

A review of the seed orchard programme in Poland

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Abstract

As results from the assumptions adopted for a long-term selective forest tree breeding programme, seed orchards in Poland constitute only a supplementary source of forest reproductive material. Following these assumptions, the share of an individual seed base used for forestry purposes cannot exceed 20 percent. 1962 hectares of seed orchards have been established so far within the State Forests National Forest Holding (State Forests NFH). Part of them established as the first conifer seed orchards in Poland today produce seeds and are used for the production of forest reproductive material, while most of the broadleaved seed orchards were established in the nineties of the past century and only entered the seed production phase. Presently, the seeds from the orchards constitute, depending on the crop, 8 – 17 percent of the reproductive material for forestry use. The estimates show that the actual area of seed orchards should fully satisfy the demand for the reproductive material from this seed base category. Recently, creation of a new category “tested” of forest reproductive material has started. The choice of tested trees will allow to establish seed orchards of the known genetic value and to select individuals with specified breeding qualities to be used for special purposes. Actions of this type have been proposed in the assumptions to the new selective forest tree breeding programme prepared for the years 2010-2035 in the State Forests NFH.

Key words: individual selection, mother trees, seed orchards, testing forest reproductive material

Introduction

The implementation of selective forest tree breeding programmes in Poland has been pursued in the State Forests NFH since the early sixties of the past century. First stands were then selected to create a selective seed base of forest tree species. Selective breeding was implemented in the State Forests NFH on the basis of the programmes developed for successive periods. The first programme was implemented in the years 1960-1975, the second one – in 1976-1990, and the implementation of the current programme 1991-2010 is coming to an end. The next stages of the selective forest tree-breeding programme assume the continuation of the key strategic goals adopted in the first stage of programme implementation taking into consideration the necessity to adjust the current goals to the changing ecological and economic conditions of forest functioning.

The strategic goals adopted for the selective forest tree-breeding programme for the years 1975-1990 were as follows:

1. Maintain the existing genetic variation in forests over a long time span.
2. Increase the productive capabilities, improvement of qualitative parameters and stability of the next generations of forests.
3. Create and maintain a seed base on the level guarantying the achievement of goals 1 and 2 (5, 6).

To achieve the strategic goals of the Programme it was assumed that population selection (seed stands) would be the main direction of the activities, while individual selection (plus trees, seed orchards, seedling seed orchards) would be complementary to these activities. The share of seeds from individual selection steadily increased in successive periods:

1960 - 1975 – 100 % of the population seed base,

1976 - 1990 – 95 % of population seeds, 5 % of seeds from the orchard,

1991 - 2010 – 85 % of population seeds, 15 % seeds from the orchard.

However, it did not reach the maximal allowable level in the State Forests NFH that is 20 percent of the total demand for seeds for restocking.

These quantities are pretty large taking into consideration the general demand for seeds in the State Forests NFH (see Table 1).

Individual seed base in Poland – the present state

In accordance with the Forest Reproductive Material Act, there are three categories of Basic Forest Material (LMP) forming the forest seed base in Poland:

Category I – stands of known origin,

Category II - selected stands,

Category III - parents of families, and the seed orchards and seedling seed orchards established on their basis (2, 3).

The first and second categories constitute a so-called population seed base, while the third “qualified” category was created on an individual selection basis. Till 2006, approx. 10,000 mother trees of the 14 main forest tree species within the State Forests NFH had been classified on the basis of phenotypic traits. A detailed specification of the qualified mother trees is given in Table 2. For indigenous trees, the amount of plus trees is strongly correlated with the share of these trees in forests. However, the share of conifers is higher, as coniferous species were qualified in the first place. Also, higher than average is the share of mother trees of admixture and introduced species, such as the common birch, European larch, black pine or Douglas fir for which seed orchards are and will be the main seed base in the nearest future.

The Table does not include individual trees selected for special purposes and used temporarily as a seed base for restocking and gene resource conservation. There are about 4,000 such trees, specifically 2,000 firs from the Sudeten region and about 1,000 common yews ready for establishing a seed base for the State Forest NFH. The majority of these trees are already in the State Forests NFH’s clone archives whose aim is preservation of all mother trees, gene reserve trees and selected nature monuments growing on forest lands.

