Models of assortment yield tables for poplar clones

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ABSTRACT: The results of research on the production of raw timber assortments for the stands of poplar clones Robusta and I-214 in Slovakia are presented in this paper. Models of assortment yield tables were constructed, separately for each clone, in dependence on the yield class and stand age. The construction was based on the models of yield tables, stand assortment tables, models of external quality and damage to stems. Robusta clone produces by about 15–20% higher proportions of the highest quality assortments than I-214 clone. I-214 clone produces faster and higher proportions of average- and below-average quality assortments.

Keywords: poplar clones; timber quality; assortment production; assortment yield tables

Assortment yield tables illustrate the lifelong development of the quality of wood produced in stands of forest tree species by means of the assortment structure. Raw wood assortments are determined according to macroscopic characteristics on the surface of stems and inside them as well as according to the length and diameter of logs. Regarding the surface characteristics mainly the presence of knots and curvature of wood fibres are important, then centricity of crosswise cuts, full bole stems, etc. Regarding the internal characteristics it is mainly the presence of rot or false heartwood. It means the raw wood assortment is composed of the specified connection of dimensional and qualitative characteristics of logs. The assortments of raw wood or their structure for individual trees or in stands may be an integrating indicator of the quality of produced wood. Based on the present knowledge, in general we can estimate the proportions of the assortments for trees or stands according to tree or stand assortment tables in dependence on basic tree or stand characteristics. The development or the production of assortments in forest stands according to individual stand components, including total production, may be given in assortment yield tables. The structure of the assortments is given in the tables in dependence on the age and site index of the stand; it means usual production characteristics being used also with traditional yield tables.

In the evaluation of hitherto knowledge of the qualitative production of tree species we must mention the works of the authors who assessed the quality of wood production on the basis of more complex and general data in the framework of total production and for all stand components, it means on the basis of assortment yield tables. In the last decades Erteld and Hengst (1966) dealt with this issue. They described and generalized possibilities and procedures of the construction of assortment yield tables. Hengst (1971), Schöpfer (1980) and Gerold and Römisch (1985) also studied the above-mentioned issues. In Austria Sterba (1983) and Kleine (1986) dealt with the principles of the construction of assortment tables including assortment yield tables for spruce. In Switzerland Bachmann (1967) obtained very similar results for 5 tree species. Though they are older, the principles and construction results are very similar. In Poland older results from assortment research performed by Gierlinski (1970) are known, in Romania this research was conducted by Giurgiu et al. (1972) and in Bohemia by Pařez (1987a,b). After generalizing

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their knowledge we may state that the methodologies of the construction of assortment tables accept mostly only dimensional sorting, where individual logs are divided according to mean diameter into diameter classes with the diameter 5 cm or 10 cm. Only occasionally are very simplified criteria used for the quality of stems or the crown parts of trees or possibly for their damage by rot. Dimensional sorting is justified in the above-mentioned cases by the fact that coniferous tree species such as spruce, fir and pine, which prevail in many countries, show very small differences in the quality of stems and prevailing assortments, frequently almost 90% of their volume, are saw logs. In this case it is sufficient to classify them into diameter classes.

In Slovakia relatively great attention is paid also to quality sorting when for logs quality characteristics of wood are also considered, for example knots, decays, false heartwood, curvature, twisted growth of wood fibres, etc. Based on the original material of empirical sorting models of tree and stand assortment tables for 8 commercially important tree species were constructed, namely for spruce, fir, pine, oak and beech Petráš and Nociar (1990, 1991) and for larch, hornbeam and birch Mecko et al. (1993). By connection of the above-mentioned models with the models of yield tables (Halaj et al. 1987; Halaj, Petráš 1998) assortment yield tables (Petráš et al. 1996) were constructed. In the last years models of the production of poplar clones Robusta and I-214 were completed. Petráš and Mecko (2001, 2005) processed their volume production into yield tables, and the quality of production started with the construction of tree and stand assortment tables (Petráš, Mecko 2007; Petráš et al. 2008) and resulted in assortment yield tables.

The aim of the paper is to present the methodology and the results of the construction of the models of assortment yield tables for poplar clones Robusta and I-214.

