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ORIGINAL PAPER

Wood quality of silver birch *Betula pendula* Roth stands growing on former agricultural lands in Poland

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ABSTRACT

Wood quality is a characteristic which refers to specific, sustainable purposes for the use of wood raw material. Various wood properties are used to determine the wood quality: anatomical, physical, and chemical, which influence the final wood product. This assessment can be estimated on standing trees before harvesting or on logs after harvesting. Understanding wood quality and the approximate volume of a forest stand is crucial for evaluating the timber's value in standing trees and for future trade planning. This knowledge gains particular significance in areas with a specific land use history, where sustainable wood production heavily relies on understanding wood quality. The objective of this study was to analyse the wood quality of silver birch *Betula pendula* assessed on the basis of morphological characteristics of the trees growing on post-agricultural land.

The study was conducted on six plots in the north-western part of Poland, the selected stands grew on former agricultural land and permanent forest land. To estimate the wood quality of standing trees selected trees and tree parameters were measured. Moreover, based on visible wood defects and morphological features wood quality classes were assessed.

In general, birch trees on former agricultural land were characterised by higher dimensions, than trees from forest land. Additionally, the standing volume of trees on former agricultural land was 20 m^3/ha higher, than that of forest land. When it comes to wood quality, over 75% of trunk lengths of trees from former agricultural land did not have any visible knots, when 62% of trunk lengths of trees from forest land were branch-free. The study also revealed a higher occurrence of high-quality and good-quality wood (14.4% and 51.7%, respectively) in trees from former agricultural land, compared to those in forest land (2.8% and 53.3%, respectively). Moreover, the trees located on permanent forest land demonstrated a higher prevalence of pulp wood.

These findings emphasize the influence of land use history on wood quality and highlight the potential benefits of wood production on former agricultural lands. Understanding the variations in wood quality in different environments can aid in optimizing wood utilization and promoting sustainable practices in the timber industry.

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KEY WORDS

Betula pendula, farmland, former agricultural land, timber quality, wood production

Introduction

Silver birch is one of the most widely speared hardwood tree species in Europe. Especially in countries of the Baltic region. In Poland, the total volume of birch growing stock is approximately 116 million m^3 (Statistics Poland, 2022), which is around 4.3% of the volume of all species. In other countries, the total volume of growing stock is even higher – 28% in Latvia, 24% in Belarus, 22% in Estonia, and around 17% in Lithuania (Hynynen *et al.*, 2010). Moreover, silver birch is a typical pioneer species, playing a significant role in the initial stages of secondary and primary succession. Modest soil requirements, rapid growth, frost tolerance, and high light-density, light seeds are features that strongly favour development and growth on open, poorly fertile sites, *i.e.*, former agricultural lands (Hynynen *et al.*, 2010; Zasada *et al.*, 2014). According to Krawczyk (2014) in Poland due to the secondary succession of former agricultural land, pine and silver birch covers around 900 thousand ha.

Due to many agrotechnical treatments *i.e.*, weeding or fertilization, the soil on post-agricultural land could accumulate organic matter (Smal and Olszewska 2008; Cukor *et al.*, 2022), which may lead to improved tree growth. Especially at the beginning of tree development. Rapid growth offers the prospect of obtaining copious quantities of raw wood material in a short production period *i.e.*, for biomass production (Stolarski *et al.*, 2013; Zasada *et al.*, 2014). In general, silver birch is high-quality wood and thus has multiple applications in the wood industry. Among others due to the high content of cellulose birch wood is a good material for paper production (Lachowicz *et al.*, 2019), when high-quality wood can be processed for ply production. Moreover, the content of high-calorie substances, makes birch wood a very good fuel as firewood (Liepiņš and Rieksts-Riekstiņš, 2013; Lachowicz *et al.*, 2018). Nonetheless, wood quality (WQ) is not easy to estimate.