The first seed orchards were establishment primarily for conifer species which are currently in the full production phase. The selection of broadleaved mother trees was started as late as in the early nineties, so the seed orchards are relatively young and just enter the production phase. The specificity of Polish forestry is establishment of large-scale seedling seed orchards i.e. generatively produced seedlings. Their progeny shows a much higher variability and they can be maintained productive for a longer period of time, which is their unquestionable advantage. The minimal number of clones in seed orchards is 40 for pine and spruce and 30 for other forest species. The clones in seed orchards are randomly distributed at minimal distances between individuals within a given clone. Three types of cutting: schematic, genetic and combined are anticipated for seed orchards. Similar rules apply to the establishment of seedling seed orchards. The first seedling seed orchards were established on the basis of clone sets from relatively large areas. Currently, attempts are made to ensure that mother tree sets for the species embraced by a detailed seed regionalisation (geographic distribution of seed regions) represent individual regions of their origin.

Data on the established seed orchards are given in Table 2.

All the seed orchards established so far belong to so-called category I, i.e. those created through the selection of mother trees on the basis of phenotypical traits. The programme for the establishment of category I seed orchards has not yet been implemented in full. We certainly do not plan to establish this type of seed orchards for most of coniferous tree species. However, we need to establish a number of seed orchards for the broadleaves so that the quantities of seeds from the seed base of this category reach 20 percent. The quantities of seeds currently obtained from seed orchards range from 8 to 17 percent depending on the year. Table 3 shows the percentage of seed base categories meeting forestry needs (data as of 2005).

An individual seed base in the assumptions for the new Programme

In accordance with the adopted strategic assumptions regarding the functioning of the forest seed base in a long time span created in the framework of selective forest tree breeding programmes, no substantial changes are foreseen in the percentage of the population and individual seed bases. However, changes that are to appear are connected with the commencement of creating a new, category “tested” of seed base. Within this category, both the population and individual seed bases are created.

The State Forests NFH, the manager of Polish forests, started testing the seed base categorized as “selected” and “qualified” created in the framework of the previously implemented selective forest tree breeding programmes. The testing programme was introduced into forest practice by Director General’s Ordinance No. 85 of 31 December 2004 on the implementation of the *Programme for testing the progeny of selected seed stands, plus trees, seed orchards and seedling seed orchards* in all the organisational units of the State Forests NFH - ref. no. ZG – 7132 – 58/2004 (1).

The aim of testing the progeny of plus trees, seed orchards and seedling seed orchards through the establishment of testing plantations is to demonstrate the high quality of the reproductive material. This is to be done by making comparative tests or by estimating its quality on the basis of genetic evaluation of core material components which, according to the Act of 7 July 2001 on forest reproductive material, include seed orchard, mother tree, clone and clone mix (Dz. U. of 18 July 2001) (7).

Moreover, progeny testing assumes the development of the principles of rational use of a seed base delimited by seed regions and identification of the area of possible transfer in accordance with the adopted areal regionalisation rules and, additionally in the mountains – the altitudinal zonation rules (4). These rules should be established on a genetic basis. Also,

the testing programme aims at the optimization of tasks presently pursued in the State Forest NFH under sustainable forest management in Poland, i.e. improvement of forest management on an ecological basis (6).

The choice of the best progeny for registration in category IV “tested” of seed base will be the effect of its genetic evaluation. The testing region comprising the territory of the Regional Directorates of State Forests is the basic unit for which seed tree and orchard progeny testing programmes are being developed. In this region, forest core material components are located i.e. plus trees, seed orchards, seedling seed orchards in the amount facilitating testing of representative progeny collections. In the case of mother trees, their number will be close to 100. The progeny of such a set will be tested in four different locations. The test sites will be established in a single-tree plot design with 64 replications (table 4).

Seed orchards and seedling seed orchards will be tested as artificial breeding populations in the sets of 30 items per set. Test sites will be established in a randomised block design in four replications with 100 seedlings in each replication (table 5).

The main actions in the part related to selective forest tree breeding planned for the implementation in the new Programme as regards individual selection will include:

a) continuation of the tasks implemented recently:

- choice and use of mother trees (DD),
- establishment of the first generation seed orchards and seedling seed orchards,
- setting progeny plantations,
- evaluation of the breeding qualities of progeny plantations entering the seed production phase.

b) New tasks related to the genetic evaluation of LMP:

- establishment, management and evaluation of LMP for the production of category III material – LMR (mother trees, seed orchards, seedling seed orchards), in progeny tests,
- choice of LMP stands for the production of LMR – category “tested”,
- development of the rules for the management and use of LMP registered in Part IV of the National Register in forestry,
- establishment of the second generation seed orchards and seedling seed orchards,
- establishment of orchard blocks with LMP of known genetic value.

