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Testing the Production Potential of Paulownia Clon In Vitro 112® in the Czech Republic

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Abstract: Paulownia is a deciduous fast-growing tree with intensive sprouting ability and is well adapted to various climatic and soil conditions. Its native area extends from the middle to the lower section of the Yangtze River. The aim of our research was to test the potential of Paulownia Clon in vitro 112® for production of saw timber in the conditions of the Czech Republic. In 2016, three private plantations were established—Střelice, Vlčatín and Vorel. The parameters that were measured were the total height, the height of the live above-ground part of each plant after the winter, the stem thickness at 10 cm above the ground, and the stem thickness at breast height. The measurements were taken from 2016 to 2021. At all plantations, the plants achieved very small mean annual increments in height (under 1 m) and thickness (under 1 cm). On average, 39% of the upper above-ground part of each plant was damaged by frost each winter and the cumulative mortality was 28% to 53%.

Keywords: ligniculture; fast-growing species; height; thickness; increment; mortality; frost damage; Central Europe; Eastern Europe

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1. Introduction

Paulownia is a fast-growing deciduous tree [1]. The native area of *Paulownia* spp. Siebold & Zucc. extends from the middle to the lower section of the Yangtze River [2]. Currently, Paulownia grows on all continents except Antarctica—as a decorative tree in parks and gardens, or as a source of wood in plantations and stands [3].

Paulownia spp. is a genus that is characterized by extremely fast growth, intensive sprouting ability and good adaptability to different climatic and soil conditions. One-year-old plants have an average height of 4 m, but some plants can reach a height of over 6 m [2]. According to Oxytree [4], six-year-old plants should reach up to a height of 18 m, and their average stem thickness should exceed 30 cm. In 2013, UCLM [5] published a report in which they describe the growth characteristics of six-year-old plants, where the average stem thickness was 30 cm, the height was 16 m and the volume of the saw timber was 0.5 m^3. Del Cerro-Barja [6] stated an average stem thickness of 30–40 cm and a volume of the saw timber of 0.3–0.5 m^3 from a 10-year-old plant. Zhao-Hua et al. [2] show that, under optimal conditions, 10-year-old plants can have a volume of 4.0–4.5 m^3 and an annual stem thickness increment of up to 4 cm per year.

In the past 20 years, there has been a massive promotion of *Paulownia* spp. as a renewable source of saw timber and chips. *Paulownia tomentosa* is considered an invasive species in many countries of the world [7,8] and was described as a species with a potentially high environmental risk in the CR [9]. Also, the law in the CR only allows for the establishment of plantations on agricultural land with the State Administration's approval [10]. However, owners usually establish small Paulownia plantations in their gardens and orchards, where approval is not required, and with plant hybrids, which sellers declare as non-invasive and as having a high production potential [10–14].

Paulownia species are classified according to the level of cultivation as: wild, semi-wild (also "naturally crossed species") and art (also "artificially crossed hybrid", hereinafter referred to as "hybrid") [15]. However, only hybrids are the most suitable for cultivation in plantations. They have been cultivated in China since the 1980s [15,16]. Breeders have been trying to breed (via crossing and artificial selection) a strong and resistant hybrid with a wide ecological valence and a high yield of quality wood [15–17]. At present, there are dozens of hybrids on the market, which are cultivated for different climatic conditions, from the first hybrids C020, C125 and PH01 to the newly cultivated hybrids, for example: Paulownia Biomass, P. Oxi, P. Shan Tong, P. Bellissia®, P. Paulemia®, P. Shan Dong, P. Cotevisa 2® and P. Clon in vitro 112®.

The Paulownia Clon in vitro 112® hybrid was cultivated in 2003 [1] as a non-invasive [18] hybrid of *Paulownia elongata* and *P. fortunei* [19]. After achieving the required quality, these individuals were reproduced using the vegetative method in vitro [20]. The clone was cultivated in the laboratory of the company IN VITRO S.L. (Barcelona, Spain). Researchers from the University of Castilla-La Mancha tested the adaptability of the growth characteristics to various types of soil [6]. The World Intellectual Property Organization has assigned the trademark application number 1181727 to this hybrid, expiring on 25th September 2023 [21]. Paulownia Clon in vitro 112® was cultivated for semi-arid climatic conditions [22] but, according to Bikfalvi [10], it is highly adaptable to local climatic conditions. This clone tolerates a temperature range of −25 to +40 °C [23]. Breeders from the Department of Forestry and Genetics at the University of Castilla-La Mancha consider this clone to be one of the most valuable paulownia varieties in terms of utility [24].

The Czech Republic (CR) is, according to maps based on the USDA Hardiness Zone Map [25], located in the 7th zone, which stretches from the south-eastern part of Germany, the foothills of the Alps, throughout the CR, Slovakia (except the Tatra Mountains), almost all of Poland and the eastern part of Hungary, up to the southern Balkans (in the south) and the Baltic states (in the north). According to the Köppen Climate Classification Map [26], the CR is located in the Dfb zone, which extends from eastern Germany, throughout Austria, the CR, Slovakia, Hungary and Romania to the upper part of the southern Balkans (in the south), the southern part of Scandinavia (in the north) and across the Baltic states, Belarus and Ukraine to the south-western part of Russia.

In 2016, three plantations were established in the Czech Republic, where the P. Clon in vitro 112® was intended as a source for saw timber. The measurements were taken in the period 2016–2021. Its aim was: (1) to evaluate the production potential of P. Clon in vitro 112® in the conditions of the Czech Republic and, also, due to similar climatic conditions, in central and eastern parts of Europe; and (2) to present verified data on the growth of P. Clon in vitro 112®, which there are few of to date.

