the measurements summarised in Table 2, also agrees well with the autoradiographlc assessment for this plant.

Exarnination of graft unions:

Autoradiographs were prepared from the hand sections cut through the graft unions of plants Al, A2, A4, A5, B1 and B2. Photographs of the sections are shown in Figure 2 and of the autoradiographs from these in Figure 3. It can be seen that whereas the autoradiographs for the healthy plants (Al, A2, A4 and A5) show a blackening corresponding with zones of phloem tissue, both above and below the actual graft union (due to the presence of photosynthate Iabelled with carbon-14) the sections of the unhealthy plants show that the phloem below the graft union carries little or no detectable carbon-14. Thus the data given in Tables 2 *and* 3, and the characteristics indicated in Figure 3, are all highly consistent.

### Conclusions

There is good evidence that for seedlings grafted with scions of Clone 104 the low rate of survival is due to the secondary phloem of the scion failing to form a functional union with the secondary phloem of the seedling stock. The second period of mortality, which could be due to inadequate xylem transport, has yet to be investigated.

The writers are uncertain whether to term such incompatibility histological or physiological; nor do they attempt any further explanation of the phenomenon.

### Acknowledgements

We are grateful to Mr. T. FAULDS who performed the grafting work and who first identified the incompatibility peculiar to grafted scions of Clone 104; also to Mr. I. J. THULIN who recognised the nature of the problem and suggested that it could be profitably investigated using radiotracer techniques.

### Summary

Translocation studies in which carbon-14 labelled photosynthates were used as tracer substances, confirmed that the failure of graft combinations is due primarily to the secondary phloem of stock and scion failing to form a functional union. A secondary cause of mortality, possibly resulting from xylem transport being inadequate, has yet to be investigated.

### Reference

THULIN, I. J., and T. FAULDS: Outdoor grafting of *Pinus radiata*. FRI Internal Report (Forest Tree Improvement No. 33, 1966).

# Comparative Qualitative Relationships of Wood Properties of Euramerican Poplars

**Dimensions of Wood Fibres and Specific Gravity*)**

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Forestry and wood industry are steadily strengthening their demands for more exact and detailed information on the forest resources and the properties of various species.

In the USA serious attention has been devoted in recent years to the problem of juvenile wood, since its low specific gravity, short wood fibres etc. make it unsuited to industrial processing (POLGE, 1965). However, the use of juvenile wood in poplars has yielded good results (JAYME et *al.*, 1943; CECH — KENNEDY — SMITH, 1960; BABICKI, 1963; MASIREVIĆ-OBLAK, 1966); as regards its degree of usefulness, poplar juvenile wood equals the wood of older plantations.

This study was designed to provide data on juvenile wood variation and inheritance.

*) From a paper read at 13th Session of International Poplar Commission, Montreal 23–28. 9. 1968. The text has been revised and illustrations added. This research has been financed in part by Grant-FG-YU-127 made by USDA, Agricultural Research Service.

Materials: At the "Tungla" plantation near Novi Sad, set up on normal carbonate alluvial soil with eight clones in a randomized block design with five replications in very dense stand (2 X 2 m.). One tree per plot (five trees in all) were harvested from each clone at age four years. Two years after thinning, 40 sample trees in all were selected again, according to the same principle as in the previous case. Thus in both cases 10 model trees were selected from each clone and cultivar. The chief taxonomic data for these trees are presented in Table 1.

Methods: For wood property determination samples were taken at breast height (1.30 m).

Alter defibration the dimensions of the wood fibres were measured by screen projection, using an A. O. Spencer microscope.

