Original scientific paper
Šumarski list 150 (9–10): 423–432, 2026

Stem and Crown Biomass Production of *Paulownia* RBTC15 Clone

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ABSTRACT

This paper examines the production potential of Croatian domestic *Paulownia* RBTC15 clone in Požega-Slavonia County over a single growing season. In total, seven fields were included in the research, together with 417 measured trees. At the level of all measured fields, an average DBH increment in researched season was 2.1 cm, and an average height increment was 1.8 m. Biomass and stem volume equations explained more than 95% of the variability. Stem and crown biomass increment together at the field level ranged from 1.04 t/ha to 12.29 t/ha, while stem volume increment ranged from 3.0 m^3/ha to 24.32 m^3/ha. For both measurements (before and after the growing season), the determined moisture content was higher in the stem than in the crown. The determined basic wood density of the stem wood was quite lower than that determined density for the crown wood. Overall results present a starting point for further research, but also provide valuable information about the production potential of an unresearched *Paulownia* clone developed for Croatian climate conditions.

Keywords:
aboveground biomass, moisture content, stem volume, wood density

DOI:
https://doi.org/10.31298/sl.150.9-10.3

How to Cite:

Ursić, B. et al., 2026: Stem and Crown Biomass Production of Paulownia RBTC15 Clone. Šumarski list 150 (9–10): 423–432, 2026. https://doi.org/10.31298/sl.150.9-10.3

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INTRODUCTION

According to the FAO (2014), future supply of roundwood is exposed to numerous uncertainties resulting from policy trends, economic incentives, the development of planted forests and climate-change-related forest disturbances. Moreover, European policies set ambitious targets to increase the share of renewable energy (European Council 2023). Expecting that it will not be possible to satisfy the growing needs for wood from natural forests alone, one of the solutions to bridge the gap is the cultivation of fast-growing species.

Among other fast growing tree species, in the past decade the genus *Paulownia* Siebold et Zucc. attracted attention from both the academia and the industry (Jakubowski 2022). *Paulownia* is a fast-growing deciduous tree represented by nine species, which are indigenous to China (Zhu et al. 1986). In normal conditions, it can grow up to 40 cm in diameter in just 10 years, while in optimal conditions, annual volume increment can amount up to 0.37 m^3 per tree (Kozakiewicz et al. 2020). Therefore, the interest for introducing this species into other parts of the world was expected.

In terms of physical and mechanical properties, *Paulownia* wood is most similar to willows and poplars (Jakubowski 2022). The basic wood density is mostly reported in the range between 240 kg/m^3 and 270 kg/m^3 (Akyildiz and Kol 2010, Kiaei 2013, Kozakiewicz et al. 2020) depending on the species, presenting a very light tree species. Regarding other wood properties (compression strength, static bending strength, modulus of elasticity, etc.), *Paulownia* wood can be used for the production of furniture parts, packaging boxes, woodworking and other products which do not require mechanical performance, e.g. energy and pulp industry (Kaymacki et al. 2013, Ab Latib et al. 2020, Jakubowski 2022).

Numerous studies have been conducted to determine the biomass yield (Zuazo et al. 2013, García-Morote et al. 2014), economic profitability (Testa et al. 2022), carbon sequestration ability (Magar et al. 2018, Ghazzawy et al. 2024), biofuel suitability (Lopez et al. 2012, Dominguez et al. 2017, Vusić et al. 2018), and optimal growth conditions (Jakubowski 2022) of the species. Together with natural forests, fast-growing species seem to play a crucial role in reducing CO_2 from the atmosphere due to their fast growth rate (Magar et al. 2018). Namely, carbon values directly influence volume and growth increment in natural forests (Đorem et al. 2024, Caglayan et al. 2025) as well as in plantations, and increase with applied treatments (e.g. thinning) (Ozkan et al. 2025). Therefore, accurate biomass measurements and analyses are not important only for the determination of sequestration rates and carbon stocks, but also for assessing potential impacts due to climate change, locating bio-energy processing plants, and mapping and planning fuel treatments (Temesgen et al. 2015).

In China and worldwide, the most used *Paulownia* species for agroforestry and plantations are *P. tomentosa* (Thunb.) Steud., *P. elongata* S.Y.Hu and *P. fortunei* (Seem.) Hemsl. and their associated hybrids (Jensen 2016). In addition to the introduced species, some countries have bred their own hybrids, resulting in numerous *Paulownia* clones such as In Vitro 112 (*P. elongata* × *P. fortunei*), SUN TZU 104 (*P. fortunei* × *P. tormentosa* × *P. elongata*), *P. paulemia* (*P. elongata* × *P. fortunei* × *P. kawakamii*), Cotevisa 2, Suntzu 11, and many others, more or less known (Feria et al. 2013, Zuazo et al. 2013, Bio Tree 2020, In Vitro 2026). All of them were developed for specific environmental conditions in which they can achieve the best results. Additionally, to achieve full potential of the used clone, a proper cultivation technique is necessary, which further depends on the plantation goal. Namely, in case when *Paulownia* is used for timber production, wider spacing should be applied compared to the biomass crops.

Even though the *Paulownia* genus attracted a lot of attention due to its fast growth, and consequently, the opportunity for carbon sequestration, long-term storage in wood products, and the substitution of high-emission materials, its production potential, together with site and management factors, have not been thoroughly investigated (Merriman et al. 2025). Constant development and improvement of *Paulownia* clones, consequently, requires monitoring of the success of newly created clones. Therefore, this study aimed to determine biomass yield of the stem and crown of Croatian domestic *Paulownia* RBTC15 hybrid in the region of Požega-Slavonia County.

