 200 m.

Treatments		Provenances												
Growthseason imitated	Daylength at	00/47		33		00/48		00/78		00/79		A-1283		
		3500 lux	5500 lux	3500 lux	5500 lux	3500 lux	5500 lux	3500 lux	5500 lux	3500 lux	5500 lux	3500 lux	5500 lux	
1955 (warm)	60° N	120	140	95	130	95	130	95	130	95	105	90	100	
	48° N	95	105	95	100	65	70	65	70	65	65	65	65	
1962 (cool)	60° N	170	155	135	155	100	155	125	155	100	105	95	70	
	48° N	125	80	105	75	65	70	65	70	65	65	65	65	
Differente between long-day and short-day treatment.		1955	25	35	0	30	30	60	30	60	30	40	25	35
		1962	45	75	30	80	35	85	60	85	35	40	30	5

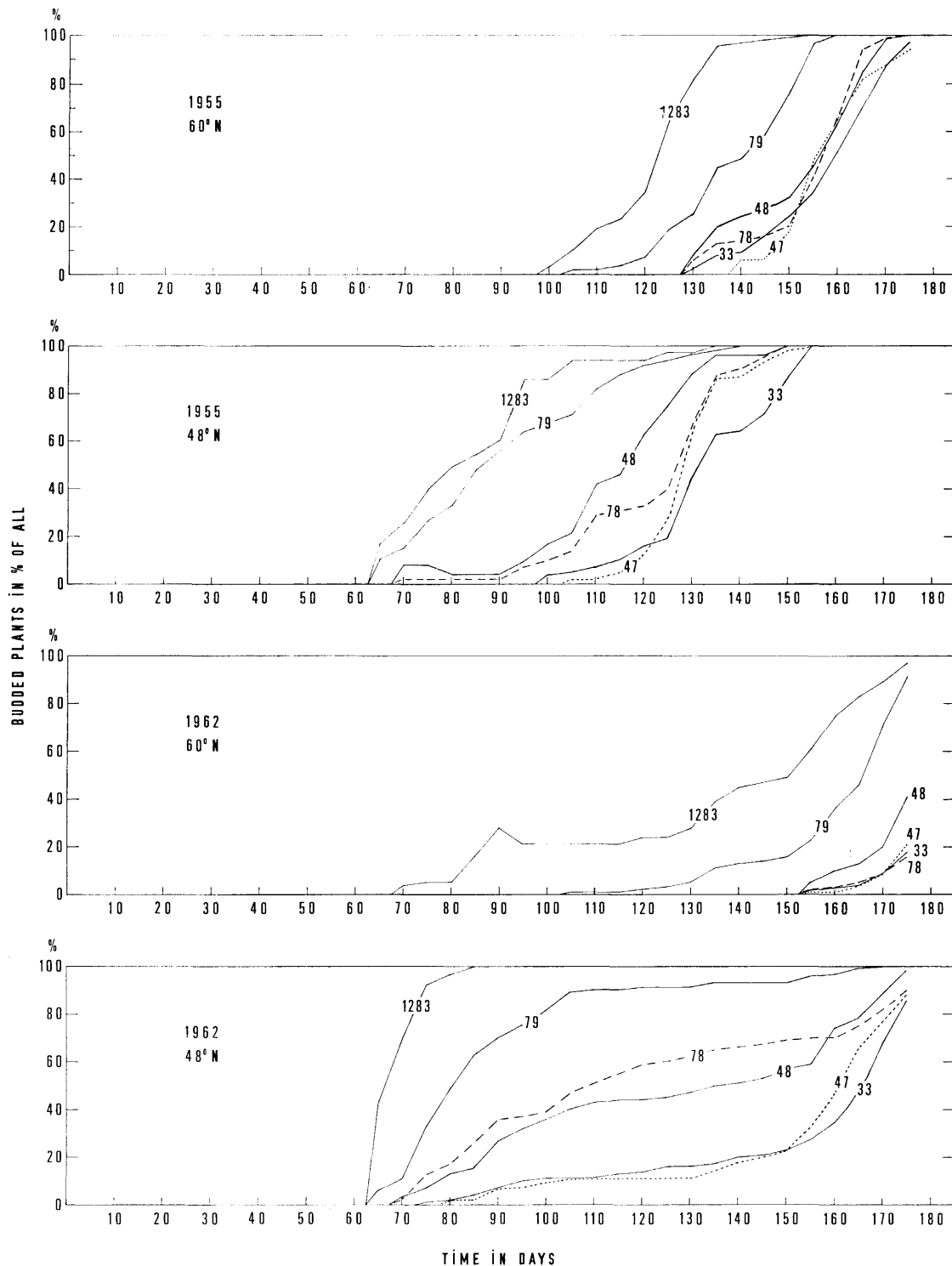


Fig. 1. — Formation of terminal buds in seedlings grown under different treatments. The growth season 1955 is warm, and 1962 cool. Daylengths correspond to 48° N and 60° N.

Unfortunately the equipment did not allow humidity to be controlled, but soil in pots was kept moist continuously through frequent sprinkling with tap water.

Results

As in nursery experiments by ROBAK, seedlings exhibiting visible terminal buds and distended apical needles were considered to have finished their growth for the present season. This criterion has been found to be valid when comparing provenances and treatments. The num-

ber of seedlings having visible terminal buds were registered every five days, and expressed in per cent of the total number of seedlings, at the time in question. The results for all provenances and treatments are given in fig. 1. It is obvious that a reduction of photoperiod, corresponding to the difference between the natural daylength of South Norway and Central Europe, has accelerated growth termination considerably. The main result is that all provenances have started to form terminal buds earlier under short-day conditions than under long-day treatment, regardless of temperature. However, the percentage

of seedlings having visible terminal buds increases most rapidly under conditions imitating a warm growth season. As a matter of fact, the percentage has reached 100% simultaneously for both short-day and long-day grown seedlings, when the latter have had more favourable temperature conditions than the former. All the same, different provenances did not show an equally strong response to temperature, but these relations will not be discussed in this paper.