*Table 1.*

| Nr. | Clones | D.b.h. in the age — cm | | Height in the age — m. | |
|---|---|---|---|---|---|
| | | 4 | 6 | 4 | 6 |
| 1. | *Marilandica* | 8.0—*10.5*—12.7 | 14.0—*14.6*—16.0 | 10.8—*12.2*—13.3 | 14.0—*14.8*—15.4 |
| 2. | *Serotina* | 6.4— *9.1*—11.5 | 10.5—*12.1*—14.0 | 10.1—*11.4*—14.0 | 14.1—*14.9*—15.8 |
| 3. | Robusta | 8.0—*10.4*—12.7 | 14.0—*14.7*—15.0 | 12.2—*14.0*—15.1 | 14.1—*14.9*—15.8 |
| 4. | *Istra* | 8.6—*10.6*—12.1 | 13.0—*13.5*—14.5 | 11.5—*12.3*—13.0 | 13.3—*14.5*—15.2 |
| 5. | Ostia | 9.2—*10.9*—12.1 | 13.5—*15.4*—16.5 | 13.8—*14.2*—14.6 | 14.4—*17.1*—17.8 |
| 6. | Jacometti | 11.5—*12.6*—13.7 | 15.0—*15.6*—17.0 | 13.8—*14.4*—14.6 | 16.8—*17.1*—17.3 |
| 7. | I-154 | 10.5—*11.7*—15.9 | 13.0—*13.8*—15.0 | 13.0—*14.0*—15.4 | 14.8—*16.7*—16.8 |
| 8. | I-214 | 11.5—*13.2*—15.0 | 15.5—*17.3*—18.5 | 14.4—*14.9*—15.2 | 17.3—*17.8*—18.3 |

Fibre length was measured with 0.1 mm accuracy and 50 × magnification. For each test an average of 340 observations were made, i. e. about 54,500 measurements were made to determine length.

The other dimensions were read with 0.01 mm accuracy and 215 × magnification. Average values were obtained on the basis of 50 observations per test, or 1,600 measurements per examined parameter.

Specific gravity was determined from green volume and ovendry weight in 30 × 30 × 20 mm specimens. The precision in reading the dimensions was 0.01 mm, and 0.01 gr in reading weight. Measurements included a total of 2960 specimens.

## Results

The dimensions of wood fibres aged 2, 3, and 4 years were measured in trees cut before thinning (40 sample trees), while the dimensions at the age of 6 years relate to 40 trees cut after thinning.

Variations in the length and width of wood fibres are presented in *Table 2 and 3.*

Breadth of wood fibres varried between 15.0 and 51.6 microns, till standard deviation from 3.55 to 5.13 microns.

Analyses of the results presented have led to the following conclusions:

— on the average, the longest fibres were found in the cultivar *Ostia*, the shortest in *I-154;*

— the widest fibres were found in another Italian clone, *I-214*, while *Robusta* had the thinnest fibres;

— the lengths of wood fibres increased with the age, while the breadth remained the same.

The lumen diameter in this plantation are shown *Table 4.*

*Table 2.*

| Nr. | Clones | Fibre length in the age microns*) | | | |
|---|---|---|---|---|---|
| | | 2 | 3 | 4 | 6 |
| 1. | *Marilandica* | 794.8 | 888.9 | 1012.7 | 1121.8 |
| 2. | *Serotina* | 828.7 | 854.3 | 947.1 | 1062.4 |
| 3. | *Robusta* | 769.4 | 877.9 | 1028.6 | 1151.6 |
| 4. | *Istra* | 762.7 | 914.6 | 1006.7 | 1200.6 |
| 5. | *Ostia* | 868.6 | 999.2 | 1090.6 | 1169.6 |
| 6. | *Jacometti* | 766.2 | 856.9 | 943.7 | 1066.2 |
| 7. | *I-154* | 771.8 | 905.2 | 929.9 | 1033.8 |
| 8. | *I-214* | 818.4 | 894.3 | 999.3 | 1094.2 |
| | Average | 797.6 | 898.9 | 994.8 | 1112.5 |

*) Length of fibres were between 400 and 1800 microns, and standard deviation from 115 to 269 microns.