2. Materials and Methods

2.1. Description of Research Plots

The plants of Paulownia Clon in vitro 112® were planted at three plantations in 2016.

2.1.1. Střelice

This plantation, with an area of 5.2 ha and an altitude in the range 320–350 m a.s.l, is situated near Střelice (49°09′13.9″ N; 16°28′21.1″ E) and was divided into two fenced plots (300 m apart). This area has been farmed in the past and, according to the pedological survey, there is Cambisol luvic soil [27]. In 2016, a total of 1523 plants were planted in holes 30 cm in diameter and 80 cm deep, with 4 m × 4 m spacing. The mean air temperatures and precipitation, obtained from the weather station in Troubsko (49°10′16.5″ N; 16°30′09.1″ E) during 2016–2020, are entered in Table 1 [28].

Table 1. The mean monthly air temperatures and precipitation in Střelice, Vlčatín and Vorel.

							Temperature						
		I.	**II.**	**III.**	**IV.**	**V.**	**VI.**	**VII.**	**VIII.**	**IX.**	**X.**	**XI.**	**XII.**
Vorel	2016	−2.5	2.5	2.7	7.0	12.9	16.9	18.2	16.4	15.0	6.9	1.8	−1.6
	2017	−6.5	0.1	5.4	6.2	13.5	17.7	17.9	18.7	11.3	8.7	3.0	−0.1
	2018	0.5	−4.5	0.0	12.5	16.3	17.2	19.5	20.7	14.0	9.6	4.0	−0.3
	2019	−3.1	0.5	4.7	9.1	10.3	20.2	18.2	19.0	12.6	8.6	5.2	0.6
	2020	−1.4	2.7	3.4	8.4	10.5	16.1	17.0	18.4	13.2	8.4	3.1	0.8
Střelice	2016	−1.3	4.4	4.9	9.0	14.9	18.8	20.1	18.2	17.0	8.7	3.6	−0.5
	2017	−5.5	1.3	7.4	8.4	15.2	20.1	20.4	20.8	13.2	10.1	4.6	1.6
	2018	1.9	−2.0	2.1	14.1	18.0	19.6	21.5	22.8	16.0	11.1	5.6	1.5
	2019	−0.9	2.4	6.7	11.1	12.2	22.0	20.3	20.8	14.6	9.9	6.8	2.0
	2020	−0.2	4.6	5.3	9.9	12.6	18.0	19.2	20.6	15.0	10.1	4.5	2.4
Vlčatín	2016	−2.0	3.3	3.5	7.8	13.9	18.2	19.6	17.4	15.8	7.4	2.4	−1.0
	2017	−6.1	0.6	6.0	7.0	14.6	19.3	19.5	19.6	11.9	9.2	3.6	0.4
	2018	1.3	−3.5	0.9	13.0	17.1	18.2	20.2	21.3	14.2	9.8	4.3	0.3
	2019	−2.1	1.1	5.2	9.4	11.0	21.0	19.2	19.6	13.0	8.6	5.8	0.9
	2020	−0.9	3.3	4.1	8.8	11.2	16.7	18.0	18.9	13.4	8.7	3.4	1.4
							Precipitation						
		I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
Vorel	2016	30.6	72.8	44.4	51.8	83.5	75.7	122.3	30.5	15.5	42.4	35.2	29.0
	2017	36.6	23.3	50.4	62.3	57.4	79.2	114.6	40.6	73.6	84.4	38.4	24.7
	2018	43.7	16.9	21.0	22.3	49.0	61.0	36.6	15.4	91.9	27.4	20.0	53.0
	2019	69.7	25.8	52.4	12.3	117.1	69.0	32.3	69.4	64.4	37.8	49.5	46.0
	2020	23.3	98.2	42.7	20.6	70.7	146.4	100.9	160.2	82.4	96.3	27.3	31.8
Střelice	2016	17.6	64.5	20.3	41.1	17.0	54.7	113.6	46.9	10.7	20.9	20.0	9.3
	2017	19.1	7.8	21.0	30.5	53.2	41.9	82.7	42.2	63.4	36.1	19.0	10.6
	2018	33.4	10.6	12.4	10.7	36.1	35.7	39.7	15.0	86.4	14.3	22.7	25.8
	2019	23.0	17.2	26.5	16.9	78.1	65.4	62.6	55.9	72.6	31.5	40.1	42.9
	2020	8.5	27.1	25.7	20.3	67.3	87.2	58.9	105.9	81.6	130.1	23.4	36.8
Vlčatín	2016	25.0	42.0	29.7	39.8	42.1	39.7	97.6	21.0	15.4	33.7	29.9	29.9
	2017	26.2	14.3	42.3	58.8	26.1	36.7	82.9	38.7	79.7	64.1	42.9	23.6
	2018	43.0	16.8	21.9	24.1	73.5	69.5	30.5	18.5	70.6	34.1	25.2	66.6
	2019	76.6	24.5	52.9	16.2	97.9	85.2	37.2	60.7	86.6	33.8	47.4	43.2
	2020	14.6	65.1	27.2	37.4	71.8	197.8	72.6	150.7	66.9	77.7	31.2	24.5

2.1.2. Vlčatín

This plantation, with an area of 0.08 ha and an altitude of 525 m a.s.l., is situated in Vlčatín (49°18′22.6″ N; 15°57′02.7″ E). This area has also been farmed in the past and, according to the pedological survey, the soil type here is Cambisol gleyic [27]. In 2016, a total of 50 plants were planted in holes 50 cm in diameter and 60 cm deep, with 5 m × 5 m spacing. The mean air temperatures and precipitation, obtained from the weather station in Velké Meziříčí (49°21′04.7″ N; 16°00′41.4″ E) during 2016–2020, are entered in Table 1 [28].

