DE GRUYTER OPEN

DOI: 10.1515/aree-2015-0009

Acta Regionalia et Environmentalica 2
Nitra, Slovaca Universitas Agriculturae Nitriae, 2015, pp. 44–46

CRITERIA FOR FELLING MATURITY OF POPLAR CLONES GROWN FOR ENERGY USE

Rudolf PETRÁŠ[1]*, Julian MECKO[1], Viera PETRÁŠOVÁ[2]

[1]National Forest Centre – Forest Research Institute, Zvolen, Slovak Republic
[2]Slovak University of Agriculture in Nitra, Slovak Republic

Poplar clones reach a big advantage over other forest tree species in the production of large amounts of above-ground biomass in a relatively short time. To increase the efficiency of production during their short life cycle, it is necessary to optimize age of their felling maturity. It should be carried out in the stands age when its average production is highest. Mathematical models of yield tables were used to derive this production. Above-ground biomass production was expressed in natural units, volume (m^3 ha^{-1}) and the capacity of calorific value (GJ ha^{-1}), but also in financial yield (€ ha^{-1}) from the sale of timber assortments including energy chips from smallwood. In terms of financial yield, Robusta stands are mature between 23 and 35 years and I-214 stands between 18 and 32 years. Main financial yield per year, on average 200–1900 € ha^{-1}, is expected from the production of assortments designed for classic industrial processing. Its increase by 50 to 100 € ha^{-1} is expected to be achieved by supplemental smallwood processing to energy chips. In terms of volume production and capacity of combustion heat, stands are mature about 5–7 years earlier.

Keywords: poplar clones, Robusta, I-214, the production of biomass, felling maturity

Particularly soft, broadleaved tree species such as bred poplar clones and willows may be included in the fast-growing tree species in the Slovak climatic conditions. Poplar clones have a big advantage over other forest tree species namely in the production of large amounts of above-ground biomass in a relatively short time. Usually it is in the range of 15–30 years. Compared to the main forest tree species such as spruce and beech, the average volume production of poplar clones is from 2.4 to 3.5 times higher and four times faster. Thus, the production potential of poplar clones is extremely high and attractive. Although forests of poplar clones represent only around 0.6% of forests in Slovakia, in lowlands and particularly floodplains of Slovakia, they are the main tree species of major economic importance.

To increase the efficiency of production during their short life cycle, it is necessary to optimize the ages of felling maturity. A stand should be cut in the time, when it is mostly appropriate. It should be in the stands age when its average production is highest. If the stand is cut sooner or later, there would be some loss in the production, which would be proportional to the deviation from the optimum of rotation age.

While stands of poplar clones constitute homogeneous tree sets (Petráš et al., 2010), the structure of essential parts such as the stem, tree crown and branches, or even of their main mechanical fractions such as wood and bark is very heterogeneous. Their composition varies with the lifelong development of the stands (Petráš et al., 2007, 2008a). Smallwood and bark dominate in the early growth stages, but with increasing age, the proportion of these parts significantly reduces. Thicker wood of higher quality dominates in older stands. The largest volumes have assortments for sawmill processing and assortments for veneer production, followed by fibre assortments, firewood and energy chips which can be produced from smallwood thinner than 7 cm. In this case, felling maturity of poplar clones can be derived from the production of prevailing and economically most important assortments (Petráš and Mecko, 1999). To apply all assortments properly in order to determine the optimal age of felling maturity, it is necessary to re-calculate the natural production in volume or energy units (Jamnická et al., 2014) to universal monetary unit (Petráš and Mecko, 1995; Petráš et al., 2008b). Halaj et al. (1990) have developed and validated a complete methodology for the derivation of the value production of main crops of forest tree species and their felling maturity. Its optimization criterion has become average annual production, or in forestry habitually used total mean increment (TMI), i.e. the mean annual increment from the total stand production. Stands are mature for felling at the age when their TMI is highest.

The aim of this work is to derive the ages for felling maturity of Robusta and I-214 poplar clones stands from their natural and value production at the energy use of above-ground biomass of trees.

