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COMPARISON OF BIOMETRIC CHARACTERISTICS OF OXYTREE PLANTING IN TRAFFIC ROUTES IN THE CITY OF LOMZA IN 2019–2020

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As part of the tripartite agreement signed on 16 April 2019 between Miejskie Przedsiębiorstwo Gospodarki Komunalnej i Mieszkaniowej Zakład budżetowy w Łomży (Municipal Utilities and Housing Company Budgetary Facility in Lomza), Instytut Ochrony Roślin Państwowym Instytut Badawczy w Białymstoku (Institute for Plant Protection of National Research Institute in Białystok) and Wyższa Szkoła Agrobiznesu w Łomży (Higher School of Agribusiness in Lomza), currently Międzynarodowa Akademia Nauk Stosowanych w Łomży (The International Academy of Applied Sciences in Lomza), 51 Oxytree trees were planted in the second half of May 2019 in the city's green belts along urban traffic routes with heavy vehicle traffic.

This paper compares the biometric traits of oxytree plantings in the city of Łomża, in two growing seasons of 2019-2020. The degree of adaptation and growth of this species tree in north-eastern Poland's urban conditions was studied. The growth rate per diameter and trunk height per development of Oxytree in two consecutive growing years were determined.

The average height of how many trees after the first growing year was 95.3 cm, with an average stem diameter of 19 mm measured at 20 cm from the ground. In the second growing year, the average height of the 51 trees was 171.9 cm, with an average stem diameter of 35 mm.

Key words: *oxytree, biometric measurements, care, fertilisation.*

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ПОРІВНЯННЯ БІОМЕТРИЧНИХ ХАРАКТЕРИСТИК НАСАДЖЕНЬ КИСНЕВОГО ДЕРЕВА НА МАРШРУТАХ РУХУ В М. ЛОМЖА У 2019–2020 РР.

А. Борусевіч, К. Цеслінський, Дж. Лісовський, Г. Порвізяк

У рамках тристоронньої угоди, підписаної 16 квітня 2019 року між Муніципальною комунальною та житлово-бюджетною установою в Ломжі (Бюджетна установа муніципального комунального господарства та житлово-комунального господарства у Ломжі), Інститутом захисту рослин, Національним науково-дослідним інститутом у Білостоку (Інститут захисту рослин Національного науково-дослідного інституту у Білостоку) та Вищою школою агробізнесу в Ломжі (нині Міжнародна академія прикладних наук у Ломжі), 51 кисневе дерево було висаджено у другій половині травня 2019 року в зелені смуги міста вздовж міських транспортних магістралей з інтенсивним транспортним рухом.

У цій статті порівнюються біометричні характеристики насаджень кисневих дерев у місті Ломжа за два сезони вегетації 2019–2020 рр. Вивчено ступінь адаптації та зростання цього виду дерев в міських умовах північно-східної Польщі. Було визначено швидкість росту на діаметр і висоту стовбура і на розвиток кисневих дерев протягом двох послідовних років вирощування. Середня висота багатьох дерев після першого року вирощування становила 95,3 см із середнім діаметром стебла 19 мм, виміряним на висоті 20 см від землі. На другий рік вегетації середня висота 51 дерева становила 171,9 см із середнім діаметром стебла 35 мм.

Ключові слова: *кисневе дерево, біометричні вимірювання, догляд, розмноження.*

Introduction

In the simplest terms, a tree can be defined as a perennial organism with woody stems that branch at a certain height above the ground and differentiate into a trunk and a crown formed above' (Borowski, 2014). Trees have always been and continue to be a natural part of man's immediate environment. Their role in human development is undeniable. It is because they perform various functions, ranging from those related to the development of the economy to their natural and recreational significance to those directly affecting people's mental and physical condition (Bartnicka & Ullman, 2009; Szczypa, 2016). The tree canopy forms an important but all too often disappearing element of urbanised areas (Garczynska et al., 2017). The rate of vegetation dieback in urban agglomerations is one of the most relevant indicators for effectively managing tree resources and entire ecosystems. McPherson (2014) determined indicators to estimate tree mortality. He calculated that under the so-called low mortality, 1% of trees die annually in the first five years and 0.5% in the following thirty years. In contrast, under high mortality, 5% of the stand die each year in the first five years and 2% in the thirty subsequent years. This high rate of plant death significantly reduces the number of trees growing to maturity and dramatically reduces the effects of space management.

