Teka Kom. Ochr. Kszt. Środ. Przyr. – OL PAN, 2013, 10, 232–236

STRUCTURE OF ABOVEGROUND BIOMASS OF SILVER BIRCH (*Petula pendula* Roth) IN THE NEIGHBOURHOOD OF NITROGEN PLANT „PUŁAWY" S.A. IN TERMS OF USE FOR ENERGY PURPOSES

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Summary. The paper presents the structure of aboveground biomass of 11-year old stands of silver birch in the vicinity of the Nitrogen Plant „Puławy" S.A. in the context of its use for energy purposes. The survival rate of the trees was determined, the amount of dry mater of wood of trunks and branches (with division into thickness classes), as well as the energy value of the biomass. Dry matter of the wood of trunks and branches amounted to, on average, 32.1 Mg · ha^{-1} – which under the unfavourable conditions of growth and development can be considered as a relatively high value. The energy value of the biomass was 599 GJ · ha^{-1}.

Key words: biomass energy, Silver birch, degraded soil

INTRODUCTION

The increasing demand for energy and the necessity of reducing environmental pollution enforce the search for more ecological solutions. One of those is the acquisition of energy from renewable sources, e.g. from biomass. The establishment of plantations of fast-growing trees and the use of dendromass permits saving such sources of biomass as forests or conventional agricultural production [Walotek *et al*. 2006]. In addition, the establishment of energy plantations on wastelands (e.g. post-industrial lands) does not pose the threat of reducing the available resources of arable and forest soils.

The objective of the study was to determine the structure of the aboveground biomass of silver birch (*Betula pendula* Roth) grown on idle lands in the neighbourhood of the Nitrogen Plant „Puławy" S.A., in the aspect of the possibility of its use for energy purposes.

MATERIAL AND METHOD

The study was conducted in 11-year old two-row stands of silver birch, established at the spacing of 1.0 × 1.5 m. The stands were established on soils developed from formations with the particle size distribution of loose sand (industrial soil and urbisols) [Kowalkowski and Kopron 2002, Pranagal and Słowińska-Jurkiewicz 2007]. The soils are characterised by disturbed chemism due to long-term nitrogen immissions. The processes of degradation of the soils are intensified by deep drainage, resulting from the exploitation of a system of deep water intakes installed in dunes [Kowalkowski *et al*. 1999].

The analyses were performed on 3 experimental areas, each with dimensions of 20 × 3 m. The heights of the trees and the diameters at breast height (DBH) were measured, and their survival rate was determined (as % of living trees in relation to the number of trees planted). One sample tree (with average height and DBH) was taken from each test area.

The following parameters were determined (after drying at temp. of 105°C): dry mater of trunks with bark, in three thickness classes: > 1.0–5.0 cm; > 5.0–10.0; > 10.0–15.0 cm (sections with thickness up to 1.0 cm were classified with the branches); dry matter of branches with bark, in two thickness classes: ≤ 1.0 and > 1.0–5.0 cm. The calorific value of the wood of the trunks and branches was determined for each thickness class – with a calculation method, on the basis of the heat of combustion determined with the calorimetric method.

The content of dry matter of wood in the bark was calculated, in $Mg \cdot ha^{-1}$, as well as its energy value in $GJ \cdot ha^{-1}$.

RESULTS AND DISCUSSION

The numbers of trees on the test areas were 22, 17 and 15 trees, respectively.

The average rate of survival in the stands under study was 50% (42–61%). The high rate of mortality of the trees may be due to disturbed physiological processes as a result of deregulation of the chemical properties of the soils, and of the continuing immission of pollutants. According to Kowalkowski *et al*. [1996], the rates of survival of 11-year old birch on a soil without mulching and a soil with peat mulch are 35% and 56%, respectively.

Under the conditions of the study, the height of the trees varied within the range from 620 to 715 cm, mean of 661.7 cm, while the DBH values were 7.3, 6.7 and 6.2 cm, respectively. According to Barzdajn *et al*. [1996], the average height of 9-year old birch trees in experimental cultivations amounts to 306.56 cm. Andrzejczyk [2008] reports that the mean height of birch at the age of 10 years is 663 cm, and the DBH – 6.7 cm.

Dry matter of wood of the trunks and branches on the particular test areas, converted to 1 ha, was 22.2, 27.5 and 46.5 Mg, mean of 32.1 tons (Fig. 1), of which nearly 70% was the mass of the trunks – 22.4 $Mg \cdot ha^{-1}$ (14.8–32.41 $Mg \cdot ha^{-1}$).