MATERIALS AND METHODS

Paulownia RBTC15

Paulownia RBTC15 (Figure 1) is a Croatian domestic clone developed by the Regional Centre for Biotechnological Research and Development of Brod-Posavina County. It has been developed by crossing two *Paulownia* species, *P. elongata* and *P. fortunei* (Anon 2025). The declared height growth rate is 3–5 meters yearly, with up to 20 m height and 30–40 cm in diameter in ages between 7 and 10 years (Anon 2025).



Figure 1 A three-year-old *Paulownia* RBTC15 plantation.

Field Measurements

This research was conducted in Požega-Slavonia County of the Republic of Croatia (45°21'20.4" N, 17°38'33.0" E). Based on the plant ages and spacing, seven fields were chosen to determine the production potential of *Paulownia* RBTC15 clone (Table 1). Research was conducted in two periods; before the growing season (February of 2022) and after the growing season (October of 2022).

Table 1 Data on age, year of planting, year of coppicing and spacing of researched fields.

Field	Year of planting	Year of coppicing	Spacing, m
1	2021	-	4 × 3
2	2020	2021	2 × 2
3	2020	2021	2 × 2
4	2019	2020	4 × 3
5	2019	2020	4 × 4
6	2019	-	3 × 3
7	2018	2019	4 × 3

For each field, in an average area (part of the field with estimated similar tree heights and overall conditions) 30 trees were selected in three rows (10 trees per row) for measurement of diameter at breast height (1.3 m above ground, DBH) using Haglöf calipers with an accuracy of 0.1 cm, and total tree height using Haglöf Vertex hypsometer with an accuracy of 0.1 m. Based on the diameter and height, an average tree was selected for detailed measurement in each field.

The average tree was felled, after which the crown was separated from the stem. The crown started at the height of the first branch since fields were pruned to define size and shape of the crown. The stem gross volume was determined by measuring 1 m long sections (except the last one, which could be maximally 1.5 m long) using Stihl measuring tape, and two mid-length diameters (Figure 2a) using Haglöf calipers. Furthermore, the green mass of the stem and crown was determined in the field using a RADWAG WLC 60/C2/K balance. Additionally, stem and branch samples were taken for further laboratory analyses of basic wood density and moisture content. For the stem, 5 cm wide discs were taken at the stem base, at breast height, each at 1 m length, and at the end of the stem (Figure 2b). In the case of branches, three average branches were sampled. Each disc was measured to determine width, disc diameter, and diameter of hollow pith using a caliper, and to determine mass using a KERN EMB-S balance, after which all samples were packaged and delivered to the Laboratory of Forest Biomass of the University of Zagreb Faculty of Forestry and Wood Technology.

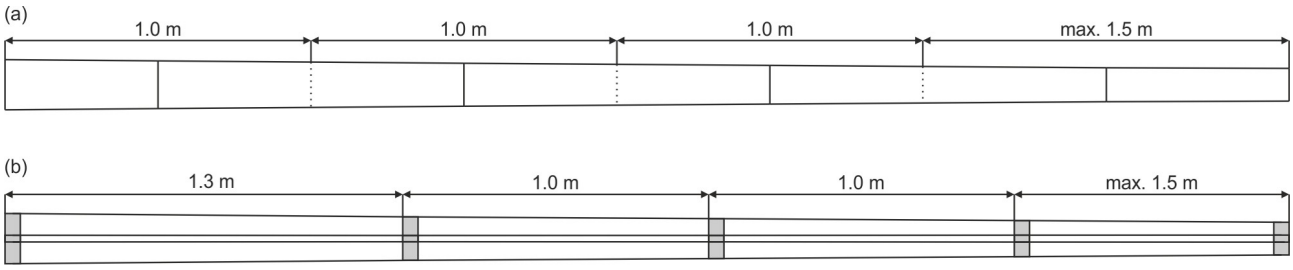


Figure 2 Scheme of: (a) gross volume determination and (b) stem sampling.

Laboratory Analysis

Laboratory analysis entailed a determination of moisture content for samples of stem and crown following HRN EN ISO 18134-2 standard (HRN EN ISO 18134-2:2017 2017). Samples were dried in heating chambers Binder FD 115 and Binder FD 250 (Binder GmbH, Tuttlingen, Germany) at 105 °C until constant mass was reached. Oven-dry mass was recorded using a Kern 440-49A balance (KERN & SOHN GmbH, Balingen-Frommern, Germany).

Data Processing and Statistical Analysis

Data processing and regression analyses were conducted in MS Excel 2412 software, while TIBCO Statistica 14.0.0.15 was employed for statistical analyses. The first data set was created based on measurements of DBH and height for 30 trees per field, after which an average tree DBH and height were calculated. The same procedure was applied for both conducted measurements in February and October. Furthermore, this data set was used to describe the DBH and height increment for investigated fields.

The second data set consisted of data collected after detailed measurements conducted on an average tree. Recorded length and mid-length diameters were used to calculate over-bark stem volume using Huber's formula. Recorded diameters of hollow pith were used to calculate hollow pith volume, for which over-bark stem volume was reduced. The same procedure was applied to calculate the volume of sampled discs for basic wood density determination. Oven-dry mass together with the volume of each disc was used to calculate basic wood density (kg/m^3). Determined moisture content in stem and crown discs was used to calculate biomass of each sampled tree, reducing the field-recorded mass by the weighted moisture content calculated based on disc green mass and determined moisture content for each stem and crown.