2.1.3. Vorel

This plantation, with an area of 0.48 ha and an altitude in the range 505–525 m a.s.l., is situated on the periphery of Lískovec (49°28′56.5″ N; 16°18′53.7″ E). This area has also been farmed in the past and, according to the pedological survey, the soil type here is Cambisol mollic [27]. In 2016, a total of 135 plants were planted in holes 30 cm in diameter and 40 cm deep, with 4 m × 3 m spacing. The mean air temperatures and precipitation, obtained from the weather station in Bystřice pod Pernštejnem (49°31′25.3″ N; 16°15′40.8″ E) during 2016–2020, are entered in Table 1 [28].

2.2. Description of Planting and Method of Cultivation

The planting material was supplied by Oxytree Solutions s.r.o. The plants had a height of 20 ± 2 cm with a root neck thickness of 5 ± 1 mm (mean ± SE) and the volume of the root ball was 0.2 L. The planting material was watered and then transported in paper boxes.

At the beginning of the second growing season, all trunks were removed, leaving stumps about 5 cm high. After sprouting, the strongest stump shoot was selected, and all others were removed. The main aim of this generally recommended cultivation intervention [1,2,5] is to create a strong root system and, subsequently, to ensure more intensive growth of newly formed plants [2].

Each winter, the top parts of all plants were damaged by frost. Zhao-Hua et al. [2] describe frost damage to the terminal bud and the first two internodes of *Paulownia fortunei* and *P. elongata* as a common phenomenon. The highest newly formed stem shoot of the plants damaged in this way takes over the role of the terminal shoot [29].

2.3. Method of Measurement

The measurement of all plants was conducted from the spring of 2016 to the spring of 2021, where the total height, the height of the live above-ground part of each plant after the winter, the stem thickness (i.e., diameter) at 10 cm above the ground, and the stem thickness at breast height (hereinafter: height, live stem part, D10 and DBH, respectively) were measured. Mortality was also quantified. The height was measured from the base of the trunk to the top of the plant each autumn after the plant stopped growing. Since the top part of the trunk of all plants was extensively damaged each year, the live stem part was measured from the trunk base to the first undamaged bud each spring before the plant sprouted. Both heights were measured using a folding rule. The D10 was measured each autumn. When the live above-ground part of the plant reached more than 1.3 m after the winter, the DBH was measured in the spring. The D10 and DBH were measured from two opposite sides using a digital calliper and, subsequently, were averaged. The mortality of the plants was observed from the time they were planted and recorded each autumn (throughout the vegetation period) and spring (throughout the winter).

2.4. Statistical Analysis

Statistical analysis of the data was performed using TIBCO Statistica® (TIBCO Statistica™, Palo Alto, CA, USA) with a reliability interval of 95%. Normality of the data distribution was examined before the main analysis. The main effects were analysed using ANOVA, after which Fisher's LSD test was applied, in order to identify differences among the main effects and interactions (values of Fisher's LSD test ("p") are always in parentheses in the results or as homogeneous groups in the figures).

3. Results

3.1. Height and Live Stem Part

After the first growing period (Figure 1), the plants grew the tallest in Vorel (78.7 ± 46.5 cm) and the smallest in Střelice (48.1 ± 23.6 cm; p = 0.0068). After the first winter, the live stem parts were the longest in Vorel (45.5 ± 33.4 cm) and the shortest in Střelice (only 10.9 ± 12.3 cm), which means that, on average, ca. 77%, 47% and 42% of the lengths of the trunks froze in Střelice, Vlčatín and Vorel, respectively. After the growing period in 2019, the plants grew the tallest in Vlčatín (217.9 ± 89.7 cm) and the smallest in Vorel (149.2 ± 64.0 cm; $p = 0.0001$). After the 2019/2020 winter, on average, ca. 42% of the lengths of the trunks froze (the most in Střelice: 51%). In the last year of measurement, Vlčatín had the tallest plants (295.0 ± 97.0 cm), then Střelice (237.8 ± 120.7 cm) and Vorel had the smallest (154.0 ± 60.9 cm), where the plants in Vlčatín were statistically significantly different from those in Střelice ($p = 0.0215$) and in Vorel ($p = 0.0001$), and the plants in Střelice from those in Vorel ($p = 0.0008$). After the last winter, on average, ca. 22% and 36% of the lengths of the trunks froze in Střelice and in Vlčatín, respectively.

