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FOREST REVIEW

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FACULTY OF FORESTRY IN SKOPJE

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TIMBER PRODUCTION IN POPLAR PLANTATIONS WITH DIFFERENT PLANT SPACING

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ABSTRACT: The paper presents the results of a study of the impact of plant spacing of different poplar clones on the revenues generated per unit area. The research was carried out in six sample plots in the period from 2007 to 2016. The research object are clones *Populus×euramericana* 'I-214', *Populus×euramericana* 'M1' and *Populus deltoides* PE 19/66. On the basis of the results of this research, it can be concluded that larger plant spacing causes an increase in revenues at the same age of a plantation, with a small difference in production costs. The type of clone has a significant impact on the potential qualitative structure of the assortments, as shown by the results of the analyses of increment of clones PE 19/66 and I-214 at the same age. Until the fifth year of age, a higher diameter increment was found for clone PE 19/66, and from the fifth year of age for clone I-214. In addition, hexagonal plant spacing produced a higher diameter increment compared to tetragonal plant spacing.
Key words: poplar, plant spacing, assortment structure, revenues and costs

1 INTRODUCTION

Poplar is the most common tree species in the forests managed by the PE "Vojvodinašume". The establishment of poplar plantations began after World War I, but plantations on large areas were established after World War II. During the 1960s, clone I-214 (*Populus×euramericana* (Dode) Guinier) was introduced into production, because it showed high production potentials and resistance to pathogens. Similar to the clones previously used for the establishment of plantations, the sensitivity of this clone to the pathogens of cortical tissue (*Dothichiza populea* Sacc. et Br.) and leaf (*Melampsora* sp. and *Marssonina brunnea* Ell. et Ev.) increased over time, as well as to the mass epiphytotics of the pathogen *populea* Sacc. et Br. on large surfaces, which culminated in 1977-78.

The problem was solved by introducing new poplar clones, primarily the clones of American black poplar (*Populus deltoides* Bartr. ex Marsh.) into production, as they showed resistance to the pathogens of bark and leaf, as well as significant advantages in terms of production in comparison with clone I-214 in the first half of rotation [11].

Nevertheless, clone I-214 is still very much present in the territory of Vojvodina. Poplar cultivation as a specific and intensive way of production of wood assortments is gaining importance worldwide and in this country due to the high value of poplar wood in use. Poplar wood is used for different purposes [4], [15], [2], [21]. [12] investigated the impact of age on the properties of wood for three clones of Euramerican poplar, including clone 'I -214', and concluded that age significantly affects them.

Since poplar is characterized by rapid growth and a short production cycle, it is increasingly used worldwide as a raw material for energy use. Research related to the testing of the energy value of poplar wood shows that its use for this purpose is justified [20], [3], [9].

Factors with an impact on the yield of wood mass per unit area are numerous, and among them need to be mentioned the type of clone, plant spacing, soil type, hydrological conditions, tending measures, etc. [22], [8], [19], [10], [5], [6]. These factors influence the length of production cycle, i.e. the efficiency of production.

Na optimalnim zemljištima, uz obezbeđenje svih potrebnih tehnoloških mera, klon I-214 nakon 31. godine starosti stabla pokazuju visok proizvodni potencijal što predstavlja i reperni osnov za postizanje visokih proizvodnih efekata u zasadima topola [1].

On optimal soils and when all necessary technological measures are provided, clone I-214 shows a high production potential after the 31st year, which also serves as a benchmark for the achievement of high production effects in poplar plantations [1].

The aim of this paper is to determine whether plant spacing has an impact on the production potential of poplar clones PE 19/66, I-214 and M1, as well as to determine the age at which profit can be expected.

2 RESEARCH OBJECT

The research was carried out in six sample plots (SPs) in the period from 2007 to 2016. In the area of PE "Vojvodinašume" in the FA "Banat", the FMU "Donje Podunavlje" compartment 54 section a and sections b (Figure 1).

Figure 1: Position of the sample plots in the FMU „Donje Podunavlje" compartment 54 section a and 54 section b

The sample plots were established in the plantations of *Populus × euramericana* 'I-214', *Populus × euramericana* 'M1' and *Populus deltoides* PE 19/66. The plant spacing is tetragonal, and the distance is 5 × 5 m and hexagonal, with distances of 6 × 6 and 6.5 × 6.5 m. The number of trees per hectare varied depending on the plant spacing and distance of planting.

