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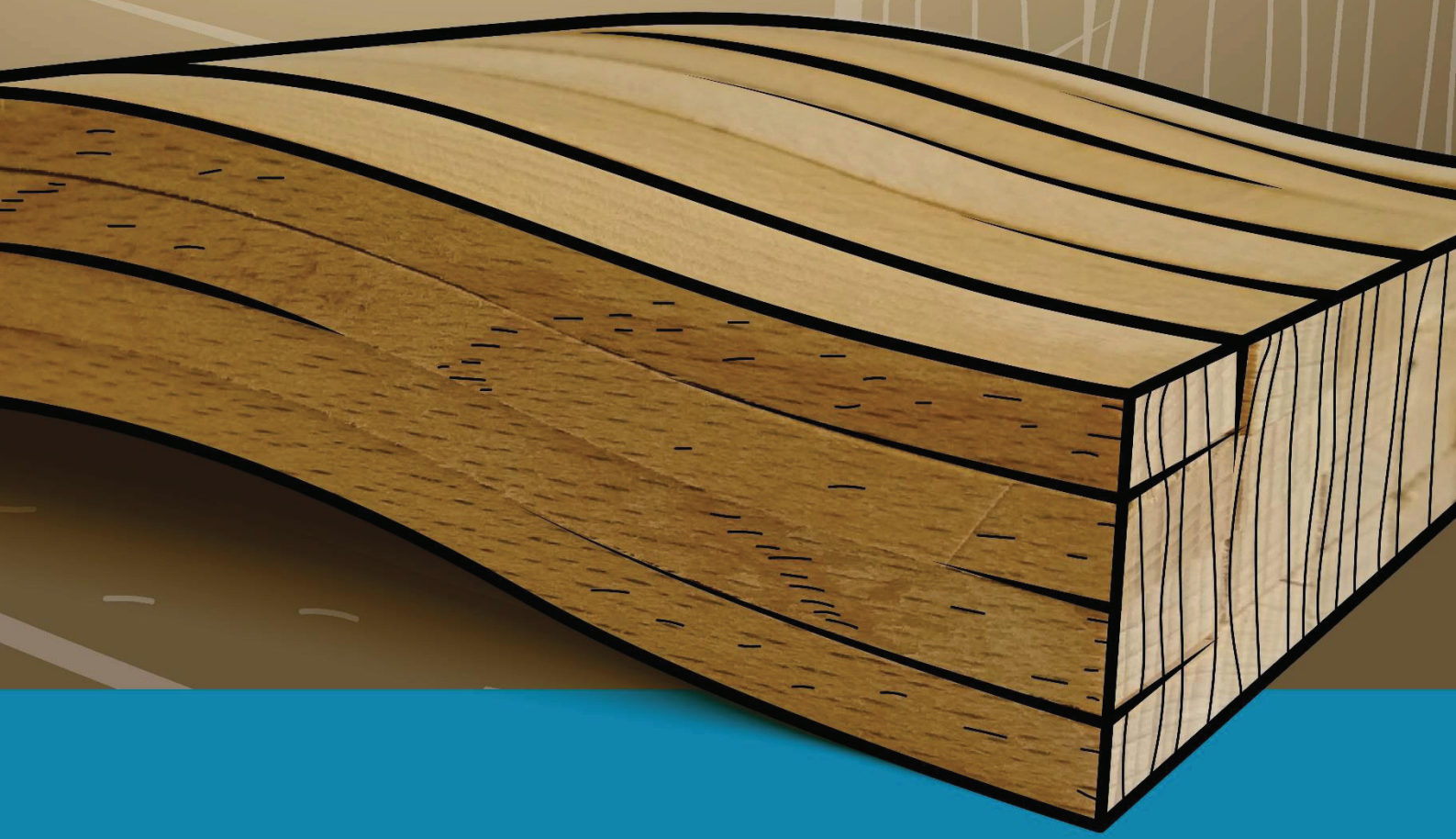

WOOD KPLUS

Mendel University in Brno

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Can the characteristics of the crown influence the stability of poplar trees?

