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TADEUSZ PRZYBYLSKI

Variability of Scots pine (*Pinus silvestris* L.) of Polish provenances

INTRODUCTION

Scots pine is the most important species for Polish forestry since it represents 73.5% (Białobok 1970) of our forests. In no other country has this species so dominant a position. At the same time it is also the most valuable forest forming species in Europe. This is the result of several causes. The wood of Scots pine is of high value suitable for various uses, the tree is adapted to relatively poor site conditions and as a result the species does not compete for land with agriculture and finally it has the widest distribution of all pines, extending from Spain to the Far East and from Lapland to northern Turkey. (Critchfield and Little 1967). Since it occurs in regions characterized by considerable climatic differences (seed climate-diagrams fig. 1) within the species several taxonomic units of various rank have developed. Besides, the migratory history of the species has resulted in that its various populations have a different degree of adaptation to the climatic conditions presently prevailing in various parts of its range. In some regions Scots pine has probably survived the whole of the Quaternary period, while through most of the present range the actual occurrence of the species varied with development and withdrawal of the Pleistocene glaciers. Where in similar conditions a population exists for tens or hundreds of millenia a far reaching ecological adaptation could have developed resulting in a narrowing of the genetic variability. On the other hand the ability to become adapted to conditions with a greater amplitude of climatic and pedological conditions permits migration, and therefore populations that occupy a region for a relatively short time are characterized by greater biological dynamics and usually also greater variability, greater than is typical for stable relict populations.

In order to determine the present variability within Scots pine it is very important to establish where were the refugia in which pine has survived the glaciation periods during the Qaternary period. According to Mirov (1967) since the Tertiary pine has survived in Portugal, in France and on the Crimea. Nordhagen (1935, after Mirov 1967) does not exclude the possibility that the glacial period could have also been survived by small pine populations in Scandinavia, in the British Isles and also in the Carpathians (Bertch 1951, after Mirov 1967).

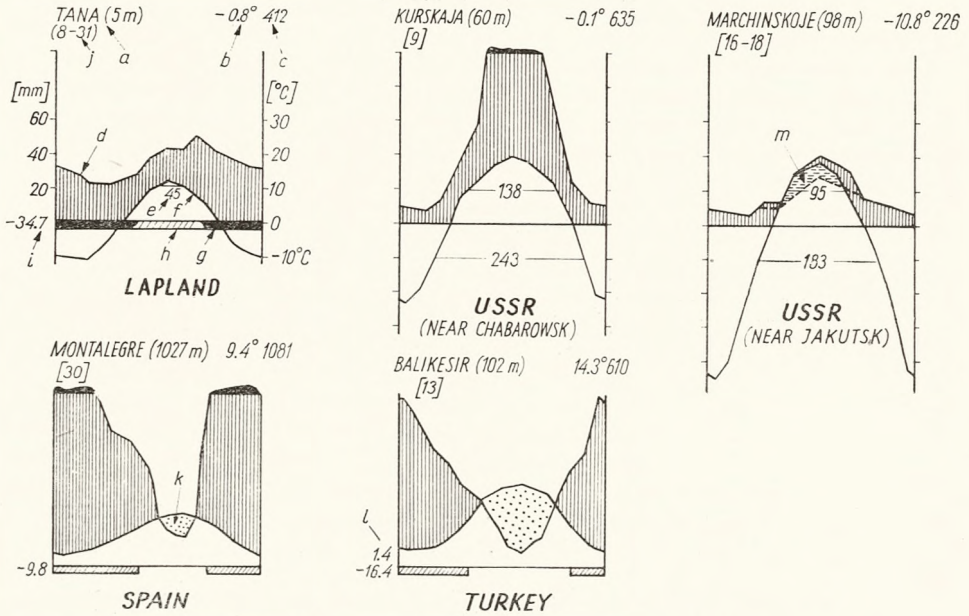

Fig. 1. Climate diagrams for extremal regions of Scots pine occurrence
a - elevation, *b* - mean annual temperature, *c* - mean annual precipitation, *d* - curve of mean monthly precipitation, *e* - no. of days with temperature above 10°C, *f* - curve of mean monthly temperatures, *g* - period with minimal daily temperature below 0°C, *h* - period with the absolute minimal temperatare below 0°C, *i* - absolute minimal temperature, *j* - number of years of observations, *k* - period of draught, *l* - mean daily minimum of the coldest month, *m* - curve of precipitation deficiency (designates the period of draught).

In order to study the variability of Scots pine in Poland it is more important to know the history of its range in eastern Europe and in western Asia. According to Mirov (1967) Pleistocene refugia have been located in south-western Siberia, and possibly also in the part of the Central Russian Lowland that was not covered by ice. From these regions Scots pine has migrated as the glaciers receded, since in early Holocene its range covered only half of the region which is taken by it now. One of the central regions of its occurrence was the basin of the central and upper Dniepr river and the regions around the Gulf of Finland (Mirov 1967).

In Poland Scots pine has occurred during the Kromerian and Masovian interglacial periods, but probably it is only since the Eem period that it is possible to speak of a continuity of occurrence of local pine populations in Poland (Staszkiewicz 1970). Scots pine has survived the period of the last glaciation in the south of the country. During the interstadial periods at the end of the Pleistocene (Bölling and Alleröd) the range expanded and then shrunk again, pine being always the pioneer species (Środoń 1959) so that after the final retreat of glaciers from Poland pine covered the whole area. On the basis of pollen counts it is believed that pine had reached a maximum of its occurrence in the Boreal period, that is 8300 to 7150 B. C. (Białobok 1970).

Staszkiewicz (1970) has suggested on the basis of biometrical studies of cones that pine of the *meridionalis* type found in the Tatras, has arrived here in the sub-Boreal period from south-western Europe, which is also claimed by Szafer (1966)

while the type *subcarpatica*, that occurs in the valley of Nowy Targ seems to originate rather from the eastern Carpathians. Pine in the north-eastern parts of the country is related to the pine from the Scandinavian region (Wright and Bull 1963) and has probably arrived in Poland from the east. Also its relation to the forms typical for Central Europe (Wright and Bull 1963) would seem to indicate that it was also under the genetic influence of the races and ecotypes formed in western Europe.

As a result of the considerable intermixing of pine populations migrating into the post-glacial regions from various directions, and therefore having various hereditary properties, the pine presently occupying Poland is genetically diverse, it is not however possible to delimit the ranges of the various races or taxonomic units within the species. The deciphering of these ranges is also hindered by the fact that from the end of the fourth millenium B. C. the influence of man on our forest cover has been considerable (Białobok 1970).

Organized silviculture, which begun at the turn of the XVIII and XIX centuries has to some extent changed the specific composition of our primaeval forests. As a result of the introduction of foreign planting material the original distribution of native populations has been to some extent altered. Deforestation for agricultural purposes took place primarily in regions where the soils are rich, that is covered by forests composed of species having greater demands on the site than pine. This has increased the percentage of pine in our forests, so that according to calculations made by Plater in 1827 the value for Central Poland was 82% (Białobok 1970). An analogous situation existed also in other regions of Poland.

The historical factors mentioned above, concerning geology, history of the species and the development of human communities result in it being very difficult to describe the variability of Scots pine on such a relatively small area as that of our country. Also a synthetic monograph on the systematics of Scots pine throughout its total range is also lacking. The extensive descriptions mentioned in the Floras of Hegi or Novak (1953) recognize the existence of subspecies and other taxa of lower rank, and the monograph of Pravdin (1964) contains an original approach to the subject, however their views are not concurrent and therefore the problem still remains open.

REVIEW OF STUDIES CONDUCTED TO DATE

Starting about 30 years ago an increasing number of reports are being published concerning provenance experiments conducted on a large scale throughout the world. Initially the experiments were being laid out rather freely which considerably reduced the value of results obtained from them. Presently, as a result of the development of experimental desings and statistical treatment of data an increasing amount of reliable information about variability in the species is being obtained.

Some of the studies based on material originating from large areas attempt a delimitation of races on the basis of various characters. As an example one can

mention the papers of Wright and Baldwin (1957), Wright and Bull (1963), Brown (1969), Khalil (1969) and King (1965) who have reported on provenance experiments established in the United States of North America and a paper by Patlaj (1965) who has summarized the results of experiments conducted in Russia and the Ukraine. Age of the plants on which the various characters have been measured, such as height, colour and length of needles, time of formation of secondary needles on seedlings, form of stem, the root system etc. has varied from a few years to a dozen or so. Results of the studies have been subjected to mathematical analyses and in this way the races of pines occurring in defined regions have been delimited (Giertych 1970). However this is a division that indicates differences between populations occurring in regions far removed from each other, and is based primarily on characters that are of value for forest production. The variability of the species should rather be of value as an indicator. Characters that differentiate races should indicate populations that are of value from the point of view of their productivity and wood quality.

In some of the studies conducted in France (Lacaze 1964) and Italy (Allegri and Morandini 1949) it is clearly stated that provenances should define certain regions from which valuable seed should be imported. In a similar fashion the purposes of provenance studies are formulated by Lines (1965) who seens them as being divisible into two stages. The first one should aim at recognizing the general scale of species variability throughout its range. The second stage should comprise more detailed studies within a subregion in order to determine the origin of races that are suitable for economically justifiable introduction. The selection and congestion of points of seed collection, that is of provenances, depends according to Lines on the ecology of the given species and the type of its range.

The studies of Wright and collaborators (1957, 1963, 1966), King (1965), Khalil (1969), Patlaj (1965) and others, which are similar in character fulfill the first of the objectives stipulated by Lines (1965). They determine the outline of the regions of occurrence of various pine races. Giertych (1970) has summarized the available reports on divisions of the total range of Scots pine into 24 regions occupied by races that somewhat differ from each other to a varying extent.

Out of these 24 races Wright and Bull (1963) consider one to be characteristic for Poland. Recent provenance studies have confirmed the theory that has been formulated on the basis of observations and comparisons by many foresters. For example Gross (1932) has described from the Mazury region a race of pine that is narrow crowned, with short, thin branches and a straight stem, that reaches considerable heights, and therefore is very valuable from the point of view of forest economy. This is in obvious analogy to the views of a pioneer of provenance studies, Vilmorin who wrote about the „Riga pine". Rubner (1959) in his study of pine races also mentions the Mazury pine (Ostpreussische Kiefer) and he believes that it also occurs in the Silesia.

Patlaj (1965) has described the pine from regions adjacent to our frontiers where the races are similar to ours. Pine from the Minsk region is characterized by a good production of the volume of timber, similarly as the pine from the Baltic regions,

besides it self-pruns readily and has a good survival percentage. Since these characters were observable in the experimental conditions of the Ukraine it has to be considered that the pine has a considerable potentatial for adaptation, similarily as pine from the analogous regions in the north east of our country.

The studies of Wright and colaborators (1957, 1963, 1966 and others) are based primarily on 2 experimental series, one organized by IUFRO in 1938 as a large international experiment (Veen 1953) and the other an experiment undertaken in 1959 by foresters in the USA on pine of 122 provenances from a major part of the range of the species.

The material from both the former and latter series confirm the distinctiveness of the Polish pine provenances. In 1938 seeds have been collected from Supraśl (NE), Bolewice (W), Rychtal (S), Ruciane (N) and Brody (SW) in the regions now within the frontiers of Poland. According to Wright and Baldwin (1957) pines originating from this region form the „ecotype *G*" into which they also include the provenance from Mustejki, Lubmol and Susk, that is from regions just east of our frontiers. The measurements covered the height of seedlings, length of needles, thickness of branches and crookedness of the trunk and also the colour of the needles was noted. In general the „ecotype *G*" was characterized by good growth, better than the pines from Lithuania and Latvia „ecotype *F*". The conclusions were based on 17 year old material.

Experiments of the second series, begun in 1959 in the USA have in all 7 Polish provenances, described by numbers and geographic coordinates but not by names. They are:

Prov. No.	Lat. N.	Long. E.	Name
211	53.8	20.3	Tabórz
317	53.7	20.5	Krutyń
558	51.5	21.5	Pionki
559	51.4	19.9	Tomaszów Maz.
560	52.4	23.8	Białowieża Forest
561	52.4	23.8	Białowieża Forest
562	51.1	20.8	Bliżyn

Material from these origins has entered into many experimental areas in various parts of USA. The seedlings were studied by several authors, who have made observations on them concerning various characters. The first results were reported by Wright and Bull (1963). They have investigated the experiments in Michigan and on the basis of seed weight, seedling height, length and colour of needles, type of buds and tendency to have a second flush in three year old seedlings they have divided the provenances into groups analysing the results by mathematical methods. The populations of pines from Poland have been recognized as a separate group *F* related to the Scandinavian group *C* from which they differed in Lammas growth, and to the German group *G* (Germany, Czechoslovakia, Rumunia and Ukraine) from which they differ in forming secondary foliage somewhat earlier and turn colours in the fall more intensly.

Studies on the materials from the same experimental series have been continued also in later years on other experimental areas and on other characters. The further studies however included only the seedlings from the Mazury region of Poland (nos. 211 and 317), however the reported results do not affect the original divisions of the range proposed by Wright and Bull (1953). King (1965a and b) has studied height, and the length and colour of needles. Pines of both the Polish provenances grow well on all the 7 experimental areas, they attain dimentions above average for the whole experiment, however the characters are relatively variable and it is only after a joint treatment of several features that it is possible to recognize groups of provenances.

Similar conclusions have been reached by Wright and others (1966) who maintain the pines from Poland as a separate group. In this case also only the two provenances from the Mazury region (nos. 211 and 317) have been studied.

The chemical analyses of seedlings (Steinbeck 1966) have indicated that the variability between experimental areas was greater than between provenences.

Three years later further studies were reported containing data from the same experimental series. Brown (1969) has studied the root systems of seedlings in the greenhouse. He observed a correlation between the length of roots and the mean annual temperature at the site of seed origin. The seedlings from the Mazury region have had a well developed root system.

Khalil (1969) has studied height of the pines, taking into consideration also some of the phenological data. In spite of corrections in the previously made divisions of pines into races, as represented in North American literature concerning pine provenances, he has still maintained the Polish provenances as a separate group, in agreement with the earlier reports.

Studies on variability of pine seedlings from the European part of its range have been also attempted in France (de Ferre and de Meric 1963). A correlation between the number of cotyledons and the number of vascular bundles in the roots has indicated the existence of races. The Polish provenences (from Forest Districts Rozpuda, Głębokie (NE), Radawnica, Dłużek and Bartel (N)) have been included in the central European race.

Besides the studies covering such a large range and attempting to systematize taxa within the species on the variety or race level there are many descriptions in the literature of individual provenances based on observations conducted on experiments containing a more limited initial material.

Erteld (1950) has described the results of German studies. He refers to the works of Wiedemann published in 1930 on the results of experiments in Chorin. His own later measurements have confirmed the opinion that pines from the Mazury region though somewhat poorer in growth than those from the Brandenburg region have a better form of the trunk. In the experimental area in Finowtal there are represented within the international experiment of IUFRO from 1938, such Polish provenances as Rychtal, Brody (SW) and Ruciane (N). It appears that the best pines in height are those from Ruciane, which also have the greatest diameters. The other Polish populations are also distinctly good volume producers and have high quality trees.