Wood quality can be defined as the suitability of raw wood material for a particular purpose (Krajnc and Hafner, 2020), as a combination of several wood properties such as anatomical, physical, or chemical that affect the final wood product. WQ can be estimated both on standing trees before harvesting and logs after harvesting (grade yield). Predicting of WQ based on grading is varied not only between softwood and hardwood species, but also depends on forestry regulations or wood industry requirements in a specific country (EN 1912. (CEN); Zarządzenie, 2019; Inter-Nordic Standard (INSTA), 1997). In general, silver birch has a low habitat requirement, but its wood quality can decrease with the decline in habitat fertility (Lachowicz *et al.*, 2014; Lachowicz and Paschalis-Jakubowicz, 2014). Tomczak *et al.* (2023) defined whether beech, birch, and oak are species suitable for producing high-quality timber on former agricultural lands by studying the morphological features of several dozen trees from each species. Although they chose stands with typical habitats for each species.

Very often wood quality is assessed based on mechanical and physical properties, in particular the density of the wood (Lachowicz *et al.*, 2018; Tomczak *et al.*, 2021, 2022). On the one hand wood density depends on many factors – both environmental and forest management, which can affect WQ. On the other hand, there are morphological characteristics of the tree trunk, which also have an impact on wood quality (Tomczak *et al.*, 2023), especially grading before and after logging. This knowledge is particularly used in forest practice (Malinowski and Wieruszewski, 2017). According to the literature differences in basic morphological parameters such as height and diameter were observed between trees from former agricultural and forest land. Both for coniferous (Bartoš *et al.*, 2010; Zeidler *et al.*, 2017; Jelonek *et al.*, 2019) and hardwood species (Cukor *et al.*, 2022; Tomczak *et al.*, 2023). From the WQ point of view, the most important characteristics are wood defects. Based on wood defects, it is easy to assess the suitability of raw materials for the timber industry. However, in the case of prediction of the wood quality of standing trees the most crucial role are morphological characteristics of the whole tree. Eventually tree branches, trunk diameter, tree height, and selected crown characteristics.

Determining WQ before cutting is an important issue from an economic point of view. Knowledge about wood quality and the approximate volume of the stand helps to evaluate the timber value of standings trees and plan future trading. This knowledge is important, especially in the case of former agricultural or abandoned lands, where the history of use is the most important factor in tree and wood development and even in sustainable wood production. Currently, many stands grown on former agricultural land are reaching the age of felling. This is an opportunity to assess the effects of several decades of silviculture. Evaluation of the effects is important for forest management and helpful in making economic decisions. At the same time, the assessment should be based on indicators or characteristics that are easy to measure. This study aimed to analyse the wood quality of silver birch *Betula pendula* Roth estimated based on the morphological characteristics of the trees with growth on former agricultural lands.

Material and Methods

Study design. The study was carried out in the north-western part of Poland in areas managed by the State Forests National Forest Holding. All study plots were localized close to each other, in the same forest district. Therefore, we can assume, that they growth in the same climate conditions and under the same forest management. The feature that differentiates the selected areas was their history of use: the selected stands grew on former agricultural land and permanent forest land. Sample plots were created in six different stands (Table 1). Plots were established in stands, where birch close to cutting age (70-80 years old) were the main species. On each plot, 60 random dominant and co-dominant birch trees were measured. In total 360 trees were measured both on former agricultural land and permanent forest land. However, for the analysis, 353 trees were included – 178 on former agricultural land (FA) and 175 on forest land (FL).

Tree measurements and assessment of the wood quality. On each plot, the same morphological features were measured for all trees. First, the north direction was marked with paint on the trunk of each tree. Then, tree diameter at breast height ($D_{1.3}$) was measured to an accuracy of 1 cm by the cross-over method, using a Haglöf calliper (Haglöf Sweden AB, Sweden) in

Table 1.
Characteristics of study plots

Forest land (FL)				Former agricultural land (FA)			
Stand number	age [year]	size [ha]	geographic coordinates	Stand number	age [year]	size [ha]	geographic coordinates
I	84	1.35	N: 54.3307, E: 17.4443	II	82	7.82	N: 54.2861, E: 17.5739
III	79	1.71	N: 54.3941, E: 17.3860	IV	79	2.06	N: 54.3583, E: 17.4638
V	79	2.88	N: 54.3241, E: 17.3957	VI	79	0.67	N: 54.3941, E: 17.3860

the directions north-south ($D_{N\text{-}S}$) and east-west ($D_{E\text{-}W}$), and tree height (H) was measured to an accuracy of 0.5 m using a Suunto PM-5 clinometer (Suunto, Finland). In the next step, the following trunk and crown characteristics were measured: length of knotless trunk – which was calculated based on the height of the first dead branch (HDB) or the height of the first live branch (HLB), and the crown base (CB). Based on these measurements, the following stand parameters were determined:

