

VARIATION OF GROWTH RING WIDTH IN MARITIME PINE *(Pinus pinaster Ait.)* WOOD

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ABSTRACT: The variation of annual ring width, with height and radial distance from the pith, was measured in 83 year-old stems of maritime pine (*Pinus pinaster Ait.*) sampled in Portugal. The aim of this study was to incorporate ring width data into sawing yield studies through simulation and tree modelling techniques. Results on data analysis measuring annual growth variation contribute also to the raw material characterisation.

Five wood discs were sampled at the tree bottom and at 5, 10, 15 and 20 meters of the height. The discs were used to measure the ring growth in eight directions. Ring width was measured by image analysis.

Growth ring variation was analyzed in vertical sequence in order to evaluate tree growth and its variation with the year, and oblique sequence in order to evaluate the behaviour of the last 13 years with the tree height. Data were evaluated with ANOVA analysis and principal components analysis to investigate the differences in trees, annual rings and radial and axial variation.

Growth rings increased within the first 5–9 growth rings from the pith and then gradually decreased. Oblique variation of growth rate shows a clear tendency to decrease until 5 meter height then increase to the top of the tree for the earlywood. For latewood growth rate did not exhibit any clear tendency but was observed a small growth at the tree top. In the case of vertical variation, growth rate decreased gradually with the year of cambium formation. We found a great variability along the tree concerning the axial and radial positions.

Variation between directions was not significant, and trees did not present a high eccentricity. It was not observed a good correlation between latewood and earlywood ring thickness.

A 3D model of the measured rings was developed for each sampled stem that allowed visualization, in 3D and 2D, of the annual growth variation for any given stem height. This growth ring model is intended to be integrated with the 3D stem models including the internal knots and stem and heartwood shape, already developed for this species. These will be the virtual raw-material input for sawing simulation software.

KEYWORDS: *Pinus pinaster Ait.*, growth rings, within-tree variability, tree modelling, sawing simulation.

1 MATERIAL AND METHODS

20 maritime pine trees were harvested in Leiria (S1). The trees in Leiria were 83 years old with an average DBH (diameter at breast height) of 47.8 cm. Biophysical and biometric stand characterization is detailed in Pinto (2004). The stems were cut into 5 m logs. From each log two discs were cut (top and bottom discs) and a central board containing the pith. The following discs were analysed: bottom, 5m, 10m, 15m and 20m.

The study of growth ring variation was made on 8 randomly selected trees of the sampled tree by measuring the annual rings in 8 directions (North, Northwest, West, Southwest, South, Southeast, East and Northeast). The latewood and earlywood in the growth ring was also measured.

For the virtual reconstruction and three-dimensional view of the log an algorithm was created, Rings2002. As input, data from the eight directions were used. In the cross-section, the xy coordinates are determined by taking North as the origin point. This was done for all the rings of the same level (wood disc).

The program calculates vectors between the pith and each directional point and extrapolates intermediate positions in order to obtain 24 vectors, which allow a more precise description of the cross section.

To calculate the z coordinates of each point, the algorithm links the different levels to the same ring and the same direction.

The output is a three-dimensional image of the stem including the growth rings. The program also allows the viewing of the growth rings in cross section at any point along the stem.

2 RESULTS AND DISCUSSION

2.1 GROWTH RING VARIATION

The growth in two opposite directions (east-west) is similar. The radial dimension of the stem decreases from bottom to the top, e.g. 20cm at the bottom and 12 cm at 20 m of stem height. The mean ring width decreases from the bottom until 10 m of height and then increases to the top.

The earlywood proportion increases from the bottom to the top (70% and 83% respectively at the bottom and 20 m of height).

The latewood width in the different rings is more uniform and regular than the earlywood width for all height levels. While earlywood is formed during a phase of high activity rate with internode elongation, the latewood ring is formed during a period of lower vegetative activity. Small changes in photoperiod, temperature and water availability cause changes in growth and therefore the variability observed in latewood is lower than the one observed for the earlywood.

In the stem top the width variation of earlywood and latewood is higher, because in that part of the stem there is a great amount of juvenile wood. These results are in accordance with the observed by Larson [1] and Smith [2].

2.2 VERTICAL SEQUENCE

In a vertical sequence, the same ring in relation to the pith is observed along the stem, therefore corresponding to a ring formed by a cambium with the same age. In this case the ANOVA results showed that the variability was mainly due to the effect of the within ring variation of latewood and earlywood (53.6%). The width of earlywood is always higher than the latewood.

A new ANOVA was made separately for earlywood and latewood. The height levels were now highly significant: for the latewood they explain 41% of the total variance and for the earlywood they explain 11%.

The effect of the measurement directions was not significant for earlywood and latewood.

2.3 OBLIQUE SEQUENCE

The analysis in oblique sequence was made with the initial 13 growth rings in all studied levels. In this case the analysis compares the rings in the same position in relation to the periphery, corresponding to rings that were formed in the same year (but with different cambial age).

In this case the ANOVA study showed that the highest variability corresponded to the cross-sectional directions where the measurement was made. This variability, may be explained by differences in the climate conditions and the insulation time for the different directions.

The height level effect explains 11% of the total variance, and can be explained by the different physiologic cambium age.

The growth ring widths for different level represent 11% of the total variation caused also by the physiologic cambium age. It was also observed that the directions (and consequently the sun exposition) influence differently the different height levels .

2.4 LOG TRIDIMENTIONAL MODEL

The collected data was used to make the stem reconstruction with the program Rings2002. In the output program it is possible to obtain the image of the cross-sections and of the stem. In the image obtained it is

possible to observe the shape of the stem, as well as the growth rings.

After the stem reconstruction it is possible to have a visualization at any point along the stem of the cross sections with growth rings and their latewood and earlywood layers.

The rings are represented alternately in two colours, red and blue, when the colour seems purple it shows that the rings are very close and therefore allow the viewing of the areas where the rings are tighter and where they are wider.

This type of ring reconstruction will be integrated in the virtual Pine log developed by Pinto (2004), and therefore complement the already existing information on the existing knots and the amount of sapwood and heartwood.

This information is important as an input to simulation programs for sawmills and veneer processing. The growth ring features can be additional variables in these programs in order to assess the quality of their outputs, in the sawn pieces and veneers.

3 CONCLUSION

Variation of growth ring width along the stem was small in the different trees. The differences of growth ring width were due to different earlywood widths. There was no correlation between latewood and earlywood width.

The percentage of earlywood was strongly correlated with cambial age in agreement with previous results for maritime pine [3][4][5] and the proportion of juvenile wood (more abundant in the level close to the crown).

The direction was not a significant factor for the variation in growth ring width.

Growth ring information could be modelled and introduced in mathematical reconstruction and 3D-models of maritime pine stems.

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