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Provenance differences in the time of spruce (*Picea abies* (L.) Karst.) flushing in Poland

Success of spruce in plantations depends to a large extent on its ability to avoid late spring forsts. Selection of spruce races resistant to late frosts is possible and necessary for regions where such frosts frequently cause damages. It appears to be well established that resistance depends primarily on late flushing (Langlet 1963, Stern 1966, Kiellander and Nilsson 1967, Tyszkiewicz 1968, Lacaze 1969). It was also noted that the late flushing spruces were more resistant to frosts than early flushing ones even before flushing begun (Day and Peace 1946) which can be explained by the parallel differences in the onset of metabolic activity in the buds as measured by respiration (Saetersdal 1956). Some of the late flushing Polish provenances are also better able to regenerate any late frost injuries (Kiellander 1970). There have been reports of lack of correlation between flushing date and resistance to late frosts (Edwards 1955, Tyszkiewicz 1968) but this can probably be accounted for by exceptionally unusual weather conditions or by thec onfounding of late frost damage with winter injury. There have been suggestions that early budding provenances are also late to terminate cambial growth in the autumn (Dietrichson 1963), however resistance to late and early frost injuries are not necessarily correlated (Kiellander and Nilsson 1967).

One would suspect that later flushing and earlier growth termination in spruce, while providing resistance against frosts adversly affects growth by shortening the vegetation period. However this does not appear to be the case, because late flushing Central European provenances are frequently also the best producers in Sweden (Langlet 1963). In France it was shown that among the high altitude provenances the lateness of flushing was positively correlated with growth vigour (Lacaze 1969).

Other reports concern correlations of flushing earliness with resistance to attack by *Lagaeonematus abietinus* Christ. (Bouvarel and Lemoine 1957) and occurrence of Lammas shoots (Holzer 1967).

Numerous provenance experiments on spruce established in various parts of Europe and North America have demonstrated that the time of flushing is determined to a large extent by the geographical origin of the seed. Edwards (1955) was the first to note that in the U. K. spruce from the Sudeto-Carpathian region is later flushing than Alpine spruce and that the Scandinavian provenances are earliest. Schönbach (1957) showed that in East Germany spruce from NE Poland is still later flushing than Sudetan spruce and that spruces from central Germany are slightly later flushing than the Alpine ones. Basically the same results were reported later by Weiss and Hoffman (1969) for the same plantation and by Troeger (1958) for three experimental areas in West Germany. In France, Balkan provenances were latest to flush, while the Alpine ones were relatively early (Bouvarel and Lemoine 1957).

In Belgium provenances from Rumania and southern Poland are latest to flush, Scandinavian ones are earliest, while the Alpine ones are intermediate. From among the latter ones, those from higher elevations flush earlier than those from lower elevations (Gathy 1960, Nanson 1964). Langlet (1963) after a thorough study of experimental areas in Sweden concludes that northern provenances and southern ones from high altitudes flush early while southern provenances generally flush later. Those from NE Poland flush extremely late. These late flushing southern provenances are winter hardy up to a latitude of 64°N and are well conditioned to escape damage at the hands of the late spring frosts. Other Swedish reports confirm this (Kiellander and Nilsson 1967, Kiellander 1970). Similarily Lacaze (1969) believes that for France spruce from NE Poland and the Baltic region is late flushing, and therefore hardy, as well as vigorous.

Also in North America Carpathian provenances and those from NE Poland were among the most resistant to late spring frosts (Slabaugh and Rudolf 1957).

It is clear therefore that Poland and Rumania as well as possibly adjacent parts of the USSR are regions where late flushing provenances are to be looked for. In the international provenance experiments only few Polish provenances were included, from Białowieża, Istebna, Radom and Brody (Pförten). German studies included also Borki (Borken), Stronie Śląskie (Seitenberg) and Piechowice (Petersdorf). Białowieża and Borki were always very late flushing in these experiments, Istebna relatively late and Radom, Brody, Stronie Śląskie and Piechowice medium late.

In order to have a clearer picture of the phenological adaptations of Polish spruce new studies were needed which would include a large number of Polish provenances. In a greenhouse experiment Janson (1968) was not able to demonstrate differences in the time at which growth of spruce of various Polish origins begun. On the other hand Tyszkiewicz (1968) who worked with the same seed lots in nursery conditions found that spruces from the southern part of the country flushed earlier than those from the NE part of the species range in Poland. Also spruces from around the mouth of the Vistula (outside the natural range of spruce), probably brought there from SW Germany in the XIX century, flushed distinctly earlier than those from NE Poland. The present report covers observations on the flushing of spruce in the spring of 1971 made on several experimental areas set up by the Institute of Dendrology and Kórnik Arboretum from material collected in various parts of Poland.

