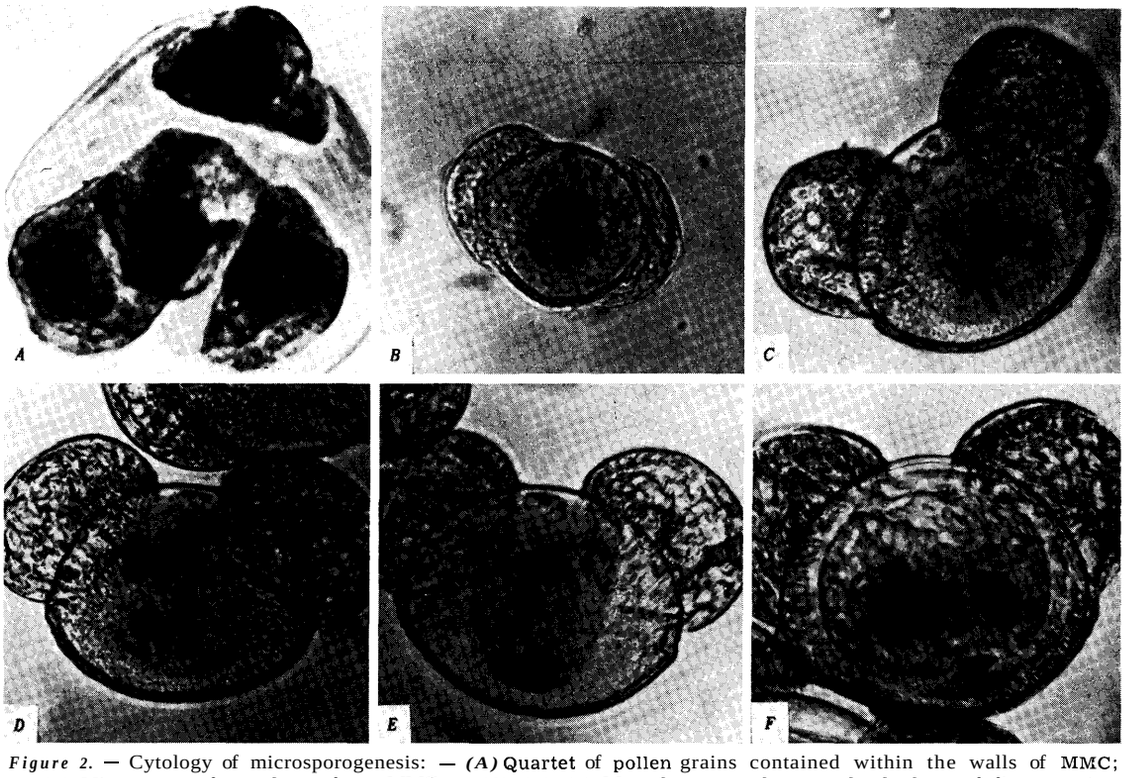

Figure 2. — Cytology of microsporogenesis: — *(A)* Quartet of pollen grains contained within the walls of MMC; — (B) Microspore after release from MMC: — *(C),* (D), (E) Metaphase, anaphase, and telophase of first vegetative divicion; — *(F)* Mature pollen grain following second vegetative division.

Dwarf Seedlings from Broomed Douglas-Fir

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Introduction

Brooming of Douglas-fir (Pseudotsuga *taxifolia* [POIR.] BRITT.), in the absence of attack by insects or plant pathogens, is occasionally found in the forests of the Pacific northwest (BUCKLAND and KUIJT, 1957). The brooming may affect whole trees or, more commonly may involve only a single branch. The brooming occurs as a result of shortened annual shoots and multiplication of buds, usually accompanied by shortening of needles and sometimes by chlorosis and gradual decline and ultimate death of the affected portion.

There is a rather large literature on brooming of forest trees, particularly conifers of the family Pinaceae. The paper by BUCKLAND and KUIJT (1957) refers to some of the more important contributions. The present study is concerned with the reproductive biology of Douglas-fir brooms, some progenies from open pollination of brooms, and possible implications for tree improvement technology, horticulture, and Christmas tree culture.

Description of brooms

The paper by BUCKLAND and KUIJT (1957) shows photographs of the general habit of upper-crown brooms in Douglas-fir.