*Table 3.*

| Nr. | Clones | Fibre breadth in the age microns | | | |
|---|---|---|---|---|---|
| | | 2 | 3 | 4 | 6 |
| 1. | *Marilandica* | 26.8 | 26.3 | 26.2 | 27.9 |
| 2. | *Serotina* | 25.5 | 25.8 | 25.3 | 26.3 |
| 3. | *Robusta* | 25.0 | 24.7 | 25.6 | 26.9 |
| 4. | *Istra* | 26.7 | 26.8 | 25.8 | 28.0 |
| 5. | *Ostia* | 25.6 | 26.0 | 26.8 | 28.4 |
| 6. | *Jacometti* | 28.0 | 27.5 | 27.4 | 28.0 |
| 7. | *I-154* | 25.6 | 26.8 | 28.5 | 28.4 |
| 8. | *I-214* | 29.1 | 29.8 | 29.4 | 32.0 |
| | Average | 26.6 | 26.7 | 26.9 | 28.2 |

*Table 4.*

| Nr. | Clones | Lumen diameter with standard in the age microns | | | |
|---|---|---|---|---|---|
| | | 2 | 3 | 4 | 6 |
| 1. | *Marilandica* | 20.0 | 19.1 | 19.3 | 20.1 |
| 2. | *Serotina* | 18.5 | 19.0 | 17.7 | 18.5 |
| 3. | *Robusta* | 18.2 | 18.1 | 18.4 | 18.6 |
| 4. | *Istra* | 19.7 | 20.0 | 19.2 | 20.1 |
| 5. | *Ostia* | 18.4 | 19.2 | 19.5 | 20.4 |
| 6. | *Jacometti* | 20.9 | 19.9 | 19.8 | 20.0 |
| 7. | *I-154* | 18.4 | 18.9 | 20.7 | 20.3 |
| 8. | *I-214* | 21.6 | 22.3 | 21.5 | 23.4 |
| | Average | 19.7 | 19.6 | 19.5 | 20.2 |

Lumen diameter was registered from 8.6 to 43.0 microns, till standard deviation was between 3.08 and 4.44 microns. — As was case with the length, so also the lumen increased with the age.

The lumen was greatest on the average in the fibre of the Italian clone *I-214*, while the cultivars *Serotina* and *Robusta* had smaller lumen diameters.

An analysis of variance of these data is given in *Tables 5—7.*

By testing the results using the analysis of variance, the following findings were obtained:

(1) as regards length of fibre, significant differences at 0.5% were obtained between poplar clones starting with the third year;

(2) statistically significant differences at 0.5% in the parameters width of fibres and lumen diameter between the clones examined were found already in the second year.

Clone means were compared by DUNCAN's multiple range test for all above parameters and results can be seen from the survey presented *(Figs. 1—3).*

The cultivars and clones have the following numbers:

| | |
|---|---|
| *Marilandica* | 1 |
| *Serotina* | 2 |
| *Robusta* | 3 |
| *Istra* | 4 |
| *Ostia* | 5 |
| *Jacometti* | 6 |
| *I-154* | 7 |
| *I-214* | 8 |

Explanations:
R — replications.
V — variants, i. e. clones and cultivars.
* — significant at 0.5 level of probability.
** — significant at 0.01 level of probability.
*** —significant at 0.005 level of probability.

The DUNCAN tests conducted indicate the following:

— with respect to the parameter length of wood fibres the clones and cultivars examined can be divided in two groups, of which the first, with longer fibres, includes *Marilandica, Robusta, Istra* and *Ostia;*

— the Italian clones: *Jacometti, I-154* and *I-214,* up to the age of four years, form a group within which the widths differed only insignificantly, while at the age of six years only clone *I-214* showed a significant difference;

— the same conclusion is true of the lumen diameter, since in respect to this dimension, too, clone *I-214* showed a significant difference.