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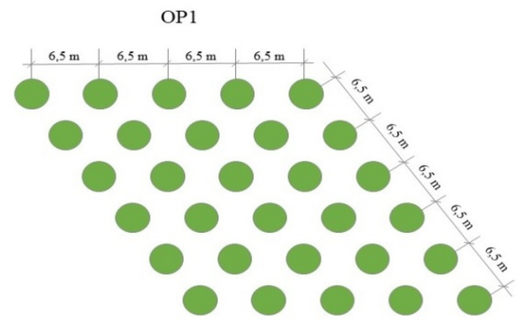
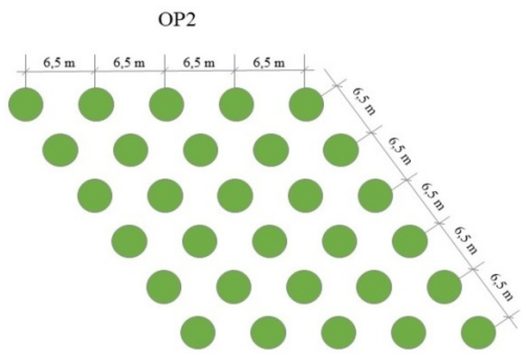
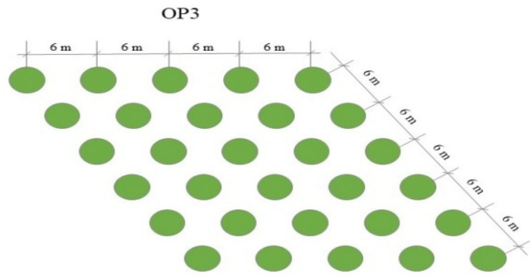
Table I shows the characteristics of plantations in which the sample plots were established.

Table I: The characteristics of plantations in which the sample plots (SP) were established

Sample plot	Type of clone	Period of measurements	Plant spacing	Spacing between the lines (m)	Number of stems per hectare	Planting depth
SP 1	I-214	1-10	hexagonal	6×6	320	shallow
SP 2	PE 19/66	1-10	hexagonal	6×6	320	shallow
SP 3	I-214	1-10	hexagonal	6,5×6,5	272	shallow
SP 4	PE 19/66	1-10	hexagonal	6,5×6,5	272	shallow
SP 5	I-214	3-13	tetragonal	5×5	400	shallow
SP 6	M1	3-13	tetragonal	5×5	400	shallow







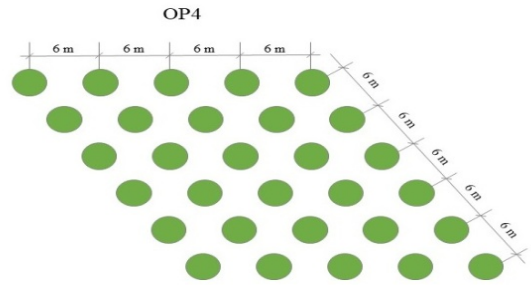
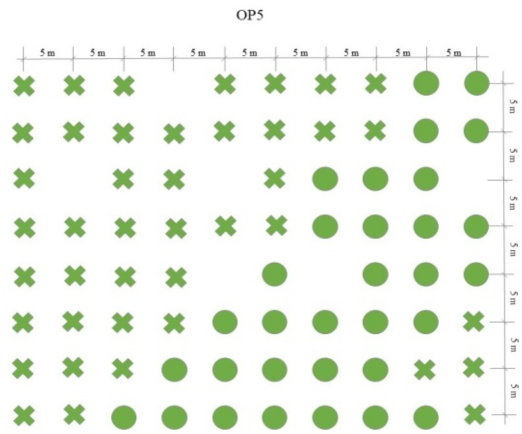


Figure 2: Scheme of the experiment with hexagonal plant spacing (SP1, SP2, SP3 and SP4)



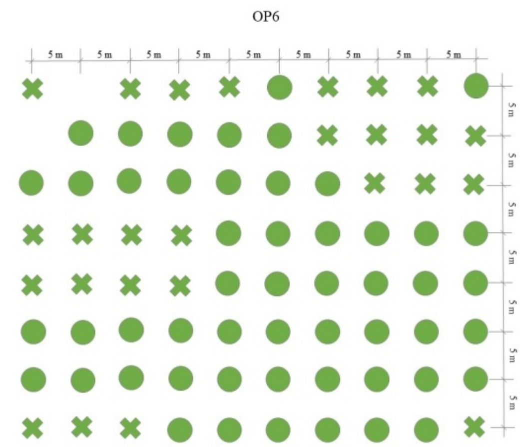


Figure 3: Scheme of the experiment with tetragonal plant spacing (SP5 and SP6)

O – denotes the place taken by the stem in the plantation, X – denotes the place where the planted tree died or was felled in the meantime.