They are also characterized by longer needles. Biebelriether (1964) has analyzed the root system of pines of various origin being over 20 years old. He has found a correlation between the quality of the boles and the depth and ramification of the root-systems. The pines from the Mazury region again proved to be best here. The high quality of pines from that region was also reported by Schmidt (1943) and Troeger (1960).

The French provenance experiments on pine have been described by Lacaze (1964). Of the Polish provenances he had the pines from Ruciane (N) and Brody (SW). Both these populations when grown in French conditions have fast growing good quality trees. For this reason Lacaze recommends that pine seed should be imported from Poland.

In Czechoslovakia the international provenance experiments of 1938 have been reported upon by Vincent and Polnar (1953). The pines from Poland have been represented there by the provenances from Bolewice (W), Brody (SW), Supraśl (NE) and Krutyń (N). The pines from Bolewice proved best in growth characters and as regards survival of seedlings, while the pines from Supraśl and Krutyń were medium as regards mortality and grew poorly compared with others.

Also in Turkey studies have been undertaken on pines of various origin. The first results have been published 20 years ago (Saatçioglu 1951). After 16 years another paper on the same subject appeared (Saatçioglu 1967). Among the studied provenances also two Polish ones were included, from Rychtal (S) and from Krutyń (N). The pines from the Mazury region (Krutyń) proved to have good growth increments, somewhat lower than the pines from southern Wielkopolska (Rychtal), but they had a considerably better survival of 79.6% as against 44.1% for the Rychtal provenance. Compared with the other provenances used in that study the Polish ones proved to be of high silvicultural value, which would tend to indicate that they have a considerable potential for adaptation. This was also confirmed by the studies conducted in Romania (Lazarescu et al. 1961).

Thus studies of considerable international scope, which have had materials from Poland generally indicate that the provenances from our country represent a separate group (race, ecotype, etc.) which appears to be related both to the populations east and north east of our frontiers and to populations in Germany (Wright and collaborators 1957, 1963, 1966). On the other hand experiments conducted on a smaller scale generally show that relative to other provenances the Polish ones have considerable silvicultural value. In the first type of studies discussed here, the characteristic of "Polish" race of pine is usually based on only a few, frequently only two samples primarily from the north-eastern part of Poland. The second type of studies investigate only the practical utility of provenances the general value of which is alredy known to silviculturalists. This is all the more an argument for undertaking detailed studies on the variability of pine in Poland, both from the point of view of intra-specific taxonomy and for the needs of the rational modern forest economy.

In any case this problem has been of interest to indiginous investigators for a long time. Pol in his geographical studies conducted in the middle of the last century has been writing about the variability and form of pine (1851, after Szafer 1916).

Suchecki (1925) in his monograph on pine has pointed out the differences between the pine from the north of the country and from the south. Extensive biometrical studies on the species have been undertaken by Sokołowski (1931). He has not described races of pine as was his original intention, but only gave a number of suggestions concerning methods. Jasieński (1934) has been studying the structure and increments in two 50 year old pine stands of indiginous and "Riga" origin which have been growing in the vicinity of Warsaw. The indiginous pine has greater growth increments and the Riga pine he has described as a "fine grained race".

The pines from the Tatra and Pieniny Mts. have been studied by Zajączkowski (1949). He has demonstrated a greater slenderness of form in the mountain pines than is the case with lowland pines. The needles were shorter, lighter coloured and the seeds were heavier.

Chojnacki (1965) has studied the variability of 7- and 10-year old pine seedlings and Chmielewski and others (1966) have investigated one year old seedlings. The latter authors have established that seedlings originating from the Mazury-Podlasie vegetational region of Poland significantly exceed in height the remaining provenances.

Detailed studies on the form of Pines growing in northeastern Poland have been undertaken by Józefaciukowa (1968). She has recognized two types of crowns: 1. narrow, long, conical, and 2. rounded, wide and shorter. Both these types occur simultaneously, however the percentage of the narrow crown forms is greater the further towards the north east is the studied stand growing.

Staszkiewicz (1961) has recognized some races of pine on the basis of a biometrical analysis of the cones. According to him *polonica* occurs in the lowlands, *subcarpatica* occurs at the feet of the Tatras in the Nowy Targ valley, *meridionalis* occurs in Koryciska in the Tatras and *suecica* in Łeba on the sea coast.

Physiological and anatomical studies on the mountain and lowland pines have been undertaken by Żelawski (1968, Żelawski and Niwiński 1966). He has established some differences in the number of stomata and a slight difference in the intensity of assimilation.

All these fragmentary informations have been pooled into a certain introductory synthesis (Przybylski 1966). However further studies that would permit the drawing of distribution maps for the ranges of different pine races in Poland are still badly needed. This is the reason why the Institute of Dendrology and Kórnik Arboretum of the Polish Academy of Sciences in Kórnik has decided to udertake the establishement of provenance experiments, the first results of which are being presented in the present paper.

METHODS AND EXPERIMENTAL MATERIAL

The main aim of the studies reported here has been to characterize the variability of Scots pine in Poland, particularily in respect of its genetic differentiation. Sites of seed collection have been so chosen as to have a representation of all the most impor-

tant forest areas of Poland, and the vegetational regions. The differentiation of Poland on the basis of macroclimatic factors is not great compared with amplitude of climatic conditions occurring throughout the range of Scots pine. However there is probably an adaptation of local populations to the conditions of the environment and therefore as far as possible accurate characteristic of the climate in the regions of seed collection and outplanting is essential as a background for the evaluation of results over many years. This problem in the study of forest trees, which are classical perennial plants, is all the more important. For this reason in table 2 data is presented concerning the climatic characteristic of the various regions of Poland considered in the studies reported here.

In fig. 2 the distribution of Polish provenances used in the study is presented. The unevenness of the distribution has several reasons. In particular the greater accumulation of the sites of seed collection in the north-eastern region was deliberate since it is from this region that seeds of best quality pine were primarily collected for

Table 1

List of pine provenances included in the experiment established by the Institute of Dendrology and Kórnik Arboretum

No.	Abbrev. used on labels	Forest District	Forest Region	Prov. no.	Long. E	Lat. N	Alt. in m.
1	BK	Bystrzyca Kłodzka	Wrocław	S-15-162	16°36′	50°17′	580
2	Bo	Bolewice	Poznań	S-08-164	16°03′	52°28′	90
3	Br	Brody	Żary	S-16-163	14°50′	51°46′	80
4	Cz	Czersk	Toruń	S-14-168	17°58′	53°52′	130
5	Dł	Dłużek	Olsztyn	S-07-139	20°39′	53°33′	145
6	JL	Janów Lubelski	Lublin	S-05-154	22°25′	50°40′	250
7	KPN	Kampinoski Park Narodowy	Siedlce	S-11-149	20°41′	52°19′	95
8	Kr	Krutyń	Olsztyn	S-07-141	21°28′	53°31′	150
9	Ku	Kubryk	Wrocław	S-15-160	17°18′	51°23′	160
10	Lu	Lubniewice	Żary	S-16-165	15°16′	52°35′	40
11	Ło	Łomża	Białystok	S-01-144	22°15′	53°05′	208
12	My	Myszyniec	Siedlce	S-11-143	21°12′	53°20′	120
13	Nu	Nurzec	Białystok	S-01-148	23°09′	52°25′	170
14	Ol	Oleszyce	Przemyśl	S-09-156	23°00′	50°15′	220
15	Pa	Parczew	Lublin	S-05-153	22°55′	51°35′	150
16	Pi	Pionki	Radom	S-10-152	21°20′	51°30′	140
17	Pr	Prószków	Opole	S-17-161	17°48′	50°35′	190
18	PPN	Pieniński Park Narodowy	Kraków	S-04-157	19°20′	49°20′	770
19	Rad	Radawnica	Szczecinek	S-12-169	16°58′	53°30′	110
20	Rat	Rataje	Radom	S-10-151	21°05′	51°00′	250
21	Ru	Ruciane	Olsztyn	S-07-140	21°31′	53°51′	145
22	Se	Serwy	Białystok	S-01-145	23°08′	53°51′	130
23	Sm	Smołdzino	Szczecinek	S-12-167	17°29′	54°45′	3
24	Sp	Spała	Łódź	S-06-150	20°10′	51°32′	150
25	St	Stepnica	Szczecin	S-13-166	14°41′	53°40′	4
26	Su	Supraśl	Białystok	S-01-146	23°07′	53°15′	165
27	Tb	Tabórz	Olsztyn	S-07-138	20°00′	53°34′	110
28	WB	Wilcze Bagno	Olsztyn	S-07-142	21°36′	53°32′	120
29	ZwB	Zwierzyniec Białowieski	Białystok	S-01-147	23°45′	52°42′	160
30	ZwL	Zwierzyniec Lubelski	Lublin	S-05-155	23°00′	50°38′	260
31	V-170		Värmland	S-26-170		59°30′	100 - 200
32	V-171		Värmland	S-26-171		59°	0 - 100
33	V-177		Värmland	S-26-177		60°	100 - 200
34	V-178		Värmland	S-26-178		59°30′	200 - 300
35	V-179		Värmland	S-26-179		60°	300 - 400

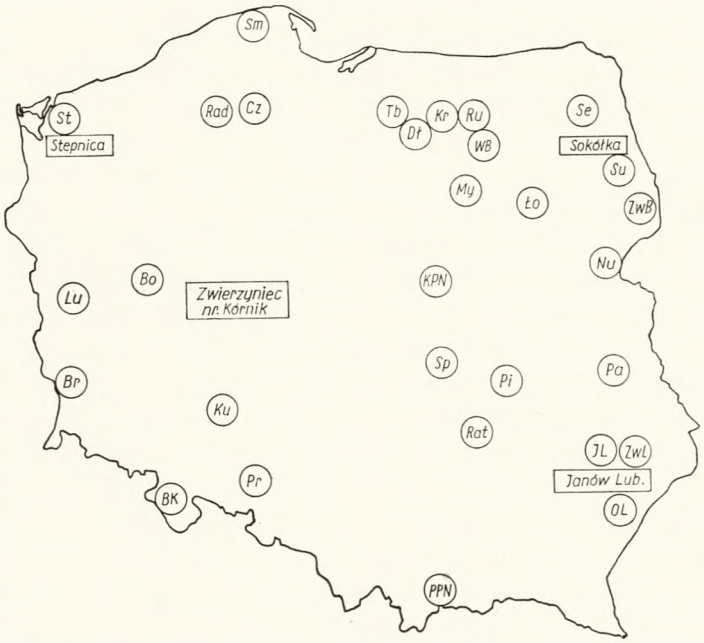

Fig. 2. Distribution of provenances used in the experiment. Abbreviations of the names of provenances are given in circles and in the rectangles names of planting sites are given

the international experiments. The information about the Polish races of pine were primarily based on the material from that region. Thus the region required more detailed studies in order to conform with the international recommendation (Lines 1965) and determine whether the northeastern pine is uniform as regards the studied characters and to establish the limits of distribution of any races that may happen to occur there. In the west and south-western part of the country, where forest management has a long history, and therefore most stands originate from plantings or artificial sowings, it is difficult to find indiginous populations of good quality. On the other hand the populations of pine from the north-eastern part of Poland have been least affected by the activity of man and therefore a greater accumulation of the sites of seed collection there provides the greatest likelihood of characterizing indiginous pine populations. For technical reasons it is not possible to include in an experiment too many studied elements, and therefore the bulk of the effort had to be directed towards the most important region. A further difficulty was caused by a complete absence of seed in certain parts of the country during the collection of materials for studies. For this reason several of the originally planned provenances have not been included in the study. In any case an attempt was made to assure that the experimental material would characterize as far as possible fully the pine population growing within the boundaries of Poland.

A basic unit of the study is a local population for a given point on the map (a Forest District) referred to here as a provenance and entered under the name of the Forest District e.g. "provenance Janów Lubelski". Here a population is meant in the

Table 2

Climatic data about sites of origin of some of the pine populations used in the provenance experiment (according to Kostrowicki, Środowisko geograficzne Polski, 1961)

Provenance	Length of summer in days	Length of winter in days	Range of insolation intensity in kcal (m^2) yr	Annual isotherms at true elev.	July isotherms at true elev.	January isotherms at true elev.	No. of days with av. temp. below 0°	No. of days with min. temp. below 0°	Vegetation season starts	Vegetation season ends	Length of veg. season in days	Duration of snow cover in days	Mean annual precip. in mm.	Frequency of dry months in %
Stepnica	50 - 60	60 - 70	55.0 - 57.5	7.0° - 7.5°	16.5° - 17.0°	−0.5 - −1.0°	20 - 30	90 - 100	1 - 5 IV	5 - 10 IX	210 - 220	40 - 50	500 - 600	60 - 70%
Łeba	50 - 60	70 - 80	55.0 - 57.5	7.0° - 7.5°	16.0° - 16.5°	−0.5 - −1.0°	20 - 30	100 - 110	5 - 10 IV	5 - 10 IX	200 - 210	40 - 50	600 - 700	30 - 40%
Czersk	60 - 70	80 - 90	55.0 - 57.5	6.5° - 7.0°	16.5° - 17.0°	−2.5 - −3.0°	40 - 50	110 - 130	10 IV	25 X - 1 XI	190 - 200	60 - 90	500 - 600	40 - 50%
Krutyń	60 - 70	110	52.5 - 55.0	6.0° - 6.5°	16.5° - 17.0°	−3.5°	50 - 60	130 - 150	5 - 10 IV	25 X - 1 XI	200 - 210	60 - 90	500 - 600	30 - 40%
Łomża	80 - 90	90 - 100	50.0 - 52.5	7.0° - 7.5°	17.5° - 18.0°	−4.0 - −5.0°	40 - 50	110 - 130	5 - 10 IV	25 X - 1 XI	200 - 210	60 - 90	500 - 600	50 - 60%
Serwy	80 - 90	110 - 120	50.0 - 52.5	6.5° - 7.0°	17.5° - 18.0°	−4.5 - −5.0°	50 - 60	130 - 150	5 - 10 IV	25 X	190 - 200	90 - 150	500 - 600	40 - 50%
Białowieża	90 - 100	100 - 110	52.5 - 55.0	6.5° - 7.0°	18.0° - 18.5°	−4.5 - −5.0°	50 - 60	130 - 150	5 - 10 IV	25 X - 1 XI	200 - 210	90 - 150	500 - 600	50 - 60%
Parczew	90 - 100	100 - 110	55.0 - 57.5	7.0° - 7.5°	18.0° - 18.5°	−3.5 - −4.0°	50 - 60	110 - 130	1 - 5 IV	25 X - 1 XI	200 - 210	60 - 90	500 - 600	50 - 60%
Janów Lub.	90 - 100	90 - 100	57.5 - 60.0	7.0° - 7.5°	17.5° - 18.0°	−4.0 - −4.5°	50 - 60	110 - 130	1 - 5 IV	25 X - 1 XI	200 - 210	60 - 90	600 - 700	40 - 50%
Oleszyce	90 - 100	90 - 100	62.5 - 65.0	7.5° - 8.0°	18.0° - 18.5°	−3.5 - −4.0°	50 - 60	110 - 130	28 III - 5 IV	25 X - 1 XI	210 - 220	60 - 90	600 - 700	30 - 40%
Spała	90 - 100	80 - 90	55.0 - 57.5	7.5° - 8.0°	17.5° - 18.0°	−3.0 - −3.5°	30 - 40	100 - 110	1 - 5 IV	25 X - 1 XI	210 - 220	50 - 60	500 - 600	40 - 50%
Pionki	90 - 100	80 - 90	55.0 - 57.5	8.0° - 8.5°	18.5°	−2.5 - −3.0°	40 - 50	110 - 130	1 - 5 IV	25 X - 1 XI	210 - 220	50 - 60	500 - 600	40 - 50%
Pieniny	50 - 60	110 - 120	57.5 - 60.0	5.5° - 6.0°	16.0° - 16.5°	−5.0 - −6.0°	60 - 70	110 - 130	10 IV	25 X	190 - 200	90 - 150	700 - 800	20 - 30%
Bystrzyca Kłodzka	50 - 60	100	57.5 - 60.0	6.5° - 7.0°	17.0°	−2.5 - −3.0°	30 - 40	110 - 130	1 - 5 IV	1 - 5 XI	210 - 220	90 - 150	700 - 800	20 - 30%
Kubryk	90	70	55.0 - 57.5	7.5° - 8.0°	17.5° - 18.0°	−1.5 - −2.0°	30 - 40	90 - 100	25 III - 28 III	1 - 5 XI	210 - 220	30 - 40	600 - 700	50 - 60%
Brody	90 - 100	60	55.0 - 57.5	8.0° - 8.5°	18.0° - 18.5°	−0.5 - −1.0°	20 - 30	90 - 100	25 III - 28 III	5 - 10 XI	220 - 230	30 - 40	600 - 700	50 - 60%
Lubniewice	90 - 100	60	55.0 - 57.5	8.0° - 8.5°	17.5° - 18.0°	−1.0 - −1.5°	20 - 30	90 - 100	28 III - 1 IV	5 - 10 XI	220 - 230	40 - 50	500 - 600	60 - 70%
Kórnik	100 - 110	60 - 70	57.5 - 60.0	8.5° - 9.0°	19.0° - 19.5°	−1.5 - −2,0°	20 - 30	90 - 100	28 III - 1 IV	5 - 10 XI	220 - 230	40 - 50	400 - 500	40 - 50%

mathematical sence, as a collection of individuals having a common character, in this case of pines originating from a given locality (Przybylski 1968).