The selection tasks included in the new Programme for the years 2010-2035 will cover:

- improvement of qualitative and quantitative traits of populations (stands) – population selection (choice of stands from the categories “selected” and “tested”),

- choice of populations and genotypes of high plasticity for breeding under the changing climate conditions (population and individual selection),
- creation of artificial breeding populations on a seed orchard basis with specified (relatively high) genetic variation (individual selection – the choice of different genotypes for tree sets for seed orchards and seedling seed orchards based on DNA analyses),
- improvement of the qualitative traits of genotypes – individual selection – the choice of genotypes of specified traits from the category “tested” – creating artificial breeding populations for forestry needs on a seed orchard basis,
- improvement of resistance traits of genotypes to biotic and abiotic stresses – individual selection – the choice of genotypes of specified traits from the category “tested” – creating artificial breeding populations for forestry needs on a seed orchard basis,
- improvement of the quantitative traits of genotypes – wood mass production in short and long rotation – individual selection – the choice of genotypes of specified traits from the category “tested” – creating an LMP base for clone and clone mix production and the establishment of seed orchards.

Anticipated effects of Programme implementation:

- creation of a “tested” category seed base representing 10 percent of the national demand for seeds (anticipated selection gain for growth traits at population level – 15%, at family level – 25 % in relation to growth traits for the material from outside the base),
- maintenance of the selected seed base representing 30 percent the national demand for seeds (anticipated selection gain for growth traits at population level – 10 %, at family level – 15%),
- maintenance of a permanent seed base from the identified source representing 60 percent the national demand for seeds (anticipated selection gain for growth traits at population level – 2-5%).

Literature:

1. Barzdajn W., Blonkowski S., Chałupka W., Fonder W., Giertych M., Korczyk A., Matras J., Potyrański A., Tabor J., Szelaż Z., Zajączkowski S. 2004. Program testowania potomstwa wyłączonych drzewostanów nasiennych, drzew doborowych, plantacji nasiennych i plantacyjnych upraw nasiennych. DGLP Warszawa: (1–81).
2. Burczyk J., Fonder W., Kowalczyk J., Lewandowski A., Matras J., Nowakowska J., Załęski A. 2003. Opracowanie szczegółowych wymagań wynikających z dyrektywy Rady 1999/105/WE z 22 grudnia 1999 roku w odniesieniu do leśnego materiału podstawowego i produkowanego z niego leśnego materiału rozmnożeniowego. Spr. Naukowe IBL, Warszawa (1–179).
3. Council Directive 1999/105/EC of 22 December 1999 on the marketing of forest reproductive material. 2000. Official Journal of the European Communities L11/17: (17–40).
4. Fonder W., Kantorowicz W., Matras J., Sabor J., Zajączkowska B., Zajączkowski G., Załęski A. 2003. Zmodyfikowanie aktualnych zasad regionalizacji nasiennej z dostosowaniem do ustawy o leśnym materiale rozmnożeniowym. Spr. Naukowe IBL, Warszawa (1–34).
5. Matras J. (kier. zespołu), Burzyński G., Czart J., Fonder W., Korczyk A., Puchniarski T., Tomczyk A., Załęski A. 2000. Program zachowania leśnych zasobów genowych i hodowli selekcyjnej drzew leśnych w Polsce na lata 1991–2010. DGLP, IBL Warszawa. Wydanie II poprawione (1–79).
6. Matras J., Fonder W. 2006. Wytyczne w sprawie ochrony leśnych zasobów genowych na potrzeby nasiennictwa leśnego. Załącznik nr 1 do zarządzenia nr 7 A z 7 kwietnia 2006 r. dyrektora generalnego LP (zn. sp. ZG/7130/7/2006) w sprawie ochrony leśnych zasobów genowych na potrzeby nasiennictwa i hodowli drzew leśnych. IBL, DGLP, Warszawa.
7. Ustawa z 7 czerwca 2001 roku o leśnym materiale rozmnożeniowym, 2001. Dz.U. nr 73 poz. 761, Warszawa.

Table 1. Seeds demand of the main forest tree species for the years (1991-2005) (KG)

Year	Pine	Spruce	Larch	Fir	Oak	Beech
1991	13 080	2750	2990	17 760	871 200	66 210
1992	13 510	2990	2663	19 190	1 153 700	105 220
1993	14 230	2620	3480	15 190	1 242 300	78 480
1994	11 570	2330	2450	13 220	1 107 100	71 780
1995	10 680	2050	2400	12 500	1 307 900	123 370
1996	11 460	1720	2500	10 500	1 245 400	72 040
1997	8090	1370	1450	16 120	1 281 100	75 170
1998	7560	1250	1310	9040	1 244 400	108 480
1999	7470	1140	1680	16 790	1 255 500	82 460
2000	8090	1045	1301	9 269	1 291 368	116 842
Mean (91 -00)	10 574	1 926	2 222	13 958	1 199 997	90 005
2001	7348	1249	1427	9 776	1 150 311	79 373
2002	7593	830	996	6 537	869 490	83 963
2003	6944	840	1102	5 974	909 805	77 861
2004	5996	795	908	6 427	890 081	87 003
2005	6479	788	800	8 785	1 125 543	74 857
Mean (01-05)	6 872	900,4	1 046,6	7 500,2	989 046	80 611,4