DBH and height increment were calculated based on the field measurements conducted at the beginning and at the end of the growing season for the average field area (around 30 trees). Additionally, DBH and height increment were calculated by dividing the determined DBH and height by the age of the field. Biomass increment and stem volume increment were calculated based on the field average tree biomass and volume amount at the beginning and at the end of the growing season. Field biomass and stem volume

increment were calculated by multiplying an average tree's biomass and volume increment by the number of planted trees per hectare.

Exponential regression analysis was employed to determine the dependence of biomass quantity on DBH. Statistical *t*-test was used to determine whether DBH and tree height at the level of the field were statistically significantly higher at the end of the growing season. Analysis of variance was used to determine whether DBH and annual height increment are statistically significant and different among the investigated fields and to determine whether moisture content and basic wood density have statistically significant difference between stem and crown, and at the beginning and end of the growing season. For the stem, analysis of variance was additionally used to determine whether basic wood density depends on the height of the sampling point, while Scheffe post-hoc test was used to additionally determine which heights had statistically significant different basic wood density.

RESULTS

As mentioned, an average area with 30 trees planted in three rows (10 trees per row) was selected for measurements, but in some cases, e.g., Field 1, one tree was not tall enough to measure DBH, so only 29 trees were measured. A total of 417 trees were included in this study.

Diameter and Height Increment

The first measurement conducted in February resulted in 208 measured trees of the RBTC15 clone. The lowest average DBH of 3.20 cm, as well as the lowest average tree height of 2.49 m, was found for Field 1 (Table 2), which is the youngest plantation founded in 2021. Table 2 also shows that average DBH and tree height increase with the age of the above- and belowground tree parts. The second measurement conducted in October resulted in 209 measured trees (Table 3).

Table 2 Descriptive statistics of measured DBH and tree height in February.

Field	N	DBH, cm				Tree height, m			
		Mean	Minimum	Maximum	SD	Mean	Minimum	Maximum	SD
1	29	3.20	1.40	4.45	0.78	2.49	1.50	3.40	0.49
2	30	3.91	0.70	5.75	1.39	3.35	1.30	4.60	1.01
3	30	6.51	4.60	8.25	0.84	5.49	4.20	6.10	0.42
4	30	7.95	2.35	11.10	2.49	5.86	2.00	7.90	1.49
5	30	10.40	4.40	12.95	1.96	6.50	2.90	8.50	1.49
6	30	13.25	10.00	14.60	1.04	9.78	8.60	10.60	0.53
7	29	14.50	11.00	16.10	1.31	10.52	8.50	11.60	0.65

Table 3 Descriptive statistics of measured DBH and tree height in October.

Field	N	DBH, cm				Tree height, m			
		Mean	Minimum	Maximum	SD	Mean	Minimum	Maximum	SD
1	30	6.41	3.90	9.05	1.43	5.34	3.20	6.80	0.95
2	30	4.95	2.25	6.30	1.05	4.37	2.40	5.70	0.95
3	30	8.54	6.70	10.10	0.97	8.00	7.00	8.90	0.46
4	29	9.85	6.05	13.55	2.26	7.06	5.40	8.50	0.90
5	30	14.14	9.25	17.55	2.25	8.26	4.30	10.60	1.75
6	30	15.22	11.50	16.80	1.18	11.94	10.40	13.70	0.91
7	30	16.30	12.65	18.15	1.37	11.92	9.70	13.20	0.84

In absolute values, Field 1 showed the highest DBH and height increment (Figure 3a) compared to Fields 2 and 3, which had the same age of aboveground parts, but also in comparison to other fields. Regardless of the same management practice (year of planting, coppicing, and spacing) for Field 2 and Field 3, notably lower DBH and height increment were observed for Field 2, indicating a possible stronger influence of environmental conditions, which were not part of this research. Since both non-coppiced fields (Field 1 and Field 6) showed a higher DBH and height increment compared to coppiced fields (Field 2, Field 3, and Field 7), a negative influence of coppicing in the investigated conditions can be observed (Figure 3). Fields 4 and 5 were founded and coppiced in the same year, but different spacing probably influenced a higher DBH and height increment in Field 5 (4×4) compared to Field 4 (4×3). Further, statistical t-test showed that all investigated fields had statistically significantly higher DBH and height after the end of the growing season (Table A1 and A2).

On the other hand, the calculated average annual DBH and height increment for the period between the plantation was founded and after the second measurement was conducted, revealed a different trend compared to the growing season of 2022 (Figure 3a). Namely, Field 5 had the highest annual DBH increment, while Field 3 had the highest annual height increment. Furthermore, oldest fields had higher DBH increments compared to the youngest fields, which is opposite to the growing season of 2022. Analysis of variance

(Table 4) showed that DBH and annual height increment were statistically different between the investigated fields (Figure 3b), and that Field 5 had statistically different DBH increment compared to the other fields (except for Field 3), as well as that Field 3 had statistically different height increment compared to the other fields.

Table 4 Analysis of variance for tree height and DBH increment among researched fields.