The criterion on the basis of which a decision was made about the collection of seed from a given stand was that it should be indiginous. The studies are to give information about the natural variability of pine and therefore they should be based on material that represents populations adapted to local conditions of the environment. In each case the indiginuity of the stand was discussed with the authorities of the respective Directorate of the Forest Region and the local Forest Officer. When it was not possible to determine with certainty whether a given stand was indiginous the quality of the stand was used as a criterion. Health and good quality of the trees is an indication that the stand even if it is introduced is adapted to the local environmental conditions. Such situations however were not common similarily as was the case in selecting seed stands.

All the stands taken into consideration from which cones have been collected were of felling age. Most of the seeds were collected from trees felled during normal felling operations, in a few cases however where felling was not envisioned for the particular year after obtaining the consent of the local Forest Officer and the Directorate of the Forest Region, a few randomly selected trees were felled specially for the purpose and cones were collected from them. In this case the recommendations of Lines (1965) who states that a representation of a population should be based on the minimum of 10 trees was accepted with the stipulation that from one three no more than 10% of the total quantity of cones for the given provenance should be collected. In the experimental population the progeny of one mother tree should not exceed 10% of the whole sample. The randomness of the selection of trees for cone collection was especially insisted upon because only in this way can a sample representative for the population be obtained.

From the methodological point of view it is very important that the provenances should be comparable. For this reason all the seeds have been collected from the site conditions of a moist pinewood, taking the necessary data from the working plan. Table 1 contains the relevant information about the studied provenances.

The cones have been collected in the fall of 1965. In all cases the collections have been made personally by staff members of the Institute of Dendrology.

The seeds have been extracted from cones in the Institute and in the spring of 1966 the seeds were sown in randomized blocks with four replicates in the forest nursery of our experimental forest Zwierzyniec. Hand sowing in single rows was employed.

In the spring of 1967 field experiments have been established from the material so prepared.

The experimental design used was a complete block with 8 replicates. Thus every provenance was represented on each experimental area by 8 plots. It was decided to have such a plot size as to have at least one tree left per plot at felling age. A larger size of the plot would unduly increase the size of the whole experiment and unnecessarily increase the volume of work needed to tend the plantations and measure it without increasing substancially the amount of information that the experiment could

yield. Thus 49 plants (7×7) were planted at a 1.2×0.5 m spacing in each plot. In the experimental area in our own Zwierzyniec forest it was possible to keep the regular spacing because the soil has been prepared by the method of full ploughing. On the remaining experimental areas strips have been ploughed as far as possible 1.2 m apart and the pines were planted in the furrows at 0.5 m spacing. The whole experiments have been surrounded by several rows of pines constituting a belt of pine seedlings also one year old but originating from the normal planting stock of the given Forest District. All the experimental areas have been planted on a site of the moist pinewood type, in such conditions as are typical for normal pine plantations. The only variable was the planting stock.

The seedlings have not been selected before planting, in order to obtain full information about the potential of each population. In the spring of 1968 beating up was performed with planting stock held in reserve. Plans of the experimental areas have been published in the Kórnik Arboretum (Przybylski 1968).

Four experimental areas have been established:

1. In the experimental forest Zwierzyniec belonging to the Institute of Dendrology near Kórnik.
2. In Forest District Janów Lubelski (Lublin Forest Region).
3. In Forest District Sokółka (Białystok Forest Region).
4. In Forest District Stepnica (Szczecin Forest Region).

Distribution of the experimental areas in various climatic regions of the country was made in order to determine the degree of adaptation of the pines to various site conditions, to determine the amount of interaction between the provenances and the conditions prevailing in the region where the experimental areas have been established.

A few words are needed here about the nature of the methods employed, that is the actual technique of establishing an experiment. The experimental plantation in Kórnik has been established on a soil that has been completely ploughed over after the stumps from the previous stand that was felled have been grubbed out. The remaining three areas, that is in Janów Lubelski, Sokółka and Stepnica have been planted over in ploughed or hand prepared furrows. In each case the same type of site was chosen, the moist pinewood, according to the official classification, in order to make the conditions for growth as uniform as possible except for the climatic variable.

The mean height of the seedlings after three vegetative periods is presented in fig. 8. which indicates that the experimental plantations differ considerably from each other. The plants growing in Zwierzyniec near Kórnik grow distinctly better than those in Janów Lubelski, Sokółka and Stepnica, and besides their general viability and growth increments are greater than in the other areas. This is the result both of the better preparation of the soil and of the tending given to the plants during the vegetative period. The plantation in Kórnik has been cleared of weeds several times during the growing season with a horse drawn planet, while the other plantations have been given a tending treatment as is normal for the local forestry practice, that is the weeds were being hand scythed. The more difficult conditions for growth have very significantly affected the results obtained in the individual experimental areas.

After the canopies of the pines will meet these differences will probably decline, however presently, in the first part of the seedling life they play a very important role.

From the same seedling material that has been used for the plantings made in the spring of 1966, also a greenhouse experiment has been established on sand cultures. In pots filled with quartz sand 50 seeds were sown. A randomized block design was used with 10 replicates, treating each pot as a plot. After germination the plants were supplied with the nutrient medium of Ingestad (1960 and 1962). In the fall of 1966 the greenhouse experiment was terminated and the seedlings were used to analyse the chemical composition in the dry weight. Also the number of cotyledons per seedling was counted immediately after germination.

After extraction of the cones the length, width and length to the widest part of 50 cones from each provenance have been measured. Also the seeds and seed wings have been measured, 50 per provenance.

METHODS OF MEASUREMENTS AND TREATMENT OF DATA

The studies have been conducted on four experimental areas in the experimental forest Zwierzyniec near Kórnik, in the forest District Janów Lubelski, F. D. Sokółka and F. D. Stepnica, as well as on seedlings from the same seedlots raised in greenhouse conditions on sand cultures. The following characters were investigated:

1. No. of plants per plot.
2. Seedling height.
3. Length of the last annual increment (starting from the second year after planting).
4. No. of lateral buds on the apical shoot.
5. No. of adventitious buds (in the first year after planting out).
6. Percentage of plants with a distinct terminal bud in the first year following planting out in the field.
7. No. of lateral shoots for the last vegetation period in the year observations vere made.
8. Length of lateral shoots.
9. Percentage of plants with Lammas' growth.
10. Percentage of plants affected by Lophodermium pinastri.
11. No. of cotyledons (in the greenhouse experiment).
12. Percentage composition of some mineral components in the dry weight of seedlings (in the greenhouse experiment).
13. Height of the seedling and length of the roots in the greenhouse experiment.

For all the characters except the number of plants per plot (character 1) the average values per plot have been calculated. When calculating the mean number of lateral buds (character 4), adventitious buds (character 5) and lateral shoots (character 7), the joint number of studied elements (buds, shoots) was divided by the number of plants in the plot. When studying the number of cotyledons (character 11) all the seedlings were scored immediately after the seed coats fell and they were classified according to the number of cotyledons per seedling. In this way the total number of cotyledons per pot was obtained and after dividing it by the number of plants in the pot the mean number of cotyledons per seedling was obtained.

Height of seedlings and the length of the annual increments of shoots and roots

(characters 2, 3, 8 and 13) have been measured to the nearest 1 cm. The joint result obtained for each plot or pot in the case of characters 2, 3 and 13 has been divided by the number of plants and in this way the mean value was obtained. In the case of character 8 the total length of the lateral shoots per plot was divided by the total number of these shoots and in this way the mean per plot was obtained.

The percentage of plants with a distinct apical bud (character 6), having Lammas shoots (character 9) and affected by Lohodermium have been obtained by counting the plants with the character and establishing their percentage from their ratio with the actual number of plants per plot.

Character 12, the analyses for potassium (K), calcium (Ca) and sodium (Na) content have been made using a flame photometer of the Flaphokol type (Humphries 1956) and nitrogen (N) was analysed by the Kieldahl method (Piper 1957).

The attack by *Lophodermium* was estimated on the basis of the appearance of the needles. Yellow needles were assumed to be an indication that the plant was attacked by the fungus. This is only an estimation. These results are being supplemented by more accurate phytopathological studies. When making statistical computations the percentage values have been converted to arcsines (Snedecor 1961). The mean values have been subjected to variance analyses and when statistically significant values were obtained in certain cases the test for the significance of the differences was employed (Oktaba 1966).

RESULTS OF THE STUDIES

MEASUREMENTS OF CONES AND SEEDS

Results of these measurements have been presented in table 3. Also the ratio of cone length to width was calculated since it characterizes the slenderness of the cones. In the same table analogous results of measurements and calculations are presented for the seed wings and for the seeds themselves. However the variability of these characters was so small (for seeds and their wings) that it appears to be of no significance.

In the table the provenances are arranged according to decreasing cone length. It appears the longest cones were collected in Serwy and shortest ones in Tabórz. There is no geographic pattern in the distribution of this character. Arrangement of provenances according to one character has little effect on the arrangement according to another one. However the narrowest cones came from Dłużek and they are also characterized by small cone length and a small seed wing. Fig. 3 illustrates the relation of cone length with cone width for the Polish provenances used in the experiment.

GREENHOUSE EXPERIMENTS

The mean number of cotyledons observed on seedlings grown in the sand cultures significantly differentiates the provenances at 0.99 level of significance as indicated by a variance analysis. The results have been plotted onto the map in fig. 4. Clinal

Table 3

Dimentions of cones and seeds (means from 50 measurements)

Provenance	Cones				Seed wings			Seeds		
	length cm	width cm	length to widest part	lenght / width	length cm	width cm	lenght / width	length cm	width cm	lenght / width
Serwy	4.53	2.07	3.30	2.19	1.69	0.53	0.32	0.42	0.23	0.18
Kampinoski Park Narodowy	4.42	2.13	3.12	2.07	1.70	0.55	0.31	0.44	0.25	0.17
Pieniński Park Narodowy	4.40	2.25	3.15	1.95	1.78	0.57	0.31	0.46	0.25	0.18
Smołdzino	4.23	1.94	3.16	2.18	1.67	0.50	0.33	0.43	0.24	0.18
Czersk	4.19	1.78	3.18	2.35	1.70	0.54	0.31	0.43	0.25	0.17
Brody	4.18	2.05	3.04	2.08	1.60	0.53	0.30	0.42	0.24	0.17
Lubniewice	4.18	2.00	3.02	2.09	1.61	0.57	0.31	0.44	0.24	0.18
Radawnica	4.18	2.09	3.06	2.00	1.64	0.51	0.32	0.43	0.24	0.18
Oleszyce	4.04	1.91	3.06	2.11	1.66	0.50	0.32	0.44	0.26	0.17
Supraśl	4.01	1.69	3.01	2.37	1.57	0.49	0.32	0.41	0.23	0.17
Zwierzyniec Lubelski	4.01	2.04	2.91	1.96	1.51	0.50	0.30	0.42	0.24	0.17
Bystrzyca Kłodzka	3.93	2.01	3.30	1.46	1.72	0.53	0.32	0.45	0.25	0.18
Prószków	3.92	1.87	2.86	2.09	1.63	0.55	0.29	0.45	0.24	0.18
Parczew	3.87	1.96	2.90	1.97	1.56	0.53	0.29	0.43	0.24	0.18
Janów Lubelski	3.86	1.81	2.72	2.13	1.58	0.58	0.27	0.41	0.25	0.16
Stepnica	3.82	1.94	2.66	1.97	1.64	0.53	0.30	0.43	0.25	0.17
Zwierzyniec Białowieski	3.82	1.78	2.86	2.15	1.63	0.53	0.31	0.44	0.24	0.18
Nurzec	3.76	1.89	2.94	1.99	1.58	0.52	0.30	0.40	0.24	0.16
Myszyniec	3.73	1.75	2.80	2.13	1.53	0.51	0.30	0.41	0.23	0.17
Kubryk	3.72	1.59	2.76	2.33	1.53	0.48	0.32	0.42	0.24	0.17
Krutyń	3.70	1.70	2.86	2.16	1.55	0.49	0.32	0.41	0.23	0.17
Wilcze Bagno	3.70	1.70	2.81	2.16	1.59	0.51	0.31	0.41	0.24	0.17
Łomża	3.67	1.84	2.78	1.99	1.48	0.51	0.28	0.40	0.24	0.16
Rataje	3.62	2.02	2.65	1.79	1.54	0.47	0.32	0.41	0.23	0.17
Spała	3.62	1.61	2.74	2.25	1.49	0.51	0.29	0.41	0.24	0.17
Pionki	3.60	1.83	2.63	1.97	1.60	0.52	0.31	0.43	0.24	0.18
Ruciane	3.50	1.50	2.70	2.33	1.61	0.49	0.33	0.40	0.24	0.16
Dłużek	3.34	1.48	2.63	2.25	1.54	0.51	0.30	0.43	0.22	0.15
Tabórz	3.30	1.60	2.50	2.06	1.45	0.49	0.29	0.40	0.24	0.16

variation for this character is very evident here. The pines from the northern part of the country have a lower mean number of cotyledons than those from the south. The nature of the variability is the same as that demonstrated by de Ferre and de Meric (1963) in France, however the actual values do not coincide with those obtained here. Among the provenances studied in Toulouse two have been included that we also had in our experiments, namely Radawnica and Dłużek. The values obtained in the present study are lower, which is indicated by the following data.