Table 2. Present state of forest seed base in Poland [ha]

Species	Populations of known origin	Selected stand	Plus trees	Seed orchards	Seedling seed orchards
Pine	154 500	6957	3670	425,78	279,30
Spruce	14 050	2277	950	75,60	10,89
Larch	1020	445	1016	252,11	171,89
Fir	5580	1370	484	80,15	15,35
Black Pine	100	72	232	25,00	110,64
Other coniferous	180	162	583	52,63	47,30
Birch	2 600	195	267	47,62	13,39
Beech	17 300	2076	553	50,47	11,22
Pedunculate Oak	13,325	1370	557	31,95	23,40
Sessile Oak	2 075	1452	332	53,38	11,00
Black Alder	6 700	563	517	50,23	0
Small-leaved Lime	300	142	135	96,56	0
Other deciduous	740	121	499	21,92	4,55
Total	219 100	17203	9795	1263,40	698,93

Table 3. Proportion (in %) of different category of FRM in seed base (2004)

Species	Populations of known origin	Selected seed stand	Seed orchards seedling seed orchards	Other
Pine	82,0	8,0	10,0	0,0
Spruce	58,0	30,0	2,0	10,0
Larch	35,0	10,0	47,0	8,0
Fir	58,0	37,0	3,0	2,0
Other coniferous	11,0	40,0	27,0	22,0
Mean	73,0	13,0	12,0	2,0
Birch	79,9	12,3	7,8	0,0
Beech	74,6	25,4	0,0	0,0
Pedunculate Oak	100,0	0,0	0,0	0,0
Sessile Oak	95,1	3,9	0,0	0,0
Black Alder	91,9	5,9	2,2	0,0
Small-leaved Lime	88,2	1,8	10,0	0,0
Other deciduous	100,0	0,0	0,0	0,0
Mean	90,1	7,0	2,9	0,0

Table 4. Number and localization the testing plots for mother trees

REGIONAL DIRECTORATE OF STATE FORESTS	SPECIES										
	PINE	SPRUCE	LARCH	FIR	D.FIR	BEECH	P. OAK	S. OAK	BIRCH	ALDER	TOTAL
Białystok	24	12					8		2	4	50
Gdańsk	8		4		2	4	1	2			21
Katowice	12	8	4	2	2	2	2	2			34
Kraków	8	2	8	8	2	4	1		2	2	37
Krosno	4	2	4	8	2	4	1			2	27
Lublin	8	2	4	2		2	1		2	4	25
Łódź	8								1	1	10
Olsztyn	16					1	1		2	2	22
Piła	8	2	1			1	1	2	1		16
Poznań	8				2		2	2		1	15
Radom	4	2	4	2		2	1			4	19
Szczecin	16	2	4			4		4	1		31
Szczecinek	8		3			1		2			16
Toruń	16					1	1	2	1	2	25
Warszawa	4									2	6
Wrocław	4	4	8	2	2	2					22
Zielona Góra	4										4
TOTAL	160	36	44	24	16	28	20	16	12	24	380

Table 5. Number and localization the testing plots for seed orchards and seedling seed orchards

REGIONAL DIRECORATE OF STATE FORESTS	SPECIES												
	PINE	SPRUCE	LARCH	FIR	D.FIR	B.PINE	BEECH	P.OAK	S.OAK	BIRCH	LINDEN	ALDER	TOTAL
Białystok	2	2						1		1		1	7
Gdańsk	2		2		1		1			1	1		8
Katowice		2	2	1	1	2	1	1	2				12
Kraków				2		2	1						5
Krosno	2	1	2	1	1		1	1					9
Lublin	2			1				1		1		1	6
Łódź	2						1			1		1	5
Olsztyn	2	1						1			1	1	6
Piła	2								1				3
Poznań	2				1	2		1	2	1		1	10
Radom			2	2								1	5
Szczecin	2				1		1	1	1				6
Szczecinek					1		1		1		1	1	5
Toruń	2				1	2			1	1			7
Warszawa	1									1		1	3
Wrocław	2	2	2	1	1			1			1		10
Zielona	1						1			1			3
TOTAL	24	8	10	8	8	8	8	8	8	8	4	8	110