Growth Intensity and Height Increment in a Young Hybrid Aspen Stand in Latvia

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Abstract: Hybrid aspen (*Populus tremuloides* x *Populus tremula*) has a very high productivity and therefore is one of the most promising alternatives for the establishment of plantations on abandoned agricultural lands in Baltic Sea region countries. In order to ensure selection of appropriate clones for the predicted changes in climatic conditions as well as to forecast possible changes in productivity and risks for hybrid aspen clones used currently, it is essential to obtain detailed knowledge on formation of its increment. Therefore the aim of the study is to assess the length of the annual height increment, factors affecting it and the pattern of its development.
Results from the hybrid aspen plantation consisting of 15 clones, measured during 4th growing season, reveal, that tree height at the beginning of the vegetation period was a significant factor influencing the length of the height increment (R^2=0.25) and the height growth intensity (R^2=0.22). Height increment was slightly longer for early flushing clones (111±5.4cm) than for late-flushing (101±7.1cm), but was not related to the length of the used vegetation period. Intensity of the height growth was strongly related to the daily mean temperature (R^2=0.76) and has two peaks – at the beginning of the growth season (end of May) and from middle of July till the end of August.

Key-Words: Productivity, clones, adaptation, vegetation period, *Populus*

1 Introduction

Hybrid aspen (*Populus tremuloides* x *Populus tremula*) has a notably (2-6 times) higher productivity than any of the parent species: American aspen and common aspen [1, 2]. It can produce as much as 8t of dry matter per ha and year in the second rotation [3]. Therefore it has been mentioned as one of the most promising alternatives for the establishment of plantations on abandoned agricultural lands in the Baltic Sea region countries [4]. Notable variation among individuals of hybrid aspen in traits characterising stem wood density, fibres, productivity as well as leaf area, number, size, intensity of photosynthesis, water use efficiency and others was found [5, 6, 7, 8, 9, 10, 11]. It indicates a notable potential of the improvement using selection.

Breeding of hybrid aspen in Latvia has been started in 1960th with the aim to create a basis of supply of raw material for matches' production [12] and continued from late 1990th with a target to develop suitable clones for cellulose and biomass production. Slight increase in fibre and stem quality traits and steep increase in productivity has been achieved, similar to that reported in Sweden: starting from 16$m^3h^{-1}y^{-1}$ on average in first stands established during 1960th and reaching 20-25$m^3h^{-1}y^{-1}$ in current stands and selections of the best clones [13].

Superior productivity of hybrid aspen clones has been attributed both to longer growth period and higher growth intensity [14]. It is important to distinguish between those factors in order to predict risks associated with the changes in climatic conditions. For example, if superiority in the length of annual shoot (height increment) for selected best clones is related to the use of a relative longer growth period, these clones potentially could have increased frost risks at present but could be capable of a better utilisation of favourable conditions in future. If, in contrast, superiority is caused by a higher growth intensity, risks of un-favourable weather conditions during the shorter growth period may have a strong negative effect.

Formation of increment depends on such environmental factors as solar radiation, moisture conditions, nutrient availability [15]. It is important to understand their influence on three growths during the vegetation period and genetic differences in this aspect in order to predict the possible adverse effect of the changes in climatic conditions and select the most appropriate clones.

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2 Problem Formulation

The aim of the study is to assess the length of the annual height increment of hybrid aspen, factors affecting it and the pattern of its development.

2.1 Material

Data collection for the study was carried out during the year 2010 in a hybrid aspen trial in the central part of Latvia (latitude 56°26' longitude 22°52'). the trial was established on former agricultural land in year 2007 using one year old containerized plants obtained via microclonal propagation. Initial spacing 3x3m, no thinning carried out. Ramets of 15 clones were randomly distributed in 25 replications. Mainly because of animals some trees had not survived and the growth of other was severely hampered, therefore only trees higher than 1 m were included in analysis and clones were represented by 18 ramets on average (ranging from 12 to 23 ramets).

2.2 Data collection

Tree height was measured before the vegetation period with 1cm precision. Bud development and bud-burst phases were assessed in 6 grades (based on standard developed by UPOV, 1981 [16]) in 5 field visits from 18th of April to 4th of May. Height increment was measured 15 times during vegetation period with frequency once per week on average from 17th of May until 29th of September. Leaf coloration and leaf fall was assessed in 3 grades in 2 field visits.