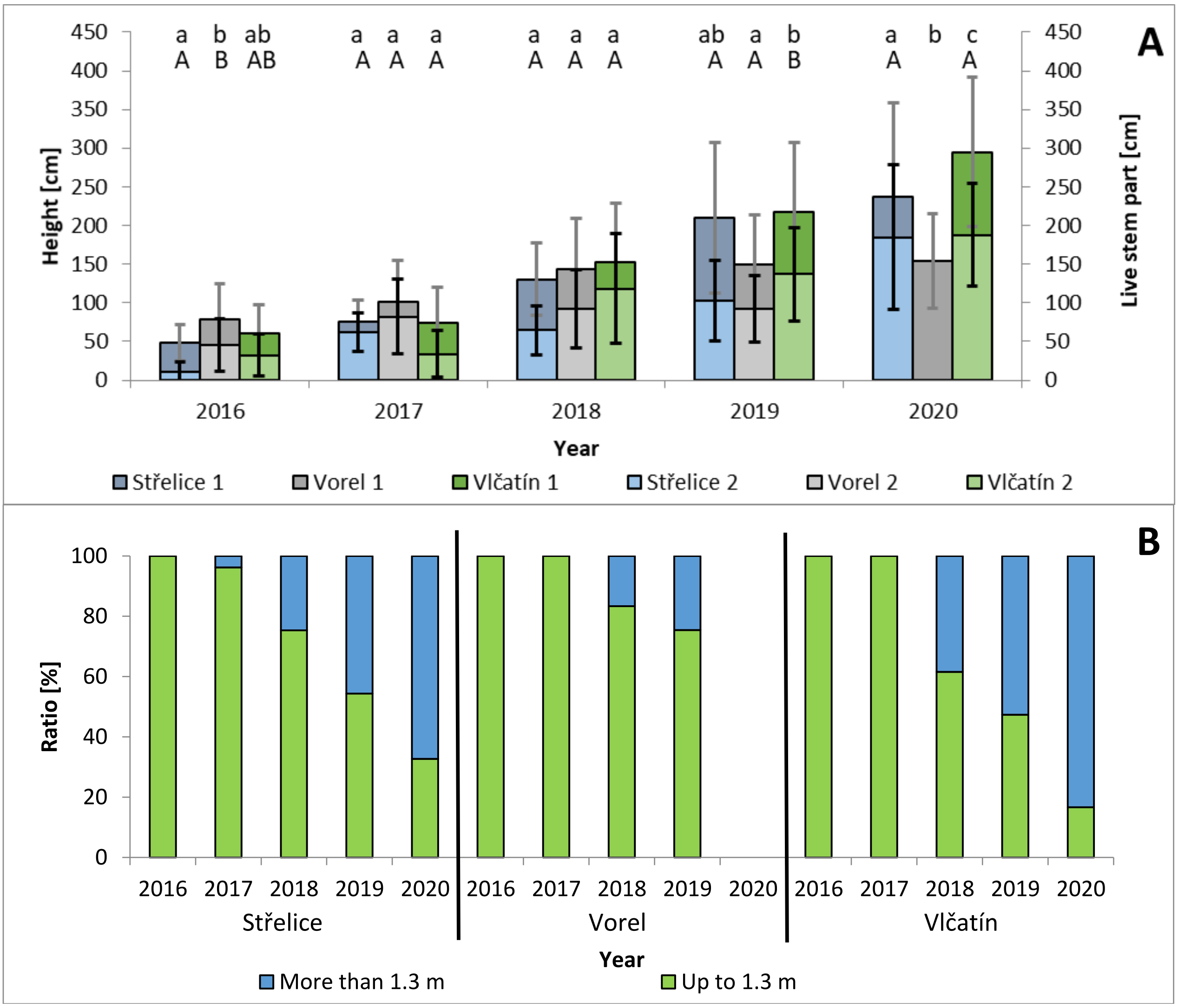

Figure 1. Development of the height and live stem part and the ratio in Střelice, Vlčatín and Vorel: (**A**) Development of the height and live stem part; (**B**) development of the ratio between the plants, which are taller or smaller than 1.3 m. The number 1 following the plantation names (i.e., Střelice 1, Vorel 1 and Vlčatín 1) denotes the heights of the plants and the number 2 (i.e., Střelice 2, Vorel 2 and Vlčatín 2) denotes the live stem part after winter. Small letters denote homogeneous groups among the mean heights of the plants in the plantations (where the reliability interval is 0.95). Capital letters denote homogeneous groups among the mean live parts of stems in the plantations (where the reliability interval is 0.95). Whiskers denote the standard deviations (gray: height and black: live stem part).

The ratio between the plants that were taller than 1.3 m (at breast height) or smaller each spring in the individual plantations show how different the growth is in each individual plantation (Figure 1). The plants in Střelice were the first to grow taller than breast height (3% of all plants at the plantation); this was in the spring of 2018. At this time, the tallest plants in Vlčatín and Vorel reached a maximum of only 1.25 m. In the springs of 2019 and 2020 (corresponding to 2018 and 2019 in the Figure 1), the greatest number of plants that exceeded breast height were in Vlčatín (38% and 53%, respectively) and the least in Vorel (17% and 25%, respectively). In the spring of 2021 (corresponding to 2020 in the Figure 1), 83% of the plants in Vlčatín exceeded breast height compared to only 67% in Střelice.

3.2. D10 and DBH

The D10s of the plants in Střelice, Vlčatín and Vorel were not statistically significantly different in any of the years of measurement, although the thickest plants were in Vlčatín and the thinnest in Střelice throughout the entire experiment (Figure 2). The DBHs of the plants in Střelice were 20.3 ± 3.2 mm and no plants were taller than 1.3 m in the other two plantations (Figure 2). In the last two measurements, the thickest plants were in Vlčatín (31.0 ± 8.8 mm in 2019 and 34.4 ± 12.9 mm in 2020). These plants were statistically significantly different from those in Střelice (p = 0.0478 in 2019 and p = 0.0484 in 2020), which were the second thickest, and from those in Vorel, which were the thinnest (p = 0.0169 in 2019).