The nominal specific gravity of the clones and cultivar examined and measured before thinning, i. e. after the fourth vegetation period, and after thinning, i. e. after the sixth vegetation period, is shown in *Table 8.*

*Table 5.* — Statistical analysis of fibre morphology determined on specimens of eight poplar's clones and cultivars.

| Source of variation | Degrees of freedom | Fibre length in microns in the age of | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2 years | | | 3 years | | | 4 years | | | 6 years | | |
| | | SS | MS | F | SS | MS | F | SS | MS | F | SS | MS | F |
| Total | 39 | 174298 | — | — | 143084 | — | — | 218757 | — | — | 192134 | — | — |
| Replications | 4 | 6605 | 1651.20 | 0.39 | 6867 | 1716.96 | 0.76 | 9848 | 2462.12 | 0.63 | 11493 | 2.873.25 | 1.31 |
| Variants i. e. clones or cultivars | 7 | 50585 | 7226.48 | 1.73 | 73356 | 10479.40 | 4.67*** | 99493 | 14213.36 | 3.63** | 119098 | 17.014.00 | 7.74*** |
| Error | 28 | 117108 | 4182.42 | — | 62861 | 2245.03 | — | 109416 | 3907.70 | — | 61543 | 2.197.96 | — |
| $\frac{S^2_g}{S^2_g + S^2_E}$ | | | 0.42 | | | 0.79 | | | 0.73 | | | 0.86 | — |

* — significant at 5% level
** — significant at 1% level
*** — significant at 0,5% level

*Table 6.* — Statistical analysis of fibre morphology determined on specimens of eight poplar's clones and cultivars

| Source of variation | Degrees of freedom | Fibre breadth in microns in the age of | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2 years | | | 3 years | | | 4 years | | | 6 years | | |
| | | SS | MS | F | SS | MS | F | SS | MS | F | SS | MS | F |
| Total | 39 | 123.13 | — | — | 138.07 | — | — | 151.82 | — | — | 144.57 | — | — |
| Replications | 4 | 8.23 | 2.05 | 1.31 | 15.53 | 3.88 | 2.57 | 17.61 | 4.40 | 2.11 | 8.51 | 2.13 | 1.72 |
| Variants i. e. clones or cultivars | 7 | 71.11 | 10.16 | 6.40*** | 80.37 | 11.48 | 7.61*** | 75.94 | 10.85 | 5.21*** | 101.27 | 14.47 | 11.66*** |
| Error | 28 | 43.79 | 1.56 | — | 42.17 | 1.51 | — | 58.27 | 2.08 | — | 34.79 | 1.24 | — |
| $\frac{S^2_g}{S^2_g + S^2_E}$ | | | 0.85 | | | 0.87 | | | 0.81 | | | 0.91 | |

* — significant at 5% level
** — significant at 1% level
*** — significant at 0,5% level

*Table 7.* — Statistical analysis of fibre morphology determined on specimens of eight poplar's clones and cultivars.

| Source of variation | Degrees of freedom | Lumen diameter in microns in the age of | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2 years | | | 3 years | | | 4 years | | | 6 years | | |
| | | SS | MS | F | SS | MS | F | SS | MS | F | SS | MS | F |
| Total | 39 | 113.94 | — | — | 101.53 | — | — | 118.60 | — | — | 124.35 | — | — |
| Replications | 4 | 6.30 | 1.57 | 0.92 | 9.52 | 2.37 | 1.85 | 20.80 | 5.20 | 3.44** | 8.10 | 2.02 | 1.62 |
| Variants i. e. clones or cultivars | 7 | 59.86 | 8.55 | 5.01*** | 56.04 | 8.01 | 6.23*** | 50.51 | 7.22 | 4.77*** | 81.28 | 11.61 | 9.29*** |
| Error | 28 | 47.78 | 1.71 | — | 35.97 | 1.28 | — | 47.29 | 1.51 | — | 34.97 | 1.25 | — |
| $\frac{S^2_g}{S^2_g + S^2_E}$ | | | 0.80 | | | 0.84 | | | 0.79 | | | 0.89 | |

* — significant at 5% level
** — significant at 1% level
*** — significant at 0,5% level

With the exception of *Marilandica* and *Ostia*, specific gravity increased with the age; the average values deviate by 2.6%.