MATERIALS AND METHODS

In the spring of 1971 observations were made on the flushing of spruce in the following experimental areas:

1° A spruce provenance experiment established in 1969 in Kórnik. The flushed seedlings were counted on each plot 6 times during the spring.

2° The same experiment established in 1969 in Forest District Międzylesie. The seedlings were counted only once (2 V 1971).

3° The same experiment established in 1969 in Forest District Orawa. The seedlings were counted only once (17 V 1971).

4° The same experiment established in Forest District Gołdap. The seedlings were counted only once (19 V 1971).

5° A spruce provenance experiment established in 1964 in Kórnik from seedlings provided by the Forest Research Institute, Warsaw. The spruces were evaluated for the degree of flushing on the 7 - 8 V 1971, using a three point scale.

6° A spruce seed orchard established in Kórnik in 1968. The spruces were evaluated for degree of flushing on the 5th of May 1971, using a three point scale.

The data from experimental areas 1° to 4° have been converted to percentages per number of living seedlings in each plot. For analyses of variance the data were further converted to arcsines.

Table 1

The origins of seeds used in the provenance experiments established in Kórnik, Międzylesie Orawa and Gołdap

Prov. no.	Forest District	Lat. N	Long. E	Altitude m	No. of trees from which seed collected
96	Brody	51°42′	14°53′	80	8
98	Kowary	50°48′	15°52′	625	10
99	Istebna	49°33′	18°52′	630	10
100	Wisła	49°37′	18°56′	650	11
101	Rycerka	49°32′	19°00′	530	10
103	Nowy Targ	49°31′	20°07′	1000	5
104	Wetlina	49°08′	22°30′	700	10
106	Garbatka	51°31′	21°36′	130	10
107	Bliżyn	51°05′	20°42′	320	10
109	Konstancjewo	53°11′	19°08′	90	10
110	Iława	53°39′	19°34′	116	10
111	Nowe Ramuki	53°39′	20°34′	126 - 180	10
112	Sadłowo	53°55′	21°06′	125 - 180	10
113	Myszyniec	53°22′	21°09′	120	10
114	Sławki	53°03′	21°07′	120 - 140	10
115	Borki	54°06′	22°05′	155	10
116	Przerwanki	54°08′	22°04′	150	10
117	Gołdap	54°20′	22°24′	150	10
118	Suwałki	53°59′	23°07′	170	9
119	Augustów	53°54′	23°11′	130	10
120	Białowieża	52°40′	23°47′	160	10
121	Zwierzyniec	52°43′	23°47′	160	8
122	Międzyrzec	52°03′	22°57′	154	18
123	Szadek	51°41′	18°59′	173	4
125	Stronie Śląskie	50°18′	16°55′	840 - 900	10
133	Dolina Chochołowska	49°13′	19°48′	1400	11
136	Neuwernsdorf, DDR	50°43′	13°31′	700	
137	Carlsfeld, DDR	50°27′	12°35′	920	
172	Värmland, Sweden	59°		0 - 100	
173	Värmland, Sweden	60°		100 - 200	
174	Värmland, Sweden	59°30′		100 - 200	
175	Värmland, Sweden	59°30′		200 - 300	
176	Värmland, Sweden	60°		300 - 400	

Table 2

The origins of seed used in the provenance experiment established in Kórnik from material provided by the Forest Research Institue in Warsaw

Provenance	Lat. N	Long. E	Altitude m
Białowieża	52°42′	23°47′	150
Zwierzyniec	52°42′	23°47′	150
Płaska	53°54′	23°20′	120
Augustów	53°52′	23°11′	120
Przerwanki	54°10′	22°04′	150
Borki	54°06′	22°05′	160
Górowo	54°20′	20°30′	200
Mestwinowo	54°00′	18°20′	100
Sobowidze	54°10′	18°30′	100
Jodłowno	53°50′	19°00′	100
Kartuzy	54°25′	18°10′	200

The observations on areas 5° and 6° have been recorded on a three point scale: 0 — unflushed, 1 — beginning to flush, 2 — flushed, and expressed as average score per plot (5°) or per clone (6°).