Figures 4 and 5 show hexagonal plant spacing in the sample plots.

Figure 4: Hexagonal distribution of stems 6×6 m of clone PE 19/66 in SP3

Figure 5: Hexagonal distribution of stems 6×6 m of clone I-214 in SP1

The same type of forest can be found in all sample plots: the forests of ash and pedunculate oak (*Fraxineto-Quercetum*) on marsh black soils. The depth of planting in hexagonal plantations is shallow, and it is deep in the ones with tetragonal spacing. All experiments were located in the area protected from floods in the FMU "Donje Podunavlje".

At hexagonal plant spacing (6 × 6 m) for clones I-214 and PE 19/66 the size of the sample plot was 0.094 ha, and at the plant spacing of 6.5 × 6.5 m it was 0.110 ha. In the case of tetragonal plant spacing (5 × 5 m) of clone I-214, the sample plot area was 0.27 ha, and of clone M1 it was 0.23 ha.

3 METHOD

In all sample plots, perimeters of the stems were measured at breast height every year. Wood volume was calculated on the basis of the diameter and height degree. The estimation of the share of technical and stack wood in the total volume was based on the experience gained in similar plantations, where wood volume had already been cut. The shares of certain quality classes in the total volume of technical roundwood were obtained on the basis of provisional assortment tables. The values of timber assortments were obtained on the basis of provisional norms and pricelists of wood assortments of the PE "Vojvodinšume". The costs of establishment and tending of the plantation were calculated. In addition, these costs included the costs of logging, skidding and the tax for felled timber.

Common statistical and mathematical methods were used in this paper.

4 RESEARCH RESULTS

Figure 6 shows wood volume per hectare and Figure 7 the mean diameter of a tree at the age of ten years in the plantations of different clones by sample plots.

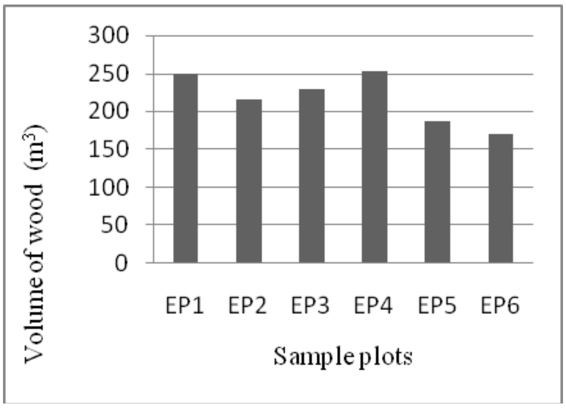


Figure 6: Wood volume in plantations of different clones

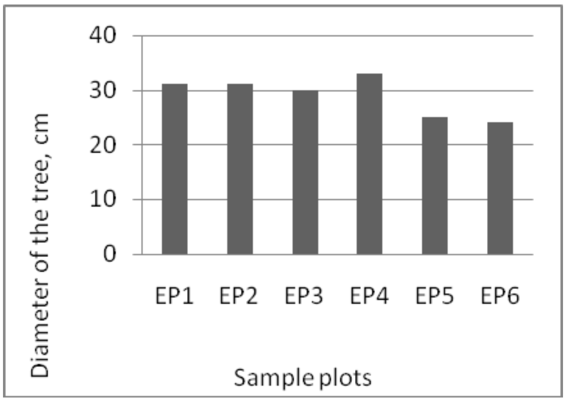


Figure 7: Mean diameter in plantations of different clones

The highest wood volume and consequently the largest mean diameter of a tree were obtained in the plantation of clone PE 19/66 (SP4), and the lowest volume was found in the case of clone M1 plantation (SP6).

Figure 8 shows the diameter increment per hectare at the age of ten years in sample plots 1, 2, 3 and 4.

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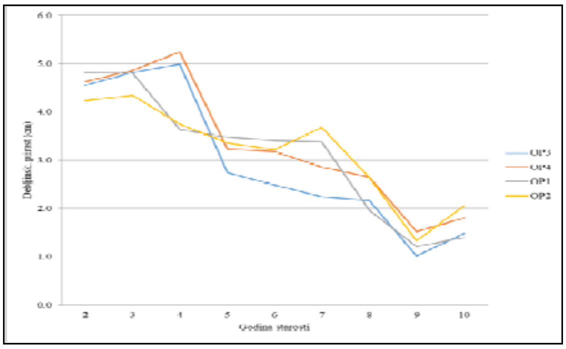

Figure 8: Diameter increment at hexagonal plant spacing

The highest diameter increment at the age of ten years was recorded for clone PE 19/66 with a 6.5 × 6.5 m plant spacing (SP2). In the period from the eight to the tenth year of age, a higher diameter increment was achieved in the plantations of clones with a larger plant spacing.

