Growth and Quality of Intra-Specific Aspen (*Populus tremula* L.) Progenies

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Summary

In this paper, the results of a series of crossing experiments after 32 years of field testing are presented. At the age 3, 7, 11 and 33 years, growth and quality of 25 progenies planted on three trial plots were assessed. The results showed clear differences in growth performance and quality of the 25 progenies among the various trial plots. On the respective trial plots, the development of the progenies was consistent over the observation period. The advantages of some progenies in quantity and quality parameters achieved during the first 10 years of growing were more or less leveled off until the age of 33 years. The mean values considering all trial plots differed only slightly. On the other hand, few progenies showed growth and quality above average on all trial plots. Some progenies performed badly on all trial plots as well.

Based on the results of the assessment at the age of 11 years, 1 progeny was approved as tested material. The quantity and quality of this progeny was not consistent until the age of 33 years. On the other hand, other progenies showed consistent quantity and quality performance above average during the entire observation time.

In future, breeding of aspen will concentrate on the broadening of the genetic base by the evaluation of more suitable combinations out of the existing trials. The objective will be to procure a maximum number of tested populations for different site conditions to minimize the risks which may derive from the use of reproductive material with limited genetic variation. Finally, the value of the tested material should not only be seen in advantages in quantity and quality performance but also in more or less predictable characteristics and growth behaviour of the material in question.

Key words: Populus tremula, intra-specific breeding, progeny testing, growth and quality characteristics.

FDC: 165.41; 165.7; 232.11; 176.1 *Populus tremula*.

History and Objectives of Aspen (*Populus tremula* L.) Breeding in Saxony

After the Second World War, the promising results of early breeding with poplar species of the section Leuce led to increased breeding efforts in Germany (SCHÖNBACH, 1957; MELCHIOR and SEITZ, 1966). In Saxony, the planting of aspen as pioneer crop in the Ore Mountains and first results of field experiments proved the impressive growth and silvicultural value of aspen on sites in the mountainous regions (SCHÖNBACH and DATHE, 1962). In 1947, selection and breeding work started under special consideration of aspen. The objective was to produce poplar varieties which can be planted on sites not suitable for existing poplar varieties (SCHÖNBACH, 1957). Following reasons favoured the special consideration of aspen (SCHÖNBACH and DATHE, 1962):

– the superior growth of young aspen on sites which are not suitable for hybrid poplars compared to other tree species;

– the better suitability of aspen wood for the production of matches compared to other tree species including cultivated poplars;

– the equal suitability of aspen wood for the production of mechanical wood pulp and cellulose compared to other cultivated poplars;

– the suitability as pioneer crop, and

– the big variation of aspen in stem form, branching and yield.

In 1948, an aspen inventory was started in East Germany and plus trees were selected according to the criteria

– straight and continuous stem,

– narrow crown,

– fine branchiness and good self pruning, and

– health at the time of selection.

The inventory resulted in the selection of 290 plus trees. In this lot, trees were included which could not fulfil the criteria set but had shown good growth rates on extreme sites compared to other tree species (SCHÖNBACH and DATHE, 1962). These plus trees were used in a set of various crossing experiments with the objectives to increase the yield and to improve the wood characteristics of aspen. Special consideration was laid on the health of the progenies, straightness and branchiness of the stem. After planting, the improved aspens should be able to compete with clear cut vegetation (SCHÖNBACH and DATHE, 1962).

In this paper, the results of a series of crossing experiments after 32 years of field testing are presented. These results are of special interest because they have been used for approval of tested material in 1974 after an assessment at the age of 11 years in 1972.

Material and Methods

Investigated progenies

In 1962, 79 inter- and intra-specific crossings with aspen and different poplar species had been carried out. Out of 69 combinations produced, 24 progenies of aspen and 1 hybrid combination between aspen and Quaking aspen (*Populus tremuloides* MICHAUX) were chosen for the establishment of 3 field trials in former East Germany (*Table 1*).

Table 1. – Progenies of crossings *P. tremula* X *P. tremula* (No 1 to 24) and *P. tremula* X *P. tremuloides* (No 25).