Provenance	Results	
	Toulouse	Kórnik
Radawnica	5.66	5.11
Dłużek	5.60	4.96

The same regularity which de Ferre and de Meric have observed throughout Europe have been also found in the limited material restricted to the region of Poland.

An analysis of variance of the root system length and of seedling height has shown that only the first character significantly differentiates the provenances. However

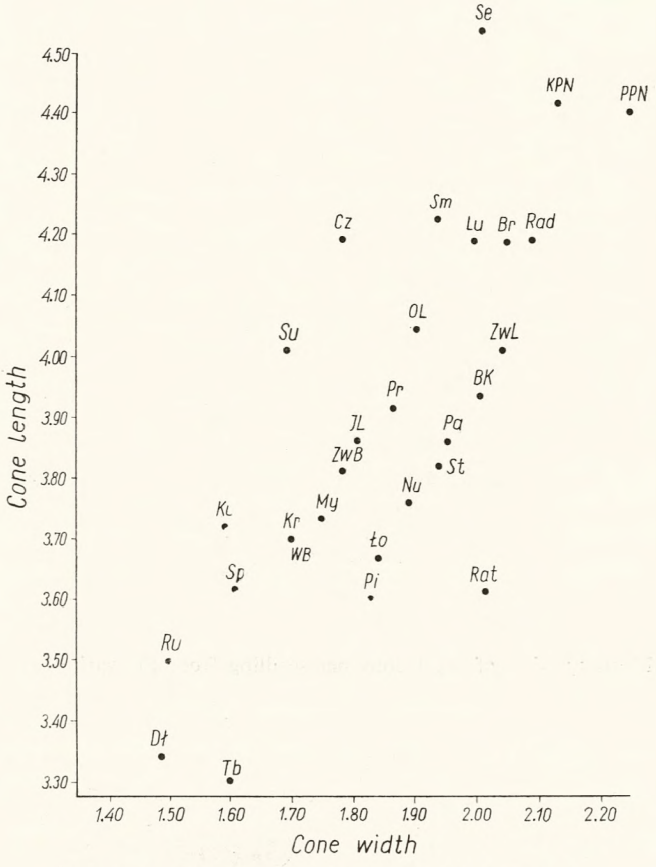

Fig. 3. Relation between cone length and cone width

an interpretation of this data appears to be rather difficult. Seedling height as well as the length of the root system is a measure of growth. However not always is the better growth of the seedling accompanied by a longer root system (Table 4). For example the tallest seedlings originate from Spała and the longest roots from Radawnica. Mean heights greater than the average for the whole experiment have been attained by seedlings of 10 provenances, primarily from central Poland (Brody, Janów Lubelski, Kampinoski Park Narodowy, Oleszyce, Parczew, Pionki, Radawnica, Rataje, Spała and Zwierzyniec Lubelski).

A root length above the mean for the whole experiment was found in seedlings from 14 provenances, without any obvious geographic localization (Bystrzyca Kłodzka, Bolewice, Brody, Dłużek, Janów Lubelski, Kampinoski Park Narodowy, Krutyń, Radawnica, Rataje, Ruciane, Serwy, Smłodzino, Supraśl and Värmland). In only 6 provenances both the root length and seedling height are above average (Brody, Janów Lubelski, Kampinoski Park Narodowy, Radawnica, Rataje, Spała).

A ratio of the root length to the length of the aerial plant part (seedling height) also does not appear to be related to geography, since the provenances from the north of the country such as Dłużek or Zwierzyniec Białowieski are characterized

Fig. 4. Mean number of cotyledons per seedling from the various provenances

Fig. 5. Percentage content of nitrogen in the dry weight of the aerial parts of pine seedlings of various provenance. The provenances whose seedlings contain more than 3.5% of nitrogen are marked with a double circle

by a low value of the ratio = 2.1, while others also of northern origin such as Supraśl and Radawnica have respectively 3.0 and 2.9.

The seedlings from Sweden are distinctly different since they had a relatively very long root system. It is 4.1 times as great as the seedling height. Of the Polish provenances the highest value of this ratio was 3.2 and 3.0 for provenances Krutyń, Supraśl and Smołdzino from the northern part of the country. This last provenance, also in other characters appears to be related to the Scandinavian pines.

To summarize this part of the results concerning the greenhouse experiment one can conclude that the best seedling height was demonstrated by pines from central Poland, however a distinct regularily of clinal type of variation in this character has not been observed.

In table 5 mean percentage values are presented for the content of some mineral elements in the dry weight of the seedlings. A variance analysis has shown that the content of nitrogen in the aerial part of the plant differentiates the provenances significantly at 0.95 level (fig. 5). Generally the seedlings from the north-eastern part of the country have a higher nitrogen content in the shoots of the plants than is the case for pine seedlings from more southerly localities. Especially high nitrogen

Table 4

Mean length of the seedling and the length of its root system in the greenhouse experiment

Provenance	Aerial part cm	Root system cm	Root system / Aerial part
Bystrzyca Kłodzka	5.4	14.2	2.6
Bolewice	5.4	14.2	2.6
Brody	5.6	15.6	2.7
Czersk	5.4	11.8	2.1
Dłużek	5.4	11.4	2.1
Janów Lubelski	5.8	15.2	2.6
Kampinoski Park Narodowy	5.8	15.0	2.6
Krutyń	4.9	16.1	3.2
Kubryk	5.3	13.4	2.7
Lubniewice	5.2	13.3	2.5
Łomża	5.2	13.1	2.5
Myszyniec	4.9	13.2	2.6
Nurzec	5.3	14.1	2.6
Oleszyce	5.7	13.6	2.3
Parczew	5.8	13.3	2.2
Pionki	5.5	13.3	2.4
Prószków	5.3	12.0	2.2
Radawnica	5.5	16.4	2.9
Rataje	5.8	15.3	2.6
Ruciane	5.4	14.6	2.7
Serwy	5.4	15.1	2.7
Smołdzino	5.0	15.3	3.0
Spała	6.6	14.2	2.1
Stepnica	4.8	11.9	2.3
Supraśl	5.2	15.9	3.0
Tabórz	4.8	11.9	2.4
Wilcze Bagno	4.8	12.9	2.6
Zwierzyniec Białowieski	4.8	11.5	2.4
Zwierzyniec Lubelski	5.9	12.5	2.1
Värmland	4.9	20.2	4.1

concentrations of 4.06% have been found in the shoots of pine seedlings from Sweden (V). This trend has been observed in earlier works (Giertych 1969).

The results concerning the content of nitrogen in the roots and potassium, calcium and sodium in the both shoots and roots do not differentiate the provenances significantly as is evidenced by the variance analyses.

FIELD EXPERIMENTS

Immediately after outplanting seedlings from a nursery into field conditions growth malfunctions result, and therefore any results obtained during the first few years have to be considered as introductory and tentative. Carefull tending of a plantation may reduce the outplanting shock to some extent as is indicated by the example of the experimental area in Kórnik. However measurements and observations were begun already in the first vegetative seasons in order to obtain a picture of the growth dynamics of the studied pine populations.

Table 5

Percentage content of some mineral elements in the dry weight of pine seedlings of various provenance

Provenance	N %			K %			Ca %			Na %		
	shoot	root	shoot / root	shoot	root	shoot / root	shoot	root	shoot / root	shoot	root	shoot / root
Bystrzyca Kłodzka	3.550	2.734	1.298	1.964	0.856	2.294	1.180	0.220	5.363	0.029	0.036	0.805
Bolewice	3.498	2.927	1.195	2.132	0.937	2.275	1.299	0.295	4.403	0.049	0.056	0.875
Brody	3.118	3.057	1.019	1.969	1.009	1.951	1.311	0.257	5.101	0.041	0.051	0.803
Czersk	3.614	2.938	1.230	1.608	0.819	1.963	1.260	0.208	6.057	0.047	0.045	1.044
Dłużek	3.754	3.113	1.205	1.782	1.003	1.776	1.202	0.216	5.564	0.033	0.053	0.622
Janów Lubelski	3.390	2.558	1.325	2.380	0.922	2.581	1.291	0.326	3.960	0.051	0.120	0.425
Kampinoski Park Narodowy	3.400	2.706	1.256	1.785	0.928	1.923	1.193	0.254	4.696	0.031	0.058	0.534
Krutyń	3.563	3.014	1.182	1.716	0.932	1.841	1.197	0.253	4.731	0.031	0.044	0.704
Kubryk	3.390	2.895	1.170	2.629	1.000	2.629	1.154	0.254	4.543	0.032	0.053	0.603
Lubniewice	3.262	3.188	1.023	2.144	1.063	2.016	1.051	0.271	3.878	0.029	0.047	0.617
Łomża	3.492	2.420	1.442	2.012	1.012	1.988	1.234	0.312	3.955	0.027	0.066	0.409
Myszyniec	3.517	2.699	1.303	1.819	0.907	2.005	1.222	0.254	4.811	0.033	0.051	0.647
Nurzec	3.190	2.689	1.186	2.051	0.985	2.082	1.168	0.289	4.041	0,030	0,052	0,576
Oleszyce	3.058	–	–	2.772	0.962	2.881	1.285	0.265	4.849	0.035	0.061	0.573
Parczew	3.423	2.706	1.264	1.768	0.872	2.027	1.074	0.280	3.835	0.035	0.061	0.573
Pionki	3.384	2.929	1.155	1.751	0.716	2.445	1.194	0.274	4.357	0.033	0.059	0.055
Prószków	3.438	2.900	1.185	1.387	0.987	1.405	1.194	0.279	4.279	0.034	0.059	0,576
Radawnica	3.207	2.169	1.478	2.237	1.012	2.210	1.209	0.240	5.037	0.036	0,058	0.621
Rataje	3.678	2.753	1.335	1.739	1.050	1.656	1.135	0.227	5.000	0.037	0.055	0.672
Ruciane	3.771	2.959	1.274	1.756	0.951	1.846	1.137	0.240	4.737	0.039	0.091	0.428
Serwy	3.373	2.833	1.190	2.064	0.832	2.480	1.249	0.269	4.643	0.037	0.051	0.725
Smołdzino	3.564	3.111	1.145	2.113	0.800	2.641	1.252	0.278	4.503	0.043	0.055	0.782
Spała	3.557	–	–	1.722	0.848	2.030	1.101	0.203	5.423	0.031	0.059	0.525
Stepnica	3.971	2.814	1.411	2.073	0.986	2.102	1.171	0.235	4.982	0.040	0.058	0.689
Supraśl	3.788	3.156	1.200	1.390	0.818	1.699	1.121	0.278	4.032	0.033	0.057	0.579
Tabórz	3.885	2.806	1.384	1.810	0.842	2.149	1.306	0.303	4.310	0.034	0.086	0.395
Wilcze Bagno	3.439	2.993	1.149	1.905	0.911	2.091	1.313	0.230	5.708	0.042	0.041	1.024
Zwierzyniec Białowieski	3.335	1.955	1.706	1.615	0.947	1.705	1.138	0.265	4.294	0.030	0.050	0.600
Zwierzyniec Lubelski	3.317	–	–	1.864	0.755	2.469	1.090	0.232	4.698	0.031	0.085	0.345
Värmland	4.061	2.681	1.515	0.958	0.662	1.447	1.041	0.271	3.841	0.024	0.037	0.648

After the first vegetative period on all four areas the seedlings were counted and in this way a comparison was obtained of the survival ability for the individual provenances. On each plot 49 plants have been planted and therefore the values are directly comparable.

In the Kórnik experimental area (in Zwierzyniec) also more detailed studies were conducted on the seedling height, plants with a well formed terminal bud were counted as well as the number of lateral and adventitious buds.

After the second vegetative period, that is in the year 1968 on the three areas outside Kórnik, that is in Janów Lubelski, Sokółka and Stepnica, the measurements and observations were conducted according to the determined and accepted methods. The results were not encouraging. Only a few of the studied characters have shown provenance differences that could be considered as significant, and therefore when describing the individual characters I have ignored data from that year.

The next and complete measurement of the material has been conducted after three vegetative seasons that is in 1969. In this case significant differences were observed between provenance means of the analyzed characters more frequently and therefore it is possible to talk about more accurate informations concerning the variability of pine populations originating from various Forest Districts in Poland.

Results of the studies have been presented as averages in tables 7, 8, 9 and 10 and illustrated in figures 6, 7, 8, 9 ,10, 11 and 12.

In the spring of 1969 observations were also conducted on the degree to which the seedlings were attacked by *Lophodermium pinastri*. The results are presented in table 6.

1. Resistance to attack by *Lophodermium pinastri*

Detailed studies on the resistance to *Lophodermium pinastri* (Schrad) Chev. of pine seedlings from various provenances are being conducted with the help of precise laboratory methods on material grown in the greenhouse by Siwecki and Chwaliński (in preparation). Here only results are presented of observations conducted in the spring of 1969 in field conditions on the four experimental areas in Zwierzyniec nr. Kórnik, in Janów Lubelski, in Sokółka and in Stepnica. Provenance differences were found to be highly (0.99) significant for the observations made in Janów Lubelski and for those made in Zwierzyniec nr. Kórnik, while those made in Stepnica and Sokółka did not reveal significant differences. No interaction was observed between provenances and experimental areas. In table 6 the mean values for the four experimental areas are given jointly and separately for each area since the mean percentages of affected plants demonstrate certain regularities.