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ABSTRACT

The stability of trees represented a concern for the specialists in forestry because the windthrows produce large damages and big economic losses. On the other hand, the trees located in public areas, which are affected by the wind could produce injuries to the people and also could prejudice the goods. Because the risk of falling is very big the case of old trees with a large crown is important to know the quality of the wood inside the tree and some growth characteristics which can influence the stability. As the crown is the most developed aerial part of the trees, its surface and volume can represent decisive factors in maintaining the tree's stability. Taking into account the importance of trees in public areas like parks, gardens and street alignments, the aim of the study is to evaluate how the growth characteristics of the crown could affect the stability of poplar trees located along an alignment. The measurements were made for 163 black poplar (*Populus nigra* L.) trees. Poplar is one of the most representative species used for the street alignments in Romania, both in cities and along the main public roads. The characteristics of the crown (height and four radii of the lower part of the crown) were measured in the field and its shape was evaluated. Moreover, the principal dimensions of the trees (height and diameter at the breast height) were measured. Because the risk of accident is caused also by the big branches which could fall from the large trees some evaluations regarding the presence of dry branches and other visible defects were made.

INTRODUCTION

The biomechanical behavior of trees under the stress of destabilizing factors is an essential step in understanding stability (Sellier et al. 2006). The main cause of the loss of tree stability is represented by strong winds (Popa, 1999, Muşat et al. 2014), but the stability of forest trees to mechanical stress also depends on other factors such as (Popa 1999, Grudnicki 2003, Jim and Zhang 2013): the way of rooting and the length of the roots, the climate, the shape of the relief and the arrangement of the trees according to it, the age of the trees, the size of the crown and its architecture, the permanence of the foliage, the slenderness of the trunk, the consistency of the stands, the regime and treatment, the exploitation methods, the production class, the longitudinal profile of the tree on the direction of the dominant wind and the health status of the trees. The alignments near the streets do not only have landscape values, they also contribute to directing the sight on the axis of the road, provide protection against the sun and serve to guide travelers during fog and snow, in Europe the alignments date for more than five centuries. Because deciduous trees are more resistant to pollution than conifers (Stravinskiene et al. 2015), they are more suitable for planting along streets. The stability is usually analyzed according to the parts of the trees, considering that they are formed by the foundation and the elevation (Grudnicki 2003), although they react differently to the action of disturbing factors. It has a decisive role in maintaining the balance, the elevation fitting in the foundation through the stump. The importance of the crown resides through the influence exerted on the stability of the trees, since the total forces applied to increase proportionally with the profile of the crown and the projected surface exposed to snow and wind pressures. Sellier et al. (2006) mention that the architecture of the aerial part of the trees is a key component in ensuring the stability of the trees. In this sense, Popa (1999) specifies that the stability of the tree is influenced by the crown through its length, diameter, shape and penetrability, which contributes decisively to explaining the behavior of trees to the action of wind and

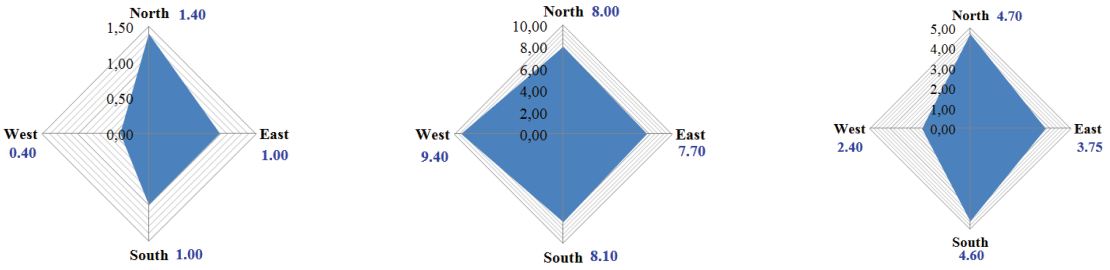
snow, influencing the stability. In the case of forest vegetation (Popa, 1999), wind pressure mainly acts on the crown of the tree, from where it is transmitted to the trunk and roots, so that the overturning force due to the pressure exerted by air currents on the crown represents about 80-90% of the total force. The aim of the study was to evaluate how the growth characteristics of the crown could affect the stability of poplar trees located along an alignment.