MATERIALS AND METHODS

Assortment yield tables show the structure of assortments, particularly their volume in m^3 or the proportion in % of the whole standing volume S(m^3,%) in dependence on the stand site index si and age t according to the relation:

$$S(\mathrm{m}^3, \%) = f(si, t) \quad (1)$$

Assortment yield tables of poplar clones were constructed by the method of simulation from the models of yield tables, stand assortment tables, models of the quality and damage to stands.

Models of yield tables

They show the development of mean and hectare parameters for total stand, main stand, secondary crop and total production in dependence on the site index and age of stand. There are separate models for the clone Robusta and for the clone I-214 (Petráš, Mecko 2001, 2005).

Only that part of them was used which gives the development of mean diameter d_v and standing volume V for the main stand and secondary crop in dependence on its site index si and age t according to the relation:

$$d_v = f(si, t) \quad (2)$$

$$V = f(si, t) \quad (3)$$

Models of yield tables as well as required relations (2) and (3) are mathematical models. The site index of the stand is given as the mean height of total stand at the age 30 years.

Models of stand assortment tables

They give the structure of assortments V% for poplar stands (Petráš et al. 2008) in dependence on their mean diameter d_v, quality qua and damage dam to stands according to the relation:

$$V\% = f(d_v, qua, dam) \quad (4)$$

The structure of the assortments is composed of the quality and diameter classes of logs in accordance with the standard of the Slovakia STN 48 0056 for the qualitative classification of broadleaved round wood adopted in 2004 or with its amended version of 2007.

The highest quality classes *I* and *II* are intended mainly for the production of industrial veneer, whereas class *II* has slightly lower requirements for the quality of wood than class *I*. Class *I* requires the minimal diameter of logs 40 cm and class *II* 20 cm. Quality classes *IIIA, IIIB, IIIC* represent high quality, average quality and lower quality saw logs with minimal diameter 20 cm. Pulpwood assortment of class *V* is intended mainly for the pulp and paper industry and class *VI* is fuel wood. The volume of wood with more extensive rot which could not be included even in class *VI* of fuel wood was classified as waste. Diameter classes of the assortments 1–6 + are defined in accordance to their mean diameter inside bark.

Models of the quality of stand and damage to stands

Quality of stands qua was evaluated according to the quality of the stems of standing trees. The stems were classified into three classes (*A, B, C*) according to external quality characteristics in the lower third of their stems:

Class *A* includes the stems of the highest quality, upright, not flattened, without knots, without twisted growth of wood fibres or any other technical defects. Only the most valuable logs may be produced from the evaluated part of stems.

Class *B* includes the stems of average quality with small technical defects (curvature, twisted growth of wood fibres), with medium large sound knots and small not sound knots. Higher quality saw logs may be produced from the evaluated part of stems.

Class *C* includes low quality stems with big technical defects (curvature, twisted growth of wood fibres, other stem deformations), while only sound knots regardless of the size and medium not sound knots are permitted. Mainly lower quality saw logs and pulpwood may be produced from the evaluated part of stems.

Damage to stands *dam* was evaluated according to visible symptoms of damage on the surface of stems. The most frequent were decays after mechanical damage of butts and buttresses, but in some localities also heavy damage to stems by wood boring insects was recorded.

The quality and damage to stands were expressed by percentage proportions of their quality classes *A*–*C* and proportions of damage to trees. Regression models of their dependence on basic stand parameters were derived from the measurements carried out on 24 assortment experimental plots. The measurements were carried out in the years 2005–2006 during the empirical sorting of trees (Petráš, Mecko 2007) on the plots. In addition to these measurements a special detection of the quality and damage to trees in other stands of poplar clones was also performed in main poplar areas of Slovakia. Mature stands separately for each clone were selected in order that all site indexes would be represented. Together for both kinds of data finding there were 87 stands for Robusta and 87 stands for I-214.

RESULTS AND DISCUSSION

Quality of stands

After a detailed analysis of empirical material the dependence of the proportions of quality classes of stems *A, B, C* on the site index of stand was shown as the most suitable. With regard to the relatively high variability of quality classes of stems it was also demonstrated that it was more suitable to balance gradual sum proportions of classes *A* and *A* + *B*. Based on their difference the proportion of class *B* is calculated easily and the part complementing 100% forms class *C*. Regression models of their dependence on the site index of the stand were derived from empirical data according to this power function:

$$qua\% = p1 + p2 \times si^{p3} \quad (5)$$

where:
qua% – proportion of quality classes of stems *A* and *A* + *B* (%),
si – site index of the stand,
*p*1–*p*3 – parameters of the function.