The heaviest wood was found in *Robusta*, while clone *I-214* had the lightest wood. The difference amounted to 28%.

The frequency distribution for the clone (cultivar) with the highest density *(Robusta)* and lowest density. *(I-214)* is presented in *Figs. 4—5* illustrating range, mean value and one standard error for all investigated trees and separately for each.

An analysis of variance of these data is given in *Tab. 9*.

On the basis of the calculated variance analysis, the statistical significance of differences was determined by DUNCAN tests, which show that only the cultivar *Robusta* and clone *I-214* differ significantly from the other clones and cultivars *(Fig. 6)*.

*Figure 1.* — Fibre length.

*1. Age 2 years*
$S_x$ = 28.92

| Clones | 4 | 6 | 3 | 7 | 1 | 8 | 2 | 5 |
|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 762.7 | 766.2 | 769.4 | 771.8 | 794.8 | 818.4 | 828.7 | 868.8 |

V = 1.73
R = 0.39

*2. Age 3 years*
$S_x$ = 21.19

| Clones | 2 | 6 | 3 | 1 | 8 | 7 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 854.3 | 856.9 | 877.9 | 888.9 | 894.3 | 905.2 | 914.6 | 999.2 |

V = 4.67***
R = 0.76

*3. Age 4 years*
$S_x$ = 27.95

| Clones | 7 | 6 | 2 | 8 | 4 | 1 | 3 | 5 |
|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 929.9 | 943.7 | 947.1 | 999.3 | 1006.7 | 1012.7 | 1028.6 | 1090.6 |

V = 3.63**
R = 0.63

*4. Age 6 years*
$S_x$ = 20.96

| Clones | 7 | 2 | 6 | 8 | 1 | 3 | 5 | 4 |
|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 1033.8 | 1062.4 | 1066.2 | 1094.2 | 1121.8 | 1151.6 | 1169.6 | 1200.6 |

V = 7.74***
R = 1.31

*Figure 2.* — Fibre breadth.

*1. Age 2 years*
$S_x$ = 0.56

| Clones | 3 | 2 | 5 | 7 | 4 | 1 | 6 | 8 |
|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 24.99 | 25.42 | 25.64 | 25.63 | 26.77 | 26.85 | 27.99 | 29.16 |

V = 6.49***
R = 1.31

*2. Age 3 years*
$S_x$ = 0.55

| Clones | 3 | 2 | 5 | 1 | 4 | 7 | 6 | 8 |
|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 24.65 | 25.77 | 26.01 | 26.33 | 26.67 | 26.76 | 27.43 | 29.84 |

V = 7.61***
R = 2.57

*3. Age 4 years*
$S_x$ = 0.65

| Clones | 2 | 3 | 4 | 1 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 25.29 | 25.59 | 25.82 | 26.21 | 26.78 | 27.49 | 28.49 | 29.41 |

V = 5.21***
R = 2.11

*4. Age 6 years*
$S_x$ = 0.50

| Clones | 2 | 3 | 1 | 4 and 6 | 5 | 7 | 8 |
|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 26.26 | 26.88 | 27.94 | 28.00 | 28.42 | 28.54 | 32.00 |

V = 11.66***
R = 1.72

*Figure 3.* — Lumen diameter.

*1. Age 1 years*
$S_x$ = 0.58

| Clones | 3 | 7 | 5 | 2 | 4 | 1 | 6 | 8 |
|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 18.21 | 18.39 | 18.41 | 18.47 | 19.76 | 19.97 | 20.86 | 21.67 |

V = 5.01***
R = 0.92

*2. Age 3 years*
$S_x$ = 0.51

| Clones | 3 | 7 | 2 | 1 | 5 | 6 | 4 | 8 |
|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 18.08 | 18.87 | 19.02 | 19.10 | 19.24 | 19.86 | 20.04 | 22.32 |

V = 6.23***
R = 1.85

*3. Age 4 years*
$S_x$ = 0.55

| Clones | 2 | 3 | 4 | 1 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 17.70 | 18.38 | 19.22 | 19.30 | 19.55 | 19.89 | 20.65 | 21.50 |

V = 4.77***
R = 3.44**

*6. Age 6 years*
$S_x$ = 0.50

| Clones | 2 | 3 | 6 | 4 | 1 | 7 | 5 | 8 |
|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 18.46 | 18.54 | 20.00 | 20.08 | 20.17 | 20.34 | 20.40 | 23.42 |

V = 9.29***
R = 1.62

Obtained results show that degree of heritability is low decreasing in fourth year, but later is again increasing.

