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Influence of Age on Sylleptic and Proleptic Free Growth of Norway Spruce Seedlings*)

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Abstract

Shoot growth of young Norway spruce (*Picea abies* (L.) KARST.) seedlings and the influence of age on two forms of shoot growth: (1) predetermined growth, in which needle primordia develop in the preceding growth period, overwinter in the bud, and elongate in the following spring, and (2) free growth, where needle primordia develop and elongate in the same growth period, were studied. One, two, and four year old seedlings of one provenance were grown under natural daylength conditions to allow free growth, and under short day conditions to prevent free growth. The results show the following trends: with increasing age increasingly larger parts of the shoot elongate in the form of predetermined growth until eventually all shoot growth develops in the form of predetermined growth on an adult tree. With increasing age free growth also changes. Whereas on one hand free growth starts immediately after the termination of predetermined growth and without setting a bud on very young seedlings of about one to three years of age on the other, it continues after setting a temporary bud on seedlings that are still young, but above the age of about three years. Therefore, free growth which starts immediately after predetermined growth is defined as sylleptic free growth (sylleptos = together), and free growth which starts after a temporary bud has been set, as proleptic free growth.

Key words: *Picea abies*, shoot growth, predetermined growth, sylleptic and proleptic free growth, lammas shoots, morphology of free growth, short day treatment.

Résumé

L'objectif de la présente recherche était d'obtenir de nouvelles connaissances sur la croissance longitudinale de bourgeons de jeunes semis d'épicéa (*Picea abies* (L.) KARST.) et sur l'influence de l'âge des plantes sur celle-ci. A cet effet furent observées:

1. La croissance prédéterminée où l'initiation des aiguilles date de l'année précédente et où l'allongement s'effectue au printemps après l'hivernage des aiguilles en bourgeon.
2. La croissance libre où l'initation des aiguilles et la pousse tombent en une même période de végétation.

Pour des plantes de deux, trois et quatre ans de même provenance, la croissance libre fut obtenue par une durée de jour naturelle et empêchée par une photopériode journalière réduite. Deux tendances de dévelopment furent constatées en fonction de l'âge augmentant des plantes:

1. La part proportionnelle de la croissance prédéterminée contribuant à la longueur finale augmente, de manière qu'après la phase de jeunesse, la pousse principale repose entièrement sur la croissance prédéterminée.
2. La croissance libre succède immédiatement à la phase de croissance prédéterminée pour ce qui est des semis très jeunes, tandis que pour les semis de, à peu près, trois ans et plus, elle ne s'effectue qu'après une interruption de croissance avec une formation de bourgeon passagère.

La croissance libre succédant immédiatement à la croissance prédéterminée est ici qualifié de 'croissance libre sylleptique' (sylleptos = [avec croissance prédéterminée] intégrée) et la croissance libre se produisant après interruption de la croissance en longueur est désignée 'croissance libre proleptique (anticipée [à l'année suivante]).

Zusammenfassung

Mit dem Ziel, das Trieblängenwachstum junger Fichtensämlinge (*Picea abies* (L.) KARST.) und den Einfluß des Alters auf das Trieblängenwachstum zu untersuchen, wurden 1.) das prädeterminierte Wachstum, bei dem die Nadelprimordien im Vorjahr angelegt und nach der Überwinterung in einer Knospe im folgenden Frühjahr gestreckt werden und 2.) das freie Wachstum, bei dem die Nadelprimordien in der gleichen Vegetationsperiode angelegt und gestreckt werden, beobachtet. Ein-, zwei- und vierjährige Pflanzen einer Herkunft wurden bei natürlicher Tageslänge wachsen gelassen, um freies Wachstum zu erlauben, und bei Kurztagsbedingungen, um das freie Wachstum zu verhindern. Mit zunehmendem Alter zeigen sich zwei Entwicklungen: 1.) der Anteil des prädeterminierten Wachstums an der Gesamttrieblänge nimmt zu, so daß der Haupttrieb nach der Jugendphase ausschließlich aus prädeterminiertem Wachstum gebildet wird. 2.) Beim freien Wachstum ist zu beobachten, daß es bei sehr jungen Sämlingen unmittelbar auf das prädeterminierte Wachstum folgt, während es bei etwas älteren Sämlingen im Alter von ca. drei Jahren aufwärts häufig erst nach einer Pause im Trieb-

*) Herrn DR. MELCHIOR zum 60. Geburtstag gewidmet.

längenwachstum gestreckt wird, bei der vorübergehend eine Knospe gebildet wird. Freies Wachstum, das unmittelbar auf das prädeterminierte Wachstum folgt, wird hier als sylleptisches (sylleptos = [mit dem prädeterminierten Wachstum] zusammengefaßt) freies Wachstum bezeichnet, und freies Wachstum, das nach einer Unterbrechung im Trieblängenwachstum gebildet wird, als proleptisches ([dem nächsten Jahr] vorweggenommenes) freies Wachstum.