Mean diameter at breast height ($D_{1.3}$), equation (1):

$$D_{1.3} = (D_{N-S} + D_{E-W}) / 2 \text{ [cm]} \tag{1}$$

Based on the location of the crown base and the height of the lower-located branch (F_B), the length (L_w/O_B) and percentage (P_w/O_B) of the knotless trunks were calculated from equations (2) and (3):

$$L_w/O_B = C_B - F_B \text{ [m]} \tag{2}$$

$$P_w/O_{B.} = (L_w/O_{B.} \cdot 100) / C_B \text{ [\%]} \tag{3}$$

Wood quality estimation. Based on visible wood defects and morphological features on the first five meters of trunk length a quality class was determined for each measured tree on every study plot, according to four grades – high-quality (A), good-quality (B), low-quality (C) and pulpwood (S). WQ of standing trees was determined by estimation of the following wood defects occurrence: knots, trunk shape, and curves (Table 2). Final classifications were done according to Polish classification rules (Zarządzenie, 2019).

Wood production. The standing volume [m^3/ha] was established based on data collected from the Forest Data Bank (FDB) of Poland (www.bdl.lasy.gov.pl). Stand descriptions for each study plot were generated, and then the selected data about the standing volume and share of each species were collected. The share of each species could be different on different plots, therefore the final volume of examined species was calculated according to Equation. 4:

Table 2.
Limitations of quality classes due to existing wood defects according to Polish classification rules (Zarządzenie, 2019)

	Wood quality class			
	A	B	C	S
Knots	sound – up to 2 cm ∅; dead – unacceptable	sound – up to 5 cm ∅; dead – up to 5 cm ∅	sound – up to 10 cm ∅; dead – up to 8 cm ∅	acceptable
Bark wrinkles	admissible with an opening angle >90°	acceptable	acceptable	acceptable
Crookedness	2 cm/m	3 cm/m	4 cm/m	10 cm along the entire length
Necrosis and cankers	one up to 6 cm in width	up to 6 cm in width	up to 12 cm in width	acceptable
Grain slope	up to 7 cm/m	up to 12 cm/m	acceptable	acceptable
Wormholes	unacceptable	unacceptable	permissible up to one-fourth of the circumference of the wood	acceptable

$$V_{sv} = (SV_{FBD} \times 100\%) / S_{FDB} \text{ [m}^3\text{/ha]} \quad (4)$$

where:

V_{sv} – final standing volume,
SV_{FDB} – standing volume from FDB,
S_{FDB} – share from FDB.

Statistical analysis. In the first step, to verify the distribution of the data, the Shapiro-Wilk test was performed. The data for all measured morphological characteristics and calculated variables led to the rejection of the normal distribution hypothesis. To compare non-parametric data, the Mann-Whitney test was performed. Statistical inference was performed at the significance level α=0.05. The RStudio program and R package 4.2.2 (R Core Team, 2022) were used to visualize and data calculations.

Results

Stem characteristics on forest and former agricultural lands. In general, trees from FA were characterized by greater diameter at the breast height and height. According to Figure 1 the distribution of those parameters was similar; however, the higher frequency of the greatest diameter value was observed on FA. Differences between mean diameter at the breast height of trees measured on former agricultural land (app. 32 cm) and forest land (app. 30 cm) were statistically significant. In the case of height, the significant differences between FA (24.5) and FL (23.4) were also found (Fig. 1).