Variable	SS Effect	df Effect	MS Effect	SS Error	df Error	MS Error	F	p
Height increment	62.43931	6	10.40655	29.81603	202	0.147604	70.50313	< 0.01
DBH increment	102.5198	6	17.08663	67.91733	202	0.336224	50.81912	< 0.01

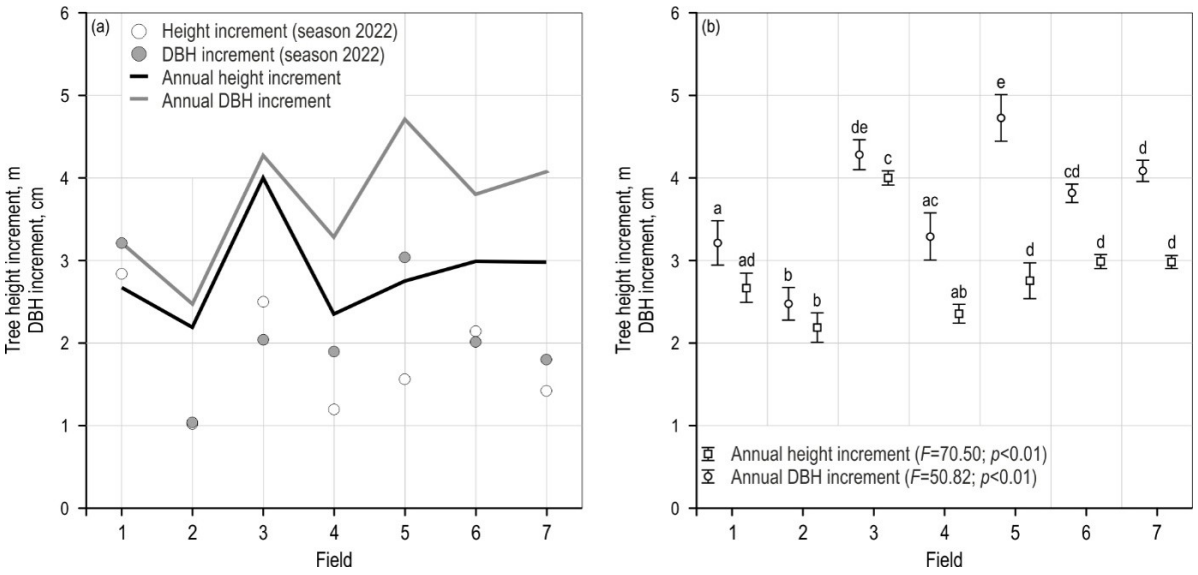


Figure 3 (a) DBH and height growth rate of the investigated *Paulownia* RBTC15 clone; (b) analysis of variance for DBH and height increment between researched fields.

Biomass Production

Researched aboveground biomass consists of the stem and the crown. In total, 14 trees were felled and measured to determine aboveground biomass. Figure 4 shows a regression analysis of the aboveground biomass dependence on DBH. Regression analysis was conducted for both measurements together, which explains over 95% of the variability (Figure 4), and therefore it is suitable to predict tree biomass based on DBH.

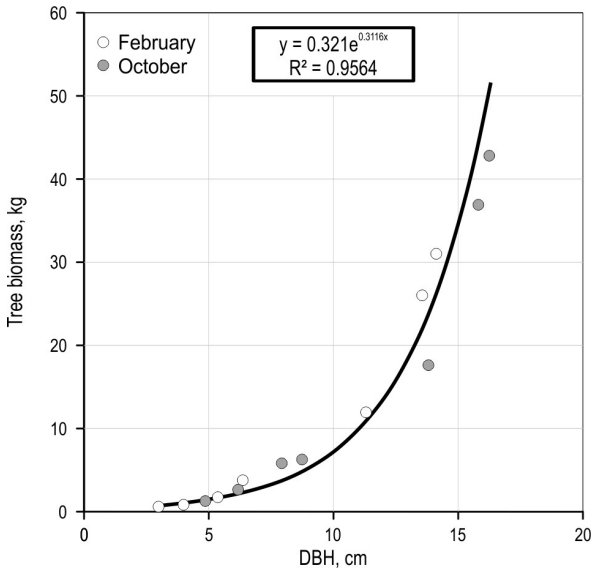


Figure 4 Regression analysis of biomass quantity.

Figure 5 shows the mass ratio between the stem and the crown in total measured aboveground biomass, together with the percentage increment of stem and crown biomass. The increment of stem and crown biomass during one growing season ranged from 38.77% for the oldest plants (Field 7) to a remarkably high 417.10% for one of the youngest plants (Field 1). High biomass increment on Field 1 can be explained by DBH and height growth rate, but also by creating a crown during the growing season. Namely, in February, plants on Field 1 consisted only of the stem without side branches, while at the end of the growing season, 26.66% of the aboveground biomass was measured as crown. Furthermore, a low share of crown biomass was observed also for Fields 2, 3, and 4 at the beginning of the season (between 3.45% and 4.41%), while at the end of the growing season this trend had changed, especially for Field 4, where the share of crown increased to 26.50%. Older plants (Fields 6 and 7) seem to maintain quite a similar ratio between the stem and the crown. This trend can be explained by the absence of pruning of older plants.