The technological assortment structure is shown in Figure 9, and the assortment structure in Figure 10.

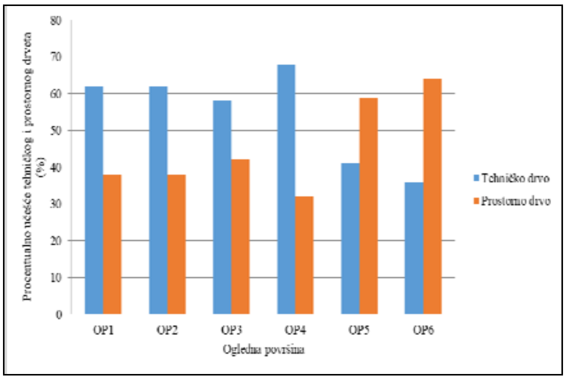

Figure 9: Technological structure of assortments

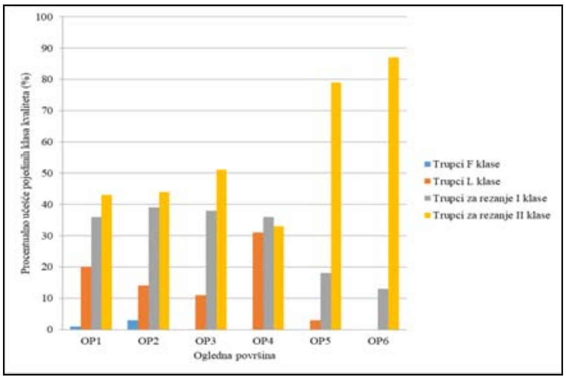

Figure 10: Assortment structure of technical roundwood

The best technological and assortment structure was achieved in the plantation of clone PE 19/66 (SP4), and the worst one in the plantation of clone M1 (SP6).

Potential assortment structure is the volume share of the assortments of wood of certain classes in the total volume of technical roundwood.

The largest share of F and L class assortments was recorded in SP1 and SP2, where plant spacing was 6.5 × 6.5 m.

Figure 11 and 12 show direct costs of production of unit products and potential revenues that would be achieved at the plantation age of ten years.

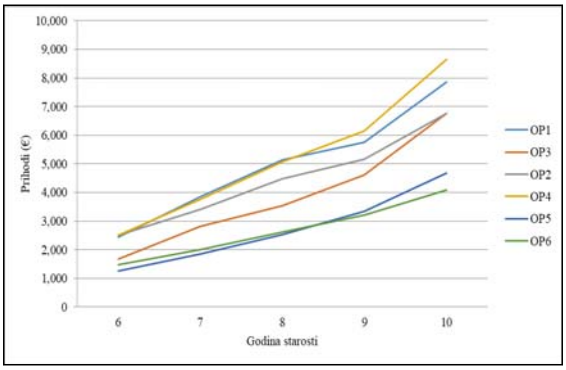

Figure 11: Dependence of profits on plantation age

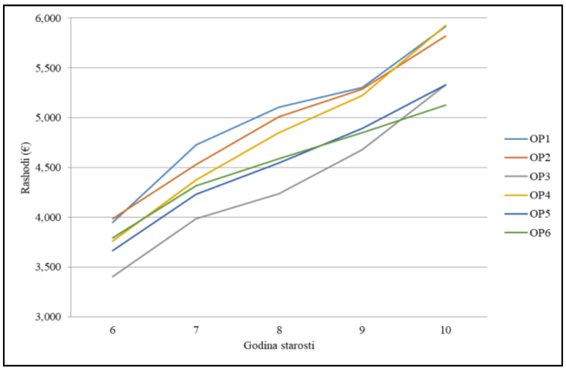

Figure 12: Dependence of expenditures on plantation age

The highest costs and at the same time revenues at the tenth year of age were achieved in the plantation of clone PE 19/66 (SP4), and the lowest values were found in the plantation of clone M1 (SP6).

The profit per hectare was calculated on the basis of the difference between revenues and costs (Figure 13).