The percentage of flushed seedlings obtained on 6 dates in area 1° have been plotted against time separately for each provenance, and from the graphs an estimate was obtained of the number of days it takes for the percentage of flushed seedlings to increase from 20% to 80%. This gave a measure of the between-tree variability in flushing time within each provenance.

The origins of the provenances used for the establishment of areas 1° - 4° are defined in table 1 and on fig. 1 - 5. The number and distribution of replicates on each experimental area have been presented in an earlier paper (Giertych 1970).

The seedlings obtained from the Forest Research Institute, Warsaw, for the establishment of area 5° originate from seed collections made in 11 forest districts the geographic coordinates of which are given in table 2 and fig. 6.

Scions for the establishment of the spruce seed orchard (6°) have been collected from plus trees in 7 forest districts the geographical coordinates of which are given in table 3 and fig. 7.

Table 3

The Forest Districts in which plus trees have been selected for the establishment of the spruce seed orchard in Kórnik

Forest District	Lat. N	Long. E	Altitude m
Białowieża	52°40′	23°47′	160
Zwierzyniec	52°43′	23°47′	160
Istebna	49°30′	18°50′	630
Witów	49°15′	19°50′	1350
Rycerka	49°30′	19°00′	530
Przerwanki	54°08′	22°04′	150
Stronie Śląskie	50°18′	16°55′	870

RESULTS

As can be seen from figs. 1 to 4 there appears to be a very close agreement between the results obtained with the same material planted in various climatic regions of Poland. In absolute values there are differences between the areas, but these have been caused by the fact that scores have been made at different times, both literally and in relation to the onset of the vegetation period in each of the locations. Analyses of variance showed that both localities and provenances significantly differ from each other in flushing dates, but there was no interaction between these two sources of variation.

Generally the shortest histograms on each of figs. 1 - 4 are to be found in the NE part of Poland, particularily provenances 121 and 120 which are from adjacent forest districts in the primaeval Białowieża forest. Within the NE part of the range of spruce the earliest to flush were seedlings from Przerwanki (prov. 116). Also relatively early flushing were the spruces from Konstancjewo (prov. 109), however these represent an outlier of spruce outside the continuous range.

In central Poland, that is in the northern part of the southern range of spruce, where the species grows only as a component of stands predominantly composed of

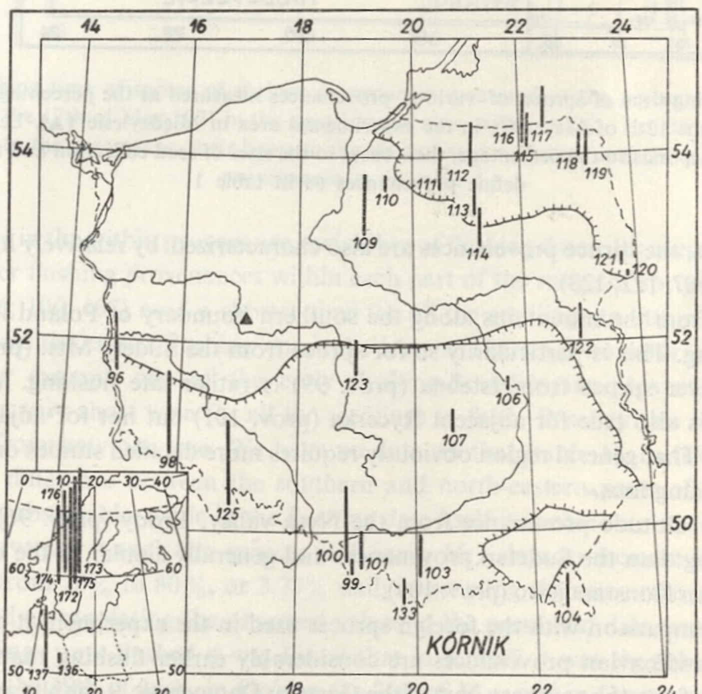

Fig. 1. Flushing time of spruce of various provenances measured as the percentage of flushed seedlings on the 4th of May 1971 in the experimental area in Kórnik (▲). Length of histograms corresponds to the percentage, their bases to the sites of seed collection and the numbers define provenances as in table 1