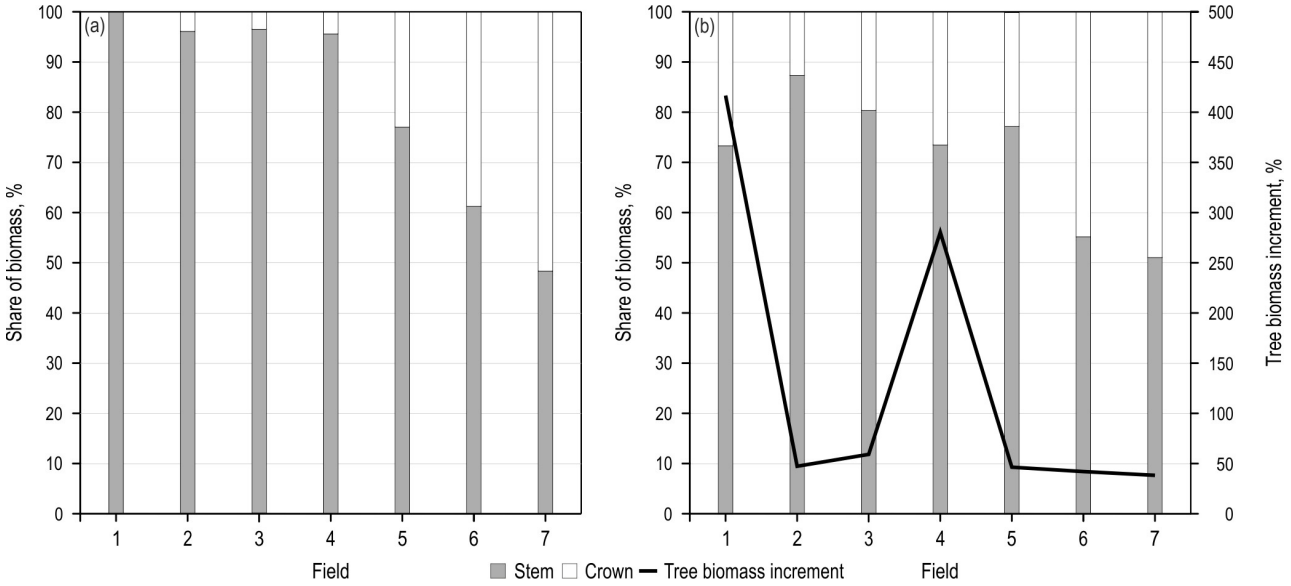


Figure 5 Aboveground biomass of *Paulownia* RBTC15 clone: (a) in February; (b) in October.

In calculation of biomass production at the field level, the spacing between plants seems to have a crucial role. Namely, Figure 6 shows annual biomass increment at the tree level (kg), and biomass increment at the field level expressed as oven-dry tons per hectare. Field 1 and Field 3 had a similar biomass increment at the tree level (2.1 and 2.2 kg/tree, respectively), but field biomass increment in Field 3 was 3.14 times higher than in Field 1. A similar trend was also observed between Fields 4 and 5, where Field 5 had higher biomass increment at the tree level, but due to the wider spacing Field 5 had slightly lower biomass increment (by 0.39 t/ha) than Field 4. Furthermore, the same trend was observed for Fields 6 and 7, where biomass increment was the highest, at 12.29 t/ha and 9.98 t/ha, respectively.

Moisture Content and Basic Wood Density

Moisture content of stem wood was statistically significant higher ($F = 18.55$; $p = <0.05$) compared to the moisture content of the crown wood for both conducted measurements (Figure 7). Furthermore, the stem wood contained higher moisture content in February (63.89% ± 5.56%) than in October (61.52% ± 3.22%), while the moisture content of the crown wood was higher in October (57.51 ± 4.26%) than in February (53.75 ± 3.24%).

Basic wood density of the crown wood was statistically significantly higher ($F = 46.76$; $p = <0.05$) compared to the basic wood density of the stem wood for both conducted measurements. Generally, wood basic density of the stem wood was between 261.38 kg/m³ ± 23.15 kg/m³ in October and 264.58 kg/m³ ± 27.93 kg/m³ in February (Figure 8a). Furthermore, the crown wood also had a higher basic wood density in February (328.19 kg/m³ ± 26.14 kg/m³) than in October (322.51 kg/m³ ± 23.83 kg/m³).

In addition, basic wood density was tested to determine whether it depends on the aboveground distance. Figure 8b shows that basic wood density decreases from the stem base to 1.3 m above the ground, then increases toward the crown. Furthermore, analysis of variance shows that basic wood density is statistically significantly different along the stem ($F = 3.20$; $p = 0.02$), while Scheffe post hoc test showed

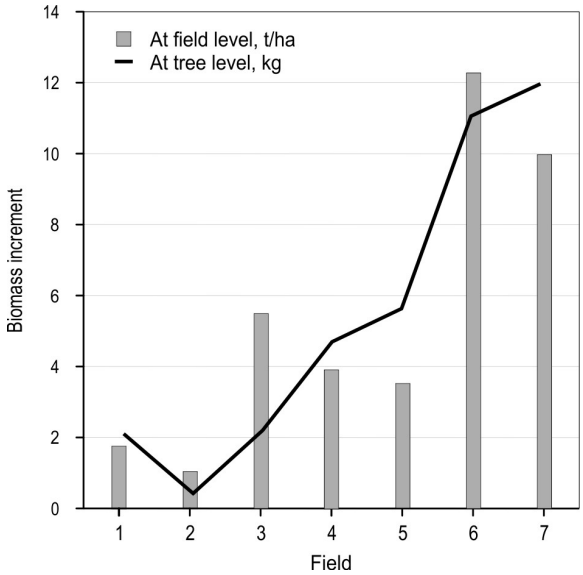


Figure 6 Determined biomass increment.