EXPERIMENTAL METHODS

The research was carried out in the area of Feldioara, Brasov County, Romania, in an alignment of black poplar (*Populus nigra* L.) located at a distance of approximately 30 km from the city of Braşov, on the European road E60. The Măieruş Corridor is characterized by the fact that in its eastern half the winds from the north and northeast are dominant, and in the west those from the northeast and northwest. In general, average speeds exceed 2 m/s in all directions and characterize the months of spring and summer, the months of May-June being the windiest of the year. The fieldwork involved measuring the biometric characteristics of the trees. For each of the 163 trees the following features were measured: tree height (h - expressed in meters, measured with the TruPulse TM 200 device), minimum diameter (d_{min}) and maximum diameter (d_{max}), respectively medium diameter (d) at the breast level (in centimeters and measured with a 100 cm forestry caliper) and crown radii in the four cardinal directions (north, east, south and west – determined with a compass; the TruPulse device TM 200 was used). Based on the field measurements, a series of auxological indicators (Popa 1999) of the crown were calculated, respectively: the mean radius of the crown (R_{med}), the diameter of the crown (b), the degree of clearance (T) and the crown area (S). Thus, the crown radii were measured as the distance between the center of the stem and the extremity of the crown projection in the four cardinal directions (Jiménez-Pérez et al. 2006), and for the average diameter of the crown, an average radius was calculated based on the 4 measured radii, which later was doubled (Jiménez-Pérez et al. 2006, Ciubotaru and Păun 2014, Muşat et al. 2014). The degree of crown development (T) was determined as the ratio between the crown diameter (b) and the tree height (h) (Popa 1999, Jiménez-Pérez et al. 2006). Even if the projected shape of the crown of a tree in the horizontal plane is always irregular, its surface can be evaluated by assimilating it with a circle, with a polygon or by interpolating with a cubic spline function (Ciubotaru and Păun 2014). To determine the area of the crown, also called the projected surface of the crown on the ground, the formula for calculating the area of the circle was applied, taking into account the medium diameter of the crown, expressed in meters, and calculated by doubling the average radius deduced and the four radii of the horizontal projection.

RESULTS AND DISCUSSION

The 163 black poplar trees analyzed had heights between 6.80 and 27.40 m with an average of 19.46 m. The diameter at the breast level ranged from 29.50 to 74 cm, with a mean of 47.34 cm. The measurement of two diameters also led to the possibility of determining the ovality of the trunk at the level of 1.30 m above the ground. Some of the evaluated trees showed ovality that can reach 20%, but the average, like the median, was around 4%. It was found that in the north, east and south directions the crowns are relatively uniformly developed, while in the west the minimum and average values of the radii are much lower (Fig.1). This does not apply to the maximum values, on the west direction being the largest radius measured. Related to the characteristics of the crown, it was found that the medium diameter of the crown ranged from 2.60 to 14.40 m, with an average of approximately 7.80 m. Based on the application of the reasoning according to which the horizontal projection of the crown is linked to a circle, areas between 5.31 and 162.78 m^2 were obtained, with an average of 52.54 m^2 and a median of 47.45 m^2. Compared to the degree of development, a variation between 0.15 and 0.61, with an average of 0.40 were found.



a) Minimum radii b) Maximum radii c) Median radii

Figure 1: The values of the minimum (a), maximum (b) and median (c) radii of the crown

It was also found that the medium radii have, most of the time, values between 3 and 5 m (Fig. 2), while the average diameter of the crown varied predominantly, as expected between 6 and 10 m (Fig. 3). Based on the medium diameter of the crowns, it worth to be mentioned that the black poplar trees in the analyzed alignment predominantly had a wide crown. In the case of ash trees located in pre-exploitable stands (Șofletea et al. 2007), the average diameters ranged between 9 and 11 m. For oak trees Dolocan and Gheorghiță (2012) obtained average diameters of the crown of about 5.2 ... 9.0 m.