Dimensions of wood fibres and basic density were to a greater extent conditioned by heredity, while the influence of outer factors, i. e. environment, is very low. When compared the results showed that dimensions of wood fibres are subject to a smaller degree of the genetic control.

Our data of degree of genetic control by specific gravity are opposite to the classification of ALLARD (cit. VIDAKOVIĆ, 1966) by whom the specific gravity of the forest trees, besides mechanical properties, increment in diameter and height belong in the third group with mid degree, while dimensions of wood fibres are classed in the first category with a very high degree of genetic control.

FARMER and WILCOX (1968) tested eastern cottonwood *(P. deltoides)* clones and obtained results for broad-sense herit-

*Table 8.*

| Nr. | Poplar clones | Basic density Mean value with standard deviation After fourth vegetation | After sixth vegetation |
|---|---|---|---|
| 1. | *Marilandica* | 0.319 ± 0.009 | 0.310 ± 0.012 |
| 2. | *Serotina* | 0.308 ± 0.024 | 0.321 ± 0.011 |
| 3. | *Robusta* | 0.334 ± 0.014 | 0.349 ± 0.010 |
| 4. | *Istra* | 0.307 ± 0.021 | 0.323 ± 0.013 |
| 5. | *Ostia* | 0.309 ± 0.012 | 0.307 ± 0.013 |
| 6. | *Jacometti* | 0.296 ± 0.020 | 0.309 ± 0.012 |
| 7. | *I-154* | 0.303 ± 0.018 | 0.304 ± 0.009 |
| 8. | *I-214* | 0.263 ± 0.008 | 0.273 ± 0.010 |
| | Average: | 0.304 ± 0.016 | 0.312 ± 0.015 |

FREQUENCY DISTRIBUTION OF SPECIFIC GRAVITY IN CLONE I-214 AND CULTIVAR ROBUSTA AT THE AGE OF FOUR YEARS. ABOVE: FOR ALL INVESTIGATED TREES BELOW: FOR EACH HARVESTED TREE MEAN VALUE, RANGE AND ONE STANDARD DEVIATION

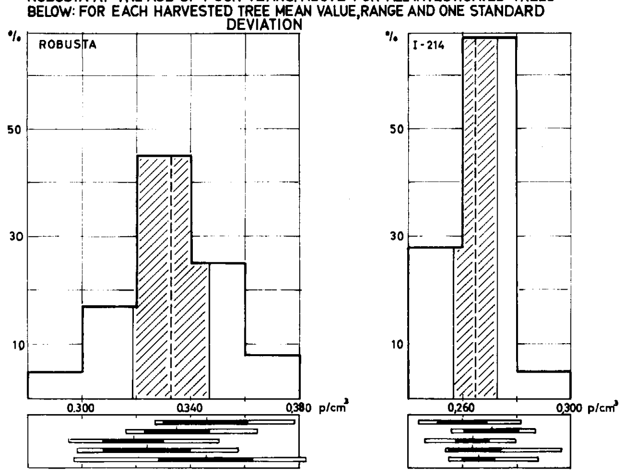


*Fig. 4.*

FREQUENCY DISTRIBUTION OF SPECIFIC GRAVITY IN ROBUSTA POPLAR AND CLONE I-214 AT THE AGE OF SIX YEARS. ABOVE: FOR ALL INVESTIGATED TREES. BELOW: FOR EACH HARVESTED TREE RANGE, MEAN VALUE AND ONE STANDARD DEVIATION