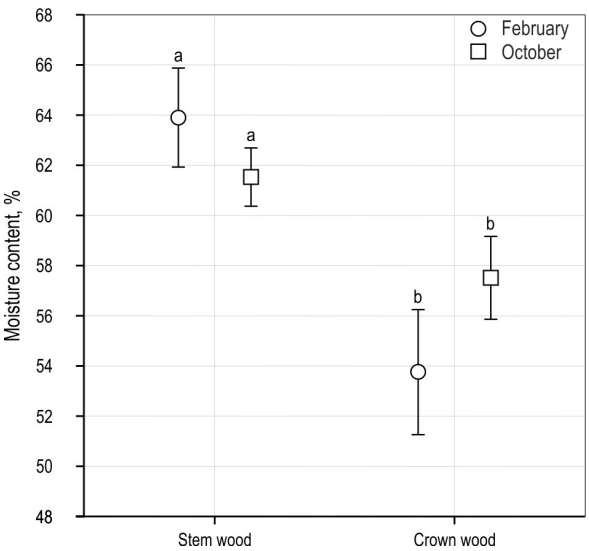


Figure 7 Analysis of variance – moisture content (vertical bars denote 95% interval of confidence).

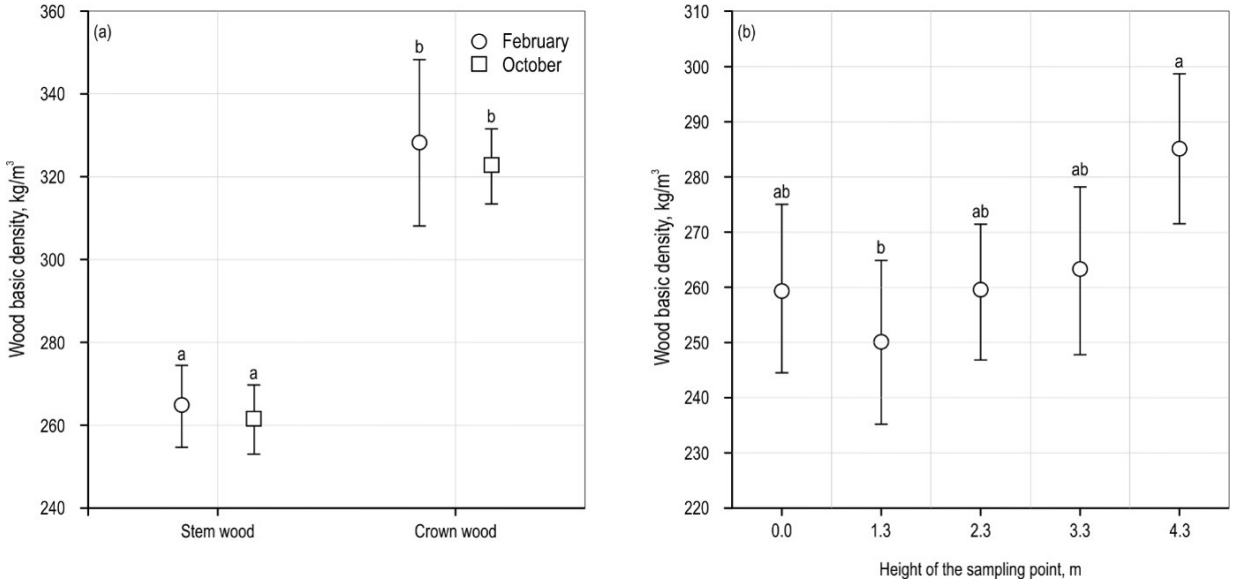


Figure 8 Analysis of variance of statistically significant differences in wood basic density: (a) between stem wood and crown wood; (b) of stem wood along the height of the sampling point (vertical bars denote 95% interval of confidence).

that it is significantly different only between 1.3 m and 4.3 m above the ground (Table A3).

Stem Properties

When plantation is used for timber production, stem volume is one of the most important parameters since it presents a merchantable volume. In this study, a geometric volume was presented to avoid the influence of the hollow pith. Figure 9a shows the regression analysis of the determined stem volume along DBH. For both measurements conducted in February and October, coefficient of determination was over 0.96. When volume increment is observed at the level of one tree, it is obvious that it increases following DBH. On the other hand, at the field level when the number of trees is included, volume increase of the field strongly depends on it. Namely, Figure 9b shows that even trees in Field 3 had 3.44 times lower volume increment compared to Field 7, including that the number of trees in calculation of volume increment in Field 7 was only 14.46% higher compared to Field 3. Field 6 had higher biomass increment then Field 7 (Figure 6), but Field 7 had higher volume increment. This trend is caused by the distribution of aboveground biomass. Namely, trees in Field 6 at the beginning the growing season had slightly over 60% of stem in total above ground biomass, while at the end of the growing season the share of crown increased up to almost 45% (Figure 5). At the same time, in Field 7 the share of stem biomass was maintained almost the same (a slight increase of 2.37% was determined) (Figure 5), resulting in a higher volume increase of stem in Field 7 compared to Field 6 (Figure 9b).