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Figure 1 shows the top of a completely broomed tree (IFA 86) among normal (younger) trees, at Matlock. This tree was cut in Mason County, Washington, the winter of 1960-61, by a logger who evidently had a market for one short knotty lag. The stump showed approximately 180 rings and was 51 cm. in diameter a size normally attained at about this age on site IV. The beight of the tree, approximately 2C meters, was considerably below the 27 meters expected on Site V. Cones had been collected from the tree in 1959, and at this time it was noted that few internodes were as long as 30 cm.

Figure 2 sbows a small, completely broomed tree, found on the west slope of the Cascades near Springfield, Oregon by Mr. FRED SANDOZ and eventually transplanted to thc experimental area of the Forest Research Laboratory of Oregon State University at Corvallis. This tree is notable not only for its compact pyramidal habit, but for its short, blunt needles and blunt buds, both of which resemble those of some *Abies* species.

Figure 3 shows a large tree, about 1.5 meters d. b. h. growing in the Pack Demonstration Forest of the University of Washington at LaGrande. This tree (IFA 29) has a single large branch, about 61 cm. in diameter, which is noticeably different from the other branches in that it is markedly sinuous, ascends rather sharply, and is covered with typically broomed foliage. Figure 4 shows a 5-year-old graft from this broom.

Figure 1. — Top of a completely broomed Douglas fir (IFA 86) at Matlock, Mason County, Washington. Photo courtesy University of Washington.

Figure 2. — A small, completely broomed Douglas fir, originally found near Springfield, Oregon. Photo courtesy Oregon State University.

Figure 3. — 60-inch Douglas fir with lowest branch ascending, sinuous, and bearing compact foliage (IFA 29).

Figure 4. — 5-year-old graft of IFA 29. See *fig. 3* for ortet.

These three growth habits are perhaps not too aptly called brooms because they owe their compact habit more to shortening than to multiplication of shoots from a single center. Other brooms, which combine great multiplication of shoots from a single point with shortening of shoots, have been observed in western Washington. Scions collected from 2 of these have been used to establish the broom tissue as grafts. Moreover, the writers have observed several small dead brooms in the slash from large old-growth trees. In at least one case, no evidence of insect or plant pathogen could be found. The death of the brooms was suspected to have been caused by shading by the upper crown.

The behavior of grafts from broomed trees

Scions have been collected and grafted successfully from 5 broomed trees. In the case of two (trees IFA 29 and 86, shown in *Figs. 3* and *1*, respectively), enough successful grafts have been made to furnish reliable data on their behavior. During the growing season in which the graft is made, elongation of the scion is conspicuously restricted, as it would have been if left on the ortet. During the next one or two growing seasons, elongation of scions is almost normal *(Figure 5)*. In fact, it was at first thought that the

Figure 5. — 2-year-old graft of IFA 86. Note long shoot produced in second year. First year elongation was very slight, as are 4th and 5th year elongation on older grafts of this clone.

broom habit had been lost in grafting presumably as a consequence of using a normal, vigorous rootstock. Finally, during the second or third year following grafting, elongation of the scions from the brooms becomes restricted and proliferation of buds increases, so that the broomed appearance is restored. This phenomenon has been observed in grafts of a bushy variant of *Tsuga heterophylla,* and in grafts of *Pinus strobus* var. *nana* Hort. made from scions furnished by Professor HENRY H. CHISMAN (see CHISMAN and LYLLO, 1958).

Figure 6. — Four 3-year-old transplants from open-pollinated progeny of IFA 29. Tree on right, phenotypically normal, and typical for 3-year-old coastal Douglas fir is 1 meter tall. Note compact root systems of dwarf trees.

Open pollinated progenies from broomed trees

AS BUCKLAND and KUIJT (1957) have indicated, cones are lacking or rare on most brooms. Nevertheless, the broom listed as IFA 29 bore a large crop of cones in 1959 and in 1962 several hundred cones were collected in both years. The tree listed as IFA 86 was less fruitful in 1959, and gave little evidence of heavy cone crops in previous years. Nevertheless, about 25 cones (virtually the whole crop) were collected in 1959. The cones collected from both brooms were noticeably small, even for old trees, but they shed reasonable yields of sound seed. ARNBORG (1946) reported that the cones from *Pinus sylvestris* broom-type trees were smaller than normal.