Correlation coefficients are relatively low. For Robusta they are in the range 0.19–0.20 and for I-214 in the range 0.34–0.59. It is obvious from the development of balanced proportions of quality classes of stems illustrated in Fig. 1 that Robusta has almost 30% of the highest quality stems of class *A*, about 56% of class *B* and 14% of class *C*. While Robusta has these proportions approximately constant in the whole site index range for I-214 clone, the quality of stems changes markedly with the site index of stand. For site classes 20–46 the proportion of the highest quality stems of class *A* increases within 4–14%, of class *B* within 32–66%, and of class *C* the proportion

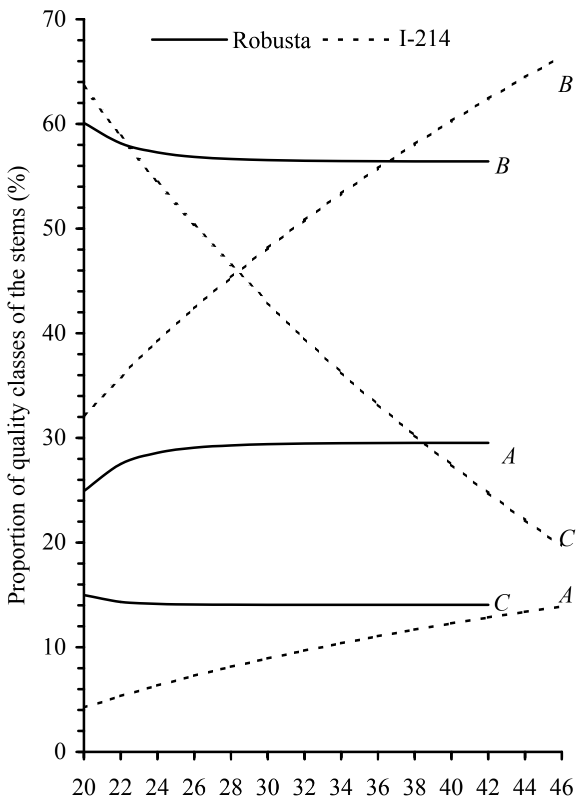

Fig. 1. Proportions of quality class *A, B, C* of stems in dependence on the site index

decreases within 64–20%. It means that Robusta has markedly higher proportions of the stems of average and mainly above-average quality in comparison with I-214. For the highest yield class Robusta has even a minimally double proportion of the highest quality stems. I-214 has a higher proportion of the stems of average quality only for above-average site indexes. The reasons must be sought in the genetic potential of both clones. Robusta has the slower diameter growth of stems as well as branches in the crown of trees. Stems are straight, without twisting of wood fibres, and in crosswise section they have a regular circular shape. The fast diameter growth of I-214 clone causes not only several deformations on the stem but also the formation of larger diameter branches which survive longer and overgrow. These differences form the basis of differences in the structure of the assortments of both clones.

Damage to stands

During the analysis of empirical material the dependence of the proportion of damaged trees on stand parameters was not confirmed. Therefore for both clones their average value was calculated, namely for Robusta clone 20.3% ± 9.81% and for I-214 clone 22.7% ± 9.86%. Statistical test confirmed with 95% probability there is not any significant difference between the two clones ($t_{calc.}$ = 1.59 and $t_{0.05,\,173}$ = 1.97). Therefore their common average value of 21.5% ± 9.88% was accepted.

Production of assortments

It is obvious from Fig. 2 that the stands of above-average site indexes of both clones are capable to produce thinner saw assortments of class *IIIA* already from the age of 6 years. One year later they produce also the assortments of class *II*, and in the stands older than 10 years even the highest quality assortments of class *I*. I-214 clone produces these assortments earlier by 1–2 years than Robusta clone due to its faster diameter growth. The highest quality saw logs culminate already at the age 10–14 years with the proportions 23–29%. Logs of class *II* culminate at the age 13–18 years with the proportions 8%–19% and the proportions of the highest quality assortments of class *I* fluently grow also at higher