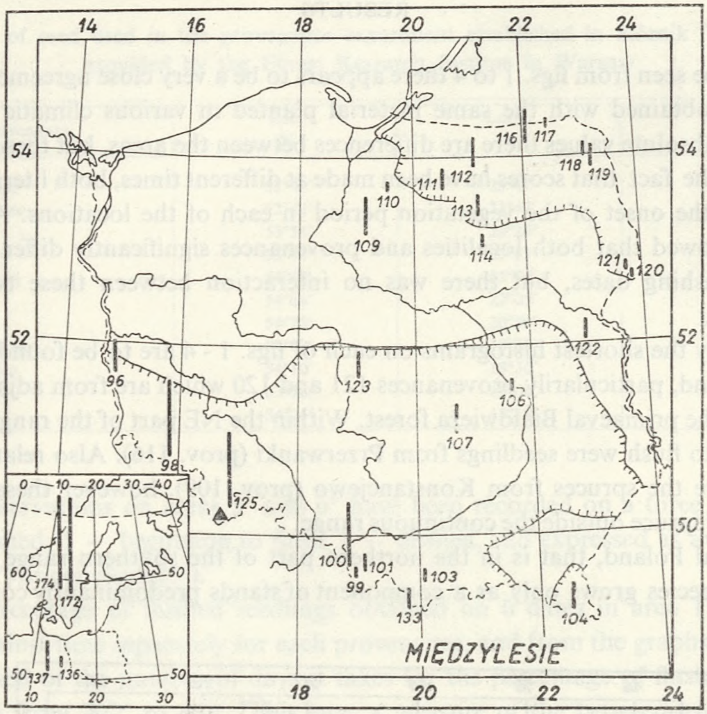

Fig. 2. Flushing time of spruce of various provenances measured as the percentage of flushed seedlings on the 12th of May 1971 in the experimental area in Międzylesie (▲). Length of histograms corresponds to the percentage, their bases to the sites of seed collection and the numbers define provenances as in table 1

other species, the spruce provenances are also characterized by relatively late flushing (prov. 106, 107, 122, 123).

Spruce from the mountains along the southern boundary of Poland is generally early flushing. This is particularily so for spruce from the Sudety Mts. (prov. 98 and 125). However spruce from Istebna (prov. 99) is rather late flushing. To a lesser extent this is also true for adjacent Rycerka (prov. 101) but not for adjacent Wisła (prov. 100). That general region obviously requires more detailed studies on the variability in flushing time.

The low altitude provenance from the Nysa valley, Brody (prov. 96) is slightly later flushing than the Sudetan provenances and generally similar to the outlier provenance from Konstancjewo (prov. 109).

From comparison with the foreign spruces used in the experiment it can be seen that the Scandinavian provenances are considerably earlier flushing than ours. The provenances from the southern part of the German Democratic Republic are generally late flushing. In particular the provenance from Neuwernsdorf (prov. 136) is comparable to our Białowieża spruce and the Carlsfeld spruce (prov. 137) flushes somewhat earlier, more like our Brody provenance (prov. 96).

From fig. 5 it can be seen that generally there is not much difference between

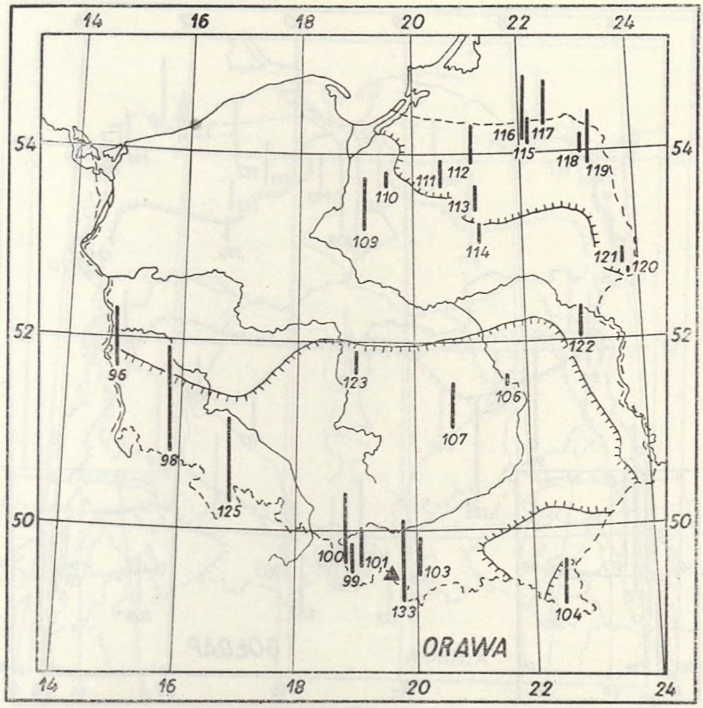

Fig. 3. Flushing time of spruce of various provenances measured as the percentage of flushed seedlings on the 17th of May 1971 in the experimental area in Orawa (▲). Length of histograms corresponds to the percentage, their bases to the sites of seed collection and the numbers define provenances as in table 1