The problem of declining green space in cities is essential because vegetation performs several functions in so-called ecosystem services. Kronenberg (2012) defines these services as the benefits the environment provides to society and the economy. Mizgajski (2008) and Cavender-Bares and co-authors (Cavender-Bares et al., 2015), on the other hand, emphasise that only the proper identification of the inter-mechanisms and interdependencies between the different ecosystem services can improve the ability of human service recipients to manage the landscape better, including the forest stand, in order to guarantee ecosystem biodiversity.

For centuries, the fate of two beings – man and trees – have been constantly intertwined, coexisting and interdependent, with man as *Homo sapiens seemingly in* complete control of this coexistence in order to benefit from it. Even today, due to their longevity, size, and many ecological, cultural, and spatial qualities, trees are essential elements of the landscape of settlements and cities.

Trees in a city are first and foremost about cleaning the atmospheric air of harmful dust, gases and excessive carbon dioxide. It is also about producing oxygen, positively impacting water resources and minimising rainwater run-off, thus preventing flooding.

In phytoremediation, plants take up harmful pollutants from the soil or air, accumulating in their organs. The leaf surface, covered with wax or hairs, can trap dust dangerous to humans and animals. It has been proven that a deciduous stand with a surface area of

1 ha is able, on the principle of 'sticking' to the leaves, to absorb 1.5 to 3 tonnes of dusty substances. At the same time, in the case of very intensive pollution, this absorption increases to as much as 5 tonnes of dust or dust. Plants can reduce the degree of dustiness by up to 75% (Woźny, 2015). Szczepanowska and Sitarski (2015) estimated that over a year, trees in the Praga Północ district collectively removed 316 kg of pollutants from the air.

The most critical biological function of trees in urban conditions is related to reducing the difference in air temperature, minimising the force of winds and limiting the amount of sunlight, in other words, generally mitigating the microclimate in built-up areas. Vegetation, through the process of transpiration and by shading adjacent land and infrastructure components, reduces diurnal temperature fluctuations, preventing the formation of so-called "heat islands" (Szczepanowska et al., 2012; Woźny, 2015; Garczyńska et al., 2017).

For several years, Poland has had a growing interest in cultivating Paulownia trees from Asia. The distinctive feature of these species and the main reason for growers' curiosity is the dynamic growth of these plants and their great adaptability to different climatic conditions.

It has also encouraged breeders and researchers to conduct a great deal of research, resulting in developing hybrids, which are grown successfully, mainly in southern European countries. The great interest in trees of this type is evidenced by statistics provided by various sources, including internet portals and the growers themselves. According to estimates, several hundred thousand Paulownia hybrids have been sold and planted in various areas of Poland. The 'Oxytree' variety alone sold more than 300,000 units, more than half – 160,000 – in 2017. At the same time, other varieties such as 'Cotta Vista 2' and 'Shan Tong' are finding their customers. The high demand among growers for new, foreign varieties of shrubs and trees and the interest of growers determine the need for research in this area. It is also essential to verify the desirability and possibility of introducing these new species in Poland (Jakubowski et al., 2018).

One of the *Paulownia* hybrids of great interest to growers is the hybrid Paulownia Clon in Vitro 112. The tree was bred under laboratory conditions at the turn of the 20th century. It was done at the In Vitro S.L. laboratory in Sant Feliu de Llobregat, near Barcelona, Spain (nursery with identification number ES-09-08-0016). The hybrid was obtained from the crossing and cloning of two species from the *Paulownieceae* family, i.e. *Paulownia elongata* and *Paulownia fortunei* (Wozniak et al., 2018; Lisowski & Porwisiak, 2020). Researchers from the Department of Forestry and Genetics at the University of Castilla-La Mancha, Spain, recognised the Clon in Vitro 112 cultivar as the best Paulownia hybrid, giving it the trade name Oxytree, meaning oxygen tree. In doing so, the Spanish researchers highlighted that the plant achieved the best results regarding heat resistance, wood quality and growth rate during their research.