Material and methods

Production of poplar stands is very well simulated by mathematical yield tables' models. Their main content is a lifelong development of above-ground biomass volume VB (m^3 ha^{-1}) by main components – wood, bark, smallwood

Contact address: *doc. Ing. Rudolf Petráš, CSc., National Forest Centre – Forest Research Institute, T. G. Masaryka 22, 960 92 Zvolen, Slovak Republic, e-mail: petras@nlcsk.org

and along the entire tree (Petráš and Mecko, 2001) depending on the age t of the stand quality q:

$$VB\ (\mathrm{m^3\ ha^{-1}}) = f(t, q) \qquad (1)$$

Other equivalents are derived from the volume production of stands' biomass by equation (1):

- The volume of raw timber by assortments for industrial processing VS ($\mathrm{m^3\ ha^{-1}}$) (Petráš et al., 2007; 2008a).
- Gross financial yield only from the production of timber assortments HV (€ $\mathrm{ha^{-1}}$) (Petráš et al., 2008b).
- Gross financial yield from the production of timber assortments HV (€ $\mathrm{ha^{-1}}$) (Petráš et al., 2008b), including the financial yield from the sale of smallwood for energy chips production.
- Calorific value capacity CV (GJ $\mathrm{ha^{-1}}$) (Petráš et al., 2013).

Total mean increment TMI is important to determine the felling maturity of poplar stands, which was calculated as a share of total production TP and stand´s age *t*:

$$TMI = \frac{TP}{t} = f(t, q) \qquad (2)$$

Same like *TP*, it is a function of the age *t* and site index *q*. TMI is calculated for all five equivalents of production.

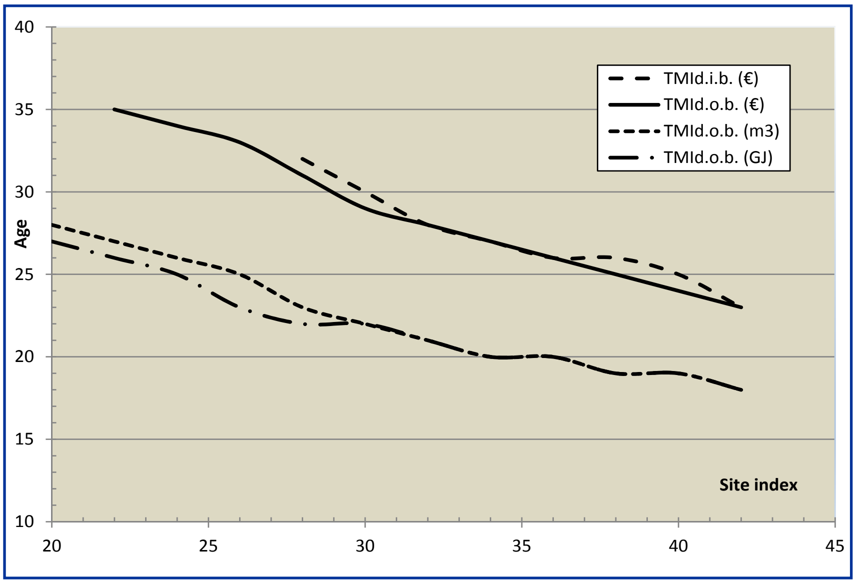

Figure 1 Robusta clone felling maturity ages according to culmination of the total mean increments (TMI) according to the structure of raw timber assortments from wood over 7 cm minimum diameter at top diameter and diameter inside bark (d.i.b.); and of the complete tree volume outside bark (d.o.b.)