Combination	Id.-no. of progenies
Uhyst 27 X Lichtenhain 1	3369
Eibenstock 3 X Spechtshausen 15	3379
Spechtshausen 8b X Spechtshausen 15	3380
Biehla 11 X Burkau 10	3382
Schandau 4 X Königstein 2	3383
Piskowitz 3 X Königstein 2	3384
Großdubrau C X Königstein 2	3387
Großdubrau X Königstein 2	3388
Graupa 1 X Königstein 2	3389
Graupa 20 X Königstein 2	3390
Biehla 11 X Königstein 2	3391
Schandau 4 X Spechtshausen 8	3392
Piskowitz 3 X Spechtshausen 8	3393
Großdubrau 5 X Spechtshausen 8	3395
Großdubrau X Spechtshausen 8	3397
Biehla 11 X Spechtshausen 8	3398
Biehla 11 X Lichtenhain 1	3404
Moritzburg 6 X Königstein 2	3407
Graupa 1 X Sachajewo (Poland)	3410
Piskowitz 3 X Spechtshausen 15	3411
Räckelwitz 7 X Burkau 10	3413
Graupa 20 X Burkau 10	3414
Piskowitz 3 X Burkau 10	3415
Großdubrau C X Wermsdorf 1	3420
Ås (Norway) X Ontario (Canada)	3430

Most parent trees which had been selected in the aspen inventory described above were situated in Saxony (*Figure 1*). With exception of the partners of the combinations 3369, 3410 and 3430, all partners had proved worthwhile in earlier trials. The combination Graupa 20 X Königstein 2 (3390) had also been tested in earlier trials. In these trials, this combination had performed more or less equal to the trial averages. For this reason, it was used as standard in the experiments presented.
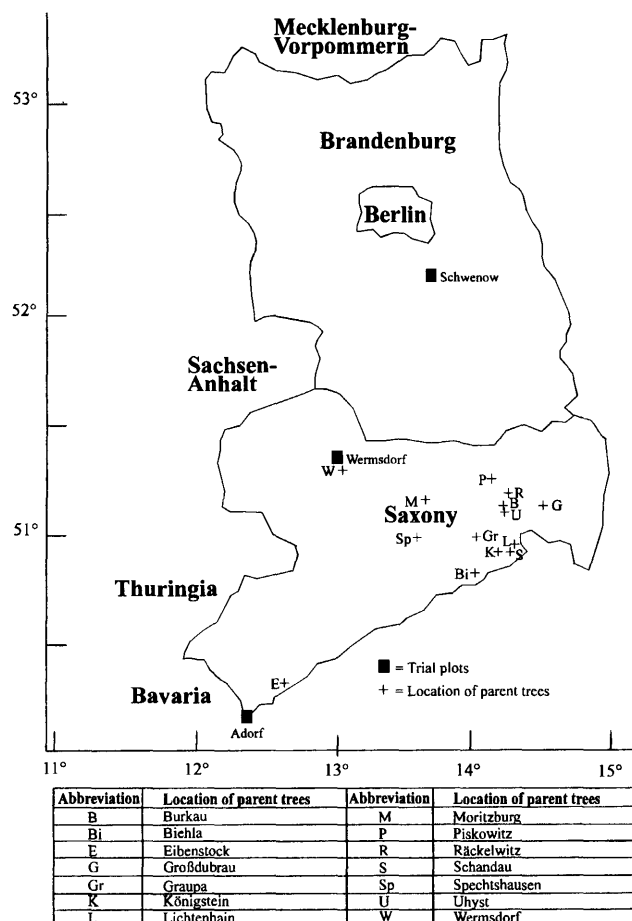

Abbreviation	Location of parent trees	Abbreviation	Location of parent trees
B	Burkau	M	Moritzburg
Bi	Biehla	P	Piskowitz
E	Eibenstock	R	Räckelwitz
G	Großdubrau	S	Schandau
Gr	Graupa	Sp	Spechtshausen
K	Königstein	U	Uhyst
L	Lichtenhain	W	Wermsdorf

Figure 1. – Location of trial plots and parent trees selected in Saxony.

Design and ecological conditions on the trial plots

In spring 1963, 3 trial plots were established with 1 year old seedlings in the forest districts of Adorf, Wermsdorf (both in Saxony) and Schwenow (Brandenburg). On all sites, the soil was ploughed in autumn 1962. The sites in Wermsdorf and Schwenow were meliorated by seeding of clover and lupine or application of chalk respectively. The bare rooted seedlings were planted in a 1.5 x 1.5 m² spacing on the plots in Adorf and Wermsdorf. In Schwenow, a spacing of 2.0 x 2.0 m² was used. On all trial sites, 4 replications with 25 plants per replication were planted.

The ecology of the trial plots shows big differences in the climatic and soil conditions (*Table 2*). Especially, the site in Schwenow is a borderline case for the planting of aspen with its poor nutrient supply and little precipitation in the vegetation period.

Assessments and statistical evaluation

The trials were assessed in 1964 (mortality, height, stem form), in 1968 (mortality, height), in 1972 (height, diameter, stem form, branchiness) and in 1994 (height, diameter, stem form, branchiness). For the assessment of quality traits different schemes had been used (*Table 3*).

Table 3. – Schemes for the assessments of stem form and branchiness (expressed as number of branches and thickness of branches).