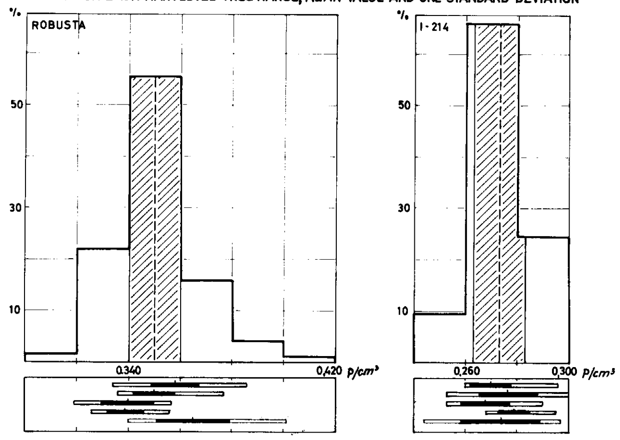


*Fig. 5.*

ability for fiber length — 0.36 and 0.69 to 0.70 for specific gravity. These results are inferior to ours.

Buijtenen, Einspahr and Peckham (1968) found that very strong genetic differences exist in wood specific gravity and percent summerwood in loblolly pines *(P. taeda)*, while tracheid dimensions are inherited to a lesser extent. It appears that major factors influencing wood specific gravity in juvenile wood are percent summerwood, wall thickness

*Figure 6.* — Specific gravity.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *1. Age 4 years* $S_x = 0.004$ | | | | | | | |
| Clones | 8 | 6 | 7 | 4 | 2 | 5 | 1 | 3 |
| $\bar{x}$ | 0.263 | 0.296 | 0.303 | 0.307 | 0.308 | 0.309 | 0.319 | 0.334 |
| V = 21.08*** R = 2.00 | | | | | | | | |
| | *2. Age 6 years* $S_x = 0.005$ | | | | | | | |
| Clones | 8 | 7 | 5 | 6 | 1 | 2 | 4 | 3 |
| $\bar{x}$ | 0.273 | 0.304 | 0.307 | 0.309 | 0.310 | 0.321 | 0.323 | 0.349 |
| V = 20.03*** R = 0.70 | | | | | | | | |

of springwood tracheids and diameter of both springwood and summerwood tracheids.

The same authors (1969) pointed to abundant evidence in the literature indicating that wood specific gravity is under moderate to strong genetic control. Specific gravity and associated fiber morphology appeared to have considerable influence on pulp and paper properties.

## Conclusion

Italian investigations Scaramuzzi (1962) indicated that wood fibre dimensions of 8—11 year old timber of clone *I-214* do not differ from ours, while fourteen and twenty year old wood clone *I-154* gave slightly inferior results. French data (1965) for 12—13 year old wood *I-214* are also inferior. For *Serotina de Champagne* and *Robusta* French investigations (1957) for 22—30 year old timber were for length and width up to 30 percent superior.

According to the above-mentioned data it can be concluded that the fibre dimensions of our poplars are very similar to those stated in literature and from this standpoint our cultivars are suitable for processing in the wood industry.

Definitely better conditions of fibre length have *Ostia, Robusta, Marilandica* and the cultivar from *Istria* while clone *I-214* has the broadest fibres with the largest lumen and the thickest walls. Italian clone *I-214* has the lightest wood while *Robusta* was the cultivar with the heaviest wood.

*Table 9.* — Statistical analysis of specific gravity determined on specimens of eight poplar's clones and cultivars.

| Source of variation | Degrees of freedom | Specific gravity p/cm3 in the age of | | | | | |
|---|---|---|---|---|---|---|---|
| | | 4 years | | | 6 years | | |
| | | SS | MS | F | SS | MS | F |
| Total | 39 | 0.016886 | — | — | 0.019680 | — | — |
| Replications | 4 | 0.000737 | 0.000184 | 2.00 | 0.000323 | 0.000081 | 0.70 |
| Variants i. e. clones or cultivars | 7 | 0.013570 | 0.001939 | 21.08*** | 0.016130 | 0.002304 | 20.03*** |
| Error | 28 | 0.002579 | 0.000092 | — | 0.003227 | 0.000115 | — |
| $\frac{S^2_g}{S^2_g + S^2_E}$ | | | 0.95 | | | 0.95 | |

* — significant at 5% level
** — significant at 1% level
*** — significant at 0,5% level

Dimensions of wood fibres and nominal specific gravity were to a great extent conditioned by heredity, while the influence of environment is very small.