provenances in the within provenance variability of flushing dates. It generally appears that the later flushing provenances within each part of the range of spruce (120, 121, 118; 99, 136; 106, 107) need a shorter time for all the seedlings to attain the flushed condition and the earlier flushing ones take longer. There are however some exceptions, as for example one of the early flushing Scandinavian provenances (prov. 172) needs a very short time for all the seedlings to flush. Possibly this seed lot was a progeny from only one tree. We have no data on that (table 1). In this character the overall difference between the southern and north-eastern parts of the species range is not observable, while in the flushing date itself it is obvious.

On the average it took the spruces in Kórnik 16.1 days to increase the flushing percentage from 20% to 80%, or 3.73% daily. Assuming the same rate in the other localities and extrapolating the observed values to the presumed date on which 50% of the seedlings were flushed it was found that in Kórnik it was the 9th of May, in Międzylesie the 19th of May, in Gołdap the 21st of May and in Orawa on the 22 nd of May.

The observations made on the spruce provenance experiment set up from material provided by the Forest Research Institute (fig. 6) generally confirm the results reported earlier for the same material (Tyszkiewicz 1968) and the results reported

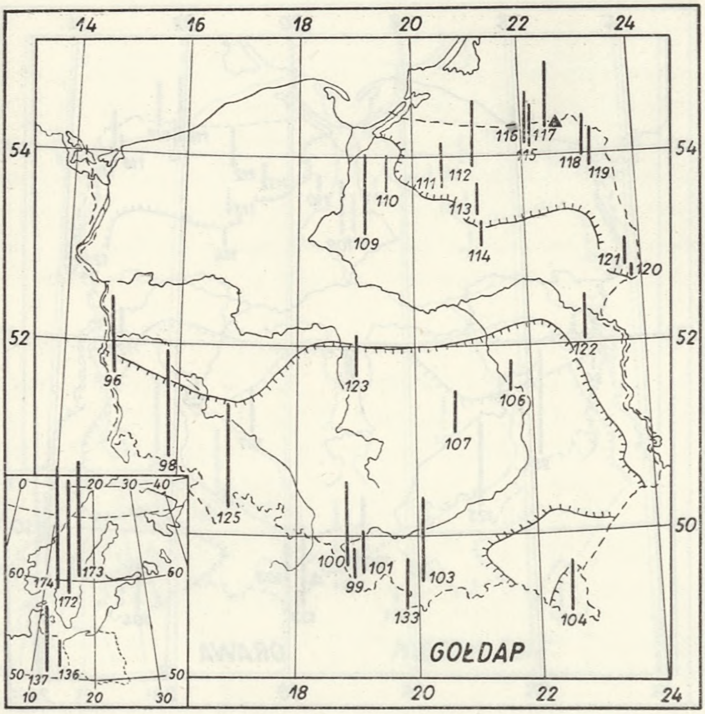

Fig. 4. Flushing time of spruce of various provenances measured as the percentage of flushed seedlings on the 19th of May 1971 in the experimental area in Gołdap (▲). Length of histograms corresponds to the percentage, their bases to the sites of seed collection and the numbers define provenances as in table 1

above. The indiginous provenances form NE Poland are late flushing and the introduced ones growing near the mouth of the Vistula are much earlier flushing.

The observations made in the seed orchard (fig. 7) do not add much new information. Spruces form the mountains in southern Poland are earlier flushing than the spruces form the NE part of the country. Spruce from Przerwanki is here again much earlier flushing than the spruce from the Białowieża region.

DISCUSSION

From the results presented above it is obvious that spruce trees growing in various climatic conditions flush in the spring at different times not only because the external climatic stimulus comes at a different time, but also because the trees are adapted to flush at various times in relation to the stimulus. Lack of significant interaction between provenances and localities in the experiment reported above would tend to suggest that flushing time in spruces of all provenances is adapted to the same stimulus, but in different time relation to it. If the adaptation were to different stimuli for various provenances the response in various localities would be somewhat different, depending on the sequence of weather phenomena developing