Introduction

In spruces and firs the basic pattern of shoot growth is predetermined growth, which involves the elongation of stem and needle primordia that are initiated in one growth period, kept overwinter in the bud and elongate in the following spring (Pollard and Logan 1974). In seedlings this pattern is modified and includes also free growth. Within a single growth period it elongates from newly initiated needle and stem primordia after the predetermined growth is completed (Jablanczy 1971, Pollard and Logan 1974, 1976). In both forms of shoot growth differences between provenances have been found (Schmidt-Vogt 1964, Holzer 1967, Pollard and Logan 1974, Cannell and Johnstone 1978). Since during the seedling stage growth of the terminal shoot is frequently used as a criterion for an early selection of seed sources for reforestation, it is important to understand the relationship between the different forms of shoot growth (Logan and Pollard 1978, Cannell *et al.* 1981).

The pattern of shoot growth of trees has been the object of studies since a very long time (Studhalter 1955). Also the ability of young Norway spruce (*Picea abies* (L.) Karst.) trees to produce further growth after predetermined growth has been reported long ago and is referred to in the well-known terms as lammas shoots, Johannistriebe, and others (Späth 1912). In 1890 Berdan (Marcet 1975) postulated that the bud breaking of a summer shoot is the beforehanded elongation of the predetermined growth which was supposed to elongate in the following growth period and thus called these "proleptic shoots" (proleptic = beforehand). In his study on "Johannistriebe" Späth (1912) found that besides proleptic shoots there were also summer shoots which elongated not from a temporary bud, but immediately after the spring shoot. Because of this characteristic he named these sylleptic shoots (syllepsis = together with [the spring shoot]). Holzer (1967) named these "durchgehende Triebe" (continuous shoots). In their original use syllepsis and prolepsis made no distinction between the activity of terminal or lateral buds. Lateron the term prolepsis was used to describe the growth from lateral buds subjacent to the terminal bud as distinct from lammas growth referred to shoots formed from terminal buds (Burger 1926, Rudolph 1964, Aldén 1971, Kozlowski 1971, Hallé *et al.* 1978).

In more recent studies it was found that the termination of spring growth is dependent not on the environment, but on the number of needle and shoot primordia initiated in the previous growing season. Since the finite number of promordia influences the time when elongation of the spring shoots is terminated, it has been named fixed growth (Nienstaedt 1966), determined growth (Hallé *et al.* 1978), or predetermined growth (Pollard and Logan 1974), which is preferred here. In contrast to predetermined growth, syllepsis and prolepsis are not terminated by a certain number of available stem or needle primordia because they can be newly initiated as long as environmental conditions are favourable. In view of this characteristic, Jablanczy (1971) referred to this form of shoot growth as free growth and Borchert (1975) as indeterminate growth.

Environmental conditions can have distinctly different influences on predetermined and free growth. Whereas a short day treatment starting at the time of bud break in spring does not stop predetermined growth before all preformed needle and stem primordia have been elongated, in free growth it immediately stops the elongation of stem and needle primordia as soon as the plants are exposed to the treatment (Dormling *et al.* 1968, von Wühlisch 1984).

Free growth can follow predetermined growth either without interruption or after a pause in shoot elongation during which a temporary bud is set. Free growth in the first form will be called here sylleptic free growth and in the second form proleptic free growth which is a synonym to the more common term lammas growth. Contrary to the above authors who used syllepsis and prolepsis to describe strictly the growth from lateral buds the terms will here be used in their original sense to describe the growth from terminal as well as lateral buds on leading shoots.

In spruce and fir free growth diminshes in about 5 to 10 years after germination (Jablanczy 1971) and free growth was generally absent in 12 year old *Picea mariana* (Pollard *et al.* 1975). Also frequency of lammas shoots decreases with increasing age (Späth 1912, Burger 1926, Leibundgut 1955, Kozlowski 1964, Holzer 1967). This study investigates the pattern of predetermined and free growth and the relationships between them in seedlings of *Picea abies* (L.) Karst. at different ages. A report has already been given on this experiment (von Wühlisch 1984).