Plant age	Parameter	Mark	Characteristics
3	Stem form	1	Continuous, straight stem, no crooks in the upper part
		2	Continuous stem, slight crooks in the lower part, bigger crooks in the upper part
		3	Continuous stem, little crooks in the lower part, serious crooks in the upper part
		4	No continuous stem, crooks and forks in the lower part
		5	Shrubby
11	Stem form	1	Continuous, straight stem, no crooks
		2	Continuous stem, little crooks
		3	No continuous stem, crooks and forks in the lower part of the stem
	Thickness of branches	1	Finely branched, thickness upto 1 cm at the stem; between whorls longer parts free of branches or only very fine branches
		2	Middle branched, thickness 1 to 2 cm at the stem; between whorls longer parts free of branches or only very fine branches
		3	Roughly branched, thickness over 2 cm at the stem, distribution of branches irregulary, no distinct whorls
	Number of branches	1	Trees up to 12 branches
		2	Trees with 13 to 24 branches
		3	Trees more than 24 branches
27/33	Stem form	9	Continuous, straight stem, no forks
		7	Continuous, straight stem, little crooks in the upper part
		5	Continuous stem, little crooks in the middle part
		3	No continuous stem or bigger crooks in the middle part
		1	Totally crooked stem with forks in lower parts, shrubby
	Thickness of branches	9	Thinly branched, angle of branches more or less 90°
		7	Slightly to middle branched, angle of branches more or less 90°
		5	Middle to thickly branched, angle of branches more or less 45°
		3	Thickly branched, angle of branches between 20 and 30°
		1	Roughly branched, angle of branches smaller than 20°

From all data collected in 1964, 1968 and 1972, basic statistical data were calculated. After testing for homogeneity of variance, the data were analysed by F-test and multiple T-test. The data collected in 1994 were processed by standard software developed at Graupa (WEISSLEDER, 1990). Following statistical methods were used: descriptive statistics, variance analysis (WELCH-test), correlation coefficient according to SPEARMAN (r_s). Because of the different development of the number of remaining individuals per progeny, it was abstained from further statistical treatment of the data. The confidence level for the significance was set with $p \leq 0.05$.

The volume of the progenies was calculated with the function of ERIKSON which is included in the standard software (WEISSLEDER, 1990).
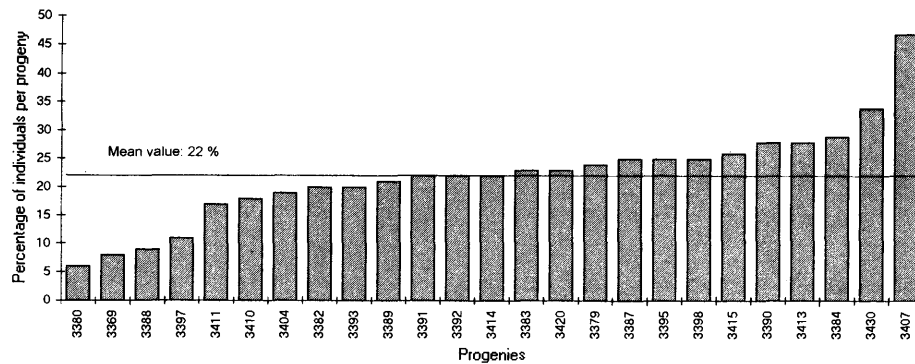
Table 2. – Ecological conditions of the trial plots.

Trial plot	Latitude	Longitude	Altitude a.s.l.	Mean temperature per year	Mean precipitation per year	Soil conditions
Adorf	12° 14`N	50° 17`E	530 m	6.5 °C	733 mm	Brown earth
Wermsdorf	13° 01`N	51° 17`E	180 m	8,4 °C	660 mm	Stagnic gleysol
Schwenow	13° 59`N	52° 05`E	100 m	8,4 °C	557 mm	Podzol

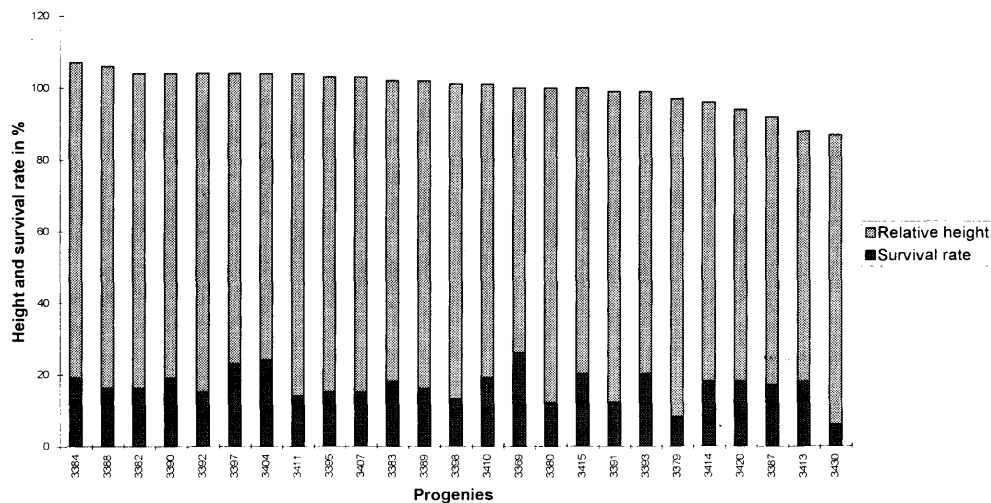*Figure 2.* – Percentage of individuals per progeny affected by fungi on the trial plot Adorf in 1972.