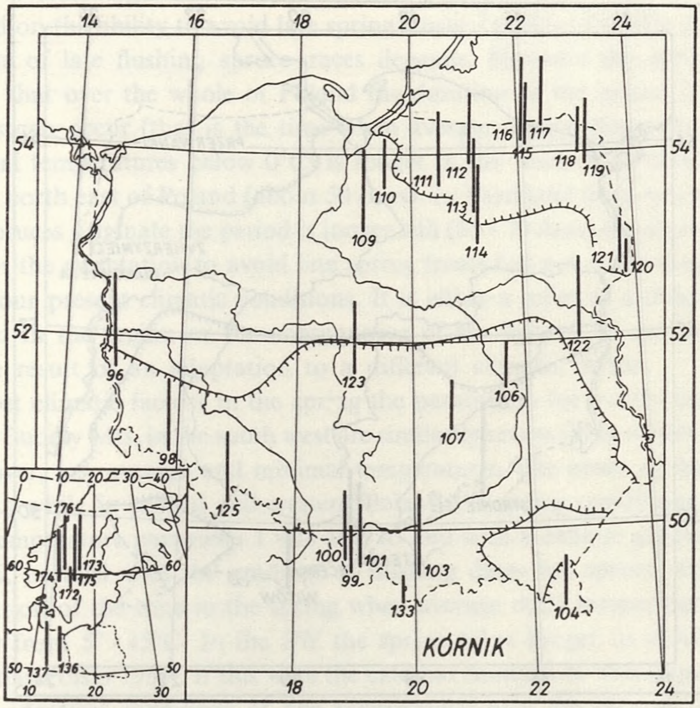

Fig. 5. Rate of flushing of various provenances as measured in the experimental area in Kórnik. The length of the histograms corresponds to the number of days it took for the percentage of flushed seedlings to increase from 20% to 80%, their bases to the sites of seed collection and the numbers define provenances as in table 1

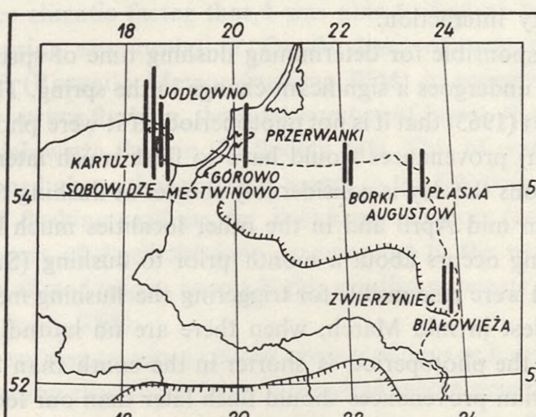

Fig. 6. Flushing of spruce of various provenances from NE Poland evaluated on the 7 - 8th of May 1971 as the degree of flushing of each seedling using a three point scale, on an experimental area in Kórnik. Length of the histograms corresponds to the flushing score, their bases to the sites of seed collection and provenance names are as in table 2

Fig. 7. Flushing of spruce grafts on a seed orchard in Kórnik averaged per Forest District from which scions were collected, as measured on the 5th of May using a three point scale. The length of the histograms corresponds to the flushing score, their bases to the sites of scion collection and the origin names are as in table 3

in each locality during the 1971 spring, and this would be reflected as a significant provenance × locality interaction.

The stimulus responsible for determining flushing time of spruce must be some climatic factor that undergoes a significant change in the spring. The results confirm the view of Langlet (1963) that it is not photoperiod. If it were photoperiod the northern (Scandinavian) provenances would have to flush much later than local ones, since in our conditions the day is considerably shorter at flushing time. Bud swelling started in Kórnik in mid April and in the other localities much later. Respiration increase in the spring occurs about a month prior to flushing (Saetersdal 1956). Thus if photoperiod were responsible for triggering the flushing mechanism it would operate at the earliest in mid March, when there are no latitudinal differences in photoperiod. Later the photoperiod is shorter in the south than in the north and therefore Scandinavian provenances should flush later than our local ones.

Possibly some temperature factor is the responsible stimulus. It is noteworthy that spruces from the more Atlantic climate of the Sudety Mts. or of Scandinavia appear to require less warmth to start flushing than do the spruces from the more continental climate of Białowieża. In other words adaptation to more severe climatic conditions would not depend on making do with less warmth but on requireing more of it to start vegetation. The evolutionary usefulness of such an adaptation may depend on the ability to avoid late spring frosts. On this of course also the economic value of late flushing spruce races depends. However the paradox of the situation is that over the whole of Poland the duration of the period in the spring when frosts can occur (that is the time when average temperatures are above 0°C and minimal temperatures below 0°C) is longer in the south west (about 60 days) than in the north east of Poland (about 50 days). In Värmland from where our Scandinavian spruces originate the period is longer still (65 - 70 days) (Walter and Lieth 1960). Thus the adaptation to avoid late spring frosts has not evolved under the influence of our present climatic conditions. It is either a relict of a different climate that existed in the region or the consequence of the history of spruce migration, or else the result of an adaptation to a different climatic factor.