The main distribution of other measured trunk characteristics -the height of the first living and dead branches, was concentrated between 10 and 20 m. Trunks of trees from former agricultural land were approximately 4 meters longer, similar differences were noticed in the case of the occurrence of the first dead branch, when the difference between the occurrence of

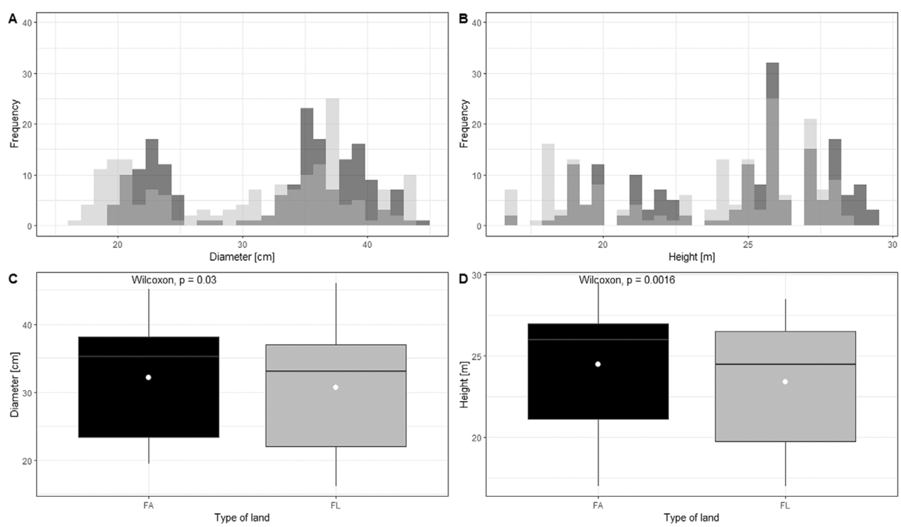

Fig. 1.

Statistical distribution and descriptive statistics of diameter (A and C) and height (B and D). Whiskers correspond to minimum and maximum values, boxes represent the 1st and 3rd quartile values, midlines indicate the median, and the white dot represents the mean value; in black - trees measured on former agricultural land, in grey – trees measured on forest land the first living branch was even higher. All differences between branches parameters measured on trees from former agricultural land and forest land were statistically significant (Fig. 2).

According to trunk characteristics, the length and proportion of the knotless trunk were analysed based on the trunk length and height of the first existing branch (open knot). Over 75% trunk length of trees from former agricultural land did not have any branches, when 62% trunk length of trees from forest land were stripped of their branches (Fig. 3). All differences between parameters measured on trees from former agricultural land and forest land were statistically significant.

A QUALITATIVE ANALYSIS OF WOOD RAW MATERIAL ON FOREST AND FORMER AGRICULTURAL LANDS. In general, on former agricultural land more high-quality (B) and good-quality wood (C) – 14.4 and 51.7% were observed, than in the case of forest land – 2.8 and 53.3% respectively. In the case of the trees located on FL, the higher occurrence of pulp wood (S) was obtained. The occurrence of high-quality (A) and low-quality (D) wood was not found on any type of land (Fig. 4). Trees from forest land graded as a high-quality class were characterised by higher dimensions in comparison to trees from the same class on former agricultural land. In the case of C and S classes, the dimensions of trees were similar on both types of land (Table 3).

SILVER BIRCH STANDS WOOD PRODUCTION ON FOREST AND FORMER AGRICULTURAL LANDS. The standing volume of silver birch stands was calculated according to forest inventory data from the Forest Data Bank of Poland. In general, the mean volume of all measured stands was 225 m^3/ha. Although birch stand growth on former agricultural land was characterized by higher standing volume by app. 20 m^3/ha (Table 4).