The open pollinated progenies of both brooms, after three years, show wide segregation in growth rate and habit. The progeny of IFA 29 ranged in height from 11 to 129 centimeters. Approximately 40 percent show various degrees of dwarfing with a mean height of 36 centimeters in contrast to a mean height of 80 centimeters for the phenotypically normal population. This corresponds to the findings of LIESE (1933) with *Pinus silvestris* brooms and of ARNBORG (1946) with entire broom-type trees of the same species. Similar results with open-pollinated progenies from brooms of *Pinus strobus* and *P. banksiana* have been reported in personal communication with ALBERT G. JOHNSON. *Figure 6* shows some of the types among the open-pollinated progeny of IFA 29.

Discussion

The results obtained from growing open-pollinated progenies from the two brooms are insufficient to permit a genetic analysis of these phenomena. ARNBORG (1946) advanced the hypothesis that since several of his broom pines were found in reasonably close proximity, some of the dwarf seedlings might have been the result of crosses between broomed trees. In the case if IFA 86, an entirely broomed tree, no careful search of its surroundings — a

dense second-growth stand — has been made for other similar trees. It seems most likely that a number of the surrounding trees, although phenotypically normal, may share some of the genes which condition dwarfism in the progeny of IFA 86. These dwarfs may be the result of backcrossing. In the case of IFA 29, a simpler hypothesis would be that the abnormal branch is a result of somatic mutation affecting one or several loci. Some of the more extreme dwarfs may be either the result of selfing within the abnormal branch or backcrossing to the normal portion of the tree, which is presumed to be heterozygous for recessive alleles homozygous in the abnormal branch or bud sport. In any event, the complexity of the segregating open-pollinated progeny of IFA 29 suggests that something other than a single locus is involved.

The ability to produce dwarf seedlings in virtually unlimited numbers which at least two of these Douglas-fir clones offer may be of substantial value in seed orchard technology, Christmas tree culture, and horticulture.

Grafts from Douglas-firs selected for superior timber-producing qualities grow rapidly under seed orchard conditions and soon produce cones out of easy reach. The development of dwarfing rootstocks is therefore an urgent concern in seed orchard technology. Scions from the original brooms may have some value as interstocks for double-working, but it might be more effective, because the roots of these dwarfs are also slow-growing, to use own-rooted dwarfing rootstocks. This is done, for example, with the well-known Malling rootstocks used for dwarfing deciduous fruit trees. So far, it has not been possible, either by conventional cuttage or by air-layering, to root material from these brooms. Some of their dwarf progeny, however, since they are still physiologically young, root rather readily. They are being increased for tests of their value as dwarfing rootstocks.

The culture of Douglas-fir Christmas trees in the Pacific northwest has long been beset with a basic anomaly. In order to restrict internode lengths and thereby produce full-crowned trees, it has been customary to grow Douglas fir for Christmas trees on the less fertile soils in the region. On many of these, mineral nutrition is so inadequate that needles are deformed and chlorotic. This has led to the application of fertilizers in the season before harvest, in order to "green-up" the trees without unduly promoting height growth. This type of culture obviously is, in part, self-defeating because the value of a Christmas tree is measured by its height. Yield and quality considerations are therefore in conflict. Some of the bushy types found among the progeny of brooms promise to make it possible to grow full-crowned trees at rapid rates of height growth on fertile soils, with a minimum cost for shearing and shaping.

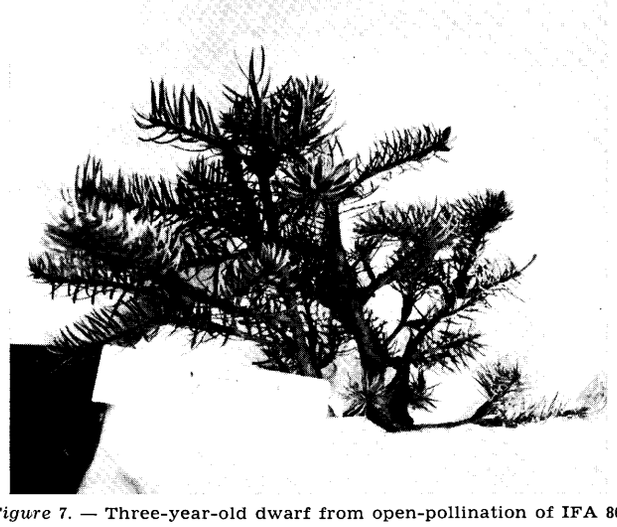

Figure 7. — Three-year-old dwarf from open-pollination of IFA 86.