Figure 3. – Relative height and survival rate in % of progenies tested over all trial plots at the age of 33 years.

Results

Survival rate

After planting in spring 1963, the progenies had very well taken root without exception. Six vegetation periods after planting, the average survival rate was 97% over all sites. Among the progenies, no significant differences in the survival rate could be observed.

In 1972, the progenies of the trial plot Adorf had been attacked by the fungi *Cytospora chrysosperma* and *Cytospora nivea*. The mortality after the attack ranged between 6% and 47%, in average 22% (*Figure 2*). The differences among the 5 most infected and the 5 least infected progenies were significant. Mainly suppressed individuals had been killed or were about to die. Apart from this, no further attacks by pests or diseases had been reported.

Before the assessment at the age of 11 years, the trial plots Adorf and Wermsdorf were thinned. In average, between 47% (Adorf) and 55% (Wermsdorf) of suppressed and caught individuals had been removed. The trial plot Schwenow had not been thinned at all because of the wider spacing used for establishment and its poor growth. This trial plot had also been damaged by deer very seriously. In Schwenow, the survival rate of the progenies (based on the assessment of 2 replications) ranged between 74% (3430) and 100% (3398) with a mean value of 92%.

Until the age of 33 years, the stem numbers of the progenies developed very differently on the trial plots. The mean survival rate over all progenies ranged between 6% on the trial plot Wermsdorf and 26% in Schwenow. The mean over all trial plots was 17%. Especially the progenies 3369, 3393, 3397 and 3404 showed survival rates above average, the progenies 3379 and 3430 below average (*Figure 3*).

Development of height and diameter

During the observation period, the progenies developed quiet differently. On the individual trial plots, the height growth of the progenies was consistent with few exceptions. No greater differences in the ranking of the progenies could be observed from assessment to assessment. With the exception of the results between the age of 11 and 33 years in Wermsdorf, the ranking of the various assessments correlated significantly in every case. Among the trial plots, consistently significant correlations between the ranking of the progenies could only be observed in the first years of growing (*Table 4*).

At the age of 33 years, the mean absolute height over all progenies varied between 20.3 m and 21.7 m in Adorf and Wermsdorf respectively and 12.5 m in Schwenow (*Table 5*). The different growth reaction of the progenies on the trial sites found its expression in the levelled of relative heights over all trial plots (*Figure 3*). Most of the progenies differed only slightly. However, significant differences among the best and

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Table 4. – Correlations of the mean height of progenies among the trial plots at different ages (*significant at the confidence level of 5 %).

Age in years	Adorf/ Wermsdorf	Adorf/ Schwenow	Wermsdorf/ Schwenow
3	0.773*	0.553*	0.515*
7	0.596*	0.617*	0.709*
11	0.601*	-0.033	0.245
33	0.252	0.065	0.253

Table 6. – Relative diameter (percentage of trial mean) and mean rank number of the progenies tested at the age of 11 and 33 years.

Number of progeny	Relative diameter at the age of 11 years				Relative diameter at the age of 33 years			
	Adorf %	Wermsdorf %	Schwenow %	Mean rank	Adorf %	Wermsdorf %	Schwenow %	Mean rank
3369	118	102	98	4	110	87	95	19
3379	101	100	88	10	93	86	89	24
3380	113	102	83	9	110	92	103	13
3382	90	100	100	20	96	103	96	15
3383	94	100	102	16	103	111	94	8
3384	93	102	115	5	115	116	105	1
3387	91	96	83	24	83	95	98	23
3388	106	101	92	12	117	105	105	1
3389	88	96	108	21	92	102	116	10
3390	88	98	108	19	93	95	102	20
3391	79	93	100	23	103	93	102	16
3392	113	100	104	7	116	106	103	4
3393	106	100	108	5	86	88	105	21
3395	101	108	110	3	104	94	108	9
3397	113	104	115	2	106	96	109	7
3398	88	102	108	12	89	103	113	10
3404	100	103	104	7	93	101	104	14
3407	96	97	85	22	95	130	111	3
3410	107	107	121	1	115	104	102	5
3411	101	98	98	17	93	101	109	12
3413	94	96	77	25	88	81	80	25
3414	96	98	110	14	98	78	95	22
3415	97	102	94	14	92	111	90	18
3420	106	102	79	17	93	105	94	17
3430	121	99	90	10	117	113	70	6
Mean diam.	6.8 cm = 100 %	9.2 cm = 100 %	4.8 cm = 100 %		18.7 cm = 100 %	27.7 cm = 100 %	12.9 cm = 100 %	