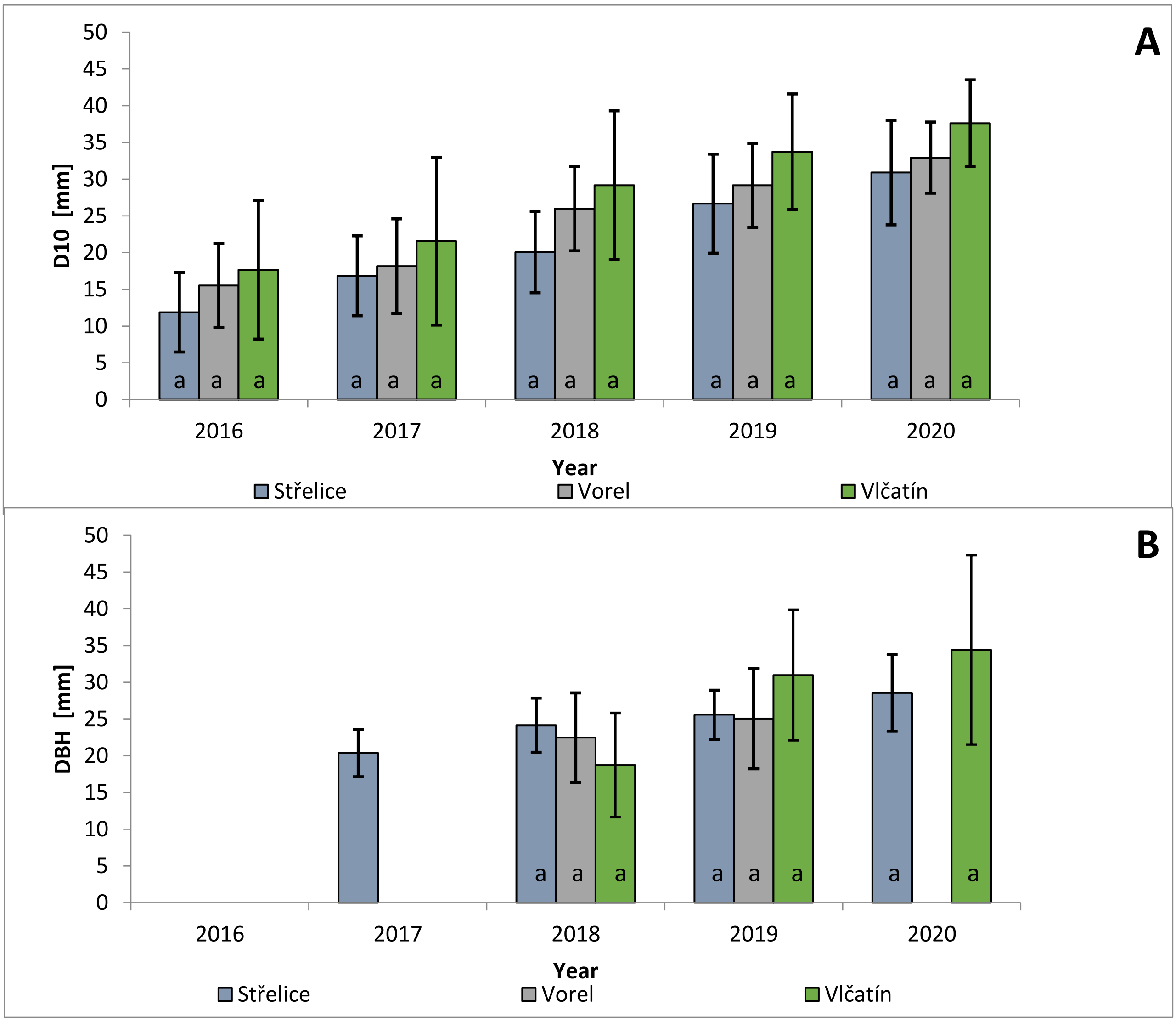

Figure 2. Development of D10 and DBH: (**A**) Development of D10; (**B**) development of DBH. Small letters denote homogeneous groups among the mean D10 and DBH of the plants at the plantations (where the reliability interval is 0.95). Whiskers denote the standard deviations.

3.3. Mortality

The plantation in Vlčatín evinced the lowest cumulative plant mortality (28%) of all plantations (Figure 3). Although mortality was the highest in Vorel (38%) in the spring of 2017, its increase was slower and slower towards the end of the measurements, and it was 53% in the spring of 2021. The plantation in Střelice had a steep rise in mortality, where it was 26% in the spring of 2017 and 43% in the spring of 2021.