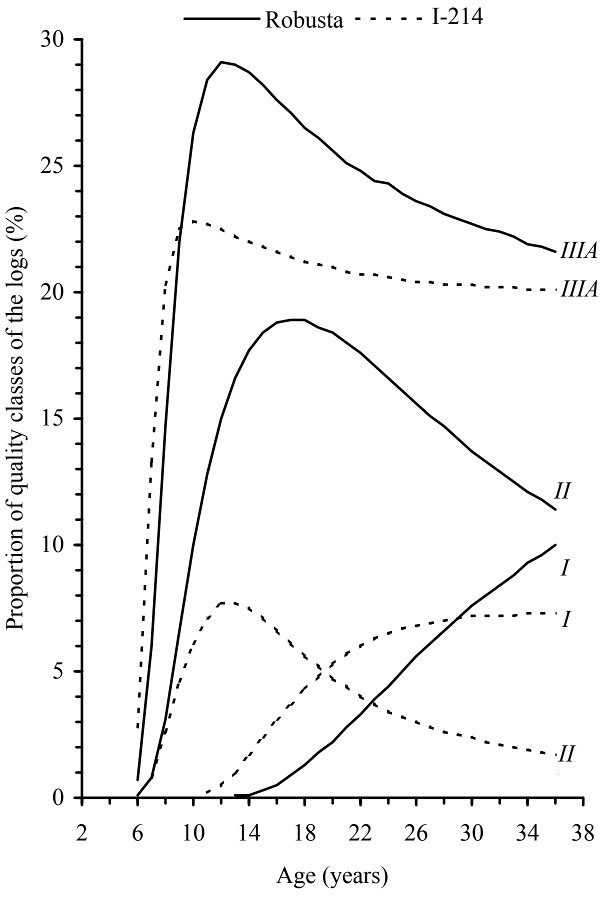

Fig. 2. Proportions of quality class *I*–*IIIA* of logs for stands of site index 40

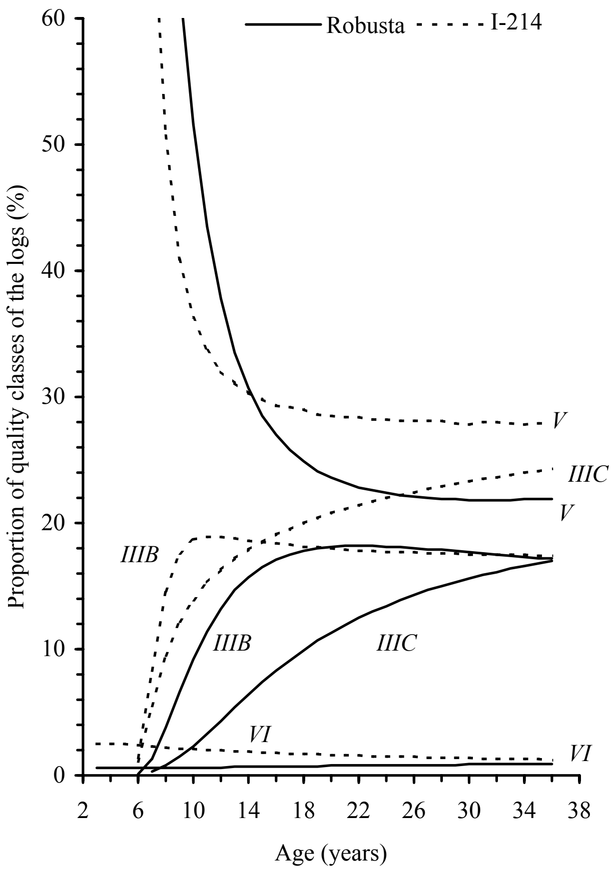

Fig. 3. Proportions of quality class *IIIB*–*VI* of logs for stands of site index 40

age. It is obvious from the comparison of both clones that Robusta has, in general, higher proportions of higher quality assortments than I-214. The proportions of the assortments of lower quality are illustrated in Fig. 3. The production of saw logs of class *IIIB* and *IIIC* usually starts at the age of 6 years. Class *IIIB* reaches quickly the values of about 19%, and with higher age the proportion slightly drops. The proportions of class *IIIC* are growing permanently with the age. The proportions of pulp assortments of class *V* show opposite development as concerns age. With higher age they decrease in hyperbola to the constant level of about 22–28% at the highest age. The proportion of fuel wood of class *VI* is constant at the level of about 1–2%. It also followed from this comparison that at the age of more than 15 years Robusta has relatively higher production of higher quality assortments than I-214.