By applying the linear regression and correlating the medium diameters of the crown with the base diameters, a direct and significant correlation between them (R^2=0.655) was found, similar with other studies (Șofletea et al. 2007, Dolocan and Gheorghiță 2012). Troxel et al. (2013) mentioned that the crown diameter is influenced by the base diameter of the trees in a proportion greater than 70% (R^2>0.700).

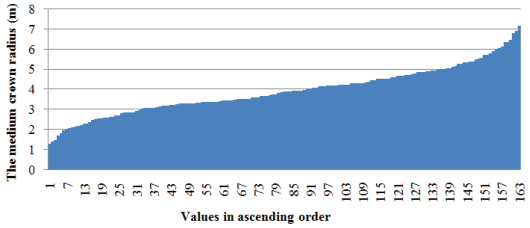


Figure 2: Variation of medium radius (m)

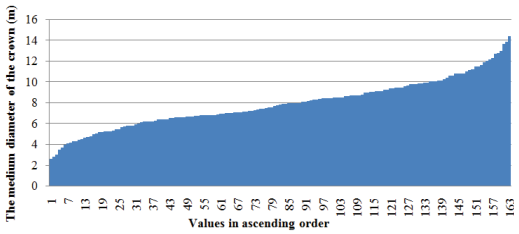


Figure 3: Variation of medium diameter (m)

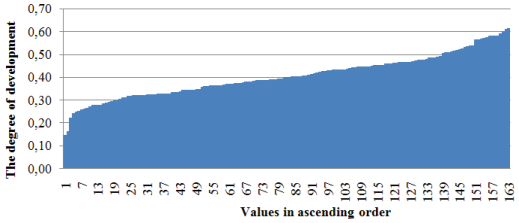


Figure 4: Variation of degree of development

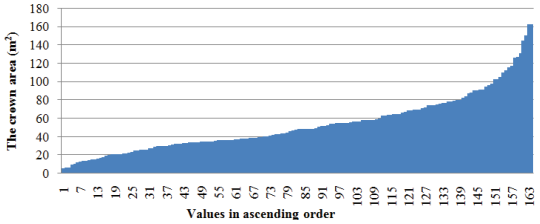


Figure 5: Variation of crown area (m^2)

On the other hand, the degree of crown's development, as a ratio between its diameter and the height of the tree, indicated predominant values between 0.30 and 0.50 (Fig. 4). Following the research undertaken, Jiménez-Pérez et al. (2006) established that the dominant trees presented on average, a crown flattening degree of 0.37, while the trees in the lower canopy present a higher value (0.45). With regard to the influence of this parameter on the stability of trees, Popa (1999) found that with the increase in the degree of the crown's development, the risk coefficient for felling also increased, the most pronounced trend being observed at heights greater than 15 ... 20 m (for spruce). Compared to the area of the horizontal projection of the crown, it can be observed that the most numerous values are found between 40 and 70 m^2, but a significant share is also represented by the crowns that have small surfaces, of 20 ... 40 m2 (Fig. 5). Jiménez-Pérez et al. (2006) observed that the trees in the upper ceiling of conifer stands have horizontal crown surfaces between 14.91 and 33.90 m^2.

To support these statements, it is worth mentioning the fact that out of the total of 163 trees analyzed in the black poplar alignment from Vadu l Roşu, only 9 specimens showed branching and, in all cases, it affected the lower third of the trees' height, out of them 7 formed 2 branches and 2 formed 3 branches.

CONCLUSIONS

Even thought the diameters at the breast level vary widely, the average and median values were close, some trees also showed ovality, which did not endanger their stability, the values being relatively low. Due to the local growing conditions, the black poplar trees have wide crowns, with a significant share of the tree height, and are relatively uniformly developed in the north, east and south directions. The medium diameter of the crown was influenced by the diameter at the breast level, showing values similar to those of ash trees in pre-exploitable forests, but larger than those of oaks. That is due to genetic influences on one hand, and on the other hand, due to the particular growing conditions.

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