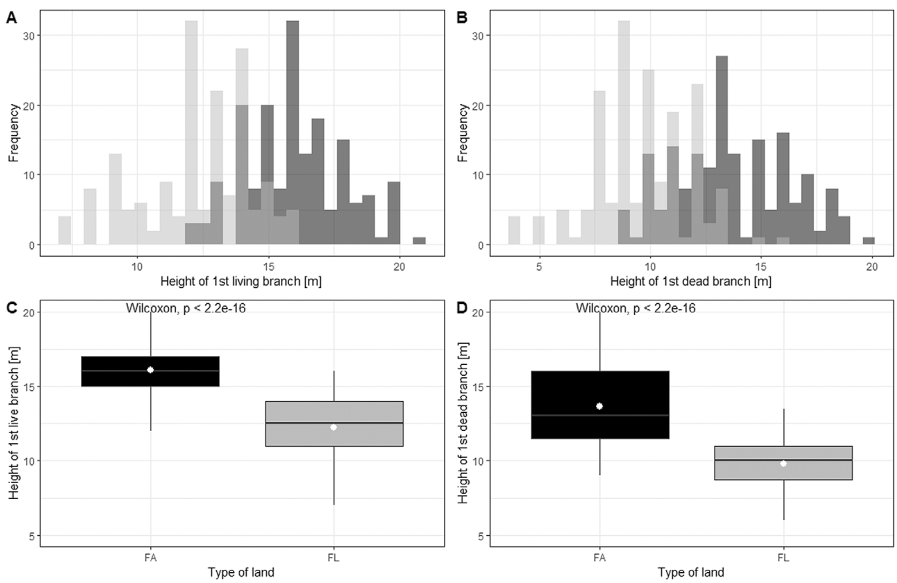

Fig. 2.

Statistical distribution and descriptive statistics of height of 1st live branch (A and C) and height of 1st dead branch (B and D). Whiskers correspond to minimum and maximum values, boxes represent the 1st and 3rd quartile values, midlines indicate the median, and the white dot represents the mean value; in black – trees measured on former agricultural land, in grey – trees measured on forest land

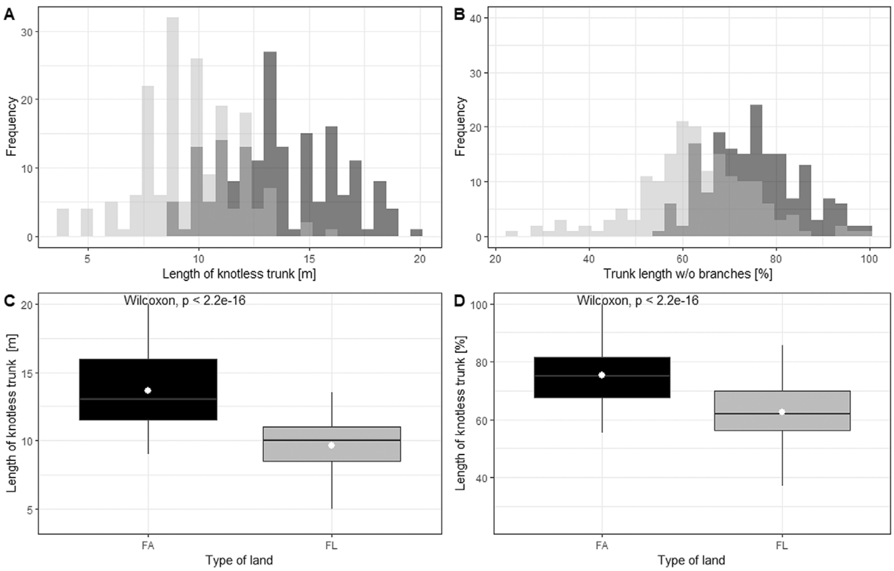

Fig. 3.

Statistical distribution and descriptive statistics of height of length of knotless trunk (A and C) and percentage length of knotless trunk (B and D); whiskers correspond to minimum and maximum values, boxes represent the 1st and 3rd quartile values, midlines indicate the median and black dots represent the mean value. In black – trees measured on former agricultural land, in grey – trees measured on forest land

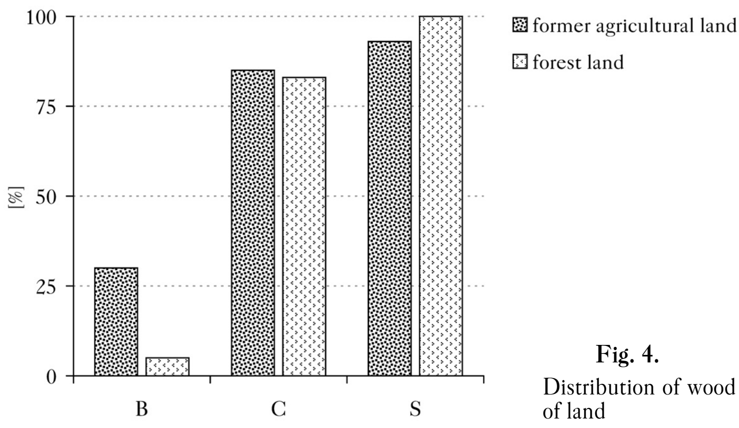

Fig. 4.

Distribution of wood quality classes by types of land

Table 3.