In recent years, sales of oxytree seedlings have been estimated at around 100 000 units per year. It is vital that in Poland, in addition to private plantations, test plantations have been established, the primary purpose of which is to research the adaptation of Clon in Vitro 112 to native climatic conditions. Examples of such test cultures include the experimental plantation in Pawlowice, run under the supervision of the University of Life Sciences in Wrocław, or the experimental plots located at the Higher School of Agribusiness in Łomża (Woźniak et al., 2018; Borusiewicz et al., 2019).

It is worth noting that Oxytree trees are becoming increasingly popular not only among growers, for whom the most important characteristics of these trees are their speed of growth and obtaining a large mass of wood in a short period of time, but they are also beginning to be appreciated as specific 'machines' for absorbing carbon dioxide and producing oxygen in urban areas. Improvements *in* air quality and their impact on climate change encourage urban green spaces to plant *Clon in Vitro 112 in* parks and green belts of transport corridors. Paulownias are also increasingly appearing in the immediate surroundings of manufacturing plants. Examples of urban habitats that have already relied on Oxytree can be found in the following cities: Wrocław, Łódź, Ostrołęka, and Łomża, whose planting of Oxytree trees in traffic routes was the subject of research in this study. After all, it should be remembered that these best hybrids of the Paulownia genus and their valuable properties have characteristics that allow them to increase urban areas' biodiversity while providing natural shelter for bees and other insects.

Aim, subject, material and methods

This study aimed to compare the biometric characteristics of Oxytree tree planting in traffic routes in the city of Łomża, in two growing seasons of 2019–2020. The degree of

adaptation and growth of this species tree in north-eastern Poland's urban conditions was studied. The growth rate of the trunk height and its diameter in two consecutive years of cultivation was determined.

The analysis covered aerobic trees (*Clon in Vitro 112*) planted in the city of Lomza (53°10'35 "N 22°04'23 "E) in the second half of May 2019 as part of a tripartite agreement signed on 16 April 2019 between Municipal Utilities and Housing Company Budgetary Facility in Lomza (Miejskie Przedsiębiorstwo Gospodarki Komunalnej i Mieszkaniowej Zakład budżetowy w Łomży), Institute for Plant Protection – National Research Institute in Białystok (Instytut Ochrony Roślin Państwowym Instytut Badawczy w Białymstoku) and Higher School of Agribusiness in Lomza (Wyższa Szkoła Agrobiznesu w Łomży), currently The International Academy of Applied Sciences in Lomza (Międzynarodowa Akademia Nauk Stosowanych w Łomży).

At the beginning of May 2019, soil samples were taken from the locations that had been mapped out for Oxytree planting and submitted to the District Agricultural and Chemical Station in Bialystok for testing to determine macro-and micro-nutrient abundance. Then, at the planned locations, holes with a diameter of 30 cm and a depth of 100 cm were drilled using a combustion drill. In the holes prepared in this way - treated with horticultural soil mixed with granulated manure – 51 *Clon in Vitro 112* seedlings were planted by MPGKiM employees in Łomża on 22 and 23 May 2019. Shortly after planting, the trees were watered generously. Plastic netting protects the planting sites from possible mechanical damage during lawn mowing and from animals.

After the aerobic tree plantings were made, maintenance treatments were carried out, i.e., watering during the lack of precipitation, shaking the soil around the planted plants and removing competing vegetation within 40 cm around the trunk. In the first decade of August 2019, a single post-emergence fertilisation was applied, using YaraMila COMPLEX multi-nutrient fertiliser with the following composition:

total Nitrogen – 12% N (including: 5% N-NO_3 and 7% N-NH_4); Phosphorus – 11% P O_{25}; Potassium – 18% K_2 O; Magnesium – 2.7% MgO; Sulphur – 20% SO_3; Boron – 0.015% B; Iron – 0.20% Fe; Manganese – 0.02% Mn; Zinc – 0.02% Zn. YaraMila COMPLEX fertiliser was applied at 100 g under each Oxytree tree.