On the other hand, the authors would like to point out the obvious difference between seedlings from Norway and Central Europe. Under every treatment used in this experiment, the West-Norwegian seedlings ceased elongating and formed terminal buds earlier than any Central-European provenance. The result confirms the theory of photoperiodic ecotypes in trees.

In table 1 is given the number of days during which growth occurred, or to be more exact, the length of time between sowing and appearance of the first terminal buds.

Data from the present experiment are in this table compared with similar data from an earlier test, in which the light intensity was considerably lower (3500 lux). Apart from the difference in the intensity of illumination, the two experiments were exactly alike. The results presented in table 1 show that increased light intensity, i. e. a step towards more natural conditions, has augmented the difference between the results of long-day and short-day treatments. This may indicate that photoperiod is of fundamental importance among climatical factors inducing dormancy in spruce seedlings, also under natural conditions.

Reference

ROBAK, H.: Nye planteskoleforsök over sambandet mellom sommerdaglengden og avslutningen av første års vekst hos gran og douglas. (New Nursery Experiments Regarding the Connection between Summer Day Length and Termination of Growth in Seedlings of Norway Spruce and Douglas Fir in their first Growth Year.) Meddel. Vestl. forstl. forsøksst. No. 36, 1962, (B. 11, 199-246)

Versuche zur Blühförderung von Waldbäumen

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Die wichtigsten Waldbäume unserer Breiten pflegen nur in mehr oder weniger großen Zeitabständen zu blühen oder gar zu fruchten. Da es jedoch in mancher Hinsicht erwünscht wäre, wenn sie das nicht nur häufiger und regelmäßiger, sondern auch reichlicher tun würden, sind seit geraumer Zeit und immer wieder Versuche unternommen worden, diese Ziele zu erreichen oder sich ihnen wenigstens zu nähern. Fragen nach etwa vorhandenen Möglichkeiten besitzen vor allem auch für Samenplantagen Bedeutung.