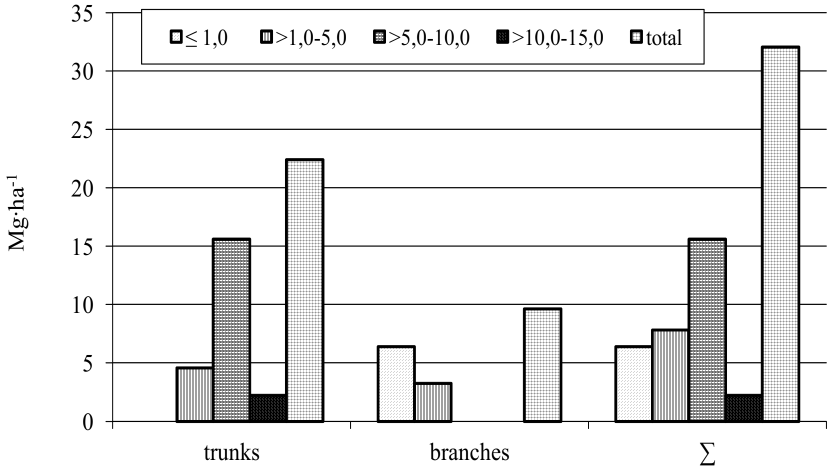

Fig. 1. Dry matter of wood of trunks and branches per 1 ha, average

Dry matter of the wood of the trunks in the thickness classes of > 1, 10–5.0; > 5.0–10.0; > 10.0–15.0 cm constituted 20, 70 and 10% of the total dry mater of the trunks, respectively.

In the case of the structure of dry mater of branches, the contribution of branches with thickness of ≤ 1.0 cm was ca. twice as high. The mean total mass of branches was 9.6 (7.4–14.9) Mg · ha^{-1} (Fig. 1).

According to Johansson [1999], the aboveground biomass of 11-year old silver birch growing in Sweden on idle agricultural lands on light loams was 53.5 Mg · ha^{-1}, of which 51.3 Mg · ha^{-1} was the dry matter of trunks and 2.2 Mg · ha^{-1} – of branches. Ferm and Kaunisto [1983] report that the aboveground biomass of 14-year old stands of birch growing in Finland on peat soils was 59 Mg·ha^{-1}. Aosaar and Uri [2008] report that the aboveground biomass of birch in a short, 8-year production cycle, depending on the spacing of the trees, varied from 22.8 Mg · ha^{-1} (35 600 trees/ha) to 31.2 Mg · ha^{-1} (11 600 trees/ha). Comparison of the above literature data with the data obtained under the conditions of our study indicates that the birch tree stands on the degraded sandy soils in the neighbourhood of the Nitrogen Plant are characterised by high levels of aboveground biomass. The comparison should take into account the unfavourable habitat conditions in which the trees grow, and their high rate of mortality.

The effects of biomass production under the conditions of our study do not appear as favourably in relation to the values obtained on willow or poplar plantations for energy purposes. Zajączkowski *et al*. [2001] report that the average annual yield of willow wood on soils developed from light boulder loam was 5.15–7.08 Mg · ha^{-1}, and that of wood from poplar plantations from 7.24 to 8.35 Mg · ha^{-1}. In the case of our study the corresponding value was 2.9 Mg·ha^{-1}·$year^{-1}$.

The highest calorific value was obtained for branches with thickness of ≤ 1.0 cm – 19.7 MJ · kg^{-1}, while that for branches of > 1.0 cm – 18.9 MJ · kg^{-1}. In the case of the wood of trunks with bark, for the thickness classes of > 1.0–5.0;

> 5.0–10.0 and > 10.0–15.0 cm the calorific value was 18.3, 18.3 and 18.7 MJ · kg^{-1}, respectively. The calorific value of birch wood under the conditions of our study was on average (trunk and branches) 18.7 MJ · kg^{-1}.

Nurmi [1993] reports that the calorific value of wood of trunks, branches and combined wood was 19.1, 19.5 and 19.2 MJ · kg^{-1}, respectively. The values obtained in our study is somewhat higher than the values reported by Grzybek [2004] for the calorific value of willow wood in bark – 18.4 MJ · kg^{-1}, oak – 18.2 MJ · kg^{-1}, or poplar – 18.5 MJ · kg^{-1}.

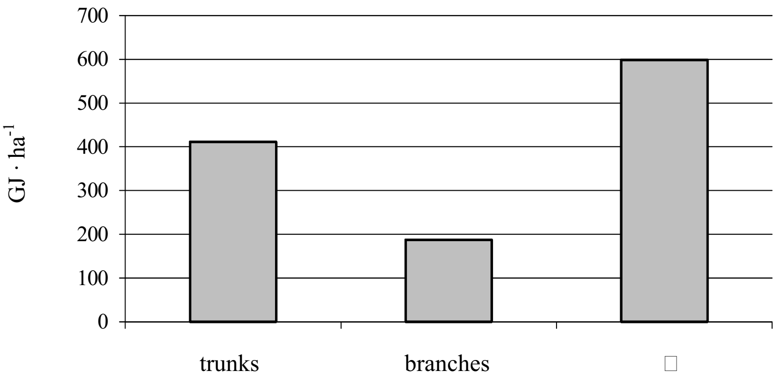

Fig. 2. Energy value (GJ · ha^{-1}) of aboveground biomass of 11-year old stands of silver birch

The average energy value of the biomass of the silver birch stands under study was 599 GJ · ha^{-1} (Fig. 2). The contribution of the wood of the trunks and the branches in the total energy value was 69 and 31%, respectively.