Trees were planted in five locations in urban green belts, in the following locations:

– Łomża, ul. Józefa Piłsudskiego plot no. 12097/2,
– Łomża, ul. Józefa Piłsudskiego plot no. 12065/3,
– Łomża, ul. Zawadzka plot no. 11272,
– Łomża, ul. Wojska Polskiego plot no. 30601
– Łomża, ul Poznańska plot no. 30929/4.

After the first year of vegetation, good overwintering of Oxytree trees planted in urban green belts in Lomza was reported. On 14 May 2020, in accordance with the guidelines of the seedling distributor, one-year shoots were pruned at a height of 5-6 cm from ground level. The pruned stem sites were treated with Miedzian WP 50 (Cu 50%) to protect the plants against fungal diseases. On the same day, mineral fertilisation was also applied at 20 g per tree, within a 30–40 cm radius from the trunk – with Polifoska fertiliser with NPK composition 8 – 24 – 24 and 8% sulphur and mixed into the soil. In early July 2020 and the second decade of August 2020, mineral fertilisation with YaraMila COMPLEX multi-nutrient fertiliser was applied at 20 g around each tree. During the second growing season of Clon in Vitro 112 trees in the traffic routes of the city of Lomza, the remaining cultivation treatments were analogous to those performed in 2019.

Compared to 2019, an innovation was that in April 2020, on plots 12097/2 and 12065/3 (Józef Piłsudski Street), flower meadows were created around the Oxytree trees as an alternative to lawns requiring frequent mowing.

Following the end of the growing seasons in both 2019 and 2020, i.e. on 21 October 2019 and 16 October 2020 respectively, biometric measurements were taken, consisting of: measuring the overall height of the trees, measuring the diameter of the plant stems at 20 cm above ground level.

The development of the oxytree trees was continuously monitored. Measurements of the trees' height and the trunk's thickness were taken at 20 cm. These were carried out using INOX Bucuresti STAS1373-55 0.05 mm callipers, a soft, flexible 150 cm FITYLE measuring tape, and a THEIS 500 cm/0.1 cm measuring strip.

In 2019, the growing period for the *Paulownia* hybrid seedlings was taken from the planting date until the first frost occurred. In 2020, on the other hand, the date that was considered the start of the growing period was

the day with an average temperature of 10 °C, while the end of the growing period was the day when temperatures below 0°C occurred.

According to the above algorithm, the growing season 2019 was 148 days; in 2020, it was less, at 139 days. Ad hoc observations and current temperature measurements were made using the DAVIES W-2020S meteorological station of the Łomża Housing Cooperative, located in the area of urban development at Konstytucji 3 Maja and Piłsudskiego Streets in the centre of the Południe Housing Estate (53° 9.76' N 022° 4.03' E)

The amount of precipitation and temperature for the study periods, i.e. 2019 and 2020, were obtained from the meteorological station of the Central Centre for Cultivar Testing of the Experimental Plant Variety Evaluation Department in Marianów (53°12'36 "N 22°06'24 "E).

Results

The soil profile on which Oxytree was planted was characterised by different contents depending on the location, while an alkaline soil reaction (pH>7.2) was recorded in all planting sites. For macronutrients, soil phosphorus, potassium and magnesium abundance were examined. As a result of the phosphorus abundance analysis, depending on the sampling location, its content took on medium, high or very high values. Indeed, it ranged from 11.1 to 22.9 $g \cdot kg^{-1}$. Similarly, the abundance of potassium in the soil varied from very low to medium, i.e. from 8.3 to 14.5 $g \cdot kg^{-1}$, while the content of magnesium ranged from low to medium (Table 1).

In the first months of growth of the Paulownia hybrid seedlings (Clon in Vitro 112) planted in the traffic routes of the city of Lomza, the climatic conditions were not favourable for their development. In the month preceding the planting, i.e. April 2019, the sum of monthly precipitation was almost ten times lower than 30-year precipitation in the corresponding time interval.