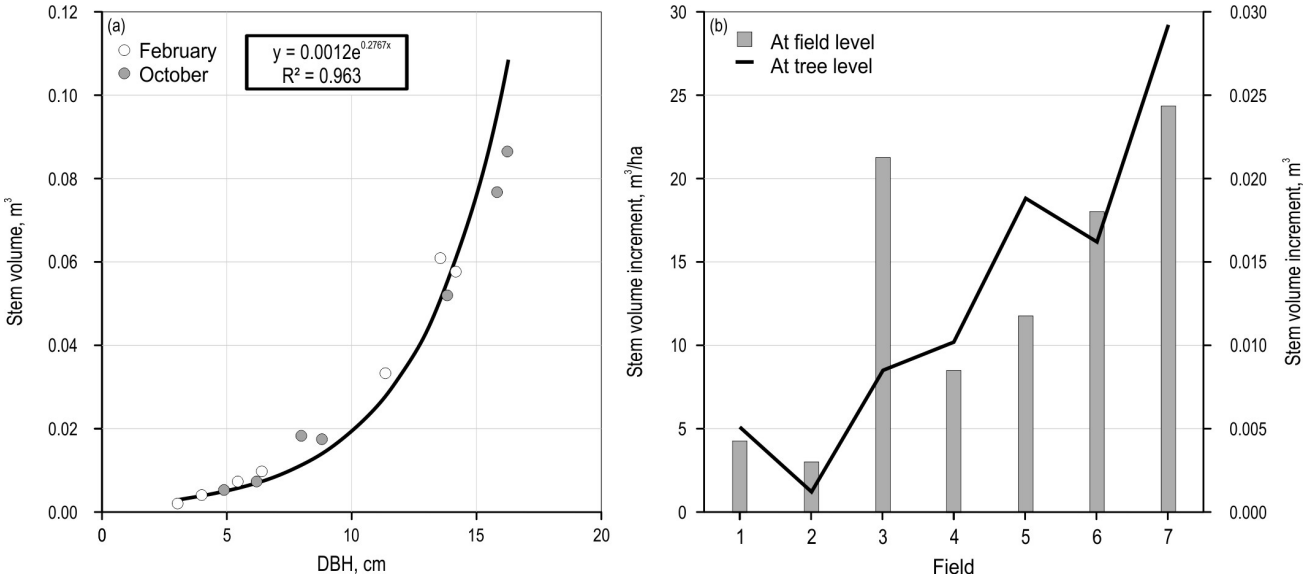


Figure 9 Determined volume: (a) regression equations; (b) increment at the field and tree level.

DISCUSSION

The aim of this research was to determine the production potential of Croatian domestic *Paulownia* RBTC15 clone. It was driven by lack of knowledge about the production potential of the clone since this is the first research on this topic. The presented study offers a valuable insight into biomass and volume increment as well as into basic wood density and moisture content of the researched stems and crowns. Due to the several limitations of this study, it presents a starting point for future research. Namely, this research helps to determine biomass and volume increment only up to four-year-old plants, which is not sufficient to determine a merchantable volume due to the small diameters of measured plants. Finally, the analysis of the soil was not conducted, which could provide important data for a better understanding of the *Paulownia* RBTC15 clone production potential.

Depending on the growing conditions, *Paulownia* could reach an imposing annual DBH and height increment. For example, in China there are example of 19 years old *P. elongata* that has DBH of 104 cm, height of 17.1 m and volume of 4.81 m^3 (Zhu et al. 1986), while in New Zealand for clone *P. elongata* "197" annual DBH increment ranged between 3.8 and 7.6 cm (Barton et al. 2007). Other studies reported an annual DBH increment of *P. elongata* × *P. fortunei* hybrids in range between 4.2 cm and 8.1 cm (Criscuoli et al. 2022, Fos et al. 2023). The results of this study reveal a lower DBH increment on the level of all investigated fields (3.6 cm), but also a wide range in annual DBH increments between fields of the same age, which is potentially the result of different growing conditions. This can be observed especially for Fields 2 and 3, where the same management treatment was applied, but probably due to different environmental conditions, it resulted in 1.55 cm lower DBH increment in Field 2 compared to Field 3. Furthermore, variation in annual DBH increments between the investigated fields could be justified by the fact that *Paulownia* has a very rapid radial growth in the first years, which stabilizes after the fifth year (Fos et al. 2023). Declared height increment for RBTC15 clone is 3–5 m yearly (Anon 2025), which is much higher than the determined 2–3.76 m increment.

In term of biomass and volume production rate, it significantly depends on spacing when it is expressed in t/ha. Furthermore, it is reported that stem biomass production strongly depends on irrigation dose and fertilization, which could increase biomass production up to 2.36 t/ha (García-Morote et al. 2014). Literature review reveals a wide range of applied spacings which, among other things, consequently resulted in a wide range of biomass and volume production reports (Zuazo et al. 2013, García-Morote et al. 2014, Jakubowski 2022, Merriman et al. 2025). The results of this study strongly support this thesis. For example, trees in Fields 1 and 3 had very similar biomass increment at the tree level (2.1 kg and 2.2 kg per tree, respectively), but Field 3 resulted in 3.14 times larger biomass increment at the field level due to smaller spacing.

The results of this research regarding moisture content and basic density suggest that moisture content decreases from the bottom to the tree crown while basic density increases. The same trend has been previously reported (Nezu et al. 2026). Furthermore, previously reported moisture content in *Paulownia* stem ranged between 58.2% and 64.9% (Berdón Berdón et al. 2017, Vusić et al. 2018, Nezu et al. 2026), supporting the results of this study.

Regarding the *Paulownia* wood density, it is considered that with a 12% moisture content it oscillates around 270 kg/m^3 (Jakubowski 2022), while basic density (0% of moisture content) ranged between 242 kg/m^3 and 272 kg/m^3 (Akvildiz and Kol 2010, Kiaei 2013, Nezu et al. 2026). This supports the findings of this study for both conducted measurements. On the other hand, declared basic density for RBTC15 clone is in range between 280 and 320 kg/m^3, which is slightly higher than the values determined in this research.

CONCLUSIONS

This research presents the results on the production potential of Paulownia RBTC15 clone in Požega-Slavonia County. Determined DBH and height increment of Paulownia RBTC15 clone correspond with previously reported results of other Paulownia clones.