slowest growing progenies could be observed on different trial plots with a range of e.g. −40 % (3430) to +14 % (3395) in Schwenow and −14 % (3387) and +9 % (3392) in Adorf (Table 5). Within the progenies, the variation of the mean height was rather low. The variation coefficients ranged from 3 % to 22 %, in average 12 %.

Table 5. – Relative height (percentage of trial mean) and mean rank number of the progenies tested at the age of 11 and 33 years.

Number of progeny	Relative height at the age of 11 years				Relative height at the age of 33 years			
	Adorf %	Wermsdorf %	Schwenow %	Mean rank	Adorf %	Wermsdorf %	Schwenow %	Mean rank
3369	118	102	108	3	107	96	98	16
3379	111	98	88	16	99	95	98	22
3380	110	103	84	7	106	98	96	14
3382	95	103	117	5	102	107	103	3
3383	91	97	97	20	99	105	101	12
3384	90	94	111	19	104	110	108	1
3387	85	96	81	25	86	95	95	24
3388	104	102	91	13	108	108	102	2
3389	89	98	103	18	95	98	113	13
3390	88	94	108	22	99	101	112	9
3391	79	97	108	21	93	101	103	18
3392	107	101	98	10	109	101	101	7
3393	110	101	102	6	99	97	101	19
3395	105	107	119	1	102	93	114	10
3397	111	102	108	3	106	104	102	5
3398	95	102	116	7	95	100	109	14
3404	105	103	113	2	102	105	106	4
3407	91	97	88	23	100	103	107	8
3410	102	98	117	9	102	97	104	10
3411	105	100	100	12	101	108	102	6
3413	98	94	78	24	97	87	80	24
3414	99	97	113	15	104	87	96	20
3415	101	103	95	11	102	104	95	17
3420	100	102	84	17	92	98	92	23
3430	117	100	84	14	98	104	60	21
Mean height	8.2 m = 100 %	11.8 m = 100 %	6.4 m = 100 %		20.3 m = 100 %	21.7 m = 100 %	12.5 m = 100 %	

$r_S = 0.604$ (Wermsdorf, age of 11 years) to $r_S = 0.917$ (Adorf, age of 11 years).

The different development of height and diameter growth on the respective trial plots led consequently to big differences in volume growth. In Wermsdorf, the trial mean over all progenies was about 7.5 times bigger than in Schwenow. Big differences could also be found in the average volume growth of the progenies and in the volume of the best individual per progeny (Table 7).

Table 7. – Volume per progeny (minimum, maximum, mean per trial plot) and single tree with the biggest volume at the age of 33 years.

Trial plot	Minimum volume		Maximum volume		Mean volume	Single tree with biggest volume	
	Progeny	m³	Progeny	m³	m³	Progeny	m³
Adorf	3387	0.164	3392	0.413	0.287	3392	0.985
Wermsdorf	3413	0.433	3407	1.041	0.647	3407	1.654
Schwenow	3430	0.022	3389	0.124	0.086	3407	0.377

Independent from the trial plot, the progenies 3397, 3404 and, with one exception, 3395 grew in height above average during the observation period. Since planting, the progenies 3382 and 3411 which started badly could steadily increase their height and had an average rank of 3 and 6 respectively after 32 years of observation. In comparison, the height growth of the progenies 3379, 3387, 3391, 3413 and 3430 was consistently bad (Table 5).

The diameter growth developed also very heterogeneously on the various trial plots with increasing age. At the age of 33 years, the mean absolute diameter over all progenies ranged between 12.9 cm in Schwenow and 27.7 cm in Wermsdorf (Table 6). With one exception (Adorf-Wermsdorf, age of 11 years, $r_S = 0.536$), no significant correlations of the diameters among the trial plots or between the assessments at the age of 11 and 33 years could be found.