The data we have at the moment do not permit the drawing of definite conclusions that would be precise about the resistance to *Lophodermium pinastri* attack. It is only possible to talk about relative comparisons, since the percentage of affected

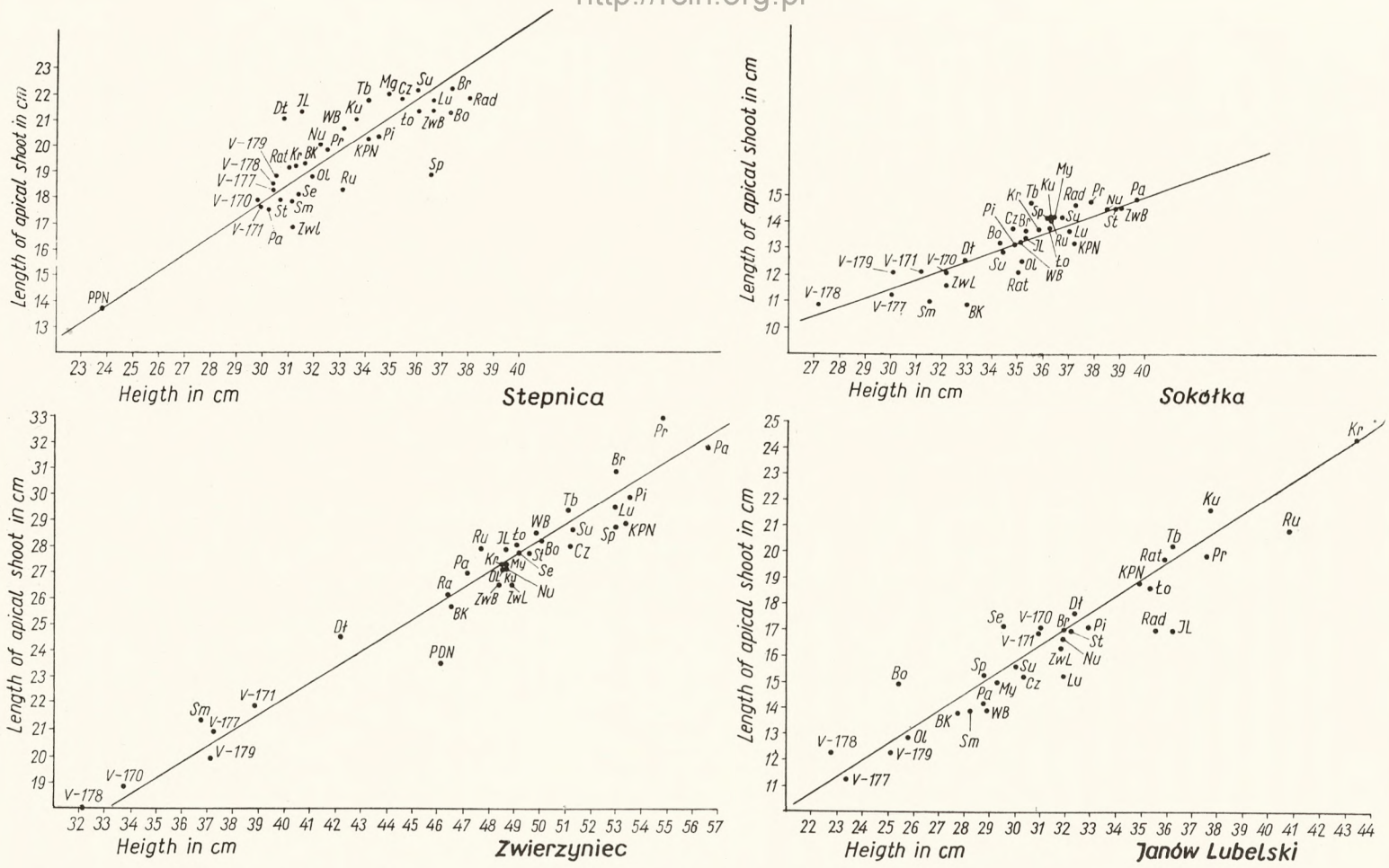

Fig. 6. Relation between the length increment of apical shoot and the mean seedling height from pines of various provenance as measured in the fall of 1969

plants was different for the various field experiments. As an example the extreme values for each area are presented below:

Total for 4 areas:	from 49.7%	(Nu)	to 58.4%	(ZwL)	— mean 31.1%
Zwierzyniec nr. Kórnik:	from 14.7%	(Tb)	to 57.3	(ZwL)	— mean 25.8%
Janów Lubelski:	from 9.3%	(St)	to 54.9	(Lu)	— mean 26.4%
Sokółka:	from 17.0%	(Kr)	to 62.8	(St)	— mean 39.6%
Stepnica:	from 26.4%	(Nu)	to 75.6	(PPN)	— mean 43.6%

From the data presented in table 6 it can be seen that the plantations in Sokółka and Stepnica were generally more heavily attacked by the parasite. A relative measure of resistance to attack by *Lophodermium* can be observed by arranging the provenances in a increasing order of susceptibility. This can best be seen by comparing the extremal provenances. In table 6 the provenances are arranged in such an order. After analysing the list it will be seen that the least affected provenances have the following positions:

Tabórz (Tb) is:

	1st in Zwierzyniec	with 14.7%
	6th in Janów Lub.	with 16.7%
	12th in Sokółka	with 33.8%
and	15th in Stepnica	with 41.2%

Nurzec (Nu) is:

	4th in Zwierzyniec	with 16.5%
	8th in Janów Lub.	with 17.2%
	2nd in Sokółka	with 25.6%
and	1st in Stepnica	with 26.4%

Smołdzino (Sm) is:

	5th in Zwierzyniec	with 17.5%
	2nd in Janów Lub.	with 9.5%
	6th in Sokółka	with 30.5%
and	13th in Stepnica	with 39.1%

Thus it is possible to speak about a greater resistance to *Lophodermium pinastri* attack by certain pine provenances such as Tabórz (Tb), Nurzec (Nu), Smołdzino (Sm), Supraśl (Su), Krutyń (Kr) and the Swedish provenances from Värmland (V-170, V-171, V-177, V-178 and V-179).

A further analysis of table 6 indicates that a certain number of provenances are such that they have shown considerable susceptibility to the attack in all the experimental areas. These are seedlings from Zwierzyniec in the Lublin region (ZwL) which were most heavily attacked in Zwierzyniec nr. Kórnik and over the whole experiment, were second in this respect in Janów Lubelski and in Sokółka, while in Stepnica only 3 provenances were attacked more heavily, namely Bystrzyca Kłodzka (BK), Oleszyce (Ol) and Pieniński Park Narodowy (PPN). Thus we can say that the following provenances were relatively susceptible to attack by *Lophodermium pinastri*: Zwierzyniec Lubelski (ZwL), Bystrzyca Kłodzka (BK), Oleszyce (Ol), Bolewice (Bo) and Rataje (Rat).

Pines of most of the provenances have an intermediate position as regards susceptibility, and frequently the result is variable for the various areas. Thus for example seedlings from Stepnica (St) were relatively resistant in Zwierzyniec nr. Kórnik but in Sokółka they were very susceptible.

In fig. 6 the percentage of plants affected by *Lophodermium pinastri* and averaged over the four experimental areas is presented. The greater resistance of pines originating from the northern part of the country is notable.

2. Seedling mortality

To a certain extent this character can be a measure of the viability of the population. A comparison of the results of studies in various experimental areas is possible because always 49 plants were planted per plot. After one year of cultivation the missing pines were replanted with material from the reserves. As a result in a few cases the number of living plants after 3 years is greater than the number

Table 6

Percentage of seedlings attacked by *Lophodermium pinastri*, in the various experimental areas

Jointly for 4 areas		In Stepnica		In Sokółka		In Janów Lubelski		In Zwierzyniec nr. Kórnik	
Prov.	%	Prov.	%	Prov.	%	Prov.	%	Prov.	%
ZwL	58.4	PPN	75.6	St	62.8	Lu	54.9	ZwL	57.3
Ol	46.9	Ol	73.5	ZwL	62.5	ZwL	50.2	PPN	42.4
BK	46.2	BK	71.0	Ol	58.6	Ło	44.5	Bo	41.7
Bo	45.3	ZwL	66.5	My	55,6	St	43.1	Rat	38.7
Lu	40.5	Bo	62,3	JL	54.7	KPN	39.0	Ol	36.9
Rat	38.6	Pa	59.9	Bo	54.2	BK	37.1	BK	36.6
Ło	38.5	Rat	52.5	BK	53.9	Pi	35.9	Ło	31.6
JL	37.3	JL	50.9	Rat	46.6	Se	35.6	KPN	30.5
KPN	35.6	Lu	50,6	WB	46.0	Pa	34.6	Lu	29.5
Pa	35.4	Pi	50.6	KPN	44.5	Ol	34.1	Dł	29.2
Br	33.6	Ku	48.3	Ku	42.6	JL	32.3	JL	29.1
Sp	33.6	Br	47.1	Sp	40.8	Bo	32.0	Sp	28.6
Pi	32.4	Ło	46.9	Ru	39.3	Ru	31.6	Br	28.6
Cz	31.8	Cz	45.7	V-178	39.3	Sp	31.5	Cz	28.1
Ku	31.2	St	45.2	V-177	38.8	Br	31.2	V-171	27.0
My	30.3	Rad	43.1	Ło	38.6	Ku	29.5	My	26.0
Se	29.2	Sp	43.1	V-171	37.6	My	29.5	Rad	25.6
Rad	28.3	WB	42.7	Pa	37.6	Cz	24.4	Pa	23.8
Dł	27.7	V-170	42.6	Lu	37.3	Dł	23.1	Se	23.3
WB	27.2	ZwB	42.2	Cz	35.9	WB	23.1	V-179	23.1
Ru	25.1	Tb	41.2	V-179	34.8	Rat	22.2	V-178	23.0
V-171	25.1	Pr	39.5	Tb	33.8	V-170	21.2	Pi	22.7
V-179	25.1	Sm	39.1	Br	33.1	Rad	20.5	ZwB	22.1
Pr	25.0	Kr	38.8	Su	32.8	Kr	19.7	Ku	21.7
V-170	24.9	KPN	38.6	Pi	32.4	V-179	19.5	Ru	20.8
V-178	24.4	Se	35.4	Dł	32.1	Pr	19.4	V-177	20.7
St	24.1	Su	34.9	Pr	30.7	Nu	17.2	Kr	20.2
Kr	23.5	V-179	33.3	Sm	30.5	V-171	17.1	Pr	20.1
V-177	23.1	V-178	29.6	Se	29.2	Tb	16.7	V-170	18.7
Tb	22.4	V-171	29.4	Rad	27.7	V-177	16.1	WB	18.3
Su	21.1	V-177	28.6	V-170	26.3	V-178	16.1	Sm	17.5
Sm	20.9	My	28.1	Nu	25.6	Su	14.8	Nu	16.5
Nu	19.7	Ru	27.3	Kr	17.0	Sm	9.5	Su	15.8
		Dł	27.3					St	15.4
		Nu	26.4					Tb	14.7
$\bar{x}$	31.1		43.6		39.6		26.4		25.8

Table 7

Mean number of seedlings per plot. (In the spring of 1967 49 seedlings were planted per plot)

Provenance	Experimental area							
	Zwierzyniec		Sokółka		Stepnica		Janów Lubelski	
	as determined in the fall of							
	1967	1969	1967	1969	1967	1969	1967	1969
Bystrzyca Kłodzka	44.9	45.0	36.0	24.1	28.3	26.5	26.9	26.0
Bolewice	45.5	46.6	33.6	23.1	35.5	32.8	25.4	28.0
Brody	40.3	45.6	37.8	22.0	34.0	33.5	29.0	32.3
Czersk	46.9	47.5	42.5	26.8	29.0	29.0	31.8	31.0
Dłużek	44.8	45.9	38.5	28.3	24.0	29.0	30.7	30.0
Janów Lubelski	45.3	44.9	39.1	25.9	32.0	31.5	29.0	38.6
Kampinoski Park Narodowy	46.8	46.3	37.8	23.4	25.5	24.8	30.0	41.3
Krutyń	44.1	43.1	40.5	30.6	23.8	24.8	25.8	26.3
Kubryk	43.5	45.1	32.1	24.6	29.3	26.8	32.8	36.7
Lubniewice	46.4	46.3	32.0	27.4	35.0	33.0	34.1	36.3
Łomża	46.0	46.6	37.0	27.5	33.5	30.0	30.4	38.0
Myszyniec	44.1	44.9	37.8	24.4	29.8	27.3	31.3	36.7
Nurzec	44.3	42.9	37.8	26.9	29.0	28.0	31.8	29.3
Oleszyce	44.3	45.1	38.5	28.8	29.0	26.5	22.8	24.0
Parczew	44.9	45.9	37.8	32.3	29.0	28.0	27.1	30.7
Pionki	46.9	45.8	38.0	26.6	35.0	36.0	30.4	28.0
Prószków	45.1	47.4	39.3	32.4	36.8	31.0	29.7	35.3
Pieniński Park Narodowy	46.1	44.6	–	–	23.5	21.0	–	–
Radawnica	44.3	44.3	41.0	32.5	43.3	39.5	21.3	23.0
Rataje	44.3	44.6	33.9	21.4	33.3	31.8	32.5	36.7
Ruciane	42.8	46.3	36.0	26.4	26.0	24.3	33.1	36.6
Serwy	43.3	45.5	37.5	29.1	30.5	28.5	27.4	20.7
Smołdzino	42.0	43.1	39.8	26.6	34.3	33.8	28.6	34.7
Spała	45.4	44.6	37.8	25.4	18.0	23.5	24.4	23.0
Stepnica	44.6	46.3	38.4	26.0	32.8	31.3	30.0	26.3
Supraśl	45.6	46.5	38.4	24.1	29.0	29.0	26.8	28.3
Tabórz	46.1	45.5	40.9	26.5	29.8	29.0	32.7	37.3
Wilcze Bagno	45.6	45.9	40.1	31.4	25.5	25.0	24.9	26.7
Zwierzyniec Białowieski	42.3	41.5	34.4	28.6	40.3	37.3	–	–
Zwierzyniec Lubelski	44.9	44.8	38.1	25.4	37.5	31.8	30.1	38.3
Värmland – 170	43.4	42.5	36.0	23.8	34.8	34.8	28.6	27.7
Värmland – 171	45.5	45.1	35.0	24.0	31.3	30.8	31.4	30.0
Värmland – 177	45.5	42.0	34.4	17.1	39.0	39.5	31.9	25.8
Värmland – 178	39.5	41.1	34.5	24.5	28.8	28.8	29.8	28.8
Värmland – 179	45.3	44.4	40.0	30.1	36.0	35.0	27.0	26.9

of living ones after one year. For all the observations variance analyses were performed and the results are tabulated in table 7.

After one year greatest mean number of seedlings per plot have been observed in the experimental area in Kórnik, it was 46.9 for the Czersk provenance and 39.5 for the population from Sweden (V-178). In fact the difference is insignificant statistically and there does not appear to be any geographical trend in this character. In the experimental area in Janów Lubelski the differences proved to be insignificant. The average numbers of seedlings per plot were much smaller and varied from 34.1 for the Lubniewice provenance to 21.3 for the Radawnica provenance. In Sokółka the differences were significant statistically yet they were not very great. The populations far removed from the site of cultivation have had a relatively smaller number of seedlings per plot: Bolewice, Kubryk, and Lubniewice. Also the Swedish and the mountain (Bystrzyca Kłodzka) provenances have had lower

survival. In Stepnica the differences were not statistically significant in survival after one year. The values ranged from 43.3 per plot for the Radawnica provenance to 23.5 per plot for the Pieniny National Park provenance.

After three vegetative periods in the field conditions the seedlings were counted again in the fall of 1969. On the area in Zwierzyniec small statistically significant differences in mortality between the provenances were obtained. A somewhat higher seedling mortality was observed in the northern provenances. In Janów Lubelski the differences between prevenances proved insignificant. The mean number of seedlings per plot varies from 41.3 for the Kampinos National Park provenance to 20.7 for the Serwy provenance. Also in Sokółka there were no significant differences between provenances the values ranging from 32.5 (Radawnica) to 23.4 (Rataje). On the other hand on the area in Stepnica provenance differences proved to be significant even though the differentiation is not very clear. The highest number of seedlings per plot has been observed for the provenance Radawnica, namely 39.5 while the lowest number for Spała, namely 23.5.