Material and Methods

One, two, and four year old Norway spruce seedlings of the provenance "Schwäbische Alb", southern Germany (Herkunftsgebiet 840 13) were obtained from a commercial nursery in April and planted into 5 liter plastic flower pots. A potting mixture of 1 m^3 peat, 200 l Perlite, 100 g Radigen (trace elements) and 1 kg Plantozan (a fertilizer with 20-10-15-5% N-P-K-Mg and trace elements) was used. In early May fourty randomized plots were established in the nursery with each plot consisting of three seedlings, one from each age group. Half of the plots were grown under an eight hour photoperiod (sd) to prevent free growth and to provide an estimate of the predetermined growth within each age group. This was done by covering the plants with sheets of black plastic at 4 o'clock in the afternoon and uncovering them at 8 o'clock in the morning. Seedlings of the other 20 plots were grown under local natural long days (ld) which reach a maximum of about 16.7 hours between sunrise and sunset in June. Thus each variant of the experiment had 20 replicant seedlings.

The initial tree heights were recorded in April (*Table 1*) and terminal shoot lengths to the nearest millimeter were recorded daily from May until August when growth had ceased. Lengths of predetermined and free shoot growth were measured separately only on shoots of seedlings where free growth elongated from a bud, that is, where a distinct boundary between predetermined and free growth was visible on the shoot. Date of bud break was recorded for each seedling as the day when the expanding terminal shoot ruptured the enclosing bud scales. Also the number of days each seedling required to complete shoot elongation was recorded. The needle complement of the terminal shoots was determined after shoot growth had ceased. Seedlings grown under the eight hour photoperiod

Table 1. — Initial plant height, average date of bud-break, and duration of shoot elongation of 1, 2, and 4 year old Norway spruce seedlings.

	Age (years)	Initial plant height (cm)	Date of bud break	Duration of shoot elongation (No. of days)
short day	1	2.8 c	May 8 a	40 d
	2	18.6 b	May 16 b	31 e
	4	34.1 a	May 21 c	32 e
long day	1	2.8 c	May 8 a	98 a
	2	18.6 b	May 16 b	90 b
	4	34.1 a	May 21 c	73 c

Means associated with common letters are not significantly different at $p \leqq 0,05$ according to the least significant differences calculated from variance analysis data.

provided an estimate of predetermined growth. The number of needles resulting from free growth was estimated by subtracting the needle number established under sd from the number established under ld. This procedure was also used to estimate the length of predetermined and free growth. Analyses of variance were calculated to test the differences between age groups and treatments for all characters.

Results

The seedlings did not suffer visibly from a planting shock, also the seedlings growing under sd conditions had a healthy appearance. As expected, the younger seedlings grew significantly less than the older ones and seedlings grown under sd had significantly less shoot elongation than seedlings grown under ld conditions *(Fig. 1, Table 2)*. Seedlings grown under sd showed significantly smaller needle numbers and shorter stem units (distance between needles) than seedlings grown under ld conditions.

Free growth was distinctly different between the 1, 2, and 4 year old seedlings. All of the 1 year old seedlings showed sylleptic free growth, whereas only five of the 2 year old, and six of the 4 year old seedlings showed sylleptic free growth out of the 20 seedlings in each case. Of

Table 2. — Average shoot elongation and number of needles counted on terminal shoots of 1, 2, and 4 year old Norway spruce seedlings.

	Age (years)	sd pg	ld pg +sfg	ld pg +sfg +pfg	Proportion of total shoot growth coming from pg %	sfg %	pfg %	sfg + pfg %
shoot	1	51	141	141	36	64	0	64
length	2	64	87	154	41	15	44	59
(mm)	4	100	147	165	61	28	11	39
needle	1	124	275	275	45	55	0	55
number	2	185	199	323	57	4	39	44
	4	347	394	460	76	10	14	24

Sd = short day, ld = long day, pg = predetermined growth, sfg = sylleptical free growth, pfg = proleptical free growth. By subtracting the measured shoot length and needle number counted on seedlings grown under sd from the measured shoot length and needle number counted on seedlings grown under ld, the free growth proportions were estimated.

the remaining 2 year old seedlings 11 showed proleptic free growth and four elongated their free growth out of poorly developed buds so that it was difficult to ascribe them to either sylleptic or proleptic free growth. On these seedlings the boundary between predetermined and free growth was characterized by shorter stem units and needle-like structures which were broad and stiff in appearence like bud scales but possessed chlorophyll *(Fig. 2, B)*. For purpose of analysis these four seedlings were considered to have produced proleptic free growth. Of the remaining 4 year old seedlings 10 showed proleptic free growth and four showed no free growth at all.