Nevertheless, the mean ranking of the progenies 3384 and 3410 was 5 or better over all trial plots at the age of 11 and 33 years. The progenies 3387 and 3413 which had already a very poor height growth showed the worst diameter growth (Table 6). The variation coefficients of the mean diameter varied between 12 % and 34 %, on average 22 % with no differences between the trial plots. In every case, significant relationships were observed between the ranking in height and diameter on the respective trial plots with coefficients ranging from

Stem form and branchiness

During the observation period, the mean stem forms of the progenies showed only slight differences. No significant differences among the progenies or correlations between the ranking of the progenies on the different trial plots could be observed. In average, the progenies had continuous stems with slight up to little crooks in the lower part and crooks in the upper part. However, the relative distribution of stems in the different stem form classes showed clear differences among the stem forms of the progenies in Schwenow and Adorf at the age of 11 years (Table 8).

The results of the assessments at the age of 11 and 33 years correlated significantly with coefficients of $r_S = 0.607$ in Adorf and $r_S = 0.685$ in Schwenow. The progenies tested had slightly better stem forms in Schwenow at the age of 33 years. The variation of the mean stem forms was bigger than the variation of the quantity traits and ranged from 11 % to 44 % with an total average of 32 %. Studies on the relationship between stem form and mean height of the progenies resulted in significant positive correlations only at the age of 11 years.

The assessment of branchiness showed also only slight differences among the trial plots and the progenies tested. At the age of 11 years, some significant and consistent differences

Table 8. – Stem form in % of the progenies tested at the age of 11 years.

| Number of progeny | Stem form in % at the age of 11 years | | | | | |
| | Adorf | | | Schwenow | | |
	1 (+)	2 (+-)	3 (-)	1 (+)	2 (+-)	3 (-)
3369	45	51	5	65	33	2
3379	37	51	12	42	51	7
3380	30	56	14	23	67	9
3382	8	58	34	27	65	8
3383	25	57	18	35	58	7
3384	7	63	30	52	48	0
3387	19	43	38	19	69	13
3388	26	63	11	47	36	17
3389	10	67	23	33	55	12
3390	11	52	37	53	47	0
3391	14	62	24	50	45	5
3392	25	61	14	41	52	7
3393	29	53	18	22	67	11
3395	21	64	15	40	58	2
3397	31	57	11	59	41	0
3398	13	70	17	39	49	12
3404	12	74	14	46	54	0
3407	16	49	35	36	50	14
3410	14	61	25	30	60	9
3411	17	69	14	43	54	2
3413	12	61	27	12	51	37
3414	32	53	15	40	56	4
3415	8	71	21	41	54	4
3420	22	58	20	16	57	27
3430	46	42	12	16	57	27
Mean value	21	59	20	37	53	9

and correlations between the results could be found. The progeny 3369 showed the most favourable results, the progeny 3407 the worst. The ranking of the progenies correlated with significant positive values between the trial plots observed.

Only at the age of 11 years, the stem form of the progenies correlated significantly with the branchiness in every case. However, no consistent relationships existed between height and diameter respectively and the branchiness. At the age of 33 years, the mean variation coefficient of the branchiness over the trial plots was 25% ranging from 12% to 38% within the progenies.

Discussion

The results of the assessments presented showed clear differences in growth performance and quality mainly among the various trial plots. On the respective trial plots, the development of the progenies was consistent over the observation time of 32 years. The advantages of some progenies in height and diameter achieved during the first 10 years of growing were more or less levelled off until the age of 33 years. The total mean values of all trial plots differed only slightly. On the other hand, few progenies showed growth and quality above average on all trial plots. Some progenies performed badly on all trial plots as well.

The trials were established on very different site conditions. Due to the diverse development of height and diameter, the plots in Adorf and Wermsdorf were thinned in 1972 before the assessment at the age of 11 years. Until the age of 33 years, no further treatment was done. According to SCHÖNBACH (1974), only suppressed and caught trees were removed. In Schwenow where the trial was established with a wider spacing, no measures were taken at all. The different survival rates on the various plots made the analysis and interpretation of the results more difficult. On the other hand, the results give important information on the development of the progenies tested until the age of 33 years and on the development of material which was approved as tested in 1974.

In former East Germany, aspen timber was mainly used for the production of matches. For this use, the procurement of larger and veneerable stems was necessary (SCHÖNBACH, 1974). In 1974, one progeny (3369) out of 25 progenies was approved as tested material at the age of 11 years. This progeny was selected because its height and diameter growth in combination with good stem form and minor branchiness. SCHÖNBACH (1974) discussed already the question of the early approval of progenies based on the height growth due to lack of results of older experiments (the rotation time of aspen was set at 40 years). Based on the results of other authors, SCHÖNBACH (1974) concluded that a progeny selected at a certain minimum age will also be top ranked at the end of the rotation time. In each case, it will be better than average.

The results showed that the selected progeny 3369 was not among the top ranking progenies at the age of 33 years. In height and diameter growth, the progeny was below average. However, other progenies which were already in the highest range at the age of 11 years still performed very well at the age of 33 years. These results show the problems of early approval of tested material.