Douglas-fir is perhaps second to *Chamaecyparis lawsoniana* among the conifers of the Pacific northwest which have made large contributions to horticulture. KRÜSSMANN (1960) lists 34 horticultural varieties of *P. menziesii*. Of these, 3 dwarf forms are named "*Globosa*", "*Monstrosa*", and "*Pumila*". No doubt these and many others can be found among the progenies of brooms. In this regard, it is interesting to note that the two progenies so far grown are quite different. The dwarfs in the progeny of IFA 86 are almost all characterized by light green, thin, upward-curving needles and rather slender twigs. Dwarfs in the progeny of IFA 29 show a much greater diversity of twig and needle types. *Figures 7 and 8* show extreme dwarfs, of widely different habit, from the 3-year-old progenies of these brooms.

Figure 8. — Three-year-old dwarf from open-pollination of IFA 29.

Summary

Brooming of whole trees of *Pseudotsuga taxifolia* or of single branches, not caused by attacks of insects or plant pathogens, is described and illustrated. Grafts from these brooms, after a year or two of luxuriant growth, revert to the compact growth habit which characterizes these brooms. This phenomenon has been noted also in *Pinus* and *Tsuga*. Some brooms, as reported by LIESE (1933) and ARNBORG (1946) for *Pinus silvestris*, produce small cones and fertile seeds. Among the open-pollinated progenies are various types of dwarf seedlings which are rather easily multiplied by rooting. They have potential value as dwarfing rootstocks for grafted seed orchards, for Christmas tree production, and for horticulture. Some of these dwarfs are illustrated.

Zusammenfassung

Titel der Arbeit: *Zwergsämlinge von besenförmig verzweigten Douglasien.*

Die besenförmige Verzweigung ganzer Bäume oder einzelner Zweige (Hexenbesen) bei *Pseudotsuga taxifolia,* die nicht durch Insekten oder sonstige Schädlinge verursacht wird, ist beschrieben und illustriert worden. Pfropfungen von solchen Besen kehren nach 1 bis 2 Jahren luxurierenden Wachstums wieder zu dem kompakten Wuchshabitus zurück, der diesen Besenformen eigen ist. Diese Erscheinung wurde auch bei *Pinus* und *Tsuga* gefunden. Einige solcher Besenformen produzieren kleine Zapfen mit fertilen Samen, wie das schon von Liese (1933) und von Arnborg (1946) für *Pinus silvestris* berichtet worden ist. Nach freiem Abblühen befinden sich unter solchen Nachkommenschaften verschiedene Zwergsämlingsformen, die ziemlich leicht durch Stecklinge vermehrbar sind. Sie haben einen gewissen Wert als Zwergunterlagen für Pfropflingssamenplantagen, für Christbaumerzeugung und für gärtnerische Zwecke. Einige dieser Zwergformen werden mit Abbildungen belegt.

Résumé

Titre de l'article: *Semis nains obtenus de Douglas présentant une mutation "en balai".*

L'article décrit, avec illustrations à l'appui, des Douglas présentant une forme "en balai" soit sur l'arbre entier, soit sur des branches isolées, cette déformation n'étant causée ni par des attaques d'insectes, ni par des parasites végétaux. Des greffes faites à partir de ces rameaux déformés, après 1 an ou 2 de croissance vigoureuse, reprennent le port compact qui caractérise cette déformation. Ce phénomène a été également remarqué dans les genres *Pinus* et *Tsuga.* Certains de ces "balais", signalés par Liese (1933) et Arnborg (1946) sur *Pinus sylvestris,* produisent de petits cônes et des graines fertiles. Parmi les descendances par fécondation libre, on trouve divers types de semis nains qui sont assez facilement multipliés par bouturage. Ils pourraient être intéressants comme porte-greffes nains pour la constitution de vergers à graines, pour la production d'arbres de Noël, et pour l'horticulture. L'article comporte des photographies de certains de ces semis nains.