The average shoot length and number of needles resulting from predetermined, sylleptic and proleptic free growth in each age group is shown in *Table 2*. Under sd conditions the difference between age groups in total shoot length and total needle number is much larger than under ld conditions. One year old seedlings had no proleptic free growth and the needle proportion resulting from sylleptic

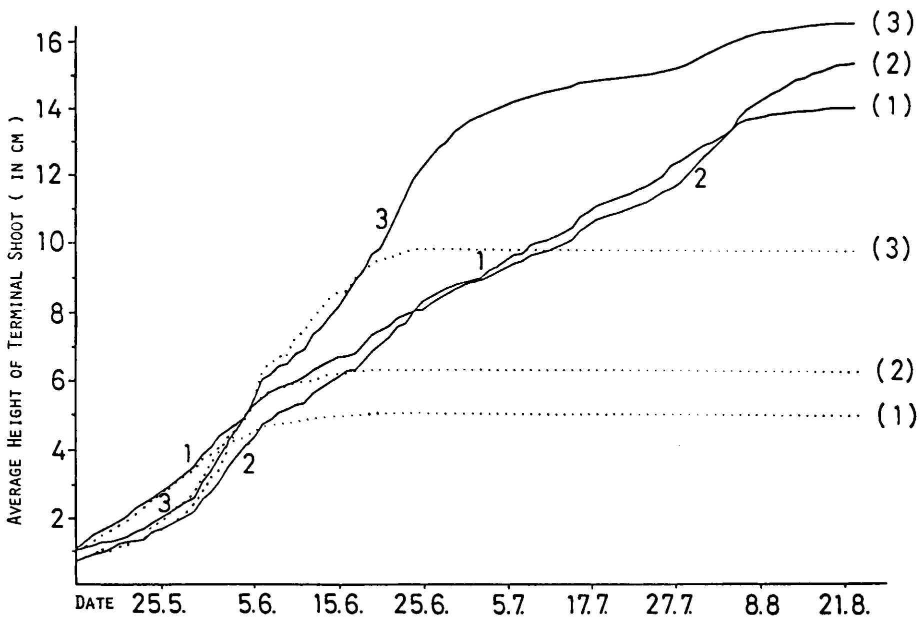

Fig. 1 — Average height growth of terminal shoot (by age)
..... Short Days (1) 1 year old seedlings
——— Long Days (2) 2 year old seedlings
(3) 4 year old seedlings