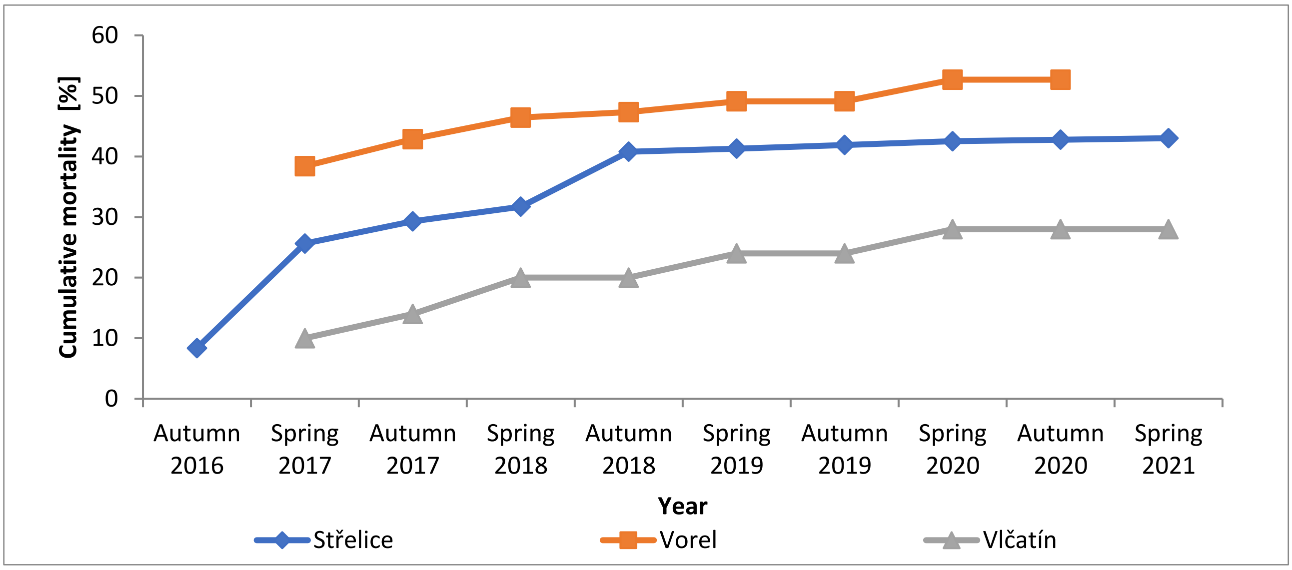

Figure 3. Development of cumulative mortality.

4. Discussion

The hybrid Paulownia Clon in vitro 112® was planted in three research plots in 2016. After the first vegetation period, the mean height was 79 cm in Vorel, 61 cm in Vlčatín and 48.0 cm in Střelice, which is nowhere near the 4 m that Icka et al. [2] measured. The mean height increment was 26 cm in Vorel, 49 cm in Vlčatín and 40 cm in Střelice, which, again, is much less than those stated by UCLM [5] and Oxytree [4] (2.7 and 3 m, respectively). Our mean height increments did not reach even 16% (according to the research plot) of what the above-mentioned sources present. The growth at our research plots was very slow in comparison with promotional information and results from Spain and Albania.

The mean thickness increments at breast height at our research plots were 4 mm in Vorel, 6 mm in Vlčatín and 5 mm in Střelice, which were also much less than that stated by UCLM [5], Oxytree [4], Del Cerro-Barja [6] and Zhao-Hua et al. [2] as being 5 cm, 5 cm, 3–4 cm and 4 cm, respectively.

The frost damage during the winter period was the most significant factor affecting mortality and growth. The lowest annual temperatures in the research areas in individual years, according to CHMI [28], are in Table 2.

Table 2. The lowest annual temperature in °C in the research areas.

	2016	2017	2018	2019	2020
Vorel	−12.2	−12.4	−13.1	−11.1	−4.4
Vlčatín	−10.8	−12.4	−11.8	−8.6	−3.3
Střelice	−9.0	−11.4	−10.2	−6.9	−3.8

Mostly, the lowest temperatures were recorded in Vorel and the highest in Střelice. The air temperature that causes severe damage or death is −20 °C [30] or −25 °C [31]. Icka et al. [1] state that plants are not damaged down to a temperature of −25 °C, which are temperatures that even the coldest areas of our research area did not reach. We, however, recorded frost damage to all trunks in all research plots after every winter. Zhao-Hua et al. [2] describe frost damage to the above-ground part during the winter as a common phenomenon, where it is usually no more than the terminal bud and the first two internodes that are damaged. However, in our case, the damage to the above-ground part was more extensive.

In Střelice during the 2016–2017 winter, on average, about 77% of the trunk was killed by frost. Also, mortality after this winter increased by about 17% (25% in total) in this area. In Vlčatín, more than 46% of the lengths of the trunks were killed by frost each winter, and the mortality always increased by about 10% and 6% after the first two winters. In Vorel, more than 42% of the lengths of the trunks were killed by frost each winter. The total mortality was 38% after the first year and almost 8% after the second. These results do not correspond to the frost resistance reported by the above-mentioned authors.

Another factor that could negatively affect the growth of the plants is the lack of water. The average amount of precipitation (during the existence of the plantations) is in Table 3 [28].

Table 3. The average amount of precipitation in mm in the research areas. The growing period was from May to September, inclusive.

	Vorel	Vlčatín	Střelice
Mean annual precipitation	650	600	480
Mean monthly precipitation (from the annual)	55	50	40
Precipitation during the growing period	390	370	320
Mean monthly precipitation (from the growing period)	65	60	55

There is less precipitation in the research plots than what is necessary for the growth of paulownia according to the data from UCLM [5], who state that the minimum amount is 750 mm, and that by Jabloński [32], who claims that 800 mm is the minimum amount. Zhao Hua et al. [2] reported that paulownia grows in areas with precipitation in the range of 500–3000 mm. In the event of less precipitation, most of the precipitation must fall during the growing period [2,33,34]. This was not evident in our research plots. TGG [33] states that at least 150 mm of monthly precipitation is necessary during the first year. The mean monthly precipitation through the growing period was 55 mm, 60 mm and 65 mm in Střelice, Vlčatín and Vorel, respectively. These values are only about one third of those stated by TGG [33].

Another factor that affected the plant growth was the length of the growing period. *Paulownia* spp. originates at a humid subtropic climate [2], where there are 8 months of mean temperatures higher than 10 °C [35], whereas the climate in the region of our research plots can, on average, offer only 5–6 months of such temperatures—the shorter the growing period, the smaller the plant increment.