Mean values of selected tree parameters according to wood quality classes

Wood quality class	Type of land	Mean diameter at the breast height [cm]	Mean diameter one meter from the ground [cm]	The mean height of a tree [m]	Length of knotless trunk [m]
B	FL	44.5	48.5	27.2	9.7
B	FA	40.3	42.5	27.7	15.8
C	FL	36.7	38.7	25.9	9.8
C	FA	36.0	38.1	26.3	14.1
S	FL	22.9	25.0	20.1	9.3
S	FA	23.2	25.2	20.7	12.1

Table 4.
Comparison of mean standing volume according to Forest Data Bank of Poland [m^3/ha]

Type	Mean volume	Minimum	Maximum
FA	235	210	250
FL	214	150	304
Mean	225	150	304

Discussion

This study aimed to analyse the wood quality of silver birch *Betula pendula* estimated based on the morphological characteristics of the trees with growth on former agricultural lands. To test this objective the data from afforested former agricultural land and forest land was collected. To eliminate the influence of age and forest management on tree characteristics, thus on the technical quality of the tree trunks, all selected stands were 80 years old. In many countries, it is a felling age for silver birch.

According to Puchniarski and Sobania (2016) in optimal climate conditions, silver birch can grow up to 30 m in height and has around 80 cm diameter. In our study, the average tree on former agricultural land had 24.5 m and was higher by 1.5 m, than avg. tree on forest land. The same phenomenon was also observed in diameter at breast height, where avg. DBH were greater on FA by 2 cm. These results are higher than those obtained by Tomczak *et al.* (2023) who also measured birch trees on former agricultural land and forest land. Nonetheless, they observed a similar phenomenon, when trees from former agricultural land were characterised by higher dimensions.

Besides dimensional characteristics of the trunk, also especially important during the estimation of the WQ of a standing tree is the occurrence of visible wood defects such as knots, bark wrinkles, crookedness, necrosis, cankers etc. Usually, the presence of wood defects is estimated without measuring. In our study, based on the measured height of the first living and dead branches, we determined the length of the knotless trunk. In general, tree trunks from former agricultural land had longer sections without branches – the average percentage of these characteristics was >70%, while in the case of the forest land significantly lower – no longer than the app. 65% of the trunk length. Cukor *et al.* (2022) examined trunk length without branches of five native species on former agricultural land. In 14 years old stands the longest clear part of the trunk was found in the sycamore – app. 54%, where the shortest in spruce – 16.1%. Unfortunately, there was no comparison with forest land. Tomczak *et al.* (2023) pointed out there was not a significant difference between the percentage of the knotless trunk length in the case of mature birch and beech stands on former agricultural land and forest land, but they proved signicificant differences in the case of oak stands. However, those measurements of birch stands were conducted only in two stands (study plots), while in our study we measured trees from six different stands. Therefore, the database is unique for interference.

Silver birch is also characterised by its high-quality wood; therefore, its wood is used in many industries. High-quality and good-quality birch wood is used for ply production for different purposes (Wang *et al.*, 2022) or even as a component of WPC composites (Kajaks *et al.*, 2017). Moreover, the content of high-calories substances, makes birch wood a particularly good fuel as firewood (Liepiņš and Rieksts-Riekstiņš, 2013; Lachowicz *et al.*, 2018). Birch wood components are also used in cosmetics, pharmaceutical and food industries *e.g.*: drinks, medicine, herbal or dietary supplements production (Verkasalo *et al.*, 2017; Staniszewski *et al.*, 2019; Chen *et al.*, 2020). As we confirmed in our study, due to the longest clear part of the trunk, good WQ based on trunk characteristics was noticed in the case of all measured trees. However, the trees from former agricultural land were characterised by a higher share of high-quality wood, when the share of good-quality wood on both types of land was similar and was over 50% of the total share. Due to its high contain of cellulose, it is an exceptionally good raw material for the cellulose industry for paper production (Lachowicz *et al.*, 2019). Over 40% of the standing trees on forest land were classified as pulp wood, which is characterised by low quality and high occurrence of visible wood defects on the trunk, especially knots and crookedness. Interesting phenomena were observed when trees from FA and FL were divided into wood quality classes. As our investigation showed, trees graded as high-quality wood were characterised by higher dimensions of the trunk. In the case of classes C and S, larger dimensions were observed on former agricultural land, when trees with grade B were bigger on forest land. Another interesting phenomenon is, that trees from FA were characterised by longer knotless trunks.