2.3 Data analysis

Average growth intensity in period was calculated dividing the difference in length of the height increment between two consecutive measurements with the number of days between those measurements. Length of the used vegetation period was estimated from the initial stage of bud-burst to complete defoliation in autumn. Standard methods of statistical analysis were used for estimations ofthe significance and correlation.

3 Problem Solution

3.1 Development of the height increment

The length of the height increment reached 109±3.7cm on average, ranging from as little as 64cm to 250cm. It was 55±1.8% from the height of the trees at the beginning of the vegetation period.

The height of the tree at the beginning of the vegetation period was a significant factor explaining the absolute length of the height increment (R^2=0.25) and has a negative correlation with the relative length (r=-0.37).

Average height growth intensity reached 8.6±0.03 mm day^{-1} and was also affected by the initial height of the tree (R^2=0.22).

Significant differences among clones were found both in the total length of the height increment (ranging from 72cm to 117cm) and in the average growth intensity (7.3 to 9.6 mm day^{-1}). The height of the trees of two clones (238±24.8cm and 164±17.8cm) deviates significantly from the trial mean (200±11.5cm), and also the length of the increment for the clone with highest trees is significantly larger. It indicates, that genotypes with a higher productivity (most suitable) already at first years have a competitive advantage also in following years, probably at least partly because of increased nutrient reserves, better resources availability, vigor. That is in line with findings from trials in the southern part of Sweden, noting, that an early differentiation among clones and therefore an early selection of the most productive is possible [17]. The intensity of the height growth has two peaks – at the beginning of the growth season (end of May) and from middle of July till the end of August (Fig.1). Other studies of hybrid aspen noted similar pattern and attributed it to time lag between culminations of the height increment of parent species – common aspen (peak in the end of May) and American aspen (peak in July) [10, 12, 18]. However, causes might be different and related to environmental variation, since similar pattern of growth intensity with two peaks was found also for other tree species, e.g. Scots pine [19].

The strongest correlation between the growth intensity and the total length of the height increment is found during the period of the second peak (middle of July till the end of August): r=0,56-0,60. There are differences among clones both in influence of the growth intensity in particular week to the length of the total height increment (R2=0.28-0.71) and the number of weeks when growth intensity has a notable (R^2>0.25) influence on height increment (ranging from 2 to 7 weeks). It might be related to different reaction of genotypes to changes in environmental conditions or different growth strategies – development of a significant part of the height increment in a relatively short, intensive growth period, trying to avoid possible adverse conditions, or, alternatively, developing it relatively evenly through the most of the vegetation period.

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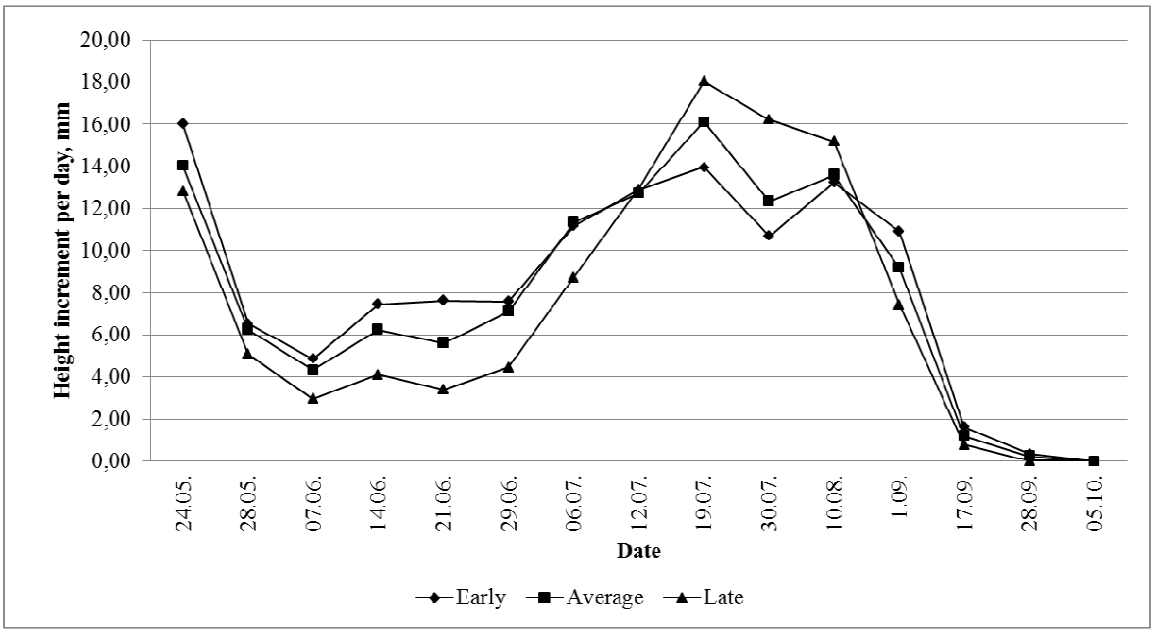