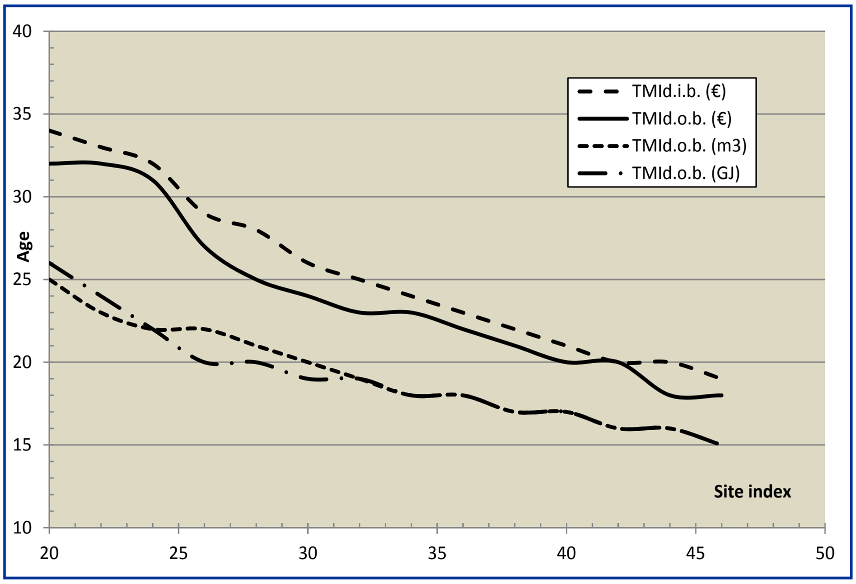

Figure 2 I-214 clone felling maturity ages according to culmination of the total mean increments (TMI) according to the structure of raw timber assortments from wood over 7 cm minimum diameter at top diameter and diameter inside bark (d.i.b.); and of the complete tree volume outside bark (d.o.b.)

Results and discussion

Ages at which TMI of poplar stands culminate are relatively different for Robusta clone illustrated in Figure 1 and I-214 clone illustrated in Figure 2. Ages are significantly reduced with higher site index in both clones. TMI for volume production and production of calorific value from the whole aboveground biomass culminate at first. Clone Robusta culminates at the age of 28–18 years at stand qualities ranging from 20 to 42. I-214 clone culminates aged from 25 to 15 years at its site index ranging from 20 to 46, i.e. 3 years earlier. The highest TMI culmination ages are found for value production of raw timber assortments. Robusta clone with its site index 28–42 shows it when aged about 32–23 years, and I-214 clone at the same stand qualities when aged 28–20 years, which is three to four years earlier. When the value of smallwood production for energy use is added to the production of assortments, then culmination ages will be reduced by about 0–3 years. For Robusta and its stand qualities from 22 to 42, it is reduced to the level about 35 to 23 years and for I-214 and its stand qualities from 20 to 46, it is reduced to the level about 32 to 18 years. It is approximately 3 years earlier for the same stand quality range from 22 to 42.

When considering which production criterion should be decisive for determining the felling maturity of poplar clones stands, it is necessary to consider in particular their value production. It is therefore by far the

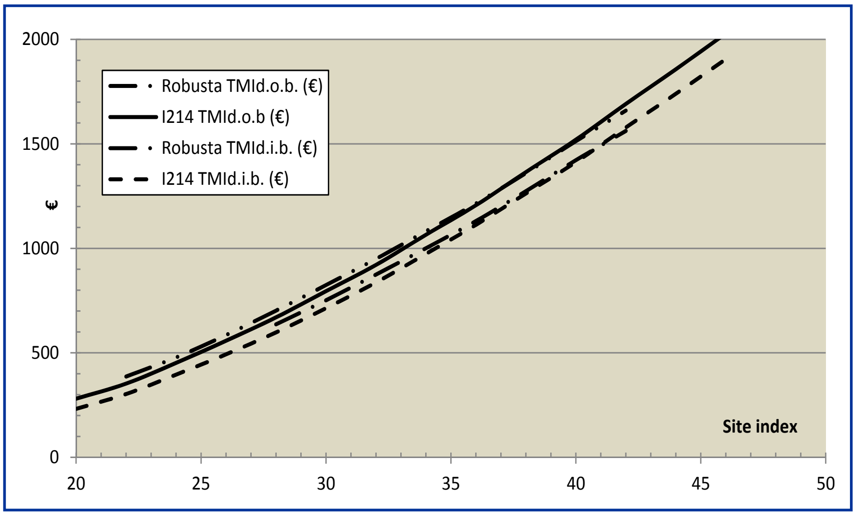

Figure 3 The value of total mean increments (TMI) of Robusta and I-214 poplar clones stands according to the structure of raw timber assortments from wood over 7 cm minimum diameter at top diameter and diameter inside bark (d.i.b.); and of the complete tree volume outside bark (d.o.b.)