Standing volume is an especially crucial factor in terms of planning forest management, especially wood harvest and future timber trade. Rytter and Lutter (2019) examined six different deciduous species growing on abandoned agricultural land and showed that it can be expected initial high productivity of trees planted on former agricultural land. Our study shows that in the case of 80-year-old birch stands, a higher volume of wood is produced on former agricultural land. Tomczak *et al*. (2023), obtained opposite results; however, they conducted a study on a smaller amount of stands and trees. Based on reports about global timber production over the 21st century (FAO 2000, 2020), knowledge about the technical wood quality before cutting is an especially important economic factor in every type of forest land and habitat. Especially in the case of former agricultural lands, which usually are underestimated and regarded as weaker sites for forestry management. However, recent studies about WQ and other wood properties are not unequivocal and have shown that wood from afforested former agricultural land is slightly lower (Kozakiewicz *et al*., 2020; Tomczak *et al*., 2022) or even higher (Tomczak *et al*., 2009). According to von Althen (1991) cultivation of hardwood species on former agricultural land is possible but could be more expensive than on forest land, because of habitat requirements. Although Tomczak *et al*. (2023) pointed out that beech, birch, and oak are also species suitable for producing high-quality timber on former agricultural land. Which may lead to getting profits from wood selling. Globally the potential to use agricultural lands for wood production is high, according to Campbell *et al*. (2008) there were 385-472 million hectares of such land, including 1.8-2.6 million ha in Baltic and Northern countries (Rytter, 2016), where silver birch finds its optimal growth conditions.

According to forestry practice, the WQ estimation of living trees should be confirmed after felling. In general, our observations, based on visual estimation of the wood quality of standing trees may provide proof, that besides specific growth conditions on former agricultural sites, birch trees can develop high-quality wood. It is important to note that we do not know the history of these stands (*e.g.*, number of planted trees, intensity of silvicultural treatments, *etc*.), thus sites from a small area (one forest district) were selected for this study. On this basis, it can be assumed that both environmental and economic conditions were remarkably similar. However, to confirm our results, the future study should consider the comparison of physical and mechanical wood properties, and the wood anatomy of wood from former agricultural land and forest land.

Conclusion

The study findings show the influence of land use history on wood quality and highlight the potential benefits of wood production of *Betula pendula* on former agricultural lands. Understanding the variations in wood quality in different environments can aid in optimizing wood production and future utilization in the timber industry. Based on obtained results it can be concluded that:

- Birch trees close to cutting age (around 70-80 years old) characterize higher dimensions and higher standing volume on former agricultural land, compared to forest land.
- Visual estimation of wood quality in standing trees may provide evidence of high-quality wood development in birch trees on former agricultural land.
- The potential for wood production on former agricultural land is high, especially in regions with optimal growth conditions for silver birch.

Author Contributions

Conceptualization – K.T. and A.T.; methodology – K.T., A.T. and T.J.; formal analysis – K.T. and A.T.; data curation and visualization – K.T., J.K.; writing-original draft preparation – K.T., J.K., A.T. and T.J.; writing-review and editing – K.T., A.T. and T.J.; supervision – A.T.

Conflicts of interest

The authors declare no conflict of interest.

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STRESZCZENIE

Jakość drewna w drzewostanach brzozy brodawkowatej *Betula pendula* Roth wyrosłych na gruntach porolnych

Określenie jakości drewna (WQ) przed rozpoczęciem procesu pozyskania jest bardzo ważne z ekonomicznego punktu widzenia prowadzenia gospodarki leśnej. Dane dotyczące jakości drewna oraz jego szacowanej miąższości pozwalają wstępnie ocenić wartość drzewostanów i zoptymalizować przychody ze sprzedaży pozyskanego drewna. Informacje te mogą mieć szczególne zastosowanie zwłaszcza dla gruntów porolnych oraz pokopalnianych, w przypadku których historia użytkowania gruntu jest kluczowym czynnikiem w rozwoju drzew, a także kształtowaniu się tkanki drzewnej. Wiele drzewostanów posadzonych na początku XX w. na gruntach porolnych osiąga obecnie wiek rębności, co pozwala na ocenę jakości dojrzałych drzew tuż przed pozyskaniem. Ocena ta powinna opierać się na wskaźnikach oraz cechach, które są łatwe do zmierzenia, a co za tym idzie pozwalają na porównanie drzewostanów między sobą. Celem pracy była analiza jakości drewna brzozy brodawkowatej *Betula pendula* Roth oszacowanej na podstawie wybranych cech morfologicznych drzew rosnących na gruntach porolnych.