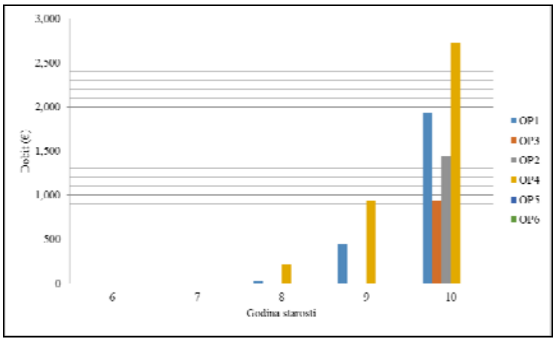

Figure 12: Correlation between the age of the plantation and revenues

At the age of eight and nine years, profits are generated in the plantation of clone I-214 (SP1) and in the plantation of clone PE19/66 (SP4). At the age of ten, profits have still not appeared in the plantations of clones with a 5 × 5 m plant spacing.

4 DISCUSSION OF RESEARCH RESULTS

In these studies the largest mean diameter and the largest volume per hectare were found in SP4 out of six sample plots, i.e. in the plantation of clone PE 19/66 with a 6 × 6 m plant spacing, while the smallest diameter and volume were recorded in SP6, where planting was performed with clone M1 using a 5 × 5 m plant spacing. This was expected, given that according to previous studies, new clones on better quality soil produce significantly higher wood mass per hectare at the same plant spacing, while the hybrid clone M1 is used more due to its resistance to disease, especially on poor soils.

The largest share of technical roundwood was found in SP4, while the lowest share was recorded in SP6. In terms of assortment structure, the best structure was achieved in SP2, and after that in SP1, where plant spacing was 6.5 × 6.5 m. Clone I-214 in SP1 is expected to reach the value of wood assortments of clone PE 19/66 in the coming years. The reason for this is higher diameter increment of clone I-214 in the period from the fifth to the tenth year of age. This is a potential assortment structure based only on dimensions, assuming that other characteristics of the stem are within tolerable limits (Nikolić, 1988, 1993, Danilović 2000).

From the seventh to tenth year of age the diameter increment is higher in the plantation with a 6,5 × 6,5 m, plant spacing, which will produce a higher value of wood assortments in the coming years, and thus higher profits compared to the plantation with a 6 × 6 m spacing.

The highest revenues were recorded in SP4, while the lowest revenues were found in SP6. The reason for this is direct connection between the diameter of a tree and potential structure of the assortments, i.e. minimum dimensions as a limiting factor in the production of more valuable assortments. The impact of this factor on the value structure of assortments amounts to 2.68% (Danilović, 2011).

Profit is achieved in the case of hexagonal plant spacing (6 × 6 m) in the plantation of clone PE 19/66 (SP4) from the age of eight to ten years, and at a 6,5 × 6,5 m spacing profit appears at the age of ten years (SP2). In the case of 6.5 × 6.5 m plant spacing of clone I-214, like in SP4, the profit appears already at the age of eight years.

In the case of 6,5 × 6,5 m plant spacing, profit was expected to be achieved earlier, due to the larger area for the development of trees. However, this did not happen, probably due to poorer rooting of the seedlings in the first years of plantation development.

In the case of tetragonal plant spacing (5 × 5 m) profit was not generated at the tenth year of age of the plantations of clones I-214 and M1. According to research data, profit will appear earlier in the I-214 clone plantation compared to the clone M1 plantation. The reason is that clone M1 on average has a higher diameter increment by 4 mm until the fifth year of age and therefore also a higher value of wood assortments, and clone I-214 from the fifth to the tenth year.

Generally, based on the results of this research, a higher value of wood assortments at the age of ten years was found at larger plant spacing compared to smaller plant spacing. At larger spacing per unit area, there is a smaller number of trees, which provides greater space per tree. Consequently, a better assortment structure can be achieved, thereby increasing the value of wood assortments.

5 CONCLUSIONS

The following conclusions can be reached on the basis of the above research:

- In the *Populus × euramericana* 'I-214' poplar plantation with a 6 × 6 m hexagonal plant spacing profit is achieved at the age of ten years, and in the case of 6.5 × 6.5 m plant spacing it appears at the age of eight years.
- In the poplar plantations of *Populus deltoides* 'PE 19/66' at a 6 × 6 m hexagonal plant spacing, profit appears at the age of eight years, and in the case of 6.5 × 6.5 m plant spacing at the tenth year.
- So far, no profit has been observed in the case of tetragonal 5 × 5 m plant spacing at the age of ten years for both clone I-214 and clone M1.
- At the same plantation age the value of wood assortments is higher at a larger plant spacing observed over a period of ten years.
- Since these are some of the first results of the research related to determining and comparing the profits in plantations of different clones, these studies need to be continued so that they can serve as the basis for selecting the suitable clone from the economic point of view.

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