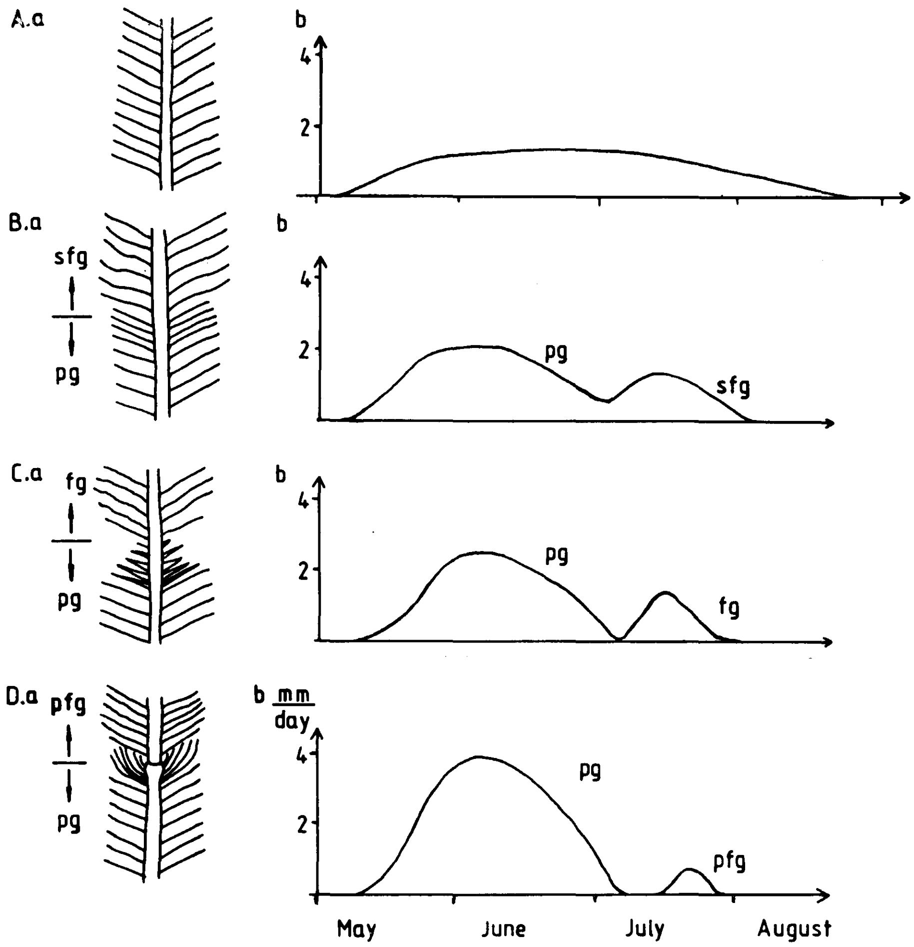

Fig. 2. — Change from sylleptic (A) to proleptic growth (D) of the leading shoot with increasing age

(A) No visible boundary between predetermined and free growth (a), and shoot elongation is slow but continuous (b).

(B) A slight boundary between predetermined and free growth, where some of the stem units are shorter and the first needles of free growth are curled which was found often (a). Shoot elongation is a little slower after predetermined growth, but accelerates again in free growth (b).

(C) A pronounced boundary between predetermined and free growth, where bud scale primordia have elongated to needle-like structures which are broad, flat rather than rhomboid, and pointed at the top. At the same time the stem units are shorter (a). The shoot elongation slows down much, but starts again with free growth (b).

(D) Pronounced boundary between predetermined and free growth with much shorter stem units, a section of the stem thickened, bud scales, last needles of predetermined growth curled up and more stout to protect the terminal bud. Free growth needles are often curled (a). The shoot elongation stops for a more or less long period of time until it starts again in free growth (b).

Pg = predetermined growth, fg = free growth, sfg = sylleptic free growth, pfg = proleptic free growth.

free growth was larger than from predetermined growth. The 2 year old seedlings had substantial proleptic free growth but only little sylleptic free growth. There was substantial sylleptic but little proleptic free growth on the 4 year old seedlings. The total needle proportion from free growth decreased with increasing age while the needle proportion established by predetermined growth increased.

Although generally there was a good agreement between shoot length and needle number established in each of the different forms of shoot growth, there were also discrepancies. In each age group the proportion of predetermined growth derived by needle counts was larger than when derived by length measurements. The opposite is true for free growth where needle counts gave smaller proportions than length measurements.

Seedlings growing under sd had earlier termination and shorter duration of shoot elongation than seedlings grown in ld conditions *(Fig. 1)*. The 1 and 2 year old seedlings grown under ld exhibited slow but steady shoot elongation that resulted in an uninterrupted change from the predetermined to the free mode of shoot growth. In contrast, the terminal shoots of the 4 year old seedlings initially elongated rapidly, but slowed after about 7 weeks. These results suggest differences in the rate of elongation between predetermined and free growth.

The average date of bud break was later on older seedlings but it was about the same on plants growing in ld and sd conditions in all three age groups *(Table 1)*. Shoot elongation stopped much earlier on seedlings grown in sd than in ld conditions. Under sd shoot elongation of older seedlings occurred over a longer period than of younger seedlings. However, the pattern was reversed for seedlings grown under ld with the shoot elongation terminating latest on the younger seedlings. The duration of shoot elongation on seedlings grown under sd was only about one third of the duration on seedlings grown under ld. The duration of shoot elongation was shorter on the older seedlings in each of the sd or ld conditions *(Table 1)*.

Figure 2 is a schematic illustration of the different forms of shoot growth produced by the Norway spruce seedlings. The graphs show the trend from a slow but continuous shoot elongation in younger seedlings to a more rapid, but intermittent form an older seedlings. The photographs in *Figure 3* correspond to the schematic illustrations of *Figure 2*.