For most climatic factors in the spring the parameters for north-eastern Poland and for the Sudety Mts. in the south west are similarily severe (long winter, persistence of snow cover, low average and minimal temperatures, late onset of the vegetation period, etc.) while in central and western Poland the spring conditions are milder. The only temperature parameter I was able to find with a definite gradient from the SW to NE, parallel with the gradient of flushing dates for spruce reported here, is the duration of the time in the spring when average daily temperatures are from 0° - 5°C or from 5° - 15°C. In the SW the spring takes longer to develop, than in the NE (Atlas Polski 1954). If this were the external stimulus to which spruce is adapted, in the identical conditions of one experimental area the spruces from regions where spring is shorter would flush as soon as temperatures increase while those adapted to more prolonged spring would be less prone to immediate flushing. Indeed the seedlings of the Białowieża provenances took less time to attain the flushed condition than the Sudetan spruce (fig. 5), but the reason why they generally flushed later than the Sudetan spruce remains unanwsered.

The only other climatic factor that I was able to find as having a SW — NE gradient in the spring was insolation. On the basis of meteorological data for 5 years, 1959 - 1963 (Roczniki Meteorologiczne PIM) it appears that in April, the crucial month for spruce flushing, the total number of hours of sunshine is considerably greater in Białowieża than in the Sudety Mts. This of course parallels the information mentioned above that spring is longer in the SW than in the NE. A correlation analysis of flushing earliness for Polish provenances (average over the four localities) with hours of April sunshine as measured in the nearest meteorological station to the site of seed origin, gave a highly significant negative value of the correlation coefficient ($r = -0.68$).

If for flushing spruces require a certain number of days or hours of direct insolation it is hardly surprising that those from Białowieża where generally April insolation is greater will flush later in any set of conditions than spruces from the Sudety Mts. adapted to a less sunny April.

Wareing (1953) has reported that bud scales of *Fagus silvatica* L. have a light transmissivness of about 0.7%. Assuming that spruce bud scales are similarily protective it can well be imagined that direct insolation is essential for the external light stimulus to reach and photochemically activate the tissues that are to start growing first in the spring. It is of course well known from nursery practice that shading will delay the flushing of spruce. However shading not only reduces insolation but also reduces the temperature.

In any case insolation by itself is obviously insufficient. In the winter long periods of clear skies occur and buds do not flush. Thus the flushing mechanism must also be controlled by a complex of factors including temperature some threshold value of which must be first attained before the sunshine factor could be of importance.

The early flushing spruces from the Vistula delta (fig. 6) obviously do not fit the pattern of distribution. April insolation in that region is comparable to that in NE Poland and therefore spruces growing there do not fit the correlation of flushing with April sunshine. The view of Tyszkiewicz (1968) that they were introduced from some distant locality, such as SW Germany, is therefore probably correct.

It was noted that spruce from Konstancjewo (prov. 109) and Brody (prov. 96) have similar flushing rates in spite of being geographically separated by the spruceless zone. This is in agreement with the results of our studies on the morphology of cones (Chylarecki and Giertych 1969) that have shown these two populations to be closely related.

Also Przerwanki (prov. 116), the provenance that flushes too early compared with adjacent ones was shown by the cone morphology study to be more related to the spruce from the mountain regions in southern Poland than to spruce from the NE part of the range. Possibly it is not indiginous. In cone morphology the Białowieża spruce (prov. 120 and 121) was found to be related to spruce from Garbatka (prov. 106) and Bliżyn (prov. 107). The similarity of flushing rates appears to support that.

Thus it appears that besides adaptation to the present climatic factors, such as April insolation, the variability of flushing times is to some extent dependent on the migratory history of spruce, both natural and caused by human intervention.

As already mentioned, the exceptional value of spruce from Istebna and the considerable variability in flushing times for spruces in adjacent regions make it imperative to study the general region more closely in this respect. Also the extent of the exceptionally late flushing spruce from Białowieża requires further investigation.