most suitable value production of raw timber assortments together with the value of smallwood intended for the production of energy chips, even though the ages of felling maturity are about 5–7 years higher than for volume production or the production of calorific value. Even Halaj et al. (1990) states that ages of felling maturity of Slovak main tree species stands derived from volume production are lower than from the value production. Differences in felling maturity of these species are greater than for poplar clones and depend mainly on quality and price of timber of a particular tree species. In Figure 3, it is apparent that in both clones and stand qualities from 20 to 46, the average annual yield from felling the entire aboveground stand biomass ranges from 250 to 2000 € ha^{-1}. When only assortments of raw timber would be used without processing the smallwood, the annual yield of stands would be lower by € 50–100 per 1 ha.

Conclusions

The criterion of mean annual increment culmination was applied in order to objectively determine the ages of poplar stands felling maturity. Stands are mature for felling in the age when their mean increment culminates. Robusta clone stands seem to have their felling maturity in the age of about 18–28 years and I-214 clone about three years earlier according to natural production evaluated in volume units or calorific value. Stands on best site index are mature for felling about 10 years earlier than those on worse site index. Stands are mature about five to seven years later by their value production. It is in the age from 23 to 35 years for Robusta clone, and three years earlier for I-214 clone, namely between 18 and 32 years. The most important financial yield per year, 200–1900 € ha^{-1} on average, is expected to be achieved from assortments designed for classic industrial processing. Its increase by 50 to 100 € ha^{-1} is expected from supplemental processing of smallwood to energy chips.

Acknowledgements

This research was supported by grants from the Slovak Research and Development Agency. Project No. APVV-0131-07.

References

HALAJ, J. – BORTEL, J. – GRÉK, J. – MECKO, J. – MIDRIAK, R. – PETRÁŠ, R. –SOBOCKÝ, E. – TUTKA, J. – VALTÝNI, J. 1990. Rubná zrelosť drevín. In Lesnícke štúdie, 48, 117 s.

JAMNICKÁ, G. – PETRÁŠOVÁ, V. – PETRÁŠ, R. – MECKO, J. – OSZLÁNYI, J. 2014. Energy production of poplar clones and their energy use efficiency. In Forest (Lesnictví), p. 150–155.

PETRÁŠ, R. – MECKO, J. 1995. Models of volume, quality and value production of tree species in the Slovak republic. In Forestry (Lesnictví), 41, p. 194–196.

PETRÁŠ, R. – MECKO, J. 1999. Rubná zrelosť topoľových klonov. In Lesnícky časopis, 45, s. 13–29.

PETRÁŠ, R. – MECKO, J. 2001. Erstellung eines mathematischen Modells der Ertragstafeln für Pappelklone in der Slowakei. In Allg. Forst-u. J.-Ztg., 172, p. 30–34.

PETRÁŠ, R. – MECKO, J. – NOCIAR, V. 2007. Modely kvality surového dreva stromov topoľových klonov. In Lesnícky časopis, 53, s. 83–97.

PETRÁŠ, R. – MECKO, J. – NOCIAR, V. 2008a. Quality of wood in the stands of poplar clones. In Journal of Forest Science, 54, pp. 9–16.

PETRÁŠ, R. – MECKO, J. – NOCIAR, V. 2008b. Value production of poplar clones. In Journal of Forest Science, 54, pp. 237–244.

PETRÁŠ, R. – MECKO, J. – NOCIAR, V. 2010. Diameter structure of the stands of poplar clones. In Journal of Forest Science, 56, pp. 165–170.

PETRÁŠ, R. – MECKO, J. – PETRÁŠOVÁ, V. 2013. Energy potential in production of fast-growing poplar clones in Slovak regions. In Acta regionalia et environmentalica 10, pp. 53–56.