Discussion

Except for five seedlings of the 60 growing in ld conditions, all exhibited further shoot growth after predetermined growth. On most of these seedlings (36) sylleptic free growth occurred, which means that no bud was set, and there was no interruption in shoot elongation. A boundary between predetermined and sylleptic free growth was not visible on these shoots. This was also found by Kozlowski (1964), Holzer (1967), Thompson (1976), and Cannell and Johnstone (1978). In contrast to this, on the 25 seedlings with proleptic free growth a distinct boundary between predetermined and proleptic free growth was visible on the shoots.

Of the two year old plants, four exhibited an upper shoot section with modified needles that closely resembled

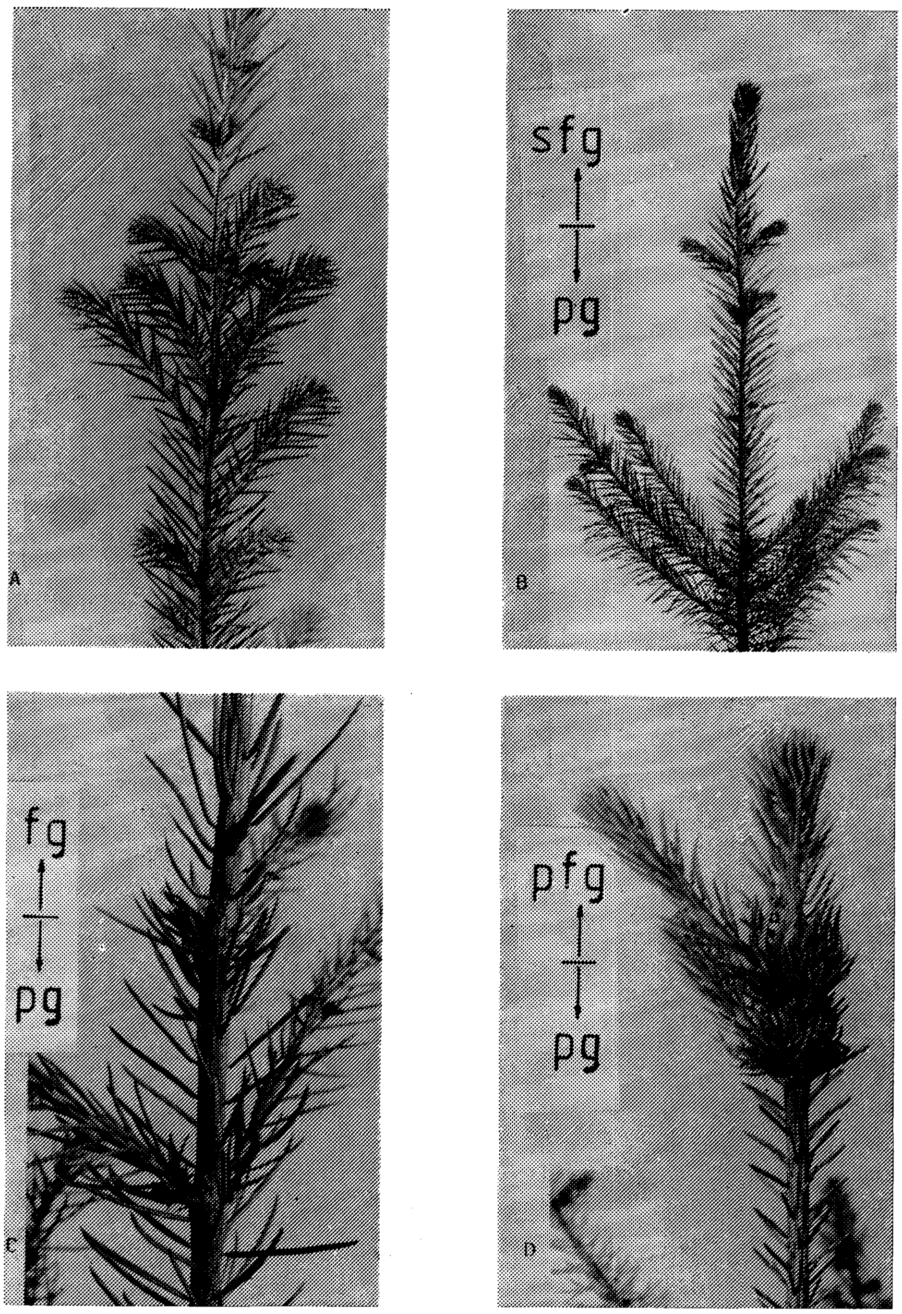

Fig. 3. — Examples of leading shoots which correspond to the types of shoots shown in *figure 2*.

needles produced by proleptic free growth, but had not formed a distinct bud before this growth occurred *(Fig. 3c)*. These four plants with a form of shoot growth that is neither distinct sylleptic nor proleptic free growth, but somewhere in between, show that there is only a gradual transition between the two. Thus, the above definition does not clearly distinguish between sylleptic and proleptic free growth. It seems as if the two forms of free growth are similar and that it is the tendency of plants to grow more intermittently with increasing age which causes the gradual change from syllepsis to prolepsis *(Fig. 2)*.