SUMMARY

Observations were conducted in the spring of 1971 on the flushing time and rate on spruces of various Polish origins growing in 6 experimental areas; major provenance experiments in Kórnik, Gołdap, Orawa and Międzylesie, a smaller provenance experiment in Kórnik, and a seed orchard in Kórnik. In all these experiments the same results were obtained. Spruce from NE Poland is late flushing, from central Poland relatively late, from the mountain regions in the south early and from the Sudety Mts. in the SW very early. Spruce from Istebna in contrast to some of the adjacent origins is relatively late flushing. Scandinavian provenances included in

the experiments were extremely early flushing and those from DDR rather late flushing.

Of the climatic factors operating in the spring that could be responsible for activating growth in buds only one appears to correlate with flushing time — namely April sunshine. The NE provenances are adapted to clearer skies and therefore once the threshold temperature is reached they appear to require more insolation than SW provenances in order to commence growth.

Some similarities in flushing times between certain provenances, correlate with similarities in cone morphology reported earlier and therefore are presumably a reflection of the migratory history of spruce populations.

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MACIEJ GIERTYCH

Zróżnicowanie terminów wiosennego otwierania się pączków u świerka (Picea abies (L.) Karst.) polskich proweniencji

Streszczenie

Wiosną 1971 r. dokonano obserwacji otwierania się pączków u świerków różnych polskich pochodzeń rosnących na 6 powierzchniach doświadczalnych; duże doświadczenie proweniencyjne w Kórniku, w Gołdapi, na Orawie i w Międzylesiu, mniejsze doświadczenie proweniencyjne w Kórniku oraz plantacja nasienna w Kórniku. Na wszystkich tych powierzchniach otrzymano zasadniczo te same wyniki. Świerk z Polski północno-wschodniej rozpoczynał wegetację późno, z Polski środkowej stosunkowo późno, z terenów górskich wcześnie, a z Sudetów bardzo wcześnie. Świerk z Istebnej, w odróżnieniu od świerka z sąsiednich terenów, rozpoczynał wegetację stosunkowo późno. Świerk z pochodzeń skandynawskich użyty w doświadczeniach rozwijał pączki bardzo wcześnie, a świerk z NRD raczej późno.

Z czynników klimatycznych okresu wiosny, które mogłyby być odpowiedzialne za aktywację wzrostu pączków, tylko jeden wydaje się korelować z terminem rozpoczęcia wegetacji, a mianowicie ilość godzin nasłonecznienia w kwietniu. Proweniencje z Polski północno-wschodniej są przystosowane do mniej chmurnego nieba i dlatego gdy osiągnięty zostaje jakiś próg temperaturowy, wydają się one wymagać większego nasłonecznienia, by rozpocząć wzrost, niż świerki sudeckie.

Podobieństwo czasu wiosennego otwierania się pączków u niektórych prowieniencji koreluje z podobieństwem w morfologii szyszek, opracowanej wcześniej, co sugeruje przypuszczalny związek z historią migracji populacji świerkowych.

МАЦЕЙ ГЕРТЫХ

Дифференциация сроков весеннего распускания почек у ели (Picea abies (L.) Karst.) польского происхождения

Резюме

Весной 1971 г. произведены были наблюдения за распусканием почек ели разного польского происхождения, растущей на 6 опытных площадях: большое исследование происхождения в Курнике, в Голдапи, на Ораве и в Мендзылесье, меньшее исследование происхождения в Курнике и семенная плантация в Курнике. На всех этих площадях получены в основном одни и те же результаты. Ель из северо-восточной Польши начинала вегетацию поздно, из средней Польши — сравнительно поздно, с горных площадей — рано, а судетская — очень рано. Ель из Истебной, в отличие от ели с соседних площадей, начинала вегетацию сравнительно поздно. Ель скандинавского происхождения, использованная в опытах, распускала почки очень рано а ель из ГДР — более поздно.

Из климатических факторов весеннего периода, которые могли бы повлиять на активацию развития почек, кажется, только один коррелирует со сроком начала вегетации, а именно: количество часов инсоляции в апреле. Ель происхождения из северо-восточной Польши приспособлена к менее пахмурному небу и поэтому, когда достигается определённая температурная граница, она, кажется, требует большей инсоляции для начала развития, чем судетская ель.

Сходство весеннего времени рахпускания почек у некоторых происхождений ели коррелирует со сходством в морфологии шишек, разработанной раньше, что заставляет предполагать связь с историей миграции популяции ели.

Rozwijający się kwiat magnolii Thompsona (*Magnolia* × *thompsoniana* Sarg.) Fot. K. Jakusz