A reason for the early approval of tested material can be found in the forest policy of the 60ies and 70ies in the German Democratic Republic. In these years, the governmental authorities demanded the production of the highest amount of timber possible. This economically justified demand led to industrial-like production methods which were characterized by short rotation times, high cutting rates, large afforestation areas and great efforts in tree breeding among others. Consequently, forest tree breeding was forced to present results as early as possible as justification of its work. This pressure resulted in the approval of tested material based only on preliminary results. In the following years, there was little interest to assess and to analyse the trials again.

Under the dry and poor site conditions of Schwenow, more individuals per progeny survived in average than on the other plots. The growth of the progenies was significantly worse. One reason for that could be neglected thinning. On the other hand, a natural differentiation of the stand could be observed. Nevertheless, with proper thinning the yield could have been improved to a certain extent.

During the observation period, advantages some progenies achieved were levelled off. Over all trials, the development of the progenies was very different, with the exception of some progenies which performed very well or very badly on all plots. The single plots per progeny were planned very small. The size of the plots could have increased favouring or hindering effects of the neighbouring progenies (HAASEMANN, 1975). On the other hand, the material tested descended mainly from superior parent trees already proved to be worthwhile. Considering that, the level of performance is expected to be already high, bigger differences are unlikely (SCHÖNBACH, 1974).

According to the current yield table for aspen in Saxony (TJURIN, 1956, in: RICHTER and FRIEDRICH, 1993; SML, 1995), the total mean height of the progenies on the trial plot in Adorf corresponds to the best valuation, a mean total increment of 9 m³ standing cross volume per year and hectare. In Wermsdorf, the mean total increment is clearly above this value. The height performance of the progenies in Schwenow ranges between a mean total increment of 3 m³ and 4 m³ standing cross volume per year and hectare.

In literature, the performance of hybrids between *Populus tremula* and *Populus tremuloides* is considered to be better than the performance of pure aspen progenies (MOHRDIEK, 1977, 1979; MELCHIOR, 1985; MUHS and MELCHIOR, 1985; JOACHIM, 1991). In the experiment presented, the only hybrid

combination *Populus tremula* X *Populus tremuloides* included shows quantity and quality performance on average or worse. In earlier trials in Saxony, the best aspen progenies proved already comparably good results to hybrid aspen progenies (JOACHIM, 1991). On trial plots in the mountainous regions of Hesse, progenies of intra- and inter-specific aspen crossings had similar height growth (FRÖHLICH and WEISGERBER, 1987).

At the age of 33 years, the variation coefficients ranged in the case of quantity parameters from 3% to 34%, in the case of quality parameters from 12% to 44%. The average over all parameters and progenies was 23%. With few exceptions, the parent trees were selected in a limited area in the south-eastern part of Saxony. The results presented show nearly the same relatively low variation of traits as aspen progenies descending from crossings among different European provenances at the age of 5 years (DIMPFLMEIER, 1963).

Between quantity and quality parameters, consistent relationships could not be described. Significantly positive correlations could only be observed at the age of 11 years. There seems to be an influence of the thinning done 1972 in Adorf and Wermsdorf. The results of the untreated trial plot Schwenow at the age of 33 years do not allow conclusions according to positive or negative correlations between quantity and quality parameters. In this case, the behaviour of aspen seems different to other species for example European larch (*Larix decidua* MILL.) or larch hybrids where relationships between stem form and height growth could be assessed (WEISER, 1992; WEISGERBER, 1992, 1995).

In literature, aspen is described as species which is vague to climate and soil characteristics (SCHÖNBACH, 1952; LEIBUNDGUT, 1969; MAYER, 1980). The results presented indicate that the ability to cope with various environmental conditions may be related to the origin of the material in question. The progeny 3390 was used as standard because of its consistent performance at the average level in earlier trials (SCHÖNBACH, 1974). In the experiments presented, this progeny performed quiet differently on the various trial plots as well as most of the other progenies tested. At the age of 33 years, only the progenies 3382, 3395, 3397, 3404 and 3411 proved similar growth above average independently of the environmental conditions.

On the trial plot Wermsdorf, the progenies showed the best growth in combination with the lowest survival rate. The trial was established on extreme stagnic gleysol. The results show clearly the potential of this species on stagnic gleysols. SCHÖN-BACH discussed 1961 critically the ability of aspen for these soils and recommended the planting of aspen on drier variations of stagnic gleysols. On the other hand, aspen could be planted on stagnic gleysols with more unfavourable conditions as pioneer crop or solitarily mixed for a limited time to avoid losses and to increase stability. However, aspen could be endangered on these soils by wind throw (LEIBUNDGUT, 1969). In Wermsdorf, no loss caused by wind throw has been observed. In opposition to the opinion of LEIBUNDGUT (1969), aspen seems to be able to develop a root system which is similarly effective in penetrating stagnic gleysols as oak or ash (KREUTZER, 1961; KÖSTLER et al., 1968).