This leaves only the two forms of shoot growth, predetermined and free growth to be clearly distinguishable. In addition, these two forms of shoot growth show a different growth behavior when exposed to a short day treatment. Sylleptic and proleptic free growth cannot be distinguished clearly but the terms syllepsis and prolepsis are helpful to be able to describe free growth more precisely.

As expected, the older seedlings had longer shoots than the younger seedlings. However, the difference between average shoot length of the 1 and 4 year old seedlings under ld conditions came to only 2.4 cm (17%), while under sd conditions the 4 year old seedlings elongated their shoots 4.9 cm more, which was twice the length of the one year old seedlings. This different behavior can be explained by the increased proportion of predetermined growth with increased age, which is clearly shown in this experiment as well as by POLLARD and LOGAN (1974), POLLARD *et al.* (1975), JABLANCZY (1971), and CANNELL and JOHNSTONE (1978). The younger seedlings under ld had extended a larger free growth proportion that compensated for the smaller predetermined growth.

A possible explanation why the 4 year old seedlings grew only 2.4 cm more than the one year old seedlings might also be due to the planting shock, which may have affected the four year old seedlings with their larger transpiring surface more than the one year old seedlings. However, this does not alter the observation that the young seedlings had a smaller needle proportion in predetermined growth than the older seedlings. Planting shock might also have influenced bud break, which was much later on the older than on the younger seedlings. Also WAREING (1965) and KOZLOWSKI (1971) reported that on older seedlings bud break occurred later than on younger seedlings.

A discrepancy was observed between the proportions of the different forms of shoot growth derived either by length measurements or by counting the number of needles established. This discrepancy is due to the fact that under sd conditions the elongation of predetermined growth is smaller than under ld conditions. This leads to an overestimation of the free growth complement and an underestimation of the predetermined growth complement when the shoot length measured on seedlings grown under sd is substracted from the shoot length measured on seedlings grown under ld conditions. POLLARD and LOGAN (1974) were aware of this inadequacy when they used this method and only estimated the needle complements of predetermined and free growth. For large scale screening operations the time consuming counting of needles is a handicap. On the other hand just measuring the shoot length is easier and might also give useful results, when the described discrepancy is accounted for. Moreover, this discrepancy can be reduced by starting the short day treatment at a later date, when the predetermined phase is almost completed, but the free growth phase has not yet started (VON WÜHLISCH 1984). Another possibility is to reduce the daylength less than was done here.

The shoot growth of plants growing under sd conditions was terminated a little later on the older than on the younger seedlings. This seems to be due to the larger predetermined growth of the older seedlings. As a rule however, older plants complete their shoot growth earlier than young plants (KOZLOWSKI 1964, LINES and MITCHELL 1966). This was the case here in seedlings growing in ld (natural day length) conditions.

As the predetermined proportion increased with increasing age, the free growth proportion decreased. This is in accordance with SPÄTH (1912), JABLANCZY (1971), and HOLZER (1967). Similar observations were made in other studies of *Picea* species (POLLARD and LOGAN 1974, POLLARD *et al.* 1975; LOGAN and POLLARD 1975; CANNELL *et al.* 1976, CANNELL and JOHNSTONE 1978).

Thus, the results show a trend in the mode of shoot growth of young Norway spruce seedlings. With increasing age, shoot growth changes from a continuous to an intermittent pattern of elongation. Very young seedlings exhibit sylleptic free growth in their first years and proleptic free growth in the following years. This has been observed on other tree species also (KOZLOWSKI 1971).

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Buchbesprechungen

A guide to forest seed handling with special reference to the tropics. By R. L. WILLAN. FAO Forestry Paper 20/2: DANIDA/FAO, Rome 1985, 379 p.