In April, the average recorded temperature was 8.6 °C, close to the multi-year (1989–2018) average temperature of 8.2 °C. A lack of precipitation also accompanied the first two decades of May 2019. It was only at the end of the second and the beginning of the third decade that 116 mm of rain fell, but the torrential nature of the rainfall caused the water to run off the soil without penetrating satisfactorily into the soil profile–nevertheless, the rains in May 2019 slightly improved soil moisture conditions. The average monthly temperature in May was 12.5 °C, 0.9 °C lower than the May temperatures recorded in the multi-year period. However, it is essential to note that the warmer end of the month and the rainfall occurring at that time significantly accelerated the growth of Oxytree seedlings during this period (Table 2).

June 2019 was one of the warmest months of the first growing season, *Clon in Vitro 112* in the municipal green areas of Lomza. The average daily temperature was 20.4 °C, 3.9 °C higher than the average of the past thirty years. The high temperatures were not accompanied by frequent rains, as the total recorded rainfall in June was 35.1 mm, less than 54% of the total rainfall simultaneously in the 1989 – 2018 multi-year period. The prominent growth of seedlings in August 2019 was undoubtedly favoured by the average daily temperature,

Table 1

The pH of the soil and its abundance in digestible macronutrients

Soil sampling location	**pH in KCl**	**Nutrient content [g·kg]$^{-1}$**		
		Phosphorus	**Potassium**	**Magnesium**
Łomża, J. Piłsudskiego plot no. 12097/2	7,6	19,0	16,6	6,8
Łomża, J. Piłsudskiego plot no. 12065/3	7,9	11,1	7,1	3,6
Łomża, Zawadzka plot no. 11272	7,5	20,5	13,9	5,6
Łomża, Wojska Polskiego plot no. 30601	7,6	22,9	14,5	5,0
Łomża, Poznańska Plot no. 30929/4	7,9	18,5	8,3	3,5

[1]*Source: Own elaboration based on OSCHR report in Białystok.*

Table 2

Average monthly temperature and monthly precipitation from April to October in the first and second growing seasons

Month	2019	2020	Multi-year average temperature 1989-2018, °C	2019	2020	Σ multi-year precipitation 1989–2018, mm
	Average temperature month, °C	Average temperature month, °C		Rainfall totals in month, mm	Rainfall totals in month, mm	
April	8,6	7,4	8,2	3,7	3,3	35,5
May	12,5	10,1	13,4	116,0	85,0	48,4
June	20,4	16,9	16,5	35,1	188,0	65,6
July	17,5	18,0	18,7	106,7	24,4	80,7
August	18,5	19,6	18,0	79,9	102,2	62,3
September	13,3	15,7	12,9	41,2	39,0	54,7
October	10,1	11,5	7,8	36,0	53,5	55,5
7-month average t^0	14,4	14,2	13,6			
Σ atmospheric precipitation				418,6	495,4	402,7

Source: own elaboration based on data from the Meteorological Station ZDOO Marianowo

18.5 °C for the month, and the significant rainfall (79.9 mm).

In 2020, being the second growing season of the oxytree, the warmest month was August, with an average temperature of 19.6 °C, and the coldest April, with an average temperature of 7.4 °C. The average temperature over the study period was 14.2 °C. It was 0.1 °C higher than the multi-year average temperature.

The average precipitation in the second growing season was 70.8 mm. The driest month was April, with a total of 3.3 mm, and the highest rainfall was in June, with 188 mm. Compared to the multi-year rainfall, the average was 30.2 mm less.

Due to the climatic conditions in which the Paulownia maples grew in the municipal green areas in Lomza, it must be acknowledged that both 2019 and 2020 were not the best years for tree development. A very dry April 2019 (the month preceding the planting of Oxytree trees), where only 3.7 mm of rainfall was recorded, and a similarly dry April 2020 (rainfall of 3.3 mm), which in turn was the month preceding the cutting of annual shoots, certainly did not have a positive effect on the growth rate of the seedlings. In doing so, it should be noted that both growing seasons analysed in the study were relatively short. For example, in 2019, the growing season (148 days) was 28 days shorter than the vegetation growing season in 2018, while in 2020, the tree growing season was 139 days, 37 days shorter than two years earlier.