3. Seedling height and the length of annual increment on the apical shoot

The full seedling height has been measured for the first time in the fall of 1967 only for the area in Kórnik. The results have been subjected to an analysis of variance that has demonstrated the existence of significant differences between the prove-

Fig. 7. Mean height in cm. of pine seedlings of various origin. The pines characrized teby the greatest mean heigh st aremarked with a double circle

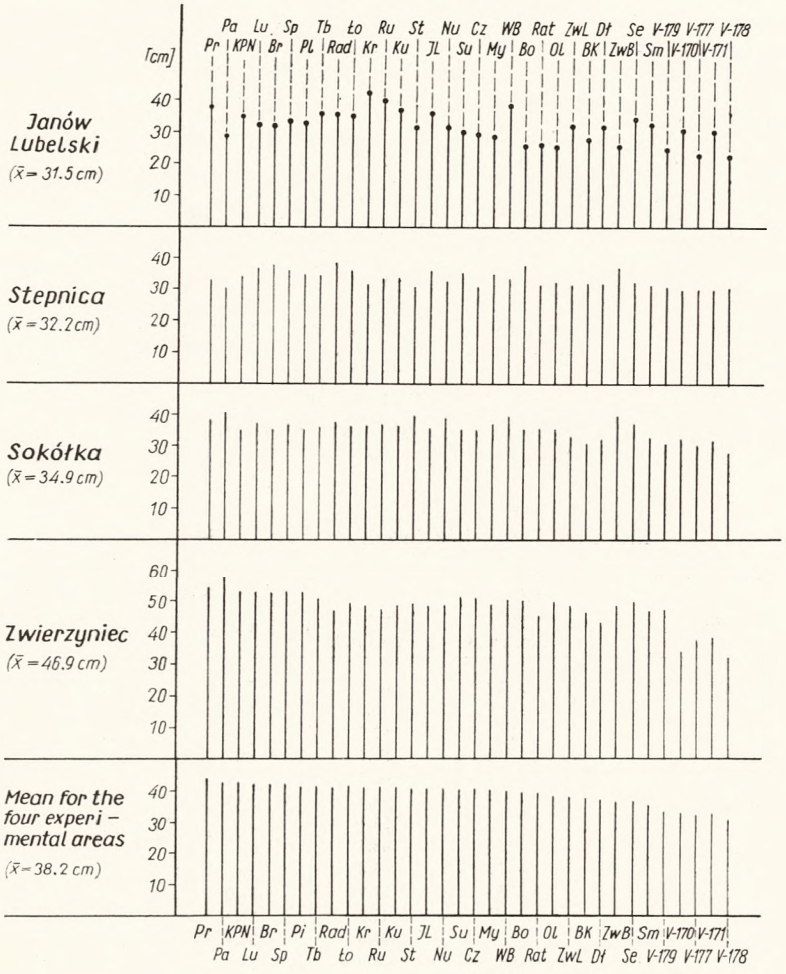

Fig. 8. Mean seedling height. The sequence is from „Pr" to „V-178" from the tallest to the shortest provenances averaged over the four experimental areas and given in the same sequence for each area

nances, however without any clear geographical distribution. The seedlings from Pieniny proved tallest (8.8 cm) and the lowest seedlings came from Sweden (V-178), Smołdzino and Nurzec, for which the mean height was 5.4 cm. Seedlings of pine from central Poland (Kampinos National Park, Pionki, Lubniewice, Parczew, Spała) have attained higher mean heights than the seedlings from Sweden or northern Poland.

After three vegetative periods the seedling height was measured on all four of the experimental areas. The average values per plot have been subjected to a variance analysis, separately for each area and jointly for the whole experiment, in order to establish whether there is any interaction between provenances and site conditions existing in the individual experimental areas. The interaction proved non significant.

With the help of the test for significance of differences between several means the respective values for the differences were calculated. The means calculated jointly for the four experimental areas (see fig. 8) differentiate the studied populations insufficiently clearly. The highest values of the means are attained by the provenances from central Poland, namely: Parczew, Kampinos, Lubniewice, Spała and Pionki as well as Prószków and Brody. The lowest seedlings originated from Scandinavia, which form an almost uniform group distinctly differing from all others. Somewhat related to them in seedling height were the pines from Smołdzino and from Bystrzyca Kłodzka. No other regional differences were observed.

The greatest mean heights ($\bar{x}$=46.9 cm) have been reached by seedlings from the experimental area in Zwierzyniec near Kórnik. In comparison with the mean heights for the whole experiment the values for the groups of provenances have not changed much from area to area, at least as regards the extreme means. The

Table 8

Mean seedling height in cm as measured in 1969

Provenance	Jointly for 4 exp. areas	Experimental areas in			
		Zwierzyniec nr. Kórnik	Sokółka	Stepnica	Janów Lubelski
Bystrzyca Kłodzka	36.77	46.5	33.0	31.6	27.7
Bolewice	38.86	50.0	34.3	37.3	25.4
Brody	41.36	52.9	35.3	37.4	32.1
Czersk	39.94	51.1	34.7	35.3	30.4
Dłużek	36.49	42.2	32.9	30.8	32.4
Janów Lubelski	40.06	48.6	35.3	35.3	36.2
Kampinoski Park Narodowy	42.04	53.3	37.3	34.1	34.9
Krutyń	40.36	48.5	35.7	31.3	43.3
Kubryk	40.33	48.8	36.3	33.6	37.6
Lubniewice	41.84	52.9	37.0	36.6	31.9
Łomża	40.59	49.0	36.3	36.1	35.4
Myszyniec	39.56	48.6	36.4	34.9	29.3
Nurzec	40.06	48.6	38.5	32.3	31.9
Oleszyce	37.96	48.5	35.1	31.9	25.7
Parczew	42.44	56.5	39.6	30.3	28.8
Pionki	41.08	53.4	34.8	34.5	32.9
Prószków	42.79	54.7	37.8	32.5	37.5
Pieniński Park Narodowy	–	46.1	–	23.7	–
Radawnica	40.61	47.1	37.3	38.0	35.7
Rataje	38.40	46.4	35.0	31.0	35.9
Ruciane	40.35	47.6	36.4	33.1	40.7
Serwy	34.83	49.1	36.7	31.4	29.5
Smołdzino	32.84	36.8	31.5	31.1	28.2
Spała	41.12	52.9	36.3	36.5	28.7
Stepnica	40.26	49.5	38.8	30.7	32.3
Supraśl	39.97	51.2	34.4	36.0	30.0
Tabórz	40.78	51.0	35.5	34.1	36.2
Wilcze Bagno	39.04	49.7	35.1	33.2	38.9
Zwierzyniec Białowieski	35.88	48.4	39.0	36.6	31.8
Zwierzyniec Lubelski	37.59	48.4	32.2	31.2	–
Värmland – 170	32.16	33.7	32.2	29.8	31.0
Värmland – 171	31.81	38.9	31.2	29.9	30.8
Värmland – 177	31.88	37.3	30.0	30.4	23.4
Värmland – 178	29.91	32.1	27.1	30.5	22.8
Värmland – 179	32.33	37.2	31.1	30.4	25.1
$\bar{x}$	38.20	46.9	34.9	32.2	31.5

Scandinavian pines gave the shortest progeny and the pines from central Poland the tallest (see fig. 7). A variance analysis has shown that there exists a significant difference between means at 0.99 level of significance. In this case among the tallest seedlings are those from Parczew, Prószków, Brody, Lubniewice, Kampinos and Spała and the shortest are from Scandinavia and from Smołdzino.

Fig. 9. Interaction effect of the experimental areas with the provenances on the mean seedling height. In the diagram the group of provenances is presented the seedling height of which was greater in Stepnica than in Sokółka

The mean height for the experimental area in Sokółka is 34.9 cm. A variance analysis has shown that there are differences between provenances at 0.99 level of significance. The tallest seedlings again originate from Parczew and Prószków however the populations from northern Poland are not much smaller, namely from Stepnica, Zwierzyniec Białowieski, Nurzec and Serwy. The lowest mean heights were again observed on the populations from Scandinavia, from Smołdzino and from Bystrzyca Kłodzka.

The results of measurements and calculations for the experimental area from

Stepnica have not shown significant differences between provenances as determined by the variance analysis. However it does appear that somewhat better results as regards growth have been obtained by seedlings from the western populations: Bolewice, Radawnica, and Brody. The pines from Scandinavia and Smołdzino belong in Stepnica as elsewhere to the shortest ones.

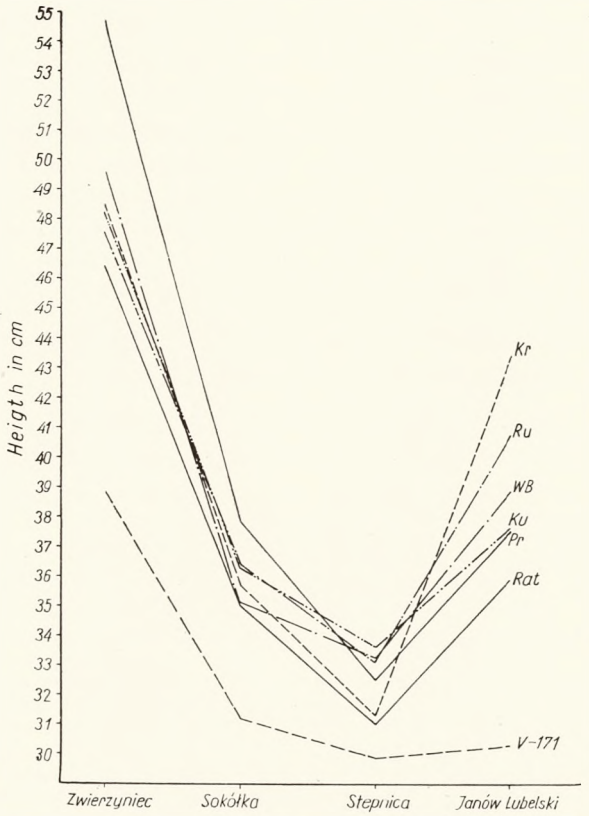

Fig. 10. Interaction effect of the experimental areas with the provenances on the mean seedling height. In the diagram the group of provenances is presented the seedlings of which attain a greater height in Janów Lubelski than in Stepnica

The shortest seedlings for the whole experiment have been obtained by the seedlings growing in Janów Lubelski, namely only 31.5 cm. Between means for the provenances there are significant differences at 0.99 level, however the groupings are somewhat different than in the other experimental areas. The tallest seedlings originate from Krutyń, Ruciane and Wilcze Bagno, that is from the Mazury region. The shortest ones are some of the Scandinavian ones (not all), those from Bolewice from Rataje and from Oleszyce. There is no distinct geographic distribution.

The interaction between the provenances and the site conditions prevailing in the experimental areas has been observed in two groups of provenances.

The first one includes the populations from Radawnica, Brody, Spała and Värmland—178, which have obtained in Stepnica higher mean values than in Sokółka (fig. 9).

The second group of provenances are those which grew taller in Janów Lubelski than in Stepnica. These are Krutyń, Ruciane, Wilcze Bagno (that is from the Mazury

region), Kubryk, Prószków and Rataje (central and western Poland) and the Scandinavian provenance V-171 (fig. 10).

It is difficult to see any geographic regularity in this respect, besides the observations that in Janów Lubelski the pines from the Olsztyn region are well adapted.

In 1969 the last annual increment in height was also measured separately and the mean values were calculated. The variance analysis has shown that the character significantly differentiated provenances in the experimental areas in Zwierzyniec near Kórnik, in Janów Lubelski and in Stepnica. This character is to a large extent dependent on the total seedling height, which is illustrated in fig. 6. This data does not offer any new information about the nature of the differentiation of pines between the studied populations.

4. Buds

In the experimental area in Zwierzyniec near Kórnik the number of seedlings with a well formed terminal bud was counted in the first vegetative period and the percentage of those seedlings was calculated. The differences between provenances proved significant. This character does appear to be related to the geographic distribution of the pine provenances with a higher percentage of seedlings with terminal buds. However the Scandinavian pines differ from the other populations in that they have a distinctly lower percentage of seedlings which towards the end of the vegetative season had a well formed terminal bud.

At the same time the number of lateral buds was counted. This character differentiates the studied populations significantly. Also a dictinct geographical pattern of distribution of this character is observable. The Polish pines from the northern part of our country and the Scandinavian ones generally form on the average a lower number of lateral buds than is the case with pines from the other regions.

A similar tendency was observed in the case of adventitious bud formation by pine seedlings after one growing season in the experimental area in Zwierzyniec. Again the pines of northern provenance on the average form fewer adventitious buds.

After three vegetative periods the mean numbers of lateral buds on the terminal shoot have been calculated. In the Zwierzyniec experimental area the means proved significantly different for the various provenances, however it is not possible to group the provenances into any distinct geographic pattern.

In Janów Lubelski, after three vegetative seasons the average number of lateral buds per terminal shoot proved to be a character that does not differentiate the provenances significantly. It ranged from 3.6 for the Kampinos provenance to 2.2 for the seedlings from Supraśl and from Sweden.

Also in Sokółka this character does not differentiate the provenances. The highest number of lateral buds was found on seedlings from Stepnica and Lubniewice (3.3) and the lowest on the seedlings from Sweden (2.4).

In Stepnica the mean number of lateral buds differentiates the provenances significantly but only on the 0.95 level. There is no pattern in the geographical distribution of that character.

Table 9

Mean numbers of lateral buds on a terminal shoot as measured in 1969

Provenance	Experimental area			
	Zwierzyniec	Sokółka	Stepnica	Janów Lubelski
Bystrzyca Kłodzka	4.9	2.5	3.9	2.5
Bolewice	5.1	2.9	3.5	3.2
Brody	5.1	2.7	4.1	3.2
Czersk	4.7	2.6	3.5	2.7
Dłużek	4.7	2.7	3.8	2.7
Janów Lubelski	4.8	2.8	3.9	3.2
Kampinoski Park Narodowy	4.8	2.9	3.6	3.6
Krutyń	5.0	3.0	3.6	2.5
Kubryk	4.7	2.9	3.4	2.8
Lubniewice	5.1	2.8	3.7	2.9
Łomża	4.7	2.9	4.4	2.9
Myszyniec	5.1	2.7	3.2	2.4
Nurzec	5.0	3.0	3.0	2.7
Oleszyce	4.4	2.7	4.2	2.8
Parczew	5.0	3.0	2.8	2.6
Pionki	4.8	2.7	3.1	2.5
Prószków	5.1	2.7	3.2	2.8
Pieniński Park Narodowy	4.9	–	4.1	–
Radawnica	4.9	3.3	3.9	2.6
Rataje	4.7	2.7	3.6	2.9
Ruciane	4.1	2.9	3.1	2.9
Serwy	4.9	2.9	2.5	2.7
Smołdzino	4.6	3.0	3.7	3.0
Spała	4.7	2.5	3.6	2.6
Stepnica	4.9	3.1	3.4	3.0
Supraśl	5.0	2.8	3.7	2.2
Tabórz	5.3	3.4	3.8	2.7
Wilcze Bagno	5.1	2.8	3.5	2.5
Zwierzyniec Białowieski	4.9	2.9	4.1	–
Zwierzyniec Lubelski	4.6	2.7	3.4	2.9
Värmland – 170	4.2	2.8	3.4	3.2
Värmland – 171	4.4	2.9	4.0	2.7
Värmland – 177	4.3	2.7	3.5	2.6
Värmland – 178	4.2	2.7	3.3	2.6
Värmland – 179	4.3	2.6	4.2	2.2

To summarize, the number of lateral buds on the apical shoot does not permit any conclusions about the distribution of that character in pine populations in Poland To a large extent the conditions of cultivation play a role here, which is indicated by the fact that the mean number of buds on an experimental area in Zwierzyniec where the soil was very well cultivated was considerably greater than in the other localities.

5. Number of lateral shoots of last year

Means were calculated on the basis of data obtained in the fall of 1969, that is after three vegetative periods since the experiment was established. The results are presented in table 10.