5. Conclusions

We observed growth and mortality of Paulownia Clon in vitro 112® in three research plots that were established in 2016. The plants achieved a very small mean annual height increment (under 1 m) and thickness increment (under 1 cm), compared to those in Spain and Albania or those promoted by the seller. Although Paulownia Clon in vitro 112® was cultivated for high adaptability to various climates, and with a higher resistance to frost, its growth here in the CR is slower than in countries with climatic conditions similar to those in the area of origin (i.e., subtropical areas, which have mild winters, hot and humid summers and at least eight months when the mean temperature does not drop below 10 °C). We assume that the values regarding frost resistance given by Barton et al. [30], El-Showk and El-Showk [31] and Icka et al. [1]—all within similar limits—undoubtedly relate to adult plants, because the trunks of our juvenile plants were significantly damaged by frost (on average, 38% of the lengths of the trunks) at temperatures of around −13 °C. There was less precipitation in our research areas than needed by Paulownia, which significantly limited its growth. It is therefore necessary to irrigate the plants until they form a rich root system, via which they can access underground water. This is why, in the conditions of the CR (and, also, presumably of Central and Eastern Europe), the rotation period of Paulownia Clon in vitro 112® will always be longer than expected.

Author Contributions: J.K.—main idea, methodology, work coordination, measurement, writing—origi-nal draft preparation, writing—editing, project administration and funding acquisition. K.N.—methodology, measurement, software, validation, formal analysis, writing—original draft preparation and writing—editing. M.K.—writing—original draft preparation and writing—editing. R.P.—modification of methodology, supervision and funding acquisition. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement: The data are available upon request from the first author.

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References

1. Icka, P.; Damo, R.; Icka, E. Paulownia Tomentosa, a Fast Growing Timber. 2016. Available online: https://www.researchgate.net/publication/309656225_Paulownia_Tomentosa_a_Fast_Growing_Timber (accessed on 23 March 2023).
2. Zhu, Z.-H.; Chao, C.-J.; Lu, X.-Y.; Xiong, Y.G. Paulownia in China: Cultivation and Utilization. 1986. Available online: https://paulowniamp.files.wordpress.com/2010/05/paulownia-in-china.pdf (accessed on 23 March 2023).
3. Hall, B. *Strickberger's Evolution: The Integration of Genes, Organisms and Populations*; Jones and Bartlett Sudbury: Sudbury, MA, USA, 2008; p. 760.
4. Oxytree. Investice Do Budoucnosti! [Investing in the Future!]. 2016. Available online: http://oxytree.cz/co-je-oxytree/ (accessed on 23 March 2023). (In Czech)
5. UCLM. Badanie Warto'sci Gospodarczej Odmian (VCU). Testowanie Clon In Vitro 112. Hibrid *Paulownia Elongata* × *Paulownia Fortunei*. Sprawozdanie Techniczne (Czerwiec 2013). [The Economic Value of Varieties (VCU) Survey. Testing Clon In Vitro 112. Hybrid *Paulownia Elongace* × *Paulownia Fortunei*. Technical Report (June 2013)]. 2013. Available online: http://x-plus.pl/wpcontent/uploads/oxytree-vcu_report-PL.pdf (accessed on 23 March 2023). (In Polish).
6. Cerro-Barja Del, A. Informe del Proyecto de Investigación: "Forestación de Zonas Semiráridas de Castilla-La Mancha noc *Paulownia* spp.". [Information from the Investigation Project: "Forest of Semi-Arid Areas of Castilla-La Mancha noc *Paulownia* spp."]. 2009. Available online: https://invitro.es/wp-content/themes/invitro/downloads/INFORME-FINAL-PAULOW.pdf (accessed on 23 March 2023). (In Spanish)
7. Essl, F. From ornamental to detrimental? The incipient invasion of Central Europe by *Paulownia Tomentosa*. *Preslia* **2007**, *79*, 377–389.
8. Snow, W.A. Ornamental, crop, or invasive? The history of the Empress tree (Paulownia) in the USA. *For. Trees Livelihoods* **2015**, *24*, 85–96. [CrossRef]
9. Pergl, J.; Sádlo, J.; Petrusek, A.; Laštůvka, Z.; Musil, J.; Perglová, I.; Šanda, R.; Šefrová, H.; Šíma, J.; Vohralík, V.; et al. Black, Grey and Watch Lists of alien species in the Czech Republic based on environmental impacts and management strategy. *NeoBiota* **2016**, *28*, 1–37. [CrossRef]
10. Act No. 334/1992 Sb. Zákon České Národní Rady o Ochraně Zemědělského Půdního Fondu [Act of the Czech National Council on the Protection of Agricultural Land Funds]. Available online: https://eagri.cz/public/web/mze/legislativa/pravni-predpisy-mze/tematicky-prehled/Legislativa-MZe_uplna-zneni_zakon-1992-334-ochranaZPF.html (accessed on 3 July 2023). (In Czech)
11. Hybrid Paulownia Tree. 2023. Available online: https://www.ipaulownia.com/en/shop/hybrid-paulownia-tree-cotevisa-2/ (accessed on 3 July 2023).
12. Paulownia. 2023. Available online: https://invitro.es/paulownia-en/ (accessed on 3 July 2023).
13. Are Paulownia Trees Invasive? 2021. Available online: https://www.chinesepaulownia.com/faq/are-paulownia-trees-invasive/ (accessed on 3 July 2023).
14. Paulownia. 2022. Available online: https://www.treeme.com/en/paulownia-en (accessed on 3 July 2023).