Despite not having the best climatic conditions, typical of north-eastern Poland, with late spring frosts accompanying the development of the trees, the growth of Paulownia hybrids on roadside green belts in Łomża was very satisfactory.

On 21 October 2019 and 16 October 2020, biometric measurements were taken of Oxytree trees planted in traffic routes in the city of Łomża, including the height and trunk diameter of Paulownia hybrids. The trunk circumference was calculated using formula 1, while formula 2 calculated the daily growth of the plants. The results of the measurements carried out on the individual plots are summarised in Table 3.

The scope of the analysis in 2019 included 51 aerobic trees (*Clon in Vitro 112*) planted in the city of Lomza in the second half of May 2019 in five locations, in traffic routes with heavy vehicle traffic. After the first vegetation period of the plants, which lasted 148 days, on the day the biometric traits of the plants were measured, no loss in their originally planted quantity was found. On the other hand, in 2020, at the time of the measurement activity, four plants were found to have been lost hence 47 *Clon in Vitro 112* trees were included in the analysis, with a second growing season lasting a shorter period of 139 days.

In 2019, the highest tree height was achieved on plot 12065/3, which was 208 cm.

Table 3

Measurement results of the biometric features of Oxytree trees in 2019–2020 on individual plots

Plot location	2019		2020	
	Oxytree height, cm	Trunk diameter, mm	Oxytree height, cm	Trunk diameter, mm
Trees on plot no. 12097/2	82,9	17	187,7	36
Trees on plot no. 12065/3	111,9	21	190,4	39
Trees on plot no. 11272	89,8	18	176,5	33
Trees on plot no. 20601	66,2	14	140,0	32
Trees on plot no. 20929/4	125,5	24	165,0	33
Average	95,3	19	171,9	35

The lowest tree only reached a height of 17 cm in 2019. On plot no. 12097/2

In 2020, during the second growing season, the tallest tree reached a height of 290 cm on plot 1265/3, and the lowest tree grew to 65 cm on plot no. 11272 (Fig. 1).

Summary

The scope of the analysis in 2019 included 51 aerobic trees (*Clon in Vitro 112*) planted in the city of Lomza in the second half of May 2019 in five locations, in traffic routes with heavy vehicle traffic. After the first vegetation period of the plants, which lasted 148 days, on the day the biometric traits of the plants were measured, no loss in their originally planted quantity was found. On the other hand, in 2020, at the time of the measurement activity, four plants were found to have been lost hence 47 *Clon in Vitro 112* trees were included in the analysis, with the second growing period lasting a shorter period of 139 days.

In 2019, the lowest average height of Oxytree trees (66.29 cm) was recorded in plot

Fig. 1. Oxytree trees at plot 11272 on Zawadzka Street. Photo by the author

no. 30601, i.e. in the plot at Wojska Polskiego Street in Łomża, while the highest, i.e. 125.5 cm, was recorded at Poznańska Street (Fig. 2).

According to a study by Lisowski and Porwisiak (Lisowski & Porwisiak, 2017), soil and climatic conditions affect the development of Oxytrees. However, they can be grown even on poor soils in partially unfavourable climatic conditions. Regardless of the location of the experiments in Poland, Oxytree is characterised by significant growth rates.

The characteristic feature of oxytree trees is their large leaves. In hot weather, they provide plenty of shade and become a valuable fertiliser when they fall. According to Lisowski and Porwisiak (2018), oxytree leaves decompose quickly after falling, and there is no trace in spring. As fertilisers, they contain about 3% nitrogen, six times more than in manure, and above-average mineral nutrients. With which they can supply themselves with nutrients through self-fertilisation.

Very similar increases in oxytree tree height and stem thickness in the first two years of cultivation were obtained by Skibko and co-authors (Skibko et al., 2021).