The biomass quantity equations provide preliminary estimates of Paulownia RBTC15 potential biomass production, which are essential for determining the current state as well as the possibilities for improving both the clone and the management practices in the future.

Due to several limitations of this study, further research is necessary to clarify high variability between fields managed under the same conditions, but also to determine the quality of merchantable timber volume.

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APPENDIX

Table A1 t-test parameters of statistically significant differences in DBH before and after the growing season.

Field	Average DBH G1	Average DBH G2	t-value	df	p	N G1	N G2	SD G1	SD G2	F-ratio variances	p variances	Mean G1 - Mean G2	Confidence 95%	Confidence +95%
1	3.20	6.41	-10.65	57	<0.01	29	30	0.78	1.43	3.35	<0.01	-3.21	-3.82	-2.61
2	3.91	4.95	-3.25	58	<0.01	30	30	1.39	1.05	1.74	0.14	-1.04	-1.67	-0.40
3	6.51	8.54	-8.66	58	<0.01	30	30	0.84	0.97	1.34	0.44	-2.03	-2.49	-1.56
4	7.95	9.85	-3.06	57	<0.01	30	29	2.49	2.26	1.22	0.60	-1.90	-3.14	-0.65
5	10.40	14.14	-6.86	58	<0.01	30	30	1.96	2.25	1.32	0.46	-3.74	-4.83	-2.65
6	13.25	15.22	-6.86	58	<0.01	30	30	1.04	1.18	1.30	0.48	-1.97	-2.54	-1.39
7	14.50	16.30	-5.14	57	<0.01	29	30	1.31	1.37	1.09	0.82	-1.80	-2.50	-1.10

G1 – measurement conducted in February, G2 – measurement conducted in October, DBH – diameter at breast height.

Table A2 t-test parameters of statistically significant differences in tree height before and after the growing season.

Field	Average TH G1	Average TH G2	t-value	df	p	N G1	N G2	SD G1	SD G2	F-ratio variances	p variances	Mean G1 - Mean G2	Confidence 95%	Confidence +95%
1	2.49	5.34	-14.40	57	<0.01	29	30	0.49	0.95	3.70	<0.01	-2.85	-3.25	-2.45
2	3.35	4.37	-4.02	58	<0.01	30	30	1.01	0.95	1.12	0.76	-1.02	-1.53	-0.51
3	5.49	8.00	-21.94	58	<0.01	30	30	0.42	0.46	1.20	0.63	-2.51	-2.74	-2.28
4	5.86	7.06	-3.70	57	<0.01	30	29	1.49	0.90	2.75	0.01	-1.20	-1.84	-0.55
5	6.50	8.26	-4.20	58	<0.01	30	30	1.49	1.75	1.37	0.40	-1.76	-2.60	-0.92
6	9.78	11.94	-11.24	58	<0.01	30	30	0.53	0.91	3.01	<0.01	-2.16	-2.55	-1.78
7	10.52	11.92	-7.14	57	<0.01	29	30	0.65	0.84	1.66	0.19	-1.40	-1.80	-1.01

G1 – measurement conducted in February, G2 – measurement conducted in October, TH – tree height

Table A3 Scheffe post-hoc test of significance difference in basic wood density between different heights.

Sampling height	0	1.3	2.3	3.3	4.3
0		0.8739	1.0000	0.9984	0.1854
1.3	0.8739		0.8996	0.7562	0.0229
2.3	1.0000	0.8996		0.9966	0.1648
3.3	0.9984	0.7562	0.9966		0.3618
4.3	0.1854	0.0229	0.1648	0.3618	

Table A4 Data about average tree DBH and height for measured fields.

Field	Date of measurement	Average height, m	Average DBH, cm	Equation	Coefficient of determination
1	February	2.5 ± 0.5	3.2 ± 0.8	TH = 1.1018 × DBH0.7031	0.8914
	October	5.3 ± 0.9	6.4 ± 1.4	TH = 1.2428 × DBH0.7859	0.9261
2	February	3.4 ± 1.0	3.9 ± 1.4	TH = 1.2919 × DBH0.7058	0.9454
	October	4.4 ± 1.0	4.9 ± 1.1	TH = 0.9756 × DBH0.9366	0.8808
3	February	5.5 ± 0.4	6.5 ± 0.8	TH = 1.9678 × DBH0.5484	0.8006
	October	8.0 ± 0.5	8.5 ± 1.0	TH = 3.5139 × DBH0.3840	0.5617
4	February	5.9 ± 1.5	8.0 ± 2.5	TH = 1.1297 × DBH0.7985	0.9454
	October	7.1 ± 0.9	9.8 ± 2.3	TH = 2.6168 × DBH0.4353	0.6122
5	February	6.7 ± 1.5	11.1 ± 2.0	TH = 1.1129 × DBH0.7476	0.4643
	October	8.3 ± 1.7	14.1 ± 2.3	TH = 2.0344 × DBH0.5216	0.1189
6	February	9.8 ± 0.5	13.2 ± 1.0	TH = 3.1692 × DBH0.4361	0.4284
	October	11.9 ± 0.9	15.2 ± 1.2	TH = 6.5896 × DBH0.2177	0.0596
7	February	10.5 ± 0.7	14.5 ± 1.3	TH = 2.4785 × DBH0.5406	0.6447
	October	11.9 ± 0.8	16.3 ± 1.4	TH = 1.8873 × DBH0.6603	0.6469

TH – tree height, DBH – diameter at breast height