Figure 1. Development of height increment of hybrid aspen clones during fourth vegetation period in year 2010

3.2 Influence of bud-burst and defoliation

Time of the bud-burst has an influence on the total length of height increment: average length of it for early-flushing clones is 111±5.4cm, for late flushing 101±7.1cm. Difference in time to reach the same stage of bud-burst among clones ranges from 4 to 12 days. Clones with late bud-burst tend to have a pronounced peak of the growth intensity (Fig. 1) forming most of the height increment during a few weeks.

A very weak correlation was found between the height increment or the height growth intensity and either lead coloration or defoliation. Partly it could be attributed to the small differences among trees in time of occurrence of these processes – only 1-2 days. Exact detection of each stage of the leaf coloration and defoliation would probably also require more frequent observations as those carried out in this study. Studies in Finland indicate that clones with a late bud-burst tend to have an earlier defoliation and therefore a shorter length of used vegetation period [20], but not a larger height increment.

The length of used vegetation period for hybrid aspen trees was 185±0.7 days. It ranged among clones from 175 to 190 days. Correlation between the length of used vegetation period and the height increment was weak or absent (Fig 2.). Similar results were found in Finland [20]. Data suggest, that there is a time-lag between the moment of termination (or close to termination) of height growth and leaf coloration. Those days with still green foliage, but practically no production could partly explain the lack of correlation between the used vegetation period and the height increment.

3.3 Influence of meteorological conditions

A strong and significant correlation (r=0.87) was found between growth intensity and daily mean temperature (Fig. 3). The influence can be demonstrated by drop in temperature during June and related notably smaller growth intensity in this month. Clones demonstrate slight differences in growth response to temperature: r=0.74 – 0.95. No tendency related to those differences and the length of the total height increment was detected.

Amount of precipitations had no pronounced effect on growth (r=0.35). It could be explained by sufficient rainfall (not lower than long-term average) and amount of water in soil, therefore water was not a limiting factor. Data about the precipitation were obtained from the closest meteorological station, located 4km for trial. However, to uncover detailed response of hybrid aspen growth on changes in water availability, in-site measurements of soil moisture need to be carried out.

Clonal differences were found in growth response to precipitation: r=0.05 – 0.39. Comprehensive studies of water use efficiency had been carried out for different populous species, indicating notable differences among clones in this trait [21]. That emphasizes the importance of a further detailed analysis in order to reveal differences in drought tolerance of hybrid aspen clones.