FAO edited this book in the light of latest comments, adding further illustrations (see also Silvae Genetica 33, 6, 1984). By its clear and well-founded presentation of problems, methods and techniques this book presents a comprehensive manual for forest seed handling. Hopefully it finds a world-wide distribution, especially in tropical regions where useful publications are rather rare in this working field. G. H. MELCHIOR

The Physiological Properties of Plant Protoplasts. Edited by PAUL-EMILE PILET. Springer-Verlag, Berlin, Heidelberg, New York, Tokyo, 1985. With 82 figures, 35 tables, and 283 pages. DM 115.00.

Plant protoplasts have been exploited as an experimental system for studies on plant propagation, somatic hybridization, and gene transfers. However, physiological, biochemical, and molecular properties of plant protoplasts are not fully understood. The present volume is an outcome of a 3-day seminar on the physiological properties of plant protoplasts, held at Lausanne, Switzerland in March 1984. Altogether there were 30 reports covering isolation, structure, and function of protoplasts. The first two papers review the status of protoplasts in physiological research, somatic hybridization, and transformation. The next 4 papers deal with isolation and viability of protoplasts. Membrane transport, vacuolation, and mitotic cycle of protoplasts are discussed in a number of papers. The physiology of guard cell protoplasts is dealt in two papers. Wall regeneration, auxin biosynthesis, and metabolic functions of protoplasts are discussed in a number of papers.

This book contains an interesting collection of papers dealing with the physiological properties of plant protoplasts. This subject matter needs to be better understood before protoplasts can be fully exploited for plant propagation, somatic hybridization, and gene transfers in the economically important crop plants. For these reasons, considerably more research is necessary in the area of protoplast physiology. This book is timely and provides useful information for those working in the area of protoplast culture.

M. R. AHUJA, Grosshansdorf

Información basica y tratamientos pregerminatios en semillas forestales (Basic data and pregermination treatments on forest tree seeds) ENRIQUE TRUYILLO NAVARRETE. Ministerio de Agricultura, INDERENA, Subgerencia de Bosques, Division de Fomento Forestal. Bogota, Colombia.

The author presents data of purity, 1000 seed weight, number of pure and impure seeds/kg, number of viable seeds and germination capacity of some 80 Columbian forest tree species and exotics to Columbia. For some 50 forest species 30 successful and unsuccessful empirically tested pregermination treatments are described. G. H. MELCHIOR

Arboles communes de la provincia de Esmeraldas, Ecuador. By E. L. LITTLE, JR., and R. G. DIXON. Programma de las Naciones Unidas para el Desarollo y la Organización de las Naciones Unidas par la Agricultura y la Alimentación, Roma 1969. Reprinted by Peace Corps, Information and Exchange 1983. 806 Conn. Ave., N.W. Wash. D.C. 20526, 536p.

220 important and common tree species of about 500 of the Esmeralda province are presented by illustration of their leaves and reproductive organs. The description of each species includes comments on the area of distribution, habitat, morphological and wood characters, use and terminology. A key based in the first step on the type of leaves permits the botanical determination of the species out of 56 families.

The Peace Corps gains merits by reprinting these long out of print publications about important South American tree species.

G. H. MELCHIOR

Illustrierte Flora von Mitteleuropa. Von GUSTAV HEGI. Band I, Teil 3, Gramineae, Lieferung 3. Bearbeitet von HANS JOACHIM CONERT. 3., völlig neubearbeitete Auflage. S. 161—240 mit 38 Abbildungen und 1 Farbtafel sowie einer Schwarz-weiß-Tafel. Verlag Paul Parey, Berlin und Hamburg. 1985. Broschiert DM 35,—.

Als Fortsetzung der Neubearbeitung von HEGI's Illustrierter Flora von Mitteleuropa liegt nun die 3. Lieferung von Band I/3 vor. In ihr wird die Bearbeitung von 8 Gräser-Gattungen der *Poaceae*, Unterfamilie *Pooideae*, fortgeführt. Hierzu gehören u. a. die weitverbreiteten Gattungen *Alopecurus*, *Phleum* und *Avena*. Die einzelnen Arten werden in gewohnter Weise sehr eingehend beschrieben und in guten Zeichnungen abgebildet. Wie im "HEGI" üblich wird auch auf Verbreitung, Vorkommen im Gebiet, Ökologie, Cytotaxonomie, Inhaltsstoffe, Nutzen und Verwendung sowie Schädlinge und Krankheiten ausführlich eingegangen. Neben den einheimischen Arten sind auch viele Adventivarten aufgeführt. Insgesamt wird auch die jetzt erschienene Lieferung dem hohen Anspruch an dieses Standardwerk gerecht. B. R. STEPHAN

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