CONCLUSIONS

1. In spite of the unfavourable growth conditions and the high mortality of the trees (50%), the 11-year old birch stands in the neighbourhood of the Nitrogen Plant „Puławy" S.A. are characterised by high levels of biomass (32 Mg · ha^{-1}) with energy value of 599 GJ · ha^{-1}.

2. Taking into account the low suitability of post-industrial idle lands for forest production, it appears justified to use the tree stands for energy purposes.

REFERENCES

Andrzejczyk T., 2008. Influence of silver birch (*Betula pendula* L.) admixture on growth and shape of pedunculate oak (*Querus robur* L.) in plantations in Krynki (in Polish). Forest District. Leśne Prace Badawcze, 69(3), 203–209.

Aosaar J., Uri V., 2008. Biomass production of grey alder, hybrid alder and silver birch stands on abandoned agricultural land. Forestry Studies, 48, 53–66.

Barzdajn W., Ceitel J., Sienkiewicz A., Zientarski J., 1996. Response of selected tree species on varied fertilisation under conditions of emission from the Nitrogen Plant Włocławek (in Polish), in: Materials of 3rd Nat. Symp. on „Biological responses of trees to industrial pollutions", (ed.) R. Siwecki. T. 1. Wyd. Sorus, Poznań, p. 267–272.

Ferm A., Kaunisto, S., 1983. Above-ground leafless biomass production of naturally generated birch stands in a peat cut-over area at Aitoneva, Kihniö. Folia Forestalia 558, 32 pp.

Grzybek A., 2004. Biomass as a source of energy (in Polish), in: Energy willow – cultivation and processing technologies, (ed.) A. Grzybek. Wyd. WSEiA, Bytom, p. 10–19.

Johansson T., 1999. Biomass equations for determining fractions of pendula and pubescent birches growing on abandoned farm land and some practical implications. Biomass and Bioenergy, 16, 223–238.

Kowalkowski A., Kopron H., 2002. Monitoring of forest environment under the effect of industrial emissions in the vicinity of Zakłady Azotowe „Puławy" – research report (in Polish). Puławy–Kielce. Manuscript, 115 pp.

Kowalkowski A., Kopron H., Lewandowska J., Jedliczko S., Płecha R., 1999. Possibilities of restoration of forest functions in long-term unbalanced forest ecosystem of the Forest Inspectorate Puławy (in Polish), in: Functioning of forest soils in endangered areas and trends of its changes (in Polish), Warsztaty Naukowe, Puławy, p. 49–63.

Kowalkowski A., Miazga S., Strykowski J., 1996. Results 20-year observations of the relative resistance of selected species of trees and bushes to permanent nitrogen immission (in Polish), in: Materials of 3rd Nat. Symp. on „Biological responses of trees to industrial pollutions", (ed.) R. Siwecki. T. 1. Wyd. Sorus, Poznań, p. 313–324.

Nurmi J., 1993. Heating values of the above ground biomass of small-sized trees. Acta Forestalia Fennica 236, 1–30.

Pranagal J., Słowińska-Jurkiewicz A., 2007. Soil cover of the research area, in: H. Domżał and E.J. Bielińska (eds), Estimation of transformations of soil environment and of stability of forest ecosystems in the area of influence of Zakłady Azotowe „Puławy" S.A. (in Polish). Acta Agrophysica, Rozprawy i Monografie, 2, 11–27.

Walotek P., Mruach D., 2006. Modelling of regional productivity of fast growing trees in short cycle of cutting rotation as a basis for planning the supply of energy raw material in the form of dendromass (in Polish). Zielona Góra, Natura 13, 61–68.

Zajączkowski K., Kwiecień R., Zajączkowska B., Wajda T., Zawadzki M., 2001. Production capabilities of selected varieties of poplar and willow in short-cycle plantations (in Polish). Manuscript, IBL, Warszawa, 66 pp.

STRUKTURA NADZIEMNEJ BIOMASY BRZOZY BRODAWKOWATEJ (*Petula pendula* ROTH) W SĄSIEDZTWIE ZAKŁADÓW AZOTOWYCH „PUŁAWY" S.A. W ASPEKCIE MOŻLIWOŚCI WYKORZYSTANIA DO CELÓW ENERGETYCZNYCH

Streszczenie. W pracy przedstawiono strukturę nadziemnej biomasy 11-letnich zadrzewień brzozy brodawkowatej w sąsiedztwie Zakładów Azotowych „Puławy" S.A. w kontekście wykorzystania jej na cele energetyczne. Określono przeżywalność drzew, wielkość suchej masy drewna pni i gałęzi (z podziałem na klasy grubości), a także jej wartość opałową. Sucha masa drewna pni i gałęzi wyniosła średnio 32,1 $Mg \cdot ha^{-1}$ – co w niekorzystnych warunkach wzrostu i rozwoju można uznać za wartość stosunkowo wysoką. Wartość energetyczna biomasy wyniosła 599 $GJ \cdot ha^{-1}$.

Słowa kluczowe: energia biomasy, brzoza brodawkowata, grunty zdegradowane