For the experimental area in Zwierzyniec the means are significantly differentiated. Most branchy were the pines from central Poland as for example from Kampinos or from Pionki. Pines originating from the north-eastern part of the country

Table 10

Mean number of lateral shoots as measured in 1969

Jointly for 4 areas		Experimental areas in							
		Zwierzyniec		Stepnica		Sokółka		Janów Lubelski	
Prov.	No.	Prov.	No.	Prov.	No.	Prov.	No.	Prov.	No.
KPN	4.71	KPN	7.46	Lu	4.02	KPN	3.43	Kr	3.00
Lu	4.61	Pi	7.08	Br	3.95	Rad	3.41	Pr	3.00
Rad	4.49	Lu	6.91	Bo	3.70	Lu	3.35	Ku	2.96
Bo	4.47	Bo	6.86	My	3.62	St	3.30	KPN	2.93
Br	4.42	Pr	6.81	Rad	3.62	Pa	3.27	JL	2.86
St	4.31	Pa	6.80	JL	3.55	Bo	3.26	V-170	2.80
Pi	4.31	Rad	6.77	Ło	3.50	Se	3.22	Dł	2.76
Ło	4.29	Br	6.62	Dł	3.47	Ol	3.21	Sp	2.73
Pa	4.29	St	6.58	Cz	3.40	Tb	3.18	St	2.73
Pr	4.29	Tb	6.58	Ru	3.40	Ło	3.15	Tb	2.70
Tb	4.29	ZwL	6.50	V-178	3.35	Br	3.11	Br	2.66
ZwL	4.18	Sp	6.53	Sm	3.30	Pr	3.11	ZwL	2.66
Sp	4.15	Ło	6.47	Pi	3.20	My	3.10	Ru	2.63
My	4.12	Se	6.45	V-170	3.20	Nu	3.08	Lu	2.60
Se	4.11	Kr	6.30	Kr	3.12	Rat	3.05	Ło	2.56
JL	4.11	Su	6.27	Ol	3.12	Ru	2.96	Su	2.56
Kr	4.10	JL	6.02	Rat	3.12	ZwL	2.96	Rat	2.50
Ol	4.05	Rat	6.02	WB	3.12	JL	2.93	My	2.46
Ru	4.05	My	6.00	ZwL	3.10	Dł	2.90	Sm	2.46
Dł	4.03	Ru	5.98	V-171	3.10	Ku	2.87	V-171	2.46
Rat	4.03	Ol	5.96	KPN	3.07	BK	2.85	Ol	2.43
Su	3.99	WB	5.95	Sp	3.07	Sp	2.83	Rad	2.43
Ku	3.91	BK	5.92	Tb	3.07	Pi	2.82	Cz	2.40
WB	3.86	Dł	5.92	V-177	3.02	WB	2.82	Pa	2.40
Cz	3.83	Cz	5.87	St	2.97	Kr	2.81	Bo	2.33
BK	3.81	V-171	5.87	V-179	2.97	V-170	2.80	Pi	2.33
V-171	3.80	Ku	5.80	Ku	2.92	V-177	2.78	V-178	2.23
Nu	3.72	V-179	5.46	Su	2.92	Su	2.76	V-179	2.13
Sm	3.68	Nu	5.42	BK	2.82	Sm	2.75	Se	2.10
V-170	3.63	Sm	5.26	Nu	2.82	V-179	2.62	V-177	2.06
V-179	3.61	V-170	5.00	Pr	2.77	V-171	2.57	BK	2.03
V-177	3.50	V-177	4.97	Pa	2.72	Cz	2.55	Nu	2.03
V-178	3.42	V-178	4.87	Se	2.72	V-178	2.45	WB	2.03
$\bar{x}$	4.1		6.2		3.2		3.0		2.5

have fewer lateral shoots. The Scandinavian pines as well as those from Smołdzino and from Nurzec have had the lowest number of branches.

In Stepnica this character does not differentiate the populations significantly.

Also the results obtained in the experimental area in Sokółka confirm the results obtained in Janów Lubelski that the Scandinavian provenances have significantly less branchy seedlings.

In Janów Lubelski the mean number of lateral shoots proved to be differentiated to a significant degree. The populations from Sweden, from Bystrzyca Kłodzka and from northeastern Poland, namely Wilcze Bagno, Nurzec and Serwy have distinctly fewer lateral shoots than the remaining ones.

A joint analysis of variance was also made for this character for the four experimental areas, in order to test whether there is any interaction between the provenances and the conditions of cultivation. This interaction proved significant at 0.99 level of confidence.

The mean values calculated over the four experimental areas indicate that most branchy are the provenances from central and western Poland (see table 10). The Swedish ones and those from Łeba (Smołdzino) and Nurzec have the lowest average values for this character.

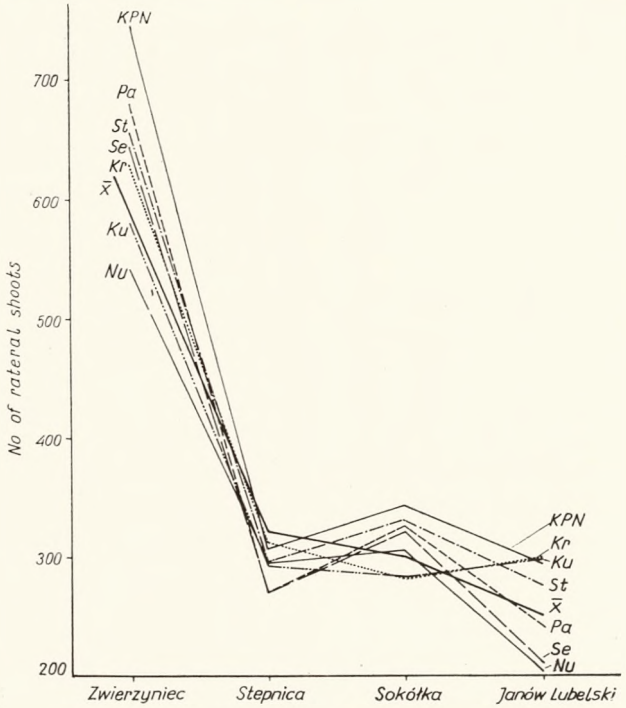

Fig. 11. Interaction effect of the experimental areas with the provenances on the number of lateral shoots. In the diagram a group of provenances is presented the seedlings of which have more lateral shoots in Sokółka than in Stepnica

The sequence of experimental areas arranged according to the mean number lateral shoots is as follows: Zwierzyniec (6.2), Stepnica (3.2), Sokółka (3.0) and Janów Lubelski (2. 5.)

The group of provenances inculding the populations from Kampinos, Stepnica, Parczew, and Serwy is responsible for the interaction because for them the number of shoots was higher in the Sokółka experimental area than in Stepnica, and the provenances Kubryk and Krutyń had more lateral shoots in Janów Lubelski than in Sokółka (fig. 11).

6. Length of lateral shoots of the last year

In the fall of 1969 the lateral shoots were measured. Variance analysis for the mean values observed in the Zwierzyniec experimental area indicated significant differentiation. Longest shoots were observed on the pines from central Poland and from some of the localities in northern Poland, the mountain provenances

had intermediate shoot lengths and the shortest ones were observed on the provenances from Scandinavia and from Smołdzino.

In Janów Lubelski this character differentiates provenances only at 0.95 level of confidence. The shortest lateral shoots have again been found on the Swedish provenances.

In Sokółka the differentiation is also slight and it does not group the provenances in a regular fashion. Among the origins with relatively short lateral shoots the Swedish provenances and the one from Smołdzino can be found.

In Stepnica the character did not differentiate the provenances significantly.

In all the experimental areas the relative shortness of the lateral shoots on pines from Sweden and Smołdzino was marked.

7. Lammas growth

In view of the scantity of data on the subject in was not possible to conduct a variance analysis here. Only the joint percentage of plants with Lammas growth has been calculated for each provenance.

In the Zwierzyniec experimental area in none of the provenances was there more than 8.9 per cent of seedlings with the condition. This high percentage was observed only on the pines from Scandinavia (V-171). The lowest percentage was 1.5% for the pines from Zwierzyniec Białowieski. The mean for the whole area was 4.2%. Generally the northern provenances had a somewhat higher percentage of plants with Lammas growth.

In Janów Lubelski the highest percentage observed was almost three times as high as the value in Zwierzyniec. It was 28% for the pines from Czersk. The lowest percentage was noted for the pines from Oleszyce – 8.3%. The mean value for the whole area was 17.7%.

In Sokółka the percentage of plants with Lammas growth was similar to the values observed in Zwierzyniec. It was from 10.4% for the Prószków provenance to 1.9% for the pines from Tabórz. Mean for the whole area was 6.1%.

The highest percentages of plants with Lammas growth have been observed in the experimental area in Stepnica, where on the average 19.1% of seedlings had the condition. The pines from Supraśl had as much as 30.2% and in all 15 provenances had more than 20% of seedlings with Lammas' growth. The lowest percentage of 2.4% was observed for the seedlings from Pieniny.

Lammas' growth does not appear to be related to the geographic position of the origin of each seed lot but primarly depends on the site and conditions of cultivation. It has to be considered therefore as a phenotypic character.

DISCUSSION OF THE RESULTS

The first results obtained on four year old seedlings, that is after three vegetative periods since outplanting in the forest do not permit to make very far reaching generalizations. Except for the experiment established in the Zwierzyniec forest

belonging to the Institute of Dendrology the pines have not yet come out of the transplanting shock, and as a result their growth is still abnormal. This is indicated by the conditions of cultivation, the generally lower number of plants with a distinctly formed habit and the statistical analyses of the various measurements which frequently did not reveal any significant differences between provenances.

The most frequently considered, and the easiest to measure character that estimates growth is the size a of seedling, particularily its height.

In this respect the provenances from central Poland were best (see fig. 7 and table 8) such as Prószków, Parczew, Kampinos, Lubniewice, Brody, Spała and Pionki. On the map in fig. 7 they have been marked with a double circle. The shortest provenances also form a clear group, namely the Scandinavian ones and from Poland the seedlings from Bystrzyca Kłodzka and Smołdzino that is the mountain ones and those which Staszkiewicz on the basis of cone morphology has described as *suecica* (Sm). Such correlations are also manifest in other characters.

The existence of a significant interaction between provenances and the site of the experimental areas (fig. 9, 10 and 11) indicates that the pines have an unequal ability to adapt to external conditions. Fig. 8 permits a comparison of the mean seedling heights for various provenances growing in our experimental areas. It can be seen from it that trees from some of the populations, e. g. from Parczew, grow well on 3 of the areas (Zwierzyniec, Sokółka and Stepnica) but on the fourth (Janów Lubelski) they attain a relatively lower height. The populations from north-eastern Poland are also not uniform. Generally those from the Mazury region (Krutyń, Tabórz, Ruciane) grow better than those form the Białystok region (Serwy and Supraśl).

Increments in lateral shoot growth characterize the variability of the individual studied populations considerably worse than seedling height did. Generally the mean length of these shoots is relatively shorter for pines of Scandinavian origin or from Smołdzino. This is probably associated with a lower mean viability of these seedlings, which has been also observed in the percentage survival. From these provenances a greater number of plants have perished.

With the growth characters also the question of seedling shape is associated, particularily its slenderness. This has been expressed as an index, namely as the ratio of seedling height to the mean length of its lateral shoots. Here a distinct influence of the environment is noticable. Data about this character have been collected in table 11 and the in a graphical form the result is presented in fig. 12.

Regardless of the provenance the more easterly is the location of the planting site, that is the direction of the more severe continental climate, the more slender do the pines become. This would indicate that the plant shape is a phenotypic character. These are of course first results obtained from the measurement of young seedlings, however they appear to throw some light on the question of narrow crowns characteristic for the pines from the north-eastern region.

The number of buds of a terminal shoot and the number of lateral shoots does not appear to be a feature that has a geographical pattern of distribution. Our populations from central Poland and those from western part of the country gene-

Fig. 12. Slenderness of pine seedlings. The heights of the triangles correspond to the mean heights of the seedlings and the bases of the triangles to the lengths of lateral shoots. The numerical values near the hypotenuses correspond to the values of the ratios of seedling height to lateral shoot length

rally had more branchy seedlings. The smallest number of shoots as well as lateral buds have been found in seedlings from the north, primarily those from Scandinavia and from Smołdzino, as well as those from the moutains (Bystrzyca Kłodzka and Pieniny). This character was observed on all the experimental areas.

The tendency for Lammas' growth, that is to have a secondary growth phase in mid summer, appears to be in the light of the presented results, similarily as seedling slenderness a character that is a function of the environment, since the largest number of seedlings with this character has been observed on all the provenances in Stepnica. For that experimental area 19.1% of the seedlings had the condition while in Janów Lubelski 17.7%, in Sokółka 6.1% and in Zwierzyniec only 4.2%. The same provenances have very variable percentages of seedlings with Lammas' growth and therefore one should not associate this character with inherited tendencies, but only with the climatic conditions prevelant in the site of cultivations.

The mortality of seedlings, illustrates to some extent the viability of the studied pine populations, but it varies not very uniformly. In the experimental area in Janów Lubelski and in Sokółka significant differences between populations have not been found. On the other hand in Stepnica this character in many respects is inversly proportional to the distance from site of origin of the seed to the location of the planting site. Thus for example the population from Radawnica was in this respect

Table 11

Shape of pine seedlings estimated by the ratio of seedling height to length of the lateral shoot, as measured in 1969

Provenance	Stepnica	Zwierzyniec	Janów Lubelski	Sokółka
Bystrzyca Kłodzka	2.26	3.05	3.18	3.97
Bolewice	2.63	2.89	2.76	4.18
Brody	2.37	2.71	3.09	3.87
Czersk	2.54	2.76	3.16	4.13
Dłużek	2.15	2.68	2.97	3.91
Janów Lubelski	2.31	2.82	3.07	4.15
Kampinoski Park Narodowy	2.51	2.96	3.26	4.05
Krutyń	2.30	2.95	3.52	3.64
Kubryk	2.20	2.90	3.11	3.74
Lubniewice	2.46	2.94	3.25	4.25
Łomża	2.36	2.78	3.19	3.82
Myszyniec	2.53	2.82	3.25	3.79
Nurzec	2,34	2.76	2.82	4.18
Oleszyce	2.28	2.94	2.98	3.86
Parczew	2.23	3.05	3.31	3.55
Pionki	2.43	3.05	3.26	4.05
Prószków	2.21	2.92	3.18	3.60
Pieniński Park Narodowy	2.52	3.11	–	–
Radawnica	2.55	3.00	3,47	4.05
Rataje	2.38	2.88	3.07	3.93
Ruciane	2.67	2.75	3.54	3.64
Serwy	2.32	2.99	3.69	4.05
Smołdzino	2.66	2.65	2.90	4.31
Spała	2.66	3.11	3.33	3.90
Stepnica	2.40	3.11	3.05	4.08
Supraśl	2.40	3.03	2.91	4.53
Tabórz	2.24	2.98	3.26	3.90
Wilcze Bagno	2.37	2.84	3.63	4.18
Zwierzyniec Białowieski	2.42	2.78	–	4.06
Zwierzyniec Lubelski	2.42	3.08	2.89	4.24
V – 170	2.57	2.76	2.92	3.97
V – 171	2.28	2.84	3.08	3.80
V – 177	2.37	2.80	3.07	4.35
V – 178	2.56	2.72	2.96	3.82
V – 179	2.45	2.86	3.34	3.99
$\bar{x}$	2.35	2.89	3.03	4.10

very viable while in the experiment in Zwierzyniec the percentage survival was relatively smaller. A similar relation is observable on the example of the provenance Smołdzino. In Zwierzyniec it has a relatively low survival while in Stepnica the mean number of seedlings alive per plot is high compared with other populations. All the Swedish provenances have in Stepnica a relatively higher percentage of seedlings still alive after three vegetative seasons than at the other planting sites. In this respect they are also similar to the Smołdzino provenance.