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Berichte

Tagung 1962 der Arbeitsgemeinschaft für Forstgenetik und Forstpflanzenzüchtung in Stuttgart-Weilimdorf

Die Arbeitstagung hat vom 10. 9. bis 12. 9. 1962 stattgefunden. Gastgeber war die Abt. Botanik und Standortskunde in Stuttgart-Weilimdorf der Bad.-Württ. Forstlichen Versuchs- und Forschungsanstalt. Der Leiter dieser Abteilung, Oberregierungsrat Dr. G. Schlenker, stand zugleich dieser Arbeitstagung vor. — Am ersten Tag sind 7 Referate gehalten worden. Die Themen werden anschließend, soweit Texte von den Vortragenden vorliegen, kurz besprochen. — Die Vortragsreihe ist am Nachmittag durch eine Besichtigung von Pappelsorten im Fasanengarten vorübergehend unterbrochen worden. — Am 11. 9. führte eine Exkursion zu Zuchtbäumen von *Pinus silvestris* in den Nordschwarzwald und zu dem Versuchsgelände der Bad.-Württ. Versuchs- und Forschungsanstalt in den Kaiserstuhl (Samenplantagen und Arboretum) sowie zu Zuchtbäumen von *Picea abies* in den Südschwarzwald. — Im Verlauf einer weiteren halbtägigen Exkursion am Nachmittag des 12. 9. wurden die Klonsammlung im Fasanengarten (Behandlung von Pfropflingen), das Populetum in Reichenberg und der Anbau von *Populus alba* × *grandidentata*-Kreuzungen im Forstbezirk Unterweissach besichtigt. — Der Vormittag des 12. 9. stand für 3 Referate und die daran anschließende Mitgliederversammlung zur Verfügung, die interne Tagesordnungspunkte verhandelte. — Die nächste Zusammenkunft der Arbeitsgemeinschaft ist für 1964 in Hann. Münden vorgesehen. Zum 1. Vorsitzenden wählte die Versammlung Herrn Professor Dr. Th. Schmucker, Hann. Münden.

Auf der Tagung 1962 wurde von folgenden Vortragenden berichtet:

F. K. Hartmann, Hann. Münden. — *Welche Bedeutung haben die natürlichen Waldgesellschaften für die Ausbildung von Baumartenrassen bzw. Ökotypen im Gebirge?*

Der Text des Vortrages folgt an anderer Stelle in dieser Zeitschrift.

H. Bartels, Hann. Münden. — *Enzymuntersuchungen an Pappelklonen.*

Der Inhalt des Vortrages soll anderweitig publiziert werden.

H. Messer, Wolfgang/Hanau. — *Güteklassifizierung von Buchen-Beständen in verschiedenen Herkunftsgebieten.*

Der Vortragstext soll einer anderen Publikation vorbehalten bleiben.

G. Schell, München. — *Erste Erfahrungen bei Kreuzungen zur Prüfung der Nachkommenschaften von Plantagenklonen.*

Über den Inhalt des Vortrages wird an anderer Stelle berichtet.

H. Dieckert, Reinhausen/Göttingen. — *Farbe und Form weiblicher Blüten bei verschiedenen Herkünften der europäischen Lärche.*

Farbe und Form der ♀ Blütenzäpfchen variieren bei *Larix decidua* sehr. Bei Vollblüte sind die Zäpfchen oft lilarot, rot, rosa, gelb, weiß, grün oder mehrfarbig. Der Gesamteindruck wird hervorgerufen durch unterschiedliche Farbtöne der Deckschuppenseitenlappen, des Deckschuppenkieles und der Deckschuppenspitze der schraubig angeordneten Einzelblüten. Im wesentlichen bestimmt die Färbung der Deckschuppenseitenlappen den Gesamtfarbeindruck. Die Färbung ist fast immer am Rand des Lappens kräftiger und wird zur Mitte hin blasser. Der Farbübergang vom Innern zum Rand des Deckschuppenlappens verläuft dabei meistens fließend, manchmal jedoch auch scharf (zum Beispiel weiß mit scharf abgesetztem roten Rand). Deckschuppenkiel und Deckschuppenspitze sind in der Regel durch eine andere Färbung deutlich von den Deckschuppenseitenlappen abgesetzt. Ihre Farbe ist grün, weiß, grau, blau, rot, braun oder mehrfarbig.

Die Form des weiblichen Lärchenblütenzapfens wird in erster Linie durch die sehr unterschiedliche Länge der Deckschuppenspitzen bestimmt.

Jede Lärche ist durch eine individuelle Blütenfarbe oder Farbkombination und durch eine bestimmte Länge der Deckschuppenspitzen (gemessen in der Mitte des Zapfens) ausgezeichnet. Diese Merkmale können eine gute Hilfe bei der Klonidentifizierung sein.