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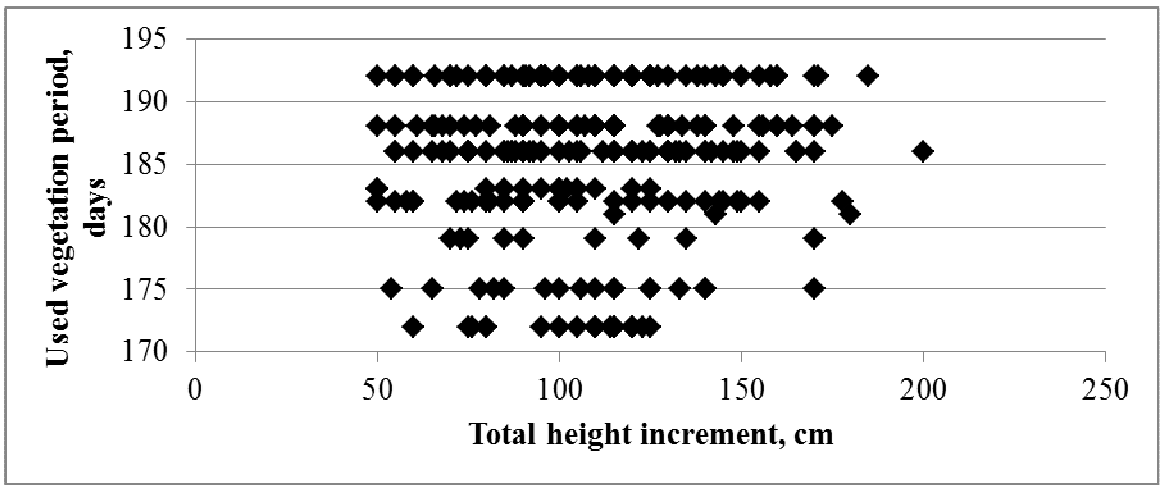

Figure 2. Relation between length of height increment and used vegetation period for hybrid aspen clones during fourth growing season in year 2010

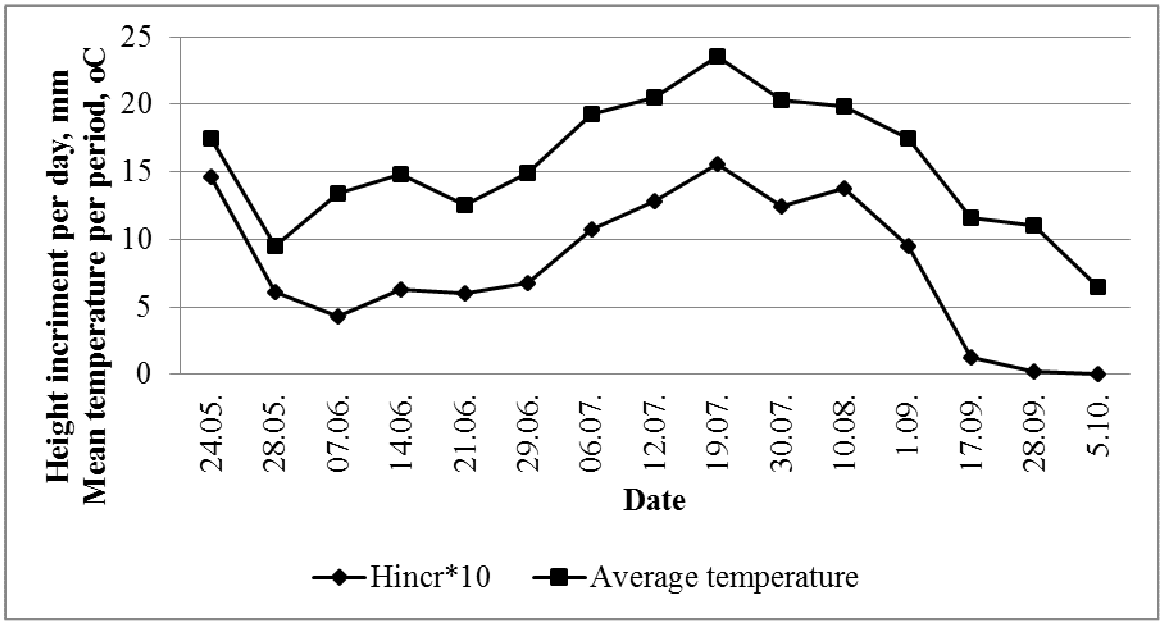

Figure 3. Connection between height growth intensity of hybrid aspen and daily mean temperature during the vegetation period

4 Conclusion

1. The length of the height increment for hybrid aspen during the 4th growing season reached 109±3.7cm and was significantly affected by genetic properties (clone) and initial height of the tree.
2. The height increment was longer for early-flushing clones, but was not related to the length of the used vegetation period.
3. The growth intensity reached 8.6±0.03 mm day^{-1} on average, had two peaks during the vegetation period and was strongly and significantly (R^2=0.76) affected by the temperature.

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