Badania przeprowadzono na sześciu powierzchniach próbnych zlokalizowanych w północno-zachodniej części Polski, na terenie Nadleśnictwa Łupawa (tab. 1). Trzy drzewostany zostały zakwalifikowane jako wyrosłe na gruncie porolnym (FA), a trzy na gruncie leśnym (FL). W celu oceny jakości drewna drzew stojących wykonano pomiary wybranych parametrów drzew. Ponadto na podstawie widocznych wad drewna i cech morfologicznych na pięciu pierwszych metrach pnia zostały określone następujące klasy jakości: drzewa bardzo dobrej jakości (A), dobrej jakości (B), średniej jakości (C) oraz o przeznaczeniu na drewno przemysłowe (średniowymiarowe) (S). Każde drzewo zostało przypisane do klasy jakości na podstawie wybranych wytycznych obowiązujących w Polsce (tab. 2). Miąższość drewna określono na podstawie opisu taksacyjnego pobranego z Banku Danych o Lasach.

Drzewa wyrosłe na gruncie porolnym charakteryzowały się większymi wymiarami pnia: pierśnicą oraz wysokością. Różnice pomiędzy średnią pierśnicą drzew mierzoną na gruntach porolnych (ok. 32 cm) i leśnych (ok. 30 cm) były istotne statystycznie. W przypadku wysokości również stwierdzono istotne różnice pomiędzy FA (24,5 m) i FL (23,4 m) (ryc. 1).

Pnie drzew z FA były dłuższe o około 4 m od pni drzew z FL. Podobne zjawisko odnotowano w przypadku wysokości występowania pierwszej martwej gałęzi, podczas gdy różnica wysokości pomiędzy występowaniem pierwszej żywej gałęzi była jeszcze większa (ryc. 2). Na podstawie długości pnia oraz wysokości pierwszej gałęzi (sęka) obliczono długość bezsęcznego pnia. W przypadku drzewostanów na gruntach porolnych pnie drzew charakteryzowały się większą długością bezsęcznego pnia, która wynosiła ponad 75% całej długości pnia. U drzew zmierzonych na FL średnia długość bezsęcznego pnia wynosiła około 62% (ryc. 3). Wszystkie różnice pomiędzy parametrami wysokości występowania gałęzi na pniach drzew z gruntów porolnych i leśnych były istotne statystycznie.

W przypadku pni na gruntach porolnych zaobserwowano sumarycznie większy udział drzew charakteryzujących się pniami dobrej (B) i średniej jakości (C) (odpowiednio 14,4 i 51,7%) niż w przypadku gruntów leśnych (odpowiednio 2,8 i 53,3%). W przypadku drzew z FL oszacowano większy udział drewna przemysłowego (S) (ryc. 4). Drzewa z gruntów leśnych zakwalifikowane jako pnie dobrej klasy jakości charakteryzowały się wyższymi wymiarami w porównaniu do drzew tej samej klasy na gruntach porolnych. W przypadku klas C i S wymiary drzew na obu typach gruntów były zbliżone (tab. 3). Średnia miąższość wszystkich zmierzonych drzewostanów wynosiła 225 m^3/ha. Drzewostany brzozowe rosnące na gruntach porolnych charakteryzowały się miąższością drzewostanów większą o ok. 20 m^3/ha (tab. 4).

Uzyskane wyniki pokazują wpływ historii użytkowania gruntów na jakość drewna i podkreślają potencjalne korzyści płynące z produkcji drewna na terenach porolnych. Zrozumienie różnic w jakości drewna w różnych środowiskach może pomóc w optymalizacji produkcji drewna oraz jego odpowiednim wykorzystaniu w przemyśle drzewnym.