15. Mal'ová, M.; Jankovič, J.; Sujová, K.; Longauerová, V.; Mútňáková, M. Paulownia—Potenciál a riziká pestovanie na Slovensku [Paulownia—Potential and risk of its cultivation in Slovakia]. In Proceedings of the Conference: Aktuálne Problémy v Ochrane lesa 2016, Nový Smokovec, Slovakia, 21–22 January 2016; pp. 87–95.
16. Paulownia Slovakia. Dôležité Informácie o Typoch Paulownie. [Important Information about Paulownia Types]. 2022. Available online: https://www.paulownia-slovakia.eu/ekologia/paulownia-v-eu/ (accessed on 20 January 2022).
17. Chinesepaulownia. Species of Paulownia. 2021. Available online: https://www.chinesepaulownia.com/about-chinese-paulownia (accessed on 23 March 2023).
18. Bikfalvi, M. Paulownia—The Intelligent Tree. 2014. Available online: http://www.paulowniagreene.ro/wp-content/uploads/2012/11/Paulownia-Clon-in-Vitro-and-Paulownia-Cotevisa-2-Presentation-EN.pdf (accessed on 23 March 2023).
19. Moreno, J.L.; Bastida, F.; Ondono, S.; García, C.; Andrés-Abellán, M.; Lopez-Serrano, F. Agro-forestry management of *Paulownia* plantations and their impact on soil biological quality: The effects of fertilization and irrigation treatments. *Appl. Soil Ecol.* **2017**, *40*, 46–56. [CrossRef]
20. Paulownia Clon In Vitro 112®. 2021. Available online: https://www.paulownia112.com/#paulownia (accessed on 23 March 2023).
21. Trademarkia. Paulovnia Clon In Vitro 112. 2022. Available online: https://trademark.trademarkia.com/wipo/trademark-1181727.htm (accessed on 23 March 2023).
22. García-Morote, F.A.; López-Serrano, F.R.; Martínez-García, E.; Andrés-Abellán, M.; Dadi, T.; Candel, D.; Rubio, E.; Lucas-Borja, M.E. Stem Biomass Production of *Paulownia elongata* × *P. fortunei* under Low Irrigation in a Semi-Arid Environment. *Forests* **2014**, *5*, 2505–2520. [CrossRef]
23. Cuomo, F. Progetto Clone In Vitro 112®. La Nuova Grande Opportunita per L'agricoltura. [Progetto Clone In Vitro 112®. The New Great Opportunity for Agriculture]. 2014. Available online: https://paperzz.com/doc/5214373/progetto-paulownia-clone-in-vitro-112 (accessed on 23 March 2023).
24. Forbes. To Drzewo Uratuje Ludzskość? [Will This Tree Save Humanity?]. 2016. Available online: https://www.forbes.pl/innogy/nauka-i-spoleczenstwo/oxytree-drzewo-ktore-szybko-rosnie-i-produkuje-duzo-tlenu/9qehy83 (accessed on 23 March 2023).
25. International Hardiness Zone Maps. 2023. Available online: https://www.plantmaps.com/index.php (accessed on 2 June 2023).
26. Köppen, W. *Das Geographische System der Klimate [Geographic System of Climates]*; Handbuch der Klimatologie; Verlag von Gebrüder Borntraeger: Berlin, Germany, 1936.
27. WRB IUSS Working Group WRB. *World Reference Base for Soil Resources 2014, Update 2015*; International Soil Classification System for Naming Soils and Creating Legends for Soil Maps; World Soil Resources Reports No. 106; FAO: Rome, Italy, 2015.
28. Historical Data—Weather—Historical Data. 2020. Available online: http://portal.chmi.cz/historicka-data/pocasi/zakladniinformace?l=en (accessed on 23 March 2023).
29. Vyskot, M. *Pěstění Lesů [Silviculture]*; SZN: Praha, Czech Republic, 1978; p. 432. (In Czech)
30. Barton, I.; Micholas, I.; Ecroyd, C. *Paulownia: Forest Research Bulletin*; Forest Research Bulletin: Rotorua, New Zealand, 2007; p. 76.
31. El-Showk, S.; El-Showk, N. The Paulownia Tree an Alternative for Sustainable Forestry. 2003. Available online: http://cropdevelopment.org/docs/PaulowniaBooklet.pdf (accessed on 23 March 2023).
32. Jablonski, D. Surowiec Drzewny. Oxytree: Drewno do Przerobu w Tartaku w 6 lat od Posadzenia Drzewa [Wood Raw Material. Oxytree: Wood for Processing at a Sawmill 6 Years after Planting the Tree]. 2016. Available online: http://www.drewno.pl/artykuly/10535,oxytree-drewno-do-przerobu-w-tartaku-w-6-lat-od-posadzenia-drzewa.html (accessed on 23 March 2023). (In Polish)
33. TGG. Paulownia: Technical Bulletin. 2011. Available online: https://www.doc-developpement-durable.org/file/Culture/Arbres-Bois-de-Rapport-Reforestation/FICHES_ARBRES/Paulownia/Paulownia%20plantations.pdf (accessed on 23 March 2023).
34. BIO TREE. Paulownia. 2022. Available online: https://paulowniatrees.eu/products/paulownia-planting-material/ (accessed on 23 March 2023).
35. Trewartha, T. *An Introduction to Weather and Climate*; McGraw-Hill Book Company: New York, NY, USA, 1943; p. 545.