The mean number of adventitious buds per seedling have also been investigated after one vegetative season, but only in the Zwierzyniec experimental area. The seedlings of northern origin have distinctly fewer adventitious buds, though there are a few provenances that are an exception to this rule.

The first Polish information about racial differentiation in resistance to attack by *Lophodermium pinastri* has been published by Siwecki (1967). This was based

on a relatively limited material, yet it has demonstrated that the pines from Nurzec (NE region) were more resistant than those from Janów Lubelski (SE region) or from Wołczyn (SW region). The initial data on the susceptibility of pine races to attack by *Lophodermium pinastri* from the extensive study being conducted by Dr. Siwecki, and made kindly available by him, indicate that the seedlings originating from Supraśl (Su), Czersk (Cz) and Smołdzino (Sm) that is from the northern region are relatively resistant while the pines from Zwierzyniec Lubelski (ZwL), (S region) Kampinos National Park (KPN) and Spała (Sp) (Central Poland) are relatively susceptible. These results are in general agreement with those obtained in the present study. Other Polish studies (Kozłowska 1968) did not show any variation in this respect.

To summarize, all the results of studies on the resistance of pines to *Lophodermium pinastri* that have been obtained to date seem to indicate that generally speaking the pines from the north-eastern part of our country are more resistant to attack by the fungus than the pines from the south-western region. These observations concern primarly our own races however it is also true that the Swedish provenances from Värmland were more resistant, which fact only supports the general conclusion.

The greenhouse experiment has permitted the observation of only two characters that differentiate the studied populations to a significant degree:

1. It has been shown that the pines from the north-eastern part of the country had generally a lower number of cotyledons than the seedlings from the south west, which is in agreement with the data published by de Ferre and de Meric (1963), even though the mean numbers of cotyledons per seedling in the populations used in the French experiment were somewhat different from the values obtained here. Both for Dłużek and Radawnica, the two Polish provenances used by the French authors, the numbers of cotyledons were higher in their study than observed here. Our results were based on material twice as numerous – about 500 seedlings – while de Ferre and de Meric have counted cotyledons on only 200 seedlings. The direction and nature of the variability was for both the studies the same.

2. It was demonstrated that in the aerial parts of the seedlings originating from north-eastern Poland the percentage of nitrogen in the dry weight is somewhat greater than in seedlings from the south west (fig. 5). This only confirms earlier informations obtained on the subject (Giertych 1969).

The content of nitrogen in the dry weight of roots does not appear to differ for the various provenances, but it is always lower than in the aerial parts. Generally the higher percentage of nitrogen in the aerial plant parts is associated with a generally higher content of the element also in the roots (see table 5).

Mean percentage values for the content of metallic elements in the dry weight appear to be, in spite of the insignificance of differences between provenances, rather characteristic. Potassium always represents a higher percentage of shoot dry weight than of the root. For the whole experiment the ratio for K% in the shoot and in the root is 2.08. Similarily with calcium (Ca) there is more of it in the shoot than in the root, on the average about 4.6 times. Sodium (Na) on the other

hand is more concentrated in the roots, the shoot/root ratio for the element being 0.59. The Swedish population from Värmland, which contained the highest concentration of nitrogen in the dry weight of the aerial seedling part, had at the same time the lowest concentration of potassium, both in the shoot and in the root.

The chemical analyses of the seedlings dry weight has not indicated any relation between the content of the studied elements and the growth results obtained for the seedlings on sand cultures. Pines of the populations which are characterized by better growth of the shoot or of the root (see table 4) do not appear to differ from the slower growing ones in the content of nitrogen, potassium, calcium or sodium.

The measurements of cones, seeds and seed wings was to have provided additional information about the variability of pine populations from the region of Poland and at the same time to tie in with the results obtained from the more extensive study conducted on a large scale by Staszkiewicz (1961). He has used a different method of collecting and measuring the material, however it is possible to compare with his results the mean values for cone length and width as well as the ratio of these two characters. For the groups of pines he has distinquished from Polish populations the values of these characters are as follows:

Character	Cone type		
	Polonica	Suecica	Subcarpatica
Length in mm	36.8	35.96	41.33
Width in mm	18.59	18.65	20.36
Length/width	1.95	1.93	2.03

According to Staszkiewicz the *polonica* type is to be found throughout the lowland parts of the country and from the Pieniny Mts., the type *suecica* is from Łeba and the type *subcarpatica* is from the Nowy Targ valley. The first one is an extensive population and the third has not been represented in the present study. The population of cones from Łeba, referred to here as the Smołdzino provenance (after the name of the Forest District) differs from the type described by Staszkiewicz in mean dimentions. The cones were 6.34 mm longer, and 0.75 mm wider and as a result the ratio of the two characters was also larger by 0.25. Mean values for all the populations were 3.88 cm in length, 1.81 cm in width and the ratio was 2.14.

Thus it is difficult to tie in here with the results of biometrical studies obtained by Staszkiewicz, particularily since his conclusions were based on numerous other characters that have not been investigated here.

The measurements of cones as well as of seeds or seed wings did not show any geographical pattern of distrubition and do not give any information about the regional differentiation of Polish pines.

Special comment however is needed about the population of pine from Smołdzino, that is from the vicinity of Łeba. Staszkiewicz (1961) has on the basis of cone measurements recognized the existance here of a form which he called *suecica*. Many

of the observations and results of measurements reported in this study indicate that this suggestion is justified, in spite of the fact that the characteristics of cone dimentions do not appear to agree here. The population from Smołdzino seems to be similar to the Swedish populations in several characters such as viability, height, number of buds and shoots, the resistance to *Lophodermium pinastri* and the content of nitrogen in the seedlings. It is difficult to decide whether the population growing in Łeba is an indiginous one, however it is most unlikely that pines from Sweden were introduced there. I would be more inclined to accede to the view that it is a relict local population.

CONCLUSIONS

The most important results of the studies reported in this paper can be summarized in the following points.

1. The studied populations, which originate from some forest-climatic regions covering relatively small areas, e. g. the Mazury Lake District region, or the region of the Podlasie Forests (Mroczkiewicz 1952) do not constitute a uniform material, that would react to site conditions of an experimental area in the same fashion. This indicates that differences do exist between the relatively small populations. In any case the problem requires further studies.

2. The pines from north-eastern parts of Poland are distinctly more resistant to attack by *Lophodermium pinastri* than the populations from the south-western regions of the country.

3. Pines of mountain origins, from Bystrzyca Kłodzka (BK) and from the Pieniny National Park (PPN) are similar in certain characters to the northern and Scandinavian pines.

4. As regards the number of cotyledons in seedlings there exists a distinct clinal variation, the number increasing in the south-westerly direction.

5. Pine seedlings of more northerly origins contain a relatively higher nitrogen concentration in the dry weight of aerial parts.

6. The pine population from Smołdzino differs considerably from all others. It is probably a characteristic relict population.

7. A distinct environmental influence was observed on the form of the seedlings, expressed as ratio of seedling height to the length of the lateral shoots. In Stepnica this ratio was 2.35 (plants with a wide profile), in Zwierzyniec 2.89, in Janów Lubelski 3.03 and in Sokółka 4.10. This ratio, which is a measure of seedling slenderness increases from west to east.

8. Lammas' growth, that is the tendency to have a second burst of growth in mid summer also appears to be a phenotypic character, depending on the conditions in the region of seedling cultivation.

9. In the present state of our studies it is still not possible to draw even provisional boudaries between individual races of pines growing in Poland. This would require further studies based on older material.

SUMMARY

The author presents first results of provenance experiments on Scots pine from 30 Polish and 5 Swedish origins.

The main experimental results are:

1. Within the forest-botanical regions there occur heterogenous pine populations, which react differently to climatic conditions, and therefore are of different adaptability.

2. The pines originating from more northeasterly regions are more resistant to attack by *Lophodermium pinastri* than those from southwestern parts of Poland.

3. Pines of mountain origin (Bystrzyca Kłodzka and Pieniny) have many characters in common with the pines from Sweden and from the northern regions of Poland.

4. Variation in the number of cotyledons per seedling is clinal in character; it increases towards the southwest.

5. Pine seedlings originating from the north have in the dry weight of their aerial parts a higher percentage of nitrogen than seedlings of southern provenance.

6. The population of pine from Smołdzino (near Łeba) differs in many characters, and it is probably an indiginous relict pine similar to the Scandinavian ones.

7. A distinct influence of the enviroment on the form of the seedlings was observed. Seedlings of the same provenances are more slender when grown in Sokółka than when grown in Stepnica. The slenderness was measured as the ratio between seedling height and the length of the lateral shoot.

Institute of Dendrology and Kórnik Arboretum
Kórnik nr. Poznań

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TADEUSZ PRZYBYLSKI

Zmienność sosny zwyczajnej (Pinus silvestris L.) w Polsce

Streszczenie

Autor przedstawia pierwsze wyniki doświadczeń z sooną zwyczajną 30 polskich i 5 szwedzkich prowenienc ji, założonych przez Zakład Dendrologii i Arboretum Kórnickie PAN w 1967 r. (Przybylski 1968) na terenie leśnictwa doświadczalnego Zwierzyniec w Kórniku oraz na terenie nadleśnictw Janów Lubelski, Sokółka i Stepnica. Rozmieszczenie badanych prowenienc ji oraz lokalizację doświadczeń terenowych ilustruje rycina 1.

Badano następujące cechy:

1. liczba żyjących roślin (sadzono po 49 na poletku),
2. wysokość siewek,
3. długość ostatniego przyrostu pędu głównego,
4. liczba pączków bocznych pędu głównego,
5. liczba pączków przybyszowych,
6. procent roślin z wyraźnym pączkiem szczytowym po 1 roku po przesadzeniu na uprawę,
7. liczba pędów bocznych,
8. długość pędów bocznych,
9. procent roślin wykazujących wtórne pędzenie,
10. procent roślin porażonych przez osutkę,
11. liczba liścieni na siewkach,
12. udział procentowy N, Na, K i Ca w suchej masie części nadziemnej i systemu korzeniowego siewek,
13. długość strzałki i systemu korzeniowego siewek z kultur piaskowych ze szklarni.

Ponadto pomierzono po 50 szyszek i nasion wraz ze skrzydełkami (tab. 12).

Dane pomiarowe zestawiono w formie średnich w tabelach 3 - 10 i 12. Wyniki poddano analizie wariancyjnej, a w przypadku istnienia różnic istotnych podzielono badane populacje na grupy statystycznie podobne przy pomocy najmniejszej różnicy istotnej wg testu Duncana (ryc. 4 - 10).

Najważniejsze wyniki badań:

1. Na obszarze regionów przyrodniczo-leśnych występują populacje sosen niejednorodne, różnie reagujące na warunki klimatyczne, a więc o różnym stopniu zdolności przystosowawczej.

2. Stwierdzono większą odporność na porażenie przez osutkę u sosen pochodzenia północno-wschodniego, niż u populacji z południowego zachodu.

3. Sosny pochodzenia górskiego (Bystrzyca Kłodzka i Pieniny) mają wiele cech zbliżonych do sosen ze Szwecji i regionów północnych Polski.

4. Zmienność średniej liczby liścieni ma charakter klinalny: rośnie w kierunku południowo-zachodnim.

5. Siewki sosen pochodzących z północy mają w suchej masie części nadziemnej nieco wyższy procent azotu niż siewki sosen pochodzeń południowych.

6. Populacja sosen ze Smołczina (okolice Łeby) wyróżnia się wieloma cechami i jest zapewne reliktową sosną rodzimą, zbliżoną do sosen skandynawskich.

7. Zaznaczył się wyraźny wpływ środowiska na pokrój siewek; siewki tych samych populacji mają bardziej smukły pokrój w Sokółce niż w Stepnicy. Miarą tej smukłości jest stosunek wysokości siewki do długości pędu bocznego.

ТАДЭУШ ПШЫБЫЛЬСКИ

Вариантность обыкновенной сосны (Pinus silvestris L.) в Польше

Резюме

Автор представляет первые результаты исследований обыкновенной сосны 30 польских и 5 шведских географических происхождений, заложенных Институтом дендрологии и Арборетумом ПАН в Курнике в 1967 году. (Przybylski 1968) на участке опытного лесничества Звежынец в Курнике а также на участках надлесничеств Янув Любельски, Сокулка и Степница. Размещение сосны исследуемых географических происхождений и локализацию местных опытов иллюстрирует рис. 1.

Исследованы следующие признаки:

1. число живых растений (высажены по 49 на участке),
2. высота сеянцев,
3. длина последнего прироста главного побега,
4. число боковых почек главного побега,
5. число придаточных почек,
6. процент растений с выразительной верхушечной почкой через 1 год после пересадки на выращивание,
7. число боковых побегов,
8. длина боковых побегов,
9. процент растений, обнаруживающих вторичное выращивание,
10. процент растений, поражённых шютте сосны,
11. число семядолей на сеянцах,
12. процентное содержание N, Na, K и Ca в сухой массе надземной части и корневой системы сеянцев,
13. длина стрелолиста и корневой системы сеянцев с песчаных культур из оранжереи.

Кроме того измерены по 50 шишек и семян вместе с крылышками (табл. 12).

Измеренные данные сопоставлены в форме средних в таблицах 3 - 10 и 12. Результаты подвергнуты были вариационному анализу, а в случае наличия существенной разницы исследуемые популяции разделены были на статистически подобные группы при помощи наименьшей существенной разницы согласно тесту Дункана (рис. 4 - 10).

Самые важные результаты исследований:

1. На территориях естественнолесных районов выступают неоднородные популяции сосны, по разному реагирующие на климатические условия, следовательно с разной степенью способности приспособления.

2. Установлена большая устойчивость перед поражением шютте сосны у сосны северо-восточного происхождения, чем у популяции с южного запада.

3. Сосны горного происхождения (Быстжыца Клодзка и Пеннины) обладают многими признаками, сближёнными к сосне из Швеции и северных районов Польши.

4. Изменчивость среднего числа семядолей носит клиновой характер: возрастает в юго-западном направлении.

5. Сеянцы сосны, происходящей с севера, содержат в сухой массе надземной части несколько больший процент азота, чем сеянцы сосен южного произхождения.

6. Популяция сосны из Смолдзина (окрестности Лэбы) отличается многими чертами и является, вероятно, реликтовой отечественной сосной, сближённой к скандинавским соснам.

7. Проявилось выразительное влияние среды на внешний вид сеянцев; сеянцы одних и тех же популяций обладают более стройным внешним видом в Сокулке, чем в Степнице. Мерой этой стройности является отношение высоты сеянца к длине бокового побега.

Fot. K. Jakusz

Kwiatostany igliczni (*Gleditsia aquatica* Marsh.)