Site index of the stand affects considerably also the production of assortments. Fig. 4 illustrates the structure of the higher quality assortments for the stands at the constant age of 30 years in dependence on their site index. Based on these values we can state that only the stands of average and above-average site indexes produce the most valuable quality class *I*. The proportion of this class is growing with higher site index and for the highest site indexes it reaches about 8–9%. The proportion of class *II* is more significant also with lower site indexes. It culminates with site indexes 30–32 with the proportion about 6% for I-214 clone and 19% for Robusta clone. Its decrease with higher site index is connected with the growth of tree diameter and shift of the highest quality logs more than 20 cm in diameter into class *I*. Quality class *IIIA* may also be included in the group of the highest quality logs. It represents the highest quality saw logs. Its proportion is permanently growing for I-214 clone with higher yield class up to the level of about 21%. On the contrary, Robusta clone has the highest proportions of about 29% already with site index 26 and from this value it is decreasing to the level of I-214 clone. Differences between the two clones are more marked when we count up the proportions of the group of the highest quality assortments of class *I–IIIA* into their total proportions. For I-214 clone this proportion increases with higher site index and within the range of site indexes 20–46 it reaches the values of about 10–30%. For Robusta

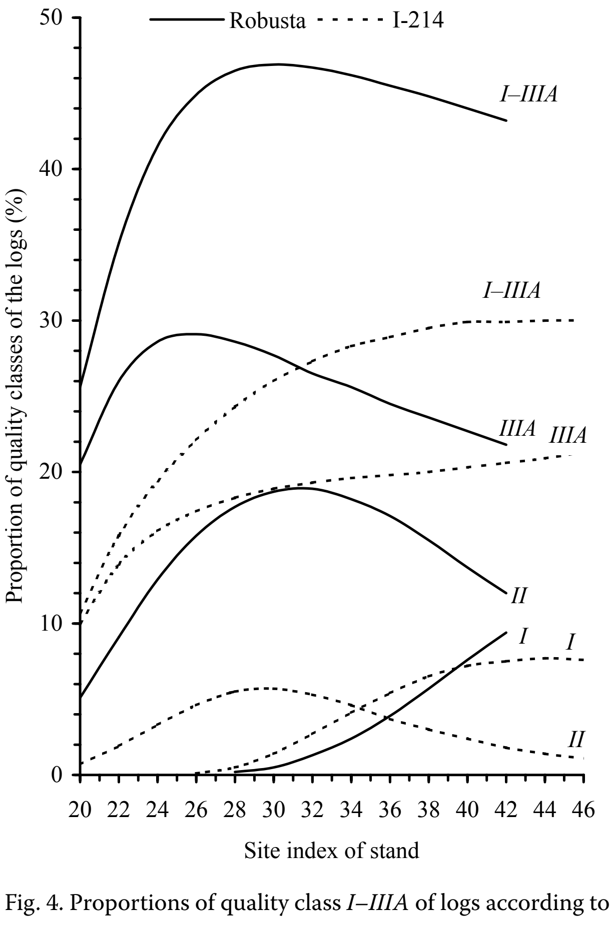

Fig. 4. Proportions of quality class *I–IIIA* of logs according to the site indexes at the age of 30 years