On marginal forest sites like stagnic gleysol, aspen is a suitable alternative to other tree species and can be used for stabilization or transformation of non site-adequate plantations. In the end, aspen can be planted as ecological mixture for biological improvement of the soil (MOHRDIEK, 1977; HORN-DASCH, 1982; WEISGERBER, 1984).

Apart from marginal forest sites, aspen offers a multitude of silvicultural uses as pioneer crop for afforestation of mixed stands, temporary species facilitating the transformation of non site-adequate plantations, single tree mixture in plantations of valuable broad-leaved species as well as temporary mixture in plantations of deciduous and conifer tree species. The ecological and biological characteristics of aspen allow to replant natural or artificial regeneration with fail patches, to under plant pre-mature stands with opened-up canopies and to stabilize unstable pure stands, also in combination with other species like Common elder (*Alnus glutinosa* [L.] GAERTN.) (SPIEKER, 1952; WEISGERBER, 1964; LEIBUNDGUT, 1969; HORN-DASCH, 1982; JOACHIM, 1991). Beside of the silvicultural advantages and the ecological stabilization, the plantation of aspen can lead to an increase of yield and value (MELCHIOR, 1985; WEISGERBER, 1984; HENGST, 1986).

The use of farmland which has been abandoned due to efforts to reduce the area of productive agricultural land, offers also possibilities for the use of aspen (MELCHIOR, 1985; LIESE-BACH et al., 1994). Again, aspen can be planted as pioneer crop for afforestation under clear cut conditions. Especially on sites in the mountainous regions which are not suitable for hybrid poplars, it can be used for the establishment of short rotation plantations for the production of renewable resources. Aspen has also proved its suitability for coal-mine spoil reclamation (AL-NAIMI, 1989).

Despite of its high ecological and silvicultural value and its wide range of uses, the demand for reproductive material of aspen is actually quiet low. In the results of the ecological forest development planning for the state forests of Saxony from 1994 up to 2003, aspen as species is not mentioned at all (WICKEL, 1995). One reason for this lack of regard is surely the widely spread opinion that aspen is not a valuable tree species and has to be treated as weed. However, in an ecological oriented forestry aspen should be an integrated part of silviculture.

At present, the little demand can be fulfilled without any problems by repeated crossings of the material in question. In future, an additional demand will possibly develop from afforestation of agricultural set-aside-land and establishment of short rotation plantations. In this case, the demand can be satisfied by the establishment of seed orchards or the vegetative propagation of favourable progenies by tissue culture (FRÖHLICH, 1982; AHUJA, 1983; NAUJOKS et al., 1987). The problems concerning the costs of the procurement of improved aspen material were already discussed by MELCHIOR (1984).

In future, breeding of aspen will concentrate on the broadening of the genetic base by the evaluation of more suitable combinations out of the existing trials. The objective will be to procure a maximum number of tested populations for different site conditions to minimize the risks which may derive from the use of reproductive material with limited genetic variation. Finally, the value of the tested material should not only be seen in advantages in quantity and quality performance but also in more or less predictable characteristics and growth behaviour of the material in question.

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Investigations on the Correlation Pattern in Even-Aged Stands of Larch

II. Dynamic Description of Phenotypic Correlations Between Neighbouring Observations[1])

By M. HÜHN[2]) and W. LANGNER[3])

Summary

The main topics of this study are a dynamic description of spatial neighbourhood correlation patterns of stands of larch and an analysis of temporal changes and time trends of such patterns during stand development. For these investigations extensive data sets from a field trial with 27 "entries" (5 *Larix europaea*, 15 *Larix leptolepis*, 7 hybrids) have been used. Single tree measurements of this trial were available for 7 stages of stand development (ages: 11, 13, 18, 19, 42, 49 and 50 years). The measured traits are height and diameter at breast height. For the 2 ages 42 and 49 only diameter measurements were available. Additionally, the diameter values are transformed and analysed as individual basal areas.

The correlative structure of this trial for measurements of neighbouring individuals [regular square spacing with wide spacings (5 m x 5 m), no artificial thinning procedures] has been described by 12 different correlation coefficients. These coefficients are defined by considering quite different spatial configurations of competitive neighbourhoods. In these procedures and analyses the diagonally located neighbours of a subject tree and its missing neighbours too are explicitly considered.

For the trait height one obtains for all ages a quite uniform correlation pattern: positive correlations with intermediate numerical amount between the trait measurement of a subject tree and the corresponding value of its neighbourhood (for different spatial definitions of neighbourhood) and less stronger negative correlations between the trait measurement

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