Conclusions

Based on the experiment carried out over two growing seasons, the following conclusions can be drawn:

1. The oxytree trees in both the first and second year of vegetation confirmed the speed of growth. In the first year, the average height of 51 oxytree trees was 95.3 cm, and in the second year, it was 171.9 cm.
2. The average stem thickness of the 51 oxytree trees measured at 20 cm from the ground after the first growing year was 19 mm, and after the second year, it was 35 mm.
3. In 2019, the highest tree height was achieved on plot 12065/3, which was 208 cm. The lowest tree only reached a height of 17 cm in 2019. On plot no. 12097/2
4. In the second growing season of 139 days, the tallest tree reached a height of 290 cm on plot 1265/3, and the lowest tree grew to 65 cm on plot no. 11272.
5. The growth of oxytree trees was strongly influenced by climatic factors and the length of the growing season. The lack of rainfall during the respective growth phases and the high temperature in the first month after planting the oxytree seedlings affected the growth and development of the plants.

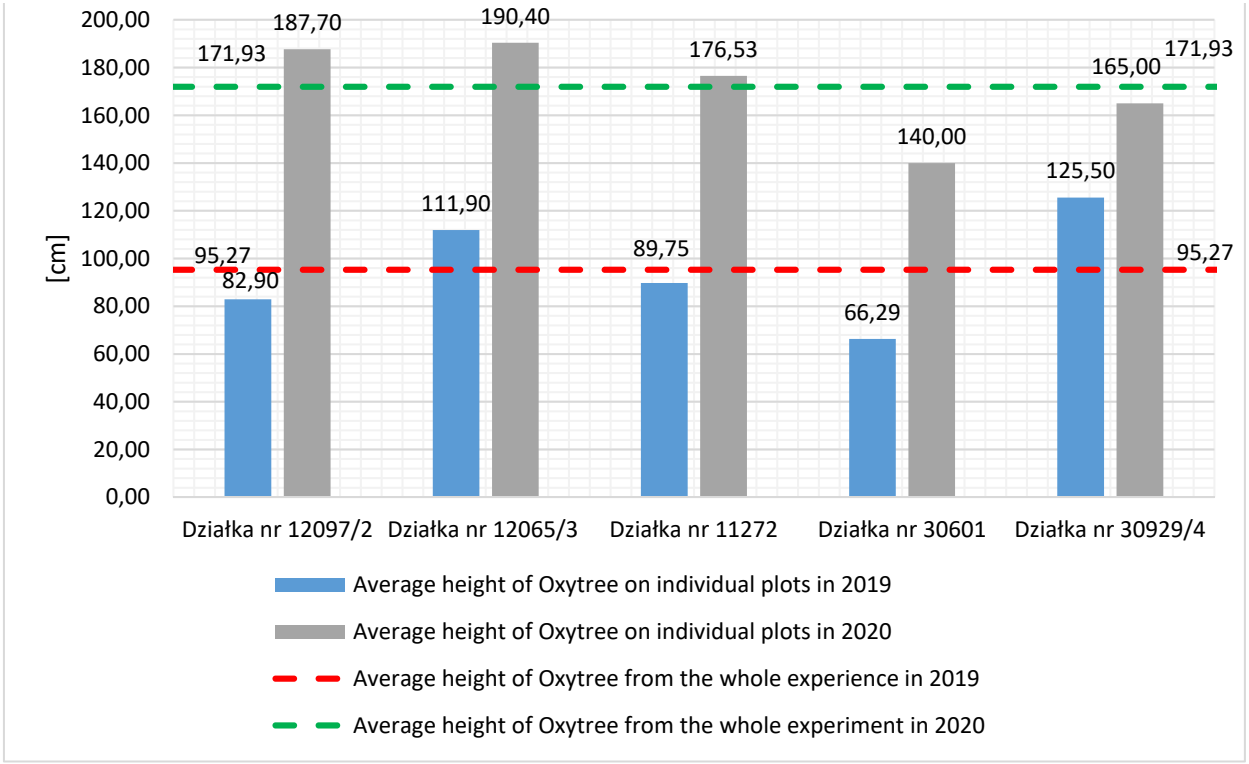

Fig. 2. Average height of Oxytree trees in 2019-2020 in individual plots, relative to average heights from the whole experiment (Source: own elaboration)

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