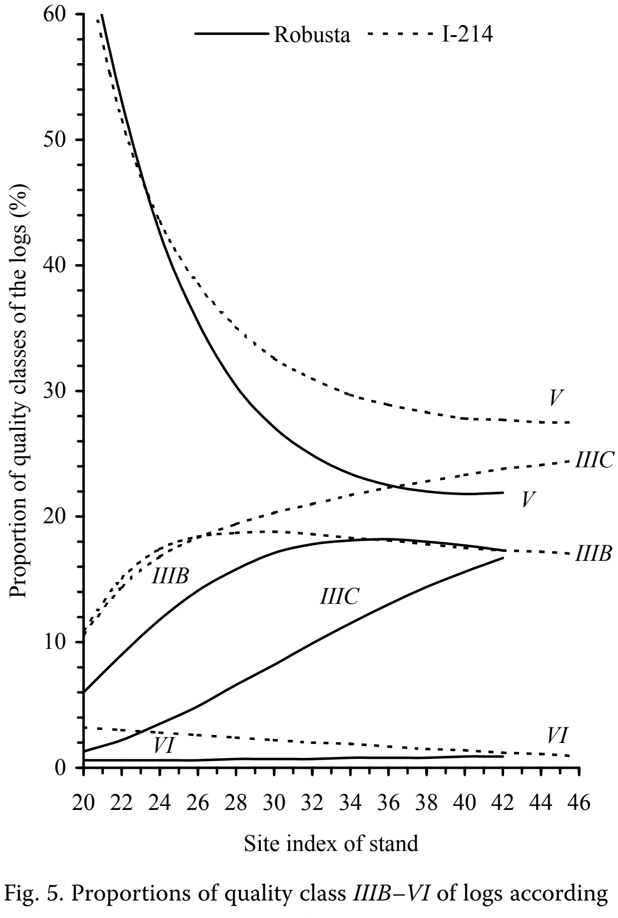

Fig. 5. Proportions of quality class *IIIB–VI* of logs according to the site indexes at the age of 30 years

these proportions are higher. They start already at the level of about 26%, culminate with site index 30 with the proportion 47%, and then start to decrease slightly to the level of 43% with site index 42. After generalizing these differences we can state that Robusta has a higher amount of the highest quality assortments by about 15–20% than I-214. Fig. 5 illustrates the structure of the assortments of average and lower quality. The proportions of class *IIIB* culminate with site indexes 30–36 with the values of about 19–18% and class *IIIC* with higher site index increases permanently. For Robusta it is about 17% and for I-214 about 25%. Pulpwood assortments of class *V* have the highest proportions with the lowest site indexes. With medium site indexes their proportions drop down to about 30% and with the highest site indexes Robusta maintains the level of 22% and I-214 27%. The proportion of fuel wood of class *VI* is at the level of about 1–3%, which is insignificant.

CONCLUSIONS

The methodology of the construction of models of assortment yield tables is presented for poplar clones Robusta and I-214 according to relation (1). The models were constructed on the basis of models of their yield tables according to relation (2) and (3), stand assortment tables according to relation (4), models of the quality of stems according to relation (5) and their average damage in stands. Robusta clone has several times higher proportions of the stems of the highest and average quality in comparison with I-214 clone. These proportions are almost constant in the whole site index range. I-214 clone is not reaching even the level of the highest quality stems of Robusta clone with the highest site indexes. It reached the proportion of the stems of average quality of Robusta clone only with above average site indexes. The age of stands positively affects the production of more valuable assortments through the intensive height and diameter growth of trees. With the highest site indexes the highest quality assortments are formed already from the age of 6 years and their proportions culminate at the age of about 10–20 years. High quality saw logs of class *IIIA* have the greatest proportion 20–30%. Both clones produce also a relatively high proportion of pulpwood assortments of class *V*. This proportion drops intensively with higher age of stands, and also in the stands older than 15 years it still reaches about 20–30%. The site index of the stand affects the production of assortments significantly as well. With the lowest site indexes only pulpwood is a decisive assortment and more significant proportions of the most valuable assortments are reached only for average and highest site indexes. Robusta clone produces with these site indexes by about 15–20% higher proportions of the highest quality assortments than I-214. But I-214 clone produces a faster and greater proportion of the assortments of average and below average quality.

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Modely sortimentačných rastových tabuliek topoľových klonov

ABSTRAKT: V práci sa prezentujú výsledky, ktoré sa dosiahli pri výskume produkcie sortimentov surového dreva pre porasty topoľových klonov Robusta a I-214 na Slovensku. Skonštruovali sa modely sortimentačných rastových tabuliek osobitne pre každý klon v závislosti od bonity a veku porastu. Podkladom pre ich konštrukciu boli modely rastových tabuliek, porastových sortimentačných tabuliek, modely vonkajšej kvality a poškodenia kmeňov. Klon Robusta produkuje približne o 15–20 % vyššie podiely najkvalitnejších sortimentov ako I-214. Ten produkuje rýchlejšie a väčším podielom sortimenty priemernej a podpriemernej kvality.

Kľúčové slová: topoľové klony; kvalita dreva; produkcia sortimentov; sortimentačné rastové tabuľky

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