Broad-sense heritability estimates for juvenile wood properties have not been published for Euramerican poplars.


### Summary

In this article are described the fibre morphology and specific gravity of the juvenile wood of eight different cultivars of Euramerican poplars, planted on alluvial soil in the bottom-land of the River Danube, near Novi Sad.

The plantation was established at very narrow spacing, $2 \times 2$ m, in a randomised manner and with five replications. It was thinned after four growing seasons. One sample tree, i. e. a total of 40 sample trees, was chosen before thinning for each clone and each replication. The same number of sample trees was chosen also after thinning.

Fibre morphology was investigated at the age of 2, 3, 4 and 6 years. Specific gravity was tested twice, i. e. before and after thinning. The results showed that the cultivar *Ostia* has the longest fibres whereas the clone *'I-214'* possesses the shortest fibres. The latter is distinguished by the widest fibre with the largest lumen and the thickest walls. *'Robusta'* poplar, on the contrary, has the narrowest fibres with a small diameter. Significant differences were obtained for length from the third year, for width and lumen diameter from the second year.

Duncan tests of fibre dimensions are presented in *Figs. 1—3 and 6.*

Specific density (specific gravity) decreases from *'Robusta'*, the heaviest, to clonee *'I-214'* the lightest. The difference between these two amounts to 28 percent. Only these two clones differ significantly from the other six.

Results indicate that the dimensions of wood fibres (length: 0.42 to 0.86, breadth: 0.81 to 0.91 and lumen diameter: 0.79 to 0.89) and specific gravity (0.95) are to a very high degree controlled by heredity while the influence of environment is very small.


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# The Occurrence of Forms of Norway Spruce Based on Branching Habit


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Within its natural range in Bulgaria, Norway spruce (*Picea abies* Karst.) shows great variation. The sources of this variation lie in the differing silvicultural conditions which occur from 900 to 2200 m. altitude leading to ecological, morphological and phenological differences.

In order to specify more exactly some of the morphological forms of spruce in the Central parts of the Rhodopa mountains eight permanent sample plots were established each containing 200 trees at 1000, 1200, 1400, 1500, 1600, 1800, 2000 and 2150 m. above sea level.

The investigations showed that each separate form of spruce is characterized by different morphological features, made apparent by the branching. The branching is determined by the form, angle, thickness and length of the second and third order branches, and especially by the second order branches. On the basis of these external features four basic forms of spruce were recognised: comb-like, brush-like, compact and flat-branched and these are 24 transitional forms. According to the dominance of the features, the transitional forms were allotted to the four basic forms and in this way were grouped into four combined forms. Each one was characterized by its distinctive ecological, biological and silvicultural features. From this follows the need for the study of these forms as a basis for their use in selection, afforestation and management.

The following basic and intermediate forms of spruce were based on branching habits and reflect a number of important silvicultural properties. The classification shows the gradual transition from one form to another, the first name representing the dominant form.

*I. Comb — Spruce:*

1. Pure-comb
2. Comb to weak-brush
3. Comb to middle-brush
4. Comb to brush — Intermediate

*II. Brush Spruce:*

1. Brush to comb-like — Intermediate
2. Brush to middle-comb-like
3. Brush to weak-comb-like
4. Pure-brush
5. Brush to weak-compact
6. Brush to middle-compact
7. Brush to compact — Intermediate
8. Brush to weakly-flat branched
9. Brush to middle-flat branched
10. Brush to flat-branched