Hinsichtlich der zahlreichen, vor allem in weiter zurückliegenden Zeiten in sehr verschiedener Weise durchgeführten Versuche soll nur auf Zusammenstellungen von KLAEHN 1948/49 (3) und LANZ 1969 (5) hingewiesen werden. In neuester Zeit haben u. a. F. BERGMAN 1955 (1), MAYER-KRAPOLL 1959 (6), HEITMÜLLER und MELCHIOR 1960/61 (2, 7) und R. KLEINSCHMIT 1961 (4) über entsprechende, teilweise schon recht erfolgreiche Versuche berichtet.

Dieser Bericht gibt einige Erfahrungen wieder, die zwischen 1949 und 1964 bei Versuchen im Lehrforstamt Bramwald der Forstlichen Fakultät der Universität Göttingen sowie in Eichen- und Buchen-Samenplantagen von Berkel bei Hildesheim und Lüss Bez. Lüneburg gesammelt wurden. Obgleich die Ergebnisse bei weitem noch nicht befriedigen, wird er erstattet, weil dem Verf. die Durchführung derartiger Versuche seit 1966 nicht mehr möglich ist.¹⁾

Die Versuche der Jahre 1949—53 an Eichen, Buchen, Fichten, Kiefern, Weymouthskiefern, Lärchen und Erlen

Die Verfahren

Ringeln und Abschnüren. Im Lehrforstamt Bramwald wurden im April und Mai 1949 je 5 100- bis 120jährige Traubeneichen, Buchen, Fichten, Kiefern, Weymouthskiefern und Lärchen sowie je 5 40- bis 50jährige Buchen, Fichten und Lärchen, in den Monaten Mai bis August 1949

mehrere mittelalte Traubeneichen und Buchen, im Herbst 1950 8 mittelalte Lärchen, ferner in den Jahren 1952/53 zahlreiche 4- bis 6jährige Rot- und Weißerlen geringelt bzw. abgeschnürt.

Das Ringeln wurde etwa in Brusthöhe mit einem 2 cm breiten Reißhaken vorgenommen, erfaßte bis auf zwei, je nach Stammstärke 3 — 6 cm breite unberührte Restflächen an gegenüberliegenden Seiten die Stämme in ihrem ganzen Umfang und drang stets durch Rinde und Bast in die äußeren Holzschichten ein. — Das Abschnüren (Strangulieren) erfolgte nach Entfernung der Borke mit 1 — 2 mm starken Stahldrähten ebenfalls etwa in Brusthöhe. An mehreren Eichen und Buchen beschränkte sich das Ringeln bzw. Abschnüren auf einige Äste.

Mulchen. Im Frühjahr 1949 sind die Stammfüße zahlreicher über 100jähriger Traubeneichen, Fichten, und Lärchen im Bramwald etwa 50 cm hoch und 3 — 4 m breit mit trockenem Adlerfarn, Gras u. a. bedeckt worden.

Düngung. In den Jahren 1949 und 1950 ist auf Pseudogleyböden des Bramwaldes eine größere Zahl über 100jähriger Traubeneichen, Buchen, Fichten, Kiefern und Lärchen nach Beseitigung des Bodenüberzuges in den Wurzelbereichen mit je 20,0 kg Branntkalk, 5,0 kg Thomasmehl, 4,5 kg schwefelsaurem Amoniak und 6 kg Patentkali gedüngt worden.

Die Ergebnisse

Neben dem Blühen und Fruchten ist das gesamte Verhalten der in den Jahren 1949 — 53 geringelten, abgeschnürten, gemulchten und gedüngten Bäume der verschiedenen Arten einige Jahre beobachtet worden. Die Auswirkungen wurden nach dem Augenschein ins Verhältnis zu unbehandelten Bäumen auf gleichen Standorten in unmittelbarer Nachbarschaft der behandelten gesetzt.

Ringeln. Die geringelten Eichen ebenso wie geringelte Äste blühten schon im Jahr der Ringelung aber auch noch im folgenden Jahr offensichtlich besser als nicht geringelte, zeigten jedoch eine schlechtere Ausbildung der Blätter.

¹⁾ Sämtliche Aufzeichnungen über die Versuche sind der Abt. C der Niedersächsischen Forstlichen Versuchsanstalt in Escherode